LIVING UNDERWATER: FISH BIOMECHANICS AND FLUID MECHANICS

FINAL REPORT

UNIVERSITY OF WASHINGTON

PhD Candidate
Caviedes-Solis Itzue W.
Biology Department

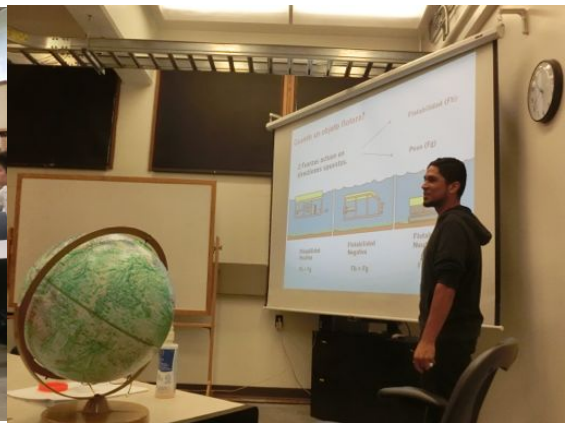
PhD Candidate
Jimenez Urias Miguel A.
School Of Oceanography

The summer camp "Living Underwater: Fish Biomechanics and Fluid dynamics" was held at the University of Washington, from Aug 29th – Sept 1st. During the first three days of the camp, the schedule was split into three blocks, each with the purpose of introducing some of the core principles of the camp. The blocks were split as shown below.

	Schedule
Block #1	***Principles of Fluid Dynamics*** 10:00am – 11:30am
Break #1	***Snacks/lunch*** (11:30am-12:00pm)
Block #2	***Principles of Fish Biomechanics*** (12:00pm - 1:30 pm*)*
Break #2	***Snacks/lunch*** (1:30pm- 2:00pm)
Block #3	***Tour to a UW lab*** (2:00pm – 3:00pm)

The last and final day (Sept 1st, 2017), the day was spent in building ROVs, and testing them in the water. The topics covered during the summer camp on the first block "***Principles of Fluid dynamics*****",** where:

	Tuesday	Wednesday	Thursday
Topics Covered	***Physical properties of water*** (density, viscosity and the continuum hypothesis)	***Vertical Force Balance*** (hydrostatic pressure, buoyancy, weight and neutral buoyancy)	***Vertical Force Balance*** (Center of gravity, center of buoyancy, and Stability) ***Horizontal Force balance*** (Drag and Thrust)



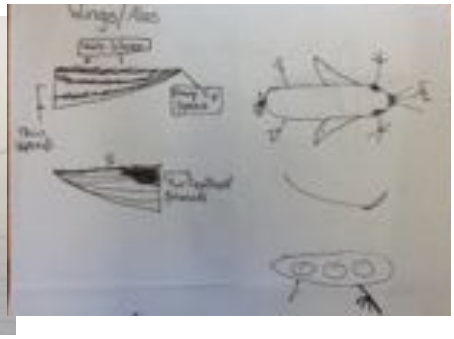
The topics covered on the second block ***"Fish Biomechanics"*** over the extent of the summer camp were

	Tuesday	Wednesday	Thursday
Topics Covered	***Environment and adaptations*** (Relations between environmental factors and morphological adaptations)	***Functional Morphology*** (How different morphological structures within the animals help them interact with their environment)	***Bio-inspired Robotics*** (Examples on bio-inspired robotics, with emphasis on the use of sensorial adaptations to measure the environment)

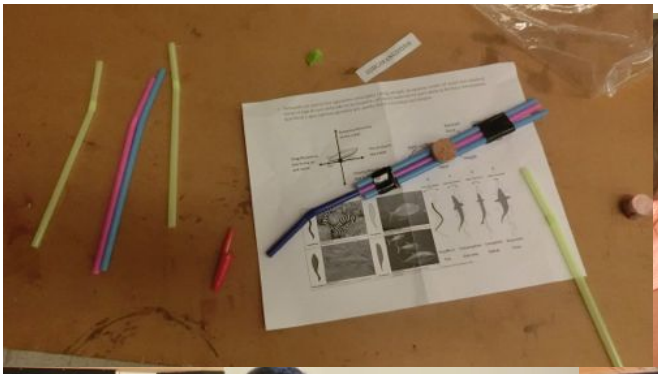
1. Environment and adaptations


2. Functional Morphology



3. Bio-inspired Robotics






Lab tours were schedule each day as follows (including department, lab and tour guide).

	Tuesday	Wednesday	Thursday
Lab Tours	**Biomechanics Lab (Biology Dept)** (Dr. Sharlene Santana)	**Fish Collection (Fisheries Dept)** Dr. Katherine Maslenikov	**Non Linear Dinamic Control Lab** (**Aeronautics and Astronautics dept**) PhD student Brian Katona

The last day, Friday Sept 1st, was dedicated entirely to assemble a couple of ROVs (Remotely Operated Underwater Vehicles). The basic materials were provided in the form of Kits from the store SeaMate. Each kit contains the basics to assemble an ROV: 3 thrusters, 1 control box and connecting wires.





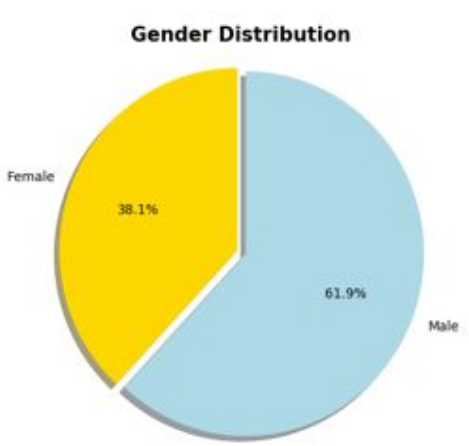

During this time, the students were split into three groups, each group working on assembling a different component of the ROV. In its totality, the students worked on

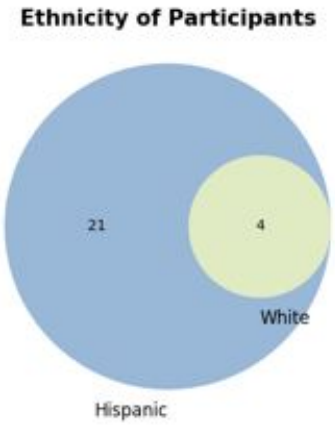
1. Assembling the control box. This required the students to safely cut, strip and crimp wires in order to make ring connectors, which connect the three different switches.

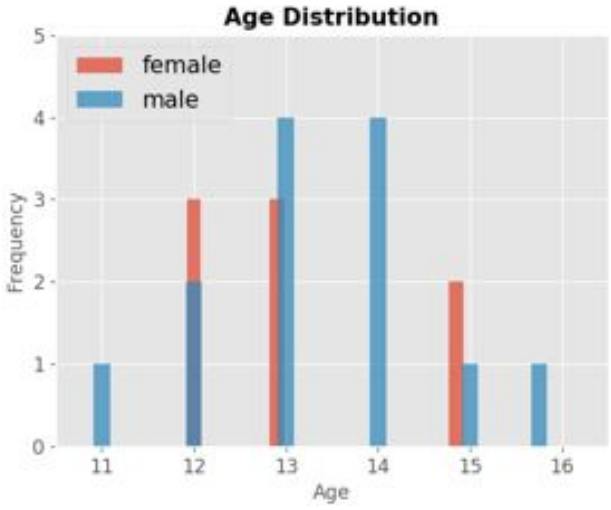
2. Assembling the tether cable that connects the motors and controls box, to the power system (a battery). This required the students to safely operate electrical tools (solder iron, multimeter), as well as safely operating hand-held tools (wire cutters, wire strippers, hot glue gun, heat gun). They learned how to recognize good electrical connections (good soldering, water proofing).

3. Building a frame made of pvc-pipes (pre-cut) and connectors to mount the connecting wires and motor thrusters.

Demographics







Demonstrated Learning from Assessments

Before the camp, students were not familiar with the basic principles of fluid dynamics. By providing examples of real-life scenarios (such as shark deep diving and migration), we assessed that the students were not familiar with concepts of pressure, density, buoyancy and weight. Neither were the students familiar with the different types of morphological adaptations the animals displayed, nor with their functionality and relation with their environment they live in.

At the end of the camp, the students were able to successfully design and construct a neutrally buoyant underwater vehicle. During the process of testing their ROV, we tested their comprehension of the subject of the very basic principles of that were not familiar with at the beginning of the camp (neutral buoyancy, density, center of gravity, center of buoyancy, drag, body shapes and the environment they would live if the ROVs where animals, morphological adaptations and their uses). Not only were the students able to explain the many difficulties they were having through the building and testing process, but they were able to do so using the very concepts we introduced them to, thus showing a gain in knowledge. In addition, using concepts introduced to them, they were able to construct the neutrally buoyant ROVs, some of them with morphological adaptations showing creative and critical thinking.

Demonstrated Increase in Skills from Observations of Students

The perfect example for this was the construction of the ROV frame. During one particular hands-on activity, the day before building the ROVs, the students were asked to construct a neutrally buoyant fish-shaped underwater robot, as described above. The students struggled for at least an hour to make their creations neutrally buoyant and also stable. Common troubles were associated to air bubbles that would make their fish-shaped submarines extremely buoyant. In addition, they had to thoughtfully place either weights (1c coins), and flotation (cork) when needed, in order for their fish-shaped submarines to have the correct orientation: once neutrally buoyant, the device needs to float horizontally, with the “eyes” on the top.

The following day, during the main camp activity, they had to build a frame that, once holding the motors, it had to also be neutrally buoyant, and stable. This time, they were much faster in their approach for where to place the floaters as well as the weights. They not only had the concepts fresh from the day before, but they had developed a skill for designing a neutrally buoyant underwater vehicle. After achieving this, they were further asked to add “morphological” adaptations to their ROV, i.e. a protruding arm or claw to be able to pick up materials from the bottom of the pool. They quickly achieve this task, while keeping in mind the neutral buoyancy and stability of their design.

Anecdotal Evidence of Impact

Please share any stories of the positive impact the camp had on your students. Direct quotes from students/parents encouraged (we do not need the names of those quoted). Direct quotes are in black and the translation in gray.

"Muchas gracias por todo, los chicos me contaban todos los dias con gran entusiasmo todo lo que hacian y aprendian, como lo de los murcielagos, los peces,las ranas, etc. Mil gracias de nuevo por la gran oportunidad."

Thanks for everything, the kids told me every day with a lot of enthusiasm everything they did and learned, like the bats, fish and frogs, etc. Thanks a lot again for the huge opportunity.

"I want to take this opportunity to thank you both for the amazing learning experience my son had at the 2017 NESSP Sumer Camp, he came home with the certainty that becoming a science person for him is possibly, if he is willing to work harder on his studies. Thank you for planting that seed on his heart."

"Mil gracias por toda la información y conocimientos que le transmitieron a mi hijo y el deseo de seguir superandose."

Thanks a lot for all the information and the knowledge that you transmitted to my son, as well as the desire to keep developing.

"As a parent, I thought the camp was amazing. Diego was not that interested in going at first, but after he was done, he was very exited about what he learned and did. He is now more interest in science and STEM. He wants to do the camp next year and invite his nieces. Excellente trabajo y muchas gracias por una exelente experiencia para mi hijo."

Excellent work and thanks a lot for an excellent experience for my son.