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COMMENT

Pseudo-replication confounds the assessment of long-distance detection of gillnets by porpoises: Comment on Nielsen et al. (2012)

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ABSTRACT: The harbour porpoise *Phocoena phocoena* is one of the small cetacean species most frequently caught in gillnets. Understanding how this occurs is important to devising effective mitigation strategies. To assess the distance at which harbour porpoises can detect and avoid gillnets, Nielsen et al. (2012; Mar Ecol Prog Ser 453:241–248) quantified the movement of porpoises through a study area when a gillnet was present, and when it was not. They claimed to provide evidence that porpoises detected gillnets at distances >80 m, much farther than was thought possible. We show, however, that their results are undermined by pseudo-replication, and hence that their conclusion is unreliable. Mixed-effects modelling (van de Pol & Wright 2009; Anim Behav 77:753-758) can be used to avoid this problem.

KEY WORDS: Harbour porpoise · Echolocation · Gillnet · Pseudo-replication

Introduction

Bycatch of small cetaceans in gillnets is one of the most significant problems in marine conservation, killing some 300 000 ind. yr^{-1} (Read et al. 2006). Harbour porpoises *Phocoena phocoena* are among the species most frequently caught. Studies using the sonar equation, the highest measured source level of porpoise clicks and measured target strength of gillnets (Kastelein et al. 2000, Villadsgaard et al. 2007) suggest that porpoises could detect gillnets at distances up to 13 to 26 m. Nielsen et al. (2012), however, claimed that harbour porpoises could detect gillnets at distances >80 m; this would be an important result for understanding and mitigating bycatch of porpoises.

Pseudo-replication confounds analysis

To quantify whether, and at what distance, harbour porpoises detect gillnets, Nielsen et al. (2012) observed the surfacing positions of harbour porpoises in the vicinity of a moored gillnet. Their first analysis was to compare the closest observed approach of each pod to the net or to a control (a net location without an actual net). They found no significant difference in closest observed approach. This analysis used only 1 representative sample from each porpoise 'follow' (a tracking sequence of surfacing locations as a pod passes through the observation area). Hence, it rightly focused solely on an analysis of the variance between 'follows'.

Their second analysis is more problematic. It compared the density of surfacings in different zones in the observation area, between 2 states — presence and absence of a net. Thus, each pod passing through the observation area contributed several surfacing locations to the analysis, and these cannot be considered independent. While the zoned analysis in Nielsen et al. (2012) may reduce the chance that subsequent surfacings fall in the same zone, the inclusion of several data points from each approach event is pseudo-replication (sensu Hurlbert 1984). Put another way, Nielsen et al.'s second analysis tries to

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infer between-treatment differences while discounting that the variance in the distribution of surfacings is composed of within- and between-'follow' variance. Thus, sample size is inflated, and the statistical results are unreliable (see also Dawson & Lusseau 2005).

Resolution by a mixed effects model

Mixed effects models can help to make inferences about fixed effects, i.e. test for differences between treatment levels, in this case presence or absence of a net, while accounting for subject-level variance (van de Pol & Wright 2009). In addition, these analyses provide a means to change the dependent variable to one providing more information about within-'follow' movement as a function of distance from the net. Variables that quantify whether or not porpoises deviate from their paths as they approach the location of the net (with the net either in place, or removed in the case of control observations) could help to infer whether or not the presence of the net influences porpoise movement, and if so, at what range. This dependent variable could be estimated for each surfacing of a porpoise, and a linear mixed effects model could be developed to infer the effect of presence and distance of the net on this deviation index, accounting for the random effect of 'follow'.

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