ACCOBAMS-ASCOBANS/JBWG2/Inf.5.3a
Dist. 31 January 2025

ICES TECHNICAL ADVICE: EU REQUEST ON ALTERNATIVE MEASURES TO PREVENT BYCATCH OF THE HARBOUR PORPOISE IN THE BALTIC SEA

(Prepared by ICES)

This paper was originally published on the ICES website (August 2024).

ICES Technical Service
Baltic Sea
Published 29 August 2024

EU request on alternative measures to prevent bycatch of the harbour porpoise (*Phocoena phocoena*) in the Baltic Sea

Service summary

ICES considers that the implementation of dynamic closures as a mitigation tool to reduce harbour porpoise bycatch in the Baltic Sea is not optimal. The reason for this is that this management tool does not appear to be appropriate to mitigate the interaction between highly mobile elusive species and fisheries with high site fidelity. In addition, dynamic closures are particularly problematic to implement in small-scale fisheries where the technology to monitor porpoise and transmit information to fishers on a timescale to have a practical effect on fishing closures is not readily available.

The most efficient way of preventing porpoise bycatch is to use fishing gears that pose less risk for porpoises. These include traps and pots, longlines, and seines, which have all shown not to catch porpoises.

Several mitigation measures involving gear modifications are currently at an experimental stage, and further thorough testing would be required to prove their efficacy before they could be recommended for applications.

Other management strategies such as economic compensations or bycatch quotas might not be currently viable for reducing bycatch of the Baltic proper harbour porpoise.

Request

DGENV special request to ICES:

Concerning the harbour porpoise in the Baltic proper, and in relation to meeting the management objective (0.7 individuals per year) provided by the ICES advice of 26 May 2020[*], ICES is requested to provide technical assistance on the following:

a. *review the effectiveness of the measures provided in the special report produced by NGOs in May 2023 as alternative measures to the use of pingers in all static net fisheries.*
b. *based on available scientific information, provide an overview of other available alternative measures, besides those proposed in the NGO report, for example involving gear modification or alternative gears[†], which could potentially meet the management objective of 0.7 individuals.*
c. *review the scientific underpinning and effectiveness of dynamic closures[‡], for achieving the management objective of 0.7 individuals per year, taking into account the concerns expressed by the NGO report, ASCOBANS Jastarnia group (action point 19 from 18th meeting Jastarnia Group)[§] and the report by the IWC scientific committee[**], as well as any other relevant scientific information available.*

[*] ICES. 2020. EU request on emergency measures to prevent bycatch of common dolphin (*Delphinus delphis*) and Baltic Proper harbour porpoise (*Phocoena phocoena*) in the Northeast Atlantic. *In* Report of the ICES Advisory Committee, 2020. ICES Advice 2020, sr.2020.04. https://10.17895/ices.advice.6023

[†] See also: ICES. 2023. EU request on review of innovative gears for potential use in EU waters and their impacts. *In* Report of the ICES Advisory Committee, 2023. ICES Advice 2023, sr.2023.13. https://doi.org/10.17895/ices.advice.24212694

[‡] Dynamic closures, discussed in the Baltic Sea Fisheries Forum (BALTFISH) as an alternative measure to pingers, means that after sighting of harbour porpoises in a certain area, stating net fisheries in this area are closed for a certain period of time. See also the explanation provided in the NGO report (May 2023).

[§] Action points from the 18th meeting of the ASCOBANS Jastarnia group, Gothenburg, Sweden, 28-30 March 2022, https://www.ascobans.org/sites/default/files/document/ascobans_jg18_action-points.pdf

[**] Report of the IWC Scientific Committee (SC69A). Bled, Slovenia, 24 April – 6 May 2023.

Elaboration of the technical service

This technical service focuses on two points contained within the original special request:

1. review the scientific underpinning and effectiveness of dynamic closures in minimizing bycatch of harbour porpoises in the Baltic proper, taking into account the concerns expressed by the NGO report, ASCOBANS Jastarnia group (action point 19 from 18th meeting Jastarnia Group) and the report by the IWC scientific committee, as well as any other relevant scientific information available.
2. based on available scientific information, provide an overview of available alternative measures to pingers, for example involving gear modification or alternative gears.

This technical service is elaborated in annexes 1 and 2.

Format of the technical service

This technical service consists of this document and two annexes – annex 1, which addresses point i) of the request, and annex 2, which addresses point ii).

Basis of the technical service

The information included in annexes 1 and 2 was compiled by ICES experts and was reviewed by members of ICES Advisory Committee and Secretariat.

Recommended citation: ICES. 2024. EU request on alternative measures to prevent bycatch of the harbour porpoise (*Phocoena phocoena*) in the Baltic Sea. *In* Report of the ICES Advisory Committee, 2024. ICES Advice 2024, sr.2024.12. https://doi.org/10.17895/ices.advice.26868907

Annex 1

1. Review the scientific underpinning and effectiveness of dynamic closures in minimizing bycatch of harbour porpoises in the Baltic proper, taking into account the concerns expressed by the NGO report[††], ASCOBANS Jastarnia group (action point 19 from 18th meeting Jastarnia Group)[‡‡] and the report by the IWC scientific committee[§§], as well as any other relevant scientific information available.

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General conclusions

The reviewers consider that the successful implementation of dynamic closures as a mitigation tool to reduce harbour porpoise bycatch in the Baltic Sea is not likely for the reasons outlined below and stated in the referenced documents. In particular, this management tool does not appear to be appropriate to mitigate the interaction between highly mobile elusive species and fisheries with high-site fidelity.

Although some theoretical evidence shows that dynamic closures have the potential to reduce bycatch of certain species, currently, there is no empirical scientific evidence that dynamic closures successfully reduce the bycatch incidents of harbour porpoises in any area or fishery. In addition, in the case of a very small (few hundreds animals for the 'Baltic-proper population') and distinct critically endangered population of porpoise (Carlström *et al*., 2022; Celemín *et al*., 2023), given the similarities with the vaquita (*Phocoena sinus*) case or the Maui dolphin (*Cephalorhynchus hectori maui*), the situation would warrant the highest level of precaution, meaning the implementation of the highest level of protection in the whole range of the Baltic harbour porpoise population. In addition, dynamic closures are particularly problematic to implement for bycatch of porpoises in small-scale fisheries where the technology to monitor the species in real-time and transmit that information to fishers in a time-scale to have a practical effect on fishing closures is not readily available.

Source	Report text	Comment
Annex I Action points from the 18th meeting of the JASTARNIA group JG18/AP19	It is noted that the real-time closures /moving-on procedure is not considered a measure to mitigate harbour porpoise bycatch in the Baltic Proper, and may be counterproductive because it prevents effective measures being taken.	*See the following comments.*
Annex II Report of the IWC Scientific Committee (SC69A)	The Committee referred to the discussion at SC68D and notes that proposals being considered for real time (dynamic) closures were unlikely to be feasible.	There is no empirical scientific evidence that dynamic closures would successfully and significantly reduce bycatch of harbour porpoise, or other small cetacean species, elsewhere.

[††] BUND, DUH, and WDC, 2023: BYCATCH MITIGATION FOR THE BALTIC PROPER HARBOUR PORPOISE. What To Do If Pingers Are Not an Option? A special report produced by Bund für Umwelt und Naturschutz (BUND), Deutsche Umwelthilfe (DUH) and Whale and Dolphin Conservation (WDC), May 2023. 18pp, https://seas-at-risk.org/publications/bycatch-mitigation-for-the-baltic-proper-harbour-porpoise-what-to-do-if-pingers-are-not-an-option/

[‡‡] Action points from the 18th meeting of the ASCOBANS Jastarnia group, Gothenburg, Sweden, 28-30 March 2022, https://www.ascobans.org/sites/default/files/document/ascobans_jg18_action-points.pdf

[§§] Report of the IWC Scientific Committee (SC69A). Bled, Slovenia, 24 April – 6 May 2023.

Report of the Scientific Committee (SC68D) referenced in Report of the Scientific Committee (SC69A)	There is a lack of evidence of similar approaches being effective in other areas.	There is currently no scientific evidence based on empirical data that dynamic closures would successfully and significantly reduce bycatch of harbour porpoise, or other species, elsewhere. For example, some theoretical evidence that dynamic closures may work for leatherback turtles (up to 2.7m long *versus* 1.5m of a harbour porpoise) (Smith *et al*., 2021), however, logistical and economic difficulties of implementing these closures are not considered. Similarly, van Beest *et al*. (2017) used simulation models to show that time-area fishing closures could reduce bycatch rates of harbour porpoise in Danish waters substantially but not completely.
Report of the Scientific Committee (SC68D) referenced in Report of the Scientific Committee (SC69A)	There are practical and logistical barriers to effectively detecting this inconspicuous species.	This approach has already proven to be unsuccessful with large whales (North Atlantic right whales; Government of Canada 2024), which are easily detectable. Nothing suggests that this application of this fishery strategy to an elusive species would be successful given the low sighting probabilities for Baltic harbour porpoises.
Report of the Scientific Committee (SC68D) referenced in Report of the Scientific Committee (SC69A)	It seems unlikely that it will be possible to effectively communicate detections to fisheries in the area and establish logical geographical and temporal boundaries within which fishing activities would be curtailed in relation to detected porpoises.	This is a particular issue for small scale fisheries, who may not have the technology onboard capable of implementing real-time dynamic closure procedures.
Annex III BUND, DUH & WDC 2023 Bycatch mitigation for the Baltic proper harbour porpoise	There is no current demonstration that dynamic closures have been effective in mitigating bycatch, and particularly for a critically endangered, small and elusive species. For example, there have been a number of challenges in implementing similar dynamic measures for right whales in the North-western Atlantic, despite these whales being much larger and more conspicuous and with a considerable amount of searching effort in place, including dedicated aerial surveys.	There is currently no scientific evidence based on empirical data that dynamic closures would successfully and significantly reduce bycatch of harbour porpoise, or other species, elsewhere. There is some theoretical evidence that they may work for leatherback turtles and harbour porpoise, however, logistical and economic difficulties are not considered in these studies (e.g. van Beest *et al*. 2017; Smith *et al*. 2021). Not only are the cetacean species considered in this study (Government of Canada, 2024) much larger (whale *versus* porpoise), the fisheries and vessels involved in mitigation are substantially larger and better equipped.
Annex III BUND, DUH & WDC 2023 Bycatch mitigation for the Baltic proper harbour porpoise	Porpoises are difficult to detect visually and the chances of a sighting being reported when animals are present is very low. Even during dedicated visual surveys for harbour porpoises in good weather conditions the probability of detection is low, and drops rapidly with increasing sea state. In fact, visual surveys are not used in the Baltic Proper because of the very low density resulting in very low sighting rates.	The use of acoustic monitoring as an alternative is problematic as a considerable array of devices would be required to cover the area of concern, which implies a significant financial investment. Continuous Porpoise Detectors (CPODs), and similar acoustic equipment, which are a less costly option, are not capable of real time transmission of data. This limits their utility for the purposes of dynamic closure implementation. They also have a very limited detection range, and can have issues with directionality of detection and masking due to noise disturbance.

Annex III BUND, DUH & WDC 2023 Bycatch mitigation for the Baltic proper harbour porpoise	Incidental sightings of harbour porpoises in the Baltic Proper generally do not correlate well with the published research of the porpoise distribution, because sightings occur so rarely and only where human activities and porpoises overlap in time and space.	Given the extremely low density of this population, dynamic closure could not rely on current distribution maps (due to their low predictive and explanatory power). Even a significantly increased observer effort (or 100% observer coverage) would be insufficient to acquire accurate real-time visual monitoring data.
Annex III BUND, DUH & WDC 2023 Bycatch mitigation for the Baltic proper harbour porpoise	Current porpoise acoustic monitoring systems are not suitable for real-time detections, which would be needed for a dynamic closure procedure. Market-available real-time detection systems can be expensive, difficult to setup, to use and to maintain, and have a limited detection range of a few hundred metres.	Agreed, the use of acoustic monitoring as an alternative is problematic as a considerable array of devices would be required to cover the area of concern, which implies a significant financial investment. CPODs, and similar acoustic equipment, which are a less costly option, are not capable of real time transmission of data. They also have a very limited detection range, and can have issues with directionality of detection and masking due to noise disturbance.
Annex III BUND, DUH & WDC 2023 Bycatch mitigation for the Baltic proper harbour porpoise	Dynamic closures would require a significant logistic effort of putting in place functional systems for reporting harbour porpoise sightings, including public education efforts to ensure that the public as well as fishers are aware of the need to report sightings.	A significant logistic investment will be needed, Also, the use of 'citizen science data' would need to be validated with dedicated observer monitoring.
Annex III BUND, DUH & WDC 2023 Bycatch mitigation for the Baltic proper harbour porpoise	There is an issue with how to mandate and enforce reporting of sightings as well as bycatch. For example, there is a conceivable risk that fishermen would refrain from reporting porpoise sightings if they knew this would result in their fisheries being closed or a need for displacement to suboptimal fishing grounds (which means there would be conflict of interest).	Agreed, self reporting of bycatch and/or reporting of porpoise sightings by fishers, could be considered an unreliable source of data, and require thorough validation with dedicated observers, given a clear conflict of interest and lack of trust on the ultimate use of such information.
Annex III BUND, DUH & WDC 2023 Bycatch mitigation for the Baltic proper harbour porpoise	The temporal delay between a sighting report and the actual closure of fisheries would very likely be too long for the closure to be relevant. Small-scale movement patterns and temporal persistence of concentrations of porpoises in the Baltic Sea are not well understood, but as marine top predators they are highly mobile, potentially travelling large distances within short periods of time. Without a good understanding of their movement patterns it is not possible to determine the necessary spatial and temporal extent of dynamic closures for them to be effective, even if porpoises were reliably detected and reported.	This is a particular issue for small scale fisheries, that may not have the technology onboard capable of implementing real-time dynamic closure procedures.

Additional information:

Designing effective bycatch mitigation programmes requires an understanding of the life histories of target and non-target species, interactions of fish and fishing gear, effects of spatial and temporal shifts in fishing effort, socio-economic impacts to the fishery, and incentives of fishery participants. The stud carried out by O'Keefe *et al*. (2013) investigated time/area closures along with other factors against a set of criteria to understand the overall effectiveness in reducing bycatch without causing unintended biological and socio-economic impacts. The study concluded that when used in combination with other mitigation techniques, time/area closures may be more effective for reducing bycatch than used alone (O'Keefe *et al*. 2013).

The very recent study by Pons *et al*. (2022) examined the effects of temporal, static, and dynamic area closures on the bycatch and target catch of 15 fisheries around the world using logbook and observer data sets. They found that dynamic area closures performed best and could reduce bycatch of all species combined by an average of 57% without sacrificing catch of target species. However, the study highlighted that dynamic closures may be difficult to implement and enforce in many regions (Pons *et al*., 2022).

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Annex 2

2. Based on available scientific information, provide an overview of other available alternative measures, besides those proposed in the NGO report, for example involving gear modification or alternative gears[***], which could potentially meet the management objective of 0.7 individuals.

Authors: Lotte Kindt-Larsen and Guðjón Már Sigurðsson

i. Alternative fishing gear

One of the most efficient ways of reducing porpoise bycatch is to switch fishing gears to gears that cause less risk to porpoise bycatch. Three gear types; traps and pots, longlines and seines have all shown not to catch porpoises and are thus described in detail below.

1. Traps and pots

General

Pot and trap fisheries account for only a small part of worldwide commercial fishing. In some countries, however, there has been a long tradition of pot fishing, particularly for catching crustaceans. With pot fishing, desired species and sizes can be targeted through gear designs and the choice of bait. Catch size is affected by trap size, bait quantity and quality, time between setting and hauling and preventing escape through the entrance. Furthermore, pots have the advantages that they are species and length selective, have low impact on the seabed, and are fuel- efficient (Suuronen *et al*., 2012). They also have low bycatch of sea birds and are mentioned in the FAO guidelines on bycatch as an alternative to minimize bycatch when no strategies appear viable (FAO, 2021).

The main challenge for widespread use of pots is attaining commercially viable catch rates and numerous fishing trials have been conducted to investigate pot catch efficiency (Furevik and Løkkeborg, 1994; Furevik *et al*., 2008; Bagdonas *et al*., 2012; Anders *et al*., 2016; Ljungberg *et al*., 2016; Jørgensen *et al*., 2017)

Trap and pot fisheries are mainly associated with capture of crustaceans or molluscs but are used for capture of demersal finfish as well. Before the switch can be made, considerable effort must be made to design the trap and test bait for the target species in question.

Traps and pots in the Baltic Sea area

Due to the absence of porpoise bycatch in the pot fishery, it could serve as an alternative fishing method in certain areas. There are, however, some issues that must be considered before implementation.

Pot trials have been conducted in the Baltic Sea mainly by Sweden and Denmark. The focus has been both on the development of the pots, to find the best suited materials, entrances, bait, and dimensions (Kindt-Larsen *et al*., 2023) and to test their economic value. A Swedish trial has evaluated cod pots versus gillnets and long-lines in two areas in the south central Baltic Sea. The comparison showed that during the first half of the year the pot fishery generated lower daily catches than the gillnet and hook fisheries, while in the second half of the year pot catches exceeded or equalled gillnet and hook catches. In addition to the time of year, the pot catches varied according to soak-time, water depth, and current speed and direction (Königson *et al*., 2015).

The pot fishery is very limited in terms of target species and most Baltic trials conducted have been in the cod fishery, which is no longer viable. Thus new efforts are needed to explore if pots for flatfish species would be valuable.

[***] See also: ICES. 2023. EU request on review of innovative gears for potential use in EU waters and their impacts. *In* Report of the ICES Advisory Committee, 2023. ICES Advice 2023, sr.2023.13. https://doi.org/10.17895/ices.advice.24212694

3. Longlines

General

Demersal longlines are used worldwide and in many countries represent a substantial part of the fishing industry. Although longlines are simple devices, set-up and rigging procedures vary widely between regions and target species. In general, longline gear is tried and tested and can be bought off the shelf from gear manufacturers for most types of target species.

Catch rates for longlines are largely dependent on the type of hooks, lines, bait, fishing depth, fishing practices and a variety of biotic and abiotic factors. All of these factors will affect fishing success and whether it can be viable commercially.

Several studies have compared catch rates from longlines with other gear types (Huse *et al*., 2000, Santos *et al*., 2002) discovering that longlines had higher catch rates compared to gillnets. Several fish size comparison studies have, however, shown that gillnets catch larger fish than longlines (Huse *et al*., 1999, 2000; Santos *et al*., 2002). As the fish caught in longlines is normally alive when hauled, it tends to fetch higher price at fish markets than gillnet caught fish.

Longlines catches are in general area, current, and season dependent. Fish are particularly hard to catch with longlines during the spawning season, when they are not feeding. Due to the great variety in catch rates, vessels that can switch between gillnets and longlines have shown to be the most profitable due to the possibility of switching between gear systems during periods when one seemed more profitable than the other.

Bycatch of cetaceans in longlines is rare, although there are some known cases of larger whales getting entangled in buoy and anchor lines, and dolphins getting hooked after depredating on fish (López *et al*., 2012; Frisch-Jordán and López-Arzate, 2024). Seabird bycatch in longlines can be considerable, despite various mitigation methods have been developed (Melvin *et al*., 2014).

Longlines in the Baltic Sea area

The species that can be caught in a Baltic longline fishery are, primarily groundfish such as cod (*Gadus morhua*), haddock (*Melanogrammus aeglefinus*), catfish (*Anarhichas lupu*s), tusk (*Brosme brosme*), ling (*Molva molva*), and hake (*Merluccius merluccius*). A specific long-line fishery for turbot (*Scophthalmus maximus*) has been tested in the Baltic but proved to be unsuccessful (Krog 2003). With the cod fishery being currently unviable due to low spawners biomass, the importance of longline fishery on cod is currently limited.

The largest catches were observed from December to April while the lowest were from May to July. Despite the very good quality and no risk of porpoise bycatch, depredation from seals is highly likely in the Baltic as well as bycatch of seabirds (ICES, 2023). Mitigation methods to reduce seabird bycatch are therefore likely to be needed.

4. Mini seine

General

Demersal or anchored seines in two main configurations ("Danish" or anchored, and "Scottish" or fly dragging) are used to some extent in demersal round- and flatfish fisheries in the North Atlantic. These vessels are usually quite large, due to the size of the gear, and the need to haul in long wings of net to get to the bag where the fish is collected. It has been proposed and theorized both in the Baltic and in other regions such as Iceland and Norway, that a smaller version of such gear, the so-called "mini seines", could be used on small vessels that would normally be equipped for gillnets. Based on knowledge from larger commercial vessels, demersal seining efficiently catches various species including species of potential interest for gillnetters like cod and plaice (Noack *et al*., 2016). We also know that bycatch of cetaceans and other marine mammals is very rare, and demersal seines are for example considered one of the "exempt" fisheries in the US Marine Mammal Protection Act Import Provisions, stating low probability of bycatch (NOAA, 2024). Additionally, the quality of fish caught in demersal seines is high (Dreyer *et al*., 2008), which can have positive effects on the profit per unit of sold fish. The reason is that that catches spend little time in the gear (Noack *et al*., 2019), thus interactions with other biological and non-biological parts of the catch or net parts are limited. The idea of the mini-seine is to scale down the entire demersal seining system to a level, which is operational by one fisher on small gillnetter vessels.

Seines in the Baltic Sea area

Gear development is a very time and resource demanding process. Denmark and Germany have made some efforts to test mini seines (Noack *et al*., in review, Thünen 2024). These trials should, however, be regarded as the initial phase of the development of small-scale seine netting, as the data foundation at present is too sparse to determine whether mini seines can be a solution for the vessels that otherwise engage in gillnetting. Despite challenges, the fishing trials have come a long way, and a system has been developed that can be operated on smaller vessels which has the potential to be used for species such as flounder, plaice, and turbot on soft bottoms in the Baltic.

To date no bycatches of porpoises, seals, or sea birds have been registered in mini seine trials, however, bycatch of cod can be substantial.

Seines require relatively soft and featureless sea bottoms, so the suitable fishing area might be smaller than that for gillnets. The bottom topography of the Baltic Sea is however rather featureless, so the gear might be appropriate.

ii. New developments in mitigation methods

1. Plastic pearls

General

One of the theories on how to mitigate bycatch of porpoises is to make the gillnets more detectable by porpoises in their surroundings. Plastic pearls made of acrylic glass (Polymethylmethacrylate, PMMA) have been found to be ideal for this purpose as they are highly reflective to sound underwater, particularly in the frequencies used by porpoises for echolocating (Kratzer *et al*., 2020, 2022). In theory, this makes the fishing gear highly "visible" to echolocating animals such as porpoises as gillnets equipped with such pearls have substantially higher acoustic backscattering strength. Gillnets with pearl-to-pearl distances of 20 cm perform best, while the acoustic backscatters of gillnets with 40 cm and 60 cm pearl-to-pearl distances are similar (Kratzer *et al*., 2022). Based on this research, a new type of gillnet, "PearlNet", was created with the potential to reduce bycatch rates by making cetaceans aware of the presence of gillnets in their surroundings. Besides reducing porpoise bycatch, for fishers to accept this mitigation tool PearlNets must be at least as effective at catching target fish species as traditional nets used as control. To demonstrate the potential of PearlNets, catch rates of target and non-target commercial species between control and PearlNets in a set net fishery for cod in the Western Baltic Sea showed that the catch rates are quite similar (Kindt-Larsen *et al*., 2024).

Despite the positive results on target species catch rates and ability to increase echo backscatter strength their ability to reduce bycatch of porpoises still needs to be demonstrated. A trial conducted in the Black Sea in a commercial gillnet fishery targeting turbot (*Scophthalmus maeoticus*) focussed on the handling of the gear and identification of requirements for a full-scale trial. The trial proved the viability of using gillnets equipped with pearls. In addition, the study showed no reduction in catches of target species and a reduction in the number of porpoises caught. However, sample size was too low to prove that the pearls reduced porpoise bycatch (Kratzer *et al*., 2021).

In April in 2024 PearlNets were tested onboard a large commercial gillnetter targeting cod (*Gadus morhua*) in northern Iceland as part of the EU Life CIBBRiNA project (https://cibbrina.eu/). The trial was operationally successful, as there were no issues with handling the long and high net strings used with the pearls attached, and preliminary analysis suggests no significant difference in fish catches. However, there were not enough porpoises caught to say for sure if the pearls reduced porpoise bycatch, and trials will continue in 2025.

Pearls in the Baltic Sea area

This mitigation method is at an experimental stage and further research is ongoing. While they might reduce bycatch rates, they are unlikely to eliminate bycatch which might be needed in the Baltic Sea given the serious threat status of the porpoise population in the area.

General

Making gillnet panels more visible by either changing the color of the twine or ropes to red or orange has been suggested as a potential mitigation of bycatch for cetaceans, birds, and sea turtles. Few publications have shown an effect, but a study in New England showed that right whales seemed to notice red or orange ropes earlier than normal green ropes (Coulter, 2019). Similarly, adding phosphor to ropes and toplines of nets to make them glow has been suggested as a mitigation method for both cetaceans and sea turtles, but this method is yet to be tested.

In a recent study in Greenland, the researchers observed reduction in bird bycatch by adding a small (45 cm high) small-meshed panel to the bottom part of the net, but the small mesh panel is in the area where most of the birds were caught (Post *et al*., 2023). If certain areas of the gillnets are more likely to catch cetaceans than other areas, a similar method could potentially be explored for porpoises in the Baltic Sea.

Another method related to the characteristics of the net is reducing net height, also sometimes referred to as tie-downs, which has shown to be successful in reducing bycatch rate of cetaceans and turtles in two experiments (Northridge *et al*., 2016). Tie-downs will change the fishing characteristics of the net which might reduce catch of groundfish, but might be useful, and potentially better for catching species such as flatfish (Kim *et al*., 2023) or monkfish species.

Net characteristics in the Baltic Sea area

These mitigation methods relevant to making gillnets more visible/detectable by porpoises are all at a very early experimental stage and further research is clearly needed. While they might reduce bycatch rates, they are unlikely to eliminate bycatch which might be needed in the Baltic Sea given the serious threat status of the porpoise population in the area. Denmark has planned to test both reduced net height and thinner twine size in 2024 and 2025.

2. Lights

General

Lights have been suggested as a practical, cost-effective solution to reduce bycatch rates in gillnet fisheries. In most cases LED lights that are designed to be used in longline fisheries to attract catch have been used in bycatch reduction trials. Illuminating the net in theory makes it more visible to cetaceans, seabirds, or turtles, reducing the probability of them getting entangled. So far studies have mainly focused on reducing bird or sea turtle bycatch and the potential effect on cetaceans is less clear but with few exceptions. A study from Peru reported that nets equipped with LEDs reduced bycatch of seabirds by 84%, sea turtles by 74% and small cetaceans by 70% (Bielli *et al*. 2020) and studies from Ghana and Cyprus have reported considerable reduction in bycatch of turtles when using LED equipped nets (Allman *et al*. 2021, Snape *et al*. 2024). Despite this success, two studies have reported an increase in bycatch of birds while using lights, one in the Baltic Sea where an increase in bycatch of long-tailed ducks was observed (Field *et al*. 2019), and one in Iceland, where an increase in surface feeding birds such as fulmars and gannets was observed (Sigurdsson 2024).

Lights in the Baltic Sea area

As evidenced above, LED equipped nets are at a very early experimental stage and further research is clearly needed. The results from the Baltic Sea that showed an increase in long-tailed duck bycatch when using LEDs need to be seriously considered.

3. Pingers

General

Traditional pingers aim to modify the behaviour of porpoises by emitting loud acoustic signals, which are believed to be generally aversive stimuli and act to displace animals from their vicinity. Pingers do, however, differ in reduction effectiveness as is summarized in table 1.

Table 1 Examples of trials on effectiveness of pingers to reduce porpoise bycatch with regards to area, brand, sound specifications, spacing, reduction effect, and trial location. Reference of the works are included.

Brand	Source level (khz)	Pinger spacing	**Reduction effect (%)**	Location	Reference
Netmark1000	105–139	92	**89**	Gulf of Maine	Kraus *et al*., 1997
Netmark 1000	105–139	92	**100**	Massacusetts	Kraus and Brault 1999
Lien	122–125	17	**88**	Washington state	Gearin *et al*., 2000
Lien	122–125	9-12	**79**	Bay of Fundy	Richter *et al*., 1999
Netmark1000	139–145	100	**77**	Bay of Fundy	Trippel *et al*., 1999
Netmark1000	132	200	**98**	Black Sea	Gönener and Bilgin 2009
Aquamark100	136–145	455	**100**	North Sea	Larsen *et al*., 2013
Aquamark100	136–145	585	**78**	North Sea	Larsen *et al*., 2013
Lu-1-prototype	145	140	**90**	North Sea	Larsen and Eigaard 2014
Banana	145	200	**60-90**	North Sea	Kindt-Larsen et al. submitted
Banana	145	500	**20-51**	North Sea	Kindt-Larsen *et al*., submitted
Banana	155	500	**72**	North Sea	Kindt-Larsen et al. submitted
Banana	145	200	**0**	N-Iceland	Sigurdsson in prep. summarized in ICES (2020)
Wideband PAL	20–160	200	**100**	N-Iceland	Sigurdsson in prep; summarized in ICES (2022)
DDD03	?	variable	**63**	Celtic sea	Northridge *et al*., 2011

Even though various pingers have been shown to be effective in reducing harbour porpoise bycatch without considerable changes in fishing practices, there are some important issues that need to be considered before implementation.

Firstly, pingers are not 100% effective, meaning that bycatch can occur even if everything is done right. Secondly, they require some attention while setting, batteries and function need to be checked regularly, and they need to be placed with correct spacing otherwise bycatch rates can increase (See Table 1). Furthermore, background noise and some degree of habitat exclusion must be expected as pingers are designed to deter porpoises from their vicinity. Habituation can, however, occur in relation to certain pinger types (Kindt-Larsen *et al*., 2019). The costs of purchasing and maintaining the pingers can be high.

Pingers in the Baltic Sea area

Despite the fact that pingers have not been used in the Baltic Sea up to this date due to military/defense reasons, they remain the most studied and most used mitigation measures available. With new pinger developments such as pingers that turn on when in presence of an echolocating animals (also known as “on-demand pingers”) that could reduce the background noise levels, it might be worthwhile to revisit applications/conversations with defensive ministries in the region to explore potential deployments in the future.

iii. Other management strategies

1. Economic compensation

General

If the implementation of management measures results in significant industry losses, one way to gain acceptance is through economic compensation. This implies compensating fisheries affected by measures such as area or time closures, and encourage fishers to either stop fishing or switch gears. Many countries do not have a tradition of economic compensation in marine mammal management; thus, examples are rare. However, for porpoise protection in the upper Gulf of California, Mexico, economic compensation has been used to protect the vaquita (*Phocoena sinus*). Alongside area closures, the Mexican government implemented economic incentives to eliminate driftnets and gillnets from the vaquita's habitat. This voluntary program offered fishers three options: (1) rent-out: an annual payment of US$3,500 to stop fishing, (2) switch-out: a US$25,000 payment and a new fishing permit to use alternative gear with no vaquita bycatch, or (3) buyouts: turning in boats, nets, and fishing permits for US$25,000 to US$35,000 (SEMARNAT 2008).

In 2008-2010, the program was modified to make the buyout option less appealing and the rent-out option more attractive. The switch-out option was also adjusted to include temporary switch-out to increase its appeal (CNANP 2008, 2009, 2010). Analysis of fishers' participation revealed that those with skills in alternative economic activities were more likely to stop fishing, while those with less productive vessels were more inclined to switch to vaquita-safe fishing methods. However, only 15.5% of the total fleet either stopped fishing or permanently switched to vaquita-safe gear as part of the program (Avila-Forcada *et al*., 2012).

Economic compensations in the Baltic Sea area

Many countries do not have a tradition of economic compensation in relation to the bycatch management of marine mammals. Swedish fishers have, however, been compensated for damages to fish catch or fishing gears caused by seals (HVm 2014).

2. Bycatch quota

General

Bycatch quotas could potentially be used to reduce or keep bycatch levels below a certain threshold. Implementing these quotas would allow a certain level of bycatch while it would be up to the industry itself to determine how the level would be kept within the defined limits. Quotas can be applied either individually or fleet-wide and transfer, purchase and lease of quotas could be possible (Alverson *et al*., 1994; O'Keefe *et al*., 2013). Quotas have not been used as a management tool to reduce bycatch of harbour porpoises, although in a theoretical study by Bisack and Sutinen (2006) individual transferable quotas (ITQ) for harbour porpoises and time/area closures were compared as management tools. To study ITQs as a management tool, these authors developed a numerical bioeconomic model of harbour porpoise bycatch in the New England sink gillnet fishery. The model incorporated spatial and temporal patterns of fish species and marine mammals over several seasons and years. The results showed that the ITQ was less costly to the industry compared to the season-port closures. The difference between the two changed depending on the bycatch quota although, in all cases, the ITQ had the lowest costs (Bisack and Sutinen 2006).

ITQs have been used mainly for management of fish catches but a bycatch ITQ study has been tested for the protection of Hooker's sea lion (*Phocarctos hooker*i) in the New Zealand squid fishery. Because Hooker's sea lions are protected, a bycatch limit has been set each year since 1992, based on population models and sustainable mortality levels. The results showed, however, that the squid fishery is much more sensitive to bycatch limits than the sea lions, that is, the fishery showed greater losses than the sea lion population showed gains under the closures (Maunder *et al*., 2000). A positive example was, however, observed in the purse seine fishery for yellowfin tuna in the Eastern Pacific. Here dolphin bycatch of various species was allowed only until a certain level of bycatch was reached, which led to a large reduction in the total dolphin bycatch (Hall, 1998; Gosliner, 1999).

Bycatch quota in the Baltic Sea area

Given the serious threat status of the Baltic Proper harbour porpoise population, this method might not be viable for the Baltic Sea, as only one animal caught can harm the population and close down the fishery at the same time. If the population recovers, this might be a potential option for management in the region.

A drawback of this method is the need for extremely thorough bycatch monitoring and enforcement and thus control, usually applied through real-time camera systems.

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