

The Effects of Size Variation on Schooling Cohesiveness

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Abstract:

Fish schooling is a common behavior in fishes that has been around for at least 50 million years. This collective movement increases swimming efficiency, foraging success, and predator detection. Schooling is determined by both instinct and learned behavior, this leads them to school with biomechanically similar fish. Understanding how fish school with morphologically dissimilar fish. Larger fish school better with smaller fish while all fish school better with fish they are socially familiar with. Disturbances that may pull schools apart are increasing over time with global climate change and increase in natural hazards, like hurricanes. This leads to a necessary understanding of fish school reaggregation behavior. This was done by testing schools of fish of similar morphologies and fish of different morphologies to see how schooling behavior varies between them. It was shown that there is no significant difference in nearest neighbor distance based on morphologies which indicates that fish are able to school with fish of dissimilar sizes. In the future other variables will need to be considered for a better picture of the behavior of these schools.

Introduction:

Aggregation is a common strategy of cooperation and defense in both terrestrial and aquatic species. In fishes, these groups typically take the forms of schools and shoals. Schooling behaviors in fishes are common, and have evolved across taxa for at least 50mya (Mizumoto et al, 2019). Schooling confers a litany of advantages. Collective movement significantly increases swimming efficiency (Marras et al, 2014; Zhang & Lauder, 2024). Foraging success improves in groups (Pritcher et al., 1982). Large aggregations of fishes have a greater chance of detecting predators (Ward et al., 2011) and can rapidly spread an alarm signal via chemical cue (Chivers &

Smith, 1998) or collective startle response (Zheng et al., 2005; Rosenthal et al., 2015). Coordinated spawning maximizes group reproductive potential (Erisman et al., 2012).

Schooling interactions are governed by both instinct and learned behavior. Fishes will subconsciously coordinate with biomechanically similar swimmers (Marras & Porfiri, 2012; Thandiackal & Lauder, 2023). However, the dynamics of schooling are not exclusively instinctual. Fishes preferentially school with morphologically similar animals. Morphologically distinct fishes in schools are at greater risk of predation (Alfonso et al, 2020). Physically larger fish school more cohesively than their smaller counterparts (Romenskyy et al, 2017), and socially familiarized fishes coordinate more effectively than strangers (Nadler et al., 2017).

Natural disturbances (e.g. storms) relocate fishes, rearrange schools, and upset established aggregation / schooling dynamics (Munks et al, 2015). If large scale disturbances like tropical cyclones increase in intensity and frequency as predicted, we may expect ecologically-relevant changes to fish school formation, dynamics, and performance (Emmanuel, 2005). Fish schooling is the behavioral manifestation of competing instincts, performance objectives, sensory inputs, and learned behaviors. In controlled artificial schooling scenarios, we may compare the relative importance of these information streams to fish school formation and cohesiveness.

Methods

Set up:

- Schooling tanks
 - 70±25 cm diameter with a depth of 34 cm

- Water used came from the puget sound and was 22.1 cm deep
- Tanks were made out of chicken wire with the outside covered in _____
- *Cymatogaster aggregata* (shiner perch) were kept in 4 separate tanks prior to the schooling test and were collected from Jackson beach by beach seine.
 - Tanks had a diameter of ___ cm and were ___ cm deep
- Trials
 - 4 fish were placed into the schooling tank and were given 15 minutes to acclimate
 - After acclimation the camera (Trust Tanor webcam 25548) recorded the tank for 30 minutes.
 - After each test all fish were then measured using standard length.
 - Four different groups of fish that were tested: all 4 being big (9.5 cm - 12 cm), all 4 as small fish (6.4 cm - 8.3 cm), 1 big with 3 small, and 1 small with 3 big fish.

Analysis:

- Video recordings are analyzed using Kinovea 2023 1.2
 - Every 5 minutes (9000 frames) nearest neighbor distances (cm) measured from the center of the focal individual's mass to the nearest neighbor.
- The area of schooling was measured using ImageJ.
 - This was done by looking at the area (cm²) that the school occupied

Results:

Figure 1:

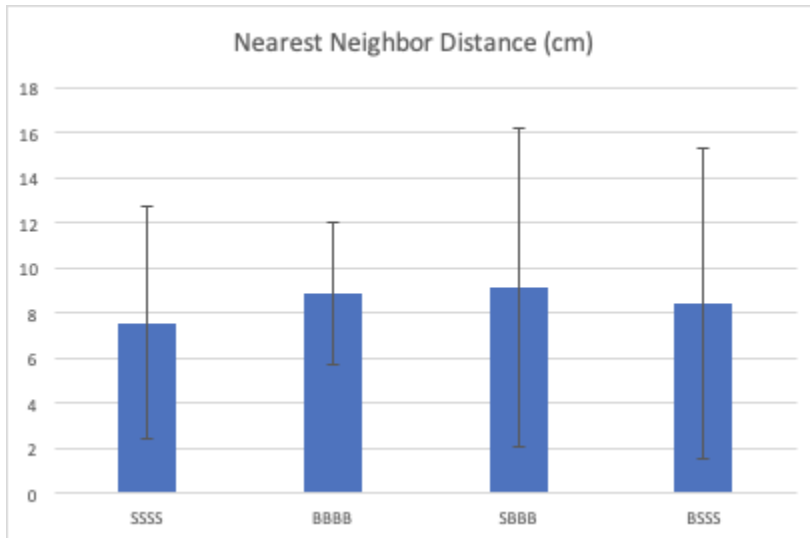


Figure 1 shows the average values of nearest neighbor distance for each schooling group. SSSS has a value of 7.57cm, BBBB has a value of 8.9cm, SBBB has a value 9.13cm, BSSS has a value of 8.43cm. This figure also shows the standard deviations for each individual grouping.

Table 1:

| Nearest Neighbor Distance T-Test | |
|----------------------------------|---------|
| Groups Compared | P-Value |
| SBBB vs SSSS | 0.091 |
| SBBB vs BBBB | 0.42 |
| SSSB vs SSSS | 0.22 |
| SSSB vs BBBB | 0.36 |

Table 1 shows the p-value comparisons for nearest neighbor distance between each fish in the schools. None of the resultant p-values which are all greater than 0.05.

The results show that fish of different morphologies do not school significantly differently from fish of similar morphologies. Figure 1 offers a visual representation of the means and standard deviations

of each individual schooling grouping. The p-values, shown in *Table 1*, for nearest neighbor distance were based on a p-value of less than 0.05. The p-values that were found were all greater than 0.05 which shows that none of the t-test results showed significant differences between the control groups BBBB and SSSS compared to SSSB and BBBS.

Discussion:

These preliminary results indicate that fish schooling does not vary significantly based on morphology of the fish in the school. This is ecologically important in order to better understand how fish may react with increasing environmental stressors like hurricanes which may disturb fish school cohesiveness (Emmanuel, 2005; Munks et al, 2015). Understanding fish schooling behavior in regards to morphology allows for better information on how the changing climate and increase in natural hazards changes the fish school makeup. In the future other variables will need to be considered for a better picture of the behavior of these schools.

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