Megaptera novaeangliae Bubble Net Feeding Behavior: A Brief Review

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Introduction

Throughout the entire natural world, there are some phenomena that are just jaw dropping. Amongst these phenomena, there is a rather interesting behavior that humpback whales, *Megaptera novaeangliae,* are known to exhibit: creating bubble nets. These bubble nets, which tend to be cylindrical in shape, are caused by a humpback expelling air through its blowhole underwater, creating a foam ring on the water's surface [1].

Humpback whales range from 12 to 16 meters in length and weigh around 36 metric tons. Humpback whales are known to actively communicate with each other through whale songs, form pods to protect and raise young calves, and migrate vast distances to avoid depleting their prey populations [2]. As marine mammals, humpback whales give live birth, nurse their offspring, and require air to breath [3]. Based on certain anatomical features, such as their pelvises and flippers, their evolutionary history is that of land dwellers that eventually returned to the sea.

Whales have evolved certain additional anatomical, physiological, and behavioral features to maintain homeostasis underwater. To collect air quickly, humpback whales have developed blow holes on the dorsal side of the body, allowing the whale to avoid having to breach the water completely to breath. Additionally, all whales have developed a remarkably large lung capacity that allows them to travel long distances and rest without heading to the often-turbulent water's surface [4]. In order to sustain their fat reserves, which are needed to retain body heat in the cold water, all whales have grown to eat smaller, more readily available prey species. Although unusual, it is explained by Lindeman's 10% rule, which states that only 10% of a prey animal's energy is transferred to its predator. By eating prey that is so close to the bottom of the food chain, whales have access to a large amount of food that can sustain their own large bodies. Whales, in general, are able to quickly put on and retain weight, vital to a marine mammal whose body needs to remain thermoregulated for homeostasis [2].

With our species of study in mind, let us now address their unusual bubble net behavior. These bubble nets, as seen in Figure 1, tend to be either cylindrical or cone-like in shape. They are caused by several humpbacks expelling air through their blowholes underwater, creating a rather chaotic foam ring on the water's surface [1]. Their prey tend to be a mix of zooplankton and krill, *Euphausiacea*, and also include several smaller salt-water fish, such as herring, *Clupea harengus*, and salmon of various types, *Salmoninae*. Whales usually do the following to make their nets:

1. A Humpback whale locates a school of fish, krill, plankton, etc. and alerts its pod members.
2. All whales swim in a circle, releasing air bubbles through their blowholes.
3. Eventually, one whale will proceed to swim up through the cylinder, with its mouth agape.
4. This whale will swim all the way to the surface, breaching the water before closing its mouth and diving out of the circle.
5. This pattern will continue until the whales have had their fill or the resource is depleted.

With its prey trapped within the bubble net, a humpback simply needs to swim up the middle of the cylinder with an open mouth to feed [3,8]. This behavior provides the whale with an optimal foraging behavior, providing a lot of food for little energy expenditure. However, the question remains of how humpback whales developed this skill, and how it works.

This behavior, like others, likely arose through experimentation. Most, if not all, multicellular organisms have been known to use play-like behaviors to learn how to act like a fully grown organism. Whales are no exception, having been observed engaging in play like behavior before [9]. Thus it is likely that this behavior started as play but eventually became common practice among humpback whales after a whale realized that its actions were catching prey.

At this point in time, there is currently no definite answer to how the whales' prey reacts to this behavior. With that being said, however, it is quite clear that each prey animal's sense of navigation is off. The bubbles are not all encompassing, so why can the prey not swim out? Much of the capability to swim relies on the nervous system. The senses that marine organisms use to navigate are primarily visual, acoustical, olfactory, and somatosensory. The gustatory system does aid some organisms with navigation, but none that live primarily in the water. So which sensory system fails krill and other whale prey when they are caught in these bubble nets?

T.G. Leighton et al. attempted to find an answer to this question by using several acoustical modeling techniques to observe the intensity of sound within bubble nets. However, they were not able to account for sound scattering or field conditions [5]. They could not find any explanation relating to the olfactory and somatosensory systems either. While there is proof that some organisms navigate by touch, these orgasms primarily tend to have either underdeveloped eyes or habitat in dark places, such as caves and the bottom of the ocean, neither of which describe the majority of humpback whales' prey species. As for the olfactory system, fish like the salmon are known to navigate with their sense of smell, but only at select times, such as when breeding [6]. A study by P.H. Patrick et al. tested the optical effects of a rapidly flashing strobe light on freshwater fish. These lights, in addition to the bubbles, were the strongest deterrent to keep several species of fish in a set location [7]. However, this experiment cannot be fully used to explain how bubble nets work either, due to the difference in test organisms and sheer scope.

With this in mind, the focus of this project is to evaluate the effects of certain stimuli 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 on fish behavior and navigation, such as an optical or acoustical stimulus, can be used to further investigate the behavioral effects bubble nets impose on species of smaller fish. Doing more experiments with such stimuli can help determine which of the prey organisms' senses is being primarily stimulated to trap the organisms within the bubble net. The species used should be similar, but not exact, to the prey preferred by *Megaptera novaeangliae.* Zebrafish, *Danio rerio*, would fit such a description. These fish are similar in size to humpback whales' prey species, and exhibit normal behaviors of small fish.

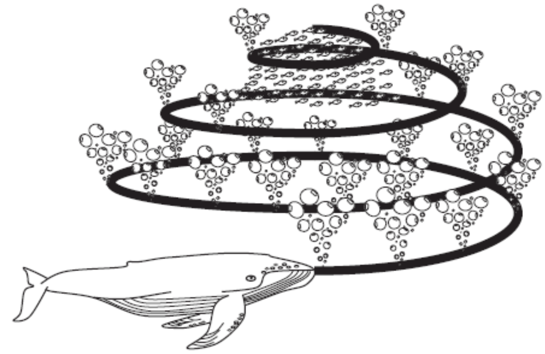

Figure 1: (From Reference 5)

Figure 5 is a diagram on what exact procedure *Megaptera novaeangliae* take in trapping their prey. At the top of the spiral, the organism opens its mouth and breaches the water, falling out of the net. [10]

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