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Community knowledge of shark ecology, abundance, and species composition in Wichubwala, Nalunega, and Porvenir communities in the Guna Yala Comarca, Panamá

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SIT Study Abroad

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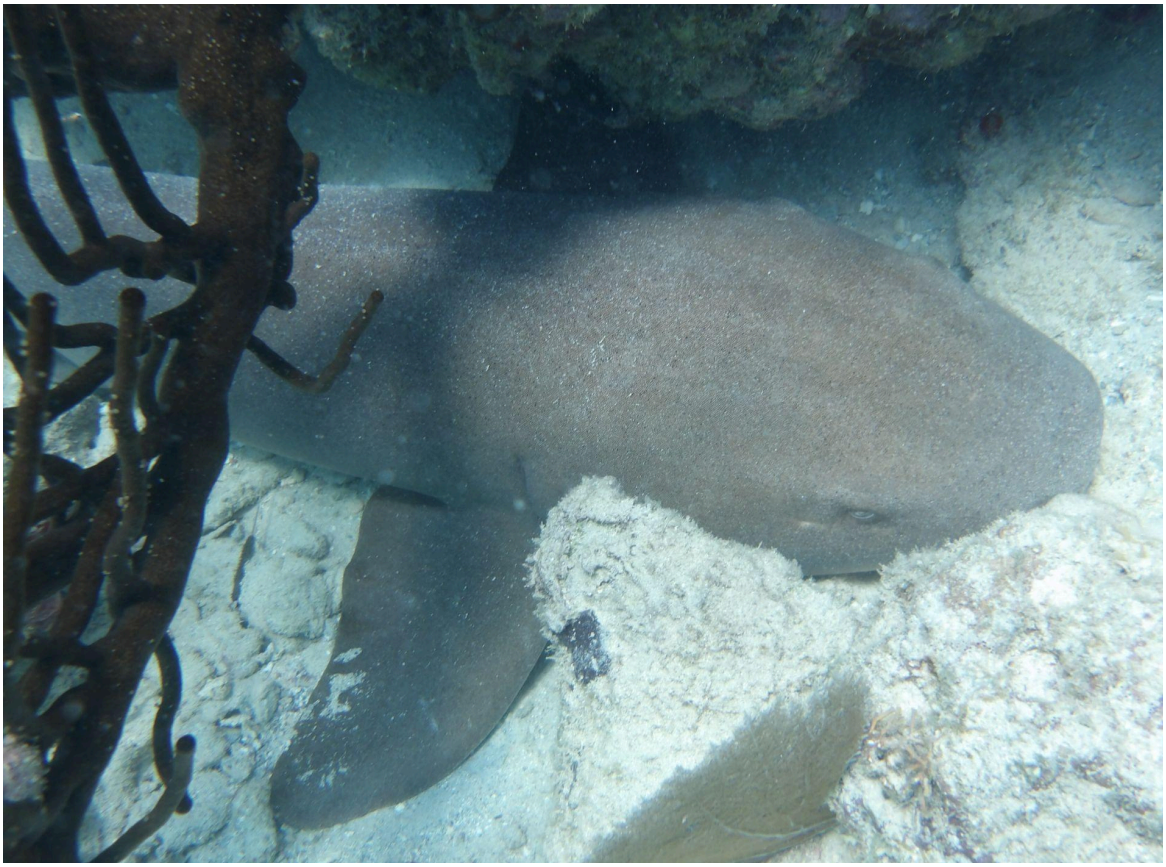

ABSTRACT

Sharks play a critical role in marine ecosystems as apex predators that exert top-down control of lower trophic levels. In recent decades, global shark populations have declined to unprecedented levels, triggering a cascade effect that threatens ecosystem functioning and, therefore, coastal community livelihoods that rely on marine resources for food and income. It is known that shark populations are vulnerable and on the decline due to anthropogenic stressors such as fishing and coastal development, but shark species composition and abundance are difficult to monitor due to the evasive nature of sharks, the often remote and inaccessible location of certain shark populations, a lack of support for shark conservation efforts, and deficient baseline data. The Guna Yala comarca, a semi-autonomous Indigenous territory located on the eastern Caribbean coast of Panama, is home to high levels of marine biodiversity, specifically in coral reef ecosystems. Guna Yala's 49 island communities practice subsistence fishing; marine invertebrates and fish are the principal protein source for communities. In the Guna Yala region, baseline data on shark species composition and abundance does not exist. Consequently, long-term shark abundance trends are not well understood in the area. It's important to understand shifting marine biodiversity and community composition in the comarca because these changes will directly impact access to food and other marine resources, threatening food, job, and cultural security. Although there is a lack of empirical quantitative research in the area, Guna communities hold valuable and diverse knowledge systems surrounding shark species composition and abundance due to their comprehensive understanding of marine ecosystems that results from the deep reliance of the communities on marine resources. The aim of this study was to examine the perspectives of Guna people on shark species composition, abundance, long-term trends, personal sentiments, and cultural significance of sharks to understand the potential of Local Ecological Knowledge (LEK) as a viable method for evaluating shark ecology in Guna Yala using a semi-structured interview technique. Interview participants were asked a series of 3 yes/no and 2 open-ended questions. Responses were recorded, translated from Spanish to English, and grouped in order to identify main themes. Analysis revealed that the majority (93%) of participants believe that sharks are important to ocean health and the majority of those asked (71% of 7 participants) said that they have observed a decline in shark abundance over the years. Nine different shark common name types were mentioned as having been observed, including the critically overfished hammerhead shark. There was low consensus regarding the question of cultural significance, indicating that 'cultural significance' may be interpreted in different ways and is difficult to quantify. Comparing interview responses with past shark abundance research in Panama and other LEK-based studies suggests that in Guna Yala, interview-based research surrounding ecological trends could be an effective and important tool in furthering our understanding of how shark communities are being altered by climate change—an initial step in identifying the impacts that changing population dynamics will have on the greater environment and on human communities.

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1. Introduction

1.1 Background

Research has demonstrated that marine ecosystems are impacted by climate change, including decreased ocean productivity, altered food web dynamics, shifting species distribution, and reduced abundance of ecosystem engineers (Hoegh-Guldberg & Bruno, 2010). It is important to investigate how climate change is affecting specific groups of marine organisms in order to better evaluate the potential synergistic effects of climate change on marine communities, and therefore on human wellbeing. Research is especially crucial in Indigenous coastal communities, where livelihoods and culture are often tightly intertwined with marine environments for subsistence, income, and resources (Busilacchi et al., 2013).

1.2. Ecosystem and species vulnerability

Neither climate change nor human activities impact all marine species evenly. Certain species are more vulnerable to the effects of shifting conditions than others and much research has been done to assess the vulnerability of different species in the face of climate change (Foden et al., 2018); however, there is little consensus on the most effective way to assess vulnerability (Wheatley et al., 2017). Therefore, predicted shifts in biodiversity and community composition may not be entirely accurate. Rather than using broad theoretical frameworks, specific, case-based field research could be an effective approach to understanding how climate change is affecting biotic communities on local scales.

Rising anthropogenically-fueled atmospheric carbon dioxide (CO_2) concentrations threaten marine ecosystem health via increases in ocean temperature and acidity, which lead to sea level rise, increased ocean stratification, decreased sea-ice extent, and altered ocean circulation and precipitation patterns (Doney et al., 2012). In recent decades, climate-related changes have been increasing at a rate that is too rapid for marine species to adapt. Coral-algae symbioses in particular are sensitive to ocean temperature changes, and thus coral reef ecosystems are being degraded at an increasingly rapid rate. Widespread bleaching events are becoming too frequent, intense, and temporally and spatially extensive for corals to functionally recover (Webb et al., 2021). Because corals are ecosystem engineers and form the basis of reef trophic webs, coral degradation exerts a deleterious bottom-up effect on marine ecosystems.

Worldwide, marine apex predator populations are in rapid decline, including sharks, large tuna, groundfish, and other reef-associated predators—large shark populations are estimated to have declined by 90% in North America (Heithaus et al., 2008) and by 74-92% in Australia (Roff et al., 2018). The decline of large shark populations exerts a top-down effect on marine ecosystems—the entire marine community changes when apex predator populations decline (Dulvy et al., 2017). Reef shark populations are supported by high habitat complexity and decreased shark populations lead to increased macroalgal growth (which decreases reef habitat complexity) due to depleted primary consumer populations (Desbiens et al., 2021). The combination of bottom-up and top-down control imbalances, compounded further by the overfishing of commercially valuable fish in recent decades, has led to global ecological collapses, shifts in community composition, and biodiversity decline, which cause changes in

ecosystem functions and depleted resources and ecosystem services for humans (Sala & Knowlton, 2006).

1.3. The trophic cascade phenomenon

Although it's important to conduct population monitoring on commercially fished species, the impacted population of any one species directly and indirectly affects many other species—a phenomenon known as 'altered food web dynamics' (Hoegh-Guldberg & Bruno, 2010). Sharks, rays, skates, and sawfish belong to a subclass of Chondrichthyes called elasmobranchs (Scoch et al., 2020), or cartilaginous fish. Sharks, which as a group occupy a large portion of the apex level of the marine trophic chain, are vital to community composition and diversity—they exert top-down control on the trophic levels beneath them. When shark populations decrease, populations of organisms lower on the food chain are thrown out of balance in what is termed a 'trophic cascade' (Bornatowski et al., 2014).

The trophic cascade phenomenon is relevant because sharks are an especially vulnerable group to the effects of climate change. Reef shark populations are impacted by human population expansion and development and are highly susceptible to population depletion by fishing due to their slow growth, maturity, and reproductive rate. In the 1980s, reef shark fisheries greatly expanded in the Caribbean, drastically depleting shark populations (Ward-Paige et al., 2010). Currently, over 33% of chondrichthyan species are threatened (an increase from 24% in 2014) (Dulvy et al., 2021), and pelagic shark and ray abundance has decreased by 71% since 1970 (Pacoureau et al., 2021).

1.4. Difficulties with shark conservation and research priorities

Shark conservation is notoriously challenging due to shark behavior and the multitude of threats that impact their populations. Sharks are evasive, often nocturnal, and many species travel great distances across depth and range throughout their day and lifespan; consequently, ecology and long-term abundance trends are not well understood. Although sharks are not a global food commodity to the same extent as other fish (e.g., tuna, snappers, groupers), large markets for shark products around the globe and by-catch of sharks while fishing for other fish contributes greatly to population decline. Additionally, marine animals like sharks often migrate across international borders (Dulvy et al., 2017), making it imperative that conservation measures are agreed upon, implemented and abided by at the international level. However, transnational maritime policies are extremely difficult to carry out effectively and most efforts remain national or local (Oremus et al., 2020). Accordingly, there is a need for specific, in-depth and long-term research in marine ecosystems around the world in order to understand how and why shark populations are shifting and changing and what can be done to conserve them.

Historically, there has been a lack of emphasis on interdisciplinary conservation research. In a study evaluating research priorities of scientists in Latin America, Becerril-García et al. (2022) found that interdisciplinary research involving community perspectives on conservation and management policies was a top priority for 59% of scientists, in comparison to the 94% that voted on sustainable fisheries management as a top priority. Becerril-García et al. (2022) argue that fisheries and fisheries management should be treated as a social-ecological system,

integrating knowledge generated both by science and communities for management and policy making.

1.5. Shark ecology in Panama & the Caribbean

It is thought that reef sharks in the Caribbean may have been exposed to the earliest and most intense human-induced stressors compared to their pelagic counterparts due to proximity to human populations, coastal fishing, and coral reef degradation (Dillon et al., 2021). However, there is a critical lack of scientific research on long-term shark abundance in the Latin American Caribbean region. In one of the few existing studies, Dillon et al. (2021) used fossilized dermal denticles to construct a model of long-term changes in shark abundance near Bocas del Toro, Panama. The study found that all shark functional morphologies decreased over time, and their results suggested that sharks were three times more abundant before humans began using marine resources in the region. Chevis & Graham (2022) also conducted a study in Bocas del Toro, Panama using baited remote underwater videos (BRUVs) and visual surveys to investigate shark composition and abundance. The study found presence of nurse sharks (*Ginglymostoma cirratum*), scalloped hammerhead sharks (*Sphyrna lewini*), blacktip sharks (*Carcharhinus limbatus*), blacknose sharks (*Carcharhinus acronotus*), sharpnose sharks (*Rhizoprionodon porosus),* and Caribbean reef sharks (*Carcharhinus perezi*) (Chevis & Graham, 2022).

In the Guna Yala archipelago on Panama's eastern Caribbean coast, historical information on the long-term trends in shark abundance are unknown (Návalo et al., 2021). Despite the emergence of new information on shark species composition in the Bocas del Toro region on Panama's western Caribbean coast (Figure 1), there may be a difference in shark species composition and abundance between Bocas del Toro and Guna Yala due to local stressors and conditions.

One of the most abundant shark species observed in the Chevis & Graham (2022) study was *Ginglymostoma cirratum*, commonly known as the nurse shark or 'gata' in Spanish. The mesopredator lives in shallow reef ecosystems and feeds on small fish and bottom-dwelling organisms like octopi and crabs (Castro, 2000). *Ginglymostoma cirratum*'s IUCN extinction risk status recently changed from 'data deficient' to 'vulnerable' (Bettcher et al., 2023). The most abundant shark species observed by Chevis & Graham (2022) was *Carcharhinus limbatus*, or the blacktip shark. The species tends to live in shallow coral and seagrass systems and has been shown to require large habitat ranges for nurseries in proximity to reef communities, highlighting the need for habitat connectivity (Legare et al., 2018) between marine ecosystems. An exciting observation made by Chevis & Graham (2022) is *Sphyrna lewini*, the scalloped hammerhead. In addition to general climate change stressors, hammerhead shark populations are one of the most heavily exploited species by shark fisheries—current hammerhead population densities are thought to be very low. Observation of the scalloped hammerhead is also interesting because this species is thought to inhabit more subtropical-to-temperate waters rather than tropical (Gallagher & Klimley, 2018). The standardized and official recording of these species is extremely valuable information for understanding shark species composition and abundance off of Panama's Caribbean coast.

Figure 1. Distance between Bocas del Toro (left highlighted region) and Guna Yala (right highlighted region) provinces (Solano, 2016).

1.6. Guna Yala

The Guna Yala Comarca is a semi-autonomous Indigenous territory in Panamá made up of 49 communities scattered throughout the more than 400 islands that make up the San Blas archipelago and the mainland territory which expands from the Caribbean coast to the continental divide (Figure 2) (López, 2019).

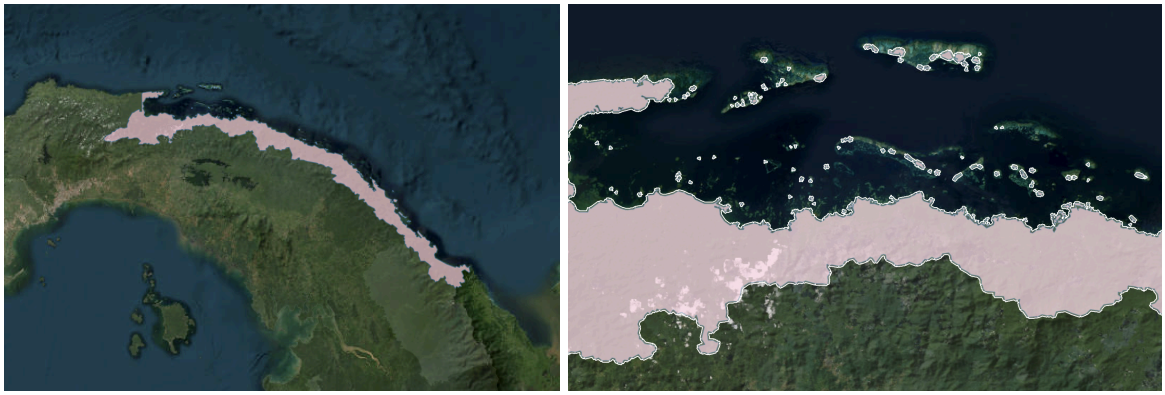

Figure 2. Guna Yala territory, highlighted in pink (Solano, 2016).

Guna Yala has been described as a 'biocultural territory' due to the high level of marine and terrestrial biodiversity that it supports and the subsistence fishing and farming lifestyle practiced in Guna communities (Apgar et al., 2015). Reefs in Guna Yala support 80% of the coral diversity of the entire Caribbean coast of Panama (Guzman et al., 2003).

Many communities in Guna Yala rely on fishing as a primary protein source and support their economy through jobs and export of seafood to other parts of Panama. Their primary products

are lobster, conch, and octopus (Harper et al., 2014). With regards to the ways in which climate change will continue to affect marine environments, it must be recognized that subsistence fishing island communities like those in Guna Yala are among the most vulnerable—already depleted fisheries are shifting away from tropical regions due to rising ocean temperatures (Oremus et al., 2020), leading to food insecurity and economic instability and threatening Indigenous livelihoods and culture (Busilacchi et al., 2013).

1.7. Local Ecological Knowledge

Local Ecological Knowledge (LEK) refers to the comprehensive understanding of an ecosystem that is often held by traditional, Indigenous, and local communities living intimately with their environment. Considered a diverse knowledge system, LEK can provide important information about an ecosystem, how it has changed over time, and what impacts those changes have had on the community. Because many of the most vulnerable ecosystems also are some of the most data-poor (Beaudreau & Levin, 2014) and therefore lack adequate baseline data for population monitoring, utilization of LEK-based methods as a proxy for scientifically-derived data has grown in popularity. The LEK method of data collection can be evaluated for validity either in combination with conventional composition and abundance survey techniques, like camera traps and line transect surveys, or through an analysis of the consistency of the information given by participants known an 'consensus analysis' (Braga‐Pereira et al., 2024). The explanation as to why this method of data collection for evaluation of species composition and abundance is not used more often may be more related to a narrow understanding held by scientists about what type of data is the "best" or the most "accurate" than in the actual quality of the information given by interview participants (Burgess et al., 2017). There are many potential situations in which LEK-based research could prove to be an effective alternative to quantitative research: situations in which past data is non-existent, in fragile ecosystems where invasive fieldwork could be particularly harmful, or when funding or resource access for a project is limited.

An LEK-based method could be a valuable tool for constructing an understanding of shark species composition and abundance and long-term trends in the Guna Yala comarca. Although there is a lack of scientific research in the region, Guna communities hold crucial knowledge surrounding long-term shark abundance and composition. Because many Guna fishermen spearfish and free dive to catch lobster and conch (Harper et al., 2014), they spend ample time in reefs and have an intimate understanding of the reef communities around the islands. Gathering data from Guna people and fishermen could help to construct an understanding of shark composition, abundance and changes over time— an important first step in developing and implementing locally-led conservation research efforts in Guna Yala.

2. RESEARCH QUESTION

What are community perspectives on shark abundance and ecosystem and cultural importance in Wichubwala, Nalunega, and Porvenir, Guna Yala, and could Local Ecological Knowledge in Guna Yala be an opportunity for understanding long-term changes in shark abundance in the Guna Yala archipelago?

3. Materials and methodology

3.1. Study site

Data for this study was collected on three islands in western Guna Yala: Wichubwala, Nalunega, and Porvenir, Guna Yala (Figure 3). Wichubwala and Nalunega are distinct communities with general populations, leaders and lawmakers. Porvenir is the island on which the Guna General Congress is located. There is no distinct community living on Porvenir, but government officials and Panamanian border police live on the island and it is frequented by Guna individuals for Congress-related matters and by those working in the tourism sector. The islands are near a mainland peninsula, but are about an hour-long boat ride from the port that connects to the only paved road in Guna Yala.

Figure 3. Project study site. 3A: Guna Yala comarca, highlighted in pink. 3B: Islands on which interviews were conducted. Source: Solano (2016)

3.2. Interview methodology

Data was collected using a semi-structured interview technique. Participants were identified with the help of the Hotel Porvenir manager who talked to Guna individuals on Porvenir, Wichubwala, and Nalunega, briefly explained the theme of the project, and asked if they were interested in participating. The 5 individuals who requested compensation were paid $5-10. Interviews were conducted in Spanish using a semi-structured method (Adams, 2015) in which a predetermined list of questions, 3 yes/no, 2 open-ended, were posed to the participant. The types of questions differed depending on the participant (e.g., fishermen were asked about typical

shark sightings, conditions, and species, while non-fishermen were only asked opinion-based questions) (Appendix I), but all participants were asked the same 5 central questions. Each interview lasted 10-15 minutes. Each interview began with a short introduction and an explanation of the research intentions (Appendix II), and a consent form was read to each participant. If verbal consent was obtained, the interview was conducted.

Fifteen individuals were interviewed over the course of 14 days in April 2024, including 3 spearfishermen who free dive to catch fish and invertebrates from Nalunega, 5 people working in the tourism industry from Wichubwala, Nalunega, and another unspecified community, 3 people involved in the Guna General Congress from Wichubwala and Nalunega, 2 women from Wichubwala, and 3 Panamanian border police officers stationed on Island Porvenir. Thirteen of the 15 participants consented to audio recordings, which were used to maximize comprehension of the responses given and improve data quality (Rutakumwa et al., 2020). Notes were taken during the two interviews in which permission to record was not granted. The interviews were transcribed from the audio recordings into writing in Spanish and then translated from Spanish to English. Responses for yes/no questions were calculated as the percentage of respondents that said yes as a method of consensus analysis (Braga‐Pereira et al., 2024), and responses to open-ended questions were categorized into general themes using a coding technique in order to parse out the strongest themes among responses (Clarke & Braun, 2016).

4. Ethics

This project has ethical implications because it involved interviewing people. There was a potential to make people feel vulnerable in their sharing of culture and personal feelings. However, no questions were asked that could pose a foreseeable risk to anyone—no one will face legal or social implications from sharing observations of and feelings about sharks.

The International Review Board (IRB) is a committee that works to ensure the safety and privacy of interview participants in research. It is important to thoroughly complete their application process in order to make sure you are thinking about the people who you will be interacting with to ensure that their safety and privacy is at the forefront of your mind during data collection. Interviews were only carried out after approval was granted by the International Review Board.

The interviews were completely anonymous with no names or descriptive characteristics recorded in order to ensure that nothing someone shared with me will ever put them at risk. There are no photos or identifying media other than voice recordings, which were only heard by me and then deleted after data analysis. Before conducting every interview, an informed consent form was read to ensure the individual understood the objectives and intention of the research, allowing people to make an informed decision about whether or not they wanted to participate; an interview was only conducted if verbal consent was clearly obtained. Permission to take an audio recording of the interview was asked of each participant and recordings were only taken if permission was granted.

5. Results

5.1. Perceived species composition and abundance

Throughout the interviews, 9 types of sharks were mentioned by their common name as having been observed in the waters around and near the comarca, including species from six families and at least twelve genera. Nurse sharks (gata) (Figure 4b) of the family Ginglymostomatidae and genera *Ginglymostoma*, *Nebrius*, and *Pseudoginglymostoma* were mentioned six times[1, 2, 8, 9, 14, 15]. Dogfish sharks (cazón) (Figure 4h) of the family Squalidae and genus *Squalus* were mentioned three times[1, 2, 12]. Tiger sharks (tigre) (Figure 4c) of the family Carcharhinidae and genus *Galeocerdo* were mentioned three times[1, 8, 9]. Blue sharks (tintorera) (Figure 4a) of the family Carcharhinidae and genus *Prionace* were mentioned three times[1, 8, 9]. Whale sharks (ballena) (Figure 4d), of the family Rhincodontidae and genus *Rhincodon*, were mentioned twice[8, 9]. Bull sharks (toro) (Figure 4e), of the family Carcharhinidae and genus *Carcharhinus* were mentioned twice[8, 9]. Lemon sharks (limón) (Figure 4f) of the family Carcharhinidae and genus *Negaprion* were mentioned twice[8, 9]. Hammerhead sharks (martillo) (Figure 4g) of the family Sphyrnidae and genera *Sphyrna* and *Eusphyra* were mentioned twice[2, 14]. Mako sharks (mako) (Figure 4i) of the family Lamnidae and genus *Isurus* were mentioned once[1] (Table 1).

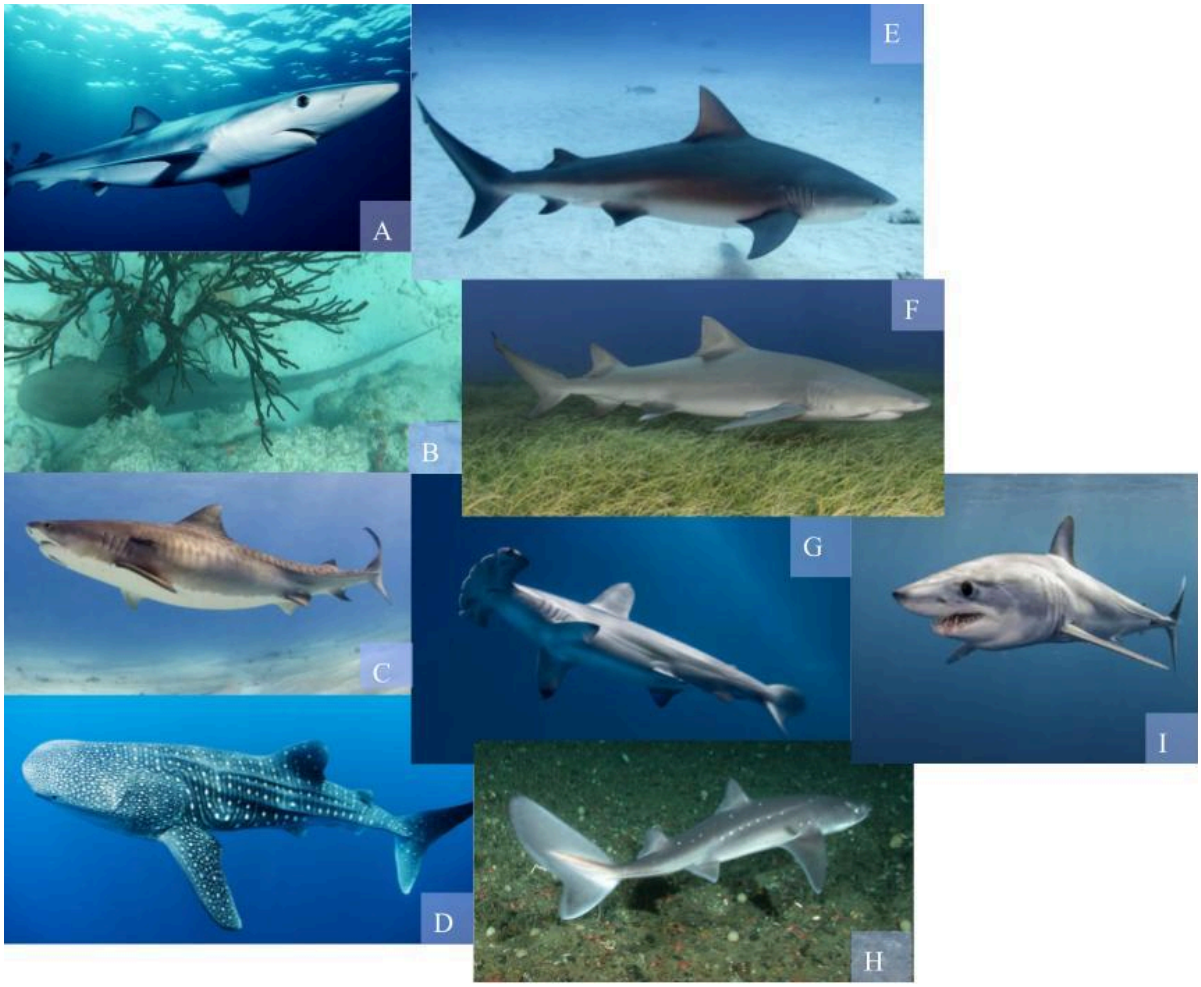

Figure 4. Examples of shark types mentioned in interviews. A: Blue shark (Conlin, 2018). B: Nurse shark (Porter, 2024). C: Tiger shark (Kok, 2012). D: Whale shark (The Excellence Collection, 2024). E: Bull shark (Snyder, 2018). F. Lemon shark (Murch, 2024). G: Scalloped hammerhead shark (Massey, 2023). H: Spiny dogfish (National Ocean Service, 2024). I: Short-finned mako shark (Getty, 2021).

Table 1. Mentions of shark common name type in interviews. Italicized words represent Spanish names used by participants.

Shark type (common name)	Number of times mentioned
Nurse shark / *gata*	6
Dogfish shark / *cazón*	3
Tiger shark / *tigre*	3
Blue shark / *tintorera o tinto*	3
Whale shark / *ballena*	2
Bull shark / *toro*	2
Lemon shark / *limón*	2
Hammerhead shark / *martillo*	2
Mako shark / *mako*	1

5.2. Perceived ecosystem roles

All participants (n=15) were asked if they thought sharks are important to ocean health, and 93% answered yes: 100% of divers (n=3)[1, 8, 9] and 92% of non-divers (n=11)[2, 3, 4, 5, 6, 7, 10, 11, 12, 13, 15] (Table 2). Non-diver C talked about how sharks maintain and control the biodiversity of the sea, "like the tiger in the mountains." Diver A said that where there are sharks, there are more fish; divers B & C shared that, "they help us…they eat the big fish that eat our fish and care for all of the animals". Diver B shared that *nali sagwet* means "care for the sharks" in Guna. A few participants said that they are important because God put all animals on the earth, so all animals are important[6, 10]. Others[1, 6, 15] were not sure exactly how they were important in the ecosystem, but did think that they were in some way.

Non-diver K responded that they are not important because they do not directly provide for the communities in any way; they cannot be eaten or sold.

5.3. Perceived long term changes in abundance

Seven of the 15 participants[1, 2, 3, 4, 6, 8, 9] (47%) were asked if they have observed or heard of any change in the abundance of sharks over the year. Five out of the 7 (71%) said that they've observed or heard from older generations that there are less sharks now than there were in the past[1, 2, 3, 8, 9] (Table 2). Non-diver B shared that, "when I was young, if you put a fish carcass in the water, 10 sharks would come; now, one might come if you're lucky." They also shared that about forty years ago the shark fin market reached the comarca and people started to hunt sharks. Although Guna people did not consume shark meat, there was money to be made from the fins; they would cut off their fins, throw the shark back in the water to die, and ship the fins away to wherever there was demand. In response to the observed drastic shark population decline, the

Guna Congress banned the hunting of sharks. Non-diver E said that their grandparents used to talk about all of the different types of sharks they used to see, but they never see them anymore.

Twenty-nine percent of interviewees said that they have not observed or heard of any change[4, 6]. Non-diver C said although sharks have declined in other parts of the world, in the comarca, there has been no change in abundance because they are a respected species and they are not hunted or eaten.

5.4. Cultural significance

All 15 participants were asked if sharks were important in Guna culture in any way. Seven out of 15 (47%) said yes; 100% of the divers[1, 8, 9] and 33% of the non-divers[2, 3, 4, 6] (Table 2). Those who elaborated on why they were significant noted that they symbolize strength[2, 4]. Non-diver B shared that, "they are important to those who understand them." Diver C noted that sharks are important to divers because they spend a lot of time around them and know that they help support the fish that they catch. Two of the participants (13%) mentioned that they do not eat shark meat out of respect[4, 14], and non-diver E shared that there is a stigma against eating shark meat because the cultural belief is that if a person eats shark meat, they will become "bad and aggressive like the shark."

Eight out of 12 (67%) of the non-divers responded 'no' to the question of cultural importance. Non-diver L noted that they thought sharks might only be important to divers and fishermen who "know them well." Non-divers F and G both shared they are important to tourism, but not directly important to culture.

5.5. Personal perspectives

The first question asked of every participant was, "How do you feel about sharks?"; 40% noted that the sharks around Guna Yala are not particularly ferocious or dangerous[3, 5, 6, 10, 14, 15]. Three participants (20%) said that sharks are only dangerous to the fishermen who are in the water with them while they are fishing[2, 3, 6]. Non-diver B said the only accidents that happen are when divers are hunting with harpoons. Divers B and C corroborated that they do not always see sharks when they are lobster fishing, which does not involve spearing the animal underwater, but when they are spearfishing, there are always sharks. The sharks are attracted by the blood in the water, and this is when accidents can happen. Four participants (27%) said that the name strikes fear and that the movies make them fear sharks[6, 11, 12, 13]. Non-divers G and L mentioned that there are other animals that are more dangerous than sharks, including crocodiles and stingrays, said non-diver L. Non-diver A said, "they don't want to eat us, but sometimes they can't tell the difference between humans and fish."

Of the 15 participants asked, 47% said that they were scared of sharks; 0% of divers and 58% of non-divers[6, 7, 10, 11, 12, 13, 14] (Table 2). All participants were also asked how they thought the majority of people in the community felt about sharks. Ten out of 15 people (67%) said that they think many people in the community fear sharks[1, 3, 5, 6, 7, 10, 11, 12, 13, 14] (Table 2). In the words of non-diver F, "everyone is scared of them". Non-diver D said that some people do not understand that the sharks here are not dangerous, so they try to kill them out of fear.

All of the divers said that they were not scared of sharks. Diver A shared that "they don't want to hurt us, they just want to eat fish. I have spent a lot of time in the water with them, and almost nothing ever happens." Divers B and C said that usually the sharks they see are "good" and do not bother them, but if a "bad" one comes, they will kill it to protect themselves. Non-diver C said that they are not scared of sharks because "they command the sea like we command the earth. In their sea, I have no power over them."

Table 2. Percentages for responses to yes/no questions. Values reflect the percentage of participants who responded 'yes'. Percentages are rounded to the nearest whole number.

	Important to ocean health?	Long-term changes in abundance?	Important to culture?	Fear of sharks?	Do others in the community fear sharks?
Overall	93% yes	71% yes	47% yes	47% yes	67% yes
Divers	100% yes	100% yes	100% yes	0% yes	100% yes
Non-divers	92% yes	50% yes	33% yes	58% yes	58% yes

6. Discussion

6.1. Intersections of local knowledge and past research

The interview responses in this study are interesting to compare with the results of the study by Chevis & Graham (2022), which found 7 shark species in Bocas del Toro, Panama. In this study in Guna Yala, 9 types of sharks in 6 families, within which are at least 12 genera, were mentioned to have been observed in the waters near the comarca. Participants talked about shark species that were not observed in the Chevis & Graham (2022) paper, including bull sharks, tiger sharks, lemon sharks, whale sharks, and dogfish. At the same time, some species observed in Chevis & Graham's (2022) study were also mentioned in the interviews, including nurse sharks and hammerhead sharks. Something mentioned by many participants was that spearfishermen often see sharks because they are spearing fish in the water, which attracts sharks. The visual transect surveys conducted in Chevis & Graham (2022) lacked this element of "chumming" the water, so it is logical that they observed less species than are seen by Guna fishermen. To be clear, the Chevis & Graham (2022) study used a standardized survey technique conducted by professionals trained in shark species identification. Additionally, the shark types mentioned in the interview responses were recollections of lifelong observations, while the transect study was conducted for a short period of time. Even so, the results from this research point to the value of local knowledge of and experience with sharks. The potential for communities to inform and create research and conservation is boundless, especially in the case of the Guna, whose livelihoods are intimately connected to the ocean and who are endowed with a deep and comprehensive understanding of marine life.

Interview responses also generally aligned with the study by Dillon et al. (2021). Dillon et al. (2021) found that shark abundance has greatly declined since the arrival of human fishing pressures in the coastal waters of Bocas del Toro. Although interview responses referred to

changes within the participants' lifetimes, the majority of participants responded that shark abundance has decreased over time. There is deficient research on the long-term trends in shark abundance on the Caribbean side of Panama, but interview responses align with past research illustrating that shark populations on the Pacific side of Panama have declined over time. Specifically, hammerhead shark populations have declined dramatically in recent years due to fishing pressures (Harper et al., 2014), which makes the mention of hammerhead shark observations by two interview participants a hopeful insight.

6.2. Intersections of personal sentiments and understandings of ecosystem roles

The relationship between the depth of knowledge and lived experience of individuals and their personal perspectives and sentiments of sharks was apparent through the interviews. Those who had spent more time in the ocean interacting with marine ecosystems were more likely to talk about the ecological value of sharks as apex predators, while those who lacked regular encounters with sharks were more likely to say they were scared of sharks and that everyone else was scared of them as well. However, an important distinction can be made between the mainstream narratives surrounding sharks in places where the marine environment is central to ways of life versus places where people have less direct interactions with sharks—the media-driven negative image of sharks that many people have is one of the most significant barriers to conservation strategy implementation (Giovos et al., 2021). When the majority of a person's understanding of sharks comes from the media, which tends to be a negative portrayal, that person is more likely to fear sharks and view them as a threat to humans, and less likely to support conservation efforts (Casola et al., 2022). It is clear from the interview responses that those who were interviewed understand the importance of sharks in the ecosystem, regardless of whether or not they fear them. It is this very relationship between lived experience and the ability to recognize the impact of change on ecosystem interactions that makes LEK an invaluable asset for assessing and addressing conservation issues.

6.3. Potential for Guna ecological knowledge as a conservation tool

Guna Yala is a prime location for integrating LEK in marine biodiversity conservation. Because Guna Yala is a marine biodiversity hotspot (Guzman et al., 2003), sufficient scientific research in the area does not exist, and many of the communities rely on marine life for food, construction, and spiritual resources, there is both a wealth of comprehensive ecological knowledge within communities and a motivation and advantage for Guna communities to engage in research efforts. The alignment of the high consensus interview responses with published scientific research suggests that LEK could be an effective tool for identifying and addressing conservation issues in the region. Approaching conservation research from a local perspective is imperative in order to do the most relevant and valuable work because local communities hold a much more comprehensive and nuanced understanding than do outside scientists of where research and conservation efforts are most needed (Sobral et al., 2017). Shark conservation efforts would be of value to Guna communities because sharks are of value to Guna communities—whether that be via culture, income, support of fish stocks, or biodiversity maintenance.

López-Angarita et al. (2021) found that Marine Protected Areas (MPAs) and responsible fishing zones cover 48% of shark nursery habitats on the Pacific coast of Panama, meaning that the

practice of sustainable marine resource use supports juvenile shark populations. This could be an explanation for why perceived shark abundance and species composition in Guna Yala is higher than in the study by Chevis & Graham (2022). The fishing in Guna Yala is predominately subsistence fishing, which are typically small operations that target invertebrates and smaller coastal fish; the Bocas del Toro region has been subject to a higher degree of industrial pelagic fishing, which results in shark bycatch and threatens shark populations (Harper et al., 2014). It makes sense that regions in which livelihood is directly dependent on environmental health are more aware of how their behavior impacts the environment, and thus are more likely to practice sustainable methods of resource extraction.

6.4. The nature of culture

There is very little scholarly research discussing the cultural importance of sharks in societies anywhere in the world, and none exists in Latin America. It is likely that this deficit is due to the often private and sacred nature of cultures, making them difficult to study ethically and respectfully. Culture is hard to quantify and simplify—there are no standards, no formulas, and no "rights" or "wrongs". Culture differs by country, by community, and even by individual identity, as seen in the interview responses of this study. Interpretations of the question of whether sharks are important in Guna culture depended on each individual's concept of culture and assumption of what the interviewer (I) meant by the term 'culture'. Some individuals passionately talked about the importance of sharks in their culture—a symbol of strength and power and a species of great respect for the Guna people. Others quickly answered that they are not significant to the culture in any way. The intersections of sharks and culture are interesting and still are not well understood in Guna Yala.

6.5. Limitations

The comparison of perceived shark species and composition to scientific surveys requires an understanding of context and nuance due to the possibility of human error. It is possible that shark species were misidentified by individuals and that observations had been passed through multiple individuals, making misinformation possible. This means the comparisons made to past studies in section 6.1 are not unequivocal. Additionally, the lack of scientific studies means that the few that exist are by no means exhaustive; qualitative data is most powerful when there is ample quantitative data for comparison.

Language may have posed a limitation to knowledge production and exchange during the interviewing process. Interpretation of information in a language that I am not fluent means that some knowledge was inevitably lost in the conversation. The translation of responses from Spanish to English also may have diluted the meaning of certain perspectives and feelings.

Sample size was small and community distribution was extremely limited due to the expansive nature of the comarca and a limited ability to travel. The results of this study are not reflective of overall Guna sentiments and perspectives, or even of those in the communities where the study was conducted. Individuals tended to be very hesitant to talk with me, and rightfully so. It is likely that this reluctance to participate resulted in a non-random sample of interview participants. Conducting this study on a larger scale could produce more definitive

results—ideally, interviewing 50 participants with at least 50% being fishermen would increase the power of the response themes and provide a more complete understanding of community-wide perspectives.

6.6. Future directions

Due to the small sample size and difficulty with participant recruitment, the results of the study are by no means conclusive. Nonetheless, the widespread understanding of the value of sharks in the ecosystem is a promising indication of the high potential for the incorporation of Local Ecological Knowledge into conservation efforts in Guna Yala. There is much future work to be done in this vein. It could be interesting to accompany Guna divers on fishing expeditions to observe what they are observing. A study could be designed based on suggestions from local fishermen who have abundant knowledge surrounding the behaviors and ecology of sharks—they know where they tend to be at what times, what they tend to be doing, how they interact with their surrounding environment, and how to coexist with them in the water. On a longer time scale, it would be interesting to combine the interview-based method with a fieldwork aspect in an effort to combine two forms of knowledge.

7. Conclusion

The results of this study reveal a high consensus among participants regarding the importance of sharks to ecosystem health and the perceived changes in shark abundance over time. Many participants said that the sharks around the island are not dangerous or aggressive; others talked about how sharks do not want to hurt humans, but many fear them because they do have the potential to cause harm. Stories were shared about experiences with sharks, personal significance, and opinions. The low consensus regarding the question of cultural importance highlights the prevalence of interpretation that is inherent in an interview-based study, especially when it is conducted in one language and translated into another. Interpreting the results of an interview-based research study is difficult, as personal opinions and observations will never fit perfectly into categories. It is important to be cognizant of the subjective nature of qualitative research when considering the takeaways of the study. At the same time, it is this very nuance of interview-based research that makes it valuable and relevant alongside empirical scientific research, providing information that cannot be learned from transect surveys. The interview responses suggest that Local Ecological Knowledge held by Guna people could be an accurate and effective way of approaching conservation work in vulnerable, biodiverse regions where past research is lacking.

The most important consideration to make when using LEK-based methods in research is that the knowledge shared by individuals should not just be taken from the community. It should be used as a framework for guiding, designing, and implementing local conservation projects. By supporting communities in conservation efforts they deem important using their experiential knowledge, some of the most pressing and neglected conservation issues could be addressed in a way that protects, supports, and celebrates local knowledge.

Works Cited

Footnotes

1. Diver A: Personal Interview, April 8, 2024
2. Non-diver A: Personal Interview, April 8, 2024
3. Non-diver B: Personal Interview, April 9, 2024
4. Non-diver C: Personal Interview, April 9, 2024
5. Non-diver D: Personal Interview, April 10, 2024
6. Non-diver E: Personal Interview, April 11, 2024
7. Non-diver F: Personal Interview, April 11, 2024
8. Diver B: Personal Interview, April 11, 2024
9. Diver C: Personal Interview, April 11, 2024
10. Non-diver G: Personal Interview, 14, 2024
11. Non-diver H: Personal Interview, April 15, 2024
12. Non-diver I: Personal Interview, April 15, 2024
13. Non-diver J: Personal Interview, April 15, 2024
14. Non-diver K: Personal Interview, April 17, 2024
15. Non-diver L: Personal Interview, April 18, 2024

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Appendices

Appendix I

Guía de entrevista - pescadores y buzos

- ¿Cuántas veces en un mes ve un tiburón?
- ¿Cuándo los ve, típicamente hay uno o más que uno?
- ¿Cuáles tipos de tiburones ve?
- ¿Cuál es más común?
- ¿Qué tamaño tiene típicamente?
- ¿Qué están haciendo normalmente cuando los ve?
- ¿Hay lugares donde normalmente ve muchos tiburones y otros lugares donde no ha visto tiburones?
- ¿Cómo piensa sobre los tiburones?
- ¿Los tiburones son importantes para la cultura Guna?
- ¿Cómo afectan los tiburones a los otros animales marinos?
- ¿Entonces donde hay tiburones, hay menos peces?
- ¿Piensa que los tiburones son importantes para la salud del mar?
- ¿Ha observado algún cambio en la abundancia de los tiburones a través de los años?
- ¿Tiene miedo de los tiburones?
- ¿Cómo cree que la mayoría de la gente aquí se siente sobre los tiburones?

No pescadores

- ¿Cómo piensa sobre los tiburones?
- ¿Tiene miedo de los tiburones?
- ¿Cómo cree que la mayoría de la gente aquí se siente sobre los tiburones?
- ¿Los tiburones son importantes para la cultura Guna?
- ¿Piensa que los tiburones son importantes para la salud del mar?

Interview guide - fishermen and divers

- How many times in a month do you see a shark?
- When you see a shark, is there typically one or more than one?
- Which types of sharks do you see?
- Which type is most common?
- What size are they normally?
- What are they normally doing when you see them?
- Are there places where you typically see a lot and places where you typically don't see any?
- How do you feel about sharks?
- Are sharks important in Guna culture?
- How do sharks affect other marine animals?
- Are there less fish in places where there are a lot of sharks?
- Do you think sharks are important for the health of the ocean?

- Have you observed any change in the abundance of sharks in the water over the years?
- Are you scared of sharks?
- How do you think the majority of people here feel about sharks?

Non-fishermen

- How do you feel about sharks?
- Are you scared of sharks?
- How do you think the majority of people here feel about sharks?
- Are sharks important in Guna culture?
- Do you think sharks are important for the health of the ocean?

Appendix II

Hola, mucho gusto, me llamo Kayley. Soy estudiante de un programa de intercambio aquí en Panamá, y estamos aprendiendo sobre las ciencias y el medioambiente. Soy de los Estados Unidos, y estudio la biología conservacional en mi universidad.

Me gustaría invitarle a participar en una entrevista para el estudio que estoy llevando a cabo para el proyecto final del programa. Mi proyecto se trata de las perspectivas y sentimientos comunidades aquí en Guna Yala de los tiburones. Su participación es voluntaria.

Voy a leer un poquito de información sobre mi investigación y la entrevista. Por favor haga preguntas sobre cualquier cosa que no entienda antes de decidir si quiere participar. Si decide participar, por favor déme su consentimiento verbal.

Hi, it's nice to meet you, my name is Kayley. I'm a student at an abroad program here in Panama, and we're learning about science and the environment. I'm from the United States and I study conservation biology at my university.

I would like to invite you to participate in an interview for the study that I'm carrying out for my final project of the program. My project will explore community perspectives and feelings here in Guna Yala about sharks. Your participation is voluntary.

I'm going to read a little bit of information about my research and the interview process. Please ask questions about anything that you don't understand before deciding whether you want to participate. If you decide to participate, please give me your verbal consent.