COLOR CUE AND MOVEMENT ATTRACTION OF BERMUDA BREAM *DIPLODUS-BERMUDENSIS*[1]

Jason Silva Moreira[2],
Biology Department, Clark University, 950 Main Street, Worcester, Ma 01610
(jmoreira@clarku.edu)

Abstract Bermuda bream (*Diplodus bermudensis*) were tested to analyze attraction to color cues. Due to their lack of interest in static colors in a preliminary study, motion was introduced. The hypothesis is that Bermuda bream are attracted to orange and blue colors, which are frequently seen in their habitat. Bream were attracted most to the color orange, but seemed to prefer a variety of colors to any single color. With the knowledge acquired from the color cue test it can be applied to other species.

Key Words: *Attraction, Color Cue, and Wavelength*

Introduction

While snorkeling in coral reefs, I observed that fish follow people who had a variety of colors on their bathing suits. Fish perceive colors differently from humans (Marshall et al.2003, and Losey et al.2003). Color is the wavelength of light. Fish in coral reefs typically display colors from 300-800 nm (Longley 1916, lythgoe, 1966, Marshall et al. 2003), a range that includes colors not seen by the human eye. The human eye can see colors between 390 - 780 nm.

Work has been done on fish's ability to perceive the range wavelengths, but their attraction to any particular wavelength has not been investigated extensively. The coral reefs in Bermuda exhibit a wide range of colors. The purpose of this study is to observe whether fish can distinguish between different color cues and if so what color is most attractive to them.

Materials and Methods

Study Organism: Bermuda bream (*Diplodus bermudensis*) was chosen for this study for its abundance and lack of timidity. It is a benthopelagic fish endemic to the waters of Bermuda. Bream have a silver body with a black dot on their tail and grow to about 30.0 cm in length.

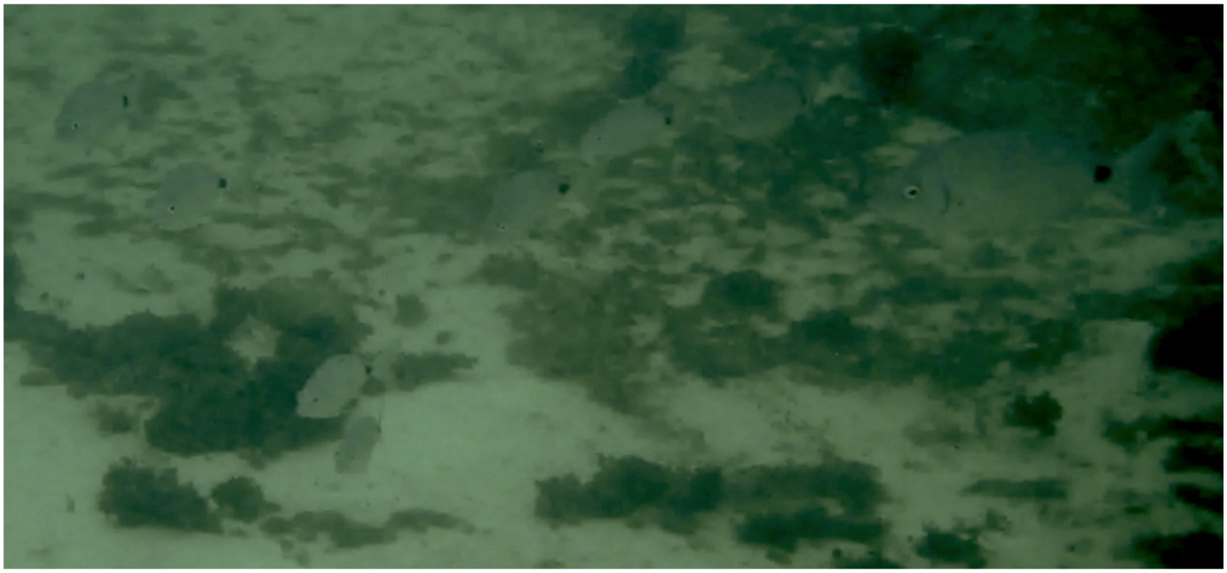

Figure 1. Bermuda Bream in tobacco bay following the orange color cue.

Study Site: This study was conducted in Tobacco Bay, Bermuda (32°N, 64°W) during October 10th to 12th, 2012. The average water temperature for Bermuda in October is 25°F. The air temperature was in the low 30s high 20s during the experiment. It also rained during the three days. All the trials were conducted during low . The three sites at Tobacco Bay were chosen based on their high density of Bermuda bream. The experiment consisted of two different tests: the stand-still-color cue and the motion color cue.

*Stand Still Color Cue.*The stand still color cue was executed by using a secchi disk and tying different colored, plastic-cage lids to a rope that was lowered into the water. The secchi disk has a marked cord for attachment of colored attractants (see supplement 1 for image). The distance between the lids varied with the water level; lids were kept as evenly distributed from each other as possible. Five colors of lids were used (purple, orange, blue, green, and pink), arranged in random order along the line. Only 3 colors were tied at each trial.

The colors were either observed or video recorded for 5 minutes. There were a total of 5 trials; each color was tested 3 times. The trial sites were in open water as well as near the corals (Figure 2).

Color Cue and Movement. Four colored fabrics (blue, green, orange, and dark blue) were set up similarly to the stand still trial to determine whether fabric makes a difference in static color attraction. The fabric color chosen was based on colors that seemed to interest the Bermuda Bream during preliminary observations as well as which colors were available. Wearing the fabric in speedo form was found the best way to test for motion and color concisely. The researcher swam backwards while recording the fish following. This motion of swimming was used during every trial. Four areas were chosen as swim sites (Figure2). The fish were counted as attracted if they followed the researcher for ~20 seconds. The size of the school was noted as well the number of fish that followed from the school. This was done to calculate the fraction of the fish from the school that were attracted to the cue, to account for variation in school sizes. Due to visibility and roughness of water only 4 trials were conducted for each of the speedo colors along with the multicolored shorts. It is important to note that during all trials, the experimenter swam through the school of fish to ensure they saw the colors.

Figure 2. A modified map by Google Earth depicting the study site, Tobacco Bay. This map shows the location of high-density schools of Bermuda Bream, the areas the researcher swam, as well as the sites for the stand still color cue experiments.

Results and Discussion

Bermuda bream were not attracted to any particular color when in the colored object was not in motion (Figure 3). In order to see if the fish were not attracted to the plastic-cage lids or the colors, fabric was used. The results were similar. None of the fish were attracted to colors. However, fish were more responsive to the combination of color and movement (Figure 4). The bream showed almost a 20% higher attraction for multicolored fabric than for any single color. Orange was individually the most attracted color for the Bermuda Bream with 68.75% of the schools attracted to them.

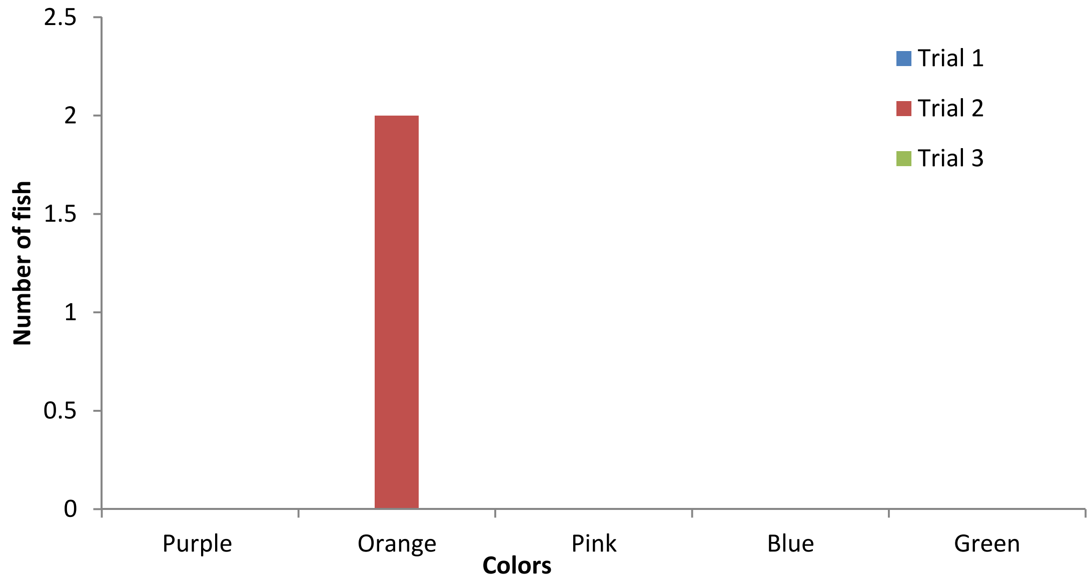

Figure 3. **Stand still color cue**. This graph shows the results for the three trials of stand still color attraction. The graph shows that the fish weren't attracted to the color cues only. Two fish approached orange once during the second trial.

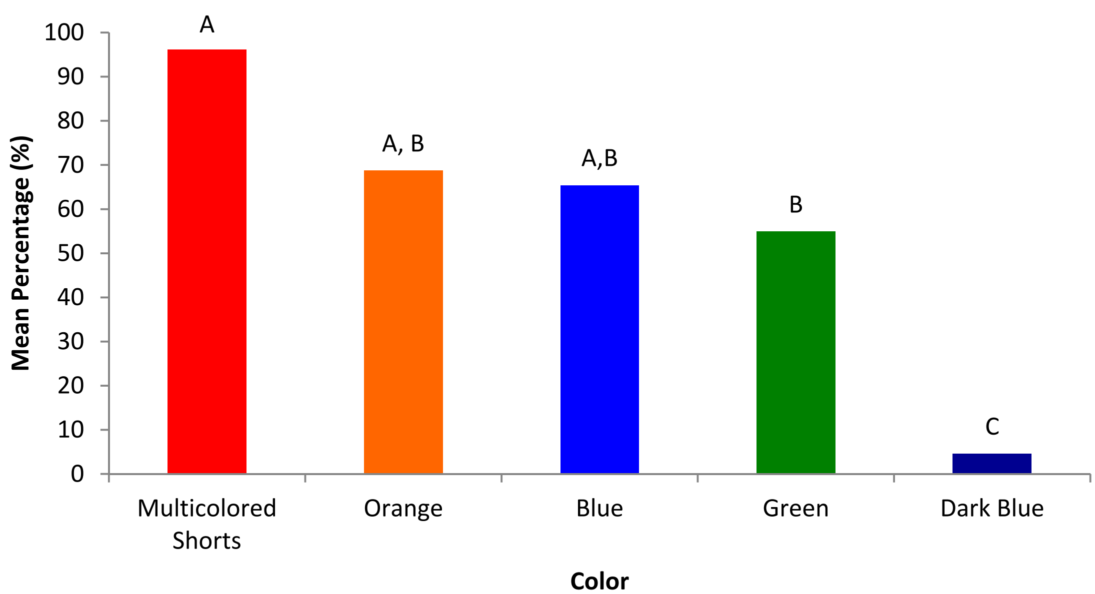

Figure 4.**Percentage of schools following color and motion cues**. This graphs shows the average percentage of the individuals from the school that followed the color cues. It shows that they were attracted more the multicolored shorts than individual color cues. It also shows the significant difference between the average mean percentages of fish attracted. The groups are divided to A, B, C and each of the groups is significantly different from one another according to the Tukey-Kramer test.

After ANOVA indicated that significant differences existed among the mean percentages ($F_{4,14}$=15.25, p=0.0001), Tukey-Kramer tests were conducted in order to identify the significant differences among the colors (Figure 4). The tests revealed that colors could be separated into three groups. Group A consisted of multicolored fabric, orange, and blue. Group B consisted of orange, blue, and green. Group C consisted of dark blue. This allows us to see the gaps in the data and where further research is needed. More trials would be needed to see if there is significant difference between multicolored shorts, orange, blue, and green.

Color is wavelength of light. Since it is impossible to observe what fish actually see. Fish could be able to distinguish more clearly between wavelengths. Colors can be matched to the spectrum from short wavelengths (purple and blue) to long wavelengths (red and orange). The multicolored shorts were made up of many colors but the primarily red. . Comparing color to their location on the spectrum shows evidence that Bermuda bream are attracted to colors around 540 nm and higher. It allows us to speculate that increase in attraction correlates with increase in wavelength the longer the wavelength the more attracted the fish are to it.

Schooling behavior might be a factor that influenced the high numbers of fish following the color cue (Hiro-Sata1994). If one individual starts following the color the other might follow out of instinct to stay together and not interest of color or motion.

Future Research

An area for future research could be looking at different color combinations to see which one attracts them most. The colorful shorts attracted the most bream, and they were composed primarily of red, blue, and white. It would be interesting to see what combination they are most attracted to and how those colors tie into their ecosystem. Also, using wavelengths to choose color combination would be of interest. Combining long and short wave lengths, as well as attraction of wavelengths not seen by the human eye (e.g., infrared and ultra violet) would also be of interest.

Literature Cited

Hiro-Sato, N. 1994. Self-organizing Dynamic Model of Fish Schooling. Journal of Theoretical Biology, Volume 171, Issue 2, 21 November 1994, Pages 123–136 http://dx.doi.org/10.1006/jtbi.1994.1218

Levine, J. S., and Edward F. MacNichol, Jr. "Color vision in fishes." *Scientific American* 246 (1982): 140+. *Academic OneFile*. Web. 21 Oct. 2012.

Losey, W. N. McFarland, E. R. Loew, J. P. Zamzow, P. A. Nelson, N. J. Marshall, and W. L. Montgomery (*2003*) Visual Biology of Hawaiian Coral Reef Fishes. I. Ocular Transmission and Visual Pigments. Copeia: September 2003, Vol. 2003, No. 3, pp. 433-454.

Longley, W. H. 1916a. Observations upon tropical fishes and inferences from their adaptive coloration. Proc. Nat. Acad. Sci 2:733–737.

Lythgoe, J. N. 1966. Visual pigments and underwater vision, p. 375–391. *In*: Light as an ecological factor. R. Bainbridge, G. C. Evans, and O. Rackham (eds.). Blackwell, Oxford.

Masuda, R., Kohji T., and Yoh Y. "School for learning: sharing and transmission of feeding information in jack mackerel Trachurus japonicus juveniles." *Fisheries Science* 78.2 (2012): 269+. *Academic OneFile*. Web. 21 Oct. 2012.

Marshall, N. J. K. Jennings, W. N. McFarland, E. R. Loew, G. S. Losey, and W. L. Montgomery (*2003*) Visual Biology of Hawaiian Coral Reef Fishes. II. Colors of Hawaiian Coral Reef Fish. Copeia: September 2003, Vol. 2003, No. 3, pp. 455-466.

Marshall, J., Jennings, K. , W. N. McFarland, E. R. Loew, G. S. Losey, and W. L. Montgomery (*2003*) Visual Biology of Hawaiian Coral Reef Fishes. III. Environmental Light and an Integrated Approach to the Ecology of Reef Fish Vision. Copeia: September 2003, Vol. 2003, No. 3, pp. 467-480.