Charlie Lemon

Summer Research 2020

Dr. Werth & Dr. Cheyne Summer Research 2020 Final Report

During this past summer research session, I was planning to get a head start on my Honors Capstone project. Titled "The Effects of *Megaptera novaeangliae* bubble-net feeding behavior on the behavior of prey species". While a this is a rather large title, this project focuses primarily on a rather interesting behavior that Humpback whales are known to exhibit: bubble-net feeding. These bubble nets, which tend to be either cylindrical or cone-like in shape, are caused by several humpback expelling air through their blowholes underwater, creating a rather chaotic foam ring on the water's surface (Wiley, D., et al., 2011).

Using the bubble nets created, the whales trap their ideal prey, generally a mix of zooplankton, krill (*Euphausiacea)*, and small fish, within the confines of this net. With these organisms trapped within the net, the humpback that is going to feed first simply needs to swim up the bubble column, until it arrives within around 10 meters of the water's surface. Then, with an open mouth, the whale lunges itself through the circle, in order to feed (Wiley, D., et al., 2011). This, in hindsight, rather genius behavior, providing the whale with a rather optimal foraging behavior, providing a lot of food with little energy expenditure.

With this behavior in mind however, I am left with the questions: "Why the bubble nets?" and "How are they so efficient?" From the whales' point of view, this behavior, like similar instances, likely arise through experimentation. Most, if not all, multicellular have been known to use play-like behaviors to both stimulate ones' own mind or in order to learn how to act like a fully grown organism. Whales, not be an exception, have been especially known to engage in play like behavior (Heimlich-Boran, J.R., 1988) as well. With this in mind, it is not too far off the surmise that this behavior was picked up after a whale realized that their actions were catching prey as well. However, what about from the prey's perspective?

At this point in time, there is currently no definite answer. T.G. Leighton et al. attempted to find an answer to this predicament using several acoustical modeling techniques to observe the intensity of the sound within the net. However, they were not able to account for sound scattering or field conditions (Leighton, T.G., et al., 2004). In the P.H. Patrick et al. study, the optical effects of a rapidly flashing strobe light on freshwater fish were tested. These lights, in addition to the bubbles used, allowed the study to find that the use of strobe lights and bubbles were the strongest deterrent to keep several species of fish in a set location (P.H. Patrick, et al., 1985). However, this experiment cannot be fully used to explain how bubble nets work either, due the differences in focus.

With this in mind, the focus of this project is to evaluate the effects of certain stimulus observed in a bubble net system to the behavior of organisms similar to the common prey organisms of *Megaptera novaeangliae.* Stimuli observed to have a significant impact of fish behavior and navigation, such as an optical or acoustical stimulus, will be used to further investigate the behavioral effects the bubble net can impose on species of smaller fish. In doing this, there will likely be some significant observations made to help figure out which of the prey organisms' senses is being primarily stimulated to trap the organisms within the bubble net.

With the scope of this project in mind, the original plan was to spend summer doing "wet lab" with the zebrafish (*Danio rerio)*, observing their reactions to certain stimuli, specifically focusing on the bubbles, light, and sound. These senses, as noted above, show the most promise in addressing how this phenomenon works from the prey's perspective. However, due to the

COVID-19 pandemic, this was not meant to be. So instead, we decided to switch gears and focus on the latter half of the project, specifically the literature analysis portion. This portion primarily focused on the other 3 major types of senses: Olfactory, Gustatory, and Somatosensory systems. While the primary prey species have not been observed using these senses for general navigation, certain species, such as salmon (*Salmoninae*), have been discovered to use smell to return to their birth ponds to lay eggs and reproduce. With all this being said, however, it is not apparent that these senses are not used by aquatic organism on a daily basis. Through either the lack of special anatomy or just the environment these species live in, the use of these senses is just not a viable option.

As for future directions, I plan to continue to refine my literary analysis, at least until we are further into the semester and pandemic. While all resources are already gathered, time being spent to perfect my own writing and analysis will be beneficial to the project whole. Once a plan for the semester is roughly set, I intend to proceed directly into the lab, actively observing the behavior of *Danio rerio*, in regard to visual and acoustical stimuli. Ideally, by the end of the year, I will have an idea on what actually keeps the prey species trapped within the bubble net. This idea, in turn, could be used for various other improvements to our aquaculture and environmental infrastructure and conservation missions.

References:

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Note: If you have questions about the project, or would like to see certain parts of my project, such as my introduction or my analysis so far on the three unlikely navigation senses, please do not hesitate to contact me at LemonC21@hsc.edu . If I were to put it all on here, it would be significantly larger and more time consuming to go through it all.