Scripps Institution of Oceanography, Center for Marine Biodiversity and Conservation

Masters of Advanced Studies Capstone Report

Tracing The Hunter: Estimating the Abundance of Vulnerable Shark Species in Wakatobi, Indonesia

by:

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Introduction

Sharks belong to the taxonomic class Chondrichthyes, or cartilaginous fishes. Even though the majority of chondrichthyans live in the sea, their distribution still covers a wide range of habitats, including freshwater riverine & lake systems, inshore estuaries & lagoons, and coastal waters out to the open sea (Cailliet et. al, 2005). Most species have a relatively restricted geographic distribution, occurring mainly along continental shelves and slopes and around islands and continents, with some smaller species being endemic to isolated regions or confined to narrow depth ranges. However, other species are distributed more broadly, having biogeographic ranges spanning ocean basins. Only a relatively small number of species are known to be genuinely wide ranging. The best studied of these are the large pelagic species, which make extensive migrations across ocean basins.

Most of the chondrichthyans are predators; however, some are also scavengers and some of the largest (whale, basking and megamouth sharks and manta rays) filter feed on plankton and small fish. However, none of these fishes are herbivorous. The predatory sharks are at, or near, the top of marine food chains (Cailliet et. al, 2005). Therefore, most shark populations are relatively small compared to those of most teleost fishes. Most shark species are opportunistic and consume a variety of food from small benthic animals such as polychaetes, molluscs, fishes and crustaceans to prey such as marine mammals including seals and cetaceans (Fowler et. al, 2005). Because many are apex predators their range can extend throughout multiple habitats in search of prey. These habitats include immediate sub tidal zone offshore

to coastal, bathyal (200-2,000 m) and even abyssal habitats (>2,000 m). Some species inhabit benthic habitats, while others are pelagic, roaming in the upper layers of the ocean. There are between 954 and 1,125 species of living elasmobranchs in at least nine major groups, representing 57 families and 182 genera (Compagno et al, 2005). It has been estimated that there are 453 species of sharks, including all described and valid species (Compagno et al, 2005). However recent efforts to identify more, poorly known, undescribed species, from remote habitats bring estimates up to about 500 (Compagno et al, 2005)

The biology of the chondrichthyan fishes is among the most poorly known and least understood of the major marine vertebrate groups (Cailliet et. al, 2005). Low research priority and difficulties in data collection for many species confound efforts to obtain biological information for many species. Furthermore, the characteristics of these cartilaginous fishes exhibit, to a greater or lesser degree: 1) low fecundity and reproductive output (small, infrequent litters); 2) Slow growth; 3) late age at maturity; 4) long gestation periods; 5) long life; and 6) high natural survivorship for all age classes (Cailliet et. al, 2005)

However, high natural survivorship is a characteristic these fishes cannot rely on in recent times due to humans increasing their reliance on marine resources. Threats posed to chondrichthyans by humans are present in almost all marine, brackish and freshwater habitats. Freshwater, estuarine and coastal species are facing threats from chemical pollution, destruction of mangrove and marsh habitat, coastal development, eutrophication and loss of nursery habitat. Coastal species have been

impacted by destructive fishing techniques such as trawling and dynamite fishing. And now with more advance fishing technologies humans have begun to exploit marine resources in remote and deep habitats, catching the majority of species that were once thought to be out of reach. It is estimated that most of commercially important pelagic sharks and rays species are experienced decline in catch rates of 50-90% because of unsustainable fishing practices (Camhi et. al, 2009). Improvements in fishing techniques have increased the efficiency of fisheries, and lead to one of the most destructive sources of mortality: bycatch, where species are not the target of specific fisheries but are caught incidentally. Many shark species are known as apex predators and serve important ecological roles within marine ecosystem. Even modest declines in their abundance can lead to extensive consequences to the ecological structure of the ecosystem and can have negative socio-economic impacts to communities dependent on marine resources (Godin and Worm, 2010).

A recent report by the International Union for the Conservation of Nature (IUCN) estimates that one-quarter of chondrichthyan fishes—sharks, rays, and chimaeras are considered threatened according to the IUCN's Red List criteria due to unsustainable fishing practices both as a targeted or incidental catch (IUCN, 2012). Large-bodied species that inhabit shallow-water are considered at the greatest risk of extinction with five out of the seven most threatened families being rays. Overall the chondrichthyan extinction risk is substantially higher than most other vertebrates, with less than one-third of the sharks, rays and skates considered non-threatened (Fig. 1 [Dulvy et al, 2014]).

Extinction Risk & Conservation of the World's Sharks & Rays

Analysis from the IUCN Shark Specialist Group, January 2014

Species Group	No. of Species Assessed under Red List™ Criteria	No. of Species Classified as Threatened*	Critically Endangered	Endangered	Vulnerable	Near Threatened	Least Concern	Data Deficient
RAYS	539	**107**	14	28	65	62	114	256
SHARKS	465	**74**	11	15	48	67	115	209
CHIMAERAS	37	0	0	0	0	3	12	22
Total Assessed	**1,041**	181	25	43	113	132	241	487

* Threatened IUCN Red List™ Categories = *Critically Endangered, Endangered* & *Vulnerable.*

Figure 1. Table of extinction risk of the world's sharks and rays (Dulvy et al, 2014)

The center of greatest chondrichthyan biodiversity lies in the Indo-West Pacific Region (as with many other fish species) with the largest area of the region overlapping with a single country, Indonesia (Fig.2). Indonesia is the largest archipelagic country in the world with 2/3 of its land area surrounded by water. Indonesia is home to more than 200 species of sharks and rays belonging to 44 families, (Allen and Erdmann, 2012). Currently, shark utilization in Indonesia tends to be for extractive use. Sharks in Indonesia are one of the most important fishing commodities and sharks are commonly found in almost every fishery in Indonesia either as target catch or bycatch. Shark fishing in this region is conducted using various types of fishing gear and most fisheries keep everything that is caught. It is also estimated that 60–70 species of sharks and rays are landed in a single geographic region (Fowler et. al, 2005). A research report in 2012 stated that 72% of sharks caught in Indonesia are considered bycatch, meaning fishermen did not

target them but retain the shark bycatch for additional income. The report also indicates that shark resources in Indonesia are decreasing 26-50% compared to conditions in early 2000 (Zainudin, 2012).

Figure 2. Map of Indonesia. Source: Google Map

Despite their importance, the sharks of Indonesia are without adequate management. This is worsened by other threats facing marine biodiversity including habitat loss and unsustainable fishing practices. A recent report by the Food and Agricultural Organization (FAO) identified Indonesia as having the greatest catches in shark species (FAO 2010). As a result, there is an urgent need to improve and develop responsible sharks management and recovery plans for Indonesia. To date, there have been limited thorough shark population assessments completed. The lack of shark data in Indonesia has resulted in the lack of policies and subsequent management practices of these cartilaginous fishes. Hence, there is more shark research that still needs to be conducted. To ensure that management practices are

initiated in place, there should be strong scientific research that identifies catch or observational data along with increased management efforts. The goal of this project is to conduct a preliminary assessment on the shark species encountered in a small region of Indonesia (Wakatobi), known to have active fisheries and recreational dive operations. To reach this goal this project set out to gather information from members of the local community who have the greatest probability of encountering shark species during their daily activities. Additionally, this project provides baseline data for the Wakatobi region and contributes towards the development of sustainable and responsible shark management in Indonesia.

Methods

Study Region: Wakatobi National Park

Wakatobi region is located in the southeastern part of Sulawesi Island, Indonesia (Fig. 2). Wakatobi is an acronym for the 4 biggest islands in the region: Wangi-wangi, Kaledupa, Tomia and Binongko. Although this region actually consist of 39 islands surrounded by fringing & barrier reefs and several offshore atolls. In 1996, the government of the Republic Indonesia through Ministry of Forestry (MoF) declared Wakatobi as a Marine National Park, protecting 13,900KM^2 of the islands and surrounding waters (Fig.2). It was designated as a Marine Protected Area in an effort to protect the high biodiversity inhabiting coral reef ecosystems and halt destructive fishing activities (Elliott et al., 2001). A Rapid Ecological Assessment by WWF Indonesia in 2004 observed over 942 fish species in these highly diverse coral

reef ecosystems. The waters surrounding Wakatobi region also serve as an important migratory corridor for charismatic marine species such as sea turtles, sharks and whales (Pet-Soede & Erdmann 2004).

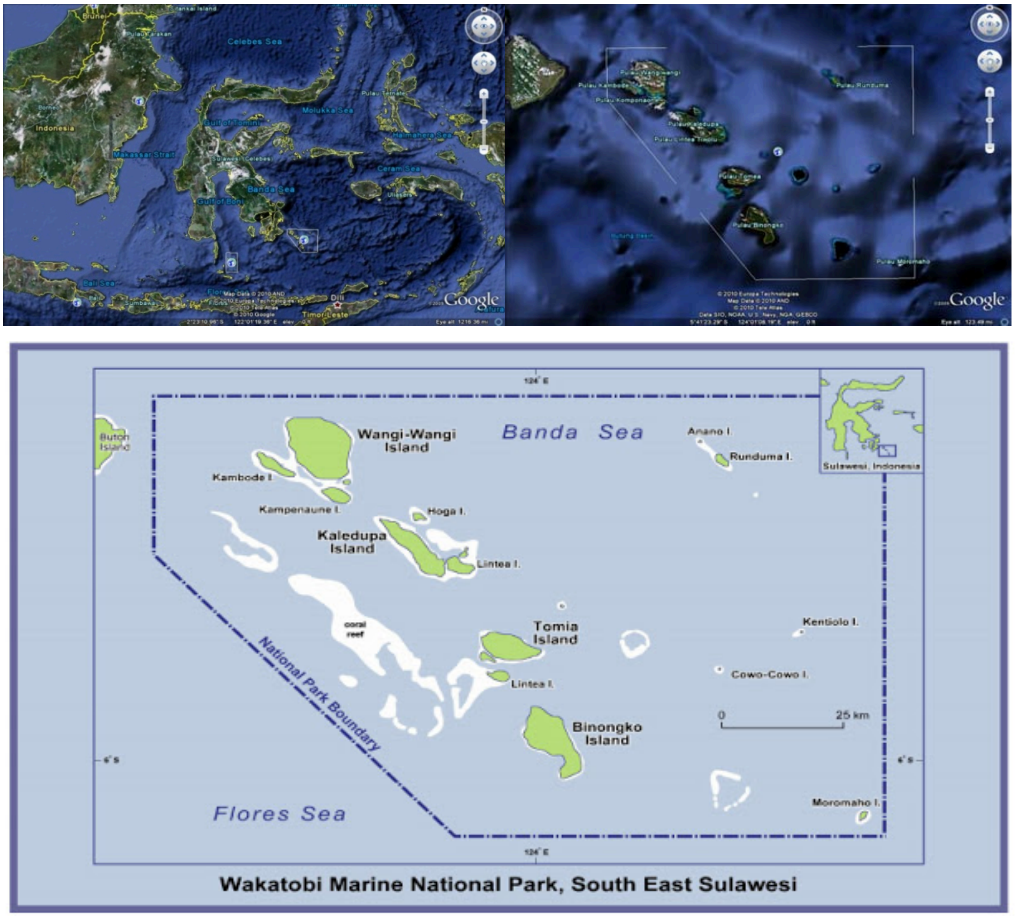

Figure 3. Wakotobi Position in Indonesia and Border of Wakatobi Regency

Wakatobi is located in the middle two ecological regions, the Sundaland ecoregion, which is comprised (biogeographically) of mainland Asian species and the New Guinean ecoregion, which is comprised of Australian species (Olson and Dinerstein 1998). The Wakatobi region is geographically located in this middle region known as the Wallacea ecoregion and shares species (flora and fauna) from Asian and

Australia. As such, it is considered to be a biodiversity hotspot containing the highest species richness known on earth. Additionally, this region also boasts high rates of endemism due to the number of islands and diverse habitats (Veron *et al*. 2009). This high level of species richness extends beyond the shores and into the sea where the marine species assemblages represent a mixture of both Pacific and Indian Ocean species (Veron *et al*. 2009). This area is referred to as the "Coral Triangle region" (Fig.4) with high biodiversity that provides a number of ecosystem services including coastal protection (Hoegh-Guldberg *et al*. 2009; Veron *et al*. 2009). Inhabitants to the region are directly dependant on the these natural marine resources for their livelihoods and well-being (Hoegh-Guldberg *et al*. 2009; Worm *et al*. 2006). The majority of these communities also base their traditions, cultures, and social structure on their relationship with the sea (Hoegh- Guldberg *et al*. 2009; Worm *et al*. 2006). There are 2 major ethnic groups in Waktobi, the Buton and Bajau people. The Buton are known as land people, while Bajau is an indigenous ethnic group of Southeast Asia who predominantly live a seaborne lifestyle residing in coastal areas of Wakatobi. Bajau people are also known as the Sea Gypsies, frequently dispersing around the islands of Indonesia, Malaysia, and the Philippines.

Data Collection

In order to conduct a preliminary assessment of shark populations in Wakatobi, a series of interviews were conducted with 2 different groups directly dependent on the marine resources of the region: fishermen and dive guides. Interviews with these two different groups were undertaken in order to acquire information about

locations of shark sightings or fisheries catch during their daily activities. Efforts were made during the interview process to ask straight-forward and unbiased questions using a questionnaire (Appendix I) focused on identifying location of activity, species targeted/observed, abundance (e.g. number of sharks), and the respondent's perception or knowledge of existing management of sharks in Wakatobi.

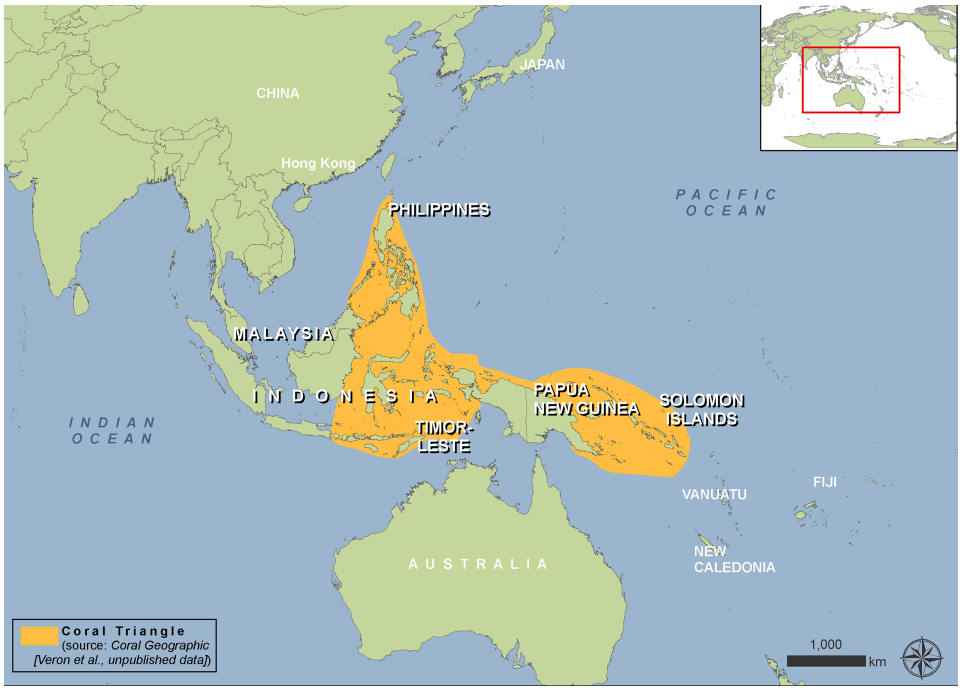

Figure 4. Coral Triangle Region.
(http://assets.panda.org/downloads/coraltrianglebasemap_3000px.gif)

Additionally, in order to assist in the identification of shark species observed, respondents were shown photos of 17 common shark species to the region (Appendix II). The list was created using several factors, such as: the status of the shark (IUCN Red-Listed, CITES appendix list, or Regional Fisheries Management

Organization (RFMO) species of concern), known to be a highly targeted commodity in fisheries, and known as a "wanted species" by dive tour operators (Table 1).

Table 1. Species of Sharks that asked during the Interview

Species	**Remarks**
Sphyrna spp (Hammerhead Sharks) Smooth Hammerhead Scalloped Hammerhead Great Hammerhead	IUCN Status: Vulnerable- Endangered, CITES List Appendix II, RFMO species of Concern
Alopias spp (Thresher Sharks) Pelagic Thresher Shark Bigeye Thresher Shark	IUCN Status: Vulnerable, RFMO species of Concern
Prionace spp (Blue Shark)	IUCN Status: Near Threatened
Isurus spp (Mako Shark) Longfin Mako Shortfin Mako	IUCN Status: Vulnerable, RFMO species of Concern
Carcharhinidae spp Sandbar Shark	IUCN Status: Vulnerable, Near Threatened, *CITES List Appendix II, RFMO species of Concern

Bull Shark Silky Shark Dusky Shark Oceanic White Tip Shark*	
Carcharhinus melanopterus (Blacktip reef shark)	IUCN Status: Near Threatened
Triaenodon obseus (Whitetip reef shark)	IUCN Status: Near Threatened
Galeocerdo cuvier (Tiger Shark)	IUCN Status: Near Threatened
Rhincodon typus (Whale Shark)	IUCN Status: Vulnerable, CITES List Appendix II, RFMO Species of Concern

However, a complete identification guide of shark species was also used if it was needed during the interview. Princeton Field Guide, "Sharks of The World" by Compagno et. al, 2005 were used as a complete identification guide. In regards to obtaining the current data about shark encounters, the initial question started with "when was the last time you caught or saw sharks?" and then gradually decreasing the time starting from the last year, last 2 years and the last time that the respondent can remember when he saw or caught sharks.

A map of the Wakatobi region was also used to get more detailed information from respondents to determine the location/s where sharks were observed or captured.

Each respondent was given one map as a tool to help him or her point the location where they saw or caught sharks in the last 12 months. Respondents were also asked questions that sought to assess their knowledge of issues related to shark conservation and management in Wakatobi. Lastly, interviews were conducted with NGO and National Park representatives to gather other relevant information pertaining to shark fisheries management.

This field study was conducted from April 25 to May 7, 2014 and took place at 3 of the larger islands in the Wakatobi region: Wangi-Wangi, Kaledupa and Tomia. Fishermen interviews were conducted in two major fishing villages: Mola village in Wangi-wangi and Sama Bahari in Kaledupa where the Bajau tribe is the primary residents of these two villages. Even though Indonesia has Bahasa Indonesia as its national language, the Bajau tribe speaks different language. As such, local guides from the bajau people provided assistance in translating questions and answers. These translators were especially important when trying to identify shark species observed or caught. Furthermore, interviews with dive guides were conducted in Wangi-wangi Hoga (part of Kaledupa district) and at Tomia island.

Results

A total of 50 fishermen and 21 dive guides were interviewed during the survey period. Most of the respondents had a long history and vast experience within their occupation. 77% of the respondent possessed more than 10 years of work experience. As a result, they had vast knowledge of their trade and were able to provide a more complete history about coastal development and fisheries activities.

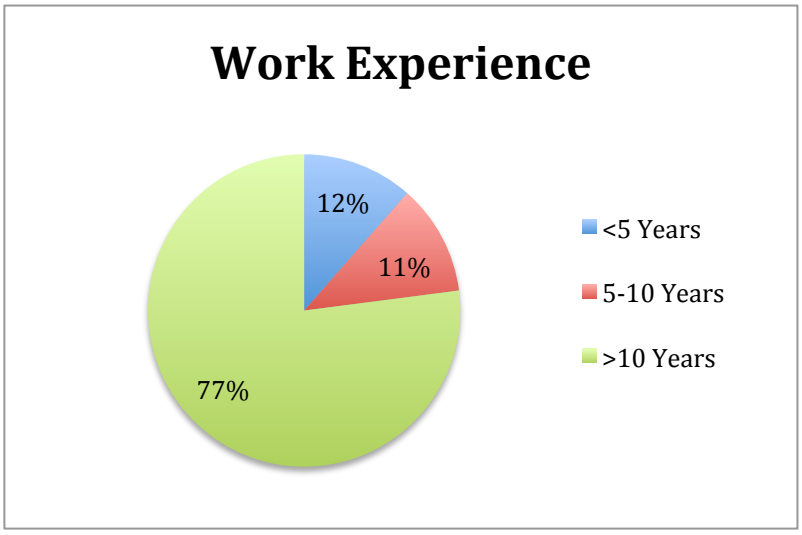

Figure 5. Chart of respondents' working experience

Responses to questions relating to shark abundance were similar among respondents. Based on the responses from the questionnaire shark fishing in the Wakatobi region began in the late 1970s and reached its peak in the late 1980s to mid 1990s. The interview result showed the oldest records of shark catch by the fishermen group was in 1987- 1988 where the fishermen caught hammerhead sharks (*Sphyrnidae*) and reef sharks (*Carcharhinidae*). In the late 1990s shark catch began to decline due to overfishing and resulted in fishermen traveling from Wakatobi to other more productive fishing grounds. This resulted in fishermen traveling great distances and exploiting sharks in Australian waters. This required fishermen to utilize mid-size vessels containing 4-5 people, traveled almost 800 KM to reach these fishing grounds. The trip required these mid-range vessels to travel to Australia through Banda Sea then past the East Nusa Tenggara. The final stop was made at Rote Island to re-fuel and re-supply before finally crossing the Timor Sea to Australian waters. However, after intensive patrol from the Australian authorities

and the rising price of the fuel in the mid 2000s led to a reduction in the number of boats making this crossing. Most of the fishermen interviewed in this project use handline as their fishing method (gear type) and primarily target tuna species (Scombridae). There are few fishermen that still target sharks primarily and typically use longline methods as well as some hand line methods but less common. Fishermen targeting sharks also used additional device called “goro-goro”, which is made from bamboo and coconut shell. This device is used to attract sharks by splashing it in the water after setting bait. The combination of bait and knocking sounds from the goro-goro prove to be an irresistible combination. Fishermen generally fished in the Waktobi region making day trips to the fishing grounds. However, some fishermen made multi-day trips with the longest trip around 3-4 days if they feel their catch is still not enough to cover the operational cost. Fishermen typically departed for fishing grounds in the evening (6-7 PM) and returned to their homeport in the morning (5-6 AM). Since the re-zonation in 2007, most of Wakatobi water is allocated as “local use zone”. Meaning it is intended for only fishermen come from inside Wakatobi, area (Appendix III).

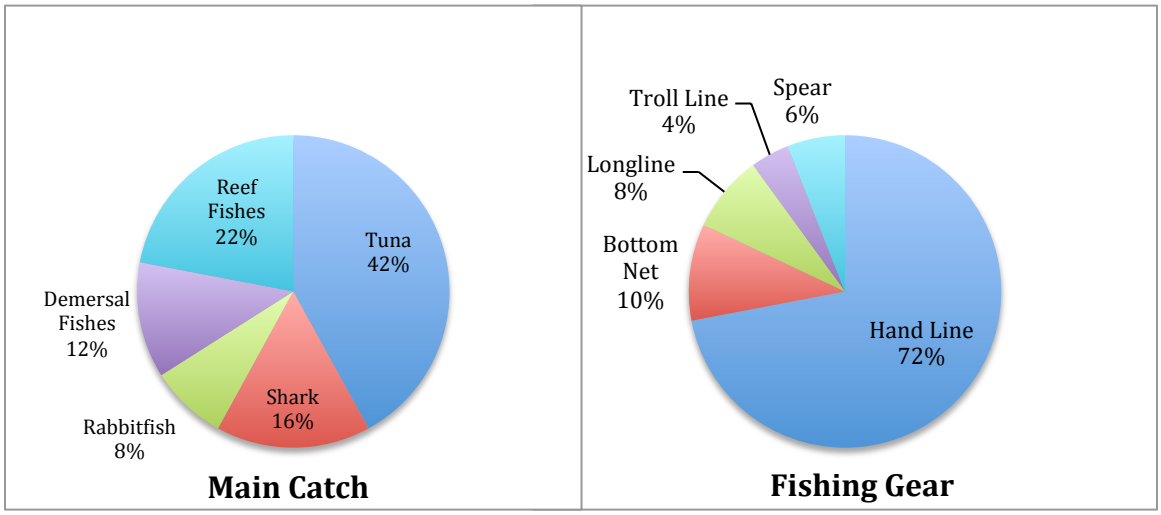

Figure 6. Chart of Main Target Catch and Fishing Gear

Among respondents in the fishermen group, only 1 respondent said he never targeted or caught sharks and his primary targets were squid using hand line. The most common species caught based on the interview was hammerhead sharks (Sphyrnidae). All sharks in the list below have been caught in the Waktobi region over the course of the last year (2013-2014 [Table 2]).

Table 2. Sharks species that caught in Wakatobi

Species	Frequentl y Caught	Location	Year	Number of Fishermen
Sphyrna spp (Hammerhead Sharks)	29	a. Wangi-Wangi: Kapota, Patuno, Bira, Sombu, b. Kaledupa: Hoga c. Tomia: Lentea d. Binongko e. Other island: Koromaha, Karang Koka, Kentiole, Moromaho, Runduma	1987, 1999, 2000, 2001, 2002, 2008, 2009, 2010, 2012, 2013, 2014	27
Carcharhinidae (Sandbar, Bull, Silky, Dusky, Oceanic White	27	a. Wangi-Wangi: Kapota, Waha, Karang Gurita b. Kaledupa: Hoga	1988, 1999, 2001, 2007,	19

Tip Sharks)		c. Tomia d. Other island: Ndaa, Koromaha, Karang Koka, Kentiole, Moromaho, Runduma, Sombano	2008, 2009, 2012, 2013, 2014	
Carcharhinus melanopterus (Blacktip reef shark)	20	a. Wangi-Wangi: Karang Kapota, Patuno b. Kaledupa: Hoga, Karang Kaledupa c. Tomia: Lentea d. Other island: Kentiole, Runduma, Moromaho, Cowo-cowo,	2002, 2009, 2011, 2012, 2013, 2014	16
Alopias spp (Thresher Sharks)	13	a. Wangi-Wangi: Karang Kapota, Rumpon Wandoka b. Kaledupa: Hoga, Karang Kaledupa c. Other island: Runduma, Sombano	2000, 2011, 2012, 2013, 2014	22
Triaenodon obseus (Whitetip reef shark)	11	a. Wangi-Wangi: Karang Kapota b. Kaledupa: Hoga, Karang Kaledupa c. Tomia: Lentea d. Other island: Runduma	2000, 2010, 2012, 2013, 2014	11
Galeocerdo cuvier (Tiger Shark)	8	a. Wangi-Wangi: Karang Kapota, Waha b. Kaledupa: Karang Kaledupa c. Tomia: Lentea	2000, 2008, 2013, 2014	8
Prionace spp (Blue Shark)	7	a. Wangi-Wangi: Karang Kapota b. Kaledupa: Hoga c. Other island: Runduma	1988, 1999, 2000, 2004, 2014	7
Isurus spp (Mako Shark)	5	a. Wangi-Wangi: Kapota, Kampenaune	2013	5

		b. Kaledupa: Hoga		
Rhincodon typus (Whale Shark)*	6	a. Wangi–wangi: Wandoka, b. Kaledupa: Hoga, Sampela	2010, 2012, 2013, 2014	6
Other Sharks and Rays (*Scyliorhinidae, Rhynchobatidae , Squalidae*)	8	a. Wangi-Wangi: Kapota b. Kaledupa: Hoga, Karang Kaledupa c. Binongko d. Other island: Koromaha	2010, 2013, 2014	7

*Sighted Whale Sharks. Fishermen in this interview didn't make whale shark as target catch

Interviews conducted with stakeholders from the dive industry showed that all respondents (dive guides) had observed sharks underwater. The most frequently observed species was the Blacktip reef shark (*Carcharhinus melanopterus*). Table 2 identifies all shark species observed in the Wakatobi region over the past year.

Table 3. Sharks species that observed in the Wakatobi region

Species	FrequentSeen	Location	Year	Number of Divers
Carcharhinus melanopterus (Blacktip reef shark)	34	a. Wangi-Wangi: Kapota, Patuno, Bira, Sombu, Nua, Waha, Karang Gurita, Sumanga, Kampenaune b. Kaledupa: Hoga c. Tomia d. Other island: Ndaa, Kentiole, Anano	2005, 2007, 2011, 2012, 2013, 2014	16
Triaenodon obseus (Whitetip reef	16	a. Wangi-Wangi: Nua, Karang Gurita, Kampenaune	2003, 2004, 2008, 2009,	14

shark)		b. Kaledupa: Hoga c. Tomia d. Other island: Karang Koko	2010, 2012, 2013, 2014	
Sphyrna spp (Hammerhead Sharks)	9	a. Wangi-Wangi: Patuno b. Kaledupa: Hoga c. Other island: Ndaa, Karang Runduma	2003, 2005, 2010, 2012, 2013, 2014	8
Rhincodon typus (Whale Shark)	8	a. Wangi-wangi: Patuno, Kapota b. Kaledupa: Hoga,	2003, 2007, 2009, 2010, 2011, 2013, 2014	9

Based on the results of the survey, Kapota Reef (Karang Kapota), North side of Wangi-wangi Island (Bira, Nua, Sombu and Patuno), and Hoga Island are the top 3 sites where fishermen most often caught sharks. And based on the results from the diver surveys, the sites where sharks were most often observed were: Wangi-wangi island (Nua, Patuno and Gurita Reef), Hoga island and Ndaa island. Star symbol indicates the highest interaction (Fig. 7). The different location of the highest shark interaction between fishermen and divers is likely because fishers and divers are not always operate in the same area. However two locations among the top 3 are the same between both groups.