SEA-BASED PRESSURES

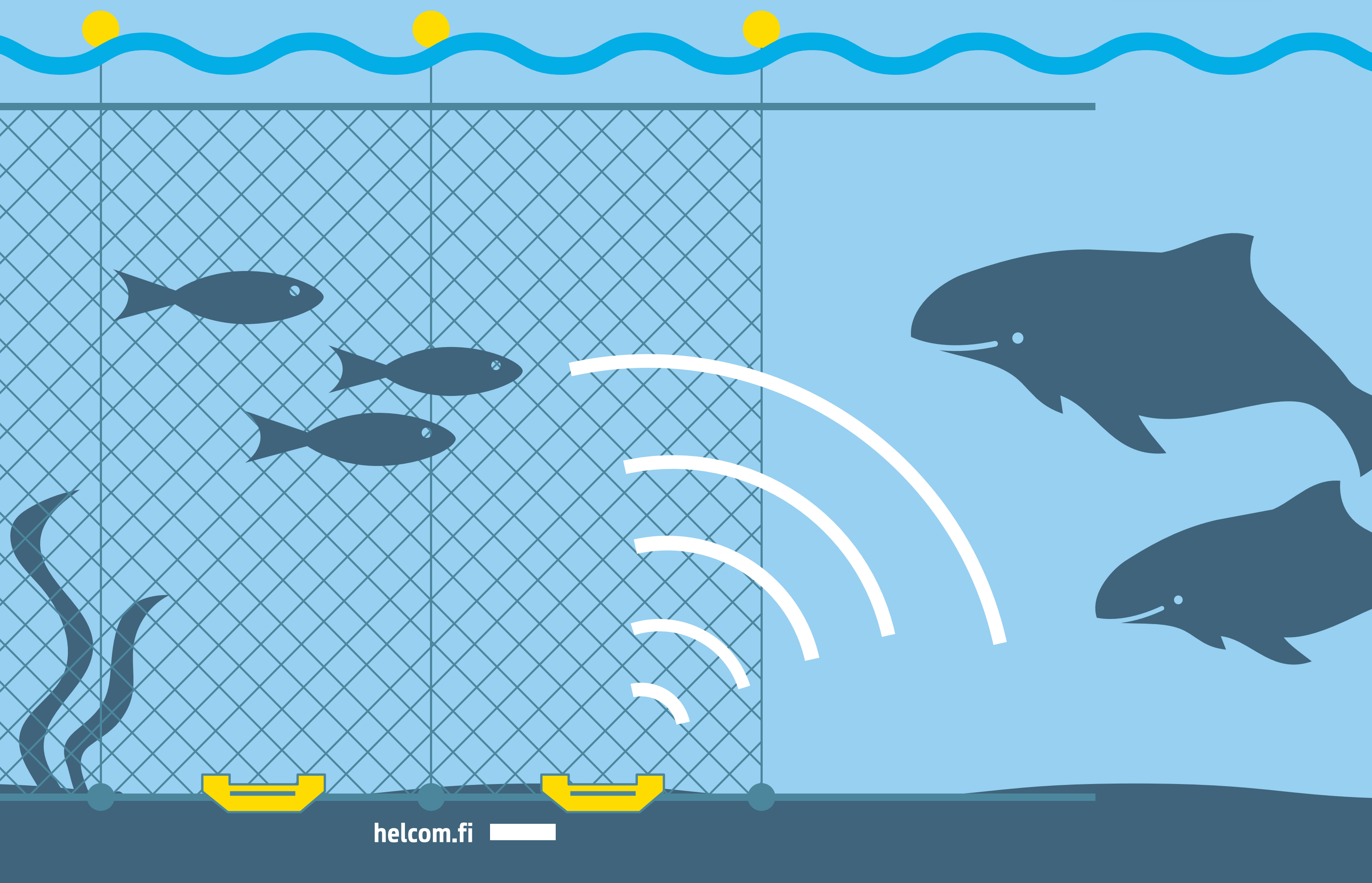
HELCOM

HELCOM Guidelines
for the design and use of acoustic deterrent devices in the HELCOM area

Baltic Marine Environment Protection Commission

Underwater noise

May 2026



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1. Introduction

The Baltic Sea Action Plan (BSAP) (HELCOM 2021a) is HELCOM's strategic programme of measures and actions for achieving good environmental status (GES) of the sea, ultimately leading to a Baltic Sea in a healthy state.

Initially adopted by the HELCOM Contracting Parties in 2007, the original BSAP had set 2021 as the target year for achieving good ecological status of the sea. However, the results of the State of the Baltic Sea report (HELCOM 2018), covering the years from 2011 to 2016, indicated already in 2018 that this target would not be met. The updated BSAP is based on the original BSAP and maintains the same level of ambition. It also retains all actions previously agreed on that are still to be implemented and includes, in addition, new actions to strengthen the existing efforts and tackle emerging concerns.

Among these BSAP actions, action S61 aims to develop and implement guidelines for the design and use of acoustic deterrent devices to avoid detrimental impacts on the environment from underwater noise by 2024. For the taxa occurring in the Baltic Sea ADDs are currently used only to deter marine mammals, but their impacts may also affect other species such as fish, diving birds and invertebrates. With the provision of these Guidelines, and their further national implementation, the action will be considered accomplished.

2. General provisions

Acoustic Deterrence Devices (ADDs) are designed and operated to prevent marine mammals from reaching structures in the vicinity of the ADD, typically fishing gear, aquaculture pens, or potentially dangerous zones around construction activities. Achieving these desired effects requires high source levels, potentially affecting marine mammals and other marine biota in unintended ways especially during continuous use at frequencies that can propagate well. The following guidelines for design and use of ADDs cover three different uses of devices:

- deterrence of one or more species of marine mammals from fishing gear or aquaculture sites, in order to prevent incidental entanglement (bycatch), or depredation and damage to the fishing gear;
- deterrence of one or more species of marine mammals from the vicinity of loud sound sources (pile driving, explosions etc.) potentially dangerous to the animals. In this case the purpose of the ADD is to displace animals to safe distances prior to exposure to the primary noise source; and
- deterrence of one or more species of marine mammals in sensitive coastal areas where restoration of fish populations is underway.

In the first case, ADDs are often used to protect the gear and catch of fisheries or farmed fish and their deployment can be long lasting, whereas in the second case, ADDs are used as mitigation devices (usually for a short time) to protect marine mammals from harm. In both applications, the design and operation of ADDs must fulfil two key requirements:

- to be sufficiently effective in achieving the intended deterrence of the relevant species, yet the ADD should not result in a significant (and hence unwanted) deterrence of other marine mammal species than the relevant ones; and
- to not be excessively effective in deterring the species. In other words, the ADD must not constitute a disproportionally large impact compared to the benefit gained by its use.

Depending on the aim of use, ADDs come in a wide variety from small low impact devices (requiring specification according to the technical measures regulation in fisheries (EU 2019) to protect marine ecosystems and fisheries resources) to bigger and more powerful devices that potentially harm marine mammals in terms of causing temporal or permanent damage to the hearing of protected species under the Habitats Directive (EEC 1992) or cause (unintended) disturbance. This conflict of aims of the different regulations is especially apparent for marine mammals but ADDs could also pose risks to sensitive fish species. Powerful devices require reporting according to the Marine Strategy Framework Directive (EC 2008). Within the HELCOM framework, this data is reported to the HELCOM/OSPAR registry of impulsive noise events.

This document aims at providing an overview of current practices, outlining the potential conflicts and describing attributes and situations influencing or limiting the applicability of ADDs. Further, recommendations are given with respect to design and use in different applications.

3. Glossary

There are various terminologies for ADDs. Especially in the US, loud ADDs are often termed Acoustic Harassment Devices (AHDs) whereas devices with a lower source level are termed ADDs or (gill net) pingers. The term 'harassment' infers intentional disturbance which is not the purpose of ADDs addressed here. A list of definitions of the terminology used in these guidelines is presented here.

Alerting devices: acoustic devices not intended to deter animals but instead alert the relevant animals (porpoises) to an imminent danger (a gill net). Although such devices therefore strictly cannot be considered to deter animals, they are nevertheless in the following treated together with traditional gillnet pingers, unless specifically stated otherwise. There is only one device available (PAL, Culik *et al.* 2015), that can be programmed to use either pinger-like signals or artificial porpoise click trains making a distinction difficult without specification of the exact signal used. However, PALs using porpoise-like signals are not strictly ADDs.

Catch-and-aquaculture-protection ADDs: ADDs with a loud aversive signal aimed at deterring seals from fishing gear or aquaculture fish pens in order to protect an economic resource from depredation or damage.

Gill net or fisheries pingers: acoustic devices which produce signals in order to keep harbour porpoises or other cetaceans at a safe distance to a net in order to reduce bycatch.

Displacement ADDs: ADDs with a loud signal aimed at keeping protected species such as harbour porpoises at a safe distance from loud impulsive noise sources such as impact piling or explosions.

Relevant species: in the Baltic Sea, these species are either seals (grey seal, ringed seal, harbour seal) or harbour porpoises which are being deterred for the reasons provided above. Other species, such as different species of dolphins, occur so rarely in the Baltic Sea, including the Kattegat and the Danish Straits, that they are not covered by these guidelines.

4. Regulatory context

The use of ADDs for the different purposes mentioned above is mandated and regulated by a large complex of legislation. Briefly, this legislation spans from different EU directives and decisions over HELCOM actions and recommendations to national legislation regarding fisheries management and nature protection. The most important documents are described and summarised in regard to ADDs in Appendix A.

The legal context of ADDs includes various nature conservation and fisheries legislation. Here, we mainly concentrate on EU legislation. Some national legislation might be more specific but are only included here sporadically. Further, a number of international agreements are of importance in the context of ADD use.

In summary the legislation concerns the protection of species (Bern, Bonn Convention) from killing and disturbance and protected cetacean species in subordinate agreements like ASCOBANS through several resolutions, protection through EU laws like the Habitats Directive and the Marine Strategy Framework Directive. ASCOBANS resolutions point out that pinger use is necessary as an interim measure to protect the critically endangered Baltic harbour porpoises and other odontocete populations and suggest guidelines for Environmental Impact Assessments (EIA) for marine noise generating activities. In fisheries regulations the use of ADDs is concerned in the Common Fisheries Policy and the Technical Measures Regulation. Both highlight that fisheries and aquaculture must be environmentally sustainable by using an ecosystem approach and by implementing and monitoring the mandatory pinger use in certain fisheries and areas.

Table 1. Main regulatory instruments at international, European and national level connected to ADDs.

<table>
<tr><th>International</th><th>European</th><th>National</th></tr>
<tr><td>Convention on the Protection of the Marine Environment of the Baltic Sea Area (Helsinki Convention, 1974, 1992)</td><td>The EU Habitats Directive (Council Directive 92/43/EEC)</td><td rowspan="4">Swedish regulations for the use of ADDs that apply to all fishing vessels below 12 m using static gear, fyke nets or gill nets in parts of the Baltic Sea sub-division 24 (HVMFS, 2024)</td></tr>
<tr><td>Convention on the Conservation of Migratory Species of Wild Animals (CMS or Bonn Convention, 1979)</td><td>The Marine Strategy Framework Directive (Directive 2008/56/EC of the European Parliament and of the Council)</td></tr>
<tr><td rowspan="2">Agreement on the Conservation of Small Cetaceans of the Baltic, North East Atlantic, Irish and North Seas (ASCOBANS, 1992), and in particular Resolutions:</td><td>The Common Fisheries Policy (Regulation (EU) 1380/2013 of the European Parliament and of the Council)</td></tr>
<tr><td>Technical Measures Regulation (Regulation (EU) 2019/1241 of the European Parliament and the Council)</td></tr>
</table>

<table>
<tr><td rowspan="3">- 9.2 on the Baltic Proper harbour porpoise (UNEP/ASCOBANS, 2020a),

- 8.8 Addressing the Threats from Underwater Munitions (UNEP/ASCOBANS, 2016b),

- 8.3 Revision of the Recovery Plan for Baltic Harbour Porpoises (UNEP/ASCOBANS, 2016a),

- 8.11 on CMS Family Guidelines on Environmental Impact Assessment for Marine Noise Generating Activities (UNEP/ASCOBANS, 2020b), and

- 6.2 on Adverse Effects of Underwater Noise on Marine Mammals during Offshore Construction Activities for Renewable Energy Production (UNEP/ASCOBANS, 2009)</td><td>Regulation on detailed rules on signal and implementation characteristics of ADDs (Commission Implementing Regulation (EU) 2020/967)</td><td rowspan="3"></td></tr>
<tr><td>Regulation on measures to reduce incidental catches of Baltic Proper harbour porpoises (Commission Delegated Regulation (EU) 2022/303)</td></tr>
<tr><td>Fisheries Control Regulation (Regulation (EU) 2023/2842 of the European Parliament and of the Council of 22 November 2023)</td></tr>
</table>

5. Conservation status of species or populations affected by ADD sounds

The conservation status of the four species of relevance for these guidelines (harbour porpoise, harbour seal, grey seal and ringed seal) differ between the species but also between the geographical region within each species. This means that specific recommendations regarding the use of ADDs should be geographically specific and thereby take these differences into consideration. See Appendix B and Table 2 for description of the current status of the four relevant species.

Table 2. HELCOM red list status of species and their subpopulations (HELCOM 2025).

Species	Subpopulation	HELCOM red list status (2024)
Harbour porpoise (*Phocoena phocoena*)	Baltic Proper	Critically endangered
	Belt Sea	Endangered
Grey seal (*Halichoerus grypus*)	Baltic Sea	Least concern
Harbour seal (*Phoca vitulina*)	Kattegat/Southwestern Baltic	Least concern
	Kalmarsund	Near threatened
Ringed seal (*Pusa hispida botnica*)	Gulf of Bothnia	Vulnerable
	Southern management units	Endangered

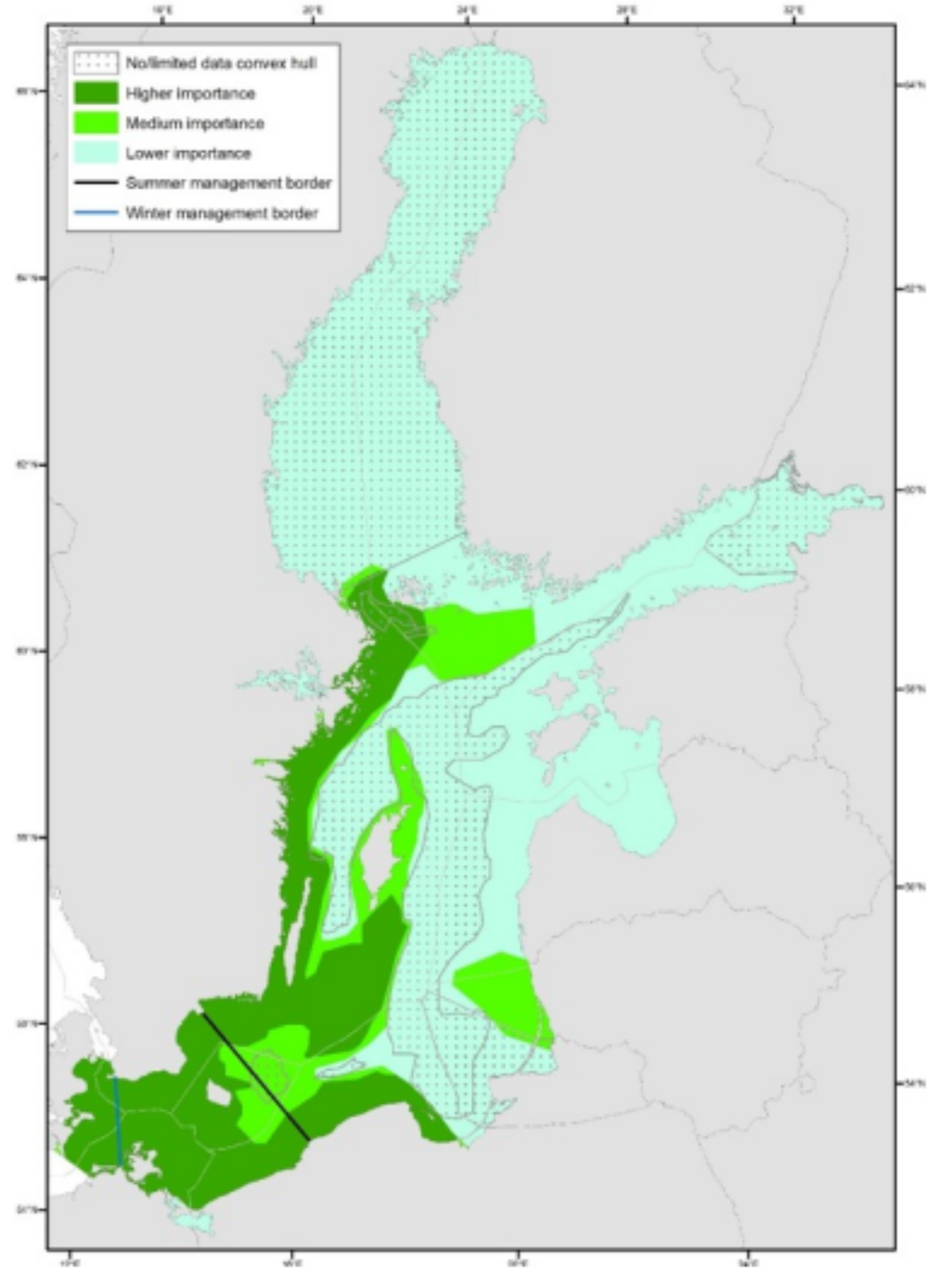

Figure. 1. Areas of importance for harbour porpoises in the Baltic Proper (Sveegaard *et al.* 2022).

6. Use of ADDs

As briefly outlined above in section 2, ADDs are used for different purposes and in different contexts. This means that ADDs differ substantially in design and operation, as their constraints and requirements differ. In this document, the use is divided into two main categories: use related to fisheries and aquaculture and use in protection of marine mammals against excessive sound exposure.

6.1. Use in fisheries and aquaculture

ADDs used in fisheries and aquaculture are again separated according to their objective: to protect marine mammals (porpoises) against bycatch and to protect fishing gear and catch/harvest against damage and depredation.

6.1.1. ADDs placed on gill nets and other gear where there is a risk of entanglement of porpoises ("fisheries pingers")

The aim of these ADDs is to deter porpoises from fishing gear, in order to prevent incidental entanglement. Fisheries pingers emit specific signals which are aversive to porpoises or other cetaceans. These can either have a constant fundamental frequency and harmonics (i.e. multiples of this frequency) or frequency sweeps. The harmonics appear to be one of the factors which make a signal aversive (Kastelein *et al.* 1995). Maintenance of pingers and compliance with regulations are critical with respect to mitigation success (Geijer & Read 2013). Typical source levels are between 130 and 150 dB (re 1µPa at 1m) (EU Commission 2020).

Fisheries pingers have shown to reduce bycatch of harbour porpoises effectively but do not eliminate bycatch (Kraus *et al.* 1997, Dawson *et al.* 2013). Overall, two pinger types have been developed, tested, and used in commercial gillnet fisheries. First the "10 kHz pinger", with a constant frequency at 10 kHz. Second the "high frequency" which uses higher frequencies (such as 50-120 kHz) and randomized signals at random intervals, see also Appendix C.

Some Navies object to large-scale gillnet pinger use for the protection of Baltic Proper harbour porpoises. Since no information on the sound properties of ADDs which may cause interference with naval activities, no recommendations can be given in this document.

6.1.2. ADDs for deterrence of seals from fishing gear and aquaculture

These ADDs aim to deter species of concern from fishing gear or aquaculture sites, in order to prevent depredation and damage to gear.

Catch-and-aquaculture-protection ADDs can be the same devices as Displacement ADDs (see section 6.2). Only the purpose is different and thus, typical source levels of these devices are closer to the higher end of the range. Catch-and-aquaculture-protection ADDs are primarily designed to deter pinnipeds but have also been used in attempts to deter other marine mammals (e.g., Tixier *et al.*, 2015). The principal mechanism by which most catch-protection ADDs used in fisheries and aquaculture are designed to illicit deterrence is to continuously emit high amplitude and aversive signals underwater around fisheries or aquaculture sites during periods of finfish production or fish capture (Schakner and Blumstein, 2013; Coram *et al.*, 2014). However, more recently produced catch-and-aquaculture-protection ADDs have also considered alternative deterrence approaches such as the use of sounds which elicit the autonomous startle reflexes associated with the flight response in pinnipeds (Götz and Janik, 2011, 2015, 2016; Hiley *et al.*, 2021). The acoustic characteristics including the amplitude, frequency ranges, duty cycle, and harmonics of catch-and-aquaculture-protection

ADDs used in aquaculture and fisheries can vary considerably (McGarry *et al.*, 2022). Typical source levels of catch-and-aquaculture-protection ADDs regardless of deterrence approach are noted to be more than 180 dB re 1 μPa rms (Lepper *et al.*, 2014; McGarry *et al.*, 2022; Todd *et al.*, 2021). The nominal or fundamental frequency range is approximately between 0.5 and 40 kHz (Lepper *et al.*, 2014; Todd *et al.*, 2021) to overlap with the audible hearing range of pinnipeds (approximately 50 Hz to 86 kHz; Southall *et al.*, 2019). Signals can also include harmonics which are multiples of the fundamental frequency. Many devices use pulsed tonal bursts, frequency sweeps or a set of frequencies broadcasted at the same time (Lepper *et al.*, 2014; McGarry *et al.*, 2022; Todd *et al.*, 2021).

Catch-and-aquaculture-protection ADDs have previously been or are presently used in many countries globally where finfish aquaculture and static fisheries occur. This includes (to the authors' knowledge): Australia (Pemberton and Shaughnessy, 1993), Canada (Jacobs and Terhune, 2002; Morton, 2000; Morton and Symonds, 2002; Yurk and Trites, 2000), Chile (Sepulveda and Oliva, 2005; Vilata *et al.*, 2010), Ireland (Coram *et al.,* 2016), New Zealand (Kemper *et al.*, 2003), Norway (Fjalling *et al.*, 2006), Turkey (Güçlüsoy and Savas, 2003), Scotland (The Scottish Government, 2021), the United States (Nelson *et al.*, 2006), and in the Baltic Sea region in Estonia (Vetemaa *et al.* 2021) and Finland (Veneranta *et al.*, 2024).

6.1.2.1 Use in static coastal net and trap fisheries

During the last three decades, increasing numbers of seals have damaged more and more coastal fishing gear and catches in the Northern Baltic Sea (Kauppinen *et al.* 2005; Blomquist & Waldo 2021; Suuronen *et al.* 2023; Svels *et al.* 2025). Attempts have been made to prevent this damage by developing seal-resistant fishing gear (Lunneryd *et al.* 2003; Suuronen *et al.* 2006; Ljungberg *et al.* 2022). The most important innovation has been the pontoon-trap, which is currently used in salmon (*Salmo salar*) and whitefish (*Coregonus lavaretus*) fishing. In a pontoon-trap, the fish chamber is protected from seals by a double layer of seal-proof netting (Hemmingson *et al.* 2008). Because only the fish chamber is protected from seals, they can still significantly damage catch in pontoon traps by attacking in other parts of the trap (e.g. in the middle chamber, wings and in leader nets). No updated fishing gear to protect gillnet fishing from seal damage has been invented yet.

Recently, acoustic deterrent devices (ADDs) (including raft-mounted deterrents and portable deterrents anchored close to traps) have provided encouraging results in preventing seal damage in Finland. An ADD works by emitting short sound pulses that a seal finds unpleasant and makes the seal move away from the sound source. Trials in Finnish, Swedish and Estonian fisheries have been conducted with ADDs transmitting 9–11 kHz pulses in variable cycles at a source level of 189 dB (re 1 μPa rms at 1 m) (Lehtonen *et al.* 2022) or 15 kHz pulse bursts at a source level of 179 dB (re 1 μPa rms at 1 m) (Fjälling *et al.* 2006; Vetemaa *et al.* 2021). The deterrent solutions tested by the Natural Resources Institute Finland (LUKE), as portable deterrent and raft-mounted deterrent (e.g., Lehtonen *et al.* 2022), not only reduce catch and gear damage in salmon pontoon-trap fishing but also provide other benefits. Since seals cannot destroy the catch, fishers can visit their traps less frequently when catches are low, which saves on working time and fuel. Fishers also spend less time repairing gear and have more time for other fishing-related work. Deterrents also lower the risk of seals becoming entangled and drowning in a trap. A seal deterrent causing deliberate extended habitat exclusion for seals can, albeit being quite invasive, be a measure to reduce seal bycatch while ensuring commercial fishing.

Seal-free areas on the coast

In gillnet fishing conducted in inner coastal waters, it is often not possible to prevent seal damage modifying existing fishing gear. Instead, placing a line of seal deterrents across the entrance to a bay for the duration of the fishing season could temporarily close entire bays from seals. However, this method of deliberate extensive habitat exclusion can be very invasive and may significantly affect the seals and potentially other species. This method is mostly used in gillnet fishery for pike perch and whitefish in narrow entrances of shallow bays in the inner archipelago areas of Finland, mostly in autumn. Fishing in such seal-free areas could be conducted without disruption from seals. In the trial, an ADD which transmitted short pulses at random intervals at 9-11 kHz at a source level of 181 dB (re 1µPa rms at 1 m) was used. The typical signal duration was 1 to 4 s emitted on average every 40 s (Lehtonen *et al.* 2023). This could potentially, given sufficient scientific evidence, also be used to protect fish stocks especially during sensitive periods for necessary conservation purposes.

To allow coastal fish populations to recover, ADDs can also be used in confined coastal areas in order to prevent seals from entering certain bays. For the purpose of fish stock restauration, the use of ADDs should be combined with additional conservation measures, including restriction of fishing. In areas of high and medium importance to harbour porpoise (Figure 1), the type and frequency range of ADDs shall be chosen in a way which has the lowest impact on harbour porpoises. Startle response devices can be tailored to specific areas by choosing a frequency with a low overlap with the hearing range of species otherwise impacted by seal scarers.

Seal-free areas in rivers

In the northern Baltic Sea, both grey and ringed seals are increasingly moving into rivers to find their food, and their presence has become a substantial problem for fisheries. Seals take fish caught in nets, damage the equipment while consuming the fish and also disturb the spawning of fish (Veneranta *et al.* 2023). In LUKE experiments in 2022 six ADDs designed to elicit a startle response (nominal frequency 8–11 kHz, source level 181 dB re 1 µPa at 1 m, randomised pulses emitted at a rate of 108 pulses per hour) were installed on the riverbed of the River Iijoki with the aim of investigating the usability of deterrents in forming a seal-free area in the river. The results showed fewer damaged whitefish above the deterrent line than below it, suggesting that deterrents reduce seal damage at least in smaller rivers (Veneranta *et al.* 2023).

6.1.2.2. Use in trawl fisheries

Even though there are a few studies which have recorded porpoise bycatch in trawl nets (Österblom 2002), bycatch of porpoises in trawl fisheries is rare. Bycatch of dolphins has also been recorded. In the past, studies have thus tested pingers to reduce dolphin bycatch in trawl fisheries, but low bycatch rates and limited replication have hindered statistical validation of their effectiveness (van Marlen, 2007; Morizur *et al.*, 2008). Many pinger trials in trawl fisheries are only found in internal reports and lack systematic design, such as proper controls or sufficient repeats, resulting in mixed and inconclusive findings (Northridge *et al.*, 2011; Stephenson & Wells, 2008). Robust evaluation requires greater observer coverage or more replicated hauls (Stephenson & Wells, 2008; van Marlen, 2007). In 2023 Pruente *et al.* however showed that bycatch of short-beaked common dolphin (*Delphinus delphis)* could be reduced by placing DDD03H (Dolphin Dissuasive Device) in pair trawls. These devices have a very large frequency range, produce a variety of signals and a source level of 174 dB re 1µPa

(Dawson *et al.* 2013) which is much louder than the pingers designed for deterring harbour porpoise from gillnet fisheries.

6.1.2.3. Use in aquaculture

In attempts to control pinniped (phocid and otariid spp.) depredation at finfish (salmonid spp.) aquaculture sites, catch-and-aquaculture-protection ADDs are often deployed as a non-lethal alternative to the shooting of seals (Coram *et al.*, 2014). Catch-and-aquaculture-protection ADDs used by aquaculture are designed to illicit deterrence of pinnipeds by either continuously emitting high amplitude (>180 dB re 1 µPa RMS) and aversive signals or startle signals underwater around finfish cages during periods of finfish production which can be up to 2 years in duration (Götz and Janik, 2011, 2015, 2016; Schakner and Blumstein, 2013; Coram *et al.*, 2014; Hiley *et al.*, 2021). Suggested deterrence distances of these ADDs (often provided by the manufacturers of these devices) vary from 30 to 300 m (Table 1). To achieve this desired deterrence effect, it is common practice within the aquaculture sector to deploy multiple catch-and-aquaculture-protection ADDs per aquaculture site. Evidence from the Scottish aquaculture sector indicated that for some device types, up to 30 ADDs can be deployed per site. However, the overall number of transducers installed at a site is typically agreed between the site manager and catch-and-aquaculture-protection ADD manufacturer (Northridge *et al.*, 2010; The Scottish Government, 2021). Generally, there is a paucity of data on which aquaculture sites are using catch-and-aquaculture-protection ADDs, the type and number of devices deployed, and the duration of active ADD use, limiting quantitative assessments of catch-and-aquaculture-protection ADD use by the aquaculture sector in countries where these devices are used (see section 6.1.2). To the authors' knowledge, 12 types of catch-and-aquaculture-protection ADDs produced by 8 manufacturers have been or are presently being used by the aquaculture sector globally as a method of pinniped deterrence (McGarry *et al.*, 2022) (see Table 3).

Table 3 Catch-and-aquaculture-protection ADDs used by the aquaculture sector including device, manufacturer, source level, frequency, duty cycle, suggested deterrence distance and method of deterrence.

<table>
<tr><th>Device</th><th>Manufacturer</th><th>Source level (dB re 1 µPa rms @ 1 m)</th><th>Frequency</th><th>Duty Cycle</th><th>Suggested Deterrence Distance</th><th>Method of Deterrence</th><th>Reference</th></tr>
<tr><td>Airmar dB Plus II</td><td>Airmar</td><td rowspan="2">198</td><td rowspan="2">10-10.3 kHz (with broadband energy from 1.5 to 50 kHz)</td><td rowspan="2">52.4%</td><td rowspan="2">31 m</td><td rowspan="2">Aversive high amplitude signal</td><td rowspan="2">(Lepper et al., 2014; McGarry et al., 2022)</td></tr>
<tr><td>Gael Force SeaGuard</td><td>Gael Force</td></tr>
</table>

MohnAqua MAG Seal Deterrent	*Airmar*						
Ace Aquatec RT1	*Ace Aquatec*	*183-185*	*1-2 kHz*	*0.2-5%*	*100 m*	*Aversive high amplitude signal*	*(McGarry et al., 2022)*
Ace Aquatec A-ASR® RT1[1]		*N/A*	*N/A*	*N/A*	*N/A*	*Startle signal*	[*https://aceaquatec.com/aquaculture-products/protect/asr-rt1*](https://aceaquatec.com/aquaculture-products/protect/asr-rt1)
Ace Aquatec Universal Scrammer US2		*181*	*8-30 kHz*	*~3%*	*Not specified*	*Aversive high amplitude signal*	*(McGarry et al., 2022)*
Ace Aquatec Universal Scrammer US3		*181*	*8-11 kHz*	*0.8-5%*	*60 m*	*Aversive high amplitude signal*	*(McGarry et al., 2022)*
Lofitech Seal Scarer / FishGuard	*Lofitech*	*191-204*	*14.6 kHz*	*Random*	*300 m*	*Aversive high amplitude signal*	*(McGarry et al., 2017)*

[1] It is unknown whether the Ace Aquatec A-ASR® RT1 produces similar acoustic signals to the Ace Aquatec RT1 as no data on acoustic characteristics have been openly provided by the manufacturer.

GenusWave Targeted Acoustic Startle Technology (TAST)	*GenusWave*	*180-182*	*1 kHz;* *700 Hz to 1.5 kHz*	*~1%*	*250 m*	*Startle signal*	*(Götz and Janik, 2015, 2016)*
SaveWave SealSalmon Saver (High-impact)	*SaveWave*	*155*	*5-30 kHz; 30-160 kHz wide band sweeps, harmonics up to 180 kHz*	*Random*	*Not specified*	*Aversive high amplitude signal*	*(McGarry et al., 2022)*
Terecos DSMS-4	*Terecos*	*177-179*	*1.8-6.8 kHz*	*Random* *(approx. 6.7% based on 8s burst every 2 min)*	*Not specified*	*Aversive high amplitude signal*	*(Lepper et al., 2014; McGarry et al., 2022)*
OTAQ Sealfence™	*OTAQ*	*165 (patrol mode)* *189 (protect mode)*	*9-11*	*0.7% (patrol)* *1.3% (protect)*	*40 m*	*Aversive high amplitude signal*	*(The Scottish Government, 2021; Lehtonen et al., 2022)*

Although catch-and-aquaculture-protection ADDs are a widely used tool by the aquaculture sector globally (see section 6.1.2), the long-term efficacy of catch-and-aquaculture-protection ADDs at deterring pinnipeds from aquaculture sites remains debated (see Appendix D).

In some locations such as on the west coast of Scotland, the widespread and prolonged use of catch-and-aquaculture-protection ADDs by this industry has resulted in this noise becoming a chronic source of coastal underwater noise pollution (Findlay *et al.*, 2018, 2021). The widespread use of these devices therefore has the potential to result in acoustic habitat degradation which has led to concerns for marine mammals inhabiting regions which overlap with aquaculture production, particularly cetacean species which are incidentally affected by exposure to catch-and-aquaculture-protection ADDs. Depending on the frequencies used there is also a potential that widespread ADD use affects other species including fish, diving birds or invertebrates.

Numerous studies have documented detrimental effects from exposure to catch-and-aquaculture-protection ADD noise on species known to inhabit the Baltic Sea, including harbour porpoise, harbour seals, and grey seals. Briefly, documented effects include temporary threshold shifts in hearing (Lepper *et al.*, 2014; Schaffeld *et al.*, 2019; Findlay *et al.*, 2021, 2022); alterations in animal behaviour including reductions in foraging activity (Elmegaard *et al.*, 2023), strong directional movements away from catch-and-aquaculture-protection ADDs (Gordon *et al.*, 2019; Graham *et al.*, 2023), increased swimming speeds and surfacing intervals (Kastelein *et al.*, 2015); and the displacement of populations from biologically important habitats (Johnston, 2002; Olesiuk *et al.*, 2002; Northridge *et al.*, 2010; Findlay *et al.*, 2024) (see Appendix D). The MSFD, D11C1 (see Appendix D) refers to population effects from noise exposure, thus, population consequences of disturbance from catch-and-aquaculture-protection ADDs such as those documented by Findlay *et al.* (2024), in combination with the potential for seals and harbour porpoises to experience auditory impacts and fitness consequences due to changes in behaviour should therefore be considered when catch-and-aquaculture-protection ADDs are proposed for use. Particularly within habitats of importance for harbour porpoises, and especially in areas relevant for the critically endangered population of this species within the Baltic Proper.

6.1.2.4. Use of explosives as acoustic deterrents in fisheries

In some regions of the world, commercially produced explosive deterrents, commonly known as seal bombs[2] are used to protect fishing gear and catch, or aquaculture sites from seal predation. They usually contain flash powder which can e.g. consist of potassium perchlorate and aluminium which burns at a high speed (fast deflagration) and thus produces loud noise. At close distance it is possible that a shock wave is generated, which however could not be recorded in measurements at larger distances (Wiggins *et al.,* 2021). Source level measurements revealed a sound exposure level of 203 dB re 1µPa²s m if integrated over the whole 100 m waveform (Wiggins *et al.,* 2021). The frequency content of seal bomb explosions has not been reported in the scientific literature but examples indicate the signal is broadband with the majority of energy below 2 kHz and some energy reaching above 10 kHz (Simonis *et al.,* 2020). Since often seal bombs are thrown at a close distance, they have a high potential for physical and auditory injury in marine mammals (Myrick *et al.,* 1990). Furthermore, since seal bombs are often used repeatedly during fishing or aquaculture operations (Krumpel *et al.,* 2021), cumulative SEL over the full period of event activity must be used to estimate the total amount of sound energy received by an animal contributing to risk of injury (Wiggins *et al.* 2021). Multiple events also have a high potential for disturbance of animals of concern but also other noise sensitive species such as the harbour porpoise (e.g., Simonis *et al.,* 2020).

6.2. Use in offshore construction (as protective measure for harbour porpoises)

In offshore construction, the aim is the deterrence of a species of concern from the vicinity of loud sound sources (pile driving, explosions etc.), potentially dangerous to the species, and with the intent to displace animals to safe distances prior to their exposure to the primary noise source. This is commonly done through the sequential use of first pingers and then loud ADDs.

Typical source levels of loud ADDs range from 145 to 191 dB re 1 µPa (RMS). The nominal or fundamental frequency range is highly variable and dependent on the species targeted for deterrence (seals: 700 Hz to ~20 kHz and for harbour porpoises from ~1 kHz to 160 kHz; McGarry *et al.* 2022). Signals can also include harmonics which are multiples of the fundamental frequency. Many devices use pulsed tonal bursts, frequency sweeps or a set of frequencies broadcasted at the same time.

In offshore construction, deterrence is used to protect harbour porpoises from impulsive noise which can lead to a temporary or permanent threshold shift (Kastelein *et al.* 2016). With the use of an appropriate deterrence measure it is ensured that the animals are deterred outside the reference area of the noise emission, where TTS/PTS may take place (as applied e.g. as reference distance for TTS of

[2] Defined as pyrotechnical devices used in some marine areas (such as in the US) to scare seals away from fishing gear or aquaculture sites.

750 m in Germany). The choice of the deterrence device depends on the predicted noise levels or the use of noise reduction measures. In addition, there is a trade-off between protection and temporary habitat loss/degradation which could last for up to 6 hours if the ADD is used alone (Brandt *et al.* 2013) but could be up to two 72 hours in combination with the effect of piling noise (Brandt *et al.* 2011). A more environmentally friendly method would be the use of alternative noise free or low-noise foundations (see Appendix E).

Seal scarers are used in Germany in offshore constructions in combination with pingers. Pingers are used as an advance warning of a much louder ADD to give especially harbour porpoise the opportunity to swim away, as loud ADDs may also cause hearing impairment themselves (Schaffeld *et al.* 2019). The recommended pre-run time for the pinger before the loud ADD is 5 minutes. This implements a "soft start" before seal scarer use in piling, (some ADDs have a soft start function themselves) in order to avoid detrimental effects by the loud ADDs themselves. This combination is used when the noise prognosis shows that the threshold value for injury (TTS/PTS) cannot be achieved at a reference distance. This is the case when exemptions from the mandatory threshold value are granted, e.g. during test or reference measurements. During test and reference measurements (without the use of noise reduction measures), fewer noise mitigation measures are applied, so that the radius for deterrence must be extended in order to prevent injury to marine mammals. Studies have shown that the effect range of seal scarers extend beyond the desired safe distance (Brandt *et al.*, 2013). A disturbance effect has been verified up to a distance of 7 km (Rose *et al.*, 2019).

Results from the acoustic monitoring of harbour porpoises in offshore construction sites with pile driving work have confirmed that the use of deterrence was effective (Voß *et al.*, 2021). The animals left the danger zone of the construction site. However, deterrence using seal scarers was associated with a temporary loss of habitat caused by the animals' flight reactions which therefore represents a disturbance (Brandt *et al.*, 2013; Dähne *et al.*, 2017; Rose *et al.*, 2019).

The development of configurable ADDs opens up the possibility of adapting deterrence to the species targeted by ADDs. This means that killing or injury from pile driving or explosions can be avoided without causing additional habitat loss and disturbance. A species to be deterred can be distinguished between seals and harbour porpoises, among others, and frequency range and source level adapted to the species. Two systems of this type are currently available: FaunaGuard and APD. The analysis of data from five offshore wind farm projects has confirmed that the use of the FaunaGuard system led to an effective harbour porpoise deterrence within a radius of 1.25 km around the pile driving site and a simultaneous reduction in detection rates up to distances of 2.5 km. The disturbance caused by the use of the FaunaGuard system has been shown to be lower compared to disturbance caused by seal scarers (Voß *et al.*, 2021). According to Voß et al (2021, 2023), deterrence was successful after 20 minutes of operating a configurable system allowing porpoises sufficient time to leave the danger area. Further details are provided in Appendix F.

6.3. Use for underwater explosions in UXO clearing and construction/rock blasting (as protective measure for harbour porpoises)

Underwater explosions are the loudest point-source of anthropogenic underwater noise. The zone in which marine mammals can be injured from an explosion such as in UXO blast-in-place operations can extend to multiple kilometres from the explosion site (Koschinski 2011, Von Benda-Beckmann *et al.*

2015). To avoid harm to marine mammals, it is intended to scare them as far as possible away from the site. For this reason, the loudest ADDs or an array of multiple ADDs are being used.

Navies often use small explosives with the intention to scare marine mammals and fish away from planned underwater explosions, e.g. during unexploded ordnance (UXO) clearance operations. These usually contain 50 to 150 g of high-explosives and can be harmful to marine vertebrates themselves (Simonis *et al.* 2020) and there is no evidence of a deterrent effect.

In construction/rock blasting, the explosives are buried or in covered drilled holes, and often smaller amounts of explosives are used compared to charges typically occurring in UXO clearance. This can reduce the impact radius for marine mammals and thus the distance at which mammals must be deterred.

7. Possible alternatives

It is outside the scope of these guidelines to enter a discussion of alternatives to the use of ADDs and their practical feasibility. However, the alternatives are, like for the ADDs themselves, dependent on the purpose of the ADD that the alternative is to replace. For bycatch reduction, alternatives aim at increasing the acoustic detectability of the net itself to porpoises, thereby increasing the likelihood that they can safely negotiate the net and avoid entanglement. Early approaches involved increasing the acoustic reflectivity of the net twine itself (Trippel *et al.*, 2003), more recent and more promising approaches involve adding reflective elements to the net (Kratzer *et al.*, 2021). Another alternative is replacing gillnets by alternative gears such as traps ore line fishing where applicable (Königson *et al.* 2015). Alternatives to using ADDs to keep seals from depredation and damaging fishing gear involve redesigning the fishing gear (e.g. seal-proof pots and traps instead of gill nets), installing barriers or increasing the strength of the net material to make it more resistant to seals. For the third use of ADDs – deterring marine mammals from dangerous noise exposure, the most effective alternatives involve reducing the noise generated in the first place or reducing the radiated noise by means of alternative foundation methods in offshore windfarms, such as jetting or suction buckets. For more details see Appendix E.

8. Key takeaways

8.1. General conclusions

Fisheries pingers can reduce bycatch of harbour porpoises but do not eliminate bycatch. The efficacy of market available devices has been tested to varying extent. All new strategies and fisheries agreements to overcome the issue of bycatch as one primary reason for decline for marine mammal populations worldwide should be considered useful and tested scientifically before large-scale implementation. Pingers are considered a temporary measure for bycatch reduction (ASCOBANS, 2016).

The efficacy of displacement-ADDs in protection of harbour porpoises against excess noise exposure is well documented, but less well documented for seals. The use of catch-and-aquaculture-protection ADDs can be effective to scare seals in some cases whereas in others there are indications of individual avoidance strategies (such as lifting the head out of the water) or tolerance in species to be deterred. Thus, ADDs are not effective in all cases. Also, there are species specific differences in effectiveness of devices and behavioural response. Often, large numbers of ADDs are being used to protect an aquaculture site or even to block off seals from bays or rivers, adding to underwater noise emissions.

The use of catch-and-aquaculture-protection ADDs to scare off grey seals and possibly harbour seals comes with detrimental side effects to other biota of which the impact on harbour porpoises is well documented. Large scale displacement from their habitat has the potential to cause negative population effects.

For the restoration of fish populations, the targeted use of ADDs to exclude seals from specific confined coastal areas can be considered. In areas of high and medium importance for harbour porpoises (Figure 1), the type and frequency range of ADDs shall be chosen in a way which has the lowest impact on harbour porpoises (for example, by the use of startle response devices).

For ringed seals, there are no studies to this date on behavioural effects or negative side effects (such as hearing impairment).

8.2. Socio-economic impacts to fisheries and aquaculture from seal depredation

The presence of pinnipeds at aquaculture and fisheries facilities can have socio-economic implications for aquaculture production including fish stress resulting in reduced feeding and fish growth, damage to nets and equipment, and/or loss of yield through fish escapes from nets/cages, and direct injury or death of fish (Northridge *et al.*, 2013; Vetemaa *et al.,* 2021; Lehtonen *et al.,* 2022; Veneranta *et al.,* 2024).

For aquaculture, Northridge *et al.* (2010) reported that seal predation occurred at 61 out of 83 sites studied in Scotland, while Quick *et al.* (2004) found that 109 out of 195 aquaculture sites in Scotland considered seal predation a problem, highlighting the potential extent of this issue within the sector. When quantified economically using data collected at 87 sites in Scotland over a 10-year period, it was found that 1.4 million fish were lost to grey and harbour seals (Northridge *et al.*, 2013). If these fish had made it to market size (approximately 5 kg) they would have been worth an estimated £25 million, equating to a loss of £26,000 per site per annum, indicating that seal depredation can result in considerable economic loss to farm managers (Northridge *et al.*, 2013). However, no more recent studies on the economic losses from seal depredation in the same or other areas globally have been conducted to the authors' knowledge.

In fisheries, the economic cost of seal-fishery conflicts has a considerable impact on individual fishers (Vetemaa *et al.,* 2021; Lehtonen *et al.,* 2022; Veneranta *et al.,* 2024 The growing grey seal population has led to increasing catch losses and gear damage in Baltic coastal fisheries, causing substantial economic impacts. In some countries, those losses are partly compensated for. The compensation gap can be as high as €10,000-20,000 per fisher per year (Svels et al., 2019).

8.3. Potential for increased tolerance and habituation to ADD noise

No studies have yet conclusively proven that catch-and-aquaculture-protection ADDs are effective at deterring pinnipeds from fisheries and aquaculture sites in the long-term, evident from studies of the same seal species which have found variable responses to devices (see Appendix D). These studies therefore indicate that some individual seals may become tolerant and/or habituate to ADD signals over time limiting the effectiveness of deterrence (see Appendix D). Additionally, it has been proposed that pinnipeds may use the acoustic signals from ADDs as a 'dinner bell' alerting and attracting them to a potential food source, however the evidence for this effect is limited (Geiger and Jefferies, 1987; Jefferson and Curry, 1996; Königson, 2007; Stansbury *et al.*, 2015; Cabrera Garcia, 2018).

8.4. Considerations for Limiting Acoustic Impacts of catch-and-aquaculture-protection ADDs

In attempts to limit impacts on incidentally exposed cetacean species, newer generations of catch-and-aquaculture-protection ADDs have reduced acoustic outputs through reductions in source levels, frequencies, duty cycles and number of and/or duration of transmission sequences (The Scottish Government, 2021). Additionally, many of these newer devices ('startle devices') now focus on producing acoustic signals which are designed to elicit the autonomous reflex associated with flight responses (startle reflex) in pinnipeds but not cetaceans, with the aim of limiting their effects beyond the species targeted for deterrence (Götz and Janik, 2011, 2015, 2016; Hiley *et al.*, 2021). In the startle reflex, flexor muscles twitch instantly as a protective measure from a potentially harmful sudden stimulus which may also be accompanied by heart rate fluctuations (Götz & Janik 2013, Baudrie *et al.* 1997). This can mediate flight responses which has been shown in tagged harbour porpoises as a reaction to conventional ADDs where a startle reflex was mixed with fleeing behaviour, altered echolocation and unusual tachycardia during dives (Elmegaard *et al.* 2023). The intended reaction to a startle device however is a startle response isolated from such strong behavioural responses.

Startle devices aim to avoid unwanted side effects by adapting the frequency of the startle signal so that it is audible for the species intended to be deterred but where other species, such as the harbour porpoise, have a lower sensitivity. At the same time, these devices have a fast rise time, and reduced duration, repetition rate (duty cycle) and source level. Using a startle signal centered at 1 kHz, seal depredation at fish farms could be reduced without affecting harbour porpoise occurrence near the fish farm (Götz & Janik 2015, 2016). The authors of those studies own patents and hold shares in a company producing these ADDs and thus, independent verification is still required.

However, simply altering the acoustic output of an ADD might not have the desired effect. For example, Benjamins *et al.* (2018) found that both high-frequency (8-18 kHz) and low-frequency (1-2 kHz) signals resulted in substantial reductions in harbour porpoise detections within 1 km of the sound source, even when tested devices operated at considerably reduced source levels (approximately 146-161 dB re 1 µPa rms) and although porpoises have a much lower hearing sensitivity for the low-frequency signal. Since it is not clear what exactly the effects of these signal alterations are on species intended and unintended to be deterred, consideration should still be given to the potential implications of exposure to any catch-and-aquaculture-protection ADD for cetaceans and other protected species (such as certain fish species) prior to their use.

The deployment of multiple devices at sites can increase the amplitude and spatial extent of catch-and-aquaculture-protection ADD noise, with potentially negative implications for marine mammals (Findlay *et al.*, 2021). Limiting the overall number of devices deployed at individual aquaculture and fisheries sites, promoting the use of startle devices and development of technologies to synchronise duty cycles or trigger activation of catch-and-aquaculture-protection ADDs may therefore help to reduce their overall acoustic outputs (The Scottish Government, 2021; Thompson *et al.*, 2021).

Limiting the number of any kind of ADDs reduces their overall impact and underwater noise pollution. Any new application may have unwanted implications for the marine environment. Walmsley *et al.* (2025) successfully tested 1 kHz startle devices in an inshore mackerel gillnet fishery to reduce depredation by grey seals. The maximum source level in the loudest third octave band was 175.4 dB (re 1 $\mu Pa^2 s$ at 1 m) or 167.8 dB for a single transmission, respectively. This source level is much higher than the source level of current gillnet pingers. The spacing of the devices in test nets was approximately 50 to 100 m whereas the typical gillnet pinger spacing is 200 m. The large-scale use of such devices in fisheries (which usually set large numbers of nets or net panels which can be many kilometres long) raises new concerns. Besides already discussed side-effects on cetaceans there might additionally be negative impacts on fish or invertebrate species. For this reason, strategic and scientifically independent assessments of the impact of any new application for ADDs on the environment is encouraged. Knowledge sharing among Contracting Parties on this matter is a first step to ensure safeguarding of marine fauna in the HELCOM area.

Modelling the amplitude and spatial extent of underwater noise from any type of catch-and-aquaculture-protection ADDs prior to deployment at aquaculture or fisheries sites using a suitable range-dependent sound propagation model which accounts for local environmental conditions (e.g., Findlay *et al.*, 2021) is a useful first step in determining potential impacts to marine species. This is of utmost importance in habitats known to be of importance for harbour porpoises and especially the critically endangered Baltic Proper harbour porpoise, given the wealth of evidence of this species responding to catch-protection ADDs (see appendix D for additional details).

8.5. Reporting

HELCOM Contracting Parties assess in a six-year cycle the spatiotemporal distribution of impulsive sound sources. For this purpose, noise-producing maritime activities are being reported by Contracting Parties to the regional HELCOM/OSPAR noise registry[3] hosted by ICES (HELCOM 2023). In particular, events of the source type ‘Sonar or Acoustic Deterrents’ cover ADDs such as those addressed in this guidance. The use of ADDs can only be reported if known to the authority in charge of reporting. For this reason, licensing of ADDs can greatly improve reporting to the impulsive noise registry and make the HOLAS assessments more reliable which is an important part of HELCOM work towards achieving good environmental status with respect to underwater noise.

8.6. Examples of ADD Licensing

To the authors’ knowledge the licensing of ADDs is not a common practice. The only evidence of licensing is in Scotland, where license requirements for the use of catch-protection ADDs at aquaculture sites have been recently implemented (The Scottish Government, 2021). This licensing was initially prompted by concerns raised by several governmental, public sector and non-governmental organisations regarding appropriate catch-protection ADD use and the potential injury of marine mammals (National Oceanographic and Atmospheric Administration, 2020; HELCOM, 2021b; Environmental Standards Scotland, 2022). A resultant policy change in Scotland therefore advised that

[3] https://www.ices.dk/data/data-portals/Pages/impulsive-noise.aspx

aquaculture operators wishing to use catch-protection ADDs as a method of pinniped deterrence apply for a European Protected Species licence (Marine Scotland, 2020, 2021) to reduce impacts to marine mammals. This change was intended to prevent offences being committed under The Conservation (Natural Habitats, &c.) Regulations 1994 (as amended the "Habitats Regulations") (Marine Scotland, 2020, 2021) for which cetaceans are listed under Schedule 2 as a European Protected Species. This directive implements certain requirements of the European Union Habitats Directive (European Council Directive 92/43/EEC) in the United Kingdom (UK). Animals listed in Annex IV(a) of the Habitats Directive, whose natural range includes any areas in the UK, are also listed in Schedule 2 of the Habitats Regulations as European Protected Species (EPS), species of European interest in need of strict protection. Regulation 39(1) sets out offences that relate to a number of specific circumstances in which EPS can be injured or disturbed, while Regulation 39(2) of this directive makes it an offence to "*deliberately or recklessly disturb any dolphin, porpoise or whale (cetacean)"*.

To meet the requirements of the EPS licenses and to use catch-protection ADDs at aquaculture sites, aquaculture sites must pass three tests, including:

1. the licence application must relate to one of the purposes referred to in Regulation 44(2) of The Conservation (Natural Habitats, &c.) Regulations 1994;
2. there must be no satisfactory alternative (The Conservation (Natural Habitats, &c.) Regulations 1994 Regulation 44(3)(a)); and
3. the action authorised must not be detrimental to the maintenance of the population of the species concerned at a favourable conservation status in their natural range (The Conservation (Natural Habitats, &c.) Regulations 1994 Regulation 44(3)(b)).

When submitting an EPS license application to use catch-and-aquaculture-protection ADDs at aquaculture sites, operators must also include specific details on: ADD type, number of devices to be used, acoustic characteristics of catch-and-aquaculture-protection ADDs to be used (source level, frequency, duty cycle), details of any trigger mechanisms or deployment protocols during seal interactions, duration of use per 24-hour period, time period of intended use, location of catch-and-aquaculture-protection ADDs on the site, manner in which ADD use would be reviewed, and criteria for deactivation or removal. Furthermore, an estimate of the number of cetaceans (by species) likely to be disturbed or injured due to catch-and-aquaculture-protection ADD use is required based on best density estimations for species and modelled cumulative underwater noise levels around the aquaculture site (to fulfil requirements of test 3 of the EPS license). If applicable, the catch-and-aquaculture-protection ADD used must also be reported to the UK Marine Noise Registry which records human activities in UK seas that produce loud, low to medium frequency impulsive noise (10 Hz to 10 kHz) as part of the UK Marine Strategy Regulations 2010 which transposed the MSFD into UK law.

8.7. Eligibility of EMFAF Funding

Due to low profitability of most small-scale fisheries, the investment into catch-and-aquaculture-protection ADDs in fisheries only pays if there is some support with public money such as from the European Maritime, Aquaculture and Fisheries Fund (EMFAF). As EMFAF regulations are interpreted differently by Baltic Sea countries, in some countries, ADDs may be eligible for EMFAF funding. For example, in Finland, EU funds have been channelled towards supporting fishers' investments in seal-proof fishing gear and seal deterrent devices. This compensation covers 50–80% of the total sum and requires cooperation with LUKE in monitoring and development. In Estonia, fishers receive 80% reimbursement for investments in seal deterrents. Between 3 and 5 Estonian fishers used this option in 2021 (Svels *et al.* 2023). Public funding of ADDs is not in the main scope of this report but it is worth highlighting the conflict between impact on the environment versus economic support for the fishers.

9. Recommendations

As described in the main body of the document there are inherent conflicts between objectives for fisheries management and objectives regarding protection of the marine environment when it comes to the use of ADDs.

There is a conflict between the legitimate wish of fisheries to use ADDs to protect their gear and catch/harvest and the obligations by the Habitats Directive, MSFD and other nature conservation legislation to protect marine mammals from injury and disturbance inflicted by sound.

More specifically, there is a conflict between efforts to further implement ADDs as a tool to protect fisheries and aquaculture resources, and the effort to restore depleted populations of harbour porpoises in the Baltic Sea to *Favourable Conservation Status*, as outlined in the Jastarnia Plan (UNEP/ASCOBANS, 2016a).

9.1. General recommendations

Consider alternatives: ADDs should only be used if there are no other equally efficient options. Depending on the purpose of ADD use, mitigation methods and non-acoustic alternatives to reduce impacts on noise sensitive species are available and should be used whenever possible (see Appendix E for additional details). In displacement ADDs this includes limiting the source level and adapting signals, e.g. by the use of configurable systems. In fisheries, the use of seal-safe traps can reduce seal depredation in the trap chamber but not in the leader nets. In aquaculture use of rigid net materials can exclude seals from the fish pen.

Low Source level: if ADDs are to be used, source levels of devices should be at the lowest levels able to achieve the desired deterrence effect.

Caution in protected areas: the use of any ADD should be severely restricted in areas that are designated as protected areas for harbour porpoises and in areas that have been identified as important for harbour porpoises (see figure 1). In a case-by-case decision pingers or displacement ADDs could be allowed in exceptional cases if the benefit outweighs the disadvantage, e.g., to protect porpoises from detonations or bycatch if no alternatives are possible.

Explosives: explosive devices are not considered an option in deterring animals due to the risk of injury they pose.

Reporting is required: to allow the required assessments in the frame of HOLAS as well as MSFD reporting obligations for HELCOM countries being EU Member States, the reporting of ADD use is required (see section 8.5). The use of ADDs for deterrence from fishing gear is to be reported to the HELCOM/OSPAR impulsive noise registry hosted by ICES, with one possible solution being national licencing, to assure reporting to the HELCOM/OSPAR registry and allow monitoring of use. Aquaculture already needs a permit, although it is unclear if the use of ADDs is covered by this permit in all countries; fisheries are different due to different legislative frameworks (no individual EIAs). If licensing of ADD is not in place, information about current use of ADDs in different industrial sectors (fisheries, aquaculture, etc.) could be obtained from users or directly from manufacturers.

Evaluation is needed: ADDs are to be scientifically evaluated before large-scale use regarding their long-term efficacy to achieve their purpose in the fisheries as well as to ascertain that no conservation conflicts arise by their use.

There is a need for compilation and critical analysis of current studies and modelling efforts on the effects of ADDs on seals.

9.2. Recommendations regarding fisheries and aquaculture

Pingers

Pingers are a temporary measure: Pingers should be regarded as a temporary mitigation measure for reducing harbour porpoise bycatch. While fisheries pingers have been shown to effectively reduce bycatch, they do not eliminate it entirely. Therefore, their use should be considered an interim solution until alternative, equally effective bycatch reduction methods are developed and implemented (UNEP/ASCOBANS, 2016a).

Logbook records are necessary: in order to assess the effectiveness of pingers it is necessary that a record of the pinger use is kept. It should be stated in the logbook whether a net is equipped with a specified acoustic device with the aim of bycatch reduction. Contracting Parties are encouraged to inform fishers to report pinger use in their logbooks to support the work of the ICES Working Group on Bycatch of Protected, Endangered and Threatened Species (WGBYC) in order to allow a scientifically based bycatch assessment.

Catch-and-aquaculture-protection ADDs

Consider non-acoustic alternatives: current commercially available catch-and-aquaculture-protection ADDs have already proven unwanted side effects on protected species such as harbour porpoises. Where possible, non-acoustic alternatives should therefore be considered before using acoustic devices (e.g., excluding devices in fish chambers of traps, use of alternative fishing gear to static nets, more rigid netting materials, etc.).

Assess adequacy: the adequacy of ADD use in aquaculture should be assessed and justified against non-acoustic alternatives (see Appendix E) as part of the permitting process. Some fisheries do not require a permitting procedure resulting in a special need to handle ADDs with a high level of precaution. ADDs using low frequency signals have longer ranges, causing potential larger scale impacts on various species including marine mammals, many fish and also invertebrate species.

Avoid noise in porpoise areas: If ADDs are considered in areas of high or medium importance to harbour porpoises (Figure 1, Sveegaard *et al.* 2022) the type and frequency range of ADDs shall be chosen in a way which has the lowest impact on harbour porpoises (for example, by the use of startle response devices).

Consider risks for biota (strategic assessment): to avoid negative effects on protected species (including the species to be deterred), a strategic assessment of catch-and-aquaculture-protection ADD use may be necessary due to the potential long-term and large-scale impacts as part of the permitting process and any required environmental impact assessment for the aquaculture facility. The risk to hearing (section 5.2) and disturbance of protected species need to be taken into account.

Limit the number of devices and source level to the "effective" range required to protect fisheries resources in cases when no other measures are feasible. In order to assess the effective range, manufacturers' statements may not be suitable/sufficient. Thus, only results of controlled scientific experiments/studies (displacement, behavioural reactions) which use underwater sound measurement standards (i.a. DIN EN ISO/IEC 17025:2018) are to be taken into account.

Startle preferred over loudness: the use of ADDs which utilise a startle deterrence approach should be preferred to devices which deter using high-amplitude signals to limit the potential for tolerance and habituation of species to be deterred. The startle signals of devices should be specific to the species to be deterred and the level of signals and duty cycle as low as possible. However, due to the lower frequency used, their effect on fish and invertebrate species are also to be assessed.

Frequency alteration can reduce large scale effects: currently catch-and-aquaculture-protection ADDs that work via intensity aim at displacing seals or marine mammals to the highest possible level using frequencies between 0.5 to 40 kHz. No plans are known to the authors to develop more nature friendly solutions, that reach the goal of excluding seals from a particular area while minimising the acoustic footprint and minimising the impact on not to be deterred species like porpoise. To protect the catch within fishing gear or finfish in aquaculture, the reported displacement ranges for harbour porpoises (up to 12 km, Dähne *et al.* 2017) are much too large, while displacement ranges for seals reported in the scientific literature is extremely variable (from a few metres to kilometres), but it is highly likely that displacement ranges are much lower for seals than for porpoises (Mikkelsen *et al.* 2017). A possible solution to reduce unwanted large-scale side-effects would be to alter the signals' frequency, since lower frequencies do not propagate well in very shallow waters and higher frequencies that are still audible to seals have a higher absorption (much depending on the salinity), both resulting in lower acoustic footprints than current ADDs have. Identifying conditions under which this could be an option, however, would require research (for details see Appendix G).

Ramp-up to reduce risk of hearing impairment: in order to reduce the risk of hearing impairment of species to be deterred and other species, catch-and aquaculture-protection ADDs must have a function which increases the source level and/or the rate of sound emission gradually when switched on).

Monitor effectiveness: long-term effectiveness of ADDs at deterring seals is important for protecting the fisheries/aquaculture resource. Effectiveness should be monitored, and if effectiveness decreases, the conditions for operation of the ADD is no longer in place.

No catch-and-aquaculture-protection ADDs in fisheries: to limit the side-effects and impacts on protected species such as the harbour porpoise and on Marine Protected Areas (MPAs), the choice of the device is important. It has been shown in modelling studies that the risk of TTS in harbour porpoises is significantly reduced in some newer generation devices (see Appendix D). Due to the potential to cause large-scale impacts using catch-and-aquaculture-protection ADDs in fisheries (e.g. gillnet and trap fisheries) is not recommended.

9.3. Recommendations to conservation managers

Displacement ADDs must not by themselves induce a larger impact than the impact they are to mitigate:

- Adapt the number of devices, source level and frequencies to the "effective" range required to ensure deterrence while also protecting sensitive species.
- The signal parameters should be matched to the species.
- The (species specific) effective deterrence distances must be documented through controlled experiments/studies by independent parties and not left to the manufacturers' statements.
- Appropriate sound propagation models, which incorporate local environmental conditions such as water depth and salinity, must be used in assessments of impact ranges. In order to reduce the risk of hearing impairment of species to be deterred and other species,

displacement ADDs must have a function which increases the source level slowly when switched on.

In addition, independent studies on intended ADD effects and unwanted side-effects and their mitigation are needed.

- Controlled studies on the efficacy of ADDs are necessary to provide reasoning for their use, since negative impacts have already been shown to affect protected species like harbour porpoises.
- Study other species which can be affected: ringed seal, invertebrates, high frequency specialists in fish.
- Better understanding of current/historic porpoise distribution (SAMBAH2, national monitoring and other research projects)- with a link to conservation objectives by HELCOM/ASCOBANS, Jastarnia Plan (UNEP/ASCOBANS, 2016a).
- Study possible (population-) impact on intentionally deterred species (grey seals, harbour seal, ringed seal, harbour porpoises).
- Study/quantify the effects of disturbance on the energy balance of affected species in order to assess cumulative, long-term effects.
- Compare / review “old” and “new” devices.

Appendix A Regulatory framework

This appendix contains regulations at international, European and national level connected to ADDs and the biota they affect. The regulations have been organised by year of signature or adoption.

International framework

Convention on the Protection of the Marine Environment of the Baltic Sea Area (Helsinki Convention, 1974, 1992)

The Helsinki Convention (HELCOM 1974, 1992) addresses the protection of the Baltic Sea from all sources of pollution (including noise) from land, air and sea. It commits the signatories to take measures on conserving habitats and biological diversity and for the sustainable use of marine resources. Promoting the use of Best Available Technology and Best Environmental Practice (BAT/BEP) is a fundamental principle of the Convention as laid out in Art. 3.

Convention on the Conservation of European Wildlife and Natural Habitats (Bern Convention, 1979)

The Bern Convention is a binding international legal instrument in the field of nature conservation. The conservation of wild flora and fauna and their natural habitats in Europe is under the provisions of the Convention on the Conservation of European Wildlife and Natural Habitats. All small cetaceans regularly present in the Baltic and North Seas are listed in its Appendix II as strictly protected species. The deliberate damage to or destruction of breeding or resting sites as well as deliberate disturbance of wild fauna as specified in Appendix II, particularly during the period of breeding, rearing and hibernation is prohibited, insofar as disturbance would be significant in relation to the objectives of the Convention.

Convention on the Conservation of Migratory Species of Wild Animals (CMS or Bonn Convention, 1979)

The Convention on the Conservation of Migratory Species of Wild Animals or Bonn Convention (CMS, Bonn Convention 1979) is an environmental treaty of the United Nations laying a foundation for internationally coordinated conservation measures throughout the range of migratory species. Under the Convention there is a regional Agreement on the Conservation of cetaceans, ASCOBANS (1992). The Baltic Proper harbour porpoise population has recently been added to CMS Appendix I which lists species or populations which are endangered and require immediate conservation action.

Agreement on the Conservation of Small Cetaceans of the Baltic, North East Atlantic, Irish and North Seas (ASCOBANS, 1992)

This Agreement is a regional agreement under the Convention on the Conservation of Migratory Species of Wild Animals (CMS, Bonn Convention). It recognises that by-catches, habitat deterioration and disturbance (including noise) may adversely affect populations of small cetaceans. In an Annex to the agreement text, the prevention of significant disturbance, especially of an acoustic nature specifies measures with respect to habitat conservation and management. Also, the use of fisheries pingers is related to the Agreement.

In various resolutions, the conservation of small cetaceans such as the harbour porpoise in the Baltic Sea is specified. Thus, Resolution 9.2 on the Baltic Proper harbour porpoise (UNEP/ASCOBANS, 2020) encourages parties to carefully monitor and study the possible disturbance and other effects on harbour porpoises of ADDs, both pingers and other types of devices. Resolution 8.8 Addressing the Threats from Underwater Munitions (UNEP/ASCOBANS, 2016b) recommends the development of international guidelines for removal of munitions including the advising on mitigation techniques such as the use of ADDs to reduce the risk of harm to marine mammals when UXO are detonated. Resolution 8.3 Revision of the Recovery Plan for Baltic Harbour Porpoises (UNEP/ASCOBANS, 2016a) involves actions on improving the knowledge on potential population-level effects of the use of pingers, and develop acoustic devices for bycatch mitigation further. Further to continue or implement the use of ADDs ("pingers") and acoustic alerting devices proven to be successful where and when deemed appropriate. Further actions on monitoring and mitigating the impact of underwater noise are also included. Resolution 8.11 on CMS Family Guidelines on Environmental Impact Assessment for Marine Noise Generating Activities (UNEP/ASCOBANS, 2020b) is also of special importance when it comes to ADD use. Chapter X includes EIA Guidelines for pingers (acoustic deterrent/harassment devices, navigation). Resolution 6.2 on Adverse Effects of Underwater Noise on Marine Mammals during Offshore Construction Activities for Renewable Energy Production (UNEP/ASCOBANS, 2009) mentions the development of effective mitigation measures, guidelines and technological adaptations to minimise any potentially significant adverse effects from offshore construction activities. This would also include the use of ADDs.

With respect to harbour porpoises, ASCOBANS has defined a conservation objective including 'to restore and/or maintain biological or management units to/at 80% or more of their carrying capacity'. This is of special importance with respect to ADDs as some devices have the potential to scare porpoises out of their habitat and thus reducing the carrying capacity. This means that the population could be decreasing although the conservation objective is achieved which is not in the sense of the Agreement.

European regulations

The EU Habitats Directive (Council Directive 92/43/EEC)

Important Articles of the Habitats Directive (ECC 1992) which relate to the use of ADDs are i.a. maintaining or restoring populations of species or populations at favourable conservation status (FCS) (Art. 1, 2 and 3), establishing necessary conservation measures in protected areas including assessing the impact of any plan or project with respect to the integrity of the site as well as avoiding significant disturbance in special areas of conservation (Art. 6), establishing a system of strict protection of Annex IV species (such as harbour porpoise) prohibiting among others deliberate capture and killing, deliberate disturbance and deterioration or destruction of breeding sites or resting places and monitor incidental capture and killing of specimens (Art. 12), taking and exploitation of Annex V species (such as the three seal species in the Baltic Sea) is compatible with their being maintained at a FCS (Art. 14), prohibiting the use of all indiscriminate means capable of causing local disappearance of, or serious disturbance to populations of Annex V species (Art. 15). The assessment of a FCS includes main pressures and threats, which could also be of an acoustic nature.

The Marine Strategy Framework Directive (Directive 2008/56/EC of the European Parliament and of the Council)

The Marine Strategy Framework Directive (MSFD) was put in place to protect the marine ecosystem and the biodiversity. A fundamental principle of the MSFD is the ecosystem approach. To help EU countries achieve a good environmental status, the Directive sets out 11 qualitative descriptors. Out of these, D1 on biodiversity and D11 on underwater noise are most related to ADDs use. Descriptor 11 states that introduction of energy, including underwater noise, is at levels that do not adversely affect the marine environment. Noise emissions from ADDs can be interpreted as impulsive noise which is dealt with under criterion D11C1 which is: the spatial distribution, temporal extent, and levels of anthropogenic impulsive sound sources do not exceed levels that adversely affect populations of marine animals. The assessment is made regionally (under HELCOM for the Baltic Sea area) and the EU has set a threshold value for impulsive noise : For short-term exposure (1 day, i.e., daily exposure), the maximum proportion of an assessment/habitat area utilised by a species of interest that is accepted to be exposed to impulsive noise levels higher than the Level of Onset of Biologically adverse Effects (LOBE), over 1 day, is 20 % or lower (≤ 20 %). For long-term exposure (1 year), the average exposure is calculated. The maximum proportion of an assessment/habitat area utilised by a species of interest that is accepted to be exposed to impulsive noise levels higher than LOBE, over 1 year on average, is 10 % or lower (≤ 10 %).

The Common Fisheries Policy (Regulation (EU) 1380/2013 of the European Parliament and of the Council)

Among the objectives of the Common Fisheries Policy (CFP) (EU, 2013) (Art. 2) are ensuring that fishing and aquaculture are environmentally sustainable, applying the precautionary principle to fisheries management, implementing the ecosystem approach to fisheries management so as to ensure that negative impacts of fishing activities on the marine ecosystem are minimised, endeavouring to ensure that aquaculture and fisheries activities avoid the degradation of the marine environment. Although not specifically highlighted in the Regulation, degradation could also be of an acoustic nature.

Technical Measures Regulation (Regulation (EU) 2019/1241 of the European Parliament and the Council)

In the Technical Measures Regulation (EU, 2019) there are specific rules on areas and fishing gears for which the use of fisheries pingers is mandatory. EU Member States shall take necessary steps to monitor and assess by means of scientific studies or pilot projects, the effects of acoustic deterrent device use over time in the fisheries and areas concerned (Annex XIII Part A 1.3). Thus, it is important to keep record of the fisheries in which fisheries pingers are used, see also Control Regulation, see below.

Details related to pinger signals are specified under Implementing Regulation (EU) 2020/967, see below.

Regulation on detailed rules on signal and implementation characteristics of ADDs (Commission Implementing Regulation (EU) 2020/967)

This regulation (EU 2020) implements the use of fishery pingers and i.a. specifies the signal characteristics and spacing of fishery pingers. Derogations from technical specifications are possible if such devices are at least equally effective (Art. 2.3).

Regulation on measures to reduce incidental catches of Baltic Proper harbour porpoises (Commission Delegated Regulation (EU) 2022/303)

For the protection of the critically endangered harbour porpoise population in the Baltic Proper some fisheries management measures have been laid down in this regulation (EU 2022) besides the seasonal or year-round closure of areas, there are areas in which pingers are mandatory for all vessels in order to reduce porpoise bycatch. These areas are in parts of Puck Bay (Poland) and Sydvästskånes utsjövatten (Sweden).

Fisheries Control Regulation (Regulation (EU) 2023/2842 of the European Parliament and of the Council of 22 November 2023)

The Fisheries Control Regulation (EU, 2023) has specific rules for completion and submission of fishing logbooks. A logbook contains i.a. the type of gear, mesh size and dimension (Art. 14). This can include the information whether a net was equipped with fishery pingers. Although this is not specifically mentioned in the Regulation, this is important information for bycatch assessments, e.g., under the MSFD, see related section. The entry in the logbook on the use of fishery pingers or alerting devices is also related to the implementation of pinger obligations (such as those defined in Regulation (EU) 2019/1241 and 2022/303) and allows its control. Thus, it should be stated in the logbook whether a net is equipped with any acoustic device with the aim of bycatch reduction.

Further, the Fisheries Control Regulation has specific rules for the tracking of vessels in or near fishing restricted areas. These can include areas in which the use of fishery pingers is mandatory (see the section on Regulation (EU) 2022/303).

National regulations

In October 2024 Sweden introduced national regulations for the use of ADDs that apply to all fishing vessels below 12 m using static gear, fyke nets or gill nets in parts of the Baltic Sea sub-division 24 (HVMFS, 2024).

Appendix B conservation status of relevant mammal species

Marine mammal species occurring in the HELCOM area include

- the harbour porpoise with its two populations in the Belt Sea and in the Baltic Proper
- the grey seal (one population in the entire Baltic Sea),
- the harbour seal (a metapopulation ranging from Kattegat into the Western Baltic Sea and a separate rare Kalmarsund population), and
- the ringed seal with a population in the Gulf of Bothnia and another one in the Southwestern Archipelago Sea, Gulf of Finland and Gulf of Riga.

Below we discuss species to be deterred and species of relevance with respect to negative side effects with a particular focus on those which have populations which are Endangered or Critically Endangered in the HELCOM red list (table 2).

The grey seals and harbour seals are the main species to be deterred, especially with catch-and-aquaculture-protection ADDs. But ADD use may also have negative impacts on individuals or the population for example by habitat deterioration, exclusion from important habitats, auditory impairment or by exerting acute or chronic stress.

With respect to fisheries pingers and displacement ADDs the harbour porpoise is the species to be deterred (. This species suffers negative impacts from ADD use (all types of ADDs as defined in chapter 3), but especially the ones which produce the most intense sound such as catch-and-aquaculture-protection ADDs. This species requires special attention because the subpopulation of the Baltic Proper is critically endangered with only about 500 individuals left (see box below). The Belt Sea population is declining (Owen *et al.* 2024) and its HELCOM Red List status is Endangered (table 2).

The ringed seal can be the species to be deterred, especially with catch-and-aquaculture-protection ADDs. ADD use may have negative impacts on individuals or the population for example by habitat deterioration, exclusion from important habitats, auditory impairment or by exerting acute or chronic stress. This species requires special attention as the management unit of the Southwestern Archipelago Sea, Gulf of Finland and Gulf of Riga has low reproduction rates and suffers from climate change (see box below). Its HELCOM Red List status is Endangered (table 2).

<u>Species/populations requiring special attention due to their bad conservation status</u>

Harbour porpoise

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Harbour porpoises in the Baltic Sea are threatened. The updated HELCOM Redlist (HELCOM 2025) lists the harbour porpoise Belt Sea population as Endangered (A2ad) and the Baltic Proper population as Critically Endangered (C2a(ii)).

The Baltic Proper harbour porpoise was once numerous and wide-spread in the Inner Baltic Sea, ranging all the way up to the northern Gulf of Bothnia. Today, only a few hundred animals remain, and they are mostly concentrated around the offshore banks south of the island of Gotland. However, the distribution still covers inshore waters of the Finnish Archipelago Sea, the Swedish coastline in the west, the Pomeranian Bay and the Polish Gulf of Gdansk and Puck Bay in the southeast. In order for the population to recover and reclaim all of its former range, it is imperative that the environment, including the level of underwater noise, has the best status possible, also in areas where porpoises are not common today. Given the many threats that impact the Baltic Proper harbour porpoise, including environmental contaminants and decreasing quality and quantity of prey, there is a need to mitigate underwater noise as far as possible, to avoid disturbance that is likely to impact both foraging and reproduction, and hence the carrying capacity for the population.

The Belt Sea harbour porpoise population has recently been found to be in decline, likely at least partly as a result of high bycatches (Owen et al 2024) and contamination (ASCOBANS 2012). Another likely threat is prey depletion as porpoises appear to be at their energetic limits. They were found to feed on very small lipid-poor fish, and due to energetic requirements this makes them vulnerable to disturbance which interrupts their feeding (Wisniewska *et al.* 2016. Rojano-Doñate *et al.* 2018). Thus, underwater noise sources such as shipping, recreational boating, seismic, sonars, offshore wind, etc. already have a high potential for negatively affecting their energy budget and may have repercussions on the population level. Any additional disturbance will worsen this and thus the introduction of new sound sources into their habitat must be avoided. A further aspect to be considered is increasing chronic stress and likely population effects.

Ringed seal

(c) Ralf Grunewald

Ringed seals in the Baltic Sea are threatened. The updated HELCOM Redlist (HELCOM 2025) lists the southern management units of the Ringed Seal in the Southwestern Archipelago Sea, Gulf of Finland and Gulf of Riga as Endangered (C1) and the management unit in the Gulf of Bothnia as vulnerable (A3c). None of the ringed seal management units achieves good environmental status (HELCOM 2023). Ice conditions are changing in both management areas. Ringed seals depend on snow caves for successful reproduction. In the Southwestern Archipelago Sea, Gulf of Finland and Gulf of Riga, they show no signs of increase in any of the areas. In the Bothnian Bay, the rate of increase is below the indicator threshold of 7%. Additional stress on the population is from by-catch, hunting, and contamination with pollutants. There is a need to reduce additional disturbance.

Appendix C ADD use for bycatch prevention

For fisheries pingers, the European Commission laid down detailed rules on signal characteristics, source levels, fundamental frequency, pulse duration and intervals (EU 2020). Two different sets of implementation characteristics are given. Set 1 includes digital pingers with 20-160 kHz wide band sweeps or 10 kHz tonal signals with high-frequency harmonics at 145 dB re 1µPa 1m with 300 ms duration and randomised or 4 s intervals. Set 2 includes analogue 10 kHz 300 ms signals at 130 to 150 dB source level produced at 4 s intervals. 'Seal-safe pingers' create signals above a seal's best hearing frequencies, e.g. sweeps ranging from 50 to 120 kHz. Their aim is to avoid attracting seals to fishing nets equipped with pingers.

With regard to pinger usage and implementation in gillnet fisheries, concerns have been raised with regard to costs, noise pollution, habitat exclusion, habituation, and population effects (Dawson *et al.* 1998, Gearin *et al.* 2000, Kindt-Larsen *et al.* 2018, Lusseau *et al.* 2023). Habituation is a concern as it can potentially lead to less effective pingers, thus increased bycatch, as pinger trials have shown that porpoise's approach pingers more closely over time (Cox *et al.* 2001, Kindt-Larsen et al 2018). Despite these concerns, pingers trials in commercial fisheries have not found evidence of an increase in bycatch rates over time (Palka *et al.* 2008, Carretta and Barlow 2011). In European fisheries, pingers have only been used to a limited extent in gillnet fisheries (ICES 2012) and long-term effects have not, therefore, been recorded in European Union waters. The spacing of pingers has been shown to play an important role in relation to bycatch rates. On one hand Larsen *et al.* showed that the spacing of Aquamark100 pingers could be increased from 200 to 455m without increasing the bycatch rate while Kindt-Larsen *et al.* (in submission, fisheries research) found that when increasing the pinger spacing of the "Banana-pinger" (FISHTEK marine) the bycatch rates increased accordingly.

A subset of ADDs in this category are the so-called alerting devices, which are also designed with the purpose of preventing bycatch, but by means of signals that are believed to increase awareness of porpoises (porpoise communication, predator signals etc.) rather than deter them from the gill nets. Currently, only one device of this type is available commercially (PorpoiseAlert, PAL). Whether this device fulfils the primary requirement of preventing bycatch without changes in the efficacy to mitigate bycatch as the deterring devices (pingers) is still unclear.

In the later years other types of pinger signals have been tested in commercial gillnet fisheries. One is the so-called PAL which reproduces natural aversive communication signals of harbour porpoises. Culik *et al.* (2015) demonstrated that harbour porpoises reacted to the PAL signal by increasing their distance to the signal source by 32 m, while increasing their echolocation rate by 10%. The PALs have since been tested in commercial fisheries in the Western Baltic Sea, showing a bycatch reduction of 64.9 % (95 % confidence interval (CI): 8.7–88.7 %) with spacing of PAL devices at 210 m and 79.7 % (95 % confidence interval (CI): 3.7–95.3 %), if spacing is kept at <=200 m (Chladek *et al.* 2020). The PAL have however also been tested in Iceland with mixed results that failed to replicate the success (ICES 2021). PALs have been handed out free of charge to fishers in Schleswig-Holstein (roughly 2.000 devices) under premises of a voluntary agreement that obligates participating fishers to use PALs on their nets or reducing their net lengths (conditions changed over time since 2017 after implementation).

The PorpoiseAlert mimics harbour porpoise high-frequency narrow band click trains at 133 kHz with a source level of 158dB re 1µPa 1m (peak) with random 1-3 s click trains at randomised intervals. The frequency used is close to the frequency which harbour porpoises use for echolocation (Villadsgaard *et al.* 2007) and is outside the hearing range of seals (Kastelein *et al.* 2009, 2018). However, side lobes of the signal may be audible to seals at close range.

Appendix D ADD use for deterring seals from aquaculture

Below is a short summary of evidence on the effects of exposure to noise produced by catch-and aquaculture-protection ADDs used by the aquaculture sector on marine mammal species found within the Baltic Sea.

<u>Effects of catch-and aquaculture-protection ADDs used in aquaculture on phocid seals</u>

Although the species to be deterred by catch-and aquaculture-protection ADDs in the aquaculture industry, the responses of phocid seals exposed to ADD noise have been found to show considerable variations with some individual seals demonstrating strong avoidance reactions during exposure to noise from these devices, while others showed little to no response.

For harbour seals, Yurk and Trites (2000) found that over a short period (14 days) an Airmar catch-and aquaculture-protection ADD was the most effective method of reducing the number of harbour seals feeding on out-migrating salmonid smolts in the Puntledge River, USA. Their results indicated fewer seals were present during use of the catch-and-aquaculture-protection ADD when compared to control nights (0.4 versus 8 animals). Conversely, Mikkelsen *et al.* (2017) reported that harbour seals moved closer to a loudspeakers broadcasting a simulated ADD signals (500 ms tone bursts at 12 kHz with source peak-to-peak level of 165 dB re 1 µPa), and harbour seals were found to showed no change in response to Airmar dB Plus II catch-and aquaculture-protection ADDs when used at an aquaculture site in Canada, with seals approaching within 45 m of the source (Terhune *et al,* 2002).

For grey seals, Gordon *et al.* (2019) conducted controlled exposure experiments using Lofitech Seal Scarer and Mohn Aqua MAG Seal Deterrent devices, they found that tagged grey seals responded at up to 3123 m (predicted received level: 111 dB re 1 µPa RMS) and 1037 m (predicted received level: 133.6 dB re 1 µPa RMS) from each device type, respectively. Contrary to this, Götz and Janik (2010) observed individual grey seals approaching an Airmar dB Plus II (which has the same acoustic output as a Mohn Aqua MAG; McGarry *et al.,* 2022) ADD within 40 m and a Lofitech Seal Scarer within 60 m, corresponding to estimated received sound pressure levels of 135 to 144 dB re 1 µPa, suggesting these same devices will not always deter individual grey seals to the extents reported by Gordon *et al.* (2019).

Newer catch-and aquaculture-protection ADDs have attempted to reduce depredation by triggering an acoustic startle response in pinnipeds. Götz and Janik (2015) found that the number of harbour seals dropped sharply within 250 m of a prototype catch-and aquaculture-protection ADD designed to elicit a startle response (200 ms long, 2-3 octave band noise pulses with a peak frequency at 1 kHz with a source level of ~180 dB re 1 µPa RMS) over a 2-month period when deployed at an aquaculture site on the west coast of Scotland, when compared to control periods. When trials of this device were then extended to cover a full production cycle (Götz and Janik, 2016), results indicated that seal predation was significantly reduced when the catch-and aquaculture-protection ADD was active. However, counter to what was expected based on the previous study from 2015, seals were still seen within 100-200 m of the transducer, which authors concluded was due to more animals surfacing to reduce the effect of the startle device.

Few studies have considered the potential impact of these devices on seal hearing. However, Findlay *et al.* (2022) estimated that one tagged harbour seal and up to 1.7% of all 10 km zones surrounding protected haul out sites for grey and harbour seals on the west coast of Scotland were exposed to catch-and aquaculture-protection ADD noise levels which exceed the temporary threshold shift (TTS) from a continuous noise source over a 24-hour period in these species (181 dB re 1 $\mu Pa^2 s$; Southall *et al.*, 2019). Additionally, Lepper *et al.* (2014) estimated that a permanent threshold shift (PTS; based on the Lucke *et al.* (2009) threshold of 200 dB re 1 µPa) could occur in seals if exposed to catch-and aquaculture-protection ADDs. For example, authors' noise levels were predicted to exceed a PTS threshold defined for harbour seals if they remained within 100 m of an Airmar dB Plus II device for 3.3 hours. These studies indicating a potential auditory risk to the species catch-and aquaculture-protection ADDs are intended to deter if individuals remain within areas exposed to ADD noise for prolonged periods.

To our knowledge, no studies have considered the potential for exposure to catch-and aquaculture-protection ADDs used by the aquaculture sector to affect the behaviour or hearing of the vulnerable Baltic ringed seals (*Pusa hispida*).

<u>Effects of catch-and aquaculture-protection ADDs used in aquaculture on harbour porpoises</u>

Exposure to noise from catch-and aquaculture-protection ADD used by the aquaculture sector to deter pinnipeds has been found to result in several effects on harbour porpoises, a species which is incidentally affected by the noise from these devices at aquaculture sites, including auditory impairment, changes in behaviour and large-scale displacement from habitats.

To date only one study has measured a TTS in a captive harbour porpoise caused by a catch-and aquaculture-protection ADD. Schaffeld *et al.* (2019) measured a 6 dB TTS at 20 and 28 kHz after exposure to an artificial ADD signal with a fundamental frequency of 14 kHz and sound exposure levels of 142 and 146.9 dB re 1 $\mu Pa^2 s$, respectively. The potential for harbour porpoises to experience TTS and/or PTS during exposure to catch-and aquaculture-protection ADD noise has also been assessed via several modelling studies. Lepper *et al.* (2014) estimated that a PTS (based on the Lucke *et al.* 2009 threshold of 200 dB re 1 µPa peak-to-peak) could occur in harbour porpoises if animals were exposed to catch-and aquaculture-protection ADDs. For example, noise levels were predicted to exceed a PTS threshold if harbour porpoises remained within 500 m of an Airmar dB Plus II device for 5.5 hours. Todd *et al.* (2021) predicted that a range of catch-and aquaculture-protection ADDs could cause TTS in very high-frequency cetaceans at ranges from 4 to 31 km from aquaculture sites depending on the device used. However, contrary to the predictions made by Todd *et al.* (2021), Hiley *et al.* (2021) reported that the risk of TTS in harbour porpoises from exposure to a modified catch-and aquaculture-protection ADD which was designed to elicit startle responses (peak frequency 10.5 kHz, range 5.5-20.5 kHz, 27 sounds total and source level 180 dB re 1 µPa RMS) was found to extend up to only 9.1 m for a 15-minute exposure and 13.4 m for a 30-minute exposure, which authors concluded was far less than TTS impact zones of other commercially available catch-and aquaculture-protection ADDs. Todd *et al.* (2021) and Findlay *et al.* (2021) also considered the cumulative effect of multiple aquaculture sites operating catch-and aquaculture-protection ADDs concurrently on the west coast of Scotland. Here, results indicated an overall increase in the amplitude and spatial extent of ADD noise, with Findlay *et al.* (2021) highlighting that the use of catch-and aquaculture-protection ADDs at 120 aquaculture sites concurrently likely led to up to 37% of a protected habitat for harbour porpoises (*Special Area of Conservation Inner Hebrides and Minches*) on the west coast of Scotland being exposed to noise sufficient to induce a TTS in this species.

Behavioural studies on the responses of harbour porpoises to catch-and aquaculture-protection ADDs have documented strong directional movements away from the source (Elmegaard *et al.*, 2023; Graham *et al.*, 2023), and a higher number of surfacings and increased swimming speeds (Kastelein *et al.*, 2015). These studies indicate that exposure to this noise source may result in an increase in energy expenditure for this species. Harbour porpoises have also been shown to reduce their echolocation behaviour during exposure to catch-and aquaculture-protection ADDs used by the aquaculture sector. For example, Elmegaard *et al.* (2023) found that four out of six tagged harbour porpoises reduced their echolocation click rate by an average of 54% in response to the onset of 14 kHz pulses produced by a Lofitech Seal Scarer. With two individuals reducing the click output level by 8 dB (95^{th} percentile).

Authors concluded that the reduction in echolocation made by these tagged individuals was likely a strong anti-predator response made in response to noise from this ADD type, which may have impeded their foraging activity and resultant energetic intake, assuming individuals were not able to compensate for lost foraging opportunities post exposure.

When used at aquaculture sites, catch-and aquaculture-protection ADDs including have been found to cause displacement of harbour porpoises at distances up to 4.3 km (Johnston, 2002; Olesiuk *et al.*, 2002; Northridge *et al.*, 2010; Benjamins *et al.*, 2018). Evidence also indicates that harbour porpoises will continue to utilise areas close to aquaculture sites using catch-and aquaculture-protection ADDs, suggesting that some individual variation in response may exist in this species. For example, Northridge *et al.* (2010; 2013) acoustically detected harbour porpoises in close proximity (<200 m) to ten active Airmar dB Plus II ADDs which had been used at an aquaculture site for several months, and found only weak to minimal responses to Terecos Type DSMS-4 devices out to a distance of 1.2 km; thus, concluding that catch-and aquaculture-protection ADDs did not completely displace all individuals from the study area. Nonetheless, a recent study by Findlay *et al.* (2024) used data collected over a 9-year period (2011-2019) on the presence of harbour porpoises and catch-and aquaculture-protection ADDs collected across the west coast of Scotland to document that harbour porpoises continued to respond to repeated and chronic ADD noise from aquaculture on this coastline. This response was suggested to begin to occur when catch-and aquaculture-protection ADD noise reached an estimated very-high frequency cetacean weighted broadband (2-40 kHz) received level in excess of 108 dB re 1 µPa RMS. Assuming the individuals in this study did not change their echolocation behaviour as has been suggested to occur by Elmegaard *et al.* (2023), authors also estimated that 34% of the total undisturbed population were predicted to become displaced from portions of their habitat due to the presence of catch-and aquaculture-protection ADDs at aquaculture sites. These results suggest that it is possible for a significant proportion of harbour porpoise populations to become displaced from biologically important habitat used for foraging, resting and reproducing if exposed to widespread, chronic and repeated catch-and aquaculture-protection ADD noise.

<u>Effects of catch-and aquaculture-protection ADDs used in aquaculture on other taxa</u>

To the authors' knowledge there are no systematic studies on unwanted side effects of ADD use with respect to fish, diving birds and invertebrates. Since ADDs use a large range of frequencies (see table 3) including harmonic frequencies, i.e., multiples of the fundamental frequency, there is a potential for impact on a number of fish and invertebrate species which have a reasonable hearing sensitivity at these frequencies. The hearing abilities of different species control how loud a species perceives a broadband sound, and thus there may be differences in response between species affected and ADDs used.

Most hearing generalists in fish are sensitive to frequencies not extending much above 1 kHz. However, there are some hearing specialists which can perceive higher frequencies. This includes herring with a hearing sensitivity extending to 3 or 4 kHz. Some species have even been shown to be sensitive to ultrasound such as some members of the family Alosinae (Popper 2008). The twaite shad (Alosa fallax) belongs to this family and might react to the sounds of catch-and aquaculture-protection ADDs operating at high frequencies.

In fish and invertebrates, various kinds of noise can for example disrupt behaviour, interrupt foraging, compromise communication and mating, affect larval settlement and development, and cause stress. Noise-induced stress can compromise reproduction, health, and immune function. At close range, hearing of some fish and invertebrate species may be impaired by loud sound sources (such as some ADDs) (Weilgart *et al.* 2018).

Also diving birds may be affected by ADD sounds as a side effect. It has been shown that common guillemots (Uria aalge) avoided a 1.5 kHz pinger (Melvin *et al.* 1999).

Appendix E Alternatives to ADDs

Alternatives in fisheries

An alternative to static nets which experience a high depredation by seals in some areas could be the use of seal-safe fish traps such as a pontoon trap. It depends on the target species of the fishery and on hydrographic features whether such traps can replace static nets (Hemmingsson *et al.,* 2008). Recently, the pontoon trap has been further developed for use in deeper and more open waters (Ljungberg *et al.,* 2025). However, seals are still often bycaught in such fish traps (Vanhatalo *et al.,* 2014). In such cases, the use of exclusion cords or excluder grids will reliably keep seals out of the trap (Lehtonen, E., Suuronen, P., 2004).

Alternatives in aquaculture

Numerous non-acoustic mitigation options have been identified and/or employed to reduce the effects of pinniped depredation at aquaculture sites (see reviews by Coram *et al.*, 2014; Thompson *et al.*, 2021). These include but are not limited to approaches such as improved animal husbandry at aquaculture sites; reduced stock density within net pens; regular removal of dead fish; modification of the cage floor to include a seal blind to make the mort sock less visible to pinnipeds or addition of a false bottom; use of electric field barriers; conditioned taste aversion; use of anti-predator nets (e.g., extremely strong and durable double-layer netting held under tension by rigid hoops); maintaining correct net tensioning; and using stronger and stiffer net materials (e.g., high-density polyethylene netting).

Alternatives in offshore construction

For the construction of offshore wind farms the monopile is by far the most commonly used method and ADDs often considered to mitigate hearing impairment by the construction noise (impact piling) by scaring harbour porpoises outside the zone of hearing impairment. The use of low-noise or noise-free alternatives would avoid the necessity of ADD. The *OSPAR inventory of measures to mitigate the emission and environmental impact of underwater noise* (OSPAR Commission, 2020) lists among others the following alternative foundation methods for offshore wind turbines:

- drilled foundations;
- gravity base foundations;
- suction bucket jackets; and
- floating wind turbines.

A promising new method is the jetting method for monopiles which has successfully been tested in sandy soils at the Gode Wind 3 offshore wind farm in the North Sea but may also be used for more complex soil conditions in the future (Buljan 2024).

Alternatives in UXO removal

Blow-in place is a standard operation for UXO clearing but it can severely injure or kill marine animals such as fish and mammals. Although due to imminent danger it may often be necessary to take care of UXO right away, in many cases UXO can be recovered without explosion if an object is safe to handle. In some cases, when recovery is not an option, it may be possible to relocate and blast an object at a less sensitive site. With respect to the shock wave a less sensitive site could be in shallow waters or a bay where the coastline or sand bar forms a natural barrier for the radiation of underwater noise. In shallow water much of the explosion energy breaks through the water surface and less energy couples to the water column. Ideally, blasts take place above the surface which is an option in tidal waters where UXO can be relocated to a shallow area at high tide and blasted at low tide (Bleicher, 2021). A method to float UXO to the surface and detonate it in air is under development. Specific objects such as certain British air-dropped mines can be defused by using detonating cord for cutting and thereby separating the instrument box from the main charge (Kinast, 2021). This would reduce the energetic conversion of explosive mass from a few hundred kg to 240 grams only. Since a few hundred grams can also injure marine mammals, ADDs are still needed but it may be possible to use less powerful sources.

Innovative approaches under development

Interactive ADDs which only produce a signal when required (in fisheries pingers when porpoises are present, in catch-and-aquaculture-protection ADDs when seals are present) are under development and could help reduce the introduction of unnecessary noise into the Baltic Sea.

Appendix F Configurable systems of displacement ADDs

The APD system generates eight different acoustic deterrence signals with durations between 9 and 18 s in a random order (Kastelein *et al.*, 2017). There is a pause of 3 to 10 s between each signal. The signals include sweeps and bursts with frequencies between 60 and 150 kHz and are played with a source level of up to 172 dB re 1 μPa 1 m. The sound power is gradually increased in the first five minutes to give the animals the opportunity to move away from the sound source in time before the maximum sound power of the APD is reached.

The FaunaGuard system is based on the same principle as the APD and generates randomized sound patterns between 60 and 150 kHz, which can be selected from nine different signal sequences. In the first five minutes of operation, it generates increasing noise levels to gradually scare away harbor porpoises (Meij *et al.*, 2015). According to the manufacturer, the signals have a duration of less than 7.5 s and an average source level of approx. 160 dB re 1 μPa 1 m. Depending on the setting, between 12 and 144 signals are emitted per hour.

Appendix G Alteration of frequencies to reduce range of side effects

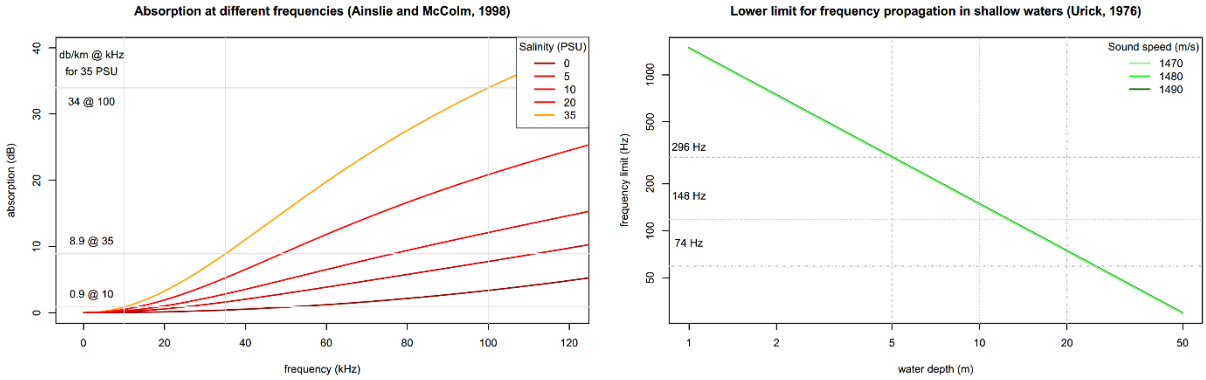

Fig XX: Left: absorption of sound in sea water shows a drastic difference with regard to salinity (assuming 50 m water depth, pH = 8, temperature 10 °C) and frequency emitted showing a potential for using higher frequencies to limit the acoustic footprint of ADDs especially in more saline waters. Right: Lower limit for the propagation of low frequency sounds depending on water depth using sound speed/water depth at typical sound speeds in the North and Baltic Seas. In very shallow waters sound with a lower frequency than indicated for 1480 m/s does not propagate and is therefore limiting unwanted exposure.

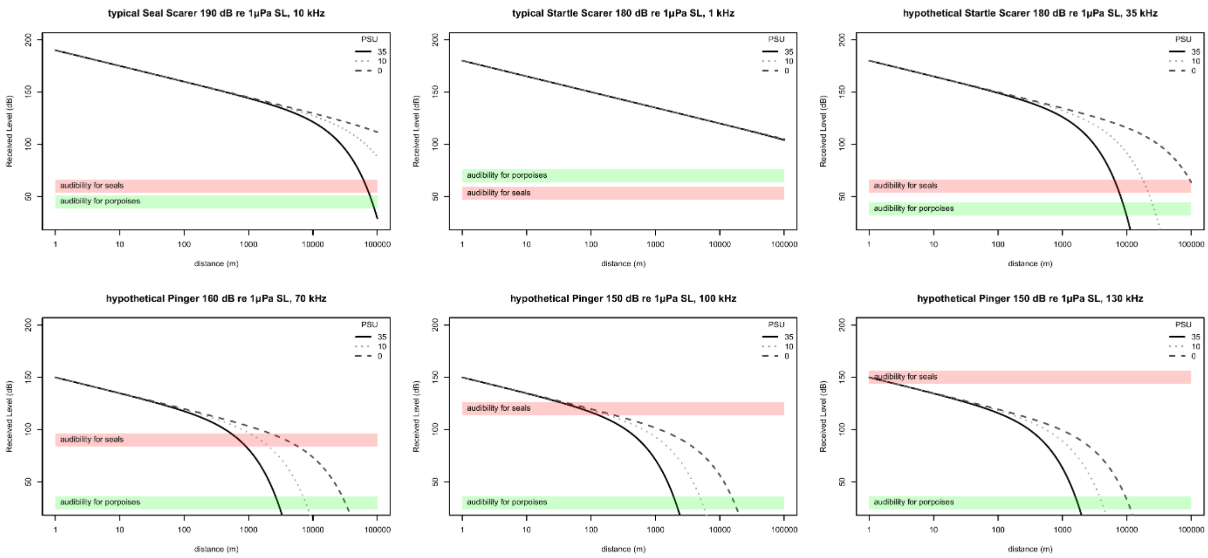

Fig XX: Sound propagation based on different salinities for different types of ADDs (50 m water depth, pH = 8, temperature 10 °C) . Depending on the hearing threshold for different species and salinities the hearing ranges are larger for seals or porpoises and therefore a potential trade-off can be utilized to limit the exposure to unnecessarily high sound levels.

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