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# Fish Bioacoustics: Evidence for Music and Noise-Induced Responses in Fish

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## ABSTRACT

Fish uses a variety of sensory systems including hearing to learn about their surrounding environment and for social interactions. Unlike other means, hearing plays special role in fish providing information from long distances even in poor visibility areas. Bioacoustics in fishes is very relevant because it is associated with survival and fitness of individual fish and fish population as well. Fish uses sound for mating, detection of prey and predator, habitat selection and migration along with conspecific communication. In fisheries, the environmental conditions have huge impacts on fish health and welfare. Studies have shown that environmental enrichment with music could improve fish growth performance and survival. On the other hand noise has the potential to do significant harms to fishes including immediate or delayed mortality, physical injuries, physiological changes, temporary or permanent hearing loss. Noise also evokes abnormal behavioral responses in fishes by masking biologically relevant sounds. The intent of this paper is to review the potential effects of sound on fishes and providing information on fish bioacoustics focusing on both music and noise as well.


**Keywords** Acoustic signals, Environmental enrichment, Fish welfare, Music, Noise.

## INTRODUCTION

Production and perception of acoustic signals are common in fishes like other vertebrates. Fish can generate acoustic signals to communicate with each other mainly for survival and reproductive success. There are more than 33000 known species of fish and at least 800 fish species from over 100 families can produce sounds (Bass and Ladich 2008). Swim bladder, sonic muscles, stridulation of bones and other mechanisms are mainly responsible for sound production in fishes. Fish responds to sound signals of the surrounding environments and able to detect direction of sound sources (Popper and Hawkins 2018). Moreover, fish are able to discriminate and analyse sounds of different frequencies and intensities (Narins *et al.* 2013, Bretschneider *et al.* 2013, Popper and Hawkins 2018). Unlike other communications, sound provides a long distance communication yet in poor visibility areas. In these ways bioacoustics play very crucial roles in fish survival and reproductive fitness.

Musical auditory environmental enrichment has been widely used to reduce stress and improve fish

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welfare and behavioral performances. In contrast, noise exposures could disrupt fish health and welfare significantly. Scientists have investigated the effects of sound signals - music as well as noise on fishes. Musical sound is nothing but ordered regular or periodic vibrations of sounds whereas noise is disordered sound waves of varying frequencies. The component frequencies of noise are random and continuous with no dominant discernible frequency.

**Sound production in fishes by various mechanisms**

In fishes sound is produced by different mechanisms; such as stridulation, muscular vibrations of sac, membrane, or appendages, forced flow through a small orifice and percussion on a substrate (Parmentier and Fine 2016). The swim bladder which regulates buoyancy is also responsible for sound production in many fishes (Colleye *et al*. 2012). The contractions of intrinsic or extrinsic muscles on and around the swim bladder change the volume of swim bladder which leads to sound production in teleost fishes (Millot *et al.* 2011). Fishes like *Cynoscion regalis*, *Prionotus scitulus*, *Arius felis*, *Bagre marinus*, *Terapon jarbua* produce tonal or pulsed sound with the help of sonic muscles (Parmentier and Fine 2016). Sound production by stridulation of pectoral spines in catfishes, stridulation of pectoral fins in croaking gourami, by grinding of pharyngeal jaws in perciform fishes and by rubbing the exoccipital bone on the back of the skull against a coronet in seahorse have been documented by scientists (Parmentier and Fine 2016). Sound production by otolith has also been reported in some fish species (Schulz-Mirbach *et al.* 2019).

**Effects of music on fish**

The potential benefits of providing music to animals including fishes have already been investigated by scientists. Researchers has pointed out that music not only promotes fish growth but also acts as stress remover in aquatic environments. Scientists have used different tempos of music namely slow tempo, medium tempo and fast tempo music to observe feeding parameters and thereby fish growth and body chemical compositions in turbot (*Psetta maeotica*). It was shown that slow tempo music had positive effect on fish growth in terms of average fish weight, relative and specific growth rate whereas the fast tempo music had negative impact on fish growth when compared with control. The carcass fat content was also significantly influenced by music treatment (Catli *et al.* 2015). Scientists have investigated that Mozart and Romanza music stimulation significantly influenced the growth of rainbow trout (*Oncorhynchus mykiss*) in rearing condition when compared to white noise treatment or control. An increased level of brain serotonin (5-HT) with its metabolite (5-HIAA) and decreased level of brain dopaminergic activity were observed in Mozart fish groups, while Romanza music stimulated fish group expressed enhanced serotonergic activity (Papoutsoglou 2013). Study has revealed that Quran and Sufi Ney music exposure had increased growth performance and feeding efficacy in *Cyprinus carpio* than control (Kusku *et al.* 2018). Exposure to Mozart and Romanza music was shown to increase the daily feeding consumption in *Cyprinus carpio* (Papoutsoglou *et al.* 2010). Zebrafish (*Danio rerio*) which is physiologically and genetically similar to rodents and humans has been enormously used as animal model in neuroscience research. Zebrafish exposed to Vivaldi's music were more active and less anxious when compared to unexposed control. Music exposed Zebra fish had reduced expression of IL-1 beta and IFN-gama pro inflammatory genes. Additionally, neurotrophin BNDF gene expression was elevated in the brain of zebrafish when they were exposed to music. Music exposure also had an anxiolytic-like behavioral pattern in *Danio rerio* (Barcellos *et al.* 2018).

**Impacts of noise on fish**

Since the time of Industrial Revolution there has been a growing increase of noise and recent studies have investigated that anthropogenic or human-generated noise has the potential to affect aquatic organisms including marine and freshwater fishes (Bolgan *et al.* 2016, Mickle and Higgs 2018). Anthropogenic noises from various sources with different acoustical characteristics may lead to changes in fish behavior and physiology by masking signal detection for auditory information during aggregation, mating, prey and predator recognition, warning danger and furthermore by affecting the auditory thresholds. The extent depends on the intensity, range and duration of sounds (Popper and Hastings 2009, Picciulin *et al.* 2010, Kight and Swaddle 2011). Anthropogenic noises are also responsible for auditory and non-auditory damages in fish. Auditory damages including destruction of hair cells and permanent or temporary hearing loss in different fish species has been reported by scientists (Popper and Hawkins 2016). Here also, the extension of damage depends on frequency, intensity, repetition rate, duration of exposure and many other factors which are species specific. Researchers have investigated that growth, behavior and body shapes were affected in larval Atlantic cod (Gadus morhua) by repeated acoustic disturbances (Nedelec *et al.* 2015). Report demonstrated an increase in cortisol level along with shifting of hearing threshold in Blacktail shiner (*Cyprinella venusta*) after exposure to high levels of traffic noise (Crovo *et al.* 2015). Study has shown that noise of 210-216 dB re 1 μPa from pile driving resulted in hair cell damage, herniation, and swim bladder ruptures in hybrid striped bass and tilapia (*Oreochromis mossambicus*) (Casper *et al.* 2013). Lake sturgeon (*Acipenser fulvescens*) and Nile tilapia (*Oreochromis niloticus*) also exhibited swim bladder damage when exposed to pile driving (Halvorsen *et al.* 2012). Zebrafish (*Danio rerio*) displayed abnormal prey-predator interactions following different noise levels; a delayed response to food and an increased handling error was observed with increasing noise levels (Sabet *et al.* 2015). Noise treatment also had detrimental effects on three-spined sticklebacks (*Gasterosteus aculeatus*) including an increase in food handling errors and decrease in discrimination between food and non-food items as a result of shifting of attention. In addition, reduced foraging efficiency and increased number of attacks for consuming the same number of prey were also noticed by noise exposures (Purser 2011). Coral reef fish (*Dascyllus trimaculatus*) when exposed to 2 days of motorboat noise, exhibited increased sheltering behavior initially but after 1 week they stop responding, indicating behavioral and physiological attenuation (Nedelec *et al.* 2016). When Ambon damselfish (*Pomacentrus amboinensis*) were exposed to direct motorboat disturbance as well as and playback motorboat noise, an increased metabolic rate has been observed in them. Fish were less responsive towards their natural predators and as a consequence they were captured more easily (Simpson *et al.* 2016). Predator vulnerability was also noticed in juvenile European eels when they were exposed to noise (Simpson *et al.* 2014). Scientists have pointed out negative impact of boat noise resulting in abnormal behavioral changes in cichlids (*Neolamprologus pulcher*) including nest digging behavior, defensive behavior and social interactions (Bruintjes and Radford 2013).

## CONCLUSION

The main aim of this paper is to gain deeper insight into potential effects of music and noise on fishes. From the above relevant data it is clear that music acts as a factor to diminish or abating stress in fish and better growth performances, feeding efficiency, survival, relaxed brain functioning and optimum homeostasis level can be achieved by different kinds of music treatments. It is important to emphasize that fish has species specific music demands. In contrast, noise is capable of causing stress responses in fishes. Stress is considered critical for fishes as it exerts injurious impacts on fish physiology including decreased growth performance, disturbed foraging behavior, immunosuppression, homeostasis level disturbance, metabolic disorders, neurohormonal disbalance and even death. But all these negative consequences of noises are also species specific. Concern has been expressed recently over potential adverse effects of noise upon marine and freshwater fishes because of their proportion in aquatic biomass. More attention is needed in research on music and noise effects studies on fishes. It is also necessary to employ such information for the protection of fishes and ecosystems as well.

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