Experiment and Analysis of the Response of Fish to Frequencies

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ABSTRACT *: Most of the traditional fish blocking technologies use nets and meshes, which cause the fish to get caught and cornered, and eventually increases the number of fish kills. Secondary damage also occurs in the hydraulic structures due to the inflow of suspended solids. Therefore, to evaluate the possibility of blocking fish using sound, this study performed fish reaction tests on 4 fish species and presented an audio frequency range which fish avoid. According to the test results, the sensitivity of audible frequency was in the following order: oily bitterling > carp > blue gill > largemouth bass. In addition, the 4 fish species were less responsive to small sounds, but we could observe a clear response above a certain decibel level (140 dB).*

KEYWORDS: *Decibel, Fish, Frequency, Response, Sound*

I. INTRODUCTION

ARecently, fish kills have been occurring frequently near the intake of power plants, the entrance of waterway tunnels, fish ways, and fish farms, and various approaches have been applied to prevent this. However, most of the traditional fish blocking technologies use nets and meshes, which cause the fish to get caught and cornered, and eventually increases the number of fish kills. In addition, the trash racks installed in the intake facilities of reservoirs or rivers are causing additional problems due to the inflow of suspended solids such as garbage, and it is also difficult to install blocking structures due to limitations in the water environment such as water depth and flow rate[1]. For these reasons, the demand to develop remote non-contact fish blocking technologies that use sound and light has been increasing.

Studies on the response of fish to sound in Korea began in the late 1990s, with early studies focused on sound response, gathering, and acoustic prospecting of certain fish species for marine fisheries or aquaculture. In particular, research on the effect on fish include studies on the stress response of fish according to artificial sound generated in the water and studies on conditioning fish using pure tones; studies have also been performed on indirect blocking of light [2-5]. However, domestic marine research on sound is still in its infancy, in which many studies focus on fishing industries.

An investigation was conducted on foreign studies of the response of fish to sounds. Most have been focused on the acoustic response of marine fishes; more recently, studies have been performed on freshwater (river) fishes. Scholik and Yan [6] performed a study on the effects of exposure to white noise (0.3-4.0 kHz, 142 dB) on cyprinid fish and the recovery after exposure. The test results showed that there were differences according to the duration and frequency of noise exposure. Research has also been performed on the long-term and short-term responses of fish to noise stress, and has found that fish are subject to noise stress and sensitive to hearing loss [7]. Popper et al. [8] found that most clupeidae fish respond to ultrasonic sounds of at least 180 kHz, while some clupeidae species did not respond to 4 kHz sounds, and Popper [9] performed a study that found sound could physiologically affect the behavior and growth of fish. Lidia et al. [10] performed research on two levels of naturally occurring noise levels (audible range of specialists and generalists). Through exposing fish to these noises, it was found that the baseline threshold of goldfish and catfish was 500 Hz, and 100 Hz for sunfish.

However, these are all studies in the early stage, and there have been no cases of research performed in actual scale experiments so far. Therefore, the purpose of this study is to find a range which the 4 fish species avoid through tests on the response of fish to frequencies.

II. STUDY METHOD

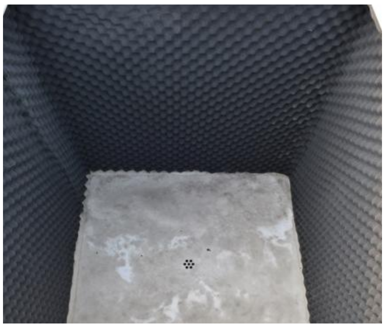
2.1 Experimental fish species

This study performed a fish reaction experiment on 4 species. The target fish species are the oily bitterling, carp, largemouth bass, and blue gill, which inhabit in Korea. Significantly, the blue gill and largemouth bass are invasive species, and various efforts are being made to reduce the number of these species in Korea.

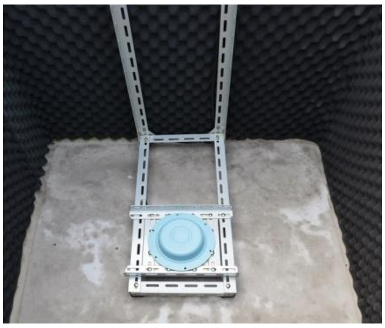
2.2 Experimental facility

The fish response tests were performed by making an acoustic experimental water tank, and we analyzed the reactions of the fish species to frequencies of certain intervals through a real-time monitoring system. For this study, a special acoustic response experimental water tank was produced to test the reaction of the fish in the water. We modified a glass water tank (size: W × D × H, 1 × 1 × 1 m) made of tempered glass and reinforced resin and finished the inner side of the water tank with a sound absorbing sponge. The sound absorbing sponge is designed to absorb the sound from the sound waves in the water tank so that the sound source is homogenized within the tank, and we installed an underwater speaker stand (integrated underwater speaker) made of aluminum angles after processing the sound absorbing sponge. Through this process, the sound response experimental water tank was able to generate the sound source in a stable state when the fish species were put into the water tank. This study used EV ’ s UW30 underwater speaker, and Figure 1 shows the experimental water tank and speaker.

In addition, multidirectional imaging systems were configured inside and outside of the experimental water tank to record and analyze the reaction (behavior) of the fish according to the sound. A waterproof camera (GoPro) was used in the water, and a Jimmy jib and camcorder (Sony Handycam PJ760) were installed at the top of the water tank to record the reaction of the fish species in a vertical direction and to perform real-time monitoring. We used an HDMI cable (25 m) and a display panel to monitor the video recorded by the camcorder in real time from a room and minimized external stimuli during the experiment. Figure 2 shows the imaging system.



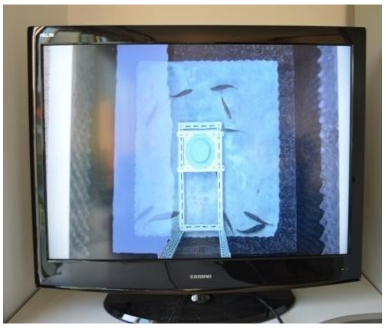
(a) Sound absorbing sponge finish



(b) Underwater speaker installation

Figure. 1 Experimental water tank and underwater speaker

(a) Waterproof camera(GoPro)



(b) Real-time monitoring of fish reaction

Figure. 2Imaging system

2.3Study method

After sound was generated in the experimental water tank, we applied a weight value of “3” for a large behavior change, “1” for a small behavior change, and “0” for no behavior change. The frequencies for the experiment are shown in Table 1 below, and Figure 3 shows photos of the experiment by each fish species.

Table 1. Response experiment frequencies

Response experiment frequencies(Hz)
50, 100, 150, 200, 250, 300, 350, 400, 450, 500, 550, 600, 650, 700, 750, 800, 850, 900, 950, 1000, 1500, 2000, 3000, 4000, 5000, 10000, 15000, 20000

(a) Oily bitterling

(b) Carp

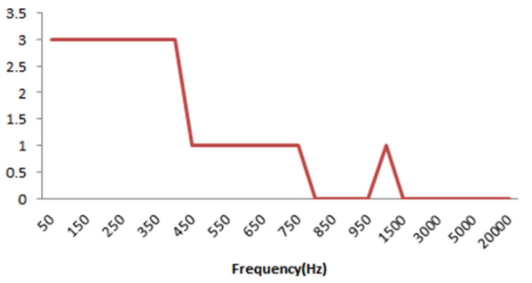
(c) Largemouth bass

(d) Blue gill

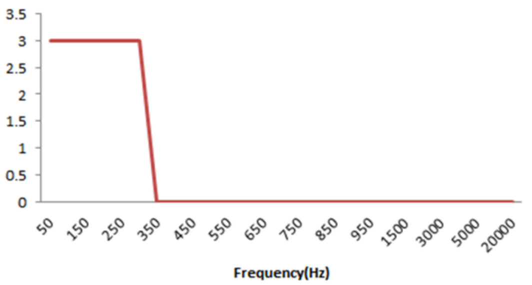
Figure. 3Sound reaction experiment by fish species

III. EXPERIMENTAL RESULTS

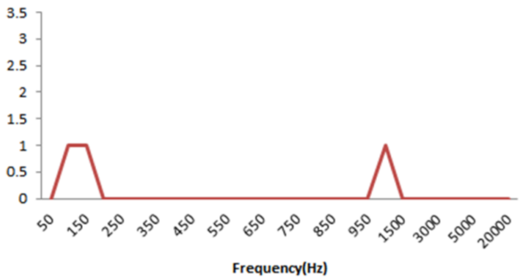
The oily bitterling responded to sound sources from 50 Hz to 750 Hz and 1,000 Hz, while no significant behavior changes were observed at other frequencies. Outside the avoidance range, they were highly active and showed free swimming regardless of the sound source. The carp generally showed an evasive response to sound sources from 50 Hz to 300 Hz, while no significant behavior changes were observed at other frequencies. They showed little activity during the experiment except at the frequencies mentioned above. The largemouth bass reacted to sound sources from 100 Hz to 150 Hz and 1,000 Hz, generally showing an evasive response, but also a tendency to approach near to the speaker at 1,000 Hz. No other behavioral changes were observed at other frequencies. They showed little activity during the experiment except at the frequencies mentioned above. The blue gill reacted to sound sources from 50 Hz to 250 Hz and generally showed an evasive response. No other behavioral changes were observed at other frequencies and they showed little activity during the experiment except at the frequencies mentioned above. Figure 4 shows a graph of the experimental results of each species.



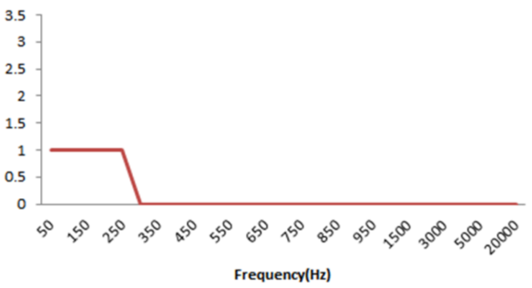
(a) Oily bitterling



(b) Carp



(c) Largemouth bass



(d) Blue gill

Figure. 4Fish reaction test results

Through the experiment, it was found that each fish species showed different reactions to the sounds. By analyzing the range of audible frequency by judging the behavior of the fish species according to the sounds, the sensitivity to audible frequencies was found to occur in the following order: oily bitterling > carp > blue gill > largemouth bass. Most of the behavior responses were judged to be evasive responses, although the largemouth bass showed a preferential reaction to 1,000 Hz. In addition, the fish species were less responsive to small sounds, but we could observe a clear response above a certain decibel level (140 dB). In particular, the sensitivity of the sound response was reduced as we repeated the experiments, in which the fish species showed weaker responses as we repeated each sound, and the response level decreased drastically after consecutive exposures.

IV. CONCLUSION

The purpose of this study was to find a frequency range that fish species avoid by performing tests on the response of fish to sound. We performed fish reaction tests on 4 fish species, and each fish species showed a different response according to the sound. Through analyzing the range of audible frequency by judging the behavior of the fish species according to the sounds, the sensitivity to audible frequency was found to be ranked in the following order: oily bitterling > carp > blue gill > largemouth bass. Most of the behavior responses were judged to be evasive responses, although the largemouth bass showed a preferential reaction to 1,000 Hz. In addition, the fish species were less responsive to small sounds, but we could observe a clear response above a certain decibel level (140 dB). In the future, reaction experiments and analyses according to the size of fish should be conducted to accumulate further data through continuous reaction tests.

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