MARELITT Baltic

Interreg Baltic Sea Region

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Environmental Impact Assessment

Retrieval of derelict fishing gear from the Baltic Sea

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Cover photo: Municipality of Simrishamn

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Executive summary

Over the past few decades, the awareness of ecological damage of the marine environment related to the presence of marine litter including *abandoned, lost and otherwise discarded fishing gear* (ALDFG), or so-called ghost nets, has augmented. These ALDFG are lost in great numbers and, with time, degrade into microplastics that enter the food chain with potential impacts far up in the ecosystem. Before degradation, impacts of ALDFG on the marine ecosystem are also related to the reduction of populations of target and non-target species by continued fishing of the ALDFG (Uhlmann, S. S. & Broadhurst, M. K., 2015; Tschernij & Larsson, 2003). ALDFG also affects animal welfare (Werner, et al., 2016).

In order to mitigate these negative impacts, various retrieval operations are carried out at the present in the Baltic Sea and other locations. Within the framework of the EU project MARELITT Baltic, WWF Germany and the MARELITT Baltic project partners coordinate ALDFG retrieval operations in the Baltic Sea, and investigate the options for ecologically sound retrieval of ALDFG. This report constitutes an Environmental Impact Assessment (EIA) of ALDFG retrieval operation techniques, with a focus on those used by MARELITT Baltic partners. The impact assessment is followed by recommendations of Good Environmental Practices that aim to serve as a guideline for ecologically sound retrieval operations of ALDFG in the Baltic Sea. At the time of writing, no known EIA of retrieval operations of ALDFG has been carried out. To put this EIA in perspective, the EIA also covers an assessment of impacts of the *zero-alternative* (leaving the ALDFG in place) and commercial bottom trawling activities.

The impacts are derived based on an estimation of the magnitude of the effects on the physical environment caused by the ALDFG retrieval operations and the sensitivity of the assessed bottom habitats. The impacts are assessed for fifteen representative habitats and habitat forming species of the Baltic Sea. In addition, *Wrecks* have been considered as a distinct habitat since they represent a major cause of ALDFG loss in the Baltic Sea (WWF Poland, 2015), but also because they can have a high cultural value and host a high biological diversity.

The environmental effects differ between the different phases (searching or retrieving) of the ALDFG operation. During the search for ALDFG, a heavy-toothed steel bar, so-called *creeper,* is typically dragged over the seafloor. The physical effects of the creeper largely depend on the design, width and weight of the equipment. The main differences between bottom trawling and the ALDFG search operation is the swept area (smaller width of the ALDFG search equipment), the weight of the equipment (lighter for ALDFG search operations) and the hauling speed (lower when searching for ALDFG) (Table 2). Within this EIA both bottom trawling and ALDFG operations are evaluated as a one-time event (no cumulative effects are considered). A localized ALDFG will be retrieved by the creeper that is manually hauled in, or with the help of a hook or a retrieval anchor (with or without a winch). For *Wrecks*, the use of divers who manually cuts off the ALDFG represents the principal retrieval method.

Impacts related to MARELITT Baltic operations are expected during the *search* phase due to potential *abrasion* and *siltation* on the assessed soft- and hard bottom habitats, as well as on habitat forming species. Expected impacts related to MARELITT Baltic *search* operations vary between *low* and *high* depending on the habitat type. *High* impact is expected on Eelgrass/Charophyte habitat, *medium* impact on other habitat forming species as well as on reefs and *low* impact on broad-scale habitats (photic and non-photic soft bottom, hard bottom and mixed bottom).

Impacts related to the *retrieval* phase of MARELITT Baltic operations are considered to be negligible on all assessed natural habitats, but can be significant on the wreck-habitat. A non-controlled method used during the *retrieval* phase on a wreck habitat with an anchor or hook will be associated with possible damage and hence a *high* potential impact. We consider that retrieval of ALDFG on wrecks, even when using a “soft-method” with divers, is still associated with a potential impact that should be minimized. The sensitivity of Wrecks is *high*, as every wreck can potentially represent a cultural heritage that will never be restored to its former (before damage) state. All wrecks may thus have a historical value and are important to preserve until authorities have been informed and have determined the status of preservation and associated precautionary methods. It is important to note that estimated impacts for wrecks assume that the wrecks *have* a cultural value (if otherwise impact is not relevant). Retrieval operations should be carefully planned on these habitats.

Search operations with creepers can also result in damage to wrecks (specifically non-documented wrecks), thus implying a potential loss of a cultural value. However, MARELITT Baltic directed search operations on Wrecks are only performed with non-invasive methods (diver and/or acoustic methods).

The impacts of the *zero-alternative* (not retrieving ALDFG) are considered *high* for all assessed habitats. Leaving the ALDFG in the marine environment means both the *introduction of marine litter* to the marine environment and a potential for ecosystem effects due to *species extraction* (ghost fishing). Overgrown nets may create artificial reef structures, where organisms can attach and grow. Nevertheless, the degradation of the net will lead to an influx of microplastic fibers into the marine environment, with potentially harmful effects on aquatic organisms. This implies that in general terms, the benefits of retrieving ALDFG on bottoms with methods employed by MARELITT Baltic outweigh the potential negative impacts caused by the retrieval operations. This is especially true as the *zero-alternative* induces impacts that are estimated to reach beyond the habitat boundary, thus potentially affecting the Baltic Ecosystem on a higher level with cascading effects.

The present EIA also emphasizes that *bottom trawling* activities result in higher impacts on the bottom habitats than MARELITT Baltic retrieval operations (as MARELITT Baltic retrieval operations are designed today).

It is important to note that search and retrieval of ALDFG should be avoided in certain habitats and under certain circumstances. It is recommended that only non-invasive search methods (hydro acoustic or divers) are used in sensitive habitats such as Eelgrass, Charophytes (stonewort) or other red-listed Baltic Sea habitats. The overall impacts of the specific retrieval should always be central during planning for both search- and retrieval operations. ALDFG operations should be planned with relevant priority lists and sufficient data on habitats, wrecks, and the decomposition state of the ALDFG.

Dictionary

ALDFG/DFG (abandoned, lost or otherwise discarded fishing gear / derelict fishing gear) * - fishing equipment as trammel-nets, gillnets, longlines, traps and bottom trawl gear lost or abandoned at sea.

Habitat -- the natural home or environment of a plant, animal, or another organism.

Suspension -- a mixture in which particles are dispersed throughout of a bulk of fluid.

Sediment - particulate matter that is carried by water or wind and deposited on the surface of the land or the seabed, and may in time become consolidated into rock.

Mud* – is a name for all the sediment types consisting of small particles such as silt, clay and colloid. The particle size is <62,5 µm.

Clay* - is a sediment type consisting of particles in the size range of 0.98–3.9 µm.

Sand - is a sediment type consisting of a range of particle sizes, from very coarse sand to very fine sand. The particle size ranges from 2 mm – 62,5 µm.

Habitat forming species* – a species that creates a habitat that becomes home for other organisms and plants.

Photic - denoting the layers of the ocean reached by sufficient sunlight to allow plant growth.

Non-photic - denoting the layers of the ocean that are not reached by sufficient sunlight to allow plant growth.

Pelagic - refers to the water column or the open sea, it consists of only water and the organisms living in it.

Benthic - refers to the lowest level of the water column including the seafloor.

Effect - a change that is a result or consequence of an action or other cause

Sensitivity - a measure that describes how damaged, injured, or distressed a habitat/organism becomes by slight changes.

Impact - The action of one object coming forcibly into contact with another. Within this report, the impact will be the change an effect will have on a habitat or an organism.

Zero-alternative* – Used in the context of impact assessments as a reference alternative to the assessed project. Within this report, it will be not retrieving the ALDFG.

*Definitions above are from Oxford dictionary except words marked with * that are taken from other sources or represent the definition the authors used for this report.*

1 Introduction

Over the past few decades, the awareness of ecological damage of the marine environment related to the presence of marine litter including *abandoned, lost or otherwise discarded* fishing gear (ALDFG), or so-called ghost nets, has increased. In order to mitigate these negative impacts, various retrieval operation campaigns are now carried out in different areas including the Baltic Sea. The retrieval method used varies between different countries and regions, and depends on factors such as what type of ALDFG is expected, water depth, bottom structure and bottom type.

The impacts of the retrieval operations have, to our knowledge, never before been thoroughly investigated and development of guidelines or good environmental practices are needed. These guidelines can be used during the planning of retrieval operations to highlight the possible impacts the operation can have on the environment and can help to minimize these impacts.

In the context of these retrieval operations, it is important to consider whether the retrieval operations themselves can cause harm to the marine environment, and therefore when it is accordingly better to avoid ALDFG retrieval. These questions are addressed in this report.

1.1 Scope and objectives

In the framework of the project MARELITT Baltic, WWF Germany investigates the options for ecologically sound retrieval of derelict fishing gear (ALDFG), from the Baltic Sea (https://www.marelittbaltic.eu/). With the aim of identifying environmentally sound retrieval techniques, the ecological impacts of different retrieval methods on the marine environment have been analysed.

The major outcome of this study consists of an Environmental Impact Assessment (EIA) of retrieval operation techniques on hard-substrate seafloor conditions, soft sediment environments as well as on wrecks. As a comparison, the results of the EIA are also discussed in relation to impacts caused by commercial bottom trawling methods used in the Baltic Sea.

The final assessment report also includes a decision tree with recommendations for good environmental practices that will serve as guidelines to achieve ecologically friendly retrieval operations of ALDFG, with focus on the Baltic Sea.

The final goal of the EIA is to facilitate the decision on the ALDFG retrieval method in relation to expected marine environmental impacts and locations for future retrieval operations. In order to accomplish this task, the following approach has been adopted.

1. Review and classification of different retrieval techniques in use (Chapter 3).
2. Evaluation of environmental physical effects for retrieval techniques on different bottom types (soft bottom, hard bottom, wrecks; Chapter 4).
3. Evaluation of ecological value and sensitivity of the receiving environment, based on identified key habitats in the Baltic Sea (Chapter 5)
4. Impact assessment of retrieval methods on different bottom types and habitats, based on the physical effect on the environment and ecological sensitivity (Chapter 6).
5. Recommendations for good environmental practices related to retrieval of ALDFG (Chapter 8).

The EIA also includes an assessment of the *zero-alternative*. The *zero-alternative* is here defined as leaving the ALDFG in the marine environment. It can both be applied in a pre-planning manner (what are the impacts without a search for ALDFG?), but will more often be applied on a retrieval assessment level or decision point (once an ALDFG has been localized, what are the impacts of retrieving the ALDFG compared to the impacts of leaving it in place?).

Within MARELITT Baltic, several partners have participated: Estonian Divers Association, Institute of Logistics and Warehousing (Poland), Keep the Estonian Sea Tidy, Keep Sweden Tidy, Kolobrzeg Fish Producers Group (Poland), Maritime University of Szczecin (Poland), Municipality of Simrishamn (Sweden) (Lead partner), WWF Germany, WWF Poland. Information for this EIA related to methods of retrieval operations has been gathered from above-mentioned partners, who have also had the opportunity to comment the report. WSP Environmental performed all the work related to this EIA as an independent consultant.

1.2 Background

1.2.1 Impacts of ALDFG

Large amounts of nets are lost or abandoned at sea. The annual number of gillnets lost in the Baltic by EU vessels during 2005-2008 ranged from 5 500 to 10 000 (WWF Poland, 2015). In Sweden, the estimated number of gillnets lost annually has been estimated at 2750 – 3000. This corresponds to approximately 156 – 165 km of nets in total length every year, and is about 0,1% of all nets used annually (Tschernij & Larsson, 2003).

Loss of fishing gear has taken place since fishing started. The causes of gear loss vary between and within different fishing areas and types of vessel used. The loss can be both accidental and intentional. Accidental gear loss is higher under more difficult fishing conditions such as bad weather, fishing on bottoms with complex structures, or fishing with very long nets and with several gears that cannot be hauled regularly (WWF Poland, 2011). Another common cause for accidental loss is fishing in areas where both gillnet fishing and trawling takes place, which can for instance result in trawlers that pass over gillnets that will subsequently become detached. The projects FANTARED I and II, partly funded by the European Commission, studied these and other reasons behind gear loss in both coastal and deeper areas, respectively (MacMullen, et al., 2004). Areas where loss of fishing equipment is likely to occur include ports or areas with high boat traffic, or areas with important tourism (i.e. watersport activities such as yachting, recreational fishing).

Abandoned fishing gear is defined as gear that has been used for fishing and intentionally been left at sea (Gillman, et al., 2016). Fishing gear may for example be abandoned by fishermen who are operating illegally, when a risk of detection occurs. Alternatively, bad weather may result in gear abandonment, as well as in accidental loss of the equipment.

Once the fishing equipment is lost and not collected, it will be considered waste. If the ALDFG consists of synthetic fibers, it will be considered plastic waste. Plastic waste is an increasing environmental problem due to the slow degradation of the material. The slow degradation results in plastic being present in the environment for a very long time in the form of large fractions, smaller fractions and microplastics. An estimation done by Jambeck, et al. (2015) showed that the land based contribution of plastic waste from 192 coastal countries in the ocean is 4.8-12.7 million tons annually. The ALDFG constitutes an additional and non-negligible source of plastic waste consisting of nets, lines, traps and other recreational or commercial fishing equipment that have been lost, abandoned, or otherwise discarded from different fishing activities (Sheavly, 2007; UNEP, 2005). This is a local as well as a worldwide problem as ALDFG pollute marine environments all over the world (Macfadyen, et al., 2009). The extent and impacts of the problem have increased significantly over the last 50 years with the increasing levels of fishing effort in relict areas, and the increasing durability of fishing gear (Macfadyen, et al., 2009). In the UK, fishing debris such as line, nets, buoys and floats is the third largest source of beach litter at 11.2% (Marine Conservation Society, 2015). In the North Sea, a recent report from Niedersachsen (Germany), showed that 33% of litter collected along the beach consisted of leftovers from nets and ropes (NLWKN, 2014). An assessment from OSPAR shows that 28% of beach litter consist of fishing nets and ropes within OSPAR waters (OSPAR, 2017), which agrees with the percentage published in other reports.

Many studies have shown how ALDFG affect the environment by damaging sensitive habitats (Arthur, et al., 2014) and creating navigational hazards (Johnson, 2000). ALDFG also contributes to overfishing as it is reducing populations of target and non-target species even after the fishing gear is lost (Uhlmann, S. S. & Broadhurst, M. K., 2015), so-called ghost fishing. According to one study conducted in the Swedish Baltic Sea, the ALDFG continue fishing with up to 20 % efficiency during the first three months after "loss" at sea and with an efficiency of 5-6% thereafter (Tschernij & Larsson, 2003). The total period with observed fishing efficiency was 27 months in that study. Smaller nets drifting in the water column (50-100 m) continued fishing for 1 day while longer net fragments (2 km) could continue fishing efficiently for at least 3 months.

Retrieval of ALDFG is not only beneficial for the habitat, but it may also increase the value of the commercial fisheries. One study conducted in Chesapeake Bay (USA) showed that removal of 34,408 derelict pots led to significant gains in gear efficiency and an additional 13,504 MT in harvest of crustaceans valued at US $21.3 million (Scheld , et al., 2016). No such study with the same scope has to our knowledge been conducted in the Baltic Sea.

1.2.2 Impacts of ALDFG retrieving techniques

To our knowledge, no studies or impact assessments have been published on ALDFG retrieval operations. This is despite the fact that retrieval campaigns are performed regularly in several countries. Canada, Norway and Poland have annual organized retrieving operations of ALDFG (Graham N.et al, 2009). The lack of published studies implies that information on impacts of ALDFG retrieval operations are scarce and impacts have to be estimated from marine activities with resembling characteristics. Since both bottom trawling and retrieval of ALDFG use bottom contacting equipment, even though different in size and weight, we can assume that some of the impacts observed for trawling also may occur during the retrieval of ALDFG, albeit on a lower level. Impacts vary in magnitude due to differences in the swept area (which is much higher for bottom trawling) and due to the frequency of disturbance (mostly limited to a one-time event for retrieval operations for ALDFG, compared to repeated events for bottom trawling). A review of potential impacts of bottom trawling is presented in the following chapter.

1.2.3 Impacts of bottom trawling

Bottom trawling is a fishing method that drags a trawl gear along the seafloor. The trawl gear can have different designs and can be classified into beam trawls, otter trawls and scallop dredges. All trawl types induce similar effects on the seafloor like scraping, scouring and suspension of bottom substrate

(Jennings & Kaiser, 1998), but the depth of the impact varies with the gear type, towing strength, type of bottom substrate and time of the year (deGroot, 1984; Mayer, et al., 1991).

In the Baltic Sea, the most frequently used gear is the otter trawl. This trawl type consists of two otter boards that are dragged on the seafloor in order to keep the trawl net close to the bottom as well as to maximize the opening of the "net mouth" (Figure 1). The otter trawl creates trenches on the seafloor that have been estimated between 15- 35 cm deep in muddy habitats (Eigaard, et al., 2016). The net itself also penetrates the sediments to a depth of approximately 2-10 cm on muddy habitats (Eigaard, et al., 2016). Both the otter boards and the net lead to suspension of the sediment (Durrieu de Madron, et al., 2005).

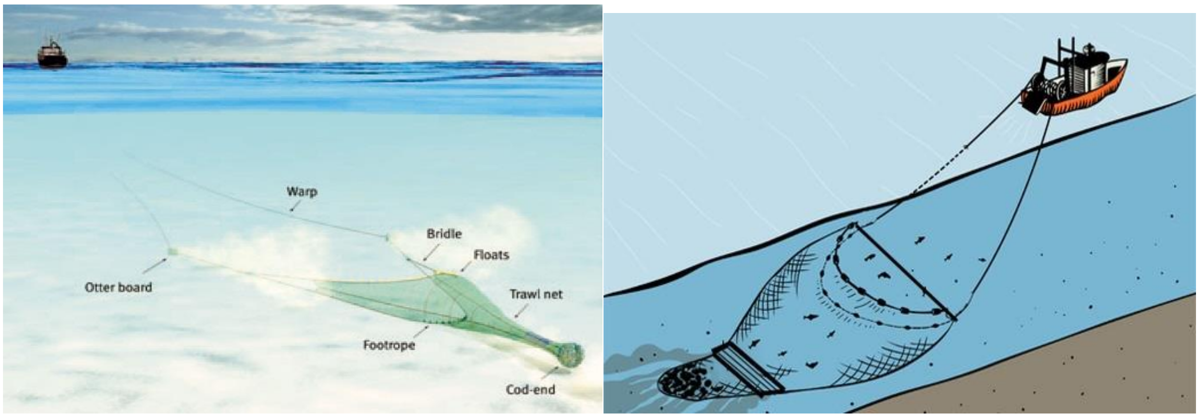

Figure 1 The picture on the left (©fishingforthetruth.co.uk) shows an otter trawl which consists of two otter boards as well as footrope and a trawl net that are dragged along the seafloor and dig into the sediment to different depths. The picture to the right (©thisfish.info) shows a beam trawl consisting of a beam connected to the trawl net, both of which have contact with the seafloor and dig into the sediment to different depths.

Studies on impacts from trawling are mainly from outside the Baltic Sea and these may consequently not be directly applicable to the Baltic Sea environment. However, these studies can serve as a good indicator of the physical effects, and to some degree also the impacts, which can be expected in the Baltic Sea. Trawling on soft bottoms will alter the characteristics of the seafloor that may become flat and lose its structural variety, which, in turn, can have a negative impact on organisms depending on structural complexity (Nairn, et al., 2004), or induce a reduction of habitat-building organisms (Thrush, et al., 1998).

Large amounts of sediment may become suspended due to bottom trawling on soft bottom habitats. In one of the few studies treating this topic, the sediment plume created by a relative small bottom trawl (25 m between the 170 kg heavy trawl doors) reached 15-18 m above the seabed and 60 m on either side of the middle of the trawl (Bradshaw, et al., 2012). This also implies that bottom trawling on contaminated sediments can lead to the release of the contaminants into the surrounding water which in turn become bioavailable for organisms again (Bradshaw, et al., 2012). Importance of sediment suspension is related mostly to sediment grain size and the drag strength of the trawl (O'Neill & Summerbell, 2011).

Studies on trawling show the removal of large amounts of organisms (up to 55% of the organisms according to Collie et al. (2000)) as well as a reduction of biomass and productivity (reduced by 56% and 21% respectively, in a study by Hiddink et al. (2006)). A change in species distribution as larger species disappear at a faster rate than smaller species has also been noted (Hiddink, et al., 2006).

Opportunistic species with short life span, who can settle in frequently disturbed habitats, are therefore favored (Engel & Kvitek, 1998; Bradshaw, et al., 2001). The sediment plume created has also been reported to induce negative impacts on the surrounding environment and organisms (Bradshaw, et al., 2012).

When comparing effects of trawling with retrieval operations of ALDFG, some considerations are important. Firstly, the magnitude of effects on the seafloor and the amount of sediment released in the water column are dependent on the weight and size of the trawls (Martín, et al., 2014). A bottom trawl will impact a larger area of the seafloor, due to the larger width of the equipment (see Chapter 3). A bottom trawl commonly used in the Baltic Sea is the otter trawl, which can have a width ranging from 25-250 m, resulting in a swept area of a similar size. As some of the equipment used during retrieval operations has a width of 0.8-1.2 m, the swept area will be smaller than for bottom trawling. An otter trawl can dig down into the sediment between 15-35 cm, which will result in large sediment resuspension into the water column. For the different retrieval methods, only one study has measured the penetration depth (MARELITT Baltic personal comment). The penetration depth of a light search device, which are neutral at any water depth, was 3 cm.

Secondly, impacts on aquatic habitats and organisms will also depend on the frequency of disturbance Bradshaw C., 2004): while bottom trawling can be assumed to be carried out with a much higher frequency, retrieval operations of ALDFG can be considered a one-time event.

1.3 Impact- and status assessments of the Baltic Sea

The HELCOM Baltic Sea Action Plan (BSAP) is an ambitious program to restore the good ecological status of the Baltic marine environment by 2021[1]. The BSAP, adopted by all Baltic coastal states and the EU in 2007, incorporates the latest scientific knowledge and innovative management approaches into strategic policy implementation, and stimulates goal-oriented multilateral cooperation around the Baltic Sea region.

Within the HELCOM work, there is also an ongoing extensive assessment of the 'ecosystem health' of the Baltic Sea carried out within the projects HOLAS I[2] and HOLAS II[3], (HELCOM, 2010) (HELCOM, 2017a). The work within HOLAS evaluate the status of the ecosystem as well as the capacity of the ecosystem to resist an external pressure. Both the *Baltic Sea Pressure index* (BSPI) and the *Baltic Sea Impact index* (BSII) are tools used within HOLAS for spatial visualization and assessment of cumulative pressures and impacts in the Baltic Sea marine area. The BSII consists of an impact assessment that is derived through a crossing of potential anthropogenic pressures for a certain area, Baltic Sea habitats (referred to as "biological ecosystem components") and a weighted evaluation of the magnitude of effects for each specific pressure on the different habitats. The weighting scores have been determined through expert panels invited by HELCOM and published scientific papers. The scores also take into account the biotope resilience and recovery from a pressure, as well as whether the pressure affects one or several species, one or several trophic levels, or the whole community. In 2010, the results were published within HOLAS I, but the work continued and the method developed and in August 2017, a first version of HOLAS II was published.

[1] http://www.helcom.fi/baltic-sea-action-plan
[2] Helcom first Holistic assessment of the ecosystem health of the Baltic sea.
[3] Helcom second Holistic assessment of the ecosystem health of the Baltic sea.

2 Method

The impact assessment is based on the assumption of a relation between a physical modification of the environment (*pressures*) and the ecological value and sensitivity of the receiving environment and therefore requires detailed information about these. In the case of this EIA, the receiving environment of ALDFG activities is restricted to the bottom habitats of the Baltic Sea. However, potential impacts of the *zero-alternative* and *bottom trawling* are partly evaluated on the broader ecosystem level, as some of the effects related to these pressures are considered more significant on this “higher” level.

The specific environment in the Baltic Sea in regard to habitats and environmental factors (such as a high baseline stress level of species due to varying salinity levels, see Chapter 2.2) provides a good reason to use a habitat classification and sensitivity scores specifically developed for the Baltic Sea.

The classification of habitats within this EIA has been adopted from the classification used within the HELCOM HOLAS II holistic assessment (HELCOM, 2017). This EIA has also, as far as possible, used the sensitivity evaluation of habitats used within the HELCOM HOLAS II impact assessment (see further Section 2.2). The rationale behind this is twofold. First, the HELCOM HOLAS project is at the time of writing the only impact assessment available that intends to cover the whole area of the Baltic (and thus the same habitats as covered by this EIA). The selection of habitats are considered a good representation of the Baltic biological entities (HELCOM, 2010). Secondly, maps of different habitats used within the HELCOM HOLAS project are publically available and are regularly updated as new data are made available. This is also important for the EIA, since one of the goals is to be of use in current and future ALDFG retrieval operations. In this context, it should also be mentioned that in another part of this MARELITT Baltic work package, maps with potential hotspots for ALDFG in the Baltic Sea are developed (Baltic map of DFG host areas developed under MARELITT Baltic project (co-funded by the INTERREG Baltic Sea Region Program 2014-2020)).

HOLAS II does not assess sensitivity on the ecosystem level (as sensitivity is associated with specific habitats). In the case of the *zero-alternative* and *bottom trawling* that create impacts on the ecosystem level, the sensitivity assessment has been based on published scientific literature and expert opinion (see Chapter 5).

2.1 Classification of habitats and habitat forming species in this EIA

The HELCOM HOLAS II habitats have been adapted in order to reach the objectives of the present EIA (Table 1).

Firstly, some HOLAS II habitats are excluded from the EIA, as effects on these are not considered relevant in the case of ALDFG retrieval operations. This is the case for pelagic habitats, seabird wintering and breeding grounds, migratory routes for birds, harbor porpoise and seal habitats that have all been excluded from the EIA. Intertidal habitats are also excluded from the assessment, as these habitats will not be included in ALDFG retrieval operations performed with vessels (as they can be reached by foot). Habitats corresponding to spawning and nursery grounds for cod and other fish species have also been excluded in the EIA as different fish species spawn and nurse at different times, even with spatial differences within the same species, which would make the EIA very complex. It is, however, recommended that sensitive periods for fish species should be considered during the planning phase. Planning aspects will further be discussed in Section 8.1.3 (Good environmental practice).

Secondly, some habitats have been treated jointly, as their characteristics and sensitivity to ALDFG retrieval operations are similar on the EIA level. This is the case for Fucus (brown algae also called bladder wrack) and Furcellaria (red algae) biotopes, as well as Eelgrass (also called sea grass) and Charophytes (stonewort). Such habitats are assumed to react similarly to pressures from ALDFG retrieval operations, such as siltation or physical disturbance.

Thirdly, three other specialized habitats will only partly be mentioned as they are considered to be covered by broader scale habitats, such as hard bottom habitats or soft bottom habitats. These habitats correspond to submarine structures made by leaking gas, Baltic esker islands and Boreal islets and small islands.

One additional habitat, not considered in the HOLAS II assessment, is wrecks, which represent a major cause to ALDFG losses (WWF Poland, 2015). Wrecks have been considered as a distinct habitat equivalent to the other assessed habitats. As a result, a total of 16 habitats are considered in this EIA (Table 1).

Table 1 Overview of habitats treated in this EIA compared to HELCOM HOLAS II. Some of the listed habitats in the table correspond to several habitats treated together, with the number of habitats highlighted in parenthesis when above 1. Habitats from HOLAS II considered in the EIA are colored green, while additional habitats also considered within study are indicated in orange. Note that terms "interlittoral" and "circalittoral" used within HOLAS II have been replaced by "photic" and "non-photic" within this EIA.

Type of habitat	Habitat	EIA	Remarks
Species data	Distribution of harbor porpoise	Not considered	Not relevant for EIA
	Seal abundance and haoulouts (4 habitats)	Not considered	Not relevant for EIA
	Wintering grounds, breeding colonies migration routes (3 habitats)	Not considered	Not relevant for EIA
	Spawning/nursery grounds and high abundance of fish species (9 habitats)	Not considered	Discussed in Chapter 8, Good Env. Practices
Water column (pelagic)	Productive surface waters	Not considered	Not relevant for EIA
	Oxygenated deep waters	Not considered	Not relevant for EIA
Habitat forming species*	Blue mussel bed	Considered	
	Eelgrass meadows	Considered jointly	Treated in EIA together with Charophytes
	Charophytes	Considered jointly	Treated in EIA together with Eelgrass
	Fucus *sp.* habitat	Considered jointly	Treated in EIA together with *Furcellaria*
	Furcellaria lumbricalis	Considered jointly	Treated in EIA together with Fucus sp.
Broad scale seabed habitats	Photic sand	Considered	
	Non photic sand	Considered	
	Photic mud and clay	Considered	
	Non-photic mud and clay	Considered	
	Photic hard bottom	Considered	
	Non photic hard bottom	Considered	
	Photic mixed bottom	Considered	
	Non photic mixed bottom	Considered	
Specific habitats	Reefs	Considered	
	Submarine structures made by leaking gas	Only partly considered**	Treated under reef habitat
	Baltic Esker Islands	Only partly considered**	Treated under photic sand habitat
	Boreal islets and small islands	Only partly considered**	Treated under photic hard bottom habitat
	Coastal lagoons	Not considered	Not relevant for EIA
	Estuaries	Not considered	Not relevant for EIA
	Large shallow inlets and bays	Not considered	Not relevant for EIA
	Mudflats and sandflats not covered by seawater at low tide	Not considered	Treated in EIA within soft sand and mud
	Sandbanks which are slightly covered by sea	Not considered	Treated in EIA within soft sand and mud
Artificial habitats	Wreck	Considered	
Ecosystem	Baltic Ecosystem	Considered	

* Defined as areas with cover of >10 % of the species.

** These more specialized habitats will only partly be mentioned as they are considered to be covered by broader scale habitats, such as hard bottom habitats. In addition, they do not refer to special biotopes such as Eelgrass or mussel banks and the sensitivity is uncertain without knowledge of the organism structure.

There are a large number of habitats in the Baltic Sea. A selection of these are covered within this EIA, which aims at strategic planning of ALDFG retrieval operations. For a specific retrieval operation, it is also important to consider the local environment where the retrieval will take place. Within the Baltic Sea many habitats are red listed (in total 57 benthic habitats according to HELCOM 2013) and not all are covered within this EIA. It is recommended that any retrieval operation with bottom contacting equipment in red listed habitats, due to potential adverse impacts, should be avoided or requires a site-specific assessment with local considerations.

The following sections include an overview of the habitats treated in the EIA. Photic and non-photic habitats will be described together, however in the sensitivity assessment, effect assessment and impact assessment they will be treated separately.

2.1.1 Photic and non-photic sand

Sand has less than 20% of mud/silt/clay fraction (<63 µm), and the proportion of sand (grain size 0.063–2 mm) exceeds 70% of the combined gravel and sand fraction. Sand habitats consist of bottoms dominated by sand particles that are frequently exposed to natural disturbances from waves, so-called *erosion bottoms.* From these sandy bottoms, the smaller particles are transported away while the larger particles can settle within the same location. The sandy habitats therefore consist of larger particle sizes in the interval between 0,063 - 2,0 mm. Depending on how exposed the habitat is the particle size can vary between areas, between fine and coarse sand. The important habitat forming species Eelgrass is found within the photic zone of sand habitats. Except for Eelgrass habitats, sandy habitats are typically dominated by endobenthic organisms (organisms that live buried in the sediment), mostly restricted to the oxygenated top-layer of the bottom. Macro-vegetation and epibenthic macro fauna is only sparsely present on sandy habitats. The depth interval for the photic sand habitat is approximately 0-10 m, but depends on the clarity of the water at the geographical location (Figure 2). Non-photic sand bottoms are bottom areas that do not receive any natural light (Figure 2).

Baltic Esker Islands are treated separately in HOLAS II. In this report these are treated as one type of photic sand bottom since the only difference from other sandy habitats is their formation. Esker islands are glaciofluvial islands consisting mainly of relatively well-sorted sand, gravel or less commonly of till, formed during the end of the last Ice age. They are found in the northern part of the Baltic Sea and include dune areas and sandy plains. The underwater environment associated with these islands is typically dominated by either vascular plants such as Charophytes or Eelgrass or by different algae.

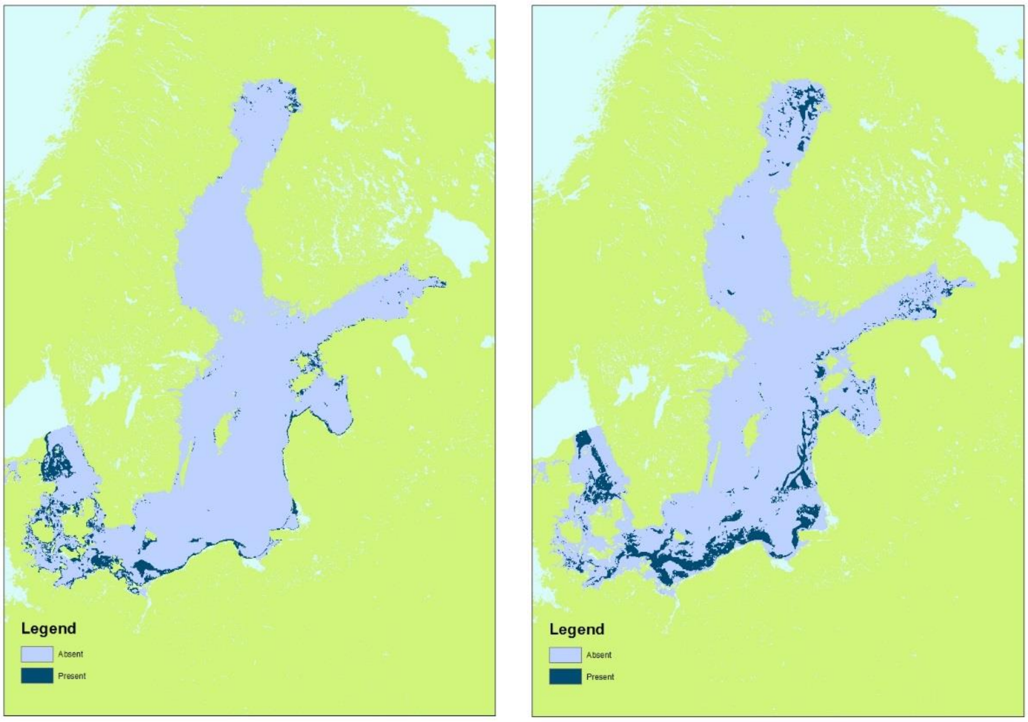

Figure 2 Distribution of photic sand bottom (left) and non-photic sand bottom (right) within the Baltic Sea. The areas where sand bottoms are present are marked with dark blue. Source HELCOM data and map service, infralittoral sand bottom and circalittoral sand bottom.

2.1.2 Photic and non-photic mud and clay habitats

From *erosion bottoms* the smaller particles (<0,063 mm) will be transported away to new bottom areas with currents until the current ceases. In this new area where the current is lower, the smaller particles are heavy enough to settle. Such areas, where sedimentation occurs, are called *accumulation bottoms*. Accumulation bottoms consist of mud and clay, which means that they are dominated by smaller particles (particle size normally ≤0,063 mm).

As in the case of sand habitats, mud- and clay habitats are typically dominated by endobenthic organisms that live in the oxygenated top layer of the sediments. The depth interval for photic mud- and clay bottom is approximately 0-10 m, but depends on the clarity of the water at the geographical location (Figure 3). Non-photic mud- and clay bottoms are bottom areas that do not receive any natural light (Figure 3).

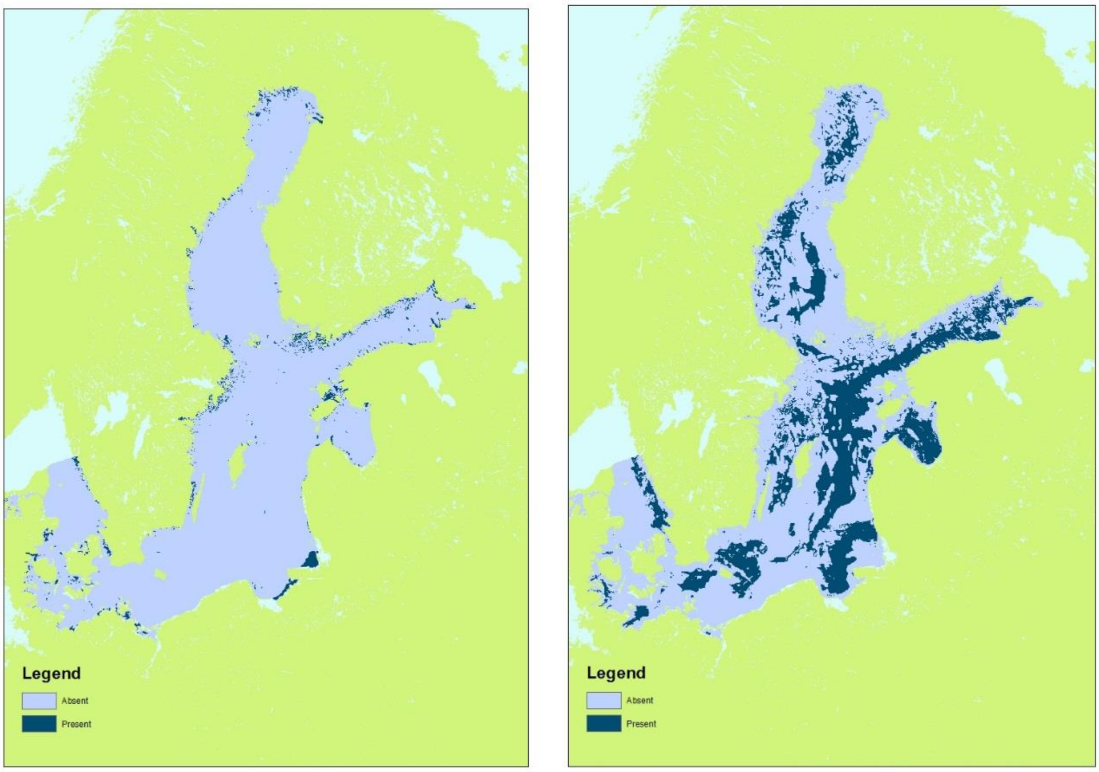

Figure 3 Distribution of photic mud and clay bottom (left) and non-photic mud and clay bottom (right) within the Baltic Sea. The areas where mud and clay bottoms are present are marked with dark blue. Source HELCOM data and map service, infralittoral mud and clay bottom and circalittoral mud and clay bottom.

2.1.3 Photic and non-photic hard bottom

Photic hard bottom habitats consist of bedrock as well as rock, other hard surfaces and coarse substrate (Figure 4). Accumulation of sediments is poor or absent and benthic organisms are dominated by *epibenthos* (living on top of bottom). Typical organisms found on photic hard bottom are Fucus species (*Fucus vesiculosis, F. serratus, F. spiralis* and *F. radicans*), Furcellaria, Blue mussels and other algae that depend on a physical structure for fixation. The underwater vegetation often consists of distinct belts with green algae closest to the surface followed by a belt of brown algae, and below that a belt of red algae. The underwater environment is vulnerable to eutrophication and siltation as decreased light availability will alter the depth distributional limits for the species in the different defined belts. Non-photic hard bottom are bottom areas that do not receive any natural light (Figure 4). Blue mussels are found down to 30 meters depth on this bottom type.

Two types of hard bottom that are considered separately in HOLAS II are Boreal Baltic Islets and small islands. In this report, we treat them as one type of hard bottom since the underwater habitat has similar characteristics to other hard bottom habitats. The small islands are found in the outer parts of the Baltic archipelagos and consist of bedrock or moraine. The islands are important nesting areas for birds and resting areas for seals.

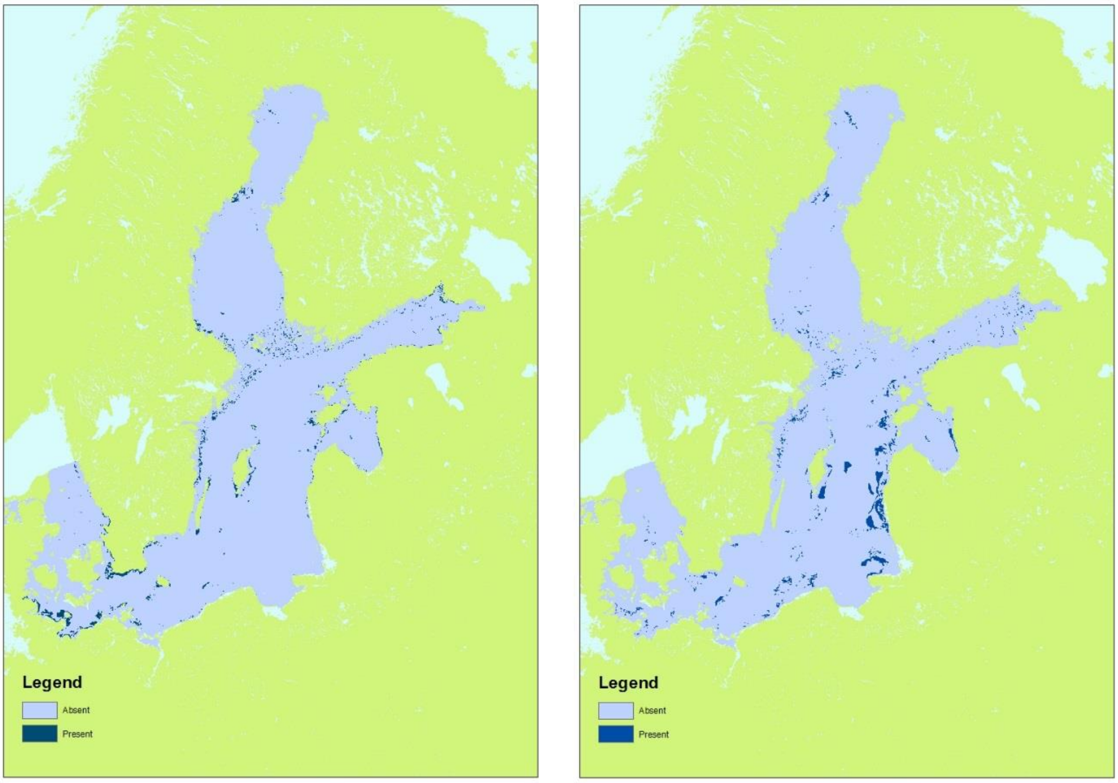

Figure 4 Distribution of photic hard bottom (left) and non-photic hard bottom (right) within the Baltic Sea. The areas where hard bottoms are present are marked with dark blue. Source HELCOM data and map service, infralittoral hard bottom and circalittoral hard bottom.

2.1.4 Photic and non-photic mixed bottom

This habitat type is characterized by less than 90% dominance of one type of habitat. It refers to a bottom with a mixture of sandy, silty, muddy and hard bottoms (Figure 5). The dominance of species and habitat types depends on the mixture of different substrates. In the photic zone, there can be a mixture of hard bottoms with algal belts and different habitats with vascular plants such as Eelgrass meadows and Charophyte habitats. In the non-photic zone, mixed substrates of importance are hard bottoms with blue mussel communities that are mixed with soft bottoms with a dominance of endobenthic organisms that live in the oxygenated top layer of the sediments.

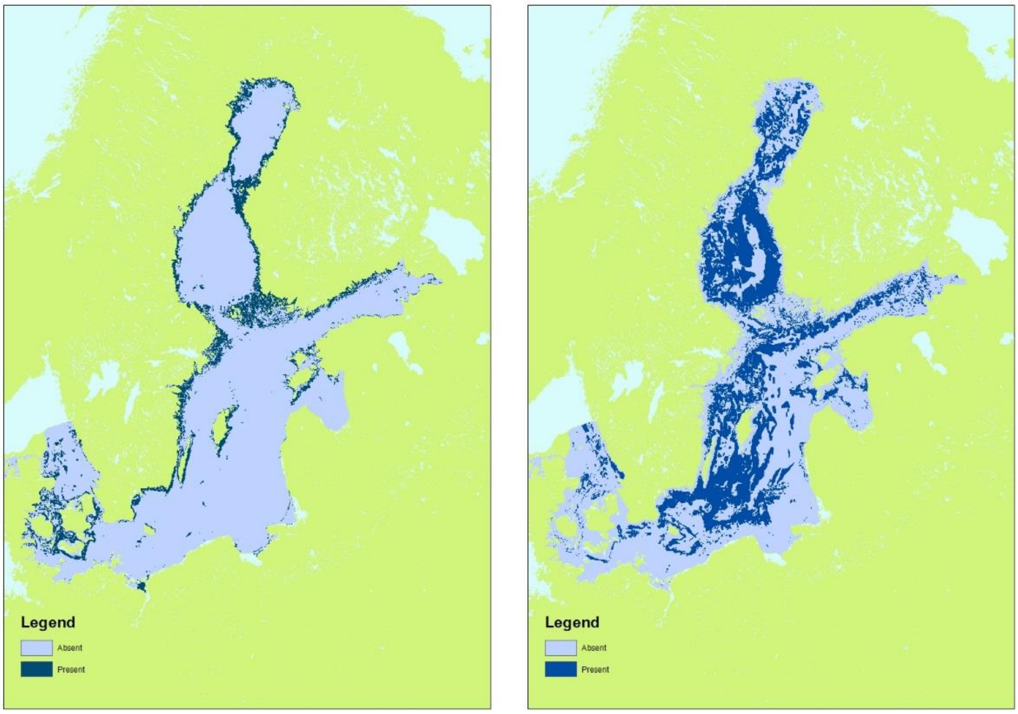

Figure 5 Distribution of photic mixed bottom (left) and non-photic mixed bottom (right) within the Baltic Sea. The areas where mixed bottoms are present are marked with dark blue. Source HELCOM data and map service, infralittoral mixed bottom and circalittoral mixed bottom.

2.1.5 Blue mussel beds

The blue mussel (*Mytilus edulis*) is a tolerant species, due to its ability to adapt to a large variation in salinity. Blue mussels found in the Baltic Sea are however physiologically stressed due to the low salinity. This explains why they are smaller in size compared to saltier water, such as the North Sea (Kautsky & Tedengren, 1992). Due to this salinity stress, the Baltic blue mussel is more sensitive to other disturbances.

Blue mussel habitats support many other organisms and are important habitats due to the resulting structural complexity for other species to hide in and attach to. Blue mussels live on both hard and soft bottom with good water circulation. In the Baltic Sea, blue mussels have few predators and few competitors that influence the species prevalence. It can dominate the biomass in coastal areas and can cover hard bottoms from the water surface down to 30 m depth (Figure 6). Even on soft bottom habitats, Mytilus edulis can be the dominating species where they can attach to leftover shells or other structures.

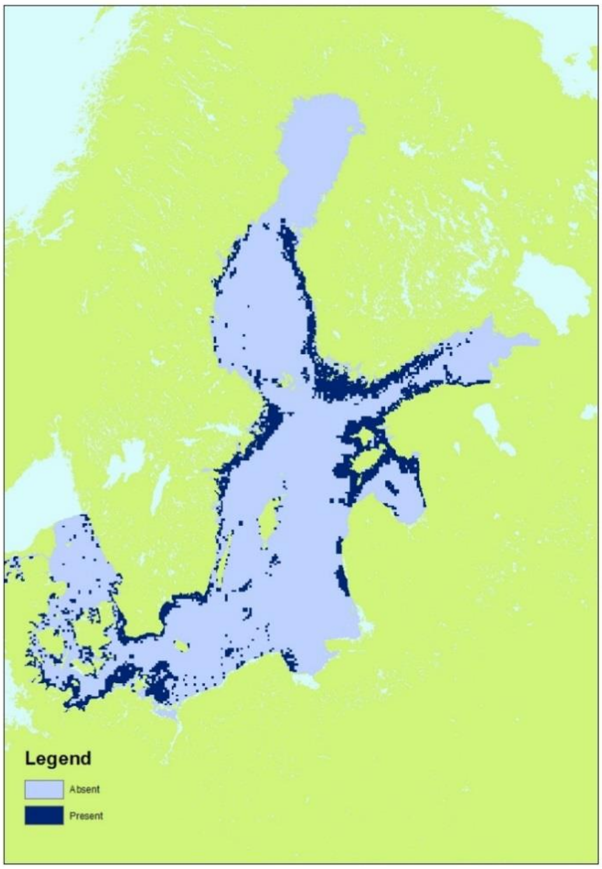

Figure 6 Distribution of Blue mussel beds within the Baltic Sea. The areas where blue mussels are present are marked with dark blue. Source HELCOM data and map service, layer Mytilus.

2.1.6 Eelgrass meadows and Charophytes

Eelgrass (*Zostera marina*) and Charophytes are found in shallow and relatively sheltered areas on both clayey and sandy bottoms (Figure 7). In HOLAS II they are treated separately, but in this EIA they are treated together as they are often found in the same places and have a similar habitat sensitivity. The Eelgrass meadows consist of one single species while Charophytes refer to a group of species. The species composition is mainly determined by the salinity of the area. The habitats are generally found between a depth of 1 to 6 m. Historically, Eelgrass distribution along the German coast was recorded at 17 m depth (published observation from 1889), while today it is limited to areas down to 4-5 m depth (Boström, et al., 2014). Eelgrass and Charophytes can create large areas with consistent vegetation cover. These meadows and areas are important nursery grounds for many fish and crustacean species and host a high diversity of species, both because of the high availability of food but also since the dense vegetation cover provides protection against predators. Both Eelgrass and Charophyte habitats are red listed and have decreased substantially during the last decades as a consequence primarily of eutrophication and exploitation of shallow sheltered bays for human activities such as harbors.

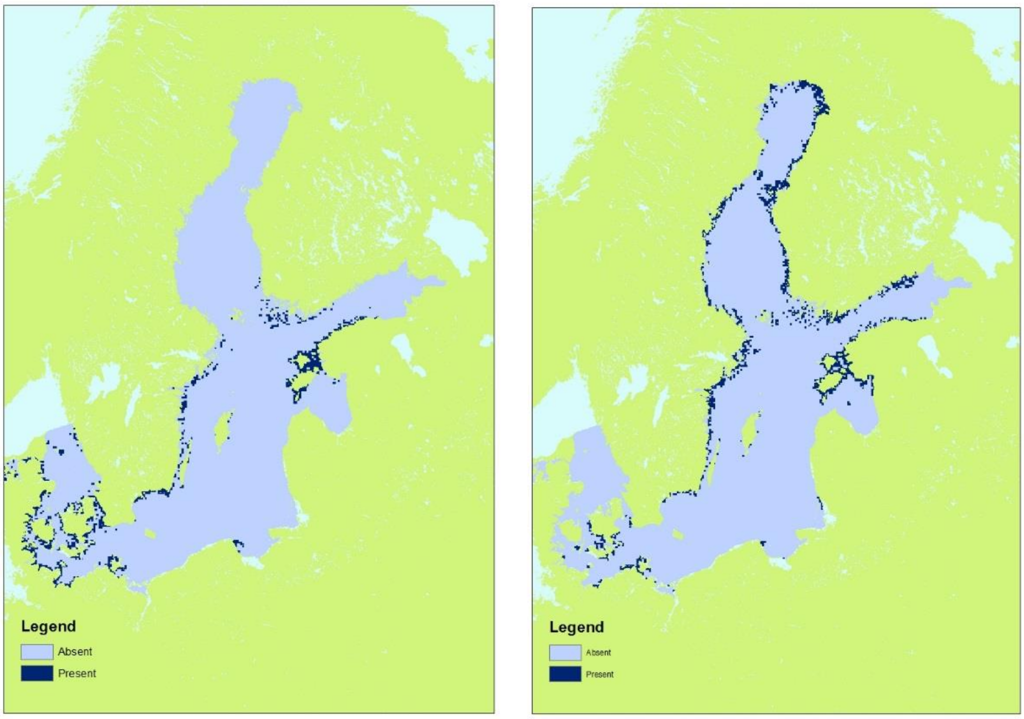

Figure 7 Distribution of Eelgrass meadow (Zostera) (left) and Charophyte (right) habitats within the Baltic Sea. The areas where Eelgrass and Charophytes are present are marked with dark blue. Source HELCOM data and map service, layers Zostera and Charophyte.

2.1.7 Fucus and Furcellaria habitats

Fucus and Furcellaria are perennial algae that are mainly found on hard substrates, such as rocks and boulders (Figure 8), but both also exist as unattached free-floating versions. The two habitats are treated separately in HOLAS II, but in this EIA these are treated together due to their similar environmental preferences and habitat sensitivity. The species dominating the Fucus habitat is bladder wrack (*F. vesiculosis*), but other species such as *F. serratus, F. spiralis* and *F. radicans* are also found in different parts of the Baltic Sea. Both Fucus and Furcellaria create areas with dense vegetation and often grow together, although Furcellaria can tolerate lower light availability and often form a belt between the Fucus belt and the red algae belt. Fucus habitats are known to support a high diversity of species because they provide both protection and high availability of food for a large variety of organisms. Furcellaria are also known to serve as important shelter for small crustaceans and other organisms.

Although Furcellaria can grow at larger depth than Fucus, both species are sensitive to low light availability and thus to eutrophication and siltation. The lower depth limit of Furcellaria is used as an indicator of ecological status by several European countries. The Fucus population has recently recovered after an all-time low during the 1980s and is today found at depths comparable to the 1940s (Jansson and Kautsky 1977, Kautsky 1995). Furcellaria is widespread and there is no immediate threat to the species in the Baltic Sea, although harvesting of the plant and eutrophication caused populations to decrease at the local scale. Furcellaria can tolerate salinities down to 3 psu and thus builds habitats for associated species in areas of the Baltic Sea where other algae, including Fucus, are absent.

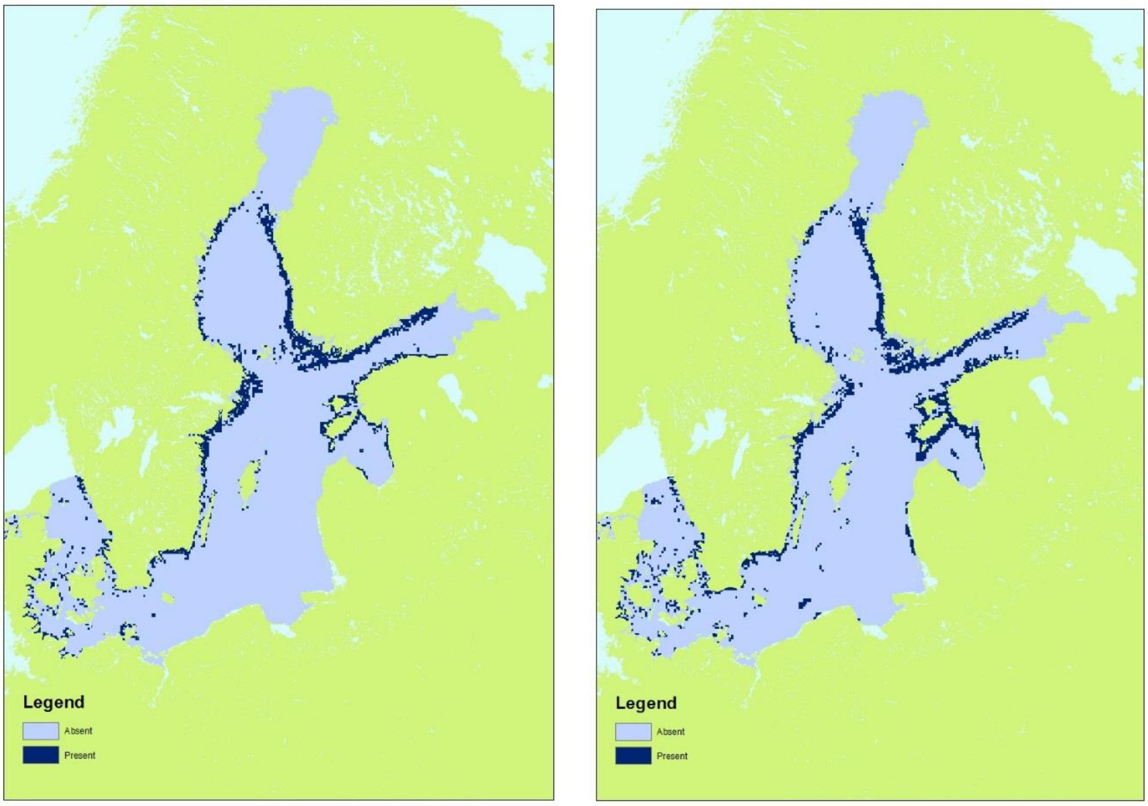

Figure 8 Distribution of Fucus habitat (left) and Furcellaria habitat (right) within the Baltic Sea. The areas where Fucus and Furcellaria habitats are present are marked with dark blue. Source HELCOM data and map service, layers Fucus and Furcellaria.

2.1.8 Reefs

Reefs are hard ridge formed structures that rise from the seafloor. Reefs consist of rock or other hard material and are found below, or mostly below the water surface (Figure 9). Structures composed by living sessile organisms such as compact mussel beds can also be considered as reefs. Reefs create complex structures and are hotspots for biodiversity. Algal zonation is a common feature in reefs and the species composition varies with salinity. Reefs are threatened by eutrophication and siltation due to decreased light availability for plants inhabiting the reefs. Fishing poses a great threat to reef structures with entangled nets and other fishing gear destroying the structural complexity, but also by directly affecting the associated plant and animal communities. Fish are often aggregated around reefs as they constitute a structural complexity providing food and protection. Reef areas have therefore been used as fishing grounds.

One type of reefs found in Kattegat are the so-called “bubbling reefs”. The bubbling reefs are treated separately in HOLAS II but here we consider them as one type of reef. They are formed by methane gas from Eemian sediments, probably originating from microbial decomposition of fossil organic material, which bubbles out from the ocean floor. The structures are only found in areas where glaciers have pushed aside the overlying sediments. Complex rock structures are formed due to aggregation of carbonate cement resulting from microbial oxidation of gas emissions. The habitat type is red listed and the structures in Kattegat are unique in Europe, and only appear in a few other places in the world.

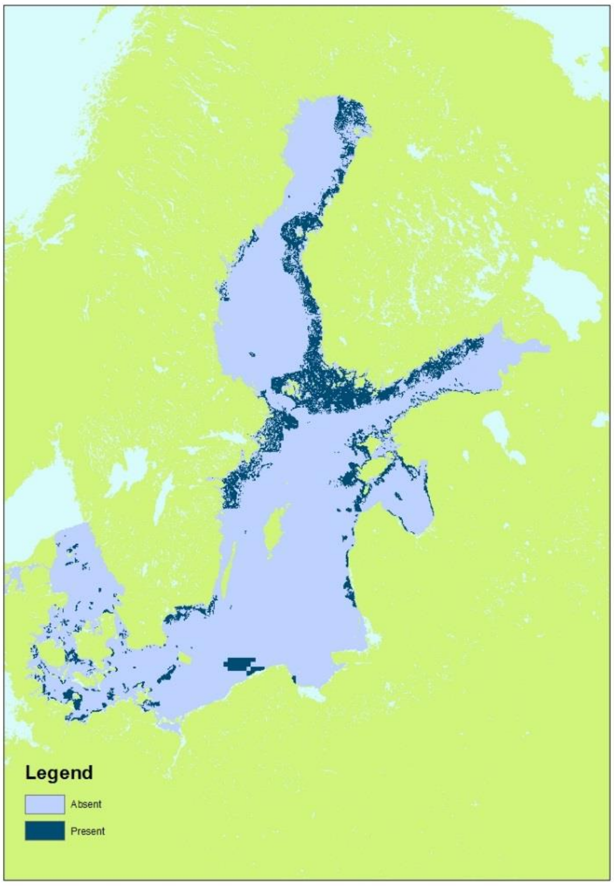

Figure 9 Distribution of reef habitats within the Baltic Sea. The areas where reef habitats are present are marked with dark blue. Source HELCOM data and map service, layer Reef.

2.1.9 Baltic Ecosystem

As previously noted, potential impacts of the *zero-alternative* and bottom trawling are partly assessed on the broader "ecosystem-level". This is because some of the effects related to bottom trawling and the *zero-alternative* are considered less relevant on the specific habitat level. As an example, extraction of fish due to ghost net fishing or bottom trawling are causing changes on an ecosystem level such as modifications in species distribution and food chains that may be irreversible (see Section 4.4). The habitat "Baltic ecosystem" thus aims to capture impacts on a higher level where the pelagic and the benthic environment are interrelated.

2.2 Sensitivity assessment

A common approach to define 'sensitivity' of a habitat or a biotope is to evaluate the likelihood of damage (termed intolerance, or resistance) due to a pressure and the rate of recovery (termed recoverability, or resilience) once the pressure has abated or been removed. A habitat could thus be considered as sensitive when it is easily adversely affected by human activity (e.g. low resistance) and recovery is only achieved after a prolonged period, if at all (e.g. low resilience or recoverability).

Different habitats vary in sensitivity when exposed to different pressures. The effects presented in Chapter 4 (Assessment of effects) will thus cause impacts of different levels, depending on the sensitivity of a specific habitat in response to that particular pressure.

As previously mentioned, sensitivity of Baltic habitats within this EIA is based upon the evaluation made for HOLAS II (HELCOM, 2017b), that was developed based on both expert evaluation and peer reviewed scientific publications. An early version of HOLAS II was published during August 2017 and the sensitivity scores presented are those used in this EIA. The only exceptions are the habitat types “Wreck” and “Baltic Ecosystem”, which are not included as habitats in HOLAS II. As no other comparable sensitivity assessment for these habitat types could be identified, the sensitivity scores used within this EIA for these two habitat types are an estimation by the authors.

Sensitivity of a habitat is related to the tolerance level of the dominating species of that habitat, which is one of the reasons why some major habitat forming species in the Baltic Sea are considered as separate habitats within the HOLAS II and this EIA (Eelgrass/ Charophytes, Fucus/Furcellaria, Blue mussel beds). The sensitivity of a habitat also depends on already present environmental stresses. In the Baltic Sea, marine species are competing for space with fresh-water species. The predominance of marine species in the south of the Baltic will shift to a dominance of fresh-water species as the salinity levels fall towards the North of the Baltic. Many of the species within Baltic Sea are, hence, living under high stress due to salinity levels that are either too low or too high, which forces them to spend more energy than would be needed in a more suitable environment. During circumstances of additional pressures, these species are particularly sensitive, due to the low excess energy they have to withstand the new stressor (Kautsky & Tedengren, 1992). The low number of species living in the Baltic Sea also adds another particular vulnerability of habitats, as there are very few other species that can replace a species if it disappears.

The HOLAS II sensitivity scores evaluate the sensitivity of habitats to different types of effects, i.e. physical disturbance or physical loss of habitat. The sensitivity scores related to each assessed habitat are based on expert evaluations of mainly three factors: *tolerance/resistance, recoverability* and *sensitivity*. Where *tolerance/resistance* represents the capacity of the habitat to withstand a pressure (not being destroyed). *Recovery rate* reflect how quickly the habitat will recover after the pressure has taken place. Impact distance was also included in setting the sensitivity score, which relates to how far the effect will have an impact (locally or large distances).

The expert evaluation of sensitivity in HOLAS II was made on a scale between 0,0-2,0 (Figure 10). The scores were divided into three different intervals: low (0-0,69), medium (0,7-1,3) or high sensitivity (1,3-2,0) (see Figure 1). Each interval was transformed into a score: 1 (Low sensitivity), 2 (Medium sensitivity) and 3 (High sensitivity) (Figure 10). These scores were used in the calculation of the resulting impact (see Section 2.4).

Scores HOLAS II	Sensitivity score EIA
0-0,7	1 (Low)
0,7-1,3	2 (Medium)
1,3-2	3 (High)

Figure 10 Interval used in order to convert the sensitivity scores from HOLAS II (HELCOM) into a 3-grade scale that was used within this EIA.

2.3 Effect assessment

Based on published scientific literature and information provided by MARELITT Baltic partners, the physical effects of ALDFG retrieval operations have been listed for each bottom type (Soft bottom, Hard bottom) as well as for Wrecks. The effects of the retrieval equipment depend largely upon the degree of bottom contact, which is determined by the design and weight of the equipment, but also on the vessel speed. Additionally, the effects will also depend on the intensity of the search (e.g. distance between transects) as well as on the frequency (how often the search will be performed in a certain area). The frequency of the search will not be included within this EIA. The effect assessment also covers an evaluation of the effects of the *zero-alternative*, as well as effects of commercial *bottom trawling* activities. The *zero-alternative* is defined as leaving the ALDFG in place (no retrieval). It can both be applied in a pre-planning manner (consequences of not performing a search for ALDFG), or during the *retrieval* phase (once an ALDFG has been localized, what are the impacts of retrieving the ALDFG compared to the impacts of leaving it in place?).

The magnitudes of the effects were evaluated on a 3-grade scale (Figure 11) based on the magnitude it is assumed to induce on the different bottom types. The effect scores were then used in the calculation of the resulting impact (see Section 2.4).

Not relevant/No effect
Low effect (1)
Medium effect (2)
High effect (3)

Figure 11 The 3-grade scale used to evaluate the effects within this EIA.

2.4 Impact assessment

The assessment of impacts is based on an estimation of the effects on the physical environment caused by the ALDFG searches and retrieval operations and on the sensitivity of the receiving environment. The receiving environment is classified into different habitats with sensitivity scores corresponding to the assessed effects. Evaluation of the different effects considered relevant to the ALDFG retrieval operations are described in detail in Chapter 4 while sensitivity scores are presented in Chapter 5. Within this EIA, the *receiving environment* is restricted to 16 different habitats and biotopes that are relevant for the Baltic Sea (see Section 2.1). The final potential impacts are derived by combining the sensitivity score of each separate habitat with the estimated magnitude of assessed effects according to the following formula (See Figure 12):

Impact score = Effect score x Sensitivity score

As both the sensitivity score (Figure 10) and the effects (Figure 11) are evaluated on a 3-grade scale (Sections 2.3-2.4), the final impact score will vary between 1 and 9 (Figure 12).

Impact Score	Assumed result
0	*Non-significant impact*
1-2	*Low impact*
3-5	*Medium impact*
6-9	*High Impact*

Figure 12 Illustration of all the possible outcomes in an impact matrix for a retrieval operation in a certain habitat.

Effect	**Habitat sensitivity**		
	Low (1)	*Medium (2)*	*High (3)*
Low (1)	*1*	*2*	*3*
Medium(2)	*2*	*4*	*6*
High(3)	*3*	*6*	*9*

3 Retrieval operations

3.1 MARELITT Baltic retrieval operations

In order to evaluate the impacts from MARELITT Baltic ALDFG retrieval operations, an understanding of the retrieval method is important. Even though the different phases of an operation and methods are similar for the different MARELITT Baltic partners, there are local differences on how the operations are carried out, as well as of the type of equipment used.

The first part of this chapter focuses on the retrieval operations. The description of retrieval operations are divided into different “phases”: planning, searching and retrieval (see Sections 3.1.1-3.1.3). The second part focuses on different equipment in use during the operation (Section 3.2), where the equipment is linked to the different phases of the retrieval operation. To enable a broader comparison between different equipment, some search methods used outside the Baltic Sea are also included. The last section (Section 3.3) proposes a classification of the different retrieval methods and equipment.

3.1.1 Planning a retrieval operation

Soft/ hard bottom

The first part of a retrieval operation is planning and aims at deciding in what area the retrieval operation will be carried out, a so-called “host area”. The selection of a host area can be based on information from fishermen, such as position of lost equipment or known bottom obstacles where fishing equipment could easily be lost. Selection of host areas can also be based on information from the coastguard authorities who may have revealed potential ALDFG locations. Recreational diver associations represent yet another source of information for the presence of ALDFG in the marine environment. Another approach to identify high-density areas of ALDFG is to base the selection of host areas on maps combining information about fishing intensity together with information on seafloor structures/obstacles. Results from seabed mapping projects (i.e. different kinds of sonar surveys) can also reveal possible locations of ALDFG. On the other hand, a potential low-density ALDFG area is a zone that is frequently bottom trawled with very few obstacles.

Interviews with or input from fishermen and fisheries control authorities have proven to be of great value within MARELITT Baltic’s activities in order to identify high-density (hotspot) areas, as well as making the retrieval operation more effective. In the southern parts of Sweden, high-density areas of ALDFG are found in areas with conflicting fisheries, where both gillnet fishing and trawling take place (Tschernij & Larsson, 2003). Estonian MARELITT Baltic partners have carried out a desktop study where weather conditions were used to find hotspot areas. In Poland, typical high-density areas are represented by zones with many underwater obstacles (personal comment MARELITT Baltic partner).

During the planning phase it is also decided what type of boat and what kind of equipment will be used for ALDFG operations. The choice of equipment depends on the bottom type (hard bottom, soft bottom, complex bottom) or presence of wrecks. In many cases, it is only the availability of vessels that decide which equipment to use during the operation. In some cases, it is preferable to choose a vessel that is easy to maneuver, which allows for turnings, zigzag pattern and quick stops when tension is noticed on the line during the *search* phase (personal comment MARELITT Baltic partner).

Wrecks

During the planning phase of a retrieval operation on a wreck, a visual inspection of the wreck is performed prior to the retrieval operation. This inspection could be performed by a sonar survey, a remotely operated vehicle (ROV), divers or, when possible, with a combination of the above-mentioned methods. In Germany, operations on wrecks use divers together with GoPro head cameras and towed camera systems. In Sweden, wreck-cleaning operations start with an inspection of a potential wreck using a ROV, diver or a sonar, or a combination of these methods. The retrieval operation is later carried out in a separate phase after considerations of priority issues and the appropriate retrieval method. In Poland, the first inspection phase is performed with a ROV. The results (films, pictures and other observations) from the inspection are evaluated and based on the results the best retrieval method can be chosen.

Before any cleaning operation on a Wreck is initiated knowledge of the local regulations regarding the cultural value of wrecks is very important. Retrieval of ALDFG on wrecks should only be carried out if the cleaning is not potentially harmful to the heritage value of the wreck. Both in Poland and in Germany any ALDFG operations on wrecks need to be approved by the cultural heritage authorities before they can take place. This is, however, not the case in Sweden.

3.1.2 Searching for ALDFG

Once a host area has been identified, the *search* phase follows. It can be classified either as a “blind search” or as a “directed search”. A blind search is performed in either a high-density or a low-density host area, often in a considerably large zone. A directed search refers to a search operation in an area where the exact or approximate position of the lost ALDFG is known (most often the case for ALDFG operations on wrecks). In some cases the ALDFG has previously been marked by a local diver with a buoy and in other cases the geographic coordinates are known.

The search for ALDFG can be performed by the fishermen themselves or during organized search operations such as in the MARELITT Baltic project. There are several search devices that can be used, some of which will be described in Section 3.2 (Search devices) while the effects of the methods will be covered in Chapter 4 (Assessment of effects).

Search device with bottom contact

During a blind search, the search device is dragged along the bottom in transects to cover the whole host area (sea Section 3.2). Transects are in some cases separated with a predetermined specific distance in order to optimize the chances for the creeper to hook into an ALDFG.

Figure 13 A search performed with a creeper without any functional structure, ©Marine center Simrishamn.

The search device is generally connected directly to a rope which is either held by a person (Figure 13) or attached to a winch. A handheld rope implies that a difference can be felt when hooking into an ALDFG compared to a bottom structure such as a rock. As a result the risk of tearing apart the hooked ALDFG is lower than when the rope is attached to the vessel. A handheld rope therefore increases the probability to retrieve the ALDFG (MARELITT Baltic partner Simrishamn).

Another solution to keep the ALDFG as intact as possible was used by Polish fishing vessels in previous ALDFG retrieval projects (lead by WWF Poland). The Polish fishermen used a winch with a stopper connected. The stopper automatically let out the rope when a friction/extra weight was hooked onto the rope/creeper, which thus prevented the boat from quickly tearing off the ALDFG from the bottom.

It is crucial to maintain a slow towing speed (1-1.5 knots) and a sufficiently low weight of the creeper to be able to observe when a net is hooked on to the search device (personal comment MARELITT Baltic partners). During searches with larger fishing vessels a speed of 3 knots was used in German waters, but this speed has in later searches been reduced to 1-1.5 knots to avoid tearing apart the ALDFG by the searching device (WWF Germany, personal comment).

In both Poland and Germany, there are restrictions on ALDFG retrieval operations inside national protected areas, where special applications to and communication with the local environmental controlling agencies are necessary. In Germany, heavy bottom touching gears are excluded inside such areas, while the light Estonian creeper is allowed on a case-by-case basis (see Section 3.2). It is therefore important to know which protective status the host area has, but also to know what the requirements are for an operation to take place in such an area.

Side scan- and multi-beam sonars

By transmitting and receiving sound in the water side-scan sonar (SSS) systems and multi-beam sonars (MBS) can get accurate and detailed information about the seafloor. These are used in increasing amounts of marine sectors, including for hydrographic surveys, marine routing investigations, and marine environment resources investigations etc. Seabed mapping technology has become more accurate and more affordable in recent years and is sometimes used during searches for ALDFG.

A SSS provides a seabed acoustic reflection image from which the seafloor terrain and texture information can be extracted. With the continuous improvements of image accuracy and the convenience of the system, SSS has become one of the major means of marine geophysical prospecting. MBS technology was developed to examine in detail large stretches of the seafloor surface and produces 2D and 3D images with exact positioning of features as small as a few centimeters and covering areas as large as hundreds of square meters.

Available sonar data can sometimes indicate locations of ALDFG, which can be of high value in order to reduce the area where a search will need to be performed. However, localization of ALDFG with sonars has proven to be difficult. In Germany SSS was tested on the Odrabank, a Natura 2000 area, where bottom-touching gears are not allowed. No nets were detected, indicating that sonars may be more applicable where relatively large or readily distinguishable items, such as pots or traps, are to be located, as gillnets can be difficult to distinguish. Nevertheless, the Estonian MARELITT Baltic partners use a sonar and/or a side scan survey before the *search* phase takes place, as it still provides important information of the seafloor in the area where the operation will take place. The efficiency of detecting gillnets with sonars will also be investigated as a part of the MARELITT Baltic project in Polish waters and the Estonian diver association is currently assessing 3D sonar image reconstruction on ALDFG locations in order to evaluate its efficiency (pers. comm. MARELITT Baltic partner).

Environmental effects related to the use of acoustic sonars, and in particular underwater noise, are not within the scope of this EIA, as they are considered to not affect the assessed bottom habitats.

Remote operated vehicles (ROVs)

ROVs were used in retrieval operations mainly to locate ALDFG during searches and for planning operations on wrecks. The ROV can be used to collect available information about the ALDFG before sending down a diver. Apart from providing important information on what action is needed at a certain location, the ROV, together with other methods such as GoPro and towed camera systems, can help to increase the safety of the divers retrieving the ALDFG. ROVs have been used in MARELITT Baltic ALDFG operations in Poland since 2011, but also in Sweden and Germany for retrieval operations on wrecks. Potential environmental impacts of this technology are considered negligible and will for that reason not be discussed further in this report.

Divers

Within the MARELITT Baltic project, divers are used during the planning, *search* and the *retrieval* phase. During the planning phase, all MARELITT Baltic partners use divers when required. They are also used in combination with other methods, such as ROV and/or SSS. The diver collects information regarding the number of ALDFG and possible risks associated with performing a retrieval operation. The diver can also have a head camera that increases the amount of collected information and documents it.

3.1.3 Retrieving ALDFG

Following the *search* phase is the *retrieval* phase, when the ALDFG is retrieved. The retrieval can take place either in a location where an ALDFG has been found on the bottom or on a wreck. As retrieval methods will differ between these two environments, they are described separately below. Retrieval of ALDFG can be performed either by the fishermen themselves or during organized retrieval operations such as within the MARELITT Baltic project. On wrecks, divers always perform the retrieval.

Chapter 4 covers the habitat related effects of different retrieval methods (Chapter 4).

Soft/ hard bottom

Once an ALDFG is hooked onto the search device, it can be retrieved using different methods. Most of the MARELITT Baltic partners use a creeper (the same as used during the search, see Section 3.2) during the first trial to haul the ALDFG on board, either manually or with a winch. If it is easy to haul, both Swedish and Estonian MARELITT partners will manually retrieve the ALDFG on board the vessel. If manual retrieval is not possible, the creeper will be connected to a winch that enables an increased power of the drag. However, a creeper used during the search can become damaged when using a winch and therefore another device, such as an anchor or a hook, can be used instead. In non-protected areas in Germany, MARELITT Baltic partners use a winch with the creeper in order to retrieve the ALDFG. If the retrieval with the creeper is difficult, a diver will attach a retrieval anchor to the ALDFG to enable the retrieval. In German and Polish waters, the retrieving ALDFG within protected areas (Natura 2000) will be performed with either a diver or a small anchor or hook.

In some cases the retrieval operation is prosponded due to special circumstances such as weather conditions or when the ALDFG is highly entangled at the bottom. Under such circumstances, the ALDFG will be marked in order to continue the retrieval another day. If the ALDFG cannot be retrieved manually or with a winch, a diver or a drop down camera may be used to collect information that can help to decide how to retrieve the ALDFG. A professional diving team can also be used directly to facilitate the retrieval operation by cutting off the ALDFG with a knife or a saw. This method is used when retrieving ALDFG within Natura 2000 areas in Germany, due to the restriction on using any bottom contacting equipment in these protected areas.

Within MARELITT Baltic, both Polish and Swedish fishermen use a gentle retrieval method, to avoid possible damage on the ALDFG. They perform the retrieval with a creeper or an anchor and manually haul in the nets. With this method, they can control the retrieval method and power of the retrieval to minimize damages on the fishing equipment. The fishing equipment has a very high cost, which is the reason why they want to minimize the damage on the nets (personal comments MARELITT Baltic partner).

Wrecks

When ALDFG is retrieved from a wreck, it is performed manually by a professional diving team, for example by German, Swedish and Polish MARELITT Baltic partners. The ALDFG is carefully disentangled with a knife or a saw, in order to minimize the risks of damaging the wreck. As soon as parts of the ALDFG are loose, air bags of different sizes are connected, in order to lift up the ALDFG away from the wreck and up to the surface. When the whole ALDFG is detached from the wreck, the ALDFG will float up towards the surface and can be retrieved by the staff on the vessel (see Figure 14). In Poland, a diver-assisted winch may be used to haul up the ALDFG (WWF Poland, 2013).

Figure 14 Picture of airbags that are used to lift up the net to the surface when parts or the whole ALDFG is disconnected from the wreck ©Keep Sweden Tidy.

3.2 Search devices

Within MARELITT Baltic, the technical devices designed for searching for ALDFG are the same whether a blind search or directed search is performed. The devices can be considered consisting of two parts: the *search* device and the supporting structure (or functional structure). The supporting structure adds weight to the search device and is designed to keep the search device on the seafloor. The searching devices used by MARELITT Baltic partners have similar designs to those described in the literature. This chapter will first describe different search devices used within the MARELITT Baltic project and those used in other regions according to available literature. The second part describes different supporting structures.

3.2.1 Creeper

The search device described in the literature is often called a creeper, terminology also used in this report. A variety of creeper designs exists (for example Graham N. et al, (2009)). However, most of the creepers are variations of the same general principles, comprising a single heavy-toothed steel bar or multiple devices (Figure 15 and Figure 16).

One or several creepers can be mounted to a functional structure (see Section 3.2.2). No clear distinction between the creeper design used on soft, hard and complex bottom has been reported. However, the MARELITT Baltic Estonian creeper (see Figure 16 and next section) is preferable on complex and hard bottom in Estonia and in general, a creeper connected to a rope is mostly used on hard bottom environments according to MARELITT Baltic partners. In a soft bottom environment, a creeper device is usually combined with a functional structure in order to control the contact between the seafloor and the creeper.

The following description of creepers is related to MARELITT Baltic operations. Other and heavier equipment is being reported from outside the Baltic (i.e. Norway), where larger depths require heavier equipment.

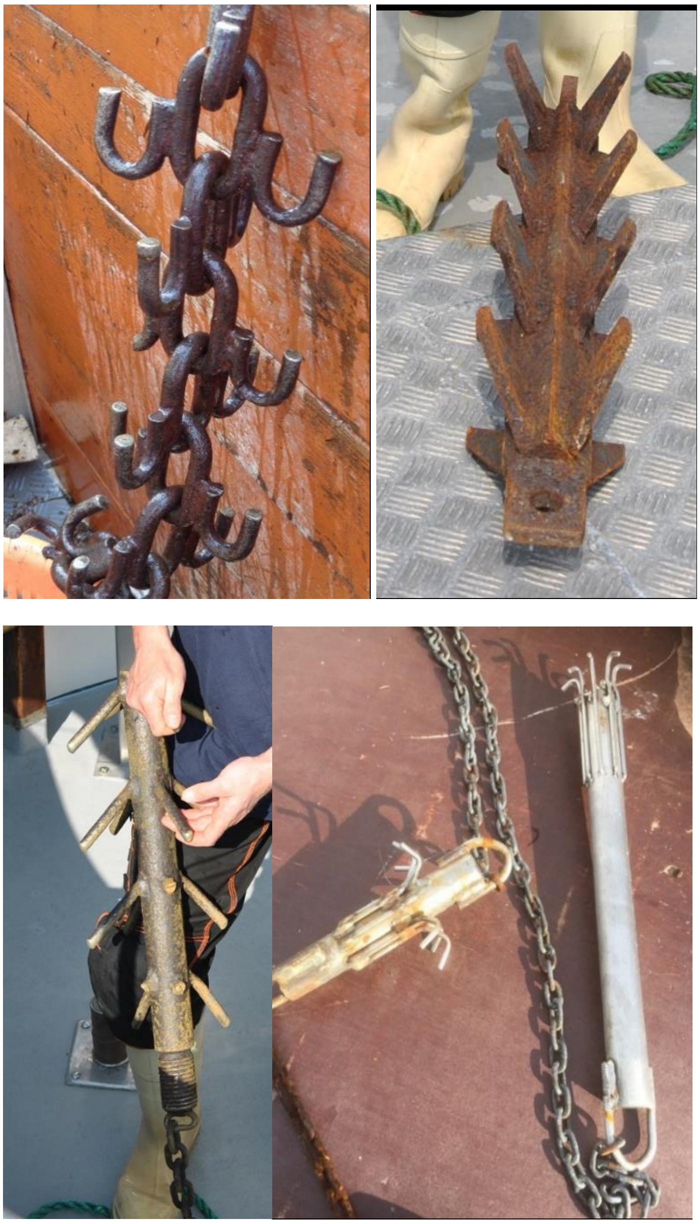

Figure 15 Different creeper design used during retrieval performed by fishermen organised by the Swedish MARELITT Baltic partner, ©Marine center Simrishamn.

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Figure 16 Upper right and left: different search devices used by the German MARELITT Baltic partners, designed by Polish fishermen prior to the initiation of the MARLITT Baltic project. The pictures show two different lengths of the rods, long rod (upper left) and short rod (upper right), ©Christian Howe. Lower left: creeper used in Poland © WWF Poland, Lower right: MARELITT Baltic Estonian creeper used on hard and mixed bottoms ©KEST.

3.2.2 Functional structure

The functional structure is added to the search device in order to optimize the contact between the creeper and the seafloor. The designs vary between countries as well as between local search operations. In its most simple design, the functional structure constitutes of one or several chains that add weight or flexibility to the rope or the creeper.

In the literature, examples of functional structures reported consist of otter boards, beams, “rock hoppers”, chains and different modifications and combinations of these (Graham N.et al, 2009). Neither beams nor otter boards are used by any of the MARELITT Baltic partners. Examples are given in the following sections.

Rubber bobbin/Rock hopper

The rock hopper, also called rubber bobbin, consists of rubber balls that roll over the seabed. They are commonly used on bottom trawls to diminish damage to the bottom sediments.. In New Foundland (Canada), a retrieval technique based on two rubber bobbins that act as wheels is in use (Graham N.et al, 2009). During 2011 and 2012, Polish fishermen designed a supporting device consisting of several rubber bobbins that role over the seabed (see Figure 17). The weight of the rubber bobbins can be filled with water to achieve neutral buoyancy at the depth where the search takes place. Since the bobbins have neutral density, they also lift up the creepers from the seafloor further reducing penetration into the seabed.

When using this functional structure, damage to the seafloor is mainly limited to that caused by the creeper, which penetrates into the sediment (Graham N.et al, 2009). The use of rubber bobbins imply a less intrusive equipment than does the use of otter boards or a rigid beam (Jennings & Kaiser, 1998).

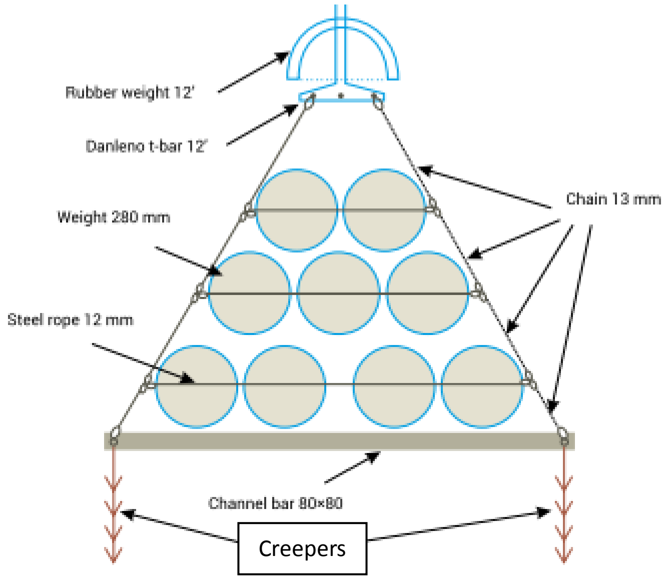


Figure 17 Functional structure with creepers used in the MARELITT Baltic project during the retrieval operations on soft bottom sediment (WWF Poland, 2015).

Otter board

Otter boards represent a common bottom trawling functional structure consisting of two heavy boards, which keep the trawl on the seafloor. In Graham et al. (2009) otter boards are noted as one of the methods used in the Baltic Sea for ALDFG retrieval. However, it is uncertain whether they are still used today, but they are included in this assessment as a comparison to methods used by MARELITT Baltic partners (no otter boards are used by MARELITT Baltic partners). The otter boards create marks like trenches on the bottom as they dig into the sediment. The otter boards also create large amounts of sediment suspension (Bradshaw, et al., 2012). Suspended sediment can have significant impacts on the environment (Newcombe & MacDonald, 1991). Otter boards also remove as well as damage fauna living in or on the seabed.

Beam

A beam is a rigid rod that can be used in order to attach creepers (Graham N.et al, 2009). The beam can also add weight to the search device and maximize the contact between the seafloor and the creeper. The beam is rigid and not flexible when dragged over a surface. It will remove major structures and leave more or less a planar surface behind. From commercial trawling activities, beams have also been reported to remove natural dunes on soft bottom surfaces or fauna adding structure to the seafloor (Jennings & Kaiser, 1998).

3.3 Classification of methods

This section presents a classification of searching devices (creepers and functional structures) based on an evaluation of their induced physical effects on the surrounding environment related to ALDFG operations. The physical effect will primarily depend on the weight, but also on the size (and design) of the device. More precisely, the design will determine the area affected by the ALDFG operation, the so-called "swept area".

The Creeper

Discussions with MARELITT Baltic partners indicate that creepers in use are principally modifications of a similar design. The weight of the device is the only major difference that will result in different physical effects on the bottom. The weight of the creeper also tends to be chosen according to bottom type and the depth at which the operation will take place. Consequently, we assume that all the different variations of the creeper used by MARELITT Baltic partners will have comparable impacts on the seafloor. The literature review indicates that heavier creepers, causing higher effects on the bottom, might be in use elsewhere, but no information is available on more exact design and weights. The creepers used by the different MARELITT Baltic partners are classified as *light weight* creepers. It is important to notice that the weight of the creeper should be adapted to the depth where the search will take place. The negative impacts will increase if the weight of the creeper is not optimal (too heavy) for the depth the search will be performed at. Size and weights of different creepers are summarized in Table 2.

Table 2 Overview of some of the different creepers used by MARELITT Baltic partners and by other organizers'

Search device	Classification	Weight (kg)	Width (m)	Country in use
MARELITT Baltic Polish creeper	Light creeper	6-8	0,8-1	Germany, Poland
Various Swedish creepers	Light creeper	11-13	0,3	Sweden
"Estonian" creeper	Light creeper	13	0,4	Estonia
German creeper	Light creeper	20	0,4	Germany
Norwegian creeper	Heavy creeper	70-75	0,8-1	Norway

Functional structure

As previously described, the design of the supporting devices varies (Section 3.2). Depending on the weight and design, we classify the supporting devices as *low* or *high* impact. The rockhopper design (Figure 17) is classified as a *low impact supporting device* due to its "flexibility", neutral buoyancy and because it rolls over the seabed. On the other hand, functional structures, such as otter boards and beams, are rigid structures that will induce a higher physical impact on the seafloor. Consequently, these are considered as *high impact supporting devices*. During retrieval operations in Norway, a frame is used when searching for ALDFG at larger depths at locations where lost nets have been reported. This is a rigid metal frame with several creepers connected and is considered to be a *high impact* supporting device. Additional weights are also added to the creeper and/or to the supporting device in order to increase the weight of the structure. If the creeper or the supporting device is not heavy enough, additional weight is necessary for the creeper to reach down to the depth where the search will take place. Such equipment includes chains of different weights. The chains in themselves may be considered *low* or *high impact* supporting devices depending on their weight. The magnitude of the effects will be larger when heavier equipment than needed is used. Size and weights of different functional structures are summarized in Table 3.

Table 3 Overview of different supporting devices used by MARELITT Baltic project or described in the literature.

Supporting device	Classification	Weight (kg)	Width (m)	Country in use
New Foundland rubber bobbin	Low impact supporting device	-	-	Canada
Rock hopper style	Low impact supporting device	54 kg (frame)	0,8-1,2	MARELITT Baltic
Light chain	Low impact supporting device	1-3	0,5	Marelitt Baltic
Otter board	High impact supporting device	100-1000	25-250	Unknown (but in use according to literature)
Heavy chain	High impact supporting device			Unknown (but in use according to literature)
Beam	High impact supporting device	100	3	Ireland and UK
Frame	High impact supporting device	100	3	Norway

4 Assessment of effects

This chapter presents the evaluation of the physical effects that the retrieval operations may cause to the environment. It also covers an evaluation of the effects of the *zero-alternative* (leaving the ALDFG in the marine environment), as well as effects of commercial *bottom trawling* activities. The effects are evaluated on a 3-grade scale based on the magnitude they are assumed to induce on the different assessed habitats.

The type and magnitude of effects vary between the different phases (searching or retrieving) of the ALDFG operation. The effect also varies depending on the habitat where the operation takes place. These factors influencing the magnitude and type of effect are covered in this EIA. To a certain degree, the effect of an ALDFG operation will also depend on how affected the area is from other human activities, such as dredging, material extraction or trawling. Such combinations of pressures which will result in more complex sets of effects are beyond the scope of this report as the focus is on ALDFG retrieval operations.

During the *search* phase of a retrieval operation, a creeper is typically dragged over the seafloor. It can be assumed to have the same type of effects, but to a lesser extent, as those observed for commercial *bottom trawling*. The magnitude of the effect of *bottom trawling* depends on the weight of the trawl (including the net, chains and the otter boards), as well as the hauling speed (Durrieu de Madron, et al., 2005). The main differences between bottom trawling and the ALDFG search operation is the size of the equipment (weight and width, see Tables 2 and 3), the swept area (wide for bottom trawling, narrow for ALDFG operations) and frequency (considered to be a one-time-event for both bottom trawling and ALDFG search operations for comparison purposes in this EIA). The hauling speed is within the same range, 0.5-3.5 m/s for bottom trawling (FAO, 2017) and 1-3 m/s for ALDFG search operations (MARELITT Baltic). Based on available scientific literature the effects on the seafloor caused by bottom trawling are principally *abrasion* and *siltation* (Section 1.2.3). Both of these effects should therefore be considered in the assessment of ALDFG operations on the seafloor.

During the *retrieval* phase no effects are expected for soft- or hard bottom habitats. However, for Wreck habitats both *structural damage* (loss of cultural value, Section 5.4) and *artificial reef damage* (Section 5.5) may occur during the *search*- and *retrieval* phase.

Two additional effects need to be considered to evaluate the *zero-alternative* (leaving ALDFG in place) and the comparable activity of commercial trawling. The first is termed *introduction of marine litter* (Section 4.3). When fishing equipment is lost, it turns into marine litter. Bottom trawling can in this way be a source of *introduction of marine litter*. If the ALDFG is not retrieved (*zero-alternative*) it will slowly degrade and start to decompose into smaller fragments such as microplastics. An effect of the *zero-alternative* is therefore the *introduction of marine litter* into the marine environment.

The second additional effect assessed for the zero-alternative and commercial trawling is termed *species extraction* (Section 4.4). In this environmental assessment, *species extraction* refers to the withdrawal of living animals from the marine environment over longer periods or in high quantities through ghost fishing due to ALDFG or through commercial bottom trawling.

Table 4 illustrates which effects are considered relevant for the different activities and alternatives (*search* for ALDFG, *retrieval* of ALDFG, *zero-alternative* or *trawling*). The table gives an overview of the effects considered relevant for the two broad-scale seabed types (soft bottom, hard bottom) and for wrecks as well as the Baltic ecosystem. These effects are habitat specific and will further be assessed in Sections 4.1-4.6. Mixed bottom can be categorized as either soft- or hard bottom depending on the dominant bottom type in a specific region. Effects relevant for habitat forming species (Eelgrass, Blue mussels and Fucus habitats) depend on the broad-scale seabed habitat they are principally associated with (see Table 4). For example, Eelgrass is associated with soft bottoms and relevant effects for this biotope are accordingly listed in Table 4 under "soft bottom".

Table 4 Table of ALDFG related operations and assessed habitats. Under each broad scale bottom type the habitats, habitat forming species and specific habitat that are considered within the same bottom type are listed. The symbol "x", indicates that the effects are assessed for all habitats in this category, while the "(x)" indicates that only the habitat forming species (Fucus, Furcellaria, Eelgrass, Charophytes, Blue mussel) are considered relevant for this specific effect.

	Soft bottom				Hard bottom				Wreck				Baltic ecosystem	
Specific habitat	Sand, Mud and clay, Mixed, Eelgrass/Charophytes				Hard, Mixed, Fucus/Furcellaria, Blue mussel beds, Reefs				Wrecks					
Activity	*Abrasion*	*Siltation*	*Introduction of marine litter*	*Species extraction*	*Abrasion*	*Siltation*	*Introduction of marine litter*	*Species extraction*	*Artificial reef dammage*	*Structure dammage (cultural value)*	*Introduction of marine litter*	*Species extraction*	*Introduction of marine litter*	*Species extraction*
Search for ALDFG	x	x			x	(x)			x	x				
Retrieval of ALDFG									x	x				
Zero alternative			x	x			x	x			x	x	x	x
Trawling	x	x	x	x	x		x	x	x	x	x	x	x	x

In Table 4 for each activity or alternative, the relevant effects are marked by an "x". For example, *abrasion* is considered a relevant effect during the *search* for ALDFG on hard- and soft-bottom habitats, but not during the *retrieval* of ALDFG on these habitats. For the habitat "Wreck", the effects considered relevant for ALDFG operations and *bottom trawling* are *artificial reef damage* and *structural damage*. *Siltation* is considered a relevant effect for ALDFG *search* and *bottom trawling* when taking place on soft bottom, but not on hard bottom (as this broad-scale habitat mostly lacks soft sediment that can be lifted into suspension).

The habitat forming species Fucus/Furcellaria and Blue mussels constitute a special case as they are primarily associated with hard bottom, but can also be found in areas with soft bottom (or mixed bottoms). The effect *siltation* is considered relevant for this habitat and a special indication "(x)" is used in Table 4 to indicate this.

4.1 Abrasion

In this part, the effect *abrasion* is discussed. This is a potential effect of the *search* phase, *bottom trawling* and the *zero-alternative*. Different search devices and activities result in different levels of *abrasion*. The magnitude of the effect also depends on the habitats where the effect occurs, as discussed further below. The habitat sensitivity corresponding to *abrasion* is covered in Chapter 5 (Habitat Sensitivity). Finally, the impact is derived from the magnitude of the effect and the habitat sensitivity score, and is covered in Chapter 6 (Impacts).

Abrasion refers to something that erodes and removes structures from a surface. Abrasion reduces heterogeneity and complexity of the seafloor. Abrasion on hard and mixed bottoms can correspond to displacement of stones and removal of biologically built complexes of the surface. On soft bottoms, abrasion corresponds to destruction of tubes and tunnels within the seabed. Dragging a beam over the seafloor will alter the characteristics, such that the seafloor becomes flat and loses its structural variety. This can have a negative impact on organisms which depend on the structural complexity of the seafloor (Nairn, et al., 2004). In this EIA, abrasion also refers to the destruction of organisms within the surface layer of the seafloor. Abrasion can also reduce the natural underwater dunes or cavities depending on the equipment used as it adds trench-like structures that can take weeks or months to recover. The depth of the trenches depends on the weight of the equipment as well as on the hauling speed (Mayer, et al., 1991).

Bottom trawling results in *abrasion* (Jennings & Kaiser, 1998). Both otter boards and trawls (nets and chains) cause abrasion during bottom trawling, although they penetrate the sediment surface to different depths, between 15-35 cm and 2-10 cm respectively (Eigaard, et al., 2016) (see Section 1.2.3). The width of an otter trawl can vary between 25 and 250 m, which results in a swept area of the same width.

The penetration depth for the search device (creeper) used within ALDFG operations has not been investigated or published in the literature. WWF Germany has therefore carried out an indentation depth measurement within the MARELITT Baltic project. The measurements were conducted directly after using a German and a Polish creeper, and showed 3-5 cm deep tracks in the sediment. These tracks were not observed 3 months afterwards. The width of a creeper is 0.8 m, which also corresponds to the width of the swept area.

By using a functional structure (chains, rock hopper style, beam or frame, see Section 3.2.2) on the search device, potential effects of *abrasion* will increase. The effect depends on the design and weight of the additional structure. However, when performing searches for ALDFG in deep water, the search device will necessarily require heavier equipment to remain on the seafloor during a blind search (dragging) due to the increased drag forces tending to lift the creeper at the end of a long dragging line. If the weight of the equipment is adapted to the water depth, the effect of abrasion will not necessarily increase with the weight of the equipment. The width of the equipment, however, determines the swept are and therefore the magnitude of the effect. The width of supporting devices varies between 1.2-3 m.

From the above discussion, it is assumed that the magnitude of the effect will increase with increasing weight and width of the bottom touching equipment. The different equipments were categorized in Section 3.2.2. The effect a*brasion* is considered important during *bottom trawling* and during the ALDFG *search* phase (see Table 4).

The magnitude of the effect is set to *high* (magnitude = 3, Table 5) for a conventional bottom trawling device, the so-called otter trawl, used in the Baltic Sea. This is justified by the high penetration depth (15-35 cm) and large swept area (25-250 m) (Eigaard, et al., 2016). For light creepers and low impact supporting devices the magnitude of the effect is set to *low* (magnitude = 1) (see Table 5), because of the lower penetration depth (3 cm) and smaller swept area (1.2 m). High-impact supporting devices such as otter boards will cause similar effects on the seafloor as a bottom trawl because of the large swept area. The penetration depth can be high if the weight is not adjusted to the water depth, which is why high impact supporting devices are considered to result in *high* negative effects (magnitude = 3) on soft bottoms. However, the effects on hard bottom, Fucus/Furcellaria and Blue mussel beds are considered to be lower (magnitude = 2) because of the smaller penetration depth. The magnitude of the effects on the Eelgrass/Charophytes is considered to be *medium* for both light and heavy creepers. The effect on Eelgrass/Charophytes is *medium* because the equipment penetrates the sediment which may result in the loss of Eelgrass/Charophyte plants, but also because the swept area is smaller than for bottom trawling and high-impact supporting devices.

Finally, *abrasion* is not considered relevant for wreck habitats as the more specific effects *structural damage* and *artificial reef damage* are assessed for this habitat type.

Table 5 Estimated magnitude of abrasion for different activities. The different scores indicate how large the abrasion will be from the different methods.

Activity		*Soft Bottom*	*Hard bottom*	*Mixed bottom*	*Blue mussel bed*	*Eelgrass/Charophytes*	*Fucus/Furcellaria*	Reefs	*Wrecks*	*Baltic Ecosystem*
Search for ALDFG	Light creeper	1	1	1	1	2	1	1		
	Heavy Creeper	2	2	2	2	2	2	2		
	Low impact supporting device	1	1	1	1	1	1	1		
	High impact supporting device	3	2	3	2	3	2	2		
Retrieval of ALDFG	Manual retrieval/winch									
	Diver (or other controlled operation)									
Zero alternative	Zero alternative (leaving ALDFG in place)									
Trawling	Bottom trawl	3	3	3	3	3	3	3		

Non-significant effect
Low effect (1)
Medium effect (2)
High effect (3)

4.2 Siltation

In this part, the effect *siltation* is discussed. This is a potential effect of the *search* phase, *bottom trawling* and the *zero-alternative*. Different search devices and activities result in different levels of siltation. The magnitude of the effect also depends on the habitats where the effect occurs, as described further below. The habitat sensitivity related to siltation is covered in Chapter 5 (Habitat Sensitivity). Finally, the impact is derived from the magnitude of the effect and the habitat sensitivity score, and is covered in Chapter 6 (Impacts).

Siltation includes both to increased concentration of suspended sediments in the water column (resuspension) and increased accumulation (temporary or permanent) of fine sediments on the seafloor. When equipment is dragged along a soft bottom seafloor, the sediment will, to some extent, lift up into the water column if the drag strength is strong enough. Sediment suspension has a negative impact on many levels of the ecosystem. The effects are often related to the time the particles stay in the water column before they resettle again, as longer suspension times result in more severe impacts even with very low concentrations of suspended sediment. The effect on different organisms is inversely correlated with particle size (Newcombe 1986). The existing background turbidity levels are also important when evaluating effects of suspended sediment (US-EPA 2006). The effects may persist for a few hours in shallow waters with strong tides, or for several days or even weeks in the deep sea (Jennings and Kaizer 1998). Apart from reducing water quality, siltation may cause several types of impacts on the bottom habitats, which include suffocation of filtering organisms (such as bivalves) and reduced sediment surface quality on hard or complex bottom habitats. A direct effect of turbid water is that less light will penetrate to primary producers, which will reduce the production that is essential for marine habitats (Sloth, et al., 1996).

Siltation is thought to occur both during the ALDFG *search* phase and *bottom trawling*. A study of bottom trawling showed that the magnitude of increased suspended sediment is determined by the towing speed, physical dimensions and weight of the gear, type of substratum, as well as the strength of currents or tides in the area (Jennings & Kaiser, 1998). A study of a relatively small bottom trawl (trawl width 25 m and 170 kg heavy trawl doors) showed a significant resuspension of sediments during bottom trawling. The suspended particles created a sediment cloud which had an extent of 18 m above the seabed and a width of 60 m (Bradshaw et al 2012). At the time of writing, the resuspension of sediments during ALDFG searches has not yet been studied.

A higher haul speed results in a higher drag strength and the sediment particles are lifted up with higher energy into the water column. With a slow speed, the sediment particles will not lift so high. The common speed during ALDFG searches is 1-3 m/s (MARELITT Baltic partner) and during *bottom trawling* 0.5-3.5 m/s (FAO). Even if the haul speeds for both activities are similar, the amount of suspended sediment also depends on the weight and dimensions of the equipment. A bottom trawl is much heavier (2 x 170 kg) and wider (25-250 m) than the equipment used during ALDFG searches (6 - 20 kg and 1.2 m wide). Heavy equipment will add more strength to the drag and penetrate deeper into the sediment surface, which will increase the amount of suspended sediment. Similarly, wide equipment affects a larger sediment surface, which also results in increased sediment suspension. The amount of suspended sediment therefore depends on weight and width of the equipment.

Within this EIA, *siltation* during retrieval of ALDFG is only considered to affect soft bottom habitats. Although siltation on hard bottom habitats is considered negligible, the associated effects will be evaluated for all habitat forming species associated with hard bottom, as they can be exposed to siltation during different activities and phases. The magnitude of *siltation* is considered to be *low* (magnitude = 1) for light creepers and low impact supporting devices for all the assessed habitats, due to their shallow penetration depth and narrow width (Table 6). On soft bottoms and Eelgrass/Charophyte habitats, high impact supporting devices are assumed to cause *high* negative effects due to *siltation*, similar to *bottom trawling* devices because of the weight and the width of the equipment. As fine particle sediments are more scarce in mussel beds, *Fucus/Furcellaria* habitats and reefs, *siltation* is estimated to be *low* (magnitude = 1) for these habitats, even with a bottom trawl. Even the heavy creeper is considered to have a *low* effect on all habitats except soft bottom. The magnitude of the effect on soft bottom is set to *medium* (magnitude = 2) because it includes photic and non-photic mud and clay, which consist of small particles (≤ 0,063 mm). The small particles will stay longer in suspension due to the slow sinking rate. For all the other habitats the suspension is assumed to be relatively short when using a heavy creeper, resulting in a *low* negative effect (magnitude = 1).

Finally, *siltation* is considered negligible (magnitude = no effect) for ALDFG retrieval operations, trawling on hard bottom habitats and for wrecks. In the case of retrieval on wrecks where the net is partially embedded in surrounding sediments, the retrieval must be considered as being performed on both soft-sediment habitat and wreck. *Siltation* is considered negligible during the *retrieval* phase. It is, however, relevant in some cases when the ALDFG is buried in the sediments, potentially resulting in temporary siltation when the ALDFG is retrieved. However, this is regarded as a special case and will be covered in Chapter 8 (Good environmental practices 8.1.9).

Table 6 Estimated magnitude of siltation for different activities. The magnitude of the different effects shows how large the effect of siltation becomes when using the different equipment. In general the magnitude of the effect increases with increasing weight and width of the equipment.

Activity		Soft Bottom	Hard bottom	Mixed bottom	Blue mussel bed	Eelgrass/Charophytes	Fucus/Furcellaria	Reefs	Wrecks	Baltic Ecosystem
Search for ALDFG	Light creeper	1		1	1	1	1	1		
	Heavy Creeper	2		1	1	1	1	1		
	Low impact supporting device	1		1	1	1	1	1		
	High impact supporting device	3		3	1	3	1	1		
Retrieval of ALDFG	Manual retrieval/winch									
	Diver (or other controlled operation)									
Zero alternative	Zero alternative (leaving ALDFG in place)									
Trawling	Bottom trawl	3		3	1	3	1	1		

Non-significant effect
Low effect (1)
Medium effect (2)
High effect (3)

4.3 Introduction of marine litter

In this part, the effect *introduction of marine litter* is discussed. This is a potential effect of the *search* phase, *bottom trawling* and the *zero-alternative*. Different search devices and activities can result in different levels of *introduction of marine litter*. The magnitude of the effect also depends on the habitats where the effect occurs, as described below. The habitat sensitivity related to *introduction of marine litter* is covered in Chapter 5 (Habitat Sensitivity). Finally, the impact is derived from the magnitude of the effect and the habitat sensitivity score, and is covered in Chapter 6 (Impacts).

When fishing equipment is lost, it becomes marine litter. If the ALDFG is not retrieved, it will slowly degrade and start to decompose into smaller fragments and microparticles. Very few studies have looked at degradation of polymer ropes, but a recent study from the Firth of Clyde outside Scotland showed that polymer ropes degrade into smaller particles resulting in 0.39-1.02% reduction of the total weight every month (Welden & Cowie, 2017). At the time of writing, no such study has been published for the Baltic Sea. Today most of the professional fishing equipment is made of non-biodegradable synthetic fibers, which slowly degrade into smaller parts and particles that can persist in the environment for long periods (Brown, J. & Macfadyen, G., 2007; Brown,, et al., 2005). The smaller parts of the ALDFG may be removed by currents and transported to other areas. The ALDFG will continue degradation into smaller and smaller fractions. With time, the ALDFG will add both macro and micro waste into the surrounding marine environment. These waste particles are preserved within the ecosystem and cause harm on several ecosystem levels.

In this EIA, the effect *introduction of marine litter* to the marine environment represents the introduction of plastic polymers into the sea. However, other kinds of litter are also introduced with the ALDFG, as has been noted during MARELITT Baltic operations (comment MARELITT Baltic partner). For example, gillnets tend to have lead lines helping the net to hang down in the water column and additional ropes, which may also be lost.

The quality of the net determines its degradation rate and can also influence the amount of annual ALDFG lost or abandoned. Professional fishermen use expensive, good quality nets and will therefore try very hard to find and retrieve the nets. For recreational fishing, however, it is common to use cheaper nets that do not encourage the user to retrieve them if they are lost. Consequently bad quality fishing nets are more easily lost and destroyed, and are more difficult to retrieve (comment MARELITT Baltic partner).

Introduction of marine litter is considered relevant for *bottom trawling* and the *zero-alternative (Table 7)*. Most fishing activities, including bottom trawling (and to a high degree gillnet fishing) introduce ALDFG into the marine environment when fishing equipment is lost. A *medium* magnitude effect is set for *bottom trawling* activity. The effect of *marine litter* is also assessed for the *zero-alternative*. If not retrieved, the ALDFG stays in the marine environment and also results in the *introduction of marine litter*. The magnitude of the effect of introducing litter to the marine environment is considered to be *medium* for *bottom trawling* and *high* for the *zero-alternative*.

The importance of considering the *zero-alternative* is to have a reference with which to compare the potential impacts of the ALDFG retrieval operation. The effect of *introduction of marine litter* is considered higher for the *zero-alternative* than for *bottom trawling*. This is because the *zero-alternative* includes ALDFG from the gillnet fishery and recreational fishing, as well as ALDFG from *bottom trawling*. The magnitude of the effect of *introduction of marine litter* due to trawling is considered to be *medium*. Trawling equipment is expensive, which leads to fishermen putting a lot of effort in finding and retrieving lost gear.

For the Baltic Ecosystem the introduction of marine litter includes the degradation and spread of persistent microfiber within the habitat. Microplastics will easily spread to other parts of the ecosystem and the effect will not necessarily be concentrated to the specific habitat. The microplastics are also persistent due to a slow degradation rate, resulting in a cumulative increase of microplastics in the whole ecosystem. The *zero-alternative* will also have a larger negative effect on an ecosystem than the *introduction of marine litter* from bottom trawling.

Table 7 Estimated magnitude of marine litter for different activities. Marine litter is only considered relevant for the zero-alternative and trawling activity.

Activity		Soft Bottom	Hard bottom	Mixed bottom	Blue mussel bed	Eelgrass/Charophytes	Fucus/Furcellaria	Reefs	Wrecks	Baltic Ecosystem
Search for ALDFG	Light creeper									
	Heavy Creeper									
	Low impact supporting device									
	High impact supporting device									
Retrieval of ALDFG	Manual retrieval/winch									
	Diver (or other controlled operation)									
Zero alternative	Zero alternative (leaving ALDFG in place)	3	3	3	3	3	3	3	3	3
Trawling	Bottom trawl	2	2	2	2	2	2	2	2	2

Non-significant effect
Low effect (1)
Medium effect (2)
High effect (3)

4.4 Species extraction

In this section, the effect *species extraction* is discussed. This is a potential effect of the *search* phase, *bottom trawling* and the *zero-alternative*. Different search devices and activities result in different levels of *species extraction*. The magnitude of the effect also depends on the habitats where the effect occurs, discussed further below. The habitat sensitivity related to *species extraction* is covered in Chapter 5 (Habitat Sensitivity). Finally, the impact is derived from the magnitude of the effect and the habitat sensitivity score, and is covered in Chapter 6 (Impacts).

In the context of this *EIA species extraction refers* to the withdrawal of live animals from the marine environment over a longer period or in “unnatural” quantities, in this case through ghost fishing due to ALDFG and commercial bottom trawling. Lost fishing equipment will continue fishing, which is one of the reasons why ALDFG operations are carried out (see Section 1.2.1), although the extraction of species from ghost fishing is low compared to commercial fishing activities. The degree of ghost fishing from ALDFG varies according to gear type and environmental conditions. Ghost fishing is more likely to occur in lost gillnets than in lost trawling equipment, even though this equipment has also been reported to continue fishing to a certain degree once lost. Exposure of the gear to environmental phenomena such as currents, waves and fouling are also key determinants of the catching efficiency of ghost nets.

The catching efficiency of lost gillnets depends on their vertical profile and the relation of the mesh size to the size and shape of targeted fish. The fishing capacity of the ALDFG also depends on the level of degradation of the ALDFG, and to which degree it is buried into the sediments. A study from the Baltic Sea showed that the catching efficiency decreased exponential by 80% within the first 3 months. The catch efficiency continued to decrease and after 27 months, it was 5-6% of the initial catch and could probably continue fishing for an even longer period (Tschernij & Larsson, 2003).

As described in Section 1.2.1, ALDFG can significantly reduce populations of different species (Uhlmann, S. S. & Broadhurst, M. K., 2015). However, on a regional scale the extraction of species by recreational and commercial fishing (trawling and gillnets) has a larger effect on the rate of *species extraction* compared to the continuous fishing by the ALDFG. Consequently, the magnitude of the effect from trawling is considered *high* (magnitude = 3, Table 8), while the effect for the *zero-alternative* related to extraction of species from ghost fishing is set to *medium* (magnitude = 2, Table 8).

Bottom trawling extracts large amounts of both targeted species and non-targeted species, and the magnitude of the effect is considered *high* because of the large amounts of species that are extracted. For the *zero-alternative,* the *species extraction* is much lower than for *bottom trawling* and the magnitude of the effect is therefore expected to be smaller. Extraction of species due to both *bottom trawling* and the *zero-alternative* have impacts both on the ecosystem level as well as on the specific bottom habitats. The effect of extracting such large amounts of fish will have negative impacts on the food web and will affect the balance between larger fish species and smaller fish species and the interactions between them. These effects are also considered larger on an ecosystem level due to *bottom trawling* than for the *zero-alternative*.

In some cases, the ALDFG will become overgrown with different organisms and constitute an artificial reef. Retrieval of ALDFG in these "reefs" induces a *species extraction* of attached organisms on a local level. Within this EIA, we have considered such *species extraction* as negligible as it is marginal compared to *species extraction* of commercial fishing or ghost fishing.

Table 8 Estimated magnitude of species extraction for different activities. Species extraction is only considered relevant for the zero-alternative and trawling activity.

Activity		*Soft Bottom*	*Hard bottom*	*Mixed bottom*	*Blue mussel bed*	*Eelgrass/Charophytes*	*Fucus/Furcellaria*	*Reefs*	*Wrecks*	*Baltic Ecosystem*
Search for ALDFG	Light creeper									
	Heavy Creeper									
	Low impact supporting device									
	High impact supporting device									
Retrieval of ALDFG	Manual retrieval/winch									
	Diver (or other controlled operation)									
Zero alternative	Zero alternative (leaving ALDFG in place)	2	2	2	2	2	2	2	2	2
Trawling	Bottom trawl	3	3	3	3	3	3	3	3	3

Non-significant effect
Low effect (1)
Medium effect (2)
High effect (3)

4.5 Structural damage (cultural value)

In this part, the effect *structural damage (*cultural value*)* is discussed. This is a potential effect of the *search* phase, *bottom trawling* and the *zero-alternative* on wrecks. Different search devices and activities result in different levels of *structural damage*. The level of the effect also depends on the habitats where the effect occurs, as discussed below. Some of the methods evaluated within this EIA are not recommended during *search* or *retrieval* operations on wrecks, and are not used on wrecks within the MARELITT Baltic project. The habitat sensitivity related to *structural damage* (cultural value) is covered in Chapter 5 (Habitat Sensitivity). Finally, the impact is derived from the level of the effect and the habitat sensitivity score, and is covered in Chapter 6 (Impacts).

The effect *structural damage* refers to partial destruction or removal of structures from wrecks. The effect is therefore only considered relevant for the habitat “Wreck” (Table 4).

All wrecks may have a historical value and are important to preserve until authorities have been informed and have determined the status of preservation and associated precautionary measures. Accordingly, when harm to a wreck considered as a cultural heritage takes place, the cultural value of the wreck is reduced due to the loss of possible historical information. *Structural damage* can occur when various types of equipment strike or hit parts of the wreck during the search for ALDFG. The damage depends on the weight of the equipment as well as the strength when it hits the wreck. The degree of damage also depends on the state of the wreck, which in turn is a consequence of factors such as age and oxygen levels in the surrounding water. The German cultural heritage authorities have raised awareness of the possible situation where ALDFG help keeping wrecks together (personal comment MARELITT Baltic partner). Retrieving the ALDFG may consequently injure parts of the wreck, which will cause a loss of the archeological value. This can happen even if professional divers are used to cut off ALDFG carefully and do not use any mechanical device for retrieval. However, it should be noted that degradation of the ALDFG will eventually occur naturally, even though this is a slower process.

Studies from the Mediterranean Sea and the Black Sea have documented damage on wrecks due to bottom trawling (Brennan , et al., 2016). However, the degree of destruction is mainly unknown and very few studies are published on the *structural damage* of wrecks due to bottom trawling activities. Only a small fraction of all wrecks that are assumed to exist in the Baltic Sea are on known locations. Activities such as bottom trawling can thus be considered to have *high* negative effect on wrecks, as there is always a potential that an unknown wreck can be damaged. In fact, wrecks are known “hot-spots” for ALDFG as they are easily tangled into these structures. Bottom trawling also has potentially negative effects on known wrecks, as these are three-dimensional structures in the water column that attract aquatic life (see further 4.6) and hence represent interesting areas for fishing.

During an ALDFG retrieval operation, wrecks can be damaged both during the *search* phase and the *retrieval* phase. When an ALDFG is attached to a wreck, it can be tangled into different parts of the wreck. To drag or move the ALDFG in an uncontrolled way can thus harm the wreck. Using a hook or anchor for the retrieval operation without any kind of underwater control is associated with a potentially *high* negative effect (magnitude = 3, Table 9), and for this reason the use of a creeper during search on a wreck should be avoided. Using a light creeper is thought to lower the potential negative effect compared to a heavier creeper. This is why the magnitude of the effect for light creepers and light supporting devices is estimated as *medium* (magnitude = 2, Table 9). The use of divers during a controlled retrieval operation is considered the best option, but even in this case, *structural damage* can occur as the ALDFG sometimes act as a supporting structure for the wrecks.

Before any retrieval operation on a known wreck, the cultural value must first be assessed in order to determine if it represents a cultural heritage or not. This is the main reason why every retrieval operation on wrecks should be performed in accordance with relevant government authority.

Table 9 Estimated magnitude of structural damage for different activities. Structural damage is only considered for wrecks and focuses on the possible loss of the cultural value of the wreck.

Activity		*Wrecks*
Search for DFG	Light creeper	2
	Heavy Creeper	3
	Low impact supporting device	2
	High impact supporting device	3
Retrieval of DFG	Manual retrieval/winch	3
	Diver (or other controlled operation)	1
Zero alternative	Zero alternative (leaving DFG in place)	
Trawling	Bottom trawl	3

Non-significant effect
Low effect (1)
Medium effect (2)
High effect (3)

4.6 Artificial reef damage

In this section, the effect *artificial reef damage* is discussed. This is a potential effect of the *search* phase, *bottom trawling* and the *zero-alternative*. Different search devices and activities result in different levels of *artificial reef damage*. The level of the effect also depends on the habitats where the effect occurs, as discussed further below. The habitat sensitivity related to *artificial reef damage* will be covered in Chapter 5 (Habitat Sensitivity). Finally, the impact is derived from the magnitude of effect and the habitat sensitivity, and is covered in Chapter 6 (Impacts).

Artificial reefs are human constructions produced in order to promote marine life. Other structures, which can function as artificial reefs are wrecks. Numerous studies show that the abundance of fish and macroinvertebrates is high near artificial structures placed on the seafloor (Jensen, 2002), in the water column or on the surface of the water (Castro, et al., 2001). However, it is not clear whether net pelagic productivity increases or rather, that these artificial structures are used to attract and aggregate species (McKindsey, et al., 2006). ALDFG can also function as artificial reefs by constituting a structure for marine organisms (such as algae, mussels and sea stars) to attach to. It can also constitute a three dimensional structure in the water that in some cases increases the bottom complexity and biodiversity, especially when the ALDFG is overgrown. When ALDFG is entangled with a wreck, it contributes to an even larger artificial reef where organisms can attach and grow. Such artificial structures can constitute biological hotspots (Krumholz & Brennan, 2015) as they provide shelter and protection from predators.

When retrieving ALDFG from wrecks, there is a possibility that a part of a functional artificial reef is damaged. All damage to the wreck will therefore also damage the reef structure. This effect is largest if the retrieval operation reduces the three-dimensional structure of the wreck itself (see Section 4.5).

The magnitude of the effect will increase with the weight of the equipment. The damage may occur during the *search* and *retrieval* phase, as well as during bottom trawling. High impact supporting devices and bottom trawling devices are the heaviest equipment and are expected to result in *high* effects (magnitude = 3, Table 10). Using a hook or an anchor during retrieval may result in *medium* effects on the artificial reef, while using a diver yields a *low* effect.

In some cases, the benefits of retrieving the ALDFG may not outweigh the negative impacts associated with the retrieval, and the ALDFG should therefore be left in place. Such cases include when ALDFG in themselves are in a condition that their fishing capacity has been lost and that they participate in the creation of the artificial reef in combination with the wreck. It is thus a relevant question to assess during planning (see Good environmental practice in Section 8.1.8 -Overgrown nets). Even ALDFG outside wreck habitats could in some cases constitute artificial reef structures. However, it is impossible to make general assumptions about the value and sensitivity of ALDFG as artificial reefs as this will vary on a case-by-case basis, especially outside the wreck habitat (where a concentration of ALDFG is commonly reported). Consequently, in this EIA it is assumed that a retrieval of ALDFG outside the wreck habitat will result in negligible impacts. Moreover, the ALDFG will eventually degrade by itself, and hence loose its function as an artificial reef. Accordingly, within this EIA, the loss of the potential value of ALDFG as an artificial reef will not be assessed as an impact.

Table 10 Estimated magnitude of artificial reef damage for different activities. The artificial reef damage is only considered relevant for wrecks. For the other habitats it is covered under abrasion.

Activity		*Wrecks*
Search for DFG	Light creeper	1
	Heavy Creeper	2
	Low impact supporting device	1
	High impact supporting device	3
Retrieval of DFG	Manual retrieval/winch	2
	Diver (or other controlled operation)	1
Zero alternative	Zero alternative (leaving DFG in place)	
Trawling	Bottom trawl	3

Non-significant effect
Low effect (1)
Medium effect (2)
High effect (3)

5 Habitat Sensitivity

This chapter presents the habitat-specific sensitivity for each of the effects assessed (Table 11). Equivalent to the assessment of effects, a higher score correponds to a higher estimated degree of sensitivity.

As previously mentioned, sensitivity scores in HOLAS II were based on expert evaluation and vary between 0.0 and 2.0 (HELCOM, 2017a). Within this EIA, the scores were divided into three different intervals representing *low* sensitivity (0-0.69), *medium* sensitivity (0.7-1.3) and *high* sensitivity (1.31-2.0). Each of the three intervals were transposed to one of the three interval scores 1 (*low*), 2 (*medium*) or 3 (*high*) (Section 2.2 and for further details appendix 1). The sensitivity scores for the treated habitats are listed in Table 11 below with a color code. The color code is only for illustrative purposes to show how the decimal numbers are divided into the different groups. The interval scores are subsequently used in the evaluation of the final impacts. The different scores related to each effect are discussed further in the following sections (Sections 5.1-5.6).

Table 11 Sensitivity scores for habitats and biotopes related to potential effects. See detailed sensitivity scores from HOLAS II in Appendix 1.

Habitat	*Abrasion*	*Siltation*	*Introduction of marine litter **	*Species extraction*	*Artificial reef dammage **	*Structure dammage (cultural value) **
Photic Sand	2	2	2	1	*na*	*na*
Photic Mud and Clay	2	2	2	1	*na*	*na*
Photic Hard bottom	2	na	2	1	*na*	*na*
Photic Mixed bottom	2	2	2	1	*na*	*na*
Non-Photic Sand	2	2	2	1	*na*	*na*
Non Photic Mud and Clay	2	2	2	1	*na*	*na*
Non photic Hard bottom	2	na	2	2	*na*	*na*
Non photic Mixed bottom	2	2	2	1	*na*	*na*
Blue mussel bed	3	3	2	1	*na*	*na*
Eelgrass/Charophytes	3	3	2	2	*na*	*na*
Fucus/Furcellaria	3	3	2	1	*na*	*na*
Reefs	3	3	2	2	*na*	*na*
Wrecks*	na	na	2	2	1	2
Baltic Ecosystem	na	na	3	3	na	na

Sensitivity score EIA
1 (Low)
2 (Medium)
3 (High)

na: not applicable
** sensitivity score is set by the authors*

5.1 Abrasion and siltation

As described in Chapter 4, the effects abrasion and siltation are classified together in HOLAS II, as one single effect termed *physical disturbance.* Consequently, HOLAS II does not give separate sensitivity scores for abrasion or siltation. In this EIA, *abrasion* and *siltation* have been treated separately because it is important to show all the potential effects of the methods used during ALDFG *search* and *retrieval* phase. This implies that sensitivity scores for *physical disturbance* are used as an indicator of the sensitivity of the habitats for both *siltation* and *abrasion*. Consequently, the difference in impacts (Chapter 6) for the effects *abrasion* and *siltation* originate from the difference in the magnitude of the effect alone (as the sensitivity score is the same for the two effects in a given habitat, Chapter 4). As *siltation* has not been considered relevant for hard bottom habitats in relation to ALDFG operations (siltation is considered negligible during search on hard bottom habitats, Chapter 4), sensitivity scores have been set to *not applicable* for these habitats (Table 11).

The HOLAS II sensitivity scores are *high* for all the habitat forming species (Blue mussel beds, Eelgrass/Charophytes, Fucus/Furcellaria), but especially *high* for Eelgrass/Charophytes for which the highest sensitivity score is set. Eelgrass/Charophytes are non-tolerant to *abrasion* because of shoots, roots and seeds, stored in the sediment that can be damaged or uprooted. The recovery of Eelgrass meadows depends on recruitment from the surrounding area through transportation of seeds and drifting shoots, and on the size of the disturbed area (Silberberger, et al., 2016); recovery can be very slow.

Eelgrass/Charophytes also have a low tolerance to *siltation* because of the large impact a reduction in light availability will have on this habitat, as they are both dependent on light to continue their photosynthesis.

The different bottom substrates (sand, mud and clay, hard and mixed) are considered to have a *medium* sensitivity to physical disturbance, with Photic bottoms having a slightly higher sensitivity score (except for hard bottom that has the same sensitivity score for both photic and non-photic). Higher sensitivity for photic habitats can be explained by their dependence on light in order to sustain their productivity.

5.2 Introduction of marine litter

Within HOLAS II, there is no sensitivity score that perfectly corresponds to marine litter of the kind that is expected from ALDFG and bottom trawling activities. The closest related score is the sensitivity with regard to hazardous substances. Marine litter is one among other pollutants included within this score that also include oil spills, chemical release, nutrients and radionuclides. Because of these diverse pollutants grouped together, the original score was not considered directly applicable for this EIA. Nevertheless, the sensitivity score used within this EIA was set within the same range as the one presented within HOLAS II (medium level). The same sensitivity score was therefore used for all the different habitats for this effect.

Introduction of marine litter is an anthropogenic phenomenon. Synthetic fibers and plastics have a very slow degradation rate and will therefore accumulate in the environment. A recent study shows that even the deepest parts of the oceans are affected by plastic pollution on an ecosystem level (Van Cauwenberghe, et al., 2013; Jamieson, et al., 2017). When ALDFG is introduced to the environment, it will affect all habitats negatively. Among the direct consequences, the residues of ALDFG or other plastic pollutants can cover sediment surfaces and burry epibenthic organisms. It can also create oxygen free patches on the bottom where it acts as a barrier for oxygen exchange within the water column. These polymers will slowly degrade and spread to all habitats and ecosystems. The smallest fragmented synthetic particles have negative impacts on a variety of organisms. Blue mussels and deposit feeders can ingest micro-plastics, which might have a negative effect on their biological and reproductive fitness (von Moos, et al., 2012; Wegner, et al., 2012).

As the polymers will spread to other parts of the marine ecosystem (independent of where it first entered the marine system), the effect is not habitat-dependent. The sensitivity of the Baltic Ecosystem is therefore set to high, while all habitats and habitat forming species have been given a medium level sensitivity. The sensitivity score for *introduction of marine litter* is set to medium (2), to reflect the estimation published in HOLAS II.

5.3 Species extraction

Species extraction occurs naturally from predation. For example, higher trophic level fish, birds or seals within the Baltic Sea carry out species extraction by predation. Human activities such as commercial fishing and recreational fishing are activities that also contribute to extraction of species. Another way of species extraction is by ALDFG (so-called ghost fishing) which has been discussed in the Introduction (Section 1.2.1) and further in detail in Section 4.4. The sensitivity score for *species extraction* is taken from HOLAS II, where the sensitivity of habitats for extraction of three commercial species are included (cod, sprat and herring). These species can all be considered as ecosystem key species of the Baltic Sea. An average of the three sensitivity scores is used within this EIA and is presented for each of the habitats in Table 11. The sensitivity score describes how sensitive each habitat is to *species extraction*, but also includes tolerance/resistance to the extraction and how quickly the habitat recovers.

The HOLAS II sensitivity assessment indicates a tolerance against *species extraction*, resulting in *low* to *medium* sensitivities for all individual habitats and habitat-forming species. At the same time, the sensitivity on an ecosystem level (Baltic Ecosystem) to *species extraction* is determined to be *high* due to the overall effects on the ecosystem.

5.4 Structural damage (cultural value)

Structural damage of wrecks can occur naturally during degradation of the structure (wood or metal). It refers to damage that occurs during the ALDFG *search* and *retrieval* phase or *bottom trawling*, for example when searching devices hit the wreck. As wrecks are not considered within HOLAS II, the sensitivity score used within this EIA has been set by the authors.

Wrecks have a *low* tolerance with respect to *structural damage* when equipment that is not possible to control is used during search and retrieval of ALDFG or during activities such as *bottom trawling* close to the wreck. Every wreck can potentially represent a cultural heritage that cannot be restored to its former (before damage) state (see Section 4.6). The sensitivity score of wrecks with respect to *structural damage* is subsequently set to *high* (3).

5.5 Artificial reef damage

The sensitivity for *artificial reefs* with respect to damage is set to *low.* Reef damage here refers to the potential damage and removal of structures from the wreck functioning as an artificial reef. This damage can happen during the *search* phase, *retrieval* phase and *bottom trawling*. The sensitivity score for the artificial reef should be determined in relation to the tolerance of the *artificial reef* to persist even after the ALDFG is retrieved. The tolerance should be evaluated during the planning of a retrieval operation on a wreck. The value of an ALDFG as an artificial reef should always be considered to ensure good environmental practice (see Sections 8.18 and 8.2).

6 Impacts

The presentation of impacts is divided into the three main habitat types; soft bottom, hard bottom and wrecks. Results for habitat forming species (Eelgrass/Charophytes, Mussel beds and Fucus/ Furcellaria habitats) are covered in separate sections. Impacts are derived from a combination of the sensitivity score and the magnitude of the effect (see Sections 2.3-2.4). This gives impact scores between 0 and 9, where 9 is the highest impact. The different degrees of impacts are decided based on the matrix presented below (Figure 18).

	Habitat sensitivity		
Effect	*Low (1)*	*Medium (2)*	*High (3)*
Low (1)	*1*	*2*	*3*
Medium(2)	*2*	*4*	*6*
High(3)	*3*	*6*	*9*

Impact Score	Assumed result
0	*Non-significant impact*
1-2	*Low impact*
3-5	*Medium impact*
6-9	*High Impact*

Figure 18 The final impact is the product of the sensitivity and the effect scores.

6.1 Soft bottom habitats

Table 12 summarizes the impacts of ALDFG retrieval operations (*search* and *retrieval*), the *zero-alternative* and *bottom trawling* on soft bottom habitats.

Table 12 Results from the EIA for both photic and non-photic soft-bottom habitats

		Photic Sand				Photic Mud and Clay				Photic Mixed bottom			
		Abrasion	*Siltation*	*Introduction of marine litter*	*Species extraction*	*Abrasion*	*Siltation*	*Introduction of marine litter*	*Species extraction*	*Abrasion*	*Siltation*	*Introduction of marine litter*	*Species extraction*
Search	Light creeper	2	2			2	2			2	2		
	Heavy Creeper	4	4			4	4			4	2		
	Low impact supporting device	2	2			2	2			2	2		
	High impact supporting device	6	6			6	6			6	6		
Retrieval	Manual retrieval/winch												
	Diver												
Zero alternative	Leaving ALDFG in place			6	2			6	2			6	2
Trawling	Bottom trawl	6	6	4	3	6	6	4	3	6	6	4	3

		Non-Photic Sand				Non Photic Mud and Clay				Non Photic Mixed bottom			
		Abrasion	*Siltation*	*Introduction of marine litter*	*Species extraction*	*Abrasion*	*Siltation*	*Introduction of marine litter*	*Species extraction*	*Abrasion*	*Siltation*	*Introduction of marine litter*	*Species extraction*
Search	Light creeper	2	2			2	2			2	2		
	Heavy Creeper	4	4			4	4			4	2		
	Low impact supporting device	2	2			2	2			2	2		
	High impact supporting device	6	6			6	6			6	6		
Retrieval	Manual retrieval/winch												
	Diver												
Zero alternative	Leaving ALDFG in place			6	2			6	2			6	2
Trawling	Bottom trawl	6	6	4	3	6	6	4	3	6	6	4	3

Non-significant impact
Low impact
Medium impact
High Impact

Potential impacts of the search and retrieval of ALDFG

For soft bottom habitats, the impacts of both *abrasion* and *siltation* vary between *low* and *high* for evaluated ALDFG retrieval methods (Table 12). The assessment indicates that impacts on all assessed soft bottom habitats due to MARELITT Baltic search- and retrieval operations (search with light creeper and low impact supporting device) are *low* for both *abrasion* and *siltation*.

The impacts on soft bottom habitats increase with the weight and design of the retrieval equipment (see Section 3.2) for both *abrasion* and *siltation* (heavier creeper and supporting device result in higher impact scores). Results also indicate that *abrasion* results are on the same level of impact independent of whether operations are performed on *Photic* or *Non-photic soft bottom*. The impact of *siltation* on *mixed bottom* habitats is considered *low* for both light and heavy creepers. This is due to the smaller areas with soft bottom material within the *mixed bottom* habitats compared to other soft bottom habitats.

Potential impacts of the zero-alternative

The impact scores of the *zero-alternative* (not retrieving the ALDFG) on soft bottom habitats are considered to be *high* for the *introduction of marine litter* and *medium* for *species extraction* (ghost fishing). Marine litter will have long lasting impacts due to the slow degradation into small particles that will spread in the environment and persist for many years. The extraction of species can also continue over many years if the ALDFG is not retrieved, however this impact is expected to be lower than for *bottom trawling*.

This implies that in general terms, impacts of retrieving ALDFG on soft bottoms, with methods employed by MARELITT Baltic partners, are lower than the impacts of the *zero-alternative*. However, this may not be the case if ALDFG is found in more sensitive habitats or if a heavy creeper or high impact supporting devices are used.

Potential impacts of bottom trawling

Bottom trawling will induce *high* impacts on all soft bottom habitats through both *abrasion* and *siltation*. The high impacts are due to the heavy and wide equipment (swept area). *Introduction of marine litter* is evaluated as *medium* due to equal sensitivity and magnitude of the effect for all assessed habitats (Sections 4.3 and 5.2). Together with other commercial fishing activities, bottom trawling is one of the main sources for the *introduction of marine litter* into the marine environment (NLWKN, 2014). Finally, *species extraction* by trawling is evaluated to have *medium* impact on the different soft bottom habitats.

6.2 Habitat forming species on soft-bottom - Eelgrass/Charophytes

Table 13 below summarizes the impacts of ALDFG *search*- and *retrieval* phases, the *zero-alternative* and *bottom trawling* for the habitat-forming species Eelgrass/Charophytes.

Table 13 Results from the EIA for Eelgrass/Charophyte habitat.

		Eelgrass/Charophytes			
		Abrasion	*Siltation*	*Introduction of marine litter*	*Species extraction*
Search	Light creeper	6	3		
	Heavy Creeper	6	3		
	Low impact supporting device	3	3		
	High impact supporting device	9	9		
Retrieval	Manual retrieval/winch				
	Diver				
Zero alternative	Leaving ALDFG in place			6	4
Trawling	Bottom trawl	9	9	4	6

Non-significant impact
Low impact
Medium impact
High Impact

Potential impacts of the search and retrieval of ALDFG

For Eelgrass/Charophytes, the impact of abrasion varies between *medium* and *high*. The impacts of siltation are mostly considered to be *medium* (Table 13). Eelgrass is very sensitive to *abrasion* because shoots, roots and seeds are stored in the sediment and will be destroyed by abrasion. This results in *high* expected impacts for *abrasion*, even for light creepers including those used during MARELITT Baltic ALDFG operations. The effect of *abrasion* during the *search* phase can be compared to pleasure boat anchoring. Studies have shown that anchoring within Eelgrass meadows remove seagrass plants and the recovery is slow (Eelgrass not regrown after 10 months) (Silberberger, et al., 2016). The recovery of the seagrass depends on the surrounding seagrass bed and the recovery will occur through transportation of seeds and drifting shoots (MARBIPP, 2001-2006), implying that regrowth will be difficult if an important part of biologically productive plants are damaged.

The impacts of siltation are due to the increase in particle concentrations in the water, which will reduce the light penetrating the water column. Eelgrass/Charophytes can tolerate shorter periods of reduced light availability, but they are sensitive to longer periods of siltation and associated reduced light availability. Longer periods with reduced light will not only reduce the depth distribution of Eelgrass (Nielsen , et al., 2002), but also the growth rate (Dennison & Alberte, 1985). A lower level of siltation results in a low impact score. The limited sediment suspension created by the search methods employed in MARELITT Baltic operations yields a *low* effect (see Section 4.2). The impact from a heavy creeper is evaluated as *medium*, due to the small swept area and the short siltation. By using heavier and larger equipment the level of siltation will increase, resulting in *high* impacts from the high impact supporting device.

As for other soft sediment habitats, heavier and larger equipment causes a higher impact on Eelgrass meadows.

Potential impacts of the zero-alternative

The impacts of the *zero-alternative* (not retrieving the ALDFG) on Eelgrass meadows are *high* regarding the *introduction of marine litter* and *medium* for *species extraction* (ghost fishing). Large marine litter on Eelgrass/Charophyte habitats can cover the plants and prevent sunlight from reaching the plants, which will eventually kill them due to low light availability. Marine litter will also have long lasting impacts due to a slow degradation into small particles that will spread in the environment and persist for many years. The *extraction of species* is also at risk of continuing for a long time (even though the catch efficiency will be reduced) if the ALDFG is not retrieved, but the extraction is lower than for bottom trawling and therefore this impact is evaluated as *medium*.

This implies that in general terms, the impacts of retrieving ALDFG, even with the methods employed by MARELITT Baltic, are on the same *high* level on Eelgrass/Charophyte habitats as the impacts caused by the *zero-alternative*. This shows that non-invasive methods, such as divers, ROV or SSS, should be employed during the search phase on Eelgrass/Charophyte habitats.

Potential impacts of bottom trawling

The results indicate that *bottom trawling* on Eelgrass/Charophyte habitats has a *high* impact for most of the effects assessed: *abrasion*, *siltation* and *species extraction*. As previously discussed, the equipment used for commercial trawling is heavy and at risk of destroying Eelgrass meadows. Together with other commercial fishing activities, it is also one of the main sources for the *introduction of marine litter* into the marine environment (NLWKN, 2014). The *introduction of marine litter* is evaluated as *medium* given both medium sensitivity and medium magnitude of the effect for all assessed habitats (Sections 4.3 and 5.2). Finally, *species extraction* within Eelgrass/Charophyte habitats is evaluated to cause a *high* impact. This is because the habitat is an important shelter, as well as an important nursery grounds, for many fish species; an extraction of fish species from this habitat will consequently result in a *high* impact.

6.3 Hard bottom habitats

Table 14 below summarizes the impacts of ALDFG *search* and *retrieval* phases, the *zero-alternative* and *bottom trawling* on hard bottom habitats.

Table 14 Results from the EIA for hard bottom habitat.

		Photic Hard bottom				Photic Mixed bottom				Non photic Hard bottom				Non Photic Mixed bottom			
		Abrasion	*Siltation*	*Introduction of marine litter*	*Species extraction*	*Abrasion*	*Siltation*	*Introduction of marine litter*	*Species extraction*	*Abrasion*	*Siltation*	*Introduction of marine litter*	*Species extraction*	*Abrasion*	*Siltation*	*Introduction of marine litter*	*Species extraction*
Search	Light creeper	2				2	2			2				2	2		
	Heavy Creeper	4				4	2			4				4	2		
	Low impact supporting device	2				2	2			2				2	2		
	High impact supporting device	4				6	6			4				6	6		
Retrieval	Manual retrieval/winch																
	Diver																
Zero alternative	Leaving ALDFG in place			6	2			6	2			6	4			6	2
Trawling	Bottom trawl	6		4	3	6	6	4	4	6		4	6	6	6	4	3

Non-significant impact
Low impact
Medium impact
High Impact

Potential impacts of the search and retrieval of ALDFG

The potential impact of ALDFG retrieval on hard bottom is limited to *abrasion* during the *search* phase. Mixed bottoms consist of hard and soft bottom areas, which is why *siltation* will be considered as an effect in this type of habitat. The impact score for *siltation* on mixed bottom is *low,* except for the high impact supporting devices and bottom trawl, for which the impact of *siltation* is evaluated as *high*. This is a result of the heavy equipment and large swept area, which may result in large amounts of resuspended sediments. For *abrasion*, the impact is considered *low* for all habitats for both light creepers and low impact supporting devices, while for heavy creepers and high impact supporting devices *medium* impacts are expected for all habitats. When the impacts on hard bottom are compared to soft bottom habitats, the impacts on hard bottomare expected to be lower due to the neglible penetration depth of search devices on hard bottom habitats. This also explains why mixed bottoms including patches of soft bottom are impacted to a greater extent by high impact supporting devices than hard bottoms. In general, the level of impacts for all hard bottom habitats increases with the size of the equipment used. The bottom trawl is the heaviest and largest equipment and all habitats will therefore be highly affected.

In mixed bottom areas where the bottom type will be dominated by soft bottom, the impacts on mixed bottom can be expected to be similar to the impacts on soft bottom.

Potential impacts of the zero-alternative

The impact scores are between *low* and *high* for the *zero-alternative* (not retrieving the ALDFG) on hard bottom habitats. Leaving the ALDFG in place means both *introduction of marine litter* to the marine environment and a high risk for *species extraction* (ghost fishing). Marine litter can cover hard surfaces that can be important for the attachment of different organisms. Marine litter will have long lasting impacts due to a slow degradation into small particles that will spread into the environment and persist for many years. The extraction of species is also at risk of continuing for a long time (even though the catch efficiency will be reduced) if the ALDFG is not retrieved, but the extraction is not as high as for bottom trawling and therefore this impact is evaluated as *medium*.

This implies that in general terms, retrieving ALDFG with methods employed by MARELITT Baltic on hard bottom habitats have lower impact than the negative impacts caused by the *zero-alternative*.

Potential impacts of bottom trawling

The impact score for bottom trawling due to abrasion is *high* on all hard bottom habitats. Siltation is considered negligible on photic and non-photic hard bottom, while for mixed bottom it is considered to result in *high* impacts. The high impact score from the bottom trawl can be explained by the heavy and wide trawl, which results in a large swept area.

Together with other commercial fishing activities, bottom trawling is one of the main sources for the *introduction of marine litter* into the marine environment (NLWKN, 2014) and the impacts are considered to be *medium* given both medium sensitivity and medium magnitude of the effect for all assessed habitats (Sections 4.3 and 5.2). The *species extraction* during bottom trawling is evaluated as *medium* on photic hard bottom and *high* on non-photic hard bottom. The difference is due to the higher sensitivity score for non-photic habitats, as evaluated in HOLAS II.

6.4 Habitat-forming species on hard bottom - *Fucus/Furcellaria* habitats.

Table 145 below summarizes the impacts of the ALDFG *search* and *retrieval* phases, the *zero-alternative* and *bottom trawling* activities on Fucus/Furcellaria habitats.

Table 15 Results from the EIA for Fucus/Furcellaria habitat.

		Fucus/Furcellaria			
		Abrasion	*Siltation*	*Introduction of marine litter*	*Species extraction*
Search	Light creeper	3	3		
	Heavy Creeper	6	3		
	Low impact supporting device	3	3		
	High impact supporting device	6	3		
Retrieval	Manual retrieval/winch				
	Diver				
Zero alternative	Leaving ALDFG in place			6	2
Trawling	Bottom trawl	9	3	4	3

Non-significant impact
Low impact
Medium impact
High Impact

Potential impacts of the search and retrieval of ALDFG

As for hard bottom habitats, the impact scores related to ALDFG *search* and *retrieval* phases on Fucus/Furcellaria habitats are limited to the *search* phase. The result from the assessment indicates a *medium* impact for both *abrasion* and *siltation* with MARELITT Baltic search methods, whereas a *high* impact from *abrasion* can be expected when high impact supporting devices and heavy creepers are used.

Siltation has not been considered as a relevant effect for Photic and Non-photic hard bottom due to the assumed weak presence of soft sediments in those habitats. Even though Fucus/Furcellaria habitats are primarily found on hard bottom, *siltation* is considered a potential effect for this habitat forming species, because sediment patches can be found within the hard bottom habitat, such as on the border to soft bottom habitats or in mixed bottom habitats.

The impact score of *siltation* is hence considered as *medium* due to the generally sparse presence of loose material that can be resuspended in this habitat (resulting in a *low* magnitude for this effect). Nevertheless, the sensitivity score as set in HOLAS II is *high* even though Fucus/Furcellaria plants can withstand a short-term exposure to increased siltation (MARBIPP, 2001-2006).

Potential impacts of the zero-alternative

The impact scores vary between *low and high* for the *zero-alternative* (not retrieving the ALDFG) on Fucus/Furcellaria habitats*,* as for all other evaluated habitats. For Fucus/Furcellaria habitats, the marine litter can cover patches of hard bottom, occupying areas with hard substrate where Fucus/Furcellaria zygotes can attach. Leaving the ALDFG in place also means both the *introduction of marine litter* into the marine environment and a high risk of *species extraction* (ghost fishing).

This implies that in general terms, the impacts of retrieving ALDFG, with methods employed by MARELITT Baltic, on Fucus/Furcellaria habitats are expected to be lower than the negative impacts caused by the *zero-alternative*. However, since the MARELITT Baltic search methods may result in *medium* impacts for this habitat we recommend using non-invasive methods such as divers, ROV or sonar technology which result in a lower impact than the *zero-alternative*.

Potential impacts of bottom trawling

The impact score of abrasion due to bottom trawling is considered *high* for the Fucus/Furcellaria habitat. The bottom trawl implies a higher impact score than *search* and *retrieval* of ALDFG, because of the large size of the equipment and the wide swept areas. The weak presence of loose material that can resuspend in hard bottom habitats results in expected *medium* impacts due to siltation.

As previously discussed, bottom trawling is one of the main sources for the *introduction of litter* into the marine environment, although not as high as for the *zero-alternative*. The resulting impact in this EIA is considered as *medium* for all habitats given both medium sensitivity and medium magnitude of the effect for all assessed habitats (Sections 4.3 and 5.2). *Species extraction* due to bottom trawling on Fucus/Furcellaria habitats induces a *medium* impact, due to the combination of a medium effect (Section 4.4) with a low sensitivity (Section 5.3).

6.5 Habitat-forming species on hard bottom- Blue mussel beds

Table 16 below summarizes the impacts of ALDFG retrieval operations, the zero-alternative and commercial trawling activities for the habitat forming species Blue mussel (*Mytilus edulis*).

Table 16 Results from the EIA for Blue mussel bed habitat.

		Blue mussel bed			
		Abrasion	*Siltation*	*Introduction of marine litter*	*Species extraction*
Search	Light creeper	3	3		
	Heavy Creeper	6	3		
	Low impact supporting device	3	3		
	High impact supporting device	6	3		
Retrieval	Manual retrieval/winch				
	Diver				
Zero alternative	Leaving ALDFG in place			6	2
Trawling	Bottom trawl	9	3	4	3

Non-significant impact
Low impact
Medium impact
High Impact

Potential impacts of the search and retrieval of ALDFG

The impact scores for both siltation and abrasion are generally *medium*, due to the short nature of the exposure and a relatively high tolerance of mussel beds. However, the impact of abrasion is expected to be *high* when a heavy creeper and a high impact supporting device is used. This is because the dragging equipment will damage or detach larger parts of the mussel bed, and potentially damage the underlying surface structure. Blue mussels have a fast recovery rate as long as the substrate remains intact and they can reattach to the same surface (MARBIPP, 2001-2006).

Blue mussels have the ability to close their shells for a short time period and protect themselves from increased siltation. Conseqently blue mussels can withstand short exposures to resuspended sediments even when these are mostly composed of inorganic particles. However, they are sensitive to suspended sediment exposure for longer periods of time especially when the suspended sediment mostly consists of inorganic particles. Blue mussels are also sensitive to the presence of soft bottom material on hard bottom surfaces, which reduces their ability to attach to the hard surface. The impacts are evaluated as *medium* for all the different to all methods related to search and retrieval of ALDFG.

Potential impacts of the zero-alternative

The impact assessment indicates impact scores between *low* and *high* for the *zero-alternative* (not retrieving the ALDFG) on Blue mussel bed habitats. Marine litter on hard bottom substrate may cover hard surfaces where the blue mussel larvae can attach. However, marine litter can also create new surfaces where the mussels can attach. Leaving the ALDFG in place means both the *introduction of marine litter* into the marine environment and a high risk for *species extraction* (ghost fishing). Marine litter will have long lasting impacts due to a slow degradation into small particles that will spread into the environment and stay over many years. Blue mussels will also ingest these small plastic particles, which can have negative consequences on their health. The *introduction of marine litter* into Blue mussel beds is therefore considered to result in *high* impacts.

The extraction of species is also at risk of continuing for a long time (even though the catch efficiency will be reduced with time) if the ALDFG is not retrieved. However, the *species extraction* is not as high as for bottom trawling, which results in a low sensitivity for this habitat (Section 5.3). The final impact is therefore considered to be on a *low* level for the *zero-alternative*.

This implies that in general terms, the impacts of retrieving ALDFG on Blue mussel bed habitats with methods employed by MARELITT results in *medium* impacts. Using non-invasive methods, such as divers, ROV or sonar technology, results in lower impacts on Blue mussel beds than search and retrieval actions with creepers, hooks, or anchors. For blue mussel beds in particular, the risk of extraction of substantial parts of the mussel bed needs to be evaluated against the benefits of plastic litter removal and the risk of microplastics entering the food web through blue mussels as filter feeding organisms.

Potential impacts of bottom trawling

The impact of bottom trawling on Blue mussel beds is *high* for *abrasion*. Blue mussels have a low resistance to *abrasion* as they are easily damaged or detached by dragging equipment. However, a relatively fast recovery can be expected in areas with low bottom trawling activity. Nevertheless, abrasion due to a bottom trawl is considerable. This can be explained by a larger swept area which results in larger patches of the mussel bed being impacted, such that it will take longer time periods for the mussel bed to recover. An indirect impact is the reduced filtration rate of the whole population, which will sustain until the population has recovered.

Blue mussels can withstand a short exposure to increased siltation, if the frequency of the pressure remains low. As the amount of soft sediment that can be suspended in mussel beds is considered to be low given the sparse presence of soft material, the impact of siltation from bottom trawling is considered to be *medium*.

Together with other commercial fishing activities, *bottom trawling* is also one of the main sources for the *introduction of marine litter* into the marine environment (NLWKN, 2014). This results in *medium* impacts due to both medium sensitivity and medium magnitude of the effect for all assessed habitats (Sections 4.3 and 5.2). Finally, the magnitude of the effect related to *species extraction* by trawling is *high*, but the final impact on Blue mussel beds will be on a *medium* level due to the *low* sensitivity score as evaluated by HOLAS II (see chapter 2.2).

6.6 Reefs

Table 17 below summarizes the impacts of ALDFG *search* and *retrieval* operations, the *zero-alternative* and *bottom trawling* activities on reef habitats.

Table 17 Results from the EIA for Reef habitat.

		Reefs			
		Abrasion	*Siltation*	*Introduction of marine litter*	*Species extraction*
Search	Light creeper	3	3		
	Heavy Creeper	6	3		
	Low impact supporting device	3	3		
	High impact supporting device	6	3		
Retrieval	Manual retrieval/winch				
	Diver				
Zero alternative	Leaving ALDFG in place			6	4
Trawling	Bottom trawl	9	3	4	6

Non-significant impact
Low impact
Medium impact
High Impact

Potential impacts of the search and retrieval of ALDFG

The impact scores for *abrasion* are between *medium* and *high* levels for all search devices. The level increases with the increased weight and size of the equipment. Heavy creepers, high impact supporting devices and bottom trawls all result in high impacts on the reef. The impacts of *siltation* are evaluated as *medium* for all the different methods. This is due to the weak siltation effect on reefs caused by a sparse presence of soft material.

Potential impacts of the zero-alternative

The impact assessment indicates *medium* to *high* impact scores for the *zero-alternative* (not retrieving the ALDFG) on reef habitats. Marine litter on hard bottom substrates can cover hard surfaces where different organismswould normally attach. Marine litter can also create new surfaces where organisms can attach. Leaving the ALDFG in place means both the *introduction of marine litter* into the marine environment and a high risk for *species extraction* (ghost fishing). Marine litter will have a long lasting impact due to its slow degradation into small particles that will spread into the environment and stay for many years, related impacts are therefore considered to be *high*, especially in environments where filter-feeding organisms dominate. The extraction of species is also at risk of continuing for a long period of time (even though the catch efficiency will be reduced with time) if the ALDFG is not retrieved. However, the *species extraction* is not as high as for *bottom trawling* and therefore results in *medium* impacts.

To summarize, the impacts of retrieving ALDFG on Blue mussel bed habitats with methods employed by MARELITT Baltic are considered higher than the impacts resulting from the *zero-alternative*. Only non-invasive methods, such as divers, ROV or sonar technology will have lower impacts on reef habitats than methods assessed within this EIA.

Potential impacts of bottom trawling

The impact of *bottom trawling* on reef habitats is considered *high* due to *abrasion*. This is due to the large swept area from the bottom trawl. As the amount of soft sediments that can be suspended on reefs is considered to be low, given the sparse presence of soft material, bottom trawling is considered to result in a *medium* impact due to *siltation*.

Together with other commercial fishing activities, bottom trawling is also one of the main sources for the *introduction of marine litter* into the marine environment (NLWKN, 2014). Marine litter can cover areas and subsequently prevent light to reach the reef habitat in these areas. The resulting impact is considered to be *medium* due to both medium sensitivity and medium magnitude of the effect for all assessed habitats (Sections 4.3 and 5.2).

The impact of extraction of species on a reef habitat is evaluated as *high*, partly due to the large variety of species associated with reef habitats.

6.7 Wrecks

Table 18 below summarizes the impacts of ALDFG retrieval operations, the *zero-alternative* and commercial *bottom trawling* on wreck habitats.

Table 18 Results from the EIA for Wreck habitat.

		Wrecks			
		Artificial reef dammage	*Structure dammage (cultural value)*	*Introduction of marine litter*	*Species extraction*
Search	Light creeper	1	6		
	Heavy Creeper	2	9		
	Low impact supporting device	1	6		
	High impact supporting device	3	9		
Retrieval	Manual retrieval/winch	2	9		
	Diver	1	3		
Zero alternative	Leaving ALDFG in place			4	6
Trawling	Bottom trawl	3	9	4	6

Non-significant impact
Low impact
Medium impact
High Impact

Potential impacts of the search and retrieval of ALDFG

Even if searching for ALDFG on wreck habitats is usually not performed with creepers, but with hydroacoustic techniques or divers (as in the MARELITT Baltic project), the impacts of these search methods are evaluated here because not all wreck locations are known and heritage value may not be considered during search operations in other countries. *Siltation* and *abrasion* are not considered relevant effects on Wrecks. Instead the potential impacts of *structural damage* (cultural value) (Section 4.5) and damage on the wreck functioning as an artificial reef (Section 4.6) are evaluated.

The impacts caused by *artificial reef damage* during the ALDFG *search* phase increases with the size and weight of the equipment used. The high impact supporting devices will result in *medium* impacts, while the lighter and smaller equipment will result in *low* impacts. Both types of equipment evaluated for the *retrieval* phase yield *low* level impacts. The impacts on the cultural value during both the *search* and *retrieval* phases are considered *high* for all methods, except for *retrieval* by a diver. The *retrieval* of ALDFG by a diver is considered as a *medium* impact method, due to the high sensitivity of the structural value (cultural value). This emphasises the importance of using professional divers trained to retrieve ALDFG from wreck habitats. However, impacts from retrieval operations on wrecks are much lower when a controlled method, such as a diver, is used compared to an uncontrolled method, such as retrieving the ALDFG with a hook or anchor (with or without a winch). As a result, diver controlled retrieval on wrecks is the only method recommended, and is the only method used within the MARELITT Baltic project.

During the search for ALDFG, the impact on the artificial reef structure is considered *low* for most methods, except for high impact supporting devices, which result in a *medium* impact. The sensitivity with respect to *artificial reef damage* is considered to be *low* and the differences in impacts between the evaluated *search* and *retrieval* methods are therefore a reflection of the magnitude of the effect. A *high* magnitude effect would be expected for high impact supporting devices and a *medium* magnitude for a heavy creeper (Section 4.6). It is important to note that specific caution should be taken for each retrieval operation performed on wrecks if the net is overgrown (see Section 8.1.8).

Potential impacts of the zero-alternative

The impact assessment indicates impacts between *medium* and *high* for the *zero-alternative* (not retrieving the ALDFG) on wreck habitats. Leaving the ALDFG in place means both *introduction of marine litter* into the marine environment and a high risk for *species extraction* (ghost net fishing). The risk of ghost fishing is especially high in this habitat, since artificial structures such as wrecks are hotspots for biodiversity. ALDFG entangled in wrecks could have a high fishing capacity given its position in the water column. The high impact score indicates that retrieval of the ALDFG is better for this habitat. But removing an ALDFG may reduce structural complexity of the wreck, especially if the ALDFG is overgrown. These cases should be evaluated individually (see Section 4.6) and are described further in Section 8.1.8.

The evaluation of the retrieval methods implies that in general terms, benefits of retrieving ALDFG on wrecks with methods employed by MARELITT Baltic outweigh the negative impacts caused by the retrieval operations with divers and other non-invasive methods. However, this result should be used with caution, as these results are only valid for wrecks that are confirmed as not being of cultural heritage value.

Potential impacts of bottom trawling

The impacts of *bottom trawling* on wrecks are considered *high*, as for the *zero-alternative*, when it comes to the introduction of litter into the marine environment. Together with other commercial fishing activities, *bottom trawling* is also one of the main sources for *introduction of marine litter* into the marine environment (NLWKN, 2014) and the impacts are considered as *medium* due to equally medium sensitivity and magnitude of the effect for all assessed habitats (Sections 4.3 and 5.2). However, bottom trawling close to a wreck habitat may damage the trawl and *introduce marine litter* into the environment, but on a lower extent compared to the *zero-alternative*.

The impact on cultural heritage from *bottom trawling* close to the wrecks is evaluated as *high*, implying that the impact of *structural damage* is *high*. The impact of the extraction of species on a wreck is also considered to be *high*. This is primarily because an artificial reef consists of a large variety of species, which may result in extraction of a variety of species.

6.8 Baltic Ecosystem

Table 19 below summarizes the impacts of the *zero-alternative* and *bottom trawling* activities for the Baltic Ecosystem.

Table 19 Results from the EIA for Baltic Ecosystem.

		Baltic Ecosystem	
		Introduction of marine litter	*Species extraction*
Search	Light creeper		
	Heavy Creeper		
	Low impact supporting device		
	High impact supporting device		
Retrieval	Manual retrieval/winch		
	Diver		
Zero alternative	Leaving ALDFG in place	9	6
Trawling	Bottom trawl	6	9

Non-significant impact
Low impact
Medium impact
High Impact

Potential impacts of the zero-alternative

The impact assessment indicates a *high* impact for the *zero-alternative* (not retrieving the ALDFG) on the Baltic Ecosystem as a whole. Leaving all ALDFG in place means both the *introduction of marine litter* into the marine environment and a high risk for *species extraction* (ghost fishing) until all ALDFG is disintegrated. The *introduction of marine litter* will induce a *high* impact on the ecosystem due to the persistence of the microplastics that can spread throughout the whole ecosystem. Impacts related to *species extraction* are lower than in the case of bottom trawling but still result in a *high* impact due to the high sensitivity of the Baltic Sea ecosystem with respect to *species extraction* on an ecosystem level.

Potential impacts of bottom trawling

The impacts of bottom trawling deduced for *species extraction* and the *introduction of marine litter* are *high* on an ecosystem level. Even though the effect with respect to the introduction of marine litter is estimated to be lower than for the *zero-alternative*, the final impacts are still *high* due to the high sensitivity of the Baltic Ecosystem associated with this effect, as explained in chapter 5. *Bottom trawling* results in a *high* impact on the Baltic Ecosystem due to a combination of a high magnitude of the effect (chapter 4) and a low tolerance of the ecosystem.

7 Summary and conclusion

7.1 Potential impacts of the MARELITT Baltic retrieval operations

The environmental impacts are based on a combination of pressures (effects) on the natural environment and the sensitivity of the receiving environment. The resulting impacts are presented in Chapter 6, while the effects and sensitivity for ALDFG retrieval operations are described in Chapters 4 and 5 respectively. It is important to note that this EIA aims to be used on a strategic level, meaning that it aims to give guidelines in planning and decision-making. The impact assessments are consequently based on general assumptions of effects and sensitivity. This simplification implies that planning also requires knowledge on the local level and on a case-by-case basis.

Regarding effects, *abrasion* (creepers and supporting devices affecting and potentially damaging the bottom) and *siltation* (resuspension and sedimentation of particles during retrieval operations) result in non-negligible impacts on the assessed seafloor habitats. The estimation of the magnitude of each effect is based on the size, design and the weight of the equipment. However, the relevance of the effects also depends on the bottom type. For example on hard bottom habitats (photic and non-photic), *siltation* is not considered a relevant effect (Section 4.2). Considering that ALDFG retrieval operations are normally a one-time event in an area and affect a relatively small geographic surface, the magnitude of effects for MARELITT Baltic search and retrieval operations are in general estimated to be *low*. However, the habitat-forming species represent an exception as *abrasion* on reefs, Fucus/Furcellaria and Blue mussel habitats is thought to result in a *medium*-magnitude effect, and a *high*-magnitude effect is expected for abrasion on Eelgrass/Charophyte habitats. These mentioned effects represent ALDFG *searches* with light creepers (see Chapter 3), which include those used in MARELITT Baltic operations. By comparison, heavier creepers or high impact support devices (not used by MARELITT Baltic) are thought to result in effects of *medium* to *high* magnitude.

Hence, effects related to MARELITT Baltic operations are generally considered to be of a *low* magnitude with some exceptions. The sensitivity (*tolerance* combined with *recovery rate*) of the receiving habitat however vary between low and high for different effects. The combined HOLAS II sensitivity score (Section 5.1) for siltation/abrasion is *medium* for broad-scale habitats and *high* for habitat-forming species. The sensitivity of a habitat increases with the increased biological value of an area, which explains why the areas with habitat-forming species have the highest sensitivity score.

Combining effect with sensitivity, the resulting impact due to *siltation* and *abrasion* from MARELITT Baltic operations is *low* on broad-scale habitats, and *medium* to *high* for habitat-forming species.

When it comes to ALDFG retrieval operations on, or close to, wrecks, the loss of cultural value due to potential damage to structures is the main potential impact. Indirectly, *structural damage* also implies a potential impact on biological diversity as wrecks often function as artificial reef habitats. However, the potential impact corresponding to the loss of cultural value is estimated to be higher (Section 6.7).

To enable a comparison between impacts caused with the different methods used during ALDFG *search* and *retrieval*, as well as impacts for the *zero-alternative* and *bottom trawling*, the highest impact is presented for each of the assessed activities and habitats in Table 20 Highest expected impact per activity on assessed habitats. Accordingly, MARELITT Baltic search operations are estimated to induce *low* to *high* impacts, where *high* impacts are expected on Eelgrass/Charophyte habitats, *medium* impacts on other habitat-forming species and *low* impacts on broad-scale habitats such as soft sediments or general hard-bottom habitats. High potential impacts are also expected from search operations with creepers if these are performed close to wrecks (known or unknown). It should be noted that MARELITT directed search operations on Wrecks are only performed with non-invasive methods (diver, acoustic methods). Impacts due to the *retrieval* phase on soft or hard bottom habitats and biotopes are considered negligible.

On wrecks, a retrieval operation with divers is estimated to induce a *medium* level impact, while a non-controlled retrieval with an anchor or hook induces high risks of damage to the wreck and hence may result in a *high* impact. It is important to notice however that this assumes that the wreck has a cultural value, as damage to the wreck otherwise is considered negligible from a cultural perspective. The evaluated *medium* impact for diver controlled retrieval operations may seem high; it is a result of the *high* sensitivity value given to Wrecks (Section 5.4) combined with a *low* magnitude of the effect (Section 4.5). This is a case where each operation needs to be planned according to the specific knowledge of the wreck where the retrieval operation will take place. In many cases, the damage to the wreck may be insignificant, which would then result in a negligible impact on its cultural value. Nevertheless, the German cultural heritage authorities have raised awareness of the possible situations where ALDFG help keeping wrecks together (personal comment MARELITT Baltic partner). Retrieving the ALDFG may consequently injure parts of the wreck, which will cause a loss of the archeological value. This can happen even if professional divers are employed to cut off ALDFG carefully without using any mechanical device for retrieval.

Employing a heavy search device, not adapted to the water depth, may result in impacts on both ecological and cultural values. This type of equipment will induce impacts similar to those expected from commercial bottom trawling (see Section 7.3). It is only on hard bottom habitats (photic and non-photic) where impacts from this type of activity are not considered to be high.

Table 20 Highest expected impact per activity on assessed habitats.
"MARELITT Baltic Search" corresponds to the searching method used in MARELITT Baltic search operations (light creeper with low impact supporting device), whereas „MARELITT Baltic retrieval operations" are divided and separated in retrieval performed with a hook (or anchor) and retrieval operations only with divers. Other hypothetical search methods (methods not used by MARELITT Baltic) include the use of a heavy creeper and a high-impact supporting device. For all the methods the weight of the equipment should be adapted to the water depth where the search is performed in order to minimize the impacts. Retrieval was only evaluated for habitats were non-negligible impacts are expected.

Phase	Search phase		Retrieval phase			
Habitat	MARELITT search	Heavy creeper / High impact supporting device	Retrieval with Hook/ anchor	Retrieval with diver	Zero alternative	Bottom trawling
Photic sand	Low impact	High Impact	No impact/Not relevant	No impact/Not relevant	High Impact	High Impact
Photic mud and clay	Low impact	High Impact	No impact/Not relevant	No impact/Not relevant	High Impact	High Impact
Photic hard bottom	Low impact	Medium impact	No impact/Not relevant	No impact/Not relevant	High Impact	High Impact
Photic mixed bottom	Low impact	High Impact	No impact/Not relevant	No impact/Not relevant	High Impact	High Impact
Non photic sand	Low impact	High Impact	No impact/Not relevant	No impact/Not relevant	High Impact	High Impact
Non photic mud and clay	Low impact	High Impact	No impact/Not relevant	No impact/Not relevant	High Impact	High Impact
Non photic hard bottom	Low impact	Medium impact	No impact/Not relevant	No impact/Not relevant	High Impact	High Impact
Non photic mixed bottom	Low impact	High Impact	No impact/Not relevant	No impact/Not relevant	High Impact	High Impact
Blue mussel bed	Medium impact	High Impact	No impact/Not relevant	No impact/Not relevant	High Impact	High Impact
Eelgrass/Charophyte	High Impact	High Impact	No impact/Not relevant	No impact/Not relevant	High Impact	High Impact
Fucus/Furcellaria	Medium impact	High Impact	No impact/Not relevant	No impact/Not relevant	High Impact	High Impact
Reefs	Medium impact	High Impact	No impact/Not relevant	No impact/Not relevant	High Impact	High Impact
Wreck	High Impact	High Impact	High Impact	Medium impact	High Impact	High Impact
Baltic Ecosystem	No impact/Not relevant	No impact/Not relevant	No impact/Not relevant	No impact/Not relevant	High Impact	High Impact

No impact/Not relevant
Low impact
Medium impact
High Impact

7.2 Potential impacts of the zero-alternative

The assessment indicates that the impacts due to the *zero-alternative* (not retrieving the ALDFG) are *high* for all assessed habitats (Table 20). Leaving the ALDFG in place means both, *introduction of marine litter* into the marine environment and a potentially high impact on the Baltic ecosystem as a whole caused by *species extraction* (ghost fishing). This implies that in general terms, there are large benefits from retrieving ALDFG, since search and retrieval operations with methods employed by MARELITT Baltic result in lower impacts than the negative impacts caused by the *zero-alternative*. This is especially true as the *zero-alternative* induces impacts that are expected to reach over the habitat boundary, thus potentially affecting the Baltic Ecosystem on a broader scale. Only when performing MARELITT Baltic search and retrieval operations on habitat-forming species and wreck habitats (*medium* to *high* impacts), impact levels are comparable to those estimated for the *zero-alternative*. Care should be taken when planning ALDFG operations on these habitats (especially with invasive search methods) as in some cases it may be better to leave the ALDFG in place (see Table 20).

7.3 Potential impacts of bottom trawling

Bottom trawling implies several pressures on the assessed habitats that induce *medium* to *high* impacts (see Chapter 6). For soft- and hard bottom habitats, these include *high* potential impacts from *abrasion* and *siltation*. Physical disturbance of the seafloor (siltation and abrasion) caused by trawling is highly problematic to marine ecosystems (Section 1.2.3), and leads to high impacts. In addition, bottom trawling (together with other commercial fishing activities) is a source for the *introduction of marine litter* into the marine environment that is estimated to result in *medium* impacts. The higher impact from trawling activities compared to ALDFG search operations is explained by the larger swept area and the deeper penetration depth of the trawl in the sediments than for the different ALDFG search devices (Section 1.2.3).

The results indicate that similar levels of impacts are expected from using high-impact supporting devices during the *search* phase as from *bottom trawling* (Table 19). This is due to the fact that the swept area is assumed similar for bottom trawling and high impact supporting devices. However, the frequency of disturbance by bottom trawling (as a repeated event) has not been considered in this EIA. If the frequency of *bottom trawling* would be added to the comparison, the difference in impact level would be higher than suggested by the results in this EIA.

On the Baltic ecosystem level, bottom trawling results in high impacts from *species extraction* because of the large amount of species and individual organisms which are removed from the ecosystem, resulting in different cascading impacts on the whole ecosystem. The assessment indicates that the impacts from *species extraction* of the *zero-alternative* (ghost fishing) are in general lower (*low* to *medium*) than impacts related to species extraction due to bottom trawling (*medium* to *high* impact) for the assessed habitats. This is due to the reduced catch-efficiency of ghost fishing over time (20% loss of efficiency during the first 3 months, Tschernij & Larsson, 2003).

7.4 Methodological issues

As in all EIAs, generalizations and simplifications of the reality have been made as complex interactions between natural phenomena and anthropogenic pressures have been translated into qualitative or semi-quantitative numbers. One such simplification is the 3-grade scale used for rating both sensitivity and effects. The generalizations imply that more detailed and local information is lost. This is non-avoidable when dealing with a biogeographic region as extensive and complex as the Baltic Sea.

Another simplification is the classification of habitats. In this EIA, classification is based on the HELCOM HOLAS II survey (with some modification, see Section 2.1) and 16 habitats are considered. Assessment of a greater number of habitats would not be suitable for an EIA at the present level. Nevertheless, the grouping of the Baltic environment habitats into the assessed habitats results in a simplification of the results obtained. For planning ALDFG retrieval operations, knowledge of the *specific area* where the operation will take place is crucial and should not be replaced by this EIA.

The sensitivity scores used in the EIA are also subject to a methodological limit. As far as possible, these scores were taken from HELCOM HOLAS II (Section 2.4), where scores were determined by external experts (see Section 2.2). Two main issues with the use of HOLAS II sensitivity scores are addressed below.

First, HOLAS II combines sensitivity scores for abrasion and siltation into one single category named *physical disturbance*. However, within this EIA it was considered important to separate the effects *siltation* and *abrasion* in order to highlight the difference in their nature and in the resulting impacts; for some habitats only one of these effects is relevant, which will only be evident when separating these effects. Using the same sensitivity score for both effects hence induces a slight methodological error as it neglects the underlying difference in sensitivity to these pressures (sensitivity to either one or the other of the effects may therefore be over-estimated).

Additionally, only individual effects are used when determining the sensitivity score and cumulative effects on the ecosystem level were not considered during HOLAS II. For example, the sensitivity score presented in HOLAS II for species extraction is given for three fish species including bycatch and varies between *low* and *medium* (Section 5.3). The HOLAS II sensitivity scores are limited to three commercial species and the scores may represent an underestimation in habitats where fishing of these commercial species does not commonly occur. Many studies have shown that species extraction is a major problem related to the ecosystem health of the Baltic marine environment and other ecosystem functions. This perspective does not seem to be reflected in the scores presented by HOLAS II, which are specifically set for a sensitivity for specific habitats (compared to the importance of the pressure in an ecosystem perspective of the Baltic Sea). To remediate for this issue, we have included a broader-scale "generalized" habitat named Baltic Ecosystem. Hence, this permitted us to relate the species extraction to the ecosystem health in a wider perspective and include species that are not of commercial interest in the consideration.

Despite these limitations related to the use of HOLAS II sensitivity scores, it is considered that they contribute to a better assessment than any other evaluation that could have been made within the limits of this study. A wider and much more costly external expert-evaluation of habitat sensitivity could not be included in the framework of this EIA for budget reasons.

7.5 Conclusions

This EIA treats potential impacts of ALDFG operations that have been classified into methods, phases and equipment used (Chapter 3). The assessment of impacts is based on an estimation of the magnitude of the effects on the physical environment caused by the ALDFG retrieval operations and on the sensitivity of the receiving environment. The receiving environment is classified into different habitats that have sensitivity scores related to the assessed effects. The impact assessment has been carried out on 16 distinctive and typical Baltic seafloor habitats and for Wrecks as a unique habitat. A more general habitat "*Baltic Ecosystem*" has also been included to make it possible to assess impacts on a higher level, outside the 15 more specific habitats. The effects and sensitivity are described in Chapter 4 and 5 respectively, while the resulting impacts are presented in Chapter 6 and discussed earlier in this Chapter.

Effects on the natural bottom habitats relevant to MARELITT Baltic ALDFG *search* and *retrieval* operations were delimited to *abrasion* and *siltation*. On Wreck habitats, relevant effects are *structural damage (cultural value)* and *artificial reef damage*. Potential impacts of the MARELITT Baltic search phase vary between *low* and *high* depending on the habitat type. Potential *high* impacts can be expected on Eelgrass/Charophyte habitats, *medium* impacts on other habitat-forming species as well as on reefs, and *low* impacts are expected on broad-scale habitats (Photic and Non-photic soft bottom, hard bottom and mixed bottom). Potential impacts of the *retrieval* phase on all assessed natural habitats are estimated to be negligible.

Impacts on Wrecks are potentially *high* when search operations are performed close to wrecks (specifically non-documented wrecks). It should be pointed out that MARELITT Baltic directed *search* operations on Wrecks are only performed with non-invasive methods (diver and/or acoustic methods), and no impacts from the search phase are expected for those non-invasive methods. A non-controlled method used during the *retrieval* phase on a Wreck habitat (with an anchor or hook) will be associated with possible damage and hence a *high* potential impact associated with loss of cultural value. We expect that retrieval of ALDFG on Wrecks, even when only divers are used, is still associated with a *potential* medium impact: the sensitivity is considered *high* as every wreck can potentially represent a cultural heritage that will never be restored to its former (before damage) state. In this context, it is important to note that estimated impacts for Wrecks assume a cultural value. All wrecks may have a historical value and are important to preserve until authorities have been informed and have determined the status of preservation and the associated precautionary methods to be used. Retrieval operations should therefore be carefully planned on these habitats.

It is important to question if the retrieval of ALDFG is better to be avoided for certain habitats or in certain circumstances. In fact, this question should always be central in planning both for the search and retrieval operations and we hope this EIA can support relevant decisions. To support decision-making, we suggest planners to read and understand in particular Chapter 8 (Good environmental practices).

The impact assessment indicates that the impact for the *zero-alternative* (not retrieving ALDFG) is *high* for all assessed habitats (Table 20). Leaving the ALDFG in place means both *introduction of marine litter* into the marine environment and potential impacts on the ecosystem due to *species extraction* (ghost fishing). This implies that in general terms, the benefits of retrieving ALDFG on bottoms with methods employed by MARELITT Baltic outweigh the negative impacts caused by the retrieval operations for most of the evaluated habitats. In other words, MARELITT Baltic ALDFG operations are creating net benefits for the marine environment. However, Eelgrass/Charophytes habitat is an exception as search operations on this sensitive habitat may result in considerable damage and consequently a *high* potential impact. ALDFG search operations may also better be avoided in areas dominated by other important habitat-forming species or known Reef habitats. It is recommended that only non-invasive search methods are used on these habitats (such as diver or hydro acoustic search methods), although localization of ALDFG with hydro-acoustic techniques has proven to be difficult (examples from Germany, see Section 3.1.2). In order to minimize impacts from future ALDFG operations, hydro-acoustic search methods should be further assessed.

Impacts of ALDFG operations have been compared to impacts of conventional bottom trawling activities carried out in the Baltic Sea, to enable a comparison with other anthropogenic pressures with similar effects. Interpretation of what a *low*, *medium* or *high* impact means to the marine environment can be clearly subjective if no such perspective is given. This EIA shows that *bottom trawling* activities are creating a higher pressure on the bottom habitats than MARELITT Baltic retrieval operations. However, the frequency of disturbance by bottom trawling (as a repeated event) has not been considered in this EIA. If the frequency of *bottom trawling* would be added to the comparison, the difference in impact level would be higher than suggested by the results in this EIA.

8 Good environmental practice and recommendations

The aim of this chapteris to serve as a guideline for basic considerations in planning and performing ALDFG retrieval operations in the Baltic Sea. It is important to address that while this EIA is aimed to be used on a strategic level, planning requires knowledge on the local level.

In this chapter important effects and problems that are relevant for an operation but are not considered within the EIA are highlighted and should also be included in the planning. These issues have not been considered in the EIA as they are considered relevant for a limited number of sites and would accordingly not give a balanced assessment where general assumptions on the Baltic Sea and retrieval operations are in focus. Listed in the following sections are special cases/problems/situations and associated factors that increase the impacts on the environment.

8.1 Specific considerations and recommendations

8.1.1 Non-invasive search methods (hydro-acoustic search methods such as side scan sonar (SSS) and multi-beam sonar (MBS))

With the continuous improvements of seabed mapping technology (SSS and MBS, see Section 3.1.2) sonars have become one of the major means of marine prospection, and are now used for various hydrographic surveys and marine environment resources investigations etc. This equipment requires highly trained staff and high investment costs, but offers a non-invasive way of searching for ALDFG on the seafloor. However, it will add an additional source of underwater noise (see Section 3.1.2).

Within the MARELITT Baltic project tests have been performed during search operations using sonar and other hydro-acoustic methods but have not resulted in localization of ALDFG with known positions. Sonar data might help to reduce the area where a blind search will be performed and consequently, impacts associated with the search of ALDFG can be avoided to some degree. However, sonars are likely to be more applicable for relatively large or readily distinguishable items such as pots or traps, while gillnets might be hard to distinguish from other marine features (such as schools of fish). The use of sonars is limited and has proven to be difficult or even unsuccessful (see Section 3.1.2). Nevertheless, identification of ALDFG such as gillnets also depends on the specific parameter tuning of the sonars for these kinds of objects, a tuning that will not be the same as that used for seabed mapping itself. More research and development is needed in this field.

RECOMMENDATIONS:

- **Continued R&D focused on the use of sonars and other hydro-acoustic methods for the search for ALDFG, as well as for data acquisition on already identified ALDFG.**

8.1.2 Red listed habitats and other sensitive habitats

The search for ALDFG with creepers on benthic red-listed habitats and other sensitive habitats should be avoided, or at least carefully planned and authorized by relevant authorities. As for the retrieval of ALDFG on these habitats, only diver controlled operations are recommended.

An assessment of the red listed marine habitats of the Baltic Sea has been produced by HELCOM (BSEP 138, 2013). The results of the assessment indicate that many of the threatened biotopes occur in the deep areas of the Baltic Sea. Many of the deep biotopes occurring on soft sediments have declined due to destructive fishing methods such as bottom trawling (HELCOM, 2013). Furthermore, many of the red-listed biotopes occur in the southwestern Baltic Sea due to the salinity-restricted distribution of the species that are characteristic of these biotopes.

According to the assessment, data availability on these biotopes is relatively poor and historical data on the distribution of these biotopes are generally lacking. This implies that red-listed habitats might occur in locations not yet identified and care should be taken when planning search operations with invasive methods in areas where these habitats are suspected to occur.

However, if commercial trawling activities are permitted and occur throughout the area where the ALDFG retrieval operations are planned, no specific consideration for sensitive or red-listed benthic habitats is necessary when planning for ALDFG search, as impacts from bottom trawling activities will be higher.

RECOMMENDATIONS:

- **Verify if commercial trawling is permitted throughout the zone where ALDFG operations are planned.**
- **Search of ALDFG with creepers on benthic red-listed habitats and other sensitive habitats should be avoided, or at least carefully planned and authorized by relevant authorities.**
- **Perform only diver controlled operations for retrieval of ALDFG on benthic red-listed habitats and other sensitive habitats.**

8.1.3 Spawning areas

The most sensitive life-stages for many marine organisms are eggs and larvae. During these early life stages, many species are highly sensitive to environmental pressures, such as increased concentrations of suspended sediment particles, which can reduce the survival rate drastically (Westerberg , et al., 1996). In Sweden, all activities that can cause resuspension of sediments are limited to certain times of the year (often banned between 1st of April and 31st of August). However, spawning and nursery periods vary between areas, and sensitivity to different pressures is species-specific. The MARELITT Baltic ALDFG retrieval operations are not expected to cause a high rate of resuspension. Nevertheless, spawning areas and nursery grounds should be considered during the planning phase of ALDFG retrieval. Both the *search* and *retrieval* phase in highly sensitive areas should better be carried out outside such sensitive periods, especially if a more intense searching operation is planned.

RECOMMENDATIONS:

- **Determine if the search area is a known or probable spawning or nursery ground.**
- **Determine dates for the sensitive period and avoid search operations during this period.**

8.1.4 Weight of the creeper

The weight of the creeper determines how deeply the creeper will dig into the sediment surface (see Chapter 3). The deeper down into the sediment the creeper digs, and the larger the area it disturbs, the more sediment will be suspended and the more organisms will be eroded from the affected area. The weight of the creeper needs to be adapted to the depth where the search will be performed. If the creeper is too light, the search will be performed with very low efficiency due to the small contact area between the creeper and the seafloor. During a planned ALDFG search, a light contact between the creeper and the bottom should be aimed for in order to have good chances of hooking into the ALDFG laying on the seafloor whilst also reducing the impacts on the bottom habitat.

RECOMMENDATIONS:

- **Adjust the weight of the creeper to the water depth where the search will be performed and to the vessel speed in order to have a light contact between the creeper and the bottom.**

8.1.5 Speed during search

The speed should be adjusted to equipment, habitat and creeper design in order to maximize the efficiency of the search for ALDFG. If the speed is too high, the contact between the creeper and the bottom surface is reduced due to the uncontrolled movements of the creeper. In general, a low speed augments the chances for the creeper to follow the bottom structures of the seafloor with less impact on the bottom structures. By using a higher speed the chances of tearing the ALDFG is larger when the creeper hooks inside the ALDFG. Within MARELITT Baltic, a towing speed of 1-1.5 knots is recommended.

RECOMMENDATIONS:

- **Adjust the speed of the vessel to the water depth where the search will be performed and to the weight of the creeper in order to have a light contact between the creeper and the bottom.**

8.1.6 Ammunition

There are many dumpsites in the Baltic Sea, where ammunition was dumped after World War II. Due to bottom trawling in these areas ammunition has been spread to other areas and can therefore also be found outside known dumpsites. The ammunition can be a threat to both the crew and the environment if the chemicals start leaking. Traces of chemical warfare agents have been found in shellfish and fish living close to dumpsites (Tengberg, et al., 2016).

Searches on dumpsites should be performed with caution and preferably without any bottom contacting equipment (hydro-acoustic search methods should be preferred). Any hit on containers/shells of the ammunition can result in leakage of the chemical agent to the surrounding environment. The chemical warfare agent that is most studied is mustard gas, which is among the chemicals dumped in the Baltic Sea. Mustard gas was shown to have toxicological effects on both human and aquatic organisms. Even if mustard gas is highly soluble, a short exposure can have very serious effects. Even controlled retrieval of ALDFG with divers on dumpsites should be avoided. Because of the potentially numerous unknown ammunition locations, supplementary precautions and consultation with relevant government authorities should be carried out prior to ALDFG retrieval actions in the Baltic Sea.

RECOMMENDATIONS:

- **Consultation with relevant government authorities should always be carried out prior to ALDFG retrieval actions in the Baltic Sea in order to identify potential dumpsites.**
- **Search on dumpsites should be performed with caution and preferably without any bottom contacting equipment (hydro-acoustic search methods should be preferred).**
- **Retrieval of ALDFG on dumpsites, even with divers, should be avoided.**

8.1.7 Retrieval on wrecks with hazardous substances

Wrecks will sometimes contain hazardous substances such as petroleum products that can be residues of fuel or of freight. In some cases, hazardous substances such as crude oil from oil spills can be accumulated near wrecks. In such situations communication with relevant government authorities should be the first step before performing retrieval operations and gather relevant information about the wreck. Such information is important during the evaluation of possible risks involved during both search and retrieval.

RECOMMENDATIONS:

- **Consultation with relevant government authorities should always be carried out prior to ALDFG retrieval actions on wrecks in order to identify risk of hazardous substances.**

8.1.8 Overgrown nets

ALDFG fishing efficiency will decrease with time and in some circumstances, nets and ropes will be overgrown with marine organisms and start to function as an artificial reef with a more or less high biological diversity. When ALDFGs are planned to be retrieved, the value of the ALDFG as an artificial reef should be evaluated before retrieval takes place. If fishing capacity is low and biological diversity can be considered augmented by the presence of the ALDFG, it should be considered if the benefits of leaving the ALDFG in place outweighs the benefits of the retrieval. If these questions arise in planning for a retrieval, it is possible that the retrieval of the specific ALDFG should not be considered a priority.

RECOMMENDATIONS:

- **Prior to retrieval, necessary documentation of ALDFG should be collected in the field. Results should conclude in an evaluation of its fishing capacity and biological reef capacity.**
- **Determine if benefits from retrieval is clearly advantageous compared to leaving ALDFG in place.**

8.1.9 Priority list of ALDFG retrieval spots

In hotspot areas or on wrecks, where there may be a high density of ALDFG, prioritizing which ALDFG to retrieve may be needed. In some cases it is not possible to retrieve all ALDFG and some information concerning their conditions can be helpful in order to make the priority list. Information concerning the following points can be included and can be important in making the prioritization:

- Fishing-capacity

  If one of several ALDFG has a very high fishing capacity, this ALDFG should be retrieved first. In some situations, which is within this EIA regarded as a special case, the ALDFG can be buried in the sediment and therefore has a fishing capacity of zero. Such an ALDFG should be considered being left in place, if no other factor is promoting its retrieval.

- Overgrown nets

  If an ALDFG functions as an artificial reef and is overgrown with a high number of organisms, it should be considered being left in place, if no other factor is promoting its retrieval.

- Material

Fishing nets are made of different quality materials. Professional fishermen usually have high quality nets made with strong, expensive materials which are therefore important for the fishermen to retrieve. However, in recreational fishery cheaper material is used. These materials easily get destroyed and do not induce a high economical loss. The polymer material used in nets contributes to the spreading of macro- and microplastics. Such synthetic fibers will remain in the environment for a long time, due to their low degradation rate. Retrieval should therefore be considered for synthetic nets. Nets can also be made of natural fibers that will degrade within a few years at the longest. It is therefore less important to retrieve nets made of natural fibers. The biodegradable nets are however much more expensive than synthetic nets and thus the use of them is very limited today.

- Sensitivity

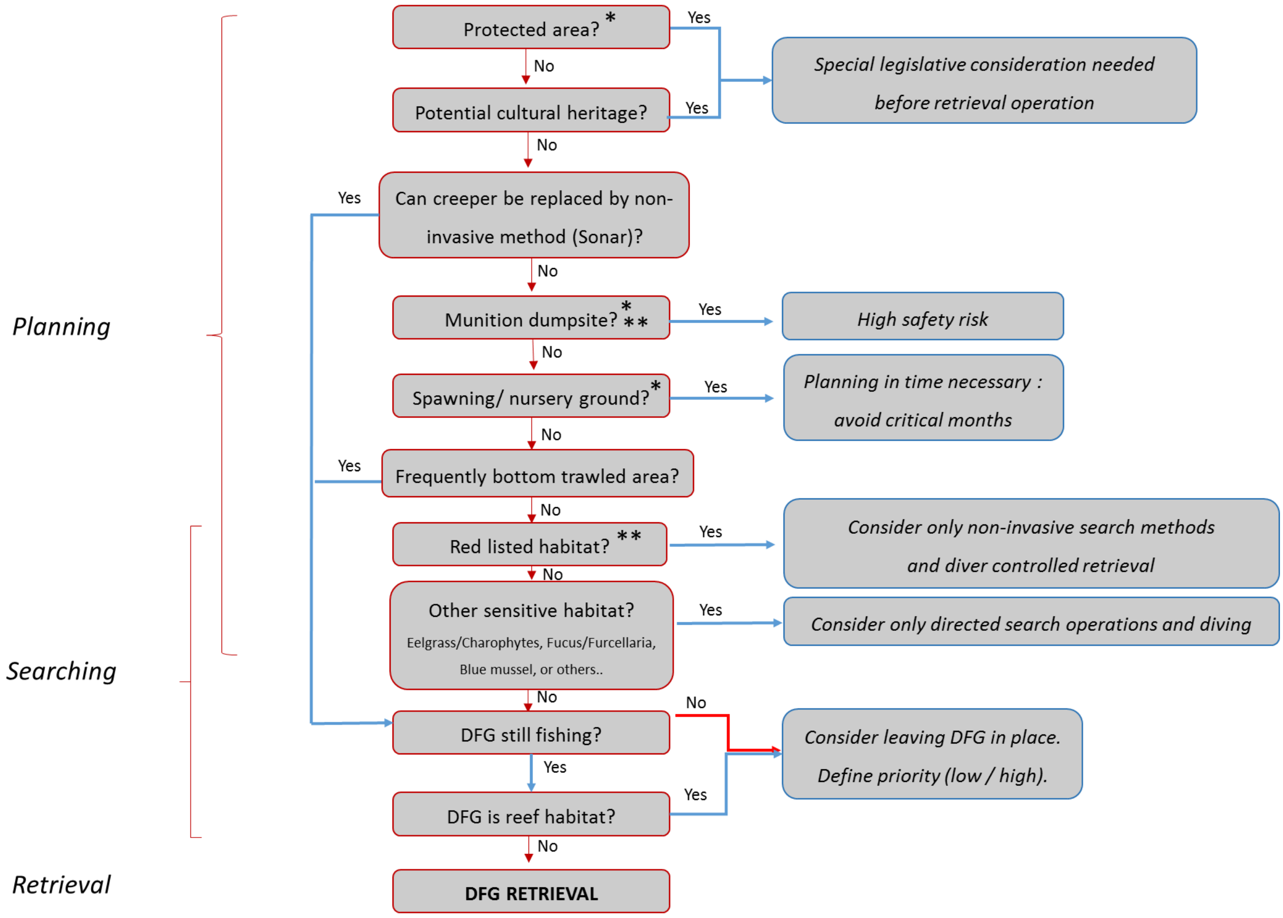
If the retrieval will take place in a sensitive area and the environmental impact assessment indicates a high impact, the ALDFG should be considered being left in place.

RECOMMENDATIONS:

- **Use priority lists for planning of ALDFG retrieval, where collected data on fishing capacity, artificial reef capacity, material of ALDFG and sensitivity of the location are weighed together in order to determine priority.**

8.2 Decision tree

A decision tree has been constructed to be used during both the *planning* and the *search* phase. The decision tree highlights some of the problems that are relevant before performing a retrieval operation. An evaluation according to good environmental practice depends on detailed information about the specific area where an operation is planned.



*spatial information is available from HELCOM. For spawning sites only information regarding cod is available, but local environmental authorities or fishermen can have other information available.

** information available in HELCOM, 2013. Red List of Baltic Sea underwater biotopes, habitats and biotope complexes. BSEP No. 138.

Figure 19 Decision tree for planning of an ALDFG retrieval operation (search and retrieval phase).

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Appendix 1

Additional information to Tabel 11 p 51.

Conversion key for the sensitivity scores presented in HOLAS II for the sensitivity scores for different effects related to different habitats used within this EIA. The presented sensitivity scores were converted to a 3-grade scale level shown below. The scores converted to the 3-grade scale was used within this EIA.

Habitat	*Abrasion*	*Siltation*	*Introduction marine litter **	*Species extraction*	*Artificial reef dammage **	*Structure dammage (cultural value) **
Photic Sand	1,2	1,2	1,0	0,3	*na*	*na*
Photic Mud and Clay	1,1	1,1	1,0	0,3	*na*	*na*
Photic Hard bottom	1,3	na	1,0	0,6	*na*	*na*
Photic Mixed bottom	1,2	1,2	1,0	0,4	*na*	*na*
Non-Photic Sand	1,1	1,1	1,0	0,3	*na*	*na*
Non Photic Mud and Clay	1,0	1,0	1,0	0,6	*na*	*na*
Non photic Hard bottom	1,3	na	1,0	0,8	*na*	*na*
Non photic Mixed bottom	1,1	1,1	1,0	0,6	*na*	*na*
Blue mussel bed	1,6	1,6	1,0	0,4	*na*	*na*
Eelgrass/Charophytes	1,9	1,9	1,0	0,9	*na*	*na*
Fucus/Furcellaria	1,7	1,7	1,0	0,6	*na*	*na*
Reefs	1,6	1,6	1,0	0,9	*na*	*na*
Wreck*	na	na	1,0	1,0	0,6	2,0
Baltic Ecosystem	na	na	2,0	2,0	na	na

Scores HOLAS II	Sensitivity score EIA
0-0,7	1 (Low)
0,7-1,3	2 (Medium)
1,3-2	3 (High)

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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

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