



**CALIFORNIA STATE SCIENCE FAIR
2013 PROJECT SUMMARY**

Name(s) Grace Baker; Julia Hwang	Project Number J0102
Project Title How Do the Sail Angle, Sail Width, and the Wind Speed Affect the Force of a Sail?	
<p style="text-align: center;">Abstract</p> <p>Objectives/Goals How do the sail angle, sail width, and the wind speed affect the force on a sail? Our hypothesis is that the largest sail at the highest wind speed will produce the greatest force. We think this because the bigger the area of the sail, the more wind can blow on it. We think if the sail is turned at a 30 degree angle, the Bernoulli effect will be greatest.</p> <p>Methods/Materials We bought sail material and sewed sails with different widths of 3", 5", and 7". We gained approval from Dr. Kevin Jones with the help of Jim Paul to use the Monterey Naval Postgraduate School's wind tunnel. Before we tested the sails we calculated the "zero" of the drag and lift of each sail using different amount weights. We measured the lift and drag of each sail and boat base or the sting, at multiple wind speeds, and angles in millivolts. We repeated these steps for all the sails while recording the data. Jim Paul helped us convert the millivolts into grams. With the data we made graphs showing the lift and drag of each sail compared to the sail angle and wind speed.</p> <p>Results -Speed increased the force on the sails by the square of the wind. -The 7" sail without battens had the most force on it at 15 degrees and 30 degrees, out of all the sails we tested. -For all the sails except the 7" sail with battens there was an optimal yaw angle, past which the force on the sail decreased. -At 30 degrees, the 7" sail with battens had not yet reached its full force, so had we been able to test it at a greater yaw angle, we could have found the optimum angle for the sail. -The 7" sail without battens was the most efficient sail based on the lift and drag ratio.</p> <p>Conclusions/Discussion Hypothesis appears to be partially correct. Conclusion 1: As the wind speed increased, the forward force on the sails increased. Conclusion 2: The sail that had the most force applied to it had a greater wind speed. Conclusion 3: The sail with the greatest area and width had the most force applied to it. Conclusion 4: For three of the four sails, the most force was applied on the sail at a 15 degree yaw angle. Conclusion 5: Even though the 7" sail without battens was the most efficient, it was not the most adequate sail that would move the boat with the most force. This was because compared to all of the other sails, the 7" sail with battens had reached its peak, even at a 30 degree yaw angle.</p>	
Summary Statement Our project discovered how the sail area, angle, and wind speed affected the force on the sail, and which sail was the most effective based on the research.	
Help Received Grace's mother taught us to sew sails; Mother drove us to the Naval Postgraduate School; Jim Paul helped us gain access to the Naval Postgraduate School equipment; Dr. Kevin Jones showed us how to work the equipment, helped us use it, and allowed us the use the equipment; Jim Paul helped us convert the	