How fish might adjust their acoustic communication in anthropogenic noise: a response to comments on Radford et al.

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We are grateful for the thoughtful and supportive commentaries (Brumm 2014; Candolin 2014; Kunc 2014; Wong 2014) written about our recent review of how fish might potentially adjust their acoustic communication in response to anthropogenic (man-made) noise (Radford et al. 2014). A clear consensus among the commentators and ourselves is the need for more studies directly investigating this issue. Here, we emphasize 3 reasons why such research is important.

First, Brumm (2014) rightly points out that we need to establish the extent of the potential problem caused by anthropogenic noise because many fish species tend to communicate acoustically over only very short distances (often <1 m). This is clearly a much smaller perceptual range than that of even the low-amplitude close calls common in many social birds and mammals (Palombit et al. 1999; Radford and Ridley 2008) and certainly than that of louder songs and alarm calls (Bradbury and Vehrencamp 2011). As Wong (2014) mentions, though, sound transmits much further and at higher amplitudes in water than in air, so the area of potential impact arising from an anthropogenic noise source may be greater than on land. The uncertainty about the likelihood of an effect is why it is crucial to obtain actual measurements of signal-to-noise ratios in natural conditions and within the usual communication ranges of fishes (Brumm 2014).

The second reason for further research, not unrelated to the first point, is that many fishes use multicomponent signaling; determining the relative importance of the acoustic component relates directly to the likely impact of anthropogenic noise (Brumm 2014; Candolin 2014). One possibility is that there is redundancy in the signaling process: the same information could be conveyed to receivers through other sensory modalities (e.g., visual, electrical, or chemical), as well as acoustically (Brumm 2014). If so, then the loss of the acoustic element of the display would not necessarily have a detrimental effect on the message conveyed. On the other hand, signals in different sensory modalities could be complementary, either providing related but different pieces of information or being used at different stages in the signaling process (Candolin 2014; Wong 2014). In such cases, loss of the acoustic component could result in changes in the information received and thus changes in responses; for instance, assessment of individual quality could be affected, leading to less selective mate choice (Heuschele et al. 2009; Candolin 2014). In all probability, the effects of anthropogenic noise will be species specific and so further work, rather than extrapolations from existing knowledge, is required.

A third reason for investigating the responses of fish to anthropogenic noise is their potential as model organisms. Ultimately, what is needed are detailed studies assessing fitness consequences (Morley et al. 2014); in the case of acoustic communication, changes by signalers could be costly and there could be direct or indirect effects on survival and reproductive success (Read et al. 2014). The majority of work conducted on how anthropogenic noise affects aquatic organisms has been on marine mammals, but for obvious reasons determining fitness consequences in such long-lived animals is difficult. Fish, and indeed invertebrates (see Wale et al. 2013a, 2013b; Nedelec et al. 2014 for recent evidence of impacts of noise), are currently understudied relative to their abundance and importance (Kunc 2014; Morley et al. 2014; Radford et al. 2014). However, species in these taxonomic groups provide more scope than marine mammals for direct assessments of fitness consequences due to their generally smaller sizes, shorter life spans, and the potential for experimental manipulation.

We therefore need new studies, ideally involving field experiments with data collected from free-ranging animals. Captive-based work, offering carefully controlled conditions and the possibility of detailed observations, can provide a valuable stepping stone in determining the potential for noise to have an impact (e.g., Bruintjes and Radford 2013; Simpson et al. 2014; Voellmy et al. 2014). However, what is vital moving forward is research conducted close to real noise sources that allows a full range of natural behaviors in environmentally realistic conditions to be determined. This undoubtedly presents a logistical challenge, but we hope our review and the associated commentaries will stimulate and inspire researchers to find innovative approaches and thus advance our understanding of how anthropogenic noise can impact fish in general and their acoustic communication in particular.

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