



**CALIFORNIA SCIENCE & ENGINEERING FAIR  
2018 PROJECT SUMMARY**

<b>Name(s)</b> <b>Kenneth Bevens; Dean Braza; Daniel Perez</b>	<b>Project Number</b> <b>S2301</b>
<b>Project Title</b> <b>Fractal Patterns: Fish Movements</b>	
<b>Abstract</b> <b>Objectives/Goals</b> Fish have been used as the test subject in many scientific psychological studies. They are used as a base of animal behavioral research. The objective of our project is to determine what the relation of fractal movements, commonly known as repeated movements, is to the number of fish. The goal is to shed more light as to why fish are used so commonly in animal behavioral sciences. <b>Methods/Materials</b> The experiment was conducted by filming one-minute videos of various fish species and in various numbers in order to observe their repeating movements. Each fish was observed for the whole one-minute period and the number of times that a fish repeated a movement was documented. A variety of graphs were made to find the best representation of the pattern. The materials included the fish in the fish tanks, a recording device (iPad), and graphing software (Desmos). <b>Results</b> Upon analyzing the graphs, it was found that the quadratic graph fit the pattern the best. This meant that the amount of repeated movements (fractal patterns) increased exponentially compared to the number of fish. <b>Conclusions/Discussion</b> Based on the information gathered, the conclusion had been made that fish repeat their movements more when more fish are present. Scientists have been using fish as a source of animal behavior data for decades. This experiment shows the extent of the behavior of fish which has not been seen before. Since it is now known that the amount of fractal movements increases exponentially with the increasing number of fish, scientists and mathematicians alike can now use this data to make equations regarding fish behavior and the patterns they make.	
<b>Summary Statement</b> The observation of fish movements in relation to fractal patterns shows that fractal patterns in fish movements exponentially increase with the number of fish.	
<b>Help Received</b> We obtained help from our Algebra/Trigonometry teacher, Kristina Horan. She offered advice on how to display and represent our data.	