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Fibropapillomatosis and Pollutants in Hawaiian Green Sea Turtles (*Chelonia mydas)*

Introduction:

Hawaiian Green Sea Turtles have, in the past, been majorly afflicted by Fibropapillomatosis, also known as FP. Scientists have theorized a possible correlation between persistent organic pollutants, (POPs), and cases of FP. Research shows that there has been a decrease in mortality rates in Hawaiian Green Sea Turtles, but there is no known origin to the disease as of now.

As the cause of FP is still undetermined, this paper will argue that the abundance of persistent organic pollutants in the environment is a contributor to the onset of fibropapillomatosis in Hawaiian Green Sea Turtles. Scientists hypothesize that there are several factors that are thought to contribute to the onset of FP. Those factors include habitat degradation, Persistent Organic Pollutants (POPs), and size, along with a few others. By looking at other published papers, this research paper will focus on the correlation between a subcategory of POPs, Polychlorinated Biphenyls (PCBs), and cases of FP in Hawaiian Green Sea Turtles. I will also mention how some scientists believe turtles can be a sentinel species and cover the historic cases of FP in Hawaii.

The question this paper aims to answer is: “Is there a correlation between the abundance of PCBs and cases of FP?” If we are able to see a distinct correlation between the previously stated components, we may be able to make a step towards finding a solution.

Background:

Fibropapillomatosis, or FP, is a tumor causing disease that can grow on turtles in areas of motion like the fins, neck, on/in the oral cavity, and can pose a threat to the livelihood of afflicted turtles and even cause death. FP is caused by a herpesvirus and is believed to be transmittable between turtles (Stacy et al., 2). FP was first documented in 1938 in Key West, Florida and the first documented case in Hawaii was in 1958 (Aguirre et, al.,275). The documented cases of FP in Hawaii increased in the 1990s and thanks to conservation efforts in the 1970s, the population of Hawaiian Green Sea Turtles have increased even with the threat of FP.

As of now, there is no evidence to show a distinct cause of FP. This is because there is an abundant amount of factors that are thought to contribute to the causation (Van Houtan, 2010). Scientists have been conducting a lot of research to try and narrow down the culprit of this disease. Muting Yan, author of one of the research papers I will cover, states that the afflicted turtles usually are large juveniles and highly reproductive adults (Yan et, al., 2018). Research shows that the affected turtles are usually ones that relocate to nearshore habitats, Van Houtan and their colleagues state that these environments must play an important role (Van Houtan, 2010). This could be a key factor in determining the cause of FP.

Luckily, I personally have not encountered a turtle with FP. I have participated in the Sea Turtle Rescue Program at UH Hilo. At the mandatory training, we were shown a presentation

about FP and the issues it can cause. Unfortunately, I have encountered a few turtles with fishing lines wrapped around their necks and fins. There was one instance where we had to recover a deceased turtle because of a fishing line wrapped around their neck. This goes to show that turtles face a lot of challenges because of human neglect, not only Fibropapillomatosis. The literature I will review in this paper is written by scientists and their colleagues well-versed on the topic of Fibropapillomatosis.

Literature Review:

Topic: Sea Turtle Sentinels

Alonso Aguirre, author of the paper "*Marine Turtles as Sentinels of Ecosystem Health: Is Fibropapillomatosis an Indicator?",* claims Turtles can be indicators of an unhealthy ecosystem. They used the word sentinel species; according to this paper, a sentinel species' health is monitored to determine the overall health of their environment (Aguirre et, al., 275). In this paper, they review multiple environmental factors and how they impact the Turtle's health. Aguirre states: "Immunosuppression could be the cause or consequence of conditions that lead to FP expression" (Aguirre et, al., 279). Aguirre also highlights that the turtles that are afflicted are generally juveniles and therefore, more coastal dwelling. He uses this to show that turtles are a perfect sentinel species. He states that it is because the juvenile turtles are constantly being seen by the public because of their close proximity to shore, hence being seen with tumors and causing the public to act to make a difference (Aguirre et, al., 276).

I believe Sea turtles can be a great sentinel species especially because they are able to be tracked and, because they are frequently seen onshore, they can be used to educate the

community on the effects us humans have on their livelihood. Take Aguirre's information into account when continuing to read the next few pages.

Topic: POPs

Like previously stated, the role of PCBs in the cases of FP are still being debated. According to the Illinois Department of Public Health, pollutants like PCBs were used in industrial buildings, transformers, and plasticizers (IDPH, 2009). They can leak into the water from spillage and improper disposal. Thankfully, the use of PCBs have been banned in Hawaii since 1979 (EPA, 2024).

The first paper I researched was written by Jennifer Keller and other co-authors. These scientists tested the theory that POPs might cause FP tumor affliction. I was really happy I found this paper because it was an experiment based in Hawaii, compared to many other great articles based in other states or countries. I felt that this article was a gem to find. Keller and her team captured 39 free ranging turtles and 14 stranded turtles. On page 7807, they also hypothesized that POPs can cause immunosuppression which may, therefore, lead to contracting FP.

After capturing the turtles, they did the standard procedures like measuring carapace length, weight. They also tagged turtles that did not already have one. Afterward, they used a mathematical formula to measure the body condition. That formula is "turtle mass (in kilograms) divided by the cubed straight carapace length (SCL) (centimeters) multiplied by 100000" (Keller et al., 7808). They compared plasma samples and measured 164 concentrations of POPs in all of the captured turtles.

They found that there was no FP in Kiholo, Moderate FP in Kapoho, and Low FP in Kailua Bay (Keller et al., 7810). And based on these findings, they concluded that there is no distinct correlation in all of the samples they took. They stated that the levels they measured did

not have a pattern of increasing POP abundance and cases of FP. They also concluded that POPs do not cause immunosuppression, instead, turtles that are immunocompromised have already developed tumors and the severity is high (Keller et al., 7814). Lastly, they stated that halogenated phenols, which are present in soaps, were a novelty find and should be further investigated (Keller et al., 7814).

This was interesting to read because even though there was reason to believe that pollutants could contribute to the onset of FP, Keller and her team proved otherwise.

The next paper I will cover is written by Muting Yan and other co-authors. This research project was based on Tern Island. Yan and their team collected samples from 43 turtles. All of these turtles had either no tumors, average tumors, or acute tumors. These turtles were a mix of male and nesting females. The team took a similar route to Keller and her team. They measured the size and weight of the turtles, and collected blood samples as well. The goal of this paper was to measure the concentration of PCBs in Hawaiian Greens along with a focus in comparing the concentrations between both sexes.

The blood they extracted from the 43 turtles was analyzed to determine the concentrations of PCBs present. This was done by using a chromatograph, a device used to identify amounts of chemical compounds in a sample (Shellie, 2023). Yan and their team determined that the PCB concentrations were higher in males than females (Yan et al., 2018). They hypothesized that this could be because of maternal transfer, meaning that the contamination they have in their bodies is transferred to the eggs she lays (Yan et al., 2018).

Yan concluded that the PCB concentrations in turtles with aggregated tumors were increased. They further propose the theory that PCBs play a role in the cases of FP within the Hawaiian Green Sea Turtle (Yan et al., 2018).

Comparing this article to Keller's, there is a disconnect when it comes to their end conclusions. This could be because of the difference in sample size, or a difference in focus of research. Either way, it was interesting to read this article because it was a similar approach to Keller's but they yielded different results.

Topic: Historic Records of FP

The next research paper I will cover is written by Kyle S. Van Houtan. The contents of this research paper focused on data within Hawaii, specifically, Oahu, Maui, and Hawaii Island. They looked at the years 1982-1999. While looking over these records spanning 28 years, they looked specifically for turtles with tumors. Kyle and his team found 3,939 records of stranded turtles fitting the role. They did this in order to further understand the disease, fibropapillomatosis.

Van Houtan and their team took those 3,939 records and looked over the land where these turtles feed, and the links between invasive macroalgae, size, disease rates, and nitrogen-footprints. I will do a brief overview of the size and disease rates with land use and nitrogen-footprint categories. To begin, they looked at different size classifications and stranding numbers throughout the 28 years and found out the disease rate correlated to size classes (Van Houtan et, al., 2010). They said it is important to understand that relationship in order to obtain accurate comparisons (Van Houtan et, al., 2010). They concluded that size is a consistent factor, meaning that "disease rates increase with size, peaks, and then decreases" (Van Houtan et, al.,

2010). This was really informative, we are able to distinctly understand that size is a big factor in contracting FP.

Then the team wanted to understand the locations where FP was found. They looked at watersheds, combining data if the watersheds were next to each other and shared waterways, or if stranded turtles were in between land boundaries of multiple watersheds. They concluded that the land humans consistently used had the highest disease rate (Van Houtan et, al., 2010).

This article was very different compared to the other two mentioned. I liked how they looked at the history records of the Hawaiian Green Sea Turtle. Although they didn't focus on PCBs, I thought it was useful to mention in this paper.

The last paper I will briefly cover is also written by Alonso Aguirre. Their focus was set on determining the relationship between pollutants and disease rate in Hawaii. This study focused on multiple pollutants, along with PCBs but I will only review the PCB results.

Aguirre and his team gathered samples from multiple juvenile turtles and tested them to determine different levels of metals found within the tissues. They found that there were no PCB residuals in the tissues analyzed (Aguirre et, al., 112). This is important to note because this means that none of the turtles captured were exposed to PCBs along with other pollutants when they were examined (Aguirre et, al., 112).

This research paper was important to include because they took into consideration other pollutants like organochlorines, selenium, organophosphates, heavy metals, and n-methyl carbonate.

Recommendations:

I believe the work that is being done currently is sufficient in its results. Research should continue to happen and I believe that it helps narrow down the options. Collaboration between scientists about their findings is key in gaining knowledge about FP. Also, I believe it would be beneficial to track and monitor juvenile turtles as they progress in age and size. If they contract FP, we could look back on where they have been, if others have been in the same area, and compare it to how much the tumor progressed to see the most likely location they contracted the disease, like what Kyle S. Van Houtan did in his paper. How financially and physically realistic is this? I am not sure, but it would be interesting if we could see a connection.

With the continual sharing of knowledge and possible tracking of the turtles, I believe that in the future, scientists will have a better understanding of FP and hopefully find the answer, whatever it is.

Conclusion:

The case of FP in Hawaiian Green Sea Turtles is a very complicated and unresolved issue. The question we aimed to answer is "Is there a correlation between the abundance of PCBs and cases of FP?" After examining these well-written papers, I conclude that there is no distinct correlation between cases of FP and abundance of PCBs. FP is a very intricate problem that needs to be carefully examined. As George Balazs stated in an email correspondence about this research topic, "sounds like you're making progress in seeing how complex and unresolved pursuing this topic will be, given the current state of knowledge". I believe he stated it perfectly, even though we were unable to see a distinct correlation between the abundance of POPs and

cases of FP, we are able to learn that it is not black and white, but a multicolored-multi layered matter.

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