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DEPARTMENT OF MARINE SCIENCE

Estimated Age Class Structure of Juvenile Oceanic Blacktip Sharks (*Carcharhinus limbatus*) in Hilo Bay, Hawai'i

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Abstract

The ecology of sharks in coastal environments is vital to understanding the ecosystem as a whole and implementing appropriate conservation actions. Little is known about the shark community in Hilo Bay, Hawaii, specifically regarding the spatial distribution and trophic ecology of various shark species. In this study baited longlines were set out periodically in Hilo Bay from March 2013 to November 2013. Captured sharks were identified, measured, tagged and released. A growth model for juvenile Oceanic Blacktip sharks (*Carcharhinus limbatus*) was developed using total length data. Stable isotope data ($\delta^{15}N$ and $\delta^{13}C$) from fin tissue samples was laid over the growth model to test for correlations in estimated age and trophic level. Four age classes of *C. limbatus* were estimated, of which one year-old sharks were most abundant Hilo Bay. Trophic levels varied greatly with possible indications of less variable diet with increased age.

Introduction

Coastal sharks in Hawaii have the important role of apex predators, yet information on their spatial distribution is limited (Gruber and Myrberg 1977, Hoover 2012). As apex predators, sharks control fish populations and maintain an overall balance in the ecosystem. In order to manage such a key part of the ecosystem and avoid over-fishing, it is essential to understand their spatial distribution, trophic position, and diet (Branstetter 1987, Heupel 2012). This information is vital to a better understanding of the ecology of sharks (Fisk 2002). Current lack of information on the ecology of sharks is due to the difficulty of studying these animals. For example, most elasmobranch species are very fragile and cannot be successfully kept in captivity, and direct observation in the field can have a high cost and can also be dangerous (Gruber and Myrberg 1977). Therefore there is a strong need for more information on shark ecology as many shark species are declining rapidly on a global scale (Knip et al. 2012).

The ecology of sharks is important because it is fundamental to understanding the underlying communities and social interactions that determine the spatial distribution of species in marine ecosystems, (Branstetter, 1987). Once the ecology of sharks is understood, steps can be taken to protect their natal grounds, prevent over-fishing, and other preventative actions (Branstetter 1987, Holland 1993). These actions can provide beneficial circumstances for the sharks, and consequently preserve them as apex predators and boost biodiversity and the balance of the ecosystem.

Mark-recapture studies have proved to be a very efficient approach to the study of sharks and their interactions with the environment (Stipendorfer 2005). Tags provide a simple and safe way to identify sharks and track their movement in the ecosystem (Gruber and Myrberg 1977). These tagging studies help to gather a basis of vital data that makes it possible for other studies to build on. In the past, this tactic has been very successful (Gruber and Myrberg 1977). It is the most popular and effective method in studying the spatial distribution of sharks in estuarine environments (Stipfendorfer 2005).

One of the most effective methods in studying the trophic ecology of sharks is stable isotope analysis. Stable isotopes such as1 5N and 13C have been used for many years to determine the roles that various species have in ecological processes, including feeding ecology (Hussey et al. 2010). This method provides long-term information on feeding behaviors of an animal (Kinney et al. 2011). This is opposed to short-term information that can be obtained from traditional stomach content analysis, which provides only the most recent ingestion and is lethal. Signatures of 15N are indicative of the trophic level of predators in the food web, and 13C suggests carbon source (Papastamatiou et al. 2010). This information is reflective of the ecological behavior of sharks over long periods of time. The specific turnover rate or diet discrimination factor of the sampled tissue (e.g. fin, blood, liver, cartilage) determines how far back the isotopic signatures date (Hussey et al. 2010).

Hilo Bay is a very unique coastal habitat that is known to be a nursery to several shark species including Oceanic Blacktip sharks (*Carcharhinus limbatus*) and Scalloped Hammerhead sharks, (*Sphyrna lewini*), but the exact spatial and temporal distribution of these sharks is currently unknown. Additionally, adult Oceanic Blacktip sharks (Carcharhinus limbatus), Sandbar sharks (*Carcharhinus plumbeus*), Scalloped Hammerhead sharks (*Sphyrna lewini*), and Whitetip reefsharks (*Triaenodon obesus*), along with Brown Stingrays (*Dasyatis lata*) have been reported (Hoover 2012). Previous student studies in Hilo Bay have shown a wide range of stable isotope signatures among elasmobranchs (Dolan, 2013).

The objective of the present study is to use mark recapture methods to collect data that can be used to determine the community structure and spatial distribution of coastal sharks in Hilo Bay. This study will result in valuable data. The knowledge derived will provide a better understanding of the ecology of sharks in Hilo Bay, and in consequence give us an idea of how we can protect these apex predators. Also an organized method of mark recapture studying that can be used in University classes as well as in future studies will be derived from this study.

Objectives:

1. Investigate whether there are different age classes of Oceanic Blacktip (*Carcharhinus limbatus*) pups in Hilo Bay using a growth model.
2. Test if there is partitioning in recourses among different age classes using stable isotope analysis.

Methods

Study site
In this study sharks were fished in Hilo bay, Hawai'i during the summer and fall of 2013. Eleven total fishing trips were conducted during the sampling period. The approximate coordinate of the location where each longline was set was recorded.

Capture of sharks
Sharks were captured by setting out baited longlines over side a 15ft inflatable boat. The hooks on the longlines were barbed circle hooks (size 5/0), set approximately 1meter apart, 30 hooks per line. Each line was deployed for 1 to 2 hours, and was set out twice per fishing trip.

Tagging equipment
Plastic spaghetti tags (Floy Inc.) were used to tag the sharks at the base of the dorsal fin. Each tag includes an identification number along with contact information.

Tagging Process
Upon pulling in the longlines, captured sharks were measured in the water over the side of the boat. Species, sex, presence or absence of an umbilical scar, and fork and total length were measured. Any visible parasites (e.g.- leeches, isopods) were collected and stored in whirl-pack bags for further analysis. The plastic spaghetti tag was applied to the base of the dorsal fin. A small tissue sample (fin clipping) from the dorsal fin of each shark was cut with a scalpel and stored in a whirl-pack bag. After the required data was collected the hook was removed and the shark released. Sharks that were deceased upon capture arrival were collected and stored frozen at the University of Hawaii at Hilo for further tissue analysis. Afterwards, specimens will be returned to the place of capture in Hilo Bay.

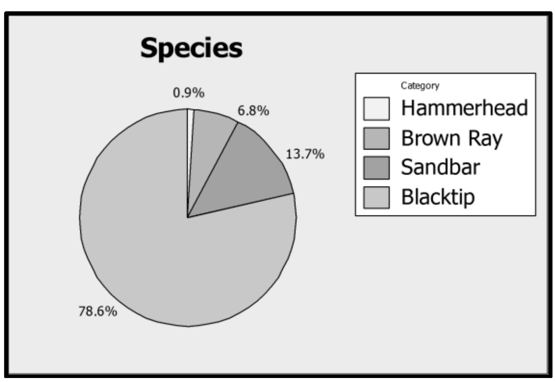
Deliverables

This study will result in a better understanding of the ecology of sharks in Hilo Bay and therefore greater knowledge on the spatial distribution and communal interactions of the sharks. The knowledge resulting from this study can be used to implement proper conservation mechanisms such as fishing regulations. A presentation of this project was given at the Marine Option Program Symposium on April 12, 2014. A data sheet was also developed which can be used in future mark recapture studies and in the University of Hawai'i at Hilo Summer class the Natural History of Sharks and Rays lab.

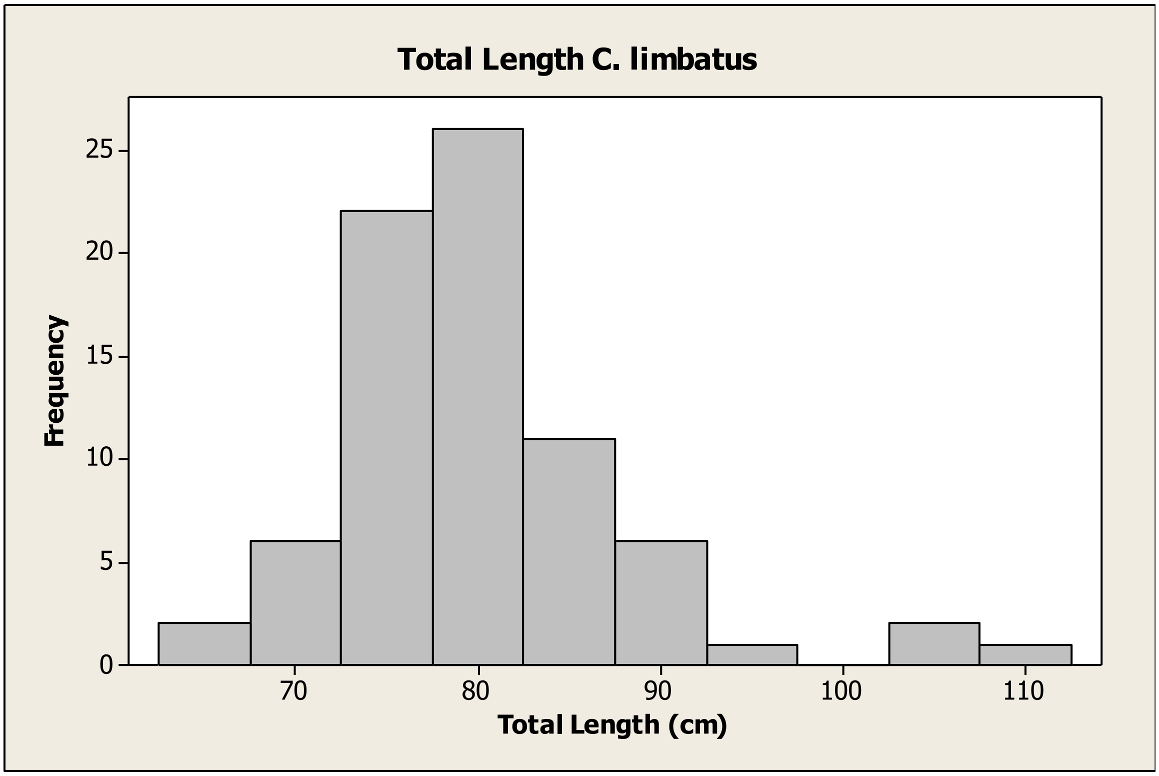
Results

1. Basic Statistics:

The focus of the present study was on the juvenile Oceanic Blacktip sharks (Carcharhinus limbatus). For each captured shark measurements of their total length, fork length, umbilical scar, sex, and a tissue sample were taken. During data collection, a total of 117 individuals were caught, 92 of which were *C. limbatus*.



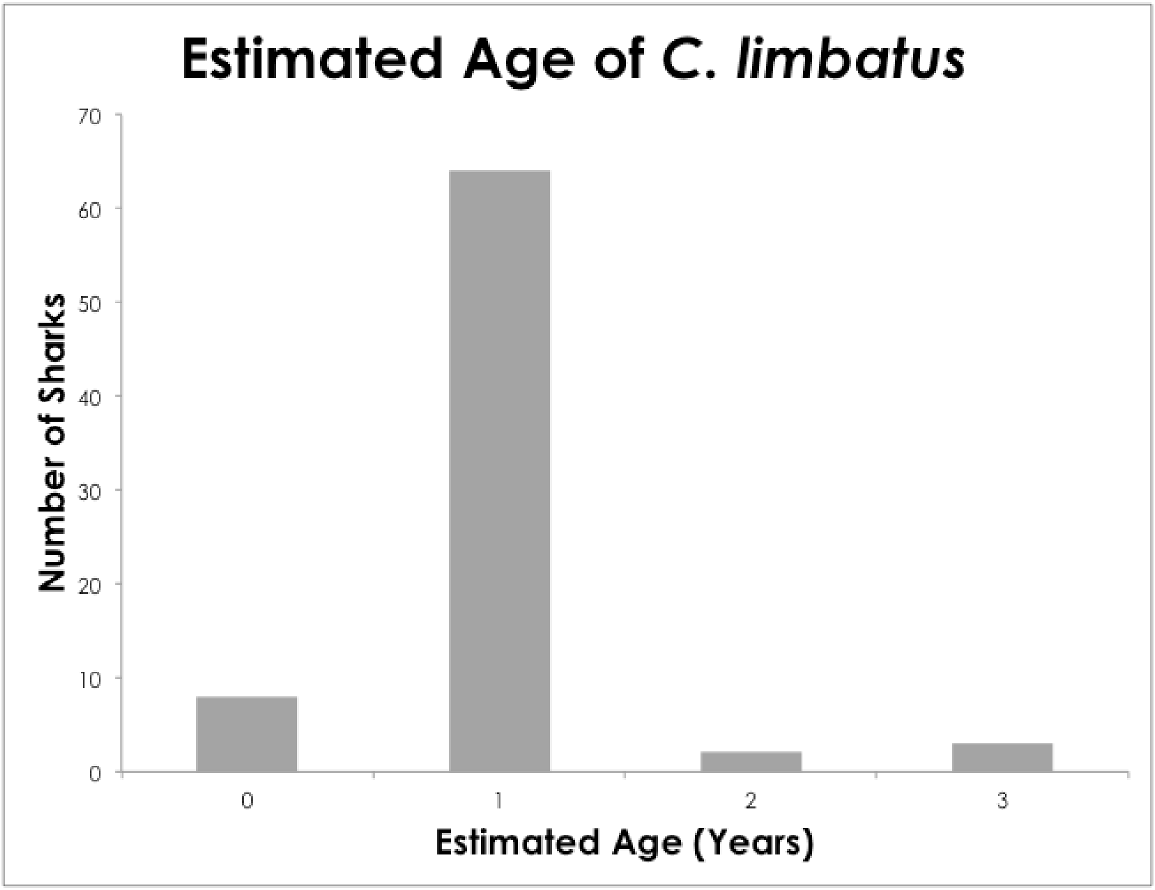
(Species distribution of total catch)



(Total length frequencies for *C. limbatus)*

2. **Comparison/Growth Model:**

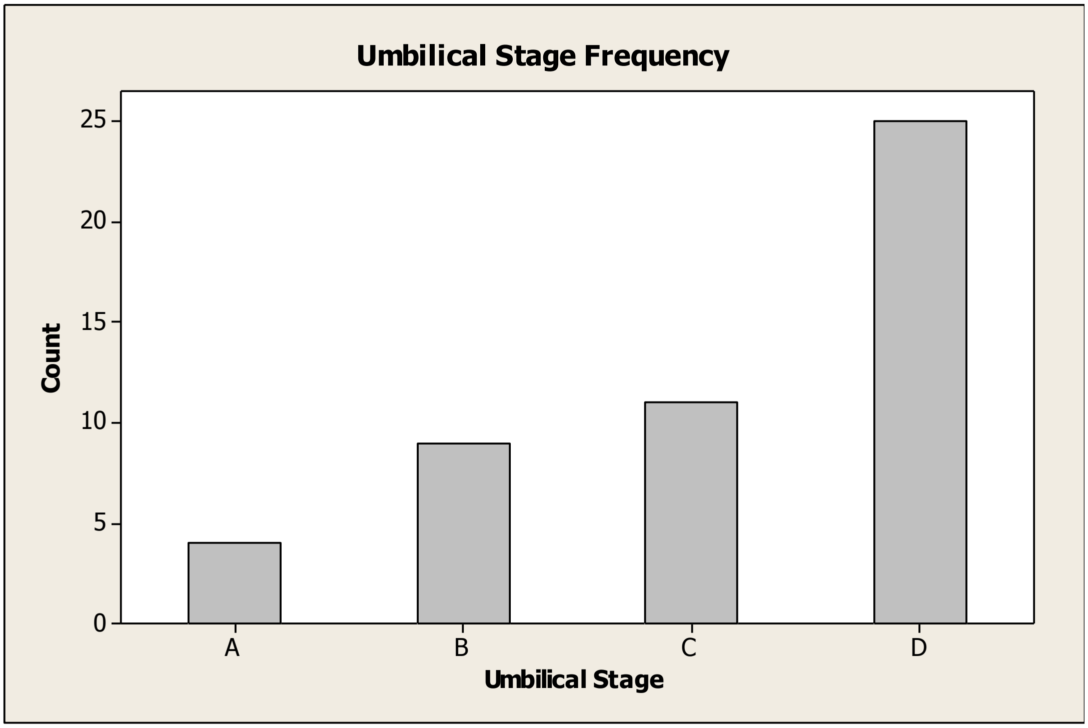
Total length measurements were used to estimate the age of sharks by using the growth rates of a similar study by Branstetter, 1987. In his 1987 paper Branstetter determined growth rates of *C. limbatus* using vertebral bands, and used the correlation between vertebral band formation and total length to determine age. Justification for comparison is based on both populations being of the same species in the same part of their life history, located at similar latitudes and similar estuarine ecosystems. It should be noted that as this study compares two different populations of *C. limbatus*, age can only be estimated, not quantified exactly. In the present study the Hilo Bay population total length data has been applied to Branstetter's growth curve to estimate the age of the sharks caught in Hilo Bay.



(The figure above displays the frequencies of each estimated age class (based on Branstetter's 1987 paper) organized according to total length. It shows that that the majority of the blacktips we sampled were 1 year old upon capture. Older sharks (ages 2-3 years) were caught much less frequently.)

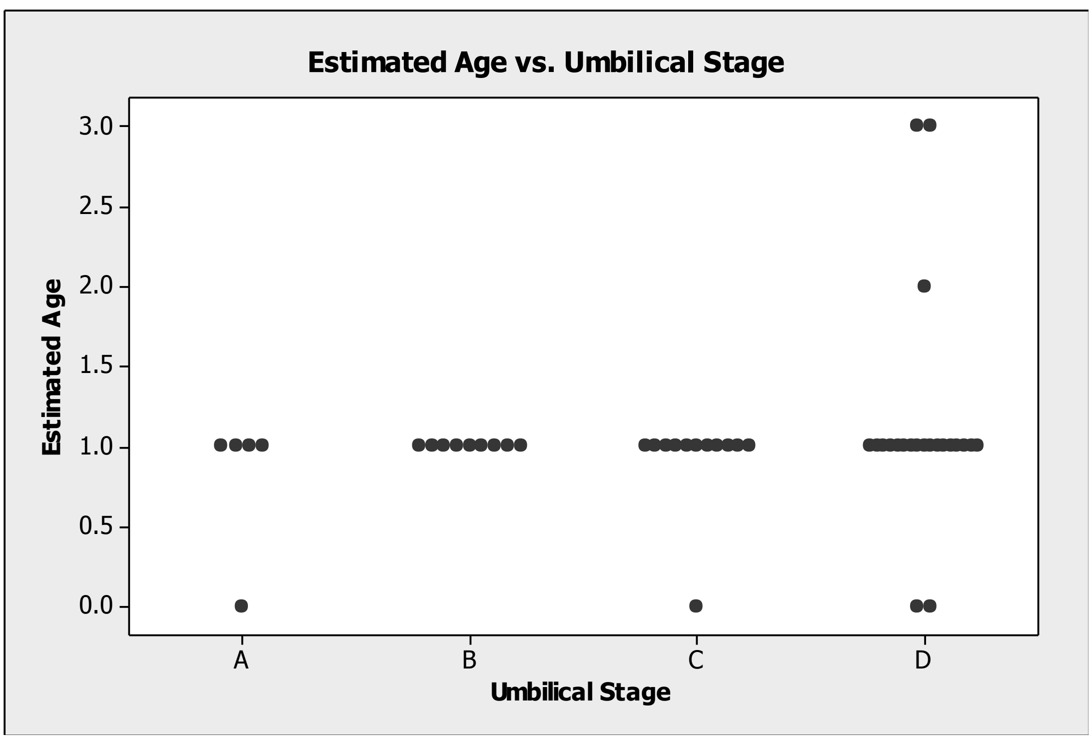
3. Umbilical data

Umbilical scar data was then applied to this to determine if there was any correlation between umbilical scar healing and the estimated ages of the sharks.



(The above figure displays the frequencies that we recorded of each umbilical stage in all of the age classes combined. The umbilical stages are as follows:

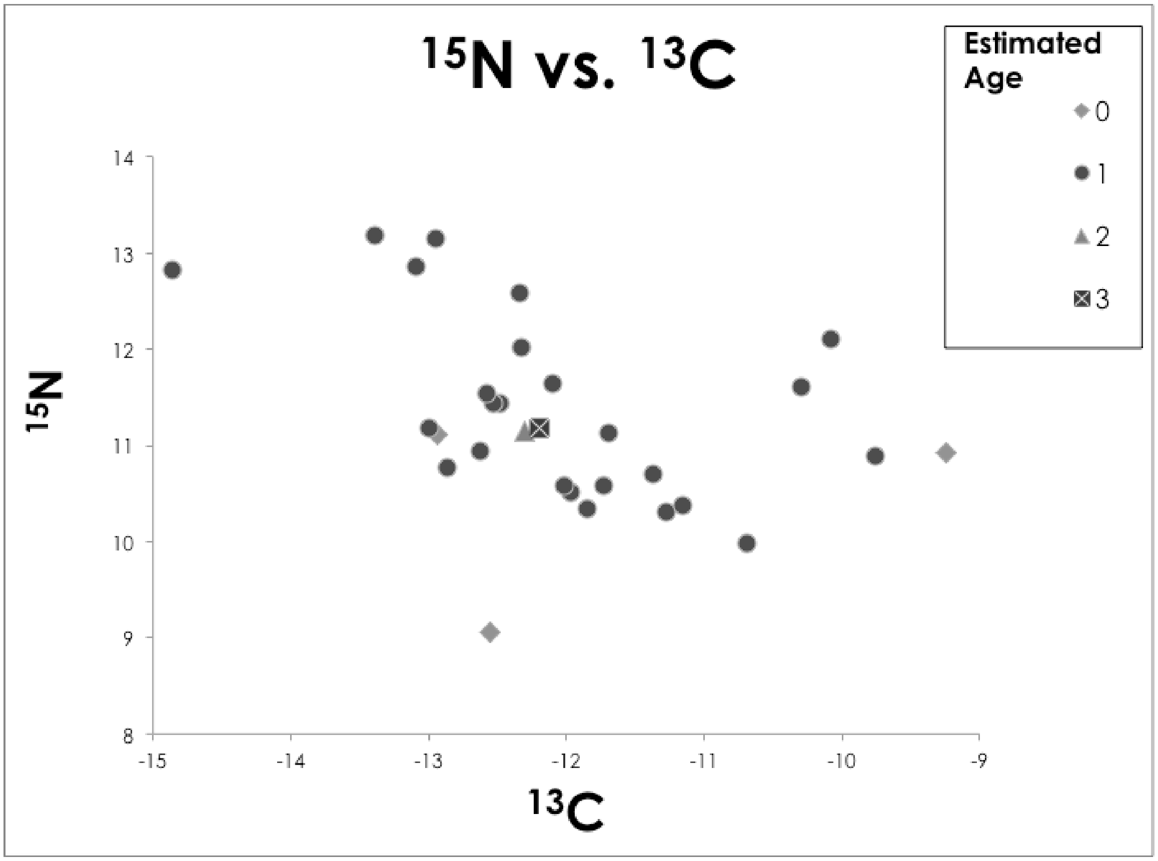
A: Open, B: Present, C: Partially Healed, D: Healed.)



(The above figure is an individual value plot of the estimated age of C. limbatus vs. the umbilical stage of each shark. Each umbilical stage is present within the 1-year age class.

4. Stable Isotope Analysis

Stable Isotope Analysis (SIA) was preformed on 33 of the 92 total Blacktip sharks captured. Samples were analyzed for 15N and 13C Signatures. The SIA data was then laid over the estimated age classes of *C. limbatus* to investigate if there is partitioning among resources between the different age classes.



(The above figure shows the SIA data. Each estimated age class is represented by a different symbol)

Conclusion

Results from this study form a picture of what the *C. limbatus* population in Hilo Bay is constructed of. Using Branstetter's (1987) growth model, it appears that most of the blacktips in Hilo Bay are 1 year of age. When applying umbilical scar data to these estimated ages, the results are quite scattered. Each umbilical stage, from open to healed, is found in the 1-year age class. Stages were not distributed in logical order from open to healed, youngest to oldest. These results may be due to variability in size at birth. This is indicative that the growth rates of the two separate blacktip populations may be incomparable.

The results from SIA are indicative of the feeding ecology of *C. limbatus*. The sharks in the 0 and 1 year age classes showed widely variable data that is suggestive of varying resource exploitation. Sharks in the older 2 and 3 year age classes showed much more stable signatures. This suggests that diet becomes less variable with age. Although the results are indicative of this, no viable conclusion can be made due to the small sample size of older sharks. The apparent decrease in diet variability with increasing age could be due to several factors. Younger, less experienced sharks may have to compete for desired prey, and therefore have to supplement their diet with less preferred items. Older, more experienced sharks are able to successfully compete for desired prey items. These factors could possibly affect the resource partitioning among the age classes observed in this study, but further supportive research is needed in this area.

Future Studies

This study provides open opportunities for further study in the population structure of blacktips in Hilo Bay. Vertebral samples can be analyzed to get an accurate age estimate specific to this population of sharks. Also, there are tissue samples from the remaining sharks that can be analyzed with stable isotope analysis. This can determine where the sharks stand in the trophic structure of the bay, and test for any partitioning in diet among the population. There is a solid basis of data to build on and a great potential to gain more knowledge on the population structure of sharks in Hilo bay.

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