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New ways to use seal deterrents to protect fisheries

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Abstract

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Seal populations in the Baltic Sea have grown rapidly and are in conflict with coastal fisheries. Acoustic deterrent devices (ADDs), also known as seal deterrents, have substantial potential to reduce these conflicts by keeping seals away from fishing gear. Deterrents also lower the risk of seals becoming entangled and drowning in fishing gear.

The use of seal deterrents requires broad acceptance by society as well as practical and clear rules. All marine mammal species in the Baltic Sea have excellent underwater hearing and are sensitive to excessive underwater noise. The use of ADDs should not cause significant harm to these animals or other marine life.

In many ADD applications further research and development work is needed to make them cost-effective, practical and ethically sound. This report presents the benefits and challenges of new seal deterrent applications developed and tested by the Natural Research Resources Institute Finland (Luke) and provides guidelines regarding the appropriate use of deterrents.

Keywords: seals, Acoustic deterrent devices, ADD, seal deterrents

Contents

1. Seal deterrents reduce seal-fishery conflicts

During the last three decades, increasing numbers of seals have damaged more and more coastal fishing gear and catches in the 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 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. 2006). 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. (Figure 1). No adequate solution to protect traditional gillnet fishing from seal damage has been invented yet.

Figure 1. Damage caused by seals to salmon caught in a fish trap. Photo: P. Suuronen

Recently, acoustic deterrent devices (ADDs) 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 (e.g., Lehtonen et al. 2022). In the Baltic Sea, ADDs have also been tested in Swedish and Estonian fisheries (Fjälling et al. 2006; Vetemaa et al. 2021).

Seal deterrents were developed in Scotland and North America to deter seals from netting cages used in salmon farming. Therefore, a considerable portion of the studies regarding deterrents have been conducted in the context of salmon aquaculture (e.g., Sepulveda & Oliva 2005). Less work has concentrated on developing applications for coastal capture fisheries. The recent efforts with seal deterrents in the Baltic Sea reflect the severity of the seal-fishery conflict in the area.

The objective of this report is to present the benefits and challenges of ADD-applications developed and tested by the Natural Resources Institute Finland (Luke) for the prevention of seal damage in coastal and river fisheries. The report also summarizes the potential adverse effects of deterrents on seals and other biota and presents the views of various stakeholders regarding the acceptability of seal deterrents. Finally, issues related to the selection and appropriate use of deterrents are briefly highlighted.

2. Basic properties of seal deterrents

To work efficiently, the sound pulses an ADD emits must be sufficiently strong and within the sensitive frequency range of seal hearing. A typical ADD emits pulses two to three seconds long, consisting of varying frequencies, transmitted in varying cycles (Suuronen et al. 2024). The sound frequency is typically 10–20 kHz, which is in the most sensitive hearing range of seals (Götz & Janik 2013). The propagation of the sound emitted by an ADD is affected by the frequency of the sound, the shape and quality of the bottom, and the stratification of the water column. The pressure of the sound decreases exponentially with the distance it travels.

The sound from an ADD can have harmful effects on seals and other biota. Many aquatic animals, marine mammals in particular, use sound for communication, orientation and finding prey. Noise can mask vital information and disrupt animal behavior (Richardson et al. 1995, Southall et al. 2007, HELCOM 2019). Noise can also cause physiological stress which can harm health and reproduction. The harbour porpoise (*Phocoena phocoena*) is the only whale species that lives permanently in the Baltic Sea (Viquerat 2014). Porpoises are highly dependent on sound for foraging, navigation and finding mates (Clausen et al. 2010). ADDs produce sounds in the sensitive hearing range of porpoises (Mikkelsen et al. 2017). Therefore, the risks caused by ADDs to porpoises should be taken into consideration. It should also be recognized that there are many other sources of human-induced noise in the sea, for instance, busy ship and boat traffic.

It is worth noting that ADDs are increasingly used worldwide in connection with underwater construction to deter seals from areas where they are at risk of being harmed, by, for example, underwater explosions. Explosions, or the noise from them, can be fatal to nearby marine mammals.

3. Luke's new deterrent applications

3.1. Features of raft-mounted and portable deterrents

Since 2018 the Natural Resources Institute Finland (Luke) has investigated the potential of using ADDs as targeted deterrents to reduce seal damage in pontoon-trap fisheries. The goal was to use an ADD next to fishing gear out at sea where there is no electricity available and attaching the ADD to the fishing gear is not feasible.

Luke developed two installation solutions using Otaq Sealfence ADDs (Appendix 1). The aim of both was to provide a way to protect a specific target, such as a trap-net while having the option of easily moving the targeted deterrent. In the first version, the ADD was installed on a raft (**Figure 2** left). Power for the ADD was provided by batteries that were charged by solar panels, a wind generator and a methanol-powered fuel cell charger on the raft. A raft-mounted ADD is self-sustaining, but is heavy and difficult to move. Therefore, an alternative, where the ADD and batteries are placed inside a polyethylene case, was developed (**Figure 2** centre). This version, called the portable deterrent, is significantly faster and easier to move from one place to place than a raft. When in use, only the top part of the device is visible above the surface (**Figure 2** right).

Figure 2. A raft-mounted deterrent with solar panels and wind turbines (left), a portable deterrent raised out of the sea (mid), and a portable deterrent anchored next to fishing gear.

In experiments where the suitability and effectiveness of raft-mounted and portable deterrents were studied pairs of pontoon-traps, one equipped with a deterrent and the other without, were compared. The deterrent was placed near the funnels of the trap (**Figure 3**). Fishers moved the deterrent from one trap to another every week to eliminate any effects of trap location. During two fishing seasons, the average salmon catch was 64 percent higher in traps with a deterrent (Lehtonen et al. 2022). Although some seal-induced damage occurred, salmon fishers have continued to use the deterrents with satisfactory results. The portable deterrent has been commercialized and has gained a large user base. Research is ongoing regarding the use of portable deterrents in other coastal fisheries such as pontoon-trap fishing for whitefish.

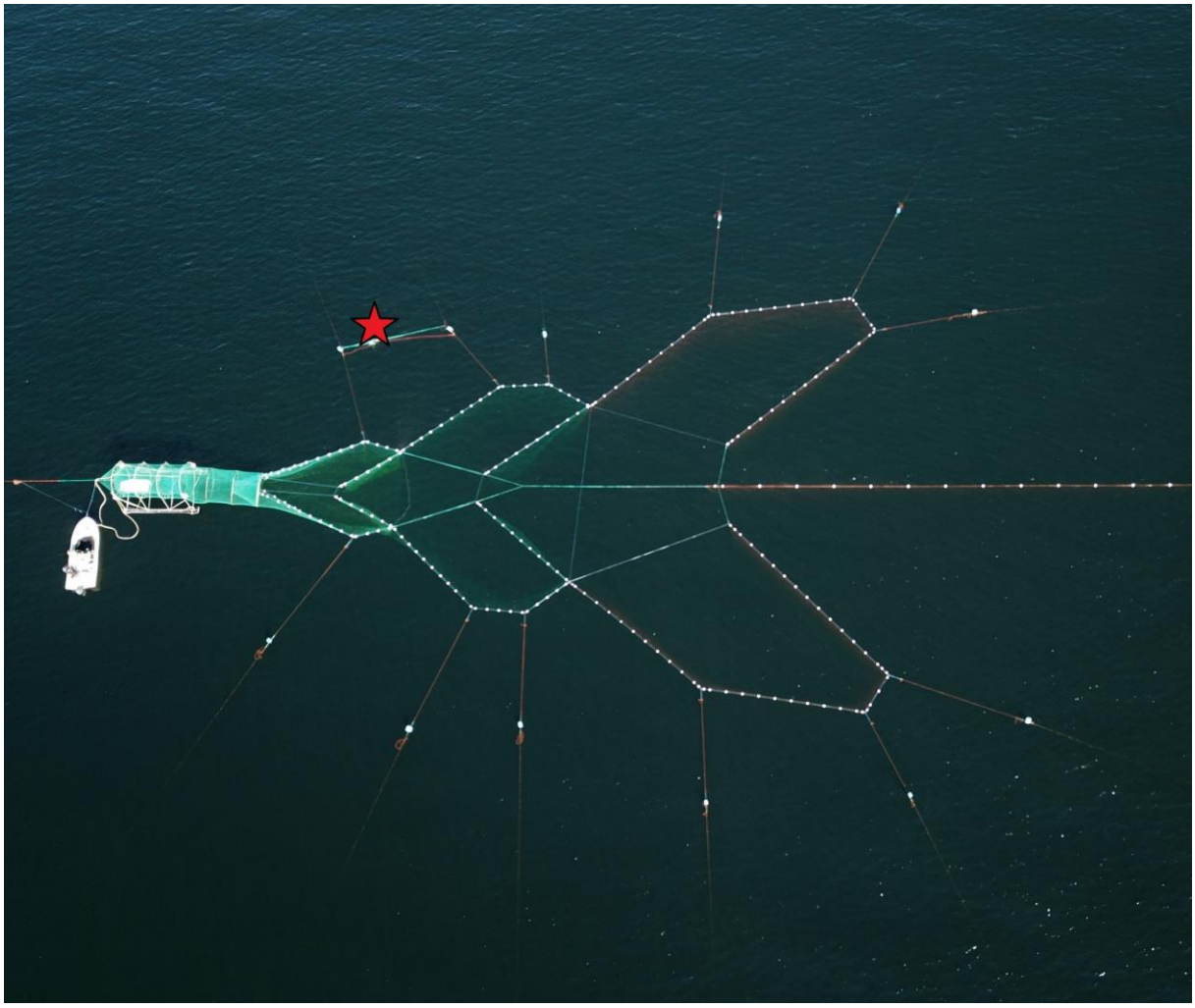

Figure 3. A seal deterrent placed near the funnels of a pontoon-trap (deterrent marked with a red star). Photo: Esa Lehtonen (Luke).

Luke's deterrent solutions 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 during times 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 should also lower the risk of seals becoming entangled and drowning in a trap. In addition to being harmful for the seal, removing an entangled or dead seal is laborious and time-consuming for the fisher. A seal deterrent can thereby promote the coexistence of seals and commercial fishing.

Salmon fishers report that they would not be able to continue fishing without seal deterrents. It is worth noting that Luke, in collaboration with the Aalto design factory, has built and assessed a prototype of an autonomously moving ADD to protect larger areas than a stationary ADD can cover. So far, there are no results on the efficiency of the moving ADD.

3.2. Creating seal-free areas on the coast and in rivers

3.2.1. Seal-free areas on the coast

In traditional gillnet fishing conducted in inner coastal waters, it is not possible to prevent seal damage by modifying existing fishing gear. Instead, placing a ling of seal deterrents across the entrance to a bay for the duration of the fishing season could temporarily close entire bays from seals. Fishing in such seal-free areas could be conducted without disruption from seals (Lehtonen et al. 2023). There are at least thirty-five bays along the Finnish coast that could be used to form temporarily "seal-free" areas (**Figure 4**). The limiting factor is that current ADDs do not work with cables longer than 200m. Given that power must be supplied from the shore this limits the technique to bays with less than 200m wide straits leading into them (400m if power can be provided from both shores). A raft-mounted device can, however, cover the areas where grid power is not available.

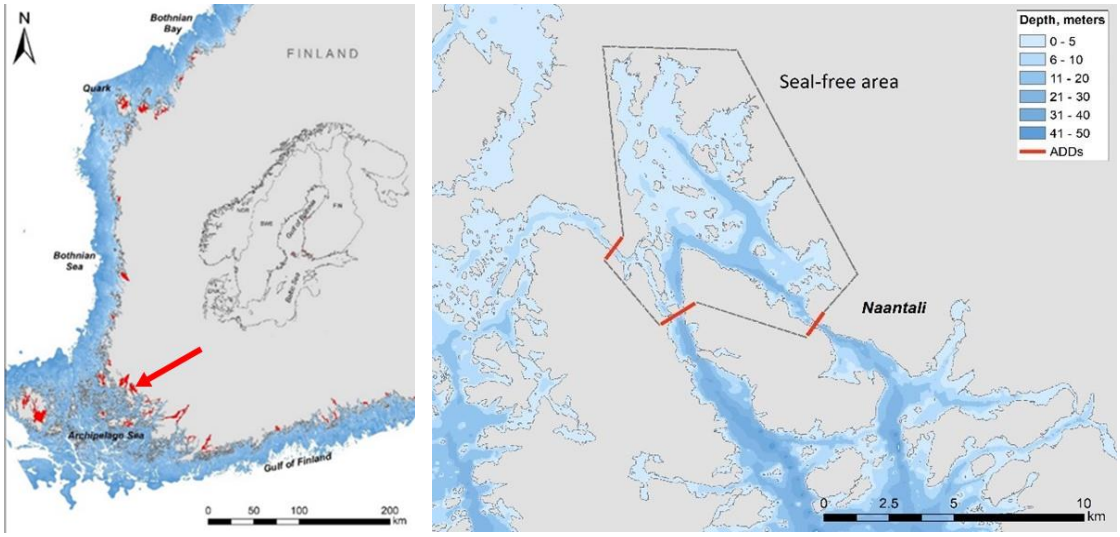

Figure 4. Left: Potential seal-free areas on the Finnish coast (marked in red). The maximum width of the straits leading to these areas is 200 meters. Right: The bay area north of Naantali has served as the main testing site for studying the viability of seal-free areas.

Raft-mounted and seabed-mounted deterrents were tested in experiments where straits were closed from seals. When deterrents are on the seabed, they do not spoil the scenery and are not susceptible to vandalism. Furthermore, sea currents and high winds do not affect them. AceAquatec US3 deterrents (Appendix 1) were used with the transmitters connected to their land-based control units via low-voltage underwater cables (**Figure 5**).

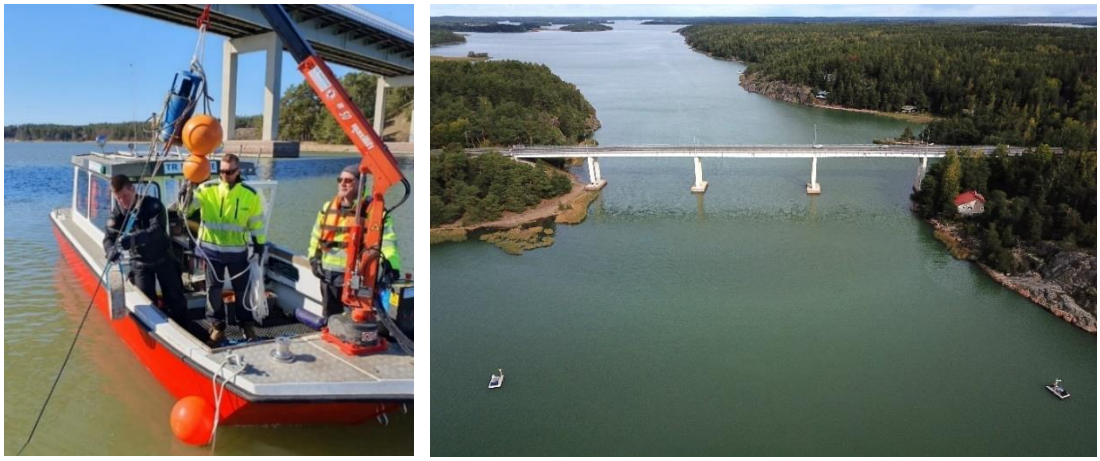

Figure 5. Left: Lowering an AceAquatec US3 deterrent to the bottom of Särkänsalmi, Naantali. The deterrent is connected to a weight that holds it on the seabed. Right: Särkänsalmi strait with raft-mounted ADDs in the lower corners of the photo. Photos: Esa Lehtonen

In pilot tests conducted in Naantali, nine deterrents were used in the three straits leading to the bay area (see **Figure 4** and **Figure 5**). According to fishers, catch and gear damage caused by seals decreased in the area after the deterrents were introduced, but the deterrents were not 100 % effective at keeping seals away from the area. Despite this, gillnet fishers in the region wanted to continue the use of deterrents in the straits, especially during the autumn when pikeperch, the most important target species in the area, enter shallow bays.

3.2.2. Seal-free areas in rivers

In the northern Baltic Sea, seals are increasingly moving into rivers to find food, and their presence has become a substantial problem for fisheries. Seals take fish caught in nets, damage equipment and may also disturb the spawning of fish (Veneranta et al. 2023).

Six seal deterrents were installed on the riverbed of the river Iijoki to investigate the usability of deterrents in forming a seal-free area in the river. The deterrents formed a barrier line intended to prevent seals from moving upstream into areas where much of the fishing takes place (**Figure 6**). There were fewer damaged whitefish above the deterrent line than below it, suggesting that deterrents reduce seal damage at least in smaller rivers such as the river Iijoki (Veneranta et al. 2023).

Figure 6. Left: Lowering a deterrent on a concrete weight into the Iijoki River. Photo: Petri Suuronen. Right: Five deterrents placed in a line across the main channel. The fence of a fish weir near the deterrents is visible in the foreground. Photo: Lari Veneranta

3.3. Challenges and advantages of ADDs in creating seal-free areas

The experiments with seal-free areas have been promising but the technique needs further development to accommodate various known issues.

It is essential that there are an adequate number of ADDs along the deterrent line. Too few deterrents leave blind spots in the acoustic barrier line. Preferably, there should be two parallel ADD-lines across the channel. It is also crucial to minimize periods when no deterrent emits sound. To ensure that ADDs are effective, they should be placed early in the season, before any seals have moved into the river and located where seals cannot bypass them.

There are some potential ways a seal can bypass deterrents. One raising its head above the surface would let it pass without discomfort. There are no verified observations of this behavior. Additionally, seals with poor hearing, due to age or other causes might not respond to the deterrent.

Sound conditions in rivers are different from those in the sea. Rivers are often shallow and there can be strong background noise from flowing water masking the sound of an ADD. Furthermore, rivers' uneven bottoms may effectively dampen sound. To ensure the passage of sound, deterrents should be placed where the bottom is as even as possible.

In some cases, especially in the larger rivers, protecting individual fishing gears with deterrents may be more effective than forming a seal-free area in the entire river (Lehtonen et al. 2024).

Seals can cause significant harm to fish species that spawn in limited areas (Veneranta et al. 2024). For instance, endangered fish species such as sea trout and migratory whitefish that migrate up rivers to spawn may be at high risk of seal predation. Seal-free areas can reduce such predation and thereby protect these fish stocks. On the other hand, when a deterrent prevents the natural movement of seals in a part of the water body at certain times of the year, it may be harmful to seals. The question has also been raised whether seal-free areas increase the number of seals somewhere else. So far, this issue has not been the subject of research.

4. Acceptance and appropriate use of deterrents

According to a stakeholder survey conducted by Luke in 2023 (Suuronen et al. 2024), the use of deterrents is widely accepted among the fisheries sector for reducing seal damage, although further research on the effectiveness of deterrents was hoped for. Recreational fishers and fishing guides considered seal-free areas beneficial when the ADDs are not installed in places where they get in the way of fishing. Some stakeholders take a cautious approach on the wider use of seal deterrents and require assurance that deterrents do not cause unreasonable harm and health risks to marine life. Some also noted that deterrents increase harmful underwater noise.

The use of seal deterrents requires caution and broad acceptance by society. When planning to use seal deterrents, the following questions should be asked: (i) to what extent can deterrents mitigate seal damage, (ii) what other options exist for resolving the problem, and (iii) does the use of deterrents cause significant harm and health risks to marine life. It is essential that the rules for the use of seal deterrents are commonly agreed-upon.

The EU Marine Strategy Framework Directive (MSFD 2008) aims to ensure good environmental status in European marine waters. In terms of underwater noise, human-caused noise must not have detrimental effects on marine life. In addition, the Baltic Sea Action Plan (HELCOM 2021a) includes an objective that there should be no or minimal harm to marine life from man-made noise. In 2021, HELCOM also published a regional action plan on underwater noise which includes a regional activity to "*reduce the impact from acoustic deterrent devices by developing and agreeing on common guidelines and regulation of the design and use of deterrent devices*". A national action to "*reduce impact from acoustic deterrent devices (including seal scarers) by developing and implementing national regulations on their use*" has also been proposed by HELCOM (HELCOM 2021b). In situations where deterrents may cause unreasonable harm to people, the environment or aquatic life, the use of deterrents needs to be restricted. When imposing restrictions, the criteria for restriction and how the rules will be monitored needs deciding. Restrictions on the use of deterrents are imposed by national authorities and water owners in each country. For the general acceptance of ADDs, minimizing negative impacts is essential.

ADD users need practical instructions on the selection, installation, maintenance and proper use of seal deterrents. They must also understand what kind of arrangements are needed in each application. Information on the spatial and temporal occurrence of noise-sensitive species is important when determining the areas and times where and when deterrents should not be used, or their use should be limited. There should be clear rules for using deterrents near housing, beaches and marinas. Special attention is needed when humans dive or swim near a deterrent. To avoid any risk, diving within 150 m of a deterrent is to be avoided and warning signs about the deterrents must always be posted on the shore. Permission for using deterrents must always be received from the water owner.

In Finland, Traficom (traffic authority) prohibits the use of deterrents on boat and ship lanes mainly because deterrents may distort the function of sonars and other marine navigation devices. Even when deterrents are outside waterways, warning signs must always be posted on the shore. The Finnish Defence Forces have instructions regarding certain critical offshore areas where the use of seal deterrents should be negotiated separately.

5. Concluding remarks

The various applications of seal deterrents have significant potential to reduce damage to and from seals and can contribute to securing the coexistence of fisheries and viable seal populations. All applications presented in this report can alleviate the damage and harm caused by seals to the fisheries sector as well as reduce the risk fishing gear poses to seals. The proper use of deterrents could effectively reduce seal-fishery conflicts, promote trust between different stakeholders and produce social sustainability. Goal-oriented cooperation can reduce disagreements and misunderstandings between actors. Nonetheless, more research and development is needed to make practical applications as cost-effective, practical and harmless as possible. The reservations associated with the use of seal deterrents should be considered. To minimize negative impacts on seals and other marine life, the use of seal deterrents requires a comprehensive spatio-temporal assessment which takes, e.g., seasonal variations in the occurrence of marine mammals into account.

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Appendix

Appendix 1. The technical characteristics of the seal deterrents tested by Luke. Frequency range informed by the manufacturers.

Model	Frequency range	Properties
Otaq Sealfence	9-11 kHz	Emits "pulse walls" lasting a few seconds transmitted at varying intervals. Each pulse is composed of several different frequencies. In Luke's measurements the device produced sound with a frequency of up to 30 kHz.
AceAquatec US3	8-11 kHz	Sends sound pulses lasting 2.8 seconds. A single pulse consists of several short, paused periods, in which the frequency distribution and intensity of the sound vary randomly. This is done to achieve the greatest possible startle response for the seal and to prevent seals from becoming accustomed to the sound. There is a randomized pause between sound pulses, the length of which can vary from a few seconds to 3 minutes. The user has a wide range of adjustment options for the settings.

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