HONDURAS DISSERTATION/THESIS PROJECT

HO32 Noisy neighbours: the role of underwater acoustics in the behaviour of reef organisms

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It is a common misconception that fish and other marine organisms live in relative silence. In fact, diving pioneer Jacques Cousteau's first full-length motion picture was entitled 'Le Monde du Silence', translating to 'the silent world'. However, we now know that coral reefs are actually very noisy places, comprised of a cacophony of biological and non-biological sounds. If you listen closely, you'll immediately notice the impulsive snaps of shrimp and the loud crunching of grazing fish and invertebrates. You might also hear the pops, chirps, grunts and whoops of fish communicating with one another to establish territories, fend off intruders or potentially find a mate. All of these sounds are put together to compose what is called a soundscape, an acoustic signature for a specific habitat.

Marine organisms are able to utilise these sounds for a variety of biological functions. For example, pelagic larval coral reef fish are capable of detecting and using sounds emanating from a reef to help guide them to suitable habitat for settlement and growth. Underwater sound may be so important to marine organisms that it is generally considered a primary source of environmental information. This idea can be counterintuitive for us humans, as terrestrial mammals, who rely heavily on vision as our main means of gathering information about our surroundings. However, the underwater world is a very different place. The density of water and fluctuation of turbidity limits light penetration beneath the surface, thus restricting visual cues for marine organisms. Similarly, olfactory cues are subject to changing currents and hydrodynamics, putting into question the reliability of source information, such as distance and direction. Alternatively, underwater sound travels extremely fast, up to four-to-five times faster through water than through air, and far, whale songs can be heard across entire ocean basins. Furthermore, sound propagates independent of hydrodynamics, meaning vital source information can be gathered. The importance of underwater sound as a source of sensory information has led to broad scientific investigation to understand of how marine organisms utilise sound and if human activity may be interfering and masking important acoustic information.

Nearly half of the world's population of 7.6 billion people live within 60 miles of a coast. As humans continue to cluster around coastlines and urban development grows, use and exploitation of continental-shelf waters will also increase. Subsequently, human-generated noise has been steadily pervading marine habitats over recent decades, causing an increase in oceanic background noise levels. The main sources of anthropogenic noise include acute sounds produced by military exercises, seismic surveys and construction pile-driving, as well as more chronic noise generated by vessel traffic and offshore windfarms. Anthropogenic noise tends to dominate biologically important, low-frequency bandwidths. Therefore, this noise has the potential to interfere with a host of important biological functions of marine organisms, such as communication, predator avoidance, foraging, and reproduction.

Operation Wallacea has recently joined up with University of Exeter's marine bioacoustics team to tackle some of the important questions of underwater sound in coral reef habitats. Exeter's team,

led by Dr Steve Simpson, has been studying bioacoustics for over a decade and are leading experts in their field. Collectively, they have shown that larval fish use reef sounds for navigation and that healthy soundscapes are diminishing as climate change decimates habitats, limiting the ability of larval fish to locate suitable environments. Their research on the impacts of anthropogenic noise has shown that noise negatively impacts survival and predator avoidance in adult and juvenile fish, interferes with social hierarchies and foraging behaviour, affects important parental and reproductive processes and that biological effects may be influenced by prior exposure history. Together, researchers at Operation Wallacea and University of Exeter are collaborating to better understand the importance of underwater sound in coral reef ecosystems and whether human interference, such as noise from boats and scuba divers, negatively impacts important biological functioning. Areas of focus for projects could include: potential correlations between habitat complexity and acoustic richness and diversity, the possible role of acoustic cues in lone-spine sea urchin recovery or the effects of noise pollution on fish vocalisation.

Recommended Reading

Anthropogenic Noise Reviews:

Kight CR, Swaddle JP. 2011 How and why environmental noise impacts animals: an integrative, mechanistic review. *Ecol. Lett.* , 1052–1061. (doi:10.1111/j.1461-0248.2011.01664.x)

Kunc HP, Mclaughlin KE, Schmidt R. 2016 Aquatic noise pollution: implications for individuals, populations, and ecosystems. *Proc. R. Soc. B Biol. Sci.* , 1–8.

Slabbekoorn H, Bouton N, Opzeeland I Van, Coers A, Cate C, Popper AN. 2010 A noisy spring: the impact of globally rising underwater sound levels on fish. *Trends Ecol. Evol.* **25**, 419–427. (doi:10.1016/j.tree.2010.04.005)

Shannon G *et al.* 2016 A synthesis of two decades of research documenting the effects of noise on wildlife. *Biol. Rev.* **91**, 982–1005. (doi:10.1111/brv.12207)

Weilgart LS. 2018 The Impact of Ocean Noise Pollution on Fish and Invertebrates. 1–34.

Williams R *et al.* 2015 Impacts of anthropogenic noise on marine life: Publication patterns, new discoveries, and future directions in research and management. *Ocean Coast. Manag.* **115**, 17–24. (doi:10.1016/j.ocecoaman.2015.05.021)

Underwater sound properties and anthropogenic noise sources:

Hildebrand JA. 2009 Anthropogenic and natural sources of ambient noise in the ocean. *Mar. Ecol. Prog. Ser.* **395**, 5–20. (doi:10.3354/meps08353

Nedelec SL, Campbell J, Radford AN, Simpson SD, Merchant ND. 2016 Particle motion: The missing link in underwater acoustic ecology. *Methods Ecol. Evol.* , 1–7. (doi:10.1111/2041-210X.12544)

Hearing and communication:

Ladich F, Schulz-Mirbach T. 2016 Diversity in Fish Auditory Systems : One of the Riddles of Sensory Biology. *Front. Ecol. Environ.* **4**, 1–26. (doi:10.3389/fevo.2016.00028)

Ladich F, Winkler H. 2017 Acoustic communication in terrestrial and aquatic vertebrates. *J. Exp. Biol.* **220**, 2306–2317. (doi:10.1242/jeb.132944)

Radford AN, Kerridge E, Simpson SD. 2014 Acoustic communication in a noisy world: can fish compete with anthropogenic noise? *Behav. Ecol* **25**, 1022–1030.

Community bioacoustics:

Gordon, T.A.C., Harding, H.R., Wong, K.E., Merchant, N.D., Meekan, M.G., McCormick, M.I., *et al.* (2018). Habitat degradation negatively affects auditory settlement behavior of coral reef fishes. *Proc. Natl. Acad. Sci.*, 115, 5193–5198.

Kaplan, M.B., Mooney, T.A., Partan, J. & Solow, A.R. (2015). Coral reef species assemblages are associated with ambient soundscapes. *Mar. Ecol. Prog. Ser.*, 533, 93–107.

Tricas, T.C. & Boyle, K.S. (2014). Acoustic behaviors in Hawaiian coral reef fish communities. *Mar. Ecol. Prog. Ser.*, 511, 1–16.

Impacts of noise:

Bruintjes R, Radford AN. 2013 Context-dependent impacts of anthropogenic noise on individual andsocial behaviour in a cooperatively breeding fish. *Anim. Behav.* **85**, 1343–1349. (doi:10.1016/j.anbehav.2013.03.025)

Purser J, Radford AN. 2011 Acoustic Noise Induces Attention Shifts and Reduces Foraging Performance in Three-Spined Sticklebacks (*Gasterosteus aculeatus*). *PLoS One* **6**, 1–8. (doi:10.1371/journal.pone.0017478)

Nedelec SL, Radford AN, Pearl L, Nedelec B, Mccormick MI, Mccormick MI, Meekan MG, Simpson SD. 2017 Motorboat noise impacts parental behaviour and offspring survival in a reef fish Motorboat noise impacts parental behaviour and offspring survival in a reef fish. *Proc. R. Soc. B Biol. Sci.* , 1–7. (doi:10.1098/rspb.2017.0143)

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Simpson SD, Radford AN. 2014 Anthropogenic noise compromises antipredator behaviour in European eels. *Glob. Chang. Biol.* , 1–8. (doi:10.1111/gcb.12685)

Simpson SD, Radford AN, Nedelec SL, Ferrari MCO, Chivers DP, Mccormick MI, Meekan MG. 2016 Anthropogenic noise increases fish mortality by predation. *Nat. Commun.* **7**, 1–7. (doi:10.1038/ncomms10544)