The Spatial Ecology of Lemon Sharks (*Negaprion brevirostris*) in Mangrove Creeks of South Eleuthera, The Bahamas

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Introduction

Sharks are a very vulnerable, endangered species. Although they are apex predators, sharks are especially susceptible to human impact. Life history characteristics such as slow growth rates, small litters, and natal site fidelity inhibit population growth rates. Sharks face major threats such as overfishing and capture as by-catch from global fisheries. Additionally, sharks are targeted by game fishermen and are often left to die, as shown in Figure 1. Advances in fishing technologies have also increased shark capture potential. The Bahamas has actively tried to protect sharks from these threats by banning long-line fishing in 1993.

Sharks in The Bahamas still face danger due to tourism. Tourism leads to coastal development, destroying large amounts of vital mangrove habitat. This specifically endangers lemon sharks because they utilize mangrove creeks as nursery grounds. Lemon sharks spend up to the first 6 years of their lives in mangrove creeks. After 12 years, females reach reproductive maturity and return to their birthplace to lay pups every 2 years, demonstrating natal site fidelity (Chapman *et al*. 2009). As a result of accommodating tourist demands, coastal development and dredging has devastated a significant portion of mangrove habitat in Bimini, The Bahamas, as shown in Figure 2. This was found to directly decrease survival rates of lemon sharks by 23.5% (Jennings *et al*. 2008).

The creeks of South Eleuthera are relatively undisturbed, making it a good place to effectively study juvenile lemon sharks. During the Fall 2010 semester of The Island School, the lemon shark project has collected and analyzed the relative abundance of juvenile lemon sharks within five local mangrove creeks. This information can be used to make informed and responsible decisions about future development in South Eleuthera.

Fig. 1 Recreational fishing pressure

Fig. 2 Results of costal development in Bimini Bay

Lemon Shark Sampling

In the study, five mangrove creeks were sampled within South Eleuthera (figure 3). In this process, sharks were captured by using a Creek Modified Survey Line (CMSL), stretching 100m across the creek mouth, with ten baited gangions. The gangions consisted of a tuna clip, braided nylon line, wire leader, and a 12/0 circle hook. The CMSL is then left in the water for a two-hour soak time. Bait is checked every 30 minutes. Hooks with no bait were re-baited at that time. When a shark is caught (figure 4), it is placed in a water-filled cooler and the following data is collected: measurements, tag identification, sex, weight, and DNA. Measurements include: pre-caudal length (PCL), fork length (FL), total length (TL), and stretched total length (STL). DNA is sent to Damian Chapman in Stonybrook University, New York.

Fig. 3 Sampling sites

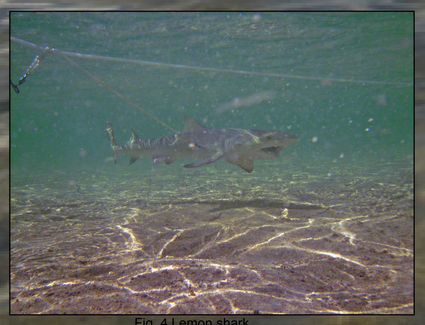

Fig. 4 Lemon shark caught on gangion

Prey Item Sampling

To determine the prey abundance within each creek, a seine net was used to collect a sample of fish species present, as seen in figure 6. The net was 100m long with circular foam floats along the top and lead weights along the bottom. One pole of the seine was planted on shore while the other was pulled into the water at a forty-five degree angle. The mobile pole was then walked to shore and the net was pulled onto the beach. The seine was either conducted in the mouth of the creek or the flats within it. When a sample was captured, the following was recorded: fish species, weight, fork length (FL), and total length (TL).

Fig. 5 Collecting prey item sample From seine net

Fig. 6 Sample collected from seine net

Results

Figure 7 is a table comparing the results from our total shark captures between males and females since the beginning of the study in February 2010. On average, females were longer and larger and had a lower recapture rate than males. Figure 8 depicts the variation in relative abundance (measured in mean CPUE) between the five creeks that we study. As shown, it was found that Broad Creek has a significantly higher relative abundance than Page (p=0.022), Kemps (p=0.040), and Plum (p=0.001). Figure 9 presents the variation in relative abundance between the three creeks on the northern side of Eleuthera (Page, Kemps, and Broad) and the two southern creeks (Deep and Plum). Figure 10 exhibits the difference in prey abundance between the studied creeks. It shows that Kemps creek has a significantly higher prey abundance than Broad, Page and Plum (p=0.015). Figure 11 displays the variance in size (measured in fork length) of lemon sharks between the five studied creeks. It was found that the lemon sharks in Deep Creek are significantly larger than Broad (p=0.000), Kemps (p=0.020), and Plum (p=0.038). Standard error is equal to one standard deviation above and below the mean.

Sex	Number	Weight (kg)	Mean TL (cm)	Recapture Rates	TL Range (cm)
Male	74	2.35	70.06	28.9%	47-101
Female	68	2.41	70.62	18.75%	57-104
Total	142	2.38	70.34	20.2%	47-104

Figure 7. Compilation of total lemon shark data between genders

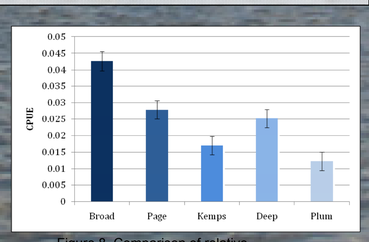

Figure 8. Comparison of relative abundance of lemon sharks between creeks

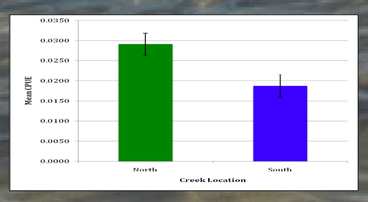

Figure 9. Comparison of relative abundance of lemon sharks between North and South

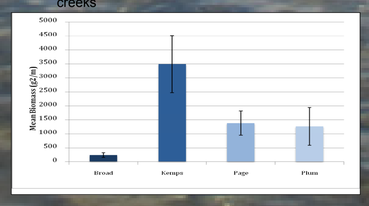

Figure 10. Comparison of mean prey biomass between creeks

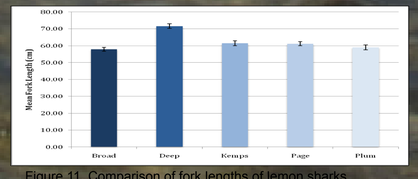

Figure 11. Comparison of fork lengths of lemon sharks between creeks

Discussion

When comparing the creeks in South Eleuthera, the Northern creeks produce higher abundance compared to the southern creeks (p= 0.029). Some factors that may create this difference are; mangrove density, sea grass distribution, and creek depth. The creeks in the north provide a larger habitat and therefore they are more likely to support larger populations. (Freites et al, 2009). Also, the northern creeks are more protected from weather versus the southern creeks, which are exposed to the Atlantic. There were also significant differences in relative abundance between the five creeks studied. Broad and Kemps (p=0.04), Broad and Plum (p=0.001), and Page and Plum (p=0.022) were all found to have significant differences. It is known that lemon sharks exhibit natal site fidelity (Chapman et al, 2009), which helps support the differences in abundance between creeks. It is interesting to note that Broad and Page, which have the most statistical significance, also hold the highest CPUE.

Kemps produced the highest biomass of prey compared to the three other creeks. After analysis, it was found that there were significant differences found between the four creeks sampled (p=0.015). Based on the work of Newman (2008), it is known that sharks prefer teleost species, primarily Mojarra. Kemps had the highest prey biomass, but the second lowest CPUE. This may suggest that Kemps is a better ecosystem for teleost fish or the biomass is not made up of the preferred prey items (Cortes and Gruber, 1990).

When looking at fork-length, seen in figure 12, between creeks, only the comparisons including Deep were statistically significant. Results include: Deep and Broad (p=0.000), Deep and Kemps (p=0.02), and Deep and Plum (p=0.038). This indicates that sharks in Deep are larger, most likely because a large creek such as Deep provides a larger home range, therefore potentially providing a larger nursery (Gruber, 1993). A larger creek also increases predation, which decreases survivorship of juvenile lemon sharks (Gruber, 2001). A decrease in survivorship, paired with an increase in competition lead to larger shark size and a stronger gene pool (Gruber, 2001).

Fig. 12 Recording fork length from juvenile lemon shark

Fig. 13. Shark caught at Deep Creek on a creek modified survey line

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