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REPLY COMMENT

Assessment of long-distance detection of gillnets by porpoises: Reply to Dawson & Lusseau (2013)

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ABSTRACT: Nielsen et al. (2012; Mar Ecol Prog Ser 453:241–248) analyzed surface observations of harbour porpoises in a small coastal area where a modified gillnet was introduced at randomized time intervals. The study concluded that porpoises reacted to the gillnet at surprisingly large distances (in some cases >80 m). Dawson & Lusseau (2013; Mar Ecol Prog Ser 478:301–302) argue that the conclusions of Nielsen et al. (2012) are undermined by pseudo-replication (a matter of concern in many field studies of marine mammals). We acknowledge these concerns, but we think that the conclusions of Nielsen et al. (2012) remain valid, as the data are best explained by harbour porpoises being able to detect and avoid gillnets at very long ranges.

KEY WORDS: Harbour porpoise · *Phocoena phocoena* · Echolocation · Gillnet detection · Pseudo-replication

Introduction

It had been assumed until recently that porpoises can only detect gillnets at very short range before swimming into them; this hypothesis was mainly derived from theoretical calculations based on data on the echo strength of nets and on harbour porpoise sound production and hearing (Kastelein et al. 2000, Villadsgaard et al. 2007). Nielsen et al. (2012) presented the first data set based on field observations of porpoises around a modified gillnet, concluding that a vigilant porpoise can detect and avoid a gillnet at very long range. This has important implications for designing techniques to alleviate the porpoise by-catch problem.

Pseudo-replication, and conclusions in Nielsen et al. (2012)

Dawson & Lusseau (2013, p. 301) evaluate the statistical analysis used by Nielsen et al. (2012). They regard the first analysis, which used approach distances, as being correct, because only 1 data point was used for each approaching porpoise pod. The second analysis, where all reported surfacings were grouped into different zones (each with an equal distance to the fishing net), is regarded as being 'more problematic': 'Each pod passing through the observation area contributed several surfacing locations to the analysis, and these cannot be considered independent'. They note, however, that zone analysis reduces the chance that subsequent data are dependent and suggest that a mixed-effect model could be used to make inferences about confounding effects on the conclusions of Nielsen et al. (2012).

The issues brought up by Dawson & Lusseau (2013) are highly relevant. In field studies it can be impossible to control for confounding factors. The usual way to deal with this problem is to minimize the factors believed to have a confounding effect and to estimate their effect on the analysis (e.g. Hurlbert 1984, Underwood 1997). For instance, although Dawson & Lusseau (2013, p. 301) argue that the first analysis in

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Nielsen et al. (2012) 'rightly focused solely on an analysis of the variance between 'follows'', this is only true if we regard each observation of a pod approaching the fishing net as being independent. However, some pods may re-enter the observation area after their first visit. In such cases, subsequent observations of the pod are *not* statistically independent from the first one, and the analysis therefore includes pseudo-replication. It is very difficult to control for such effects (since it is impossible to track and identify porpoises for more than a few minutes). However, we (and apparently also Dawson & Lusseau 2013) regard such events as being rather unlikely, and therefore we think that they have little influence on the conclusions in Nielsen et al. (2012).

It is true that some data points in the second analysis, which was based on zoned surface observations, in Nielsen et al. (2012) are dependent, as the data contain subsequent surface observations of the same harbour porpoises. Due to the spurious nature of harbour porpoise swimming and the fact that it is impossible to recognize most individuals, it is very difficult to assess how large this effect is. We estimate that in 2008 each tracked porpoise contributed with 12.1 surfacings and in 2009 with 7.4 surfacings to the analysis.

On the other hand, the study area was 200 by 400 m and therefore small enough for a porpoise to swim straight through without surfacing at all, i.e. porpoises can enter the study area and surface once, several times or not at all. Compared to other studies (e.g. references in Dawson & Lusseau 2005), many of which observed porpoises at distances of several kilometers, the small study area in Nielsen et al. (2012) should minimize the dependency between individual points. In addition to this, the movements of the porpoises were not restricted by anything other than the net. If porpoises chose to stay within the study area for more than one surfacing, this was of the animal's free will and considered an important part of the behavior that we were investigating.

Swimming tracks and surface locations during experimental conditions (gillnet present) were different from the controls (gillnet absent) in both 2008 and 2009, but there was no difference in distribution between the control, nor between the experimental periods (Nielsen et al. 2012, Figs. 1, 2 & 5, Table 2 therein). The probability of having observed the same individual porpoises in both 2008 and 2009 is small. The results are exactly what would be expected from the most parsimonious explanation, i.e. that avoidance of the gillnet determined the distribution of porpoises in the study area. Pseudo-replication would only create significant differences in animal distributions between experimental conditions and controls, but not between controls or experimental conditions between years.

If the data contain multiple observations of the same individuals, this may actually make the result conservative. Multiple observations may create more noise in the data, as animals approaching the net may be logged several times, at various distances from the net, rather than only at their closest range to the net.

Pseudo-replication concerns unwarranted conclusions that result from pushing the analysis beyond that which is supported by data. The arguments in Dawson & Lusseau (2013) run into a similar problem: they disregard that Nielsen et al. (2012) mention the following caveats: (1) the gillnet was not completely realistic, as meshes had been cut to avoid risk of entanglement (p. 242, 245); (2) following the behavior of a single animal within the pod, rather than following all animals, limits the analysis. Moreover, the study area in Nielsen et al. (2012) was relatively small, and zonation made the risk of pseudo-replication much smaller than was the case in the studies criticized in Dawson & Lusseau (2005).

Any discussion of statistical analysis depends on the hypothesis being tested. In Nielsen et al. (2012), the question investigated was at which distances harbour porpoises may detect gillnets. We do not claim that porpoises *always* detect gillnets and are distributed as was the case in our study; the considerable by-catch rates of this species demonstrate that it cannot be so. Instead, our article highlights that previous estimates of porpoise behavior around gillnets are to a large extent based on assumptions which may not be valid and are not based on appropriate experimental data. In field studies on the actual distribution of harbour porpoises around gillnets, the issue of pseudo-replication would be more relevant than is the case in Nielsen et al. (2012).

Outlook

Dawson & Lusseau (2005, 2013) raise valid concerns regarding pseudo-replication in mammal studies, but the risk of inflating the conclusions must be balanced against the likelihood of these problems actually occurring. It is difficult to control for all confounding factors in experimental field biology, and it is necessary to evaluate the consequences of the confounding factors.

Dawson & Lusseau (2013) suggest that the data in Nielsen et al. (2012) should be re-analysed using a mixed model, but this approach would only be powerful if single individuals or pods could be identified, and this is not possible in harbour porpoises. As there are only a few observations per pod, another approach could be to simply omit the dependent data points. An analysis of tipping points of the independently selected data points may be another option.

Alternative analyses of our data set will not eliminate the problem of pseudo-replication. As in many other studies of unidentified individual animals whose whereabouts cannot be constantly observed, it is impossible to discern how many times the same pod is observed and whether porpoises switch from one pod to another. Nielsen et al. (2012) is important towards understanding harbour porpoise behavior, despite shortcomings in the experimental design. Further investigations using more sophisticated techniques will hopefully avoid the drawbacks in the current experimental designs.

Editorial responsibility: Matthias Seaman, Oldendorf/Luhe, Germany

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