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FOLLOW-UP STUDY AFTER FOUR YEARS SHOWS REDUCED DETERRENCE EFFECT OF PINGERS ON HARBOUR PORPOISES IN NORWEGIAN GILLNET FISHERY

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ABSTRACT

We report results from follow-up field trials testing acoustic deterrents (pingers) as a measure to reduce harbour porpoise (*Phocoena phocoena)* by-catch rates in coastal gillnet fisheries in Norway. Twelve gillnet fishers conducted a total of 308 fishing trips, fishing with and without pingers in alternating weeks between January and April 2024. Harbour porpoises were by-caught in both pingered (9 porpoises) and control nets (25 porpoises), with most (~73%) taken in control nets. Average by-catch rates were calculated using a generalised linear mixed model (GLMM) approach. The average harbour porpoise by-catch rate was estimated at 0.061 (95% CI 0.034 – 0.098) porpoises per net km day in control nets and 0.031 (95% CI 0.011 – 0.060) porpoises per net km day in pingered nets. This shows that the by-catch rate in pingered nets was about 50% lower than in control nets (95% CI 0 – 83%). This estimate is lower (i.e. the pinger effect size is smaller) than a directly comparable study (Moan & Bjørge, 2023). Possible causes include limited sample size, the use of bait bags to attach pingers to the nets, reporting biases, and/or desensitisation/habituation of porpoises to the pinger sounds. Extra time use due to pingers was low, about two minutes per haul. The use of bait bags seems to have mitigated some, but not all the practical issues reported earlier. The pooled pinger effect size estimate using data from both Moan and Bjørge (2023) and the present study, was estimated at 72% (95% CI 44 – 89%).

Keywords: by-catch, fishery interactions, pingers, marine mammals, small cetaceans, harbour porpoise

INTRODUCTION

Every year, about 2,900 harbour porpoises (*Phocoena phocoena*) are killed as unintentional by-catch in commercial gillnet fisheries along the Norwegian coast (Moan et al., 2020). This number is considered a minimum estimate, since it is unlikely that 100% of all by-catch is registered in current by-catch monitoring in Norway (NAMMCO, 2022). Additionally, harbour porpoise by-catch in other gear types and in recreational fisheries, have also been documented in Norway, and is not negligible, although the total number of porpoises killed in this way is not known (Moan, 2023). Depending on the exact geographic delineation, estimates of harbour porpoise abundance in this region range from about 130,000 (NAMMCO, 2022), 180,000 (Moan et al., 2020) to 256,000 (Leonard & Øien, 2019) animals. Despite the commonness and ubiquity of harbour porpoises in Norway, our current understanding of the population structure, spatial distribution and other important aspects of porpoise ecology in Norway is very limited. This makes it difficult to assess the impact of fisheries induced by-catch mortality on the "Norwegian" part of the harbour porpoise population in the Northeast Atlantic. However, even in the best possible scenario, the level of harbour porpoise by-catch in Norwegian waters is concerning (Moan et al., 2020; NAMMCO, 2022). There are several reasons to try and reduce this by-catch. Given their abundance, broad distribution and trophic level, harbour porpoises most likely have important roles in marine ecological communities in the coastal Northeast Atlantic. When porpoises become entangled in gillnets, they are rendered helpless, and the outcome is almost always death by suffocation (not drowning) (IJsseldijk et al., 2021). Removing porpoise carcasses from gillnets can be time-consuming for fishers and marine mammal entanglements can cause damage to the gillnets (e.g. Lowry & Teilmann, 1994). In a bigger perspective, a sustained high by-catch level may have commercial and economic consequences for fishery nations such as Norway, as fish market access is becoming more and more contingent on sustainable, well-managed fisheries. In the US, for example, new legislation prohibits the import of fish and fish products from fisheries that have unsustainable marine mammal by-catch levels from 2026 (Williams et al., 2016).

The most common measure to reduce harbour porpoise by-catch in gillnets is the use of pingers, a type of acoustic alarm that is attached to the gillnets and emits short pings at intervals to deter porpoises away from the nets. The use of pingers on gillnets to reduce by-catch risk for harbour porpoises is a well-tested by-catch mitigation method, that is now supported by an extensive body of scientific research (e.g. Carlström et al., 2009; Dawson et al., 2013; Omeyer et al., 2020; Palka et al., 2008; Pinn, 2023). In Moan and Bjørge (2023), we reported results from commercial fishery trials with two types of pingers in Norwegian commercial gillnet fisheries. Those trials were conducted in 2018-2020, in cod and monkfish fisheries. The results were promising, with by-catch rates estimated at 94%

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(95% CI 77-100%) lower in pingered nets than in control nets. In 2021, the use of pingers became compulsory in gillnet fisheries in the Vestfjord (northern Norway, fishery statistics area 00, Figure 1) between January and April. The Vestfjord was selected because regional by-catch estimates revealed that this area was a hotspot for harbour porpoise by-catch in gillnet fisheries (Moan et al., 2020). The Vestfjord is the main fishing grounds during the winter gillnet fishery targeting cod (*Gadus morhua*), which makes up the biggest part of the largest commercial coastal gillnet fisheries in Norway (Fangel et al., 2015). At the time pingers became mandatory in the cod winter gillnet fishery, they were not in common use in Norway, if they were used there at all.

After the first season of mandatory pinger use, the Directorate of Fisheries, the Institute of Marine Research and the Norwegian Fishermen's Association conducted an evaluation of pinger use in the Vestfjord (Fiskeridirektoratet, 2021). The evaluation showed that many fishers were unhappy with the process leading up to the pinger mandate, in particular with regards to the short hearing deadline and poor dissemination of related background information. The evaluation also showed that in the first season of mandatory pinger use, fishers had very mixed experiences with using pingers, with a number of fishers having issues such as mechanical damage, water intrusion and pingers getting wrapped up in net meshes. Thus, there has most likely been a learning curve in the use of pingers for the end users, i.e. the fishers. At present, four years later, the pinger mandate is still in effect. In this paper, we report results from a second set of fishery field trials testing pingers, as a follow-up to the previous study from 2018-2020. The aim of this new study was to collect additional data on the effectiveness of pingers to reduce harbour porpoise by-catch risk, after three years of mandatory pinger use in the Vestfjord, to aid efforts towards well-informed, effective harbour porpoise by-catch mitigation in Norway and elsewhere.

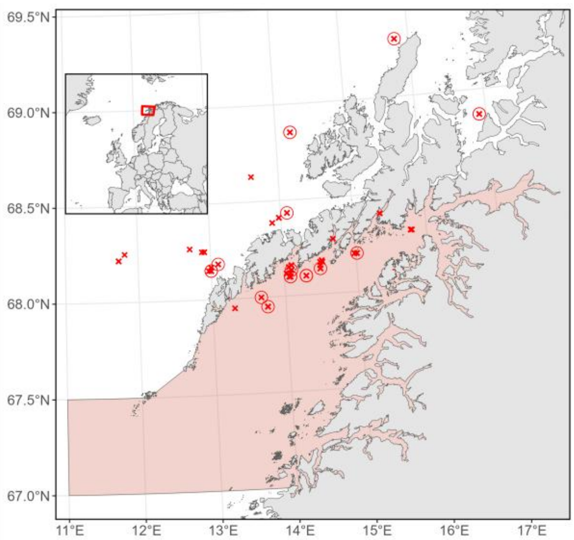

Figure 1. Map showing the study area, with the Vestfjord, where using pingers is mandatory for part of the year, highlighted in pink. Red crosses indicate approximate locations of fishing sites. Encircled red crosses indicate harbour porpoise by-catch locations. The inset map shows Vestfjorden in its wider geographical setting.

MATERIALS AND METHODS

Setup and design

The design of the field trials was similar to the one used in Moan and Bjørge (2023), and may be considered a repetition of that study, but for only one season, and with other fishers. A total of 15 participants were recruited from among active commercial gillnet fishers. The participants came from two recruitment groups. For the first group, we took a random sample from a list of all the fishers that had landed catch in Vestfjorden the previous year and contacted them by phone. They were interviewed briefly to determine their eligibility and willingness to participate. For the second group, we received a list of names from the Norwegian Fishermen's Association. Fishers received a full complement (i.e. enough pingers to cover their total length of nets with one pinger per 200 m) of one of two types of pingers, either the Fishtek Banana Pinger (emitting pings of 50-120 kHz @145 dB, lasting 400 milliseconds per 4-12 sec), or the Future Oceans 70 kHz dolphin pinger (70 kHz @ 145 dB, lasting 300 milliseconds per 4 sec),. These are the same two types of pingers that were tested in Moan and Bjørge (2023). All the pingers received a new, fresh replacement battery before being delivered to the fishers, although they were not acoustically tested. Pingers were attached to the float line of the nets at approximately 200 m intervals, in accordance with manufacturer guidelines, either by tying them directly to the nets, or by putting them into small bait bags, that were then tied to the float line. The second method was meant to alleviate reported problems of pingers getting entangled in the meshwork of the nets, or getting jammed in the hauling machinery. Each fisher decided which method to use on his or her vessel.

Data collection

All fishers fished as they normally would, except every other week, the pingers were removed (either from the bait bags, or from their plastic casings, which were left attached to the nets). After each haul, the fishers filled out a data form, self-reporting their catch and by-catch, (by species and weight), as well as other relevant information about the fishing operation, including coordinates of the fishing site, total number of nets used, mesh size, minimum and maximum depth along the nets, hauling date, fishing duration and whether pingers were used or not. Since using pingers is mandatory when fishing with gillnets in the Vestfjord between January 1st and April 30th, we obtained permission for the fishers participating in this trial to be exempt from this regulation for the duration of the trial, from the Directorate of Fisheries (permit ref 24/50). At the start of every week, SMS messages were sent out to all participants, reminding them to activate (reattach) or deactivate (remove) pingers from their gillnets. This common schedule was intended to time-synchronise the use of pingers among different fishers, and in this way reduce any spillover effects of pingers from adjacent fishing sites in situations where two or more fishers set gillnets close to each other.

Analysis

The difference in counts of by-caught harbour porpoises in nets with and without pingers (not differentiating between the two types of pingers) was assessed using a generalised linear mixed model (GLMM) framework, to allow for testing different error distributions, zero inflation and the incorporation of random effect structures. The response variable was the number of by-caught porpoises. Pinger was specified as a binary factor variable (either "yes" or "no") and fitted as a fixed effect. This means that, like in Moan and Bjørge (2023), the two types of pingers were assumed to be equivalent in terms of their deterrence effect. Vessel ID was added as a random effect. The logarithm of fishing effort, i.e. the product of net length and fishing time, i.e. net km days was specified as an offset, under the assumption that by-catch rates are proportional to fishing effort. For example, a fishing effort of "1 km day" could be either a string of nets 1 km long, fishing for 24 hours, or a string of nets 1,5 km long fishing for 16 hours. In R syntax, the base model can be written:

$$porps \sim offset(net - km - days) + (1|vessel\_id) + pinger \qquad \textit{(eq. 1)}$$

In addition to this base model, we also tested three other plausible model formulations, including covariates for day of the year and day of the month (to capture temporal variation in porpoise presence), as well as depth and gillnet half mesh size (since gillnets with different mesh sizes may have different entanglement probabilities).

$$porps \sim offset(net - km - days) + (1|vessel\_id) + pinger + day\_of\_year + day\_of\_month \qquad \textit{(eq. 2)}$$

$$porps \sim offset(net - km - days) + (1|vessel\_id) + pinger + depth\_min \qquad \textit{(eq. 3)}$$

$$porps \sim offset(net - km - days) + (1|vessel\_id) + pinger + half\_mesh \qquad \textit{(eq. 4)}$$

We tested Poisson and negative binomial (NB) error distributions, as well as their zero-inflated counterparts (ZiP and ZINB, respectively), since these distributions are suitable for modelling skewed count data with many zeros. All models were initially fitted using a Poisson error distribution. If a model showed evidence of overdispersion, we tried to address this by refitting the model using the negative binomial (NB) error distribution. We tested two types of the NB distribution, i.e. with variance parameterised as a linear or quadratic function of the mean, denoted NB1 and NB2, respectively, and selected the NB model with the lowest AICc score. The choice of using NB instead of ZiP to address overdispersion reflected a preference for simpler models. If a Poisson model did not show evidence of overdispersion, but showed evidence of zero-inflation, it was refitted using the zero-inflated Poisson distribution. If a NB model showed evidence of zero-inflation, it was refitted using the zero-inflated NB distribution. Finally, we considered the model with the smallest AICc among the four different model formulations listed above as the "best" model and used that as a basis for generating pinger effect estimates.

We also calculated simple ratio estimates for the overall BPUEs - by-catch rate of harbour porpoises per unit effort (eq. 2). This was calculated separately for nets with and without pingers, with no post-stratification of data.

$$bpue = \frac{porps}{effort} \qquad \textit{(eq. 5)}$$

From each pair of pingered-control net by-catch rate estimates, we calculated the pinger effect size η as the additive inverse of the relative harbour porpoise by-catch rate in pingered nets (B_p) vs control nets (B_c), i.e.:

$$\eta = 1 - \frac{B_p}{B_c} \qquad \textit{(eq. 6)}$$

This entire estimation procedure was then repeated for different measures of fishing effort, i.e. catch and number of trips/hauls.

Additionally, to assess the overall effect of pingers, we pooled data from this study and Moan and Bjørge (2023), and repeated the estimation procedure described above, except that when fitting the GLMMs, the data source (i.e. study) was also added as an additional random effect. The validity of pooling data like this relies on the assumption that the two studies were conducted in a sufficiently similar manner.

We used the R packages glmmTMB v.1.1.10 (Brooks et al., 2017) and ggeffects v.2.0.0 (Lüdecke, 2018) to fit GLMMs and calculate marginal effects. We used check_overdispersion and check_zeroinflation from the R package performance v.0.12.4 (Lüdecke et al., 2021) to test for overdispersion and zero-inflation, using default values for all parameters. We used the R package AICcmodavg v.2.3-3 (Mazerolle, 2020) to calculate AICc scores. Confidence intervals were calculated using a standard bootstrapping procedure, i.e. using the 2.5 and 97.5th quantiles from the distribution of bootstrap estimates, based on 1,000 resamples with replacements and with no structure or conditions applied on resampling. All data and R code that were used in the analyses, as well as results in CSV files, are publicly available at https://doi.org/10.21335/NMDC-1533529600. R code can also be accessed at https://github.com/supermoan/ping2024.

RESULTS

As part of their ordinary commercial fishing activity, 12 fishers conducted 308 gillnet fishing trips with a total fishing effort of about 702 net KM days between January and April 2024. Pingers were used on 129 of those trips (41%). Most trips (225) were conducted in the Vestfjord, where pingers were mandatory in the study period (Figure 1). Figure 2 shows a breakdown of

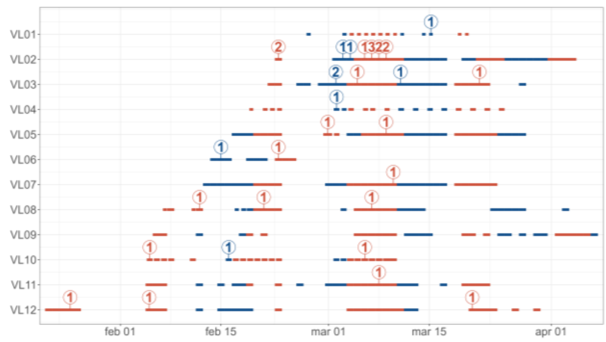

Figure 2. Overview of gillnet fishing activity and by-catch by vessel (VL01-VL12). The lengths and positions of the horizontal bars represent the reported fishing duration (time fished) and date/time, respectively, and the colours indicate when pingers were used (blue = pingers used, red = pingers not used). The encircled numbers above the bars indicate body counts of by-caught porpoises at the times indicated.

Table 1. Different estimates of marginal harbour porpoise by-catch rates per unit fishing effort, in control and pingered nets, calculated using on different measures of fishing effort (net km days, tonnes of landed catch, and number of hauls). RR indicates the relative by-catch rate in pingered vs control nets.

Fishing effort	Treatment	SR estimate (95% CI)	GLMM estimate (95% CI)
Net KM days	Control	0.062 (0.036 - 0.092)	0.061 (0.034 - 0.098)
	Pinger	0.030 (0.011 - 0.053)	0.031 (0.011 - 0.060)
	RR	**0.485 (0.173 - 1.080)**	**0.505 (0.169 - 1.085)**
Catch (tonnes)	Control	0.140 (0.080 - 0.207)	0.133 (0.077 - 0.200)
	Pinger	0.070 (0.024 - 0.122)	0.068 (0.025 - 0.116)
	RR	**0.500 (0.169 - 1.083)**	**0.514 (0.188 - 1.043)**
Number of hauls	Control	0.098 (0.056 - 0.149)	0.126 (0.069 - 0.240)
	Pinger	0.050 (0.017 - 0.092)	0.074 (0.027 - 0.152)
	RR	**0.062 (0.036 - 0.092)**	**0.061 (0.034 - 0.098)**

gillnet fishing activity for each vessel over time (blue or red horizontal bars), with blue colours indicating when pingers were used. Harbour porpoises were by-caught in both pingered (9 porpoises) and control nets (25 porpoises), but with most (~73%) taken in control nets. One vessel (VL11) caught no porpoises, while another (VL02) caught 12 porpoises. The remaining vessels each caught between 1 to 5 porpoises. By-catch occurred throughout the period of data collection. There was no by-catch of other species of marine mammals, such as harbour seals.

The best models (the models with the smallest AICc) used equation 2 for all measures of fishing effort. The best models used the NB error distribution (net km days, catch) and the Poisson error distribution (number of hauls). The estimated marginal harbour porpoise by-catch rates per unit fishing effort, with and without pingers, and the associated relative rates, estimated using both approaches described above, are shown in Table 1. Corresponding estimates agreed well between simple ratio and GLMMs estimates, especially when using net KM days or number of hauls as a proxy for fishing effort. The estimated relative rate of harbour porpoise by-catch in pingered gillnets varied from about 50% to 59%, suggesting a pinger-associated harbour porpoise by-catch reduction effect size of 41 – 50%.

Results from applying the same estimation approach to the combined data set (i.e. data from the present study and from Moan and Bjørge (2023) pooled together), are shown in Table 2. Based on these results, the estimated relative rate of harbour porpoise by-catch in pingered gillnets varied from about 19% to 25%, suggesting a pinger-associated harbour porpoise by-catch reduction effect size of 75 – 81%. There were larger differences between simple ratio and corresponding GLMM estimates derived from pooled data than for estimates only using data from 2024. More detailed results are available in the Supplementary Information, Table SI1.

DISCUSSION AND CONCLUSIONS

The estimated effect of the pingers on harbour porpoise by-catch rates reported here is lower than the pinger effect estimate of 94% reported in Moan and Bjørge (2023), where the same two types of pingers were tested. The estimated effect size of about 50% is also somewhat lower than what has been reported in several other studies that have tested the effect of other, similar types of pingers on harbour porpoise by-catch rates (e.g. Dawson et al., 2013), although Morizur et al. (2009) reported a similar by-catch reduction effect estimate of 51%. Kindt-Larsen et al. (2025) similarly reported a comparable by-catch reduction effect estimate of 64%. We speculate that some possible causes for why the effect size estimate in this trial may be lower than previously reported estimates include 1) insufficient sample size, 2) the use of bait bags, 3) reporting biases and 4) habituation.

Table 2. Different estimates of marginal harbour porpoise by-catch rates per unit fishing effort, in control and pingered nets, calculated using on different measures of fishing effort (net km days, tonnes of landed catch, and number of hauls). RR indicates the relative by-catch rate in pingered vs control nets.

Fishing effort	Treatment	SR estimate (95% CI)	GLMM estimate (95% CI)
Net KM days	Control	0.020 (0.013 - 0.028)	0.029 (0.019 - 0.041)
	Pinger	0.005 (0.002 - 0.009)	0.008 (0.003 - 0.016)
	RR	**0.249 (0.088 - 0.497)**	**0.283 (0.114 - 0.569)**
Catch (tonnes)	Control	0.751 (0.503 - 0.912)	0.717 (0.431 - 0.886)
	Pinger	0.051 (0.032 - 0.077)	0.128 (0.067 - 0.214)
	RR	**0.015 (0.006 - 0.027)**	**0.025 (0.008 - 0.051)**
Number of hauls	Control	0.287 (0.100 - 0.619)	0.193 (0.062 - 0.418)
	Pinger	0.713 (0.381 - 0.900)	0.807 (0.582 - 0.938)
	RR	**0.084 (0.057 - 0.114)**	**0.078 (0.053 - 0.106)**

Generally, in scientific sampling, the smaller the sample size, the less representative it is of the population under study (Babcock et al., 2003; Cao et al., 2002). Fishery by-catch data often exhibit a heterogenous and clumped distribution across observations (Babcock et al., 2003), so it is conceivable that an insufficient sample size, by chance, may cause by-catch events that would otherwise have a substantial impact on by-catch rate estimates, to be "missed". With a small sample size and few study participants, the effect of user errors (i.e. mishandling the pingers such that they malfunction or function less optimally) can also have a large effect on results. The present study spanned four months and included 308 trips. By comparison, the study reported in Moan and Bjørge (2023) spanned 24 months and included 735 trips, albeit with fewer vessels (8 vessels). However, results from a simulation study that estimated pinger effects based on down-sampled data from Moan and Bjørge (2023) (i.e. simulated data sets of equal size to the present study were created by sampling with replacement from the original data) suggested that it is unlikely that the discrepancy between the results from this study and the results from Moan and Bjørge (2023) can be explained by an insufficient sample size.

Another possible explanation for the relatively low effect size estimate is that the use of bait bags to attach pingers to gillnets may have obstructed the acoustic signal emanating from the pingers, so that the acoustic coverage around the gillnets was reduced or otherwise suboptimal compared to direct attachments of pingers to the nets. Bait bags have not been used in any other pinger studies, including Moan and Bjørge (2023). The use of bait bags emerged among fishers after the introduction of the pinger mandate in 2021 as a measure to address various practical issues with pingers, including entanglements and out-popping (pingers ejecting from their plastic covers due to physical pressures exerted during setting or hauling). Further studies are needed to assess whether pinger output is indeed affected by being enclosed in a bait bag, and whether current fishery regulations should be updated to prohibit the use of bait bags. This has important implications for effective pinger-based harbour porpoise by-catch mitigation, since pingers can only deter porpoises when they are actually used, and compliance to the pinger regulations is most likely greatly affected by practical considerations. If fishers perceive pingers to be impractical to use, they are more likely not to use them, or to use them incorrectly (i.e. using too few pingers, not replacing damaged or malfunctioning pingers, etc.), especially if the pinger regulation is not enforced.

The self-reporting side of the study is another aspect that must be considered. Collecting fishery data through self-reporting is often regarded as unreliable (Walsh et al., 2002; Sampson, 2011), especially in situations where the reporters may have vested interests in one particular outcome, and data cannot be independently verified. When the 2018-2020 trials were conducted, pingers were not widely known among fishers. When the present study was conducted, fishers were already intimately familiar with pingers through the pinger mandate, through extensive critical reporting in the fishery newspapers and through their own experiences. These circumstances constitute an important difference in the fishery-industrial and fishery-regulatory climate under which these two Norwegian pinger studies were conducted. It is possible that this may have contributed to reinforcing negative attitudes to pingers among fishers, including the ones that participated in this study. It can be expected that any bias because of this, whether conscious or unconscious, is most likely to manifest as an overemphasis of by-catch in pingered nets and an underemphasis of by-catch in control nets, but the extent to which this applies to this study is unknown and unknowable. Vessel-borne remote electronic monitoring may be a suitable way to independently verify data collected in future studies of this kind, to assess potential reporting biases.

A fourth possible reason for the reduced pinger effect estimate in this study is habituation. Since January 2021, the use of pingers in the Vestfjord has been mandatory between January and April every year. Even though compliance to the pinger mandate has only been around 62% (Fiskeridirektoratet, 2021), this still means that there have been a substantial number of active pingers in the Vestfjord in these years, especially around fishing "hot spots", where the density of gillnets (and pingers) may become very high. Harbour porpoises in those spots, and in the general Vestfjord area may have been continually or regularly exposed to pingers over an extended period every year over the last four years. It is possible that prolonged exposure of this kind has caused porpoises to become desensitised/habituated to the pinger sounds, so that their aversion response has been reduced over time. The potential for desensitisation and habituation is a common concern associated with pinger use, with some studies (using other, but similar pinger types) reporting evidence of habituation (e.g. Carlström et al., 2009; Cox et al., 2001), while others report no evidence of habituation (e.g. Carretta & Barlow, 2011; Kyhn et al., 2015; Königson et al., 2022; Omeyer et al., 2020; Palka et al., 2008). The two types of pingers tested in this study both had features that were specifically intended to reduce or prevent habituation, such as randomising the frequency of the acoustic signals (within a suitable range) and randomising the interval between successive pings. It is possible however, that such anti-habituation features may be less effective when pingers are used in very high densities, such as during the winter cod fishery in Norway. The need to account for other factors is especially evident from the large difference in estimated by-catch per unit effort in control nets in this study and Moan and Bjørge (2023). A more sophisticated, longer-term, multi-year study, where the presence of porpoises and other relevant biotic and abiotic factors are monitored concurrently, is necessary to obtain conclusive results regarding habituation.

Given that there is a significant difference between the pinger effect size estimates obtained in the present study and the one reported in Moan and Bjørge (2023), the question arises – which estimate is the most accurate one, in terms of representing the effect of pingers on harbour porpoise by-catch rates in Norwegian commercial gillnet fisheries? Arguably, there is more uncertainty associated with the more recent estimate from a data collection and data reliability perspective. The most recent estimate is also a bit of an outlier in comparison to results from pinger studies from other regions, as discussed above. Even so, it would be unwise to disregard these more recent results. A more balanced approach may be to consider these two studies together, and use the pinger effect estimate based on the combined datasets from *both* the present study and Moan and Bjørge (2023), of 72% (95% CI 44 – 89%), to inform any pinger-based by-catch mitigation efforts for harbour porpoises in Norwegian commercial gillnet fisheries, while keeping the important caveats discussed above in mind.

ADHERENCE TO ANIMAL WELFARE PROTOCOLS

The research presented in this article has been done in accordance with the institutional and national laws and protocols for animal welfare that are applicable in the jurisdictions where the work was conducted.

AUTHOR CONTRIBUTION STATEMENT

AM: conceptualisation, investigation, methodology, project administration, data curation, formal analysis, visualization, writing – original draft, review and editing; **AB**: conceptualization, funding acquisition, methodology, writing – original draft, review and editing.

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