

The Application of Low Frequency Vibration In Fishing Crankbait To Aide The

Attraction of Predatory Fish

Literature Review

The behavior of fish can be used to determine the effectiveness of a bait on catching a species of fish. Crankbaits, a bait with its shape mimicking a small bait fish with swimming motion, are used to target predatory fish such as largemouth bass. Such baits can cause more aggressive fish to become vulnerable to recreational angling (Mittelbach, Ballew, & Kjelvik, 2014). With crankbaits having to be lightweight and still stay underwater, weights of various metals and types have been placed into them to keep them underwater, such as heavier tungsten weights to create more drag, which results in more vibration (Jarboe, 2010).

The anatomy of a fish reveals that fish have a structure on their side, called a lateral line, which allows them to detect changes in pressure and vibrations within the water. Fish can use their lateral line to feel vibrations and perceive other objects in the water, akin to how a bat uses echolocation. Fish can use the reflection of the vibration made by their movements in the water to identify and detect objects in the water (Popper & Carson, 1998). The ability to use their lateral lines to visualize the water around them and feel vibrations in the water has also been implemented by cod ranchers to bring fish to feeding areas in order to catch them easier (Björnsson, 2018). Crankbait designers have tested numerous ways to create more vibration in a crankbait to attract more fish, such as using electronics that use bait noise through a speaker to

attract predatory fish (Thomas, 2012) or crankbaits that “swim” through the water to appear like a bait fish (Bailey, 2002). The behavior of fish also is dependent on the seasons, such as spring when fish are spawning or fall when their metabolisms slow down, and whether or not they are stocked, or moved from hatcheries into main bodies of water in the spring or fall (Strange & Kennedy, 1979). One of the main reasons for this change in behaviors in the seasons is due to the temperature of the water.

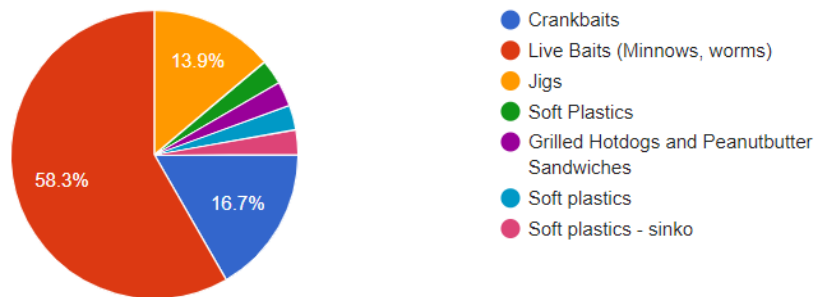
According to North (1980), “During the fishing seasons, the relationship between angling success and temperature was apparent as a seasonal fluctuation in angling success which followed fairly closely the seasonal varieties in water temperature.” (p. 7). The hobby of angling uses crankbaits which target these behaviors by mimicking a bait fish actively moving around the water.

With the improvements being made to fishing baits constantly, inexperienced fishermen may be struggling to catch fish due to the ineffectiveness of the bait that they are using. A market research survey in the local area found that out of 36 responses shown in Figure 1 (below), 58.3% of anglers prefer to use live baits such as minnows or worms, and only around

16.7% prefer to use crankbaits for fishing for predatory fish.

Crankbaits, however, are

mimics of these live baits and, if done correctly, can be seen by predatory fish as an actual bait fish, and would be more inclined to attempt to consume the crankbait. This is



most apparent in the electronic bait noises created by the crankbait made by Thomas (2012). These designs for improved crankbaits are a driving factor in fishing innovation and the changing age of technology requires integration into fishing as well.

In a study done by Björn Björnsson (2018), who has received a doctorate in aquaculture, it was discovered that by using low frequency sound, signals could travel longer distances underwater than other stimuli. Fish have directional hearing and are sensitive to low frequencies in the 100 to 300 Hertz range because of the senses that are incorporated into their lateral lines (Björnsson, 2018, p. 1259). Furthermore, a study by Popper and Carlson (1998) found that fish use their movement in the water to “detect and identify, even ‘image,’ objects in water” (p. 686). These senses within the lateral line allow fish to hunt for their prey better and can be used by anglers to deceive a fish into consuming their bait. In another study by Kastelein et al. (2019), researchers concluded that the female porpoise, labeled F05, had a swimming speed above the normal speed for a harbor porpoise because of the noise from the pile drivers. Consequently, this made it harder to catch the fish because making more motion in the water leads to pushing the fish away. The fourth study by Hart and Collin (2015) further shows that most, if not all, fish have senses that are affected by vibrations in the water. Hart and Colin study the effectiveness of repellents on sharks to protect swimmers and those around shark infested waters. Some of these repellents vibrate at a low frequency to resemble a struggling fish or one that is injured to lure sharks away from the repellent user. These sources provide evidence for the behaviors of fish and how their senses in

the lateral lines have a connection to the predatory nature of certain fish, such as bass, pike, and also sharks.

When reviewing the existing designs and prototypes of crankbaits, I have noticed a lack of designs on the use of vibrations in the form of electronics in order to attract fish more effectively. James Mayer (2013) designed a crankbait that attached a set of light metal balls hooked to a chain to make the crankbait appear to be bleeding. The basic design creates a simple attraction for a fish. In a design made by Joseph Jarboe (2010), his crankbait included a tungsten composite weight that vibrates more as it moved through the water, which generated more sound than a normal lighter-weight crankbait in order to better attract fish. Thomas (2012) integrated technology in the form of small electronics with a speaker to play bait noises to attract fish. These three patents come close to my prototype idea, but according to my research in the United States Patent and Trademark Office database, there is not a patented crankbait that uses vibration provided by electronics to attract predatory fish. In this study, I propose the following research question: to what extent does electronic vibration inside of a crankbait affect the catch rates of predatory fish in the Midwestern United States? Anglers are not utilizing technology to target the senses of fish. This may be caused by the lack of a cheap, effective crankbait that targets the senses of fish. I plan to solve this problem by creating a crankbait that vibrates using electronic vibration with a motor and to improve upon the existing designs of crankbaits in order to increase the efficiency of catching fish per cast by targeting lateral lines to cause a higher attraction to the crankbait.

Methods

Behaviors Of Largemouth Bass

Male largemouth bass are known to become more aggressive in guarding nests during and after the spawning season in the spring, becoming more aware in protecting offspring and have a higher reproductive rate than less bold largemouth bass, but in return have a higher angling rate (Mittelbach, Ballew, Kjelvik, 2014). These bold fish are sought after by anglers because of their increased chance to bite a baiting attempt and are what drive the sport of fishing. These behaviors are also true in other predatory fish, such as perch, crappie, and catfish. However, artificial baits such as crankbaits have been proven to not be as efficient as using live baits or other natural baits. According to Härkönen, Hyvärinen, Niemelä, and Vainikka (2016), who is associated with the University Of Eastern Finland, “in particular, the relatively inefficient artificial method applied first yielded perch with a high tendency to actively explore their environment (i.e fast exploration and high acute activity) whereas the more efficient natural method used later was applicable to capture also the slow explorers and low activity types” (p. 28). Angling success can be found by the amount of fish that are caught on a bait or lure with the type of pole used. Using the amount of fish caught in a certain amount of time, it can be determined if a bait is successful compared to other baits used in the same area.

Goals

The goals of the study were to gain a higher catch rate with 40 casts on a crankbait modified with electronic vibration compared to 40 casts with a crankbait that is unmodified. A secondary goal for this project was to complete the first with a budget of

25 US Dollars. These goals were established in order to accomplish the study objective of creating a more effective bait for fishermen to use to catch more predatory fish.

Prototype Design

In order to test the effectiveness of electronic vibration in the attraction of fish, a prototype crankbait had to be designed. I chose a taller and narrower body compared to other crankbaits. This was chosen so that the vibration motor, battery holder, and switch would comfortably fit without too much stress being put on the wiring. In order to insert the electronics into the body of the crankbait, an incision in the middle of the crankbait's top had to be made, which was made large enough to add the electronics but narrow enough that it would fit the switch securely. The vibration motor was secured to the bottom of the crankbait with a clear epoxy, and was left to dry before the waterproof seals were created. Once the epoxy dried, a caulk seal was used around the switch in order to seal the main chamber of the crankbait from water damage. To protect the switch, a layer of moldable glue, a rubber-like substance that is able to bend easily, was molded around the switch so that it could still be depressed to turn on the vibration motor. Once the seals had days to dry, the crankbait was painted with orange, white, and black to model the patterns of a prey species of fish (Appendix A). This was done to the control crankbait (Appendix B) as well.

Data Collection

Quantitative data was collected in order to address the study's goals. I based my study for testing vibration's effects on attracting predatory fish on Björnsson's 2018 study. This quantitative data was collected on items such as the catch rate of the

experimental and control baits, the temperature of the water and air on the day of fishing, the average size of fish caught, and the dates of the fishing trips, and data on anglers, such as their experience in years. Quantitative data was collected on the weather patterns of the day, such as if there is wind present and its velocity, if it was cloudy or sunny (expressed on a scale from sunny to cloudy, with each weather condition assigned numbers), and if it is raining or other types of precipitation. This data will be analyzed to consider other variables that could be affecting the catch rates of each of the baits, such as the temperature and wind patterns causing fish to be inactive. If these data points still suggest that my prototype crankbait has a higher catch rate on days with decreased catch rates for both, then this could imply that the prototype is effective.

The study was completed on April 9th and April 10th of 2020, at a small, privately stocked farm pond in Southeastern Indiana. Weather conditions for the testing dates were windy, with scattered precipitation and a high temperature of 52 degrees Fahrenheit on April 9th and windy with a slight overcast, no precipitation, and a high of 49 degrees Fahrenheit on April 10th. The conditions at the pond were considered to mimic lakes in the area with different predatory species being stocked, but specifically designed for fishing so there was an expected increase in the catch rate that would be compared to natural lakes in the area. The fishing dates were chosen because they were the dates that were consecutive days with minimal change in temperature and weather conditions. The method of fishing was catch and release, so the number of fish in the pond remained as similar as possible across both days. The fishing was done on

a small dock on the lake as it served as a landmark to conduct the study on both days. The casts for the study were chosen to be from the furthest edge of the lake and reeling through the middle with a variation of an estimated five feet due to winds and the shifting of the crankbait mid-cast because it would gather data on the most change in water depth, where there are more fish. The testing was designed to be completed over the course of two days, with testing the experimental bait in the morning and afternoon of April 9th and testing the control crankbait in the morning and afternoon of April 10th.

To collect data, an experienced angler was needed, along with a standard fishing pole, the experimental crankbait, the control crankbait, thermometers, and a weather application or website. The data collected from these observations will be plugged into a spreadsheet, with the temperatures and weather plugged in relative to the day that they are collected and the fishing line and fishing pole type will be recorded in the spreadsheet as well and used in order to evaluate the conditions in the analysis section.

Limitations

When the study was conducted, there were challenges that arose. In the early months of 2020, The COVID-19 pandemic interrupted the flow of goods and services throughout the United States and in turn, interrupted shipping worldwide. The interruption of shipping worldwide led to the delay of crucial parts to the construction of the crankbait, such as the vibration motors, switches, and the body of the bait itself. Second, the time of year and the behavior of fish during the winter months led to a decreased overall catch rate between both baits due to decreased activity by fish. The

budget provided for the study was an anticipated challenge, with a budget of 25 US dollars. The final major anticipated challenge to the study was the efficiency of the unmodified crankbait.

There were additional limitations that could have impacted the success of the study. While it is difficult to determine the exact impact that these limitations had, it is impossible to deny that they had a factor in the result of the trials of the experimental and control crankbait. These factors of limitations are necessary to address for the future of research in the current field of electronic vibrations in fishing baits in order to avoid them and improve any such bait in the future.

The first limitation is with the shell of the crankbait. As the crankbait was bought commercially online, the crankbait has been mass produced in a factory and comes as a single closed mold. In order to modify this crankbait, it had to be cut into with plastic cutting tools and resealed with waterproof sealant. The easiest way to remove the chances of failure from the bait in terms of seal failure would be to produce the crankbait in two halves and mold the electronics directly to the body of the crankbait, rather than to insert the parts in and seal through a hole in the top.

The second major limitation was with the natural conditions of the lake. The lake was a muddy color on the 9th of April, as there was heavy rainfall the day before. This could not have been avoided due to the lack of control of the weather. The dates for the testing were still ideal due to the temperature of the lake, winds, and air temperature, but the tests could have been impacted as the muddy color led to decreased visibility in

the water.

The final limitation was with the durability of the sealants purchased. Due to the budget of 25 US Dollars for the project, the sealants were less than ideal. The main failure on the prototype was due to taking on water, which can be attributed to the failure of the main caulk, epoxy, and moldable glue blend. If the prototype and study were to be replicated, the use of a more durable, marine grade sealant would lead to the success of the crankbait's longevity and thus become a marketable bait to the market of angling.

These limitations combined had negative effects on the results of the study. With steps being taken to remedy them, the outcome of catch rates for the experimental bait could have increased more than expected from its current standings. Having a larger budget would have led to the creation of a custom crankbait sealed around the electronics instead of becoming modified to hold the electronics. Using a more suitable sealant for waterproofing the switch of the crankbait would lead to a longer product life and become a viable bait to be used by anglers. The delays of materials due to the pandemic of COVID-19 limited the testing dates, which could have been selected to where the water was clear and two consecutive days with nearly identical temperature. With these limitations addressed, a second study could be performed that would allow with more certainty for unbiased, unskewed results.

Results

Data

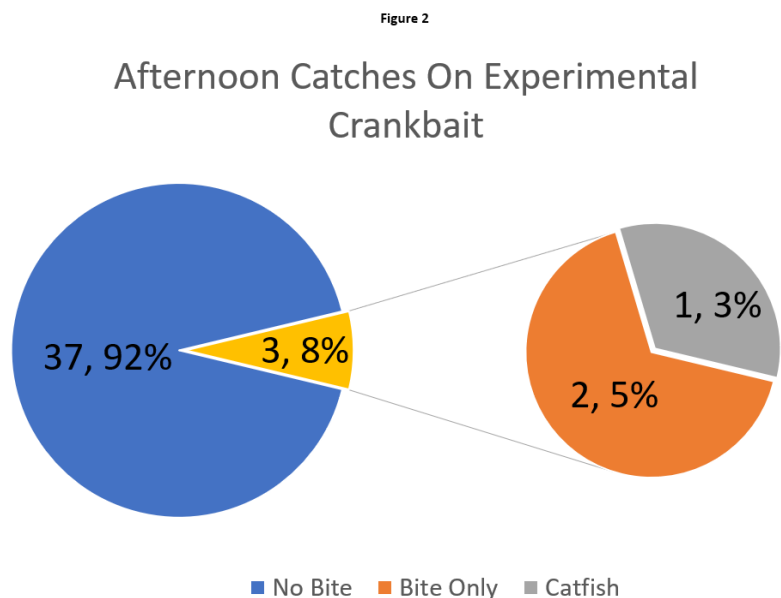
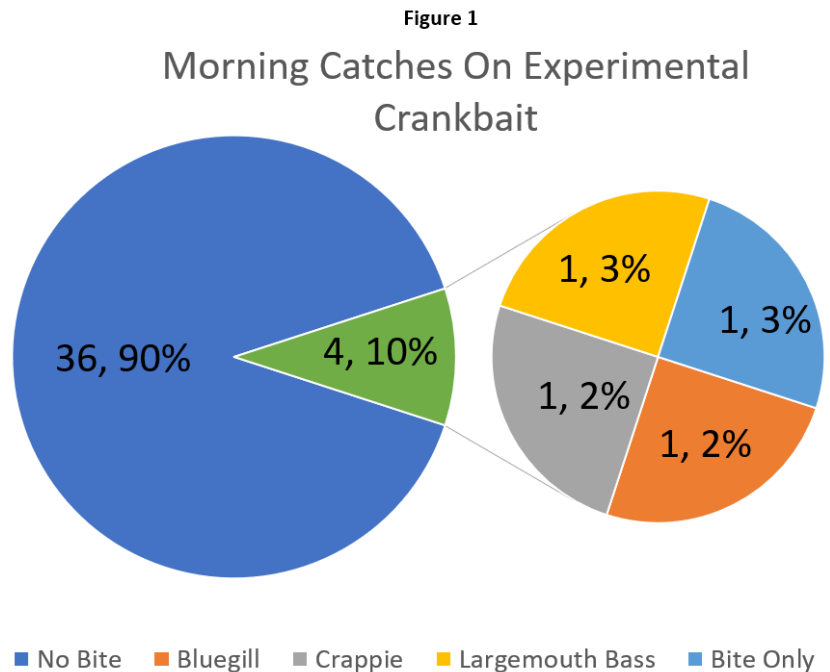
The data for the study was collected as four individual tests in the span of two days: the morning test of the experimental crankbait, the afternoon test of the experimental crankbait, the morning test of the control crankbait, and the afternoon test of the control crankbait.

In Figure 1, as shown to the right, includes the trials that ended with no bite on the lure (36) and the number of trials that ended with a bite (4)

along with the different species that were caught

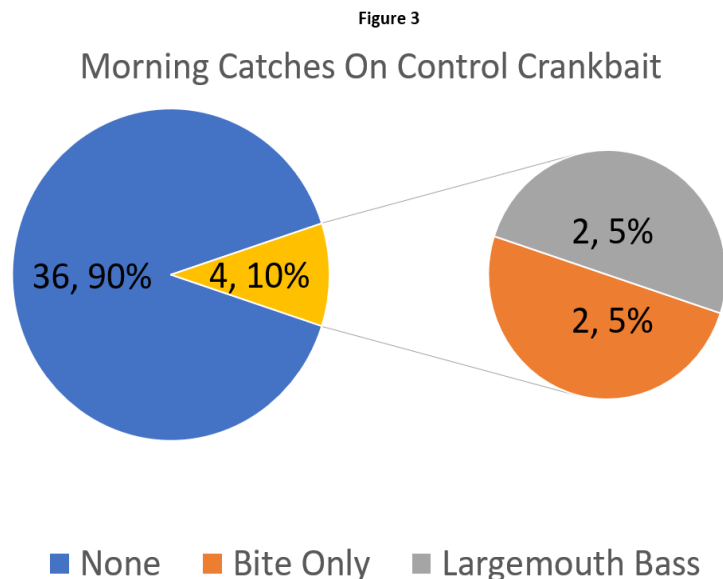
during those four trials. The four trials were a cast with a bite on the lure but not a successful capture of a species, a bluegill spanning ten inches in length, a largemouth bass spanning fourteen inches in length, and a crappie spanning thirteen inches in length. The afternoon trial for the experimental bait is shown in figure two, where the bait had three bites on the lure,

but only one resulted in a species captured, which was a catfish spanning 22 inches in length. For these trials, it was concluded that



the morning trial had a catch rate of .075, or .75 percent, and the afternoon trial had a catch rate of .025, or .25 percent, which was found by taking the number of trials that ended with a species captured and dividing that by the total number of trials for that period, which was forty casts. It is worth mentioning that the experimental crankbait ceased operation after the 34th cast due to water penetrating the watertight seal, disabling the electronics. To remedy this, the data was extrapolated from the collected data and was decided that no further species would be captured. For the control bait in which I am comparing my prototype to in this study, I conducted two tests identical to the experimental crankbait on the following day. The weather conditions were almost identical in temperature and with slight overcast, with the wind speed on April 10th being eleven miles per hour to the northwest as compared to the wind speed on April 9th being thirteen miles per hour to the northwest. The decision to spread the testing out for two days was made due to the nearly identical weather patterns and temperature readings in the water in order to get a less biased test when related to bait aversion, or learning to avoid fishing baits due to being captured before, by fishing the entire trial in one day. Figure 3 shows the

number of casts in which ended without a bite on the line (36) and the number of trials that ended with bites (4), which is further split up into casts that ended with a bite



but no species captured (2) and the number of trials that ended with a bite and species caught (2). The species caught in the morning with the control crankbait were both largemouth basses, which spanned eleven and ten inches in length respectively. The fourth and final trial

conducted was the afternoon trial for the control crankbait, which is shown in figure four to the right. Trial four ended with 37 casts receiving no bite and three trials receiving bites. Of those three

bites, only one resulted in the capture of a species, which was a bluegill spanning ten inches in length. For the morning trial, the catch rate of the control bait was .05, or 5 percent. For the afternoon trial of the control bait, the catch rate was .025, or 2.5 percent.

Analysis

The data was analyzed using the catch rates of each of the bait’s morning and afternoon trials, and the size of each of the species collected.

Figure 4

Afternoon Catches On Control Crankbait

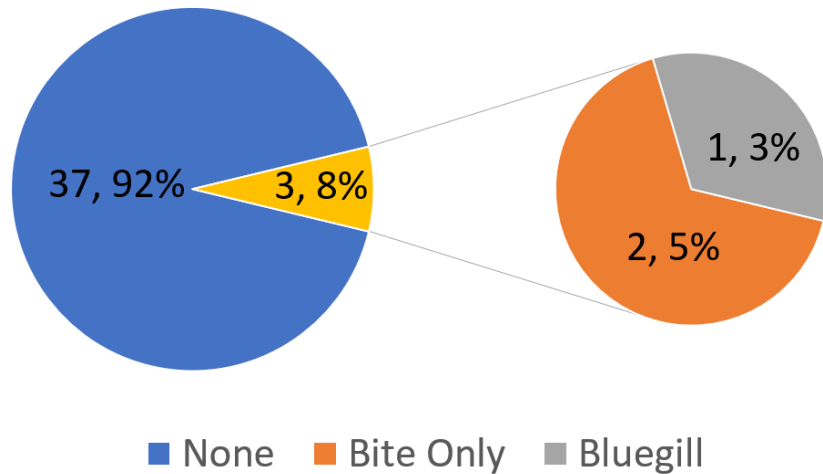


Table 1		
Catch Rates for Experimental and Control Bait		
Trial Period	Control	Experimental
Morning	.05	.075
Afternoon	.025	.025

These catch rates are presented in table one, which is an accurate representation of a typical angling session at those time periods at lakes in the Midwestern region of the United States. The improved catch rate for the morning session of the experimental crankbait provides an indication that the fish were more attracted to the experimental crankbait to a higher extent than to that of the control crankbait. Furthermore, there was also indication that the experimental crankbait attracted what appears to be larger

species sizes than that of the control crankbait. Table two provides the length in inches of each individual species

Table 2	Control	Experimental
Trial Period	Species (Size)	Species (Size)
Morning	Largemouth Bass (11")	Crappie (13")
	Largemouth Bass (10")	Largemouth bass (14") Bluegill (10")
Afternoon	Bluegill (10")	Catfish (22")

captured by each of the baits during the individual trial periods. For both trials of the experimental crankbait, the experiment had attracted larger fish of different species than that of the control crankbait. In order to exclude outliers in the length of certain species, such as the catfish on the experimental crankbait, I have taken the median size for each of the crankbaits. The experimental crankbait had a median of 13.5 inches, compared to the median of 10 inches of the control crankbait.

At the lowest level of amalgamation of the four trials, the experimental crankbait succeeded in improving the catch rate of the morning trials of predatory fish. Furthermore, the experimental crankbait succeeded in the capture of larger species than that of using an unmodified version of the crankbait. Due to the mechanical failure of the experimental crankbait at the conclusion of the afternoon trial, it is unknown

whether the experimental crankbait would have succeeded in the capture of more species. One of the possible outcomes that could have occurred from the experimental crankbait successfully completing the afternoon trial is the successful capture of a larger bluegill than that of the control crankbait. The second outcome is the outcome that was extrapolated and used in the calculation of the catch rate, which was that the crankbait had failed to capture any further species during the final casts. This outcome was chosen to mimic that of the control crankbait and of the conclusion that fishing during the afternoon period of a given day results in a low yield for fish.

Conclusion

Based upon the information gathered from the trials in this study, it can be concluded with a reasonable amount of certainty that the electronic vibration provided by the implementation of electronics into a fishing crankbait has increased the rate of capture in predatory fish and increased the size of the species that it attracts. This basis was made using the catch rates of the two morning trials of the experimental crankbait and the control crankbait and the median of both the morning and afternoon trials combined from the control crankbait and the modified crankbait.

Future Direction

For a future direction, I would recommend experimentation of the batteries and voltages used in the powering of the crankbait's vibration motor in order to test for a

higher or lower voltage increasing the attraction of the crankbait. As the vibration had attracted predatory fish, the frequency in which it vibrated was directly impacted by the voltage being applied to the motor. If the motor's input voltage is changed to be increased or decreased, the outcome can be studied in the behavior of fish and their attraction or repulsion to the bait.

This is one of the few considerations for the future of electronics implementation into fishing baits. While technology in the field of small circuitry improves, more work will need to be put into the studies of their implementation into fishing baits to determine their effectiveness in order to gain the maximum catch rate achievable by using vibration.

Appendix I

A. Experimental Crankbait Prototype



B. Control Crankbait



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