

Invited reply

Exposure to seismic survey alters blue whale acoustic communication

The authors of the comment first argue that ‘the definition of a ‘seismic period’ (Pinet *et al.* 2010) is not accurate enough and thus the relationship between seismic activity and calling behaviour is not clearly demonstrated nor is it supported’. The data and the evidence presented in our paper emphatically refute this argument. The definition of a ‘seismic period’ was defined to be very simple so as to eliminate the very reasons that the authors of the comment try to use to argue their case. On days and during times when seismic sparker pulses were present, as detected on data from all five seafloor recorders in the area where blue whales were closely observed and monitored, the rates of audible calling increased relative to periods when seismic sparker pulses were not present (Di Iorio & Clark 2010).

The authors of the comment present four items of contention.

- (i) On day 11 (11 August 2004), the seismic survey vessel was docked in the harbour and not operating. This is correct. Indeed, no sparker pulses were recorded on that day. The fact that in the electronic supplementary material, table, in our paper, day 11 was listed as ‘a day on which the sparker noise was not detectable on all recording units’ is a mistake that occurred when creating the table. The error has been corrected (electronic supplementary material, Di Iorio). In the first article version, day 11 was used as a ‘no-seismic’ day but it was omitted from the analyses in the published article because it did not fulfil all the requirements needed for these analyses any more.
- (ii) The authors of the comment state that on day 8, a ‘no-noise day’ in our study, the ship was closer to our recording area than on day 4 (4 August 2004), a day that was considered as a ‘seismic day.’ Sparker pulse noise presence or absence was determined by carefully listening to and visually inspecting all five channels of recorded data. Day 8 was considered a no-noise day because during the day, there were periods of either very faint pulses or no pulses. We do not know the reason for this discrepancy. Received sound level is not simply a question of distance

but a function of multiple environmental factors, including the dynamic oceanographic properties of the St Lawrence estuary and the position of the operating vessel (e.g. relative to deep channels) that can significantly affect the propagation of a broadband signal.

- (iii) The authors of the comment argue that shipping noise is not regularly present in our study area. This is incorrect. About 6000 merchant ships transit annually through the St Lawrence estuary with up to five ships per hour on busy days during the summer. From our long-term recordings, we know that the whales are continuously exposed to noise from commercial shipping and that the number of merchant ships passing in the seaway through the study area was very similar between the periods of field observation with and without seismic sparker pulses. The ambient noise levels during these two conditions were similar except for the presence/absence of sparker pulses. Therefore, vessel noise was not a factor that can explain the observed changes in blue whale vocal behaviour.
- (iv) As mentioned above, there were periods during sparker operation days when sparker pulses were not or were only barely detectable. This variation may have been a result of several factors, such as changes in the sparker source vessel’s position and orientation relative to the seafloor recorders, a temporary shutdown of the sparker system or the oceanographic characteristics affecting signal transmission. Progressive increases and decreases of sparker noise levels occurred regularly and were not unexpected. However, in the seven cases used in the third analysis (fig. 2c), 1 h of a no-seismic period was always followed by a 1 h period with unambiguous sparker pulse occurrence.

We agree with the authors of the comment that ‘whale responses may vary depending on several parameters’, and that knowledge of the location of the operating vessel would allow a much more accurate analysis of such responses. Obviously, we would have integrated such data if they had been available, and we would still be interested in doing it for a more detailed analysis. Nevertheless, we believe that our analysis and results are straightforward and provide evidence that blue whales acoustically responded to the presence of seismic sparker operation by increasing their rates of calling.

Finally, the authors of the comment argue that the ‘sparker source is obsolete for modern hydrocarbon exploration’, which in this case is incorrect considering that one of the main objectives of the survey was also to locate areas of natural gas in the St Lawrence estuary (Bellefleur *et al.* 2006). Irrespective of the reason for the survey, it was conducted in the season and one of the areas with highest whale density, which Fisheries and Oceans Canada is considering for the establishment of a marine-protected area. Future seismic operations, also deploying low-medium power profilers, should therefore take into account the potential effects on whales and plan the surveys in a way to minimize the impacts on these

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animals and by considering the involvement of marine mammal observers.

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