Master‘s thesis

Is it Possible to Demonstrate That Shark Diving Can Become More Profitable Than Shark Fishing?

Identifying Economic Values and Trends in the Fishing and Diving Industries of Southern Thailand

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Declaration

I hereby confirm that I am the sole author of this thesis and it is a product of my own academic research.

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Abstract

A number of studies show that the economic value of sharks as a non-consumptive resource is far more valuable than the income generated through the consumed sharks, as the living sharks can be re-visited repeatedly throughout their entire life span. In this thesis shark landing observations at the port of Songkhla (Thailand) were combined with various interviews and surveys adressing both shark-based industries in Southern Thailand to elucidate the probability of shark diving ultimately becoming more economically feasible than shark fishing. The results revealed that the catch composition was greatly dominated by *Chilscyllium* spp., while the formerly plentiful neritic sharks, and a propular species in the diving community, represented only a minor part of the total quantity. Around 50% of the entire quantity was likely to be juvenile sharks and due to resource depletion most sharks were harvested in Indonesian waters by offshore large-scale trawlers. Diver respondents were on average willing to pay an additional US$ 11.70 for every dive, assuming it included high biodiversity and the presence of sharks, which potentially could yield nearly twice the economic return compared to the annual shark fishery production of Thailand. Both industries confirmed that the shark stocks had been in rapid and obvious decline in 10-15 years, which would only intensify with time under the current fishery regulations and culminate in local extinction of numerous of shark species, thus, limiting the growth of shark diving in Thailand. As the results revealed that shark diving eventually could become economically more viable than shark fishing, the management recommendations included a complete trawler ban concerted with a buyback trawler plan, marine national park enforcement and buffer zones to ensure the long-term sustainable use of sharks as a non-consumptive resource in Thailand.

Keywords: Consumptive use of sharks, Non-consumptive use of sharks, Thailand, Willingness to Pay (WTP), Shark Conservation, Management.

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Acronyms

ASEAN	Association of Southeast Asian Nations
BOBLME	Bay of Bengal Large Marine Ecosystem Project
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
CPUE	Catch Per Unit Effort
CVM	Contingent Valuation Method
DMCR	Department of Marine and Coastal Resources
DNP	National Park, Wildlife and Plant Conservation Department
DOF	Department of Fisheries of Thailand
FAO	Food and Agriculture Organization of the United Nations
GOF	Gulf of Thailand
IUCN	International Union for the Conservation of Nature
IUU	Illegal, Unreported and Unregulated Fishery
KTKP	Koh Tao and Koh Phangan
MNP	Marine National Parks
MPA	Marine Protected Area
NGO	Non-Governmental Organisation
NPOA-sharks	National Plan of Action for the Conservation and Management of Sharks
TAT	Tourism Authority of Thailand
THB	Thai Baht
SEAFDEC	Southeast Asian Fisheries Development Centre
WTP	Willingness to Pay

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"In the past, when the fishermen went out fishing and they caught a lot of fish, they would give a lot of the fish to their friends or the neighbourhood, but now, when they fish they catch very little, so they sell everything they catch. No matter what fish they catch, they sell everything. If you would ask the fishermen to give up fishing sharks it would be very difficult because they invest one time and they have to sell as much as they can."

- Fishery Scientist from Ranong Province, 2014

1 Introduction

Global Shark Fisheries, Overfished?

For the past few decades, it has been widely recognised that the world's shark stocks have been driven into significant declines through targeted and non-targeted fishing (Bonfil, 1994; Baum et al., 2003; Ebert et al., 2013) and that the larger sized sharks are particularly at risk of extinction due to their complex life history (Baum et al., 2003; Baum & Myers, 2004; Myers & Worm, 2005; Dulvy & Forrest, 2010). Sharks have been harvested and utilised for thousands of years (Walker, 1998; Vannuccini, 1999), but in the middle of the 1980s, the global shark fishing industry grew significantly, which was greatly accelerated by the growing demand for sharks' fins (Camhi et al., 1998; Walker, 1998; Baum *et al.,* 2003; Worm *et al.*, 2013, Ebert *et al.,* 2013; Dulvy et al., 2014). In Thailand, the shark meat is generally considered of lower quality (Chen & Phipps, 2002; Sattar & Anderson, 2011) and a product mostly consumed by impoverished people (Vannuccini, 1999). The sharks' fins, however, can reach high prices on the market due to the great demand for shark fin soup a luxurious dish chiefly consumed in China (Camhi *et al.* 1998; Stevens *et al.* 2000; Ferretti et al., 2010; Sattar & Anderson, 2011; Worm et al., 2013) and by ethnic Chinese minorities (Vannuccini, 1999; Dent & Clarke, 2015). Today, all shark commodities have some market value (Davidson et al., 2015) thus, most shark-consuming nations - including Thailand – tend to land the harvested sharks whole (SEAFDEC, 2006a; SEAFDEC, 2012; Sattar & Anderson, 2011; Worm et al., 2013).

Estimations of annual catch and mortality rate ranges between 63 and 273 million sharks (Worm et al., 2013). The scale of the harvest has driven many shark populations into rapid declines (Baum et al., 2003; Myers et al., 2007) and some ecosystems have already lost between 79-90% of the entire shark populations during the past three decades (Dulvy et al., 2014; Baum & Myers, 2004; Baum et al., 2003). Although most of the world's targeted shark fisheries have been discontinued due to long-term catch declines (Ebert et al., 2013), sharks are still caught in large quantities as bycatch in mixed-species fisheries that target the more resilient and productive bony fishes (Bonfil, 1997; Camhi et al., 1998; Musick, 1999; Ebert et al., 2013). This continuing harvest represents a great threat to the longer-lived shark species and creates an elevated risk of a future extinction to many of them (Musick, 1999; Ebert et al., 2013; Worm et al., 2013).

Sharks have a distinct biology, much similar to whales and sea turtles, and entirely different to bony fishes (Musick, 1999). In ecological terms, they are k-selected species generally characterised as long-lived animals with slow maturity rates, long gestation periods and low fecundity (Camhi et al., 1998 & Walker, 1998; Stevens et al. 2000; Ferretti et al. 2010; Worm et al., 2013). Most shark species are highly vulnerable to overexploitation, and once overfished it can take many years for the depleted stock to rebound (Musick, 1999; Stevens et al. 2000; Worm et al., 2013). In a comparison study between sharks and teleosts (bony fish), sharks were shown to be more susceptible to fishing mortality than the teleost species and experienced twice the extinction risk from modest fishing mortality (Myers & Worm, 2005). Most sharks are apex predators, which have an important ecological role in marine ecosystems as they keep the fish population in balance and reduce potential diseases from spreading among prey species (Terborgh & Estes, 2010). Taking out keystone predators like sharks from ecosystems can have devastating consequences for economies, lead to trophic cascades, invoke proliferation of small predators and the consequent potential destruction of multiple species within the web (Myers et al., 2007; Terborgh & Estes, 2010).

As a consequence of the alarming decline in shark abundances, scientists, conservationists and organisations have been raising concern about sharks and their future existence, while emphasising the urgent need to improve the management of the global shark stocks (Bonfill, 1994; Camhi et al., 1998; Baum et al., 2003; Lack & Sant, 2009; Davis & Boris, 2013; Davidson et al., 2015). In most fisheries, shark catches are poorly managed (Stevens et al., 2010) or are often neglected in the management plans (Bonfil, 1997; Davis & Boris, 2013). Generally, there is a paucity of stock assessments, species-specific and fishery landing data concerning sharks (Bonfil, 1997; Camhi, 1998; Stevens et al., 2000; Graham, 2003; Lack & Sant, 2009; Fischer et al., 2012). Moreover, most countries have little political interest and sparse funds allocated to managing their shark stocks, mainly due to their comparatively low economic value (Weber & Fordham, 1997; Bonfil, 1997; Stevens et al., 2000; Dulvy et al., 2008; Fischer et al., 2012; Davis & Boris, 2013).

In 1999, the Food and Agriculture Organization of the United Nations (FAO) developed a voluntary International Plan of Action for the Conservation and Management of Sharks (IPOA-sharks) (Lack & Sant, 2009) to encourage shark-fishing nations to perform

sustainable use of their shark resources (FAO, 2015). Developing a National Plan of Action (NPOA) on state level has proven to be a complicated and prolonged process for many nations such as Thailand, however. This has resulted in implementation constraints (Dulvy et al., 2008; Lack & Sant, 2009, 2011; Fischer et al., 2012; Davis & Boris, 2013). Apart from a total fishing ban on the whale shark (*R. typus*) (Fishing Act B.E. 2490), Thailand has not introduced any legal framework or shark finning bans in their economic exclusive zone (EEZ) (Chen & Phipps, 2002; Sattar & Anderson, 2011; Fischer et al., 2012; Krajangdara, 2014). Since sharks are not targeted species in Thailand (Fowler et al., 2005; Sattar & Anderson, 2011; Krajangdara, 2014), controlling the shark bycatch is not considered as being of the same importance as controlling the target fisheries (Interviewee I). In Thailand, however, sharks are still harvested in large numbers as a bycatch (Fowler et al., 2005; Sattar & Anderson, 2011) and the country is among the world's top shark fishing nations (Lack & Sant, 2009, 2011; Fischer et al., 2012).

Shark-Based Ecotourism

As a counterbalance to killing sharks and utilising them as a consumptive resource, their non-consumptive usage in terms of shark diving has in recent years gained a foothold on the global market with at least 376 shark ecotourism operators located in 29 different countries, including Thailand (Catlin & Jones, 2010; Gallagher & Hammerschlag, 2011). The aspects of diving with sharks and watching them in their natural surroundings have proven to be an invaluable asset profiting numerous local communities in developing and developed countries (Newman & Medcraft, 2002; Graham, 2004; Gallagher & Hammerschlag, 2011; Vianna et al., 2011b) and, at the same time, a feasible alternative aiming to conserve and ensure the long-term sustainable use of sharks (Vianna et al., 2011b).

Estimations suggest that a charismatic mega fauna like the Whale shark (*Rhincodon typus*) can annually generate around US$ 47.5 million to the world's economy. If Whale sharks would frequently return to the same dive location throughout their life span, one Whale shark could potentially be worth more than US$ 2 million (Graham, 2004). In 2003, the Whale shark industry in Belize was worth US$ 3.7 million over a six-week period (Graham, 2003), while Whale shark excursions in the Maldives generated US$ 9.4 million from direct expenditures in 2013 (Cagua et al., 2014).

Although Whale sharks are among the most favoured and charismatic sharks to dive with (Newman & Medcraft, 2002; Catlin & Jones, 2010; Gallagher & Hammerschlag, 2011; Vianna et al., 2011b), shark diving is not only confined to this species (Anderson & Ahmed, 1993; Vianna et al., 2011b; Gallagher & Hammerschlag, 2011). In 2011, the entire shark diving industry in Fiji contributed with US$ 42.2 million to the nation's economy through dive-based activities including up to eight different species of sharks (Vianna et al., 2011a), while the shark diving industry in Palau, which predominantly involves divers' interactions with the Whitetip reef shark (*Triaenodon obesus*) and the Grey reef shark (*C. amblyrhynchos*), produces US$ 18 million per annum. Shark diving can become a very profitable attraction and is demonstrated to be a decent economic alternative to shark fishing (Vianna et al. 2011b). If well managed, it can produce large revenues to local communities in the longer term (Graham, 2004; Vianna et al., 2011a; Vianna et al., 2011b; Gallagher & Hammerschlag, 2011), which should provide great incentives to conserve them (Graham, 2004).

Thailand is generally ranked about the 4th in "top 10 dive destinations in the world" and PADI certifies more new divers in Thailand than in the rest of Asia combined. It also has a wide array of shark species (Compagno, 1997; Krajangdara, 2014) considered highly valuable in the global shark diving community (Graham, 2004; Vianna et al., 2011b; Gallagher & Hammerschlag, 2011; Vianna et al., 2011a) and attractive dive site attributes comprising of coral reefs and warm waters (Newman & Medcraft, 2002; Dearden et al., 2006), which are important drivers for SCUBA divers (Lew, 2013). However, even though Thailand has ideal marine conditions for shark diving, factors like overfishing and habitat destruction are rapidly decreasing the shark stocks (Vidthayanon, 1997), potentially hindering the future chances of shark sightings in Thailand.

Motivation

Shark diving is globally a growing industry that can benefit multiple groups of people across sectors. With a well-established dive industry and all year diving opportunities, this thesis explores the probability of shark diving ultimately becoming more economically feasible than shark fishing in Southern Thailand. To understand if this could be a viable

solution in the longer term, the two industries directly involved and somewhat dependent on the presence of sharks the fishing industry and the diving industry have been researched using both a thorough literature review and complex field work consisting of personal observations, interviews and surveys. The field study area for this thesis is in Songkhla (Southern Thailand), which has been carried out over a period of four months, from October 2014 to January 2015.

Research Objectives and Questions

The goal of the literature search has been to describe the current state of the two industries, the shark fishing industry and the diving industry in Thailand, one representing a consumptive use of sharks and the other one illustrating the non-consumptive use of sharks, with potential for their conservation. A hypothesis was formulated that the profitability of the shark fishing industry is declining both due to decimated/overfished stocks and due to lack of protective regulation, while the profitability of the shark diving industry is rising. The applied field research was done with three main objectives in mind: a. to familiarise the researcher with a new culture and to help her deal with the language barrier; b. to verify the truthfulness of the theoretical description of the two industries and the trends identified by the literature search and c. to identify potential policy measures that might help in the future a transition from mostly consumptive use of sharks to a mostly non-consumptive use in the tourism industry. The details of the goals of the field research and of the methods used are given below:

(I) This study provides a small-scale insight into the shark fishing industry in Songkhla based on shark landing observations and informal interviews aiming (a) to estimate the economic value of the landed sharks, (b) to discover general stock trends and the level of demand of the sharks as a consumptive resource and (c) to make a first time attempt to establish a supply and value chain of the landed sharks.

(II) The results will be combined with information from surveys addressing dive customers, dive instructors and dive operation managers in Thailand (a) to identify the level of demand for shark diving, (b) to uncover customers' conservation attitudes and preferences for sharks and (c) to determine if it is realistic and feasible for Thailand to promote shark diving on a higher level in the future.

(III) In addition to elucidating if shark diving can become more ingrained in the tourism sector and even potentially compensate for lost revenue from shark fishing, the investigation of the location of shark dive sites and stakeholder suggestions can be used (a) to propose fishery management and conservation recommendations in an effort to conserve the remaining shark stocks in Thailand and (b) to suggest future commercial use of sharks in a non-consumptive industry and some ways to achieve the transition. In order to identify these matters, the following research questions have been used in this study:

1. Which shark species are landed at the port of Songkhla, Thailand, in what numbers, including estimated length and biomass (kg) and what is their conservation status based on the criteria of the IUCN Red List?

2. In comparison to the present and the past few decades, what are the main trends of the shark stocks in Southern Thailand?

3. What are the main findings of the value chain of shark products in Southern Thailand, and who are the consumers of the shark-derived products?

4. Are divers in Southern Thailand willing to pay additional money per dive to explore high biodiversity environments that include sharks and what is the general attitude towards shark conservation?

5. What are the economic benefits and the future prospect of shark diving in Thailand?

6. Which policy measures can assist in facilitating a transition to a non-consumptive use of sharks and thereby increase the sight-predictiability of sharks in Southern Thailand?

The thesis provides small-scale insights into the shark fishing industry and diving industries in Southern Thailand through landing observations, interviews and multiple surveys targeting the diving industry. The following chapters present a literature review of the Thai marine fishery post the introduction of demersal trawlers, an overview of the

shark fishing industry and shark-derived products as well as a description of shark-based [dive] activities inside and outside Thailand, including some comments from scientists and stakeholders related to the industries. After that follows a descriptive overview of the methods, a presentation of the focal study and distribution areas for this study and an introduction of the results. The results are then analysed and discussed in order to elucidate the current situation and to determine the feasibility of the rational long-term economic use of sharks in the shark diving industry compared to the shark fishing. The discussion also highlights the limitations and potential bias in the study, as well as future research. Another chapter provides management and conservation recommendations based on the collected data and the analysis. It is followed by a concluding chapter.

2 Theoretical Background and Literature Review

The research uses as theoretical background, the theory of renewable resources use with a special focus on consumptive and non-consumptive uses of shark stocks. It also uses valuation theory and a non-market valuation technique, WTP (Harris and Roach, 2013).

2.1 Overview of the Thai Marine Fishery

The Kingdom of Thailand is one of the world's leading fishing nations and is currently ranked third after China and Norway, supplying important sources of income to many people directly and indirectly involved in the industry (Eiamsa-ard & Amornchairojkul, 1997; Piumsombun, 2003; ILO, 2013). However, since the introduction of trawling more than half a century ago, the coastal resources both in the Andaman Sea and the Gulf of Thailand have been rapidly depleted, resulting in stakeholder conflicts, declining fish stocks and deterioration of marine ecosystems (Eiamsa-ard & Amornchairojkul, 1997).

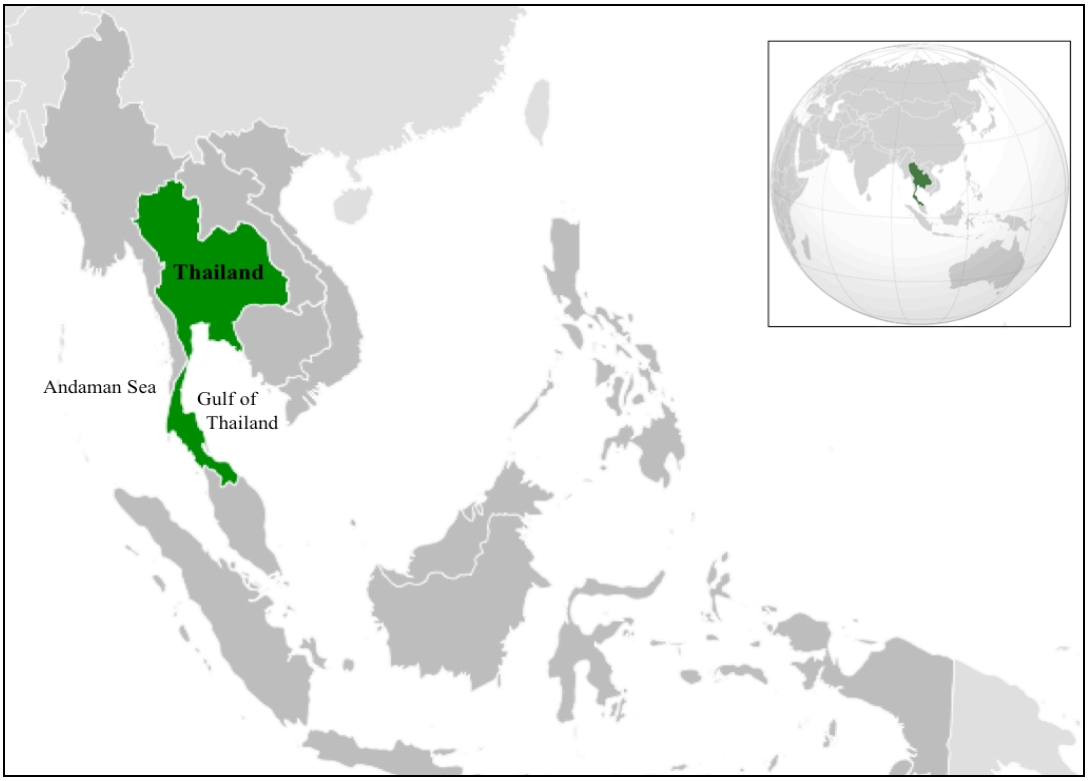


Figure 1: A modified map of Thailand and the location of the country on a global scale (green). *Source: Wikipedia.org (2015)*

Small-Scale and Commercial Fisheries

The marine fishery sector consists of two types of fisheries: small-scale and commercial fisheries (FAO, 2009). The commercial fishery includes medium and large-scale fishing vessels capable of fishing offshore for days without docking. This contrasts with the practice of small-scale fishing boats, which operate around 3-5 km from the coast (Achavanuntakul et al., 2014; Teh et al., 2015) in estuaries, bays and coastal areas on a daily basis (Funge-Smith et al., 2005; FAO, 2009). The medium-scale fishing vessels, which are 14 m, typically operate in Thai waters using trawlers and purse seiners and will normally spend a few weeks at sea (Keong, 1996; Eiamsa-ard & Amornchairojkul, 1997). The large-scale fishing vessels, which are larger than 14 m and have greater and more efficient fishing gear, will spend several months or years operating in international waters before returning to harbour (ILO, 2013; Interviewees G and B). This is a great contrast to small-scale fishermen, who will usually deploy more selective gear such as crab and shrimp gill nets, traps, set bag nets, lift nets, hooks and lines, from boats of less than 10 gross tonnage (Pimoljinda, 2002; Achavanuntakul et al., 2014).

After the introduction of the more modern and improved fishing gear, conflicts between the two fisheries arose. The trawlers would start colliding with the static and less efficient gear deployed by small-scale fishermen, which only seemed to fuel the situation in a time of declining marine resources (Teh et al., 2015; Thai Fisheries Act 2015). Currently, due to limited marine resources, unclear regulations and low penalties from encroachment (Sirichai, 2003) (as cited in Achavanuntakul et al., 2014, pp. 50), commercial fishing vessels are illegally operating within the 3 km zone from the coastline (Pimoljinda, 2002) (exclusively designated for small-scale fishermen), destroying delicate habitats and marine ecosystems (Achavanuntakul et al., 2014).

Introduction of Trawling

In the beginning of the 1960s, when the trawlers eventually became successfully introduced and until the early 1980s, the marine fishery in Thailand experienced rapid growth due to a higher profitable gain from trawling compared to the previous less efficient, small-scale fishing gear (Pauly, 1979; Panayotou & Jetanavanich, 1987; Pimoljinda, 2002; Pauly & Chuenpagdee, 2003; Teh et al., 2015). As it was an easy and cheap business to enter with no fishing ground restrictions (Chuenpagdee & Pauly, 2003),

the number of trawlers (otter board, pair and beam) in Thai waters quickly expanded in the first following years (Boonyubol & Pramokchutima, 1984; Supongpan & Boonchuwong, 2010; Teh et al., 2015). From 1960 to 1965, the number of trawlers increased by around 550, equivalent to an increase of 23%, while the fishery production increased with up to 83.8% (392,666 million tons) (Boonyubol & Pramokchutima, 1984; Supongpan & Boonchuwong, 2010). By 1989, the number reached about 13,100 trawlers (Funge-Smith et al., 2005; Teh et al., 2015). Due to a 'limited entry' regulation later implemented, allowing no trawler licenses issued (FAO, 2015b), the number of trawlers was markedly reduced by 2013 to 3,192 (DoF, 2015a). However, Teh et al. (2015) pointed out that a number of vessels operate as trawlers, while only being approved for gillnet fishing, which merely just seems to shift the problem to somewhere else.

In 50 years, the catch per unit effort (CPUE) reduced with 94%. After the trawler introduction, the CPUE went from 297,80 kg/hour in 1961 to 49,77 kg/hour in 1981 (Boonyubol & Pramokchutima, 1984) and by 2010, it had reduced even further to 17,8 kg/hour (Boonwanich & Boonpakdee, 2009) (as cited in Achavanuntakul et al., 2014, pp. 17). Figure 2 illustrates how the CPUE of the research vessels for demersal fishes gradually decreased from the early 1960s to early 1980s in the Gulf of Thailand.

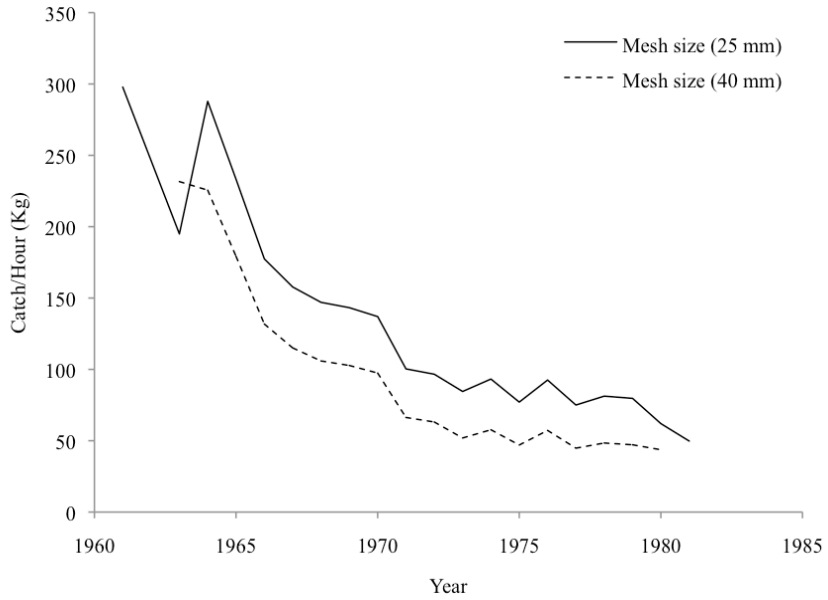


Figure 2: *Catch per unit effort of the demersal fish caught by the research vessels in the Gulf of Thailand from 1961 – 1981. Source: Boonyubol and Pramokchutima (1984)*

2.1.1 Fishery Management Policies

Introduction

The Thai fisheries are managed under the Thai Fisheries Act (1947), which was amended in 1953 and 1985 (Achavanuntakul et al., 2014), but due to continuous deterioration of the marine resources and limited fishing grounds and gear conflicts, the previous Fisheries Act was considered outdated and a New Fisheries Act B.E. 2558 (2015) was launched in April 2015 (MOAC, 2015). In June 2015, Thailand further improved their legal framework and upgraded it in accordance with international standards (Royal Thai Government, 2015a). The upgrading came in the wake of pressure from the European Union (EU) announcing that Thailand had six month (stated in April 2015) to improve the management of illegal, unreported and unregulated (IUU) fishing in the Thai fishery industry or EU would ban all imports of marine products from Thailand (European Commission, 2015). Despite a number of revisions, there is still no conservation law implemented to protect sharks and other long-lived animals in Thailand (Chuenpagdee & Pauly, 2003), apart from the whale sharks (R. typus) (Chen & Phipps, 2002). Krajangdara (2014) suggests that the regulations established under the Thai Fisheries Act (1947) can implicitly assist or conserve the sharks in Thailand, however. The first fishery regulations have been initially imposed by the DoF to replenish and recover marine resources considered economically important to Thailand, while the more recent initiatives have largely been enforced in an effort to combat IUU fishing and to comply with international standards (DoF, 2015b; Royal Thai Government, 2015a).

Area and Seasonal Closures

Since 1984, DoF have imposed seasonal closures each year in the GoT (26.400 km^2) from February 15 - May 15 and in the Andaman Sea (4,969km^2) from April 1 - June 30 to protect the smaller fish species and the larvae production in Thai waters (Krajangdara, 2014; Royal Thai Government, 2015b; DoF, 2015b; DoF, 2015c). With the exception of this period, when trawlers are required to use minimum 4.7 cm mesh sizes in certain areas (FAO, 2009), there are no mesh size regulations enforced. Thus, most fishermen operate with small cod-end mesh sizes (Eiamsa-ard & Amornchairojkul, 1997), down to 1.5 cm where almost no animals can escape, but vessels typically use a mesh size of 2.0 cm or less (Achavanuntakul et al., 2014). On some provincial levels, fishermen are encouraged by the fishery officials to increase the mesh size to 4 cm, but since it requires compliance among

stakeholders, it is not easily enforced (Interviewee I). Introducing larger mesh sizes can prevent juveniles from getting captured in the nets until they are mature and therefore, capable of maintaining the reproductive cycles or allowing individuals to grow up to a specific size where they obtain higher market values (Jones, 1983).

Gear Restrictions & Limited Entry

Since 1972, DoF has prohibited trawlers and push netters from fishing within a distance of 3000 meters from the coastline (Chuenpagdee & Pauly, 2003; Krajangdara, 2014) due to high destruction on the coastal, benthic habitats, but also for the reason that large quantities of economically important juvenile fishes are taken by these practices in the shallower areas (FAO, 2009; Boonwanich & Boonpakdee, 2009) (as cited in Achavanuntakul et al., 2014, pp. 20). In 1980, a limitation on trawlers and push netters was issued in order to manage the number of trawlers and push netters entering the business (FAO, 2009; Chuenpagdee & Pauly, 2003), but likewise to reduce the fishing effort so the fish stocks could replenish (Chuenpagdee & Pauly, 2003).

New Marine Initiatives: Monitoring, Control and Surveillance (MCS)

Thailand has stepped up in combating IUU fishing by imposing a number of new fishery initiatives aiming at reducing fishing effort and making the fishing industry more transparent and in line with international requirements (Royal Thai Government, 2015a). These regulations include:

- *Increased Fines:* Offenders can now be fined up to THB 30 million.
- *The Port in – Port out Control Center (PIPO):* Upon arrival and departure from commercial ports, fishing vessels, larger than 30 gross tons, are now required to report their presence with valid and mandatory documentation.
- *Fishing Vessel Survey:* A thorough nationwide vessel survey has reduced the number of unlicensed vessel operators, who are now prohibited from fishing.
- *Fishing Day Limits:* Trawlers and purse seiners are now facing a limit on fishing days to reduce fishing effort and to ease threats to juvenile fishes.
- *Vessel Monitoring System (VMS):* Fishing vessels, larger than 30 gross tons, are required to install and use VMS devices.

National Parks Act B.E. 2504 (1961)

The Royal Forestry Department[1] (now administered by DNP) has established 26 marine national parks (MNPs) (Sethapun, 2000), located along the coast in the Andaman Sea and in the Gulf of Thailand. Although with some flexibility, the current legislation prohibits all fishing activity in the park areas in order to protect the existing marine ecosystems from overexploitation (Sethapun, 2000; Panjarat, 2008). However, fishing activity within the marine parks is a reoccurring issue, as several of the MNPs have been established on locations usually used as traditional fishing grounds for small-scale fishers (Sethapun, 2000; Panjarat, 2008; Bennett & Dearden, 2014). This is a situation that has given rise to conflicts in the fishing communities, as many of the small-scale fishermen have ended up feeling neglected and constrained from the restrictions (Chuenpagdee & Pauly, 2003; Bennett & Dearden, 2014). Another commonly experienced issue within the marine parks are the detrimental and illegal fishing activities from trawlers and push netters, which have resulted in severe marine resource declines and destruction of seabed habitats (Panjarat, 2008).

In Thailand, most MNP fees are usually set five to ten times higher for foreign divers than for Thai divers (Asafu-Adjaye & Tapsuwan, 2008). The fees are then transferred to Governmental funds and, once a year, the capital is allocated to all the MNPs based on the size of the area and the need of management (Sethapun, 2000) and thus, it is not necessarily based on the park's popularity or the revenue generated within the site (Asafu-Adjaye & Tapsuwan, 2008). This can give rise to some issues, however, as MNPs with a higher number of visitors may need more funding for management than the less popular parks (Asafu-Adjaye & Tapsuwan, 2008).

Protected areas can serve as a successful conservation and fishery management tool, if effectively managed (Bennett & Dearden, 2014). They can increase the biodiversity and the species density (Sethapun, 2000), may lead to a spill over effect (MedPAN, 2012; Hoyt, 2014), bring an economic gain for local communities (Sethapun, 2000; Bennett & Dearden, 2014) and can generate revenues from tourism (Worachananat, 2007; Bennett & Dearden, 2014). But in order to create successful MNPs several factors need to be present such as stakeholder compliance, clear communication (Worachananat, 2007; Bennett &

[1] The National Park, Wildlife and Plant Conservation Department (DNP) took over administration in 2002.

Dearden, 2014; Hoyt, 2014), bottom-up management (Hoyt, 2014) as well as sufficient resources to enforce the rules and monitoring of the protected areas (Chuenpagdee & Pauly, 2003; Worachananat, 2007; Bennett & Dearden, 2014). In addition to the economic gain from MNPs, as alternative livelihoods, locals can be employed as rangers or managers to patrol and manage the reserves (Bennett & Dearden, 2014), though, this implied that the locals will be paid monthly salaries high enough to ensure they can make a living (Bennett & Dearden, 2014).

Artificial Reefs

Since 1987, DoF has deployed small-scale artificial reefs (478 km^2) and large-scale artificial reefs (1,435 km^2) in both the Andaman Sea and the GoT, with the objectives to conserve and replenish fishing grounds, to protect nursery grounds, to improve fishers' income and to minimise conflicts between stakeholder groups (SEAFDEC, 2010). As the artificial reefs are large, concrete constructions, these solutions could potentially also hinder trawlers and push netters from operating at locations where they are deployed (SEAFDEC, 2010), thus, also serving as an effective barrier to protect delicate habitats. Regular evaluations of the artificial reefs suggest that constructions are inhabited by various fish species, which eventually attract large commercial fish species which are economically important to fishermen (SEAFDEC, 2006b), therefore, deploying artificial reefs is a well-liked management initiative among most Thai fishers (SEAFDEC, 2010).

2.1.2 Effects of Overfishing on the Marine Resources

Overexploitation of the Gulf of Thailand

Although the 1960s and 1970s are marked as an era with high marine catches (Boonyubol & Pramokchutima, 1984; Pimoljinda, 2002; Pauly & Chuenpagdee, 2003; Teh et al., 2015), the demersal resources of the GoT have been overfished since the middle of the 1970s, which eventually led to a decline of marine catches in the early 1980s (Pauly, 1979; Boonyubol & Pramokchutima, 1984). Thus, it is now widely recognised that the demersal resources are entirely overexploited, in particular in the GoT (Pauly, 1979; James et al., 1991; Pimoljinda, 2002; Chuenpagdee & Pauly, 2003; Pauly & Chuenpagdee, 2003; Supongpan & Boonchuwong, 2010; Achavanuntakul et al., 2014; Teh et al., 2015). One of the main factors contributing to this development was the increased fishing effort in the GoT due to growing investments in demersal trawlers (Boonyubol & Pramokchutima,

1984; Pimoljinda, 2002; Pauly & Chuenpagdee, 2003; Teh et al., 2015). Additional events such as the global oil crisis in 1973-1974 and the declaration of the Exclusive Economic Zone (EEZ) in the neighbouring countries (Cambodia, Malaysia and Vietnam) also seemed to contribute to the declining catches, since many of the larger trawlers would return to fish in the GoT, as a result of lost fishing grounds in international waters and increased oil prices (Boonyubol & Pramokchutima, 1984; Panayotou & Jetanavanich, 1987; Pauly & Chuenpagdee, 2003; Teh et al., 2015). Further reasons are probably increased population and growth coupled with expansion of animal feed mills (Eiamsa-ard & Amornchairojkul, 1997; Chuenpagdee & Pauly, 2003), which process low-valued trashfish into animal feed and fishmeal (Funge-Smith et al., 2005; Achavanuntakul et al., 2014).

Trashfish

Trashfish often comprise of large proportions of juvenile fishes with high, commercial value (James et al., 1991; Eiamsa-ard & Amornchairojkul, 1997; Kaewerrn & Wangvoralak, 2004; Funge-Smith et al., 2005; Supongpan & Boonchuwong, 2010; Achavanuntakul et al., 2014), charismatic fish and sharks considered economic important in diving communities (Interviewee G) and smaller sized fishes with little market value, unsuitable for human consumption (James et al., 1991; Funge-Smith et al., 2005; Achavanuntakul et al., 2014). Trashfish tends to mean the mashed up mess at the bottom of the cod-end or products poorly handled which have been spoiled; it is therefore anything that cannot otherwise be sold. Despite that trashfish catches have been declining in the past years (DoF, 2014), the prices are still rising due to the increased demand from agriculture and aquaculture industries that turn the low-value protein into fishmeal and animal feed for farmed animals (James et al., 1991; Eiamsa-ard & Amornchairojkul, 1997; Kaewerrn & Wangvoralak, 2004; Funge-Smith et al., 2005; Achavanuntakul et al., 2014).

Leaving the commercially important juvenile fishes in the ocean until adulthood will only make them much more profitable post-harvest than the low-valued trashfish (Funge-Smith et al., 2005), which in the longer term should generate higher revenues for Thailand (Interviewee G). As an illustration: if the Spanish Mackerel (*Scomberomorus commerson*) is harvested at a reasonable size compared to being utilised as fishmeal and animal feed (70 THB/kg), it can produce 100 times or even more the price (Interviewee G), but since all trashfish catches will be purchased, there are per se no economic incentives for the

fishermen to discontinue this fishing practice (Funge-Smith et al., 2005; Supongpan & Boonchuwong, 2010; Achavanuntakul et al., 2014). In response to intensive trawling, the catch composition has now changed from larger economically important species towards smaller and less valuable fishes (Pauly, 1979; James et al., 1991; Eiamsa-ard & Amornchairojkul 1997; Supongpan & Boonchuwong, 2010). Also categorised as biomass fishing (James et al., 1991), the demersal trawlers are therefore currently deploying unselective fishing gear aiming at increasing the total catch of the smaller sized fish further down the food web to supply the fishmeal and animal feed industries (James et al., 1991; Piumsombun, 2003; Funge-Smith et al., 2005; Achavanuntakul et al., 2014).

2.1.3 Reminiscences of a Retired Fisherman From Songkhla[2]

There are still some old fishermen who remember what it was like before the collapse of the Gulf fishery. Presented are the reminiscences of one such old man, to demonstrate how fishermen see the ocean and its resources and how the situation changed soon after the introduction of trawlers in Thailand.

"In the 1960s […], when I was in my twenties […], I started working as a fisherman […] and then I retired 40 years later, in the early 1990s […]. In the beginning, we used gillnet, which caught many sharks. [I had] a boat with engines, which was around 8 meters, [but then] the fisheries changed into trawlers [and] I swapped to trawling instead and sold my gillnetting gear around the 1970s. Gillnets could not compete with the trawlers, […] there were so many of them, […] they all swarmed around in the sea of Songkhla. When we left gillnets [in the water] and the trawlers came, we could not recover it in time, so the trawlers ruined the gillnets […]. Around 1970 to 1972 many of [the gillnet fishermen] fled and started operating in Vietnamese waters, because there were so many trawlers in the sea and so little fish for the gillnet fishermen to catch. In the 1980s […], the fish abundance started declining steadily in Thai waters. Even trawlers they would have to go to neighbouring countries. My goal was to do anything, which could earn good money. [For example, we] got caught in the Malaysian water, without any authorisation to fish. There is no fence in the sea; the area is based on a map and sometimes we had to pay fines. These days, the resources keep running out of our sea. If you trawl in Thai waters, it is not worth the gas price. You need to go to neighbouring countries to fish in order to make profits. It

[2] The interview was conducted in November 2014 in Songkhla.

was the reason why my boat went to Malaysia and then got caught. If I trawled in Thai waters, I could not be sure if I could fill my boat in 20 days, but if I went to Malaysia, ten days would be enough to fill up the boat with fish, of which you could earn around 200.000 to 300.000 THB[3] (US$ 5579 – US$ 8368)[4].“

“In the past, there were many sharks in the sea, but around 30 years later, they became harder and harder to find, actually to the point where they were almost nonexistent. [The sea] was very productive back then and […] sometimes I would catch big [sharks] over 100 kilos […] or […] sharks just over 50 kilo. In terms of the small sharks, I got them every day. I guess they were around two to three kilo and maybe sometimes four to five kilos. [Sharks] are hard to find these days. Maybe you catch one shark per night nowadays, but now they are usually caught in Malaysia or Indonesia. We do not have them in our water. [Compared to previous and present time, the abundance of sharks] has declined enormously and probably eight out of ten are now gone. The decline does not concern me, the [sharks] will definitely disappear. The sharks are caught as a bycatch in the fisheries [and as a fisherman] you do not feel that losing sharks is a pity, because they do not really give us any benefit. Some fishermen only think about trawling and harvesting all out of the sea. They do not care. […] Everything that is caught is valuable [because] these days everything can be sold. Every species can be sold, even the crab, the rock crab. Now we sell them, but in the past we just threw them back into the sea. This is very different from when I started fishing back in the days.”

“Now, gas is quite expensive, it’s hard to find labourers to work on the boats and because Southern Thai people don’t really want to work on the boats anymore, the fishing industries need to get foreign people to work on the boats instead.” “When I was still fishing, there were many people signing up for a job. I could choose who ever I wanted to have on the boat with me. If they weren’t good, such as messing up the gear, we could just fire them and easily find a new replacement.”

[3] Currency exchange retrieved from XE Currency on 8 October 2015 with US$ 1 equal to THB 35,85.
[4] That amount of money was a lot back then and if compared to today, one haul with a mixed catch, which is done one to two times per day, can bring in around 7000-8000 THB (US$195 – US$ 223) (Interviewee C).

"[In terms of replenishing the productivity of the sea], there are ways like dropping structures in the sea such as trains, rocks, etc. It is like building a habitat. The trawlers cannot reach these grounds and destroy it (the habitat), so the fishes can repopulate. The structures are too large and if they trawl in there, their net will be damaged. In Songkhla, […] they constructed large concrete structures and deployed them along the shore. After having deployed these structures there seems to be more fishes. […] It is getting better and, currently, people from Songkhla hire small boats to go out fishing with their fishing rod in those areas."

2.2 Biology and Ecological Importance of Sharks

2.2.1 General Biology

Sharks have roamed the ocean for more than 400 million years, making them one of the oldest living vertebrates on earth (Camhi, 1998; Worm et al., 2013). Together with rays and skates, sharks are classified as elasmobranches, which typically refers to their cartilaginous skeleton, the five to seven gill slits openings, the lack of swim bladder and a body comprising of placiod scales (dermal denticle) with one or more dorsal fins on the back (Ebert et al., 2013; Klimley, 2013). The sharks occupy various oceanic zones. Compagno (1997) explains that the sharks inhabiting South China Sea can be divided in three overall habitat categories: marine continental shelves extending from the intertidal zone to 200m, which also includes species occupying freshwater habitats, continental slopes from 200m to more than 2000 m in depth and the oceanic species which inhabit the open ocean, outside the shelf and higher than the ocean floor. On a global scale, most species are confined to continental shelves and slopes (Cailliet et al., 2005; Ferretti et al., 2010) in the Indo-West Pacific Region (Stevens et al., 2000; Musick, 2005), while only a smaller group is known for being wide-ranging species including the blue shark (*Prionace glauca*), oceanic whitetip shark (*C. longimanus*) and mako sharks (*Isurus* spp.) (Cailliet et al., 2005; Ferretti et al., 2010).

In South East Asia the shark species diversity is large (SEAFDEC, 2006a), however, based on the most recent shark species checklist from 2012 (Krajangdara, 2014), the number of species has been reduced, by perhaps, 11 species since at least, 1997 (Vidthayanon, 1997). Although, the list from 1997 was only a preliminary checklist, where of eight of the

species were considered as ‘possibly occurring’ or ‘doubtful species’ in Thai and adjacent waters, at total of 75 species were reported. When compared with the 2012 census, which included 19 families in total, 53 species were reported on both 1997 and 2012 lists, 22 species from 1997, did not occur, on the more recent list and 11 new species were reported on the 2012 list (Vidthayanon, 1997; Krajangdara, 2014).

The Bristly catshark (*Bythaelurus hispidus*) is one of the smallest sharks in Thailand growing to a maximum of 29 cm, while the Whale shark (*R. typus*) is the largest shark, growing to between 1700 cm and 2100 cm (Ebert et al., 2013). The highest biodiversity of sharks is occurring in the neighbouring Indonesian waters, which also show high numbers of endemic shark species (Stevens et al., 2000). Figure 3 illustrates how the species richness of sharks and their relatives is more pronounced throughout the tropical and coastal regions and that Thailand is among some of the most species rich countries in the world.

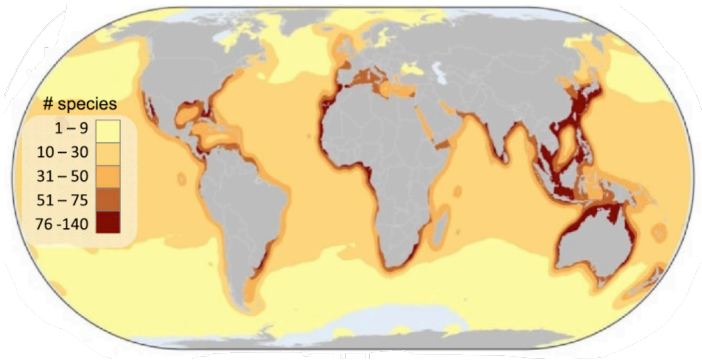


Figure 3: *Global species richness of sharks and their relatives.* Source: Dulvy et al. (2014)

Understanding of life history traits of sharks i.e. age and growth, reproduction strategies and basic distributional and abundance information is necessary to gain insight into the species’ resilience under a given fishing pressure, and ultimately, to applying the optimal management measure (Camhi et al., 1998; Cailliet et al., 2005). It can be said that most sharks are k-selected species, with few or no enemies, so they grow at a much lower rate, have a long life span with low fecundity and reproduce small litter sizes in comparison to r-selected teleost fishes, which spawn hundreds of thousands of eggs every year and generally reach sexual maturity much faster (Cailliet et al., 2005; Dulvy & Forrest, 2010; Ebert et al., 2013). Sharks have developed three different reproductive strategies of which some require high maternity investment from the female shark (Ebert et al., 2013).

- *Oviparity:* Around 40% of all sharks are oviparous, including the Zebra shark (*Stegostoma fasciatum*) and the Bamboo shark (*Chiloscyllium* spp.), which develop eggs and usually attach the hardy and leather-like egg cases to the seafloor or crevices to ensure their safety from predators (Klimley, 2013). Juveniles of some species can take more than 12 months before hatching (Ebert et al., 2013). The adult oviparous sharks are typically smaller than the live-born species and often reside in demersal habitats (Klimley, 2013).

- *Ovoviviparity (aplacental viviparity):* Ovoviviparous shark species - e.g. the Whale shark (*R. typus*) and the Nurse shark (*Ginglymostoma cirratum*) develop eggs inside and carry them in a uterine structure until they hatch; the mother then gives birth to live pups (Klimley, 2013). The pups are nourished by their yolk sac, while some species additionally also digest mucus obtained from the uterus of the female shark (histrotrophy) (Klimley, 2013). A few species also consume unfertilised eggs and sibling embryos prior to birth (intrauterine cannibalism) – a behaviour that is seen with the Great white shark (*C. carcharias*) and the Sandtiger shark (*Carcharias taurus*) (Klimley, 2013).

- *Viviparity (placental viviparity):* Viviparous female sharks nourish their pups through an umbilical cord from a placenta attached to the wall in the uterus (Ebert *et al.,* 2013). Species using this reproductive strategy include the Bull sharks (*C. leucas)*, Blue sharks (*P. glauca*) and Hammerhead sharks (*Sphyrna* spp.) (Ebert et al., 2013; Klimley, 2013).

The last two reproduction strategies require much more investment from the female compared to oviparous reproduction, and so some species may need resting years between breeding episodes (Ebert et al., 2013; Klimley, 2013). For instance the gestation period of the aplacental viviparous Shortnose spurdog (*Squalus megalops*) takes up to 24 months and then it gives birth to 2-4 pups measuring around 20-24 cm (Klimley, 2013), while the Whale shark may give birth to up to 300 pups (58-64 cm) in one litter (Klimley, 2013). A clear advantage from the two viviparous strategies is that the pups are protected during the entire gestation period (although not the case with intrauterine cannibalism) and then fully

developed at birth, whereas the oviparous species on other hand spend less maternity "investment" in their pups (Ebert et al., 2013; Klimley, 2013).

Vulnerability to Fishing

Although sharks generally are species of low reproductive capacity compared to bony fish, levels of productivity among the shark species do vary greatly, which means some sharks are more able to withstand fishing pressure (Walker, 1998; Stevens et al., 2000; Cailliet et al., 2005). The smaller and typically faster-growing sharks potentially can be harvested on a sustainable level, if appropriate gear type and efficiency restrictions are applied in the fishery in concert with careful monitoring and precautionary management approaches (Walker, 1998; Worm et al., 2014). However, there are exceptions: the heavily-fished deep-water Dogfishes (*Squalus* spp.) which appear to be amongst the slowest-growing species, with only a few pups per pregnancy, may not be able to support a sustained fishery effort of any magnitude (Camhi et al., 1998; Walker, 2005). In general, Ebert et al. (2013) state that it would not be unusual to discover that most of the deep-water sharks mature at around 40 years and that they can live up to 100 years.

The larger, slow-growing sharks (Dulvy & Forrest, 2010) in shallow coastal areas, where they are easy targets for the fishermen, are under the greatest threat of extinction (Cailliet et al., 2005; Walker, 2005; Dulvy et al., 2014). Smith et al. (1998) stated that some of the long-lived coastal species with the least rebound probability are the Dusky shark (*Carcharhinus obscurus*), the Sandbar shark (*C. plumbeus*), the Bull shark (*C. leucas*), the Scalloped hammerhead (*sphyrna lewini)* and the Lemon shark (*Negaprion spp*.), while the faster growing small-size coastal sharks display a higher likelihood of survival from overexploitation (as cited in Stevens et al. 2000, pp. 482).

In addition to fishing mortality, coastal and euryhaline species are generally also more exposed to human induced impacts than the deep-sea and oceanic sharks. Habitat degradation like mangrove deforestation, coastal development and pollution are altering important breeding, pupping and nursery grounds for these species, while reducing the potential of survival (Walker, 2005; Dulvy et al., 2014). Even though the deep-water sharks are much more sensitive to fishing pressure, the coastal and pelagic sharks (>1 m) are still at 50% higher risk of going extinct, which is likely due to the fact that the fishing

vessels can access their habitats compared to the inaccessible deep ocean (Dulvy, et al., 2014). Dulvy et al. (2014) have identified three overall global hotspots, which are threatening shark species living at or near the coastal and continental shelf (<200 m), in the neritic and epipelagic zone and in the deep water (>200 m) (Figure 4).

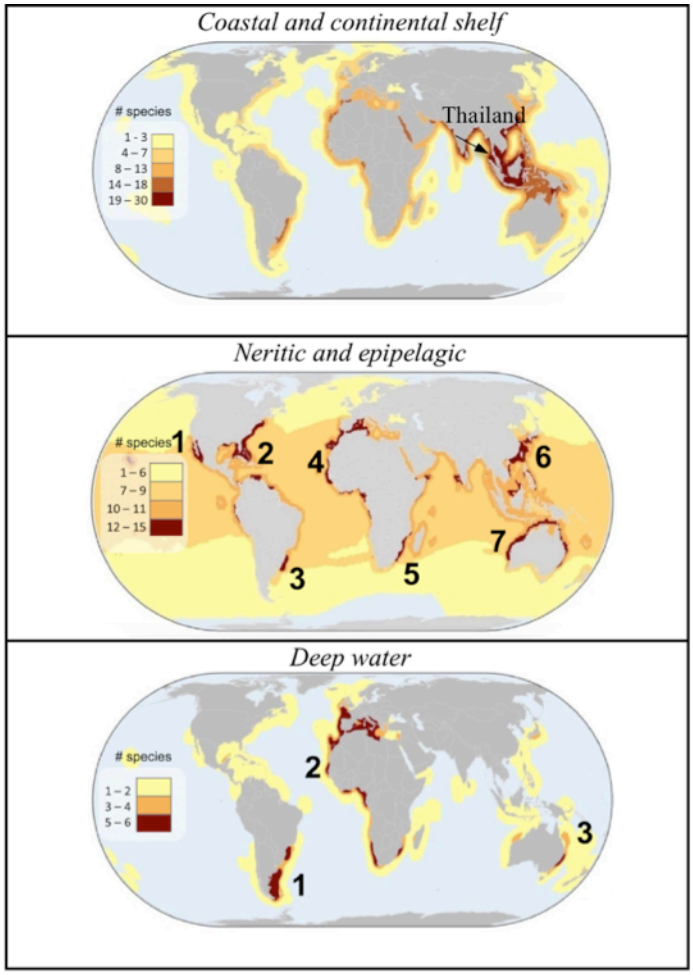


Figure 4: *Global hotspot threats to sharks and their relatives.* Source: Dulvy et. al., (2014)

In Thailand, the highest number of jeopardised species is among the demersal shark species inhabiting the coastal and continental shelf areas (Figure 4), estimated to be between 19-30 species. The threat hotspot extends throughout large parts of Asia, i.e. from India and Myanmar to the coral triangle and up towards the East China Sea. Compared to the demersal species, there are fewer oceanic species (10-11) in peril; however, the number of oceanic species is still in the second highest category of threatened species.

Currently, there are no deep-water shark species in Thailand that are known to be under threat; the hotspots are predominantly found on three widespread locations i.e. along the southwest coast of South America, from the southern tip of Africa along the coastline to Norway and into the Mediterranean sea and the south-eastern tip of Australia (Dulvy et al., 2014).

2.2.2 Ecological Importance of Sharks

Except for the larger filter feeders including the Whale shark (*Rhincodon typus),* the Basking shark (*Cetorhinus maximus*) and the Megamouth shark (*Megachasma pelagios*) - most sharks are predators, so they are often near or at the top of the food chain (Stevens et al., 2000; Cailliet et al., 2005). Sharks – especially the larger species – can be key ecological factors across large spatial scales. By preying on meso-predators, they maintain equilibrium across ecosystems by ensuring that the mesospecies do not become excessively abundant and over-predate on species further down the food web (Shepherd & Myers, 2005; Cailliet et al., 2005; Ferretti et al., 2010; Heithaus et al., 2010). Thus, if apex sharks are heavily fished from an ecosystem, it can have ecological consequences for the entire community structure and likely result in top-down trophic cascades and a mesopredator release that reduces the overall diversity and biomass (Stevens et al., 2000; Shepherd & Myers, 2005; Bascompte et al., 2005; Lack & Sant, 2006; Ferretti et al., 2010; Simpfendorfer et al., 2011; Ruppert et al., 2013).

Some data suggest that only slight fishing effort can lead to considerable reductions of large, coastal sharks, and as a result from their absence, it may conversely change the abundance and distribution of other species in the ecosystem (Stevens et al., 2000; Ferretti et al., 2010). For example, in a simulation study where the Tiger sharks (*Galeocerdo cuvier*) were removed from the Hawaiian coral reef of the French Frigate Shoals, the results showed vast changes in the structure of the ecosystem (Stevens et al., 2000): a great number of different species increased, including reef sharks, sea turtles, bottom fish, seabirds, monk seals, while the tuna and jack fish stocks nearly collapsed (Stevens *et al.,* 2000).

Marine ecosystems are complex by nature (Ferretti et al., 2010; Stevens et al., 2000) and the removal of sharks in a community does not necessarily increase the level of prey species. Another simulation suggested that the ecosystem of the Venezuelan Shelf would experience an increase of marine species uncommonly preyed upon by the sharks, while some prey species would reduce if the shark population declined in numbers (Stevens et al., 2000). Healthy coral reefs need herbivorous fishes (Jennings & Kaiser, 1998; Bascompte et al., 2005), as they consume algae on the reefs, which in turn allow space for coral colonies to develop (Jennings & Kaiser, 1998). Some studies suggest that the removal of apex sharks can have a reducing effect on the population of herbivorous fishes, which, will, in response, lead to increased algae cover and eventually to loss of living corals (Jennings & Kaiser, 1998; Bascompte et al., 2005; Ruppert et al., 2013). Although the removal of apex sharks from two different reef ecosystems did not seem to impact the abundances of corallivores and planktivores, these groups would however, react to the decreasing health of corals (Ruppert et al., 2013).

Consequences of this ecological impact from the removal of sharks can be interpreted in terms of heavy economic losses, as human-targeted resources react to the trophic imbalance (Stevens et al., 2000; Simpfendorfer et al., 2011). To illustrate: for a number of years, great sharks were removed from a large ecosystem due to intense fishing in North Carolina, which resulted in a mesopredator release (Myers et al., 2007). The population of Cownose Ray (*Rhinoptera bonasus*), the sharks' major source of food, subsequently increased greatly as a result of reduced predation (Myers et al., 2007). The mesopredator rays subsequently depauperised populations of their favourite prey (scallops) upon which a major fishery relied (Myers et al., 2007). After a few decades, a local and well-established fishery dependent on the scallops in the bay was destroyed, as the abundance of scallops had reduced to a level where the business could no longer continue operating (Myers et al., 2007). A similar situation happened in Tasmania, where a shark fishery was established nearby a crayfish industry, but after a few years, both industries had gone insolvent. The removal of the sharks in the area made the octopuses proliferate due to a reduction in predation pressure from the sharks, which allowed the octopuses to over-predate on the crayfish (Wallett, 1983) (as cited in Stevens et al., 2000, pp. 484).

The consequences of removing sharks from ecosystems are highly unpredictable, as it depends on the trophic interaction of the species within the given community and their existing role (Stevens et al., 2000; Baum & Worm, 2009; Ferretti et al., 2010; Heithaus et al., 2010). Many studies argue that sharks play a vital role in shaping ecosystems and that the removal of top-predator sharks may lead to algae-dominated ecosystems, decreasing biodiversity and destruction of live corals (Stevens et al., 2000; Bascompte et al., 2005; Myers et al., 2007; Ferretti et al., 2010; Heithaus et al., 2010; Ruppert et al., 2013).

2.2.3 IUCN Red List

There are more than 500 species of sharks in the world (Ebert et al., 2013), but the number is probably closer to 1000 (Klein & Techera, 2014). Globally, 69 shark species are categorised as 'Near Threatened' on the IUCN (International Union for the Conservation of Nature) Red List and 74 are 'Threatened' with extinction, which is a direct response from increased fishing mortality, the complexity of their life history and ecological factors (Graham, 2003; Ebert et al., 2013; Dulvy et al., 2014; IUCN Red List, 2015). This means that around one-third of all shark species (30,3%) are currently 'Threatened' or 'Near Threatened' with extinction, but in reality this is most likely an underestimate (Ferreti et al. 2010; Dulvy et al., 2014). Even more species may be under threat, since 214 shark species are reported as a "data deficient", the paucity of distributional, population and life history data for these species potentially camouflaging their real status (Dulvy et al., 2008; 2014).

In Thailand, up to 67.2% of the entire shark species present are either 'Near Threatened' or 'Threatened' with extinction and at least one is considered 'Critically Endangered'. More than 20% are categorised as 'Data Deficient' or 'Not Evaluated' and only 9,4% are considered of 'Least Concern' (Krajangdara, 2014, IUCN Red List, 2015). Table 1 displays the number of shark species in Thailand and their current status based on information from the IUCN Red List.

Table 1: *IUCN status of the sharks in Thailand.* Source: Krajangdara (2014)

IUCN Red List status	Total # of Species	Critically Endangered	Endangered	Vulnerable	Near Threatened	Least Concern	Data Deficient	Not Evaluated	-
Sharks: Thailand	**64**	1	2	17	23	6	11	2	2
	100%	1,6%	3,1%	26,6%	35,9%	9,4%	17,2%	3,1%	3,1%

Sharks are a diverse group of animals inhabiting many different habitats (Simpfendorfer et al., 2011), which can vary largely in terms of productivity, fecundity, abundance, life span, migratory behaviour, etc. Due to variance between the species, there is no universal management measure that can be applied to all the species (Klein & Techera, 2014; Lack, 2014), even were management agencies interested in shark management policies. Facts indicate that Thailand is aware of the issue concerning diminishing shark stocks, however, since sharks are considered bycatch only, it is unlikely that resources will be devoted to shark management without an indication of economic importance (Sattar & Anderson, 2011; Interviewee I).

There is great need for comprehensive assessments of each sharks' biology and their ecological role in the diverse ecosystems in order to implement the most effective fishery management that aims to improve and conserve the stocks (Walker, 1998; Simpfendorfer et al., 2011; Lack, 2014), including quota systems, mesh size regulations, MPAs, shark sanctuaries or closures (Simpfendorfer et al., 2011; Klein & Techera, 2014; Ward-Paige, 2014). With some species exhibiting highly migratory behaviour, including the Whale sharks (R.typus), the Great white sharks (Carcharodon carcharias), the Mako sharks (Isurus spp.) and the Bull sharks (C. leucas) (Topelko & Dearden, 2005), management is more complicated and will require cooperation on regional or cross-jurisdictional levels (including international maritime boundaries and EEZs) in order to introduce meaningful shark conservation measures (Camhi, 1998; Topelko & Dearden, 2005; Sattar & Anderson, 2011; Simpfendorfer et al., 2011; Klein, 2014).

Most sharks are exceptionally vulnerable to overfishing given their life history (Camhi et al., 1998; Musick, 1999; Stevens et al. 2000; Dulvy et al., 2008; Ferretti et al. 2010; Worm et al., 2013) and in the absence of scientific data and shark fishery management it is impossible to manage shark stocks sustainably (Klein & Techera, 2014; Worm et al., 2014). Even though it is recognised that there generally is a need for improved shark conservation across world regions (Lack, 2014; Klein & Techera, 2014; Worm et al., 2014), shark stocks are largely unmanaged in most multispecies fisheries, especially in the highly diverse Indo-West Pacific region (Stevens et al., 2000). Assuming that the current fishing pressure remains unchanged, evidence shows that many shark populations will only continue decreasing (Worm et al., 2013) and eventually push several shark species towards extinction (Ebert et al., 2013; Worm et al., 2013).

2.3 Sharks as a Consumptive Resource

2.3.1 Shark Fisheries in Thailand

Shark fisheries have existed at least since the 1960s in Thailand (Vidthayanon, 1997), which traditionally have been supplying coastal communities with an income and as a cheap source of protein (Rose, 1996; SEAFDEC, 2006a; Sattar & Anderson, 2011). In response to increased prosperity in Asia, the worldwide demand for shark fins rose rapidly in the 1980s, which intensified global shark catches and multiplied the fin prices at an enormous rate (Bonfil, 1994; Keon, 1996; Rose, 1996; Bonfil, 1997; Stevens et al., 2000). This has created incentives for some fishermen to conduct shark finning at sea due to the much lower-valued body taking up space on the vessels (Keon, 1996; Weber & Fordham, 1997; Bonfil, 1997; Stevens et al., 2000); a wasteful and inhumane practice where all the fins are cut of the shark and the rest of it is thrown back into the ocean, often while still being alive (Keong, 1996; Bonfil, 1997; Vannuccini, 1999; Lack & Sant, 2006).

Statistical data from FAO show that from 2000 to 2009, the world's 26 shark fishing nations were accountable for 84% of the global shark catches[5], but these numbers are in reality likely to be much higher, as many catches remains underreported i.e. the quantity of bycatch or discard (Bonfil, 1994; Rose, 1996; Fischer et al., 2012; Worm et al., 2013). In the same period, Thailand was ranked the 12th shark fishing nation with an average catch

[5] These catches included all chondrichthyans (sharks, rays and chimeras)

of 20,749 t/year (Fischer et al., 2012) and the world's top exporter of shark fins with an export of almost 99% of the total quantity (Mundy-Taylor & Crook, 2013).

It is widely recommended by scientists to specify down to species level, especially aimed at countries regularly harvesting sharks (Dulvy et al., 2008; Fischer et al., 2012; Dent & Clarke, 2014; 2015), even so all shark landings are unspecified in Thailand and instead aggregated under 'shark' in the annual fishery report (Bonfil, 1997; DoF, 2015d). This is not an unusual case, as most of the leading shark fishing nations does not specify shark species in their reports (Musick & Musick, 2011). In 2007, only 20% of the entire shark catches reported to FAO was classified down to species level, while the remaining 80% was congregated in generic categories (Lack & Sant, 2009). Stevens et al. (2000) explain that sharks, especially as bycatch, are often unspecified in fisheries like demersal trawling, gillnetting and long-lining and by combining all shark species under one category it may mask current trends and let shark stock collapses pass through unnoticed (Stevens et al., 2000; Sattar & Anderson, 2011; Musick & Musick, 2011; Worm et al., 2013; Davidson et al., 2015). The solid foundation of sustainable shark fishery management includes reporting species-specific data upon landing, as it reduces species camouflaging, which ultimately allows fishery managers to apply the most appropriate fishery methods to sustain the stocks; and if possible, this should also include discarded catches as well (Davidson et al., 2015).

In Thailand, sharks are generally not a targeted species and are typically harvested as a bycatch in other fisheries (Keong, 1996; Vidthayanon, 1997; Sattar & Anderson, 2011; Krajangdara, 2014). Sharks are caught in both small-scale (SEAFDEC, 2012) and commercial fisheries (Bonfil, 1994), although, the majority of the shark catches is mainly carried out by commercial fishing vessels (Bonfil, 1994; Keong, 1996; Rose, 1996). Presently, most commercial fishing vessels harvest sharks on a daily basis, especially those operating in international waters, as the competition has become too great in the GoT (Interviewee I). Controlling shark bycatch is a challenging issue, however, especially in countries with insufficient fishery reporting systems that systematically collect and gather landing data (Stevens et al., 2000; SEAFDEC, 2006a); hence, large quantities of shark bycatch are often not reported (Stevens et al., 2000; SEAFDEC, 2006a; Dulvy et al., 2008; Worm et al., 2013).

Fishing Gear

Thai vessels do not deploy a special type of gear that particularly targets sharks (Krajangdara, 2014), however, otter board trawlers followed by pair trawlers are significantly the most predominant fishing practices responsible for catching sharks (Bonfil, 1994; Keong, 1996; Vidthayanon, 1997, SEAFDEC, 2006a; Sattar & Anderson, 2011; Krajangdara, 2014). In a study conducted in 2003-2004, SEAFDEC (2006a) concluded that 96.57% of the total shark catches in Thai waters, where caught by 'trawlers', while 'purse seiners' contributed with 2,15% and the remaining percentage was attributed to 'other fishing gear'.

Fishing Grounds

Sharks are harvested both in national and adjacent international waters and those that are caught outside Thai jurisdiction are mainly fished in Indonesia, Myanmar, Bangladesh, Malaysia and Vietnam (Rose, 1996; Keong, 1996; SEAFDEC, 2006a; Interviewees F and G). Presently, it is not uncommon to discover that most of the sharks landed on the west coast (e.g. Phuket or Ranong) are largely harvested in the waters of Myanmar, while the landed sharks on the south east side e.g. Songkhla are often caught in Indonesian waters (Interviewee G). Excepting the information from a logbook survey from 1998-2009 addressing commercial and small-scale fisheries (Teh et al., 2015), the current fishery statistics only includes marine catches from the GoT and the Andaman Sea, thus, no shark catches harvested in international waters are presented in the reports (DoF, 2015d). From 1999 to 2013, 4,404 tons/year of sharks were on average harvested in the GoT, while much fewer sharks were taken in the Andaman Sea (2,534 tons/year) (DoF, 2015d). These numbers indicate that the GoT is clearly the main fishing ground for sharks, as 63.5% of the total capture production of sharks was on average harvested in the GoT, while the remaining 37.6% was from the Andaman Sea (DoF, 2005, 2006, 2011, 2015d).

2.3.2 Shark Capture Fishery Landings

From the beginning of the 1990s, the quantity of landed sharks and the value of the fishery rose steadily until it peaked in 2003, subsequently followed by a sharp decline (Figure 5) (DoF, 2005, 2006, 2011, 2015d; Dent & Clarke, 2015). In 2003, Thailand landed 14,400 tons of sharks, while less than 10 years later in 2011; the landings had declined to 1,400 tons, a reduction of more than 90% (DoF, 2005, 2006, 2011, 2015d). This trend also

correlates with others studies that report a decline in the global shark landings in this period (Lack & Sant, 2009; Musick & Musick, 2011; Fischer et al., 2012; Dulvy et al., 2014; Dent & Clarke, 2015). This global trend signalled that it was a result of overexploitation of the world's shark stocks rather than a result of improved fisheries management or declining demand (Clarke & Dent, 2014; Davidson et al., 2015). In the same period, Thailand was among the five countries experiencing the greatest reduction in shark landings, amongst which a common denominator was that few or no shark fishery management measures were implemented (or even considered) (Davidson et al., 2015).

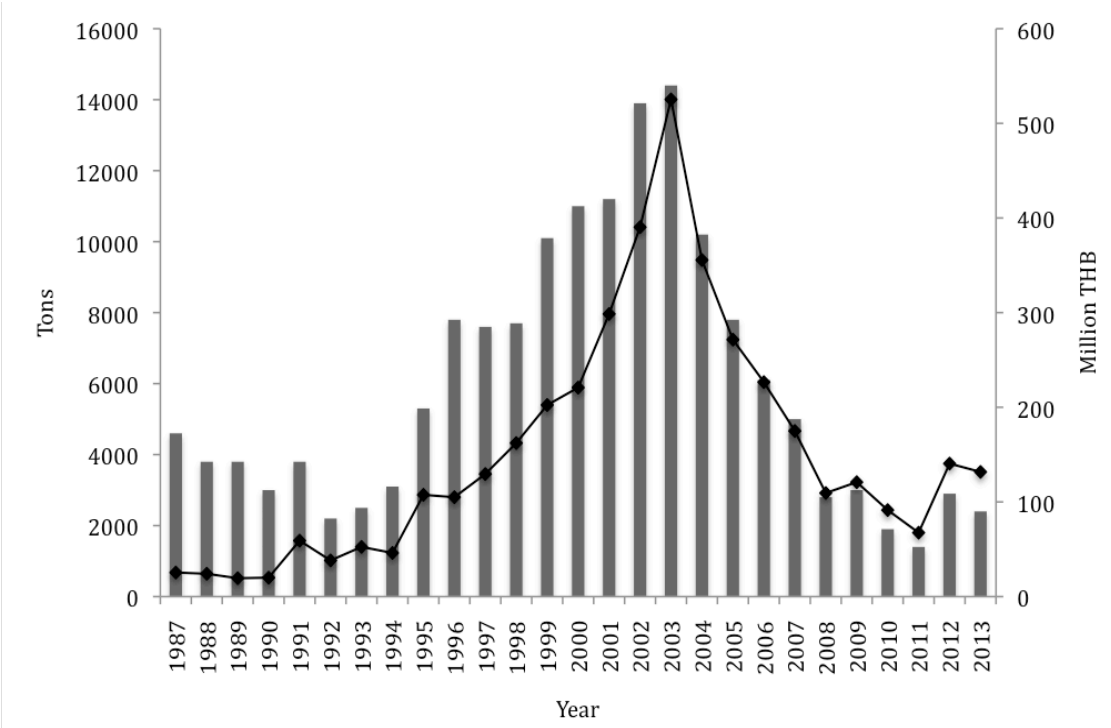


Figure 5: *Shark production in Thailand (quantity and value) from 1987 to 2013*. Source: Keong (1996) and DoF (2005, 2006, 2011, 2015d)

Shark landings historically have comprised only a minor part of the overall marine production in Thailand (Keong, 1996; Vannuccini, 1999; SEAFDEC, 2006a; SEAFDEC, 2012; Ebert et al., 2013; Krajangdara, 2014) and are among the lower-valued fish products, from the fishery sector (DoF, 2015d). From 2010 to 2013, Thailand earned on average 159.7 billion THB (US$ 4.4 billion) per annum from their entire fishery production as a whole (2.97 million tons), of which the annual total production of sharks (2,200 tons) was around 108 million THB (US$3 million) (DoF, 2015d). The revenue from sharks over the

period represented was therefore just 0.07% of the total fisheries revenues in Thailand (Table 2).

Table 2: *A selection of high and low valued products of the Thai marine fishery sector from 2010 to 2013.* Source: DoF (2015d).

Species	2010		2011		2012		2013	
	Tons	THB*	Tons	THB*	Tons	THB*	Tons	THB*
Higher Value								
Squid	89,000	6,435.0	93,500	7,855.8	80,100	8,252	75,600	7,879.4
Indo-Pacific mackerel	127,000	4,274.2	147,800	5251.5	129,000	4,907.6	145,300	6,000.9
Swimming crabs	22,800	2,520.7	28,800	3,243	33,500	4,184.7	25,700	3,561.7
Trash fish	419,000	2,745.2	355,800	2,483.6	321,700	2,502.5	323,600	2,4761
Cuttlefish	23,700	1,696.3	23,000	1,729.7	24,700	2,155.4	25,200	2,217.5
Threadfin breams	42,300	1,310.2	49,400	1,963.5	53,300	2,151.7	65,100	2,792.5
Anchovies	138,600	1,634.2	142,800	1,846.2	129,400	1,899.9	116,700	1,704.5
Indian mackerel	38,700	1,159.5	54,200	1,867	48,800	1,883.4	50,100	2,1064
Lower Value								
Rays	4,800	175.8	3,400	103.4	4,300	169.7	4,100	147.9
Sharks	1,900	91.4	1,400	67.5	2,900	140.5	2,400	131.7
Mantis shrimp	700	69.9	200	18.9	300	22.9	900	101.8
Catfish eel	400	35.7	500	53.8	500	45.1	600	61.8
Tunas	4,200	188.7	400	21.5	500	37.7	300	16.7

* (Million THB)

Species Composition

In 1991, DoF estimated that up to 95% of the shark catches comprised of shark species less than 1.5 m in length, predominantly the *Carcharhinus* spp. (Bonfil, 1994, Keong, 1996; Rose, 1996), while the remaining species were Bamboo sharks (*Chiloscyllium* spp.), Hammerhead sharks (*Sphyrna* spp.), Zebra sharks *(Stegostoma fasciatum)* and Tawny nurse sharks (*Nebrius ferrugineus)* (Keong, 1996). In a more recent study from 2003-2004, results showed that a total of 25 different species were identified on the fishing ports. The ten most common species taken by the fishing vessels were the *Chiloscyllium* spp. (71.11%), *Carcharhinus* spp. (12.56%), *Sphyrna lewini* (5.33%), *Atelomycterus marmoratus* (1.67%) and *Alopias vulpinis* (1,11%) (SEAFDEC, 2006a). Sharks of other species comprised 8.22% of reported landings in aggregate.

Nowadays in the southern part of the GoT, including Songkhla, most of the sharks landed by demersal trawlers are the Bamboo sharks[6] (*Chiloscyllium* spp.), standing in contrast to previous years, which comprised more of the once plentiful species i.e. the Spottail shark (*Carcharhinus sorrah*), the Grey reef shark (*Carcharhinus amblyrhynchos)* and the Scalloped hammerhead shark (*Sphyrna lewini*) (Interviewee I). Thus, these species previously more abundant are becoming scarcer, with increasing irregularity between the landings, suggesting that the shark biodiversity in the GoT is decreasing (Interviewee I). Table 3 shows the relative abundance of occurrence of the species identified at the port of Songkhla from landings in 2007. The reversal of the previous dominance of landings by small carcharhinids appears to have occurred rapidly – shark landings nowadays are overwhelmingly dominated by Bamboo sharks

Table 3: *Level of occurrence of the landed shark species in Songkhla in 2007. The information was obtained from a report, which was briefly shown during an interview in Songkhla, thus, the original source is unknown. The levels are indicated with plusses, whereas as one plus (+) demonstrates a lower level of occurrence, while three plusses (+++) demonstrate a higher level of occurrence. (Trends were confirmed by a secondary source: Interviewee I).*

Scientific name	Common name	Level of Occurrence
Atelomycterus marmoratus	Coral catshark	++
Chiloscyllium punctatum	Brownbanded bamboo shark	+++
Carcharhinus amblyrhynchos	Grey reef shark	++
Carcharhinus brevipinnia	Spinner shark	+
Carcharhinus leucas	Bull shark	+
Carcharhinus sorrah	Spottail shark	+++
Hemigaleus microstoma	Sicklefin weasel shark	+
Sphyrna lewini	Scalloped hammerhead shark	++

2.3.3 Utilisation of Sharks

In recent years, the demand for most shark-derived products on domestic and international markets has been increasing (Dent & Clarke, 2015), therefore, most [Thai] fishers do not intentionally discard sharks at sea any longer, as all catches are now marketable (Interviewees F; G and I). For that reason, all shark landings, which are processed into a wide range of products, are fully utilised in Thailand (Weber & Fordham, 1997; Vannuccini, 1999; Musick, 2005; SEAFDEC, 2006a; 2012; Dent & Clarke, 2015).

[6] Prefer habitats favoured for fishing by the trawlers (Ebert *et al.,* 2013; Interviewee I).

The most important commodities are the meat, fins and skin (Vidthayanon, 1997), while other shark-derived products of lesser importance, yet, still saleable, are shark jaws/teeth, stuffed sharks (Vidthayanon, 1997) as well as liver oil and miscellaneous off-cuts (SEAFDEC, 2006a; 2012; Krajangdara, 2014). In Thailand, the landed sharks vary in sizes and in terms of utilisation; therefore, the value of the individual species differs according to their purpose. In markets on both the Andaman side and in the Gulf of Thailand, the requiem sharks reach higher prices than other smaller size sharks, which are typically *Chiloscyllium* spp., *Atelomycterus marmoratus* and *Mustelus sp.B* (SEAFDEC, 2006a).

Meat

The meat from at least 25 species of sharks is traded on markets in Thailand (SEAFDEC, 2006a) and is consumed either as fresh/frozen, dried unsalted/salted/sweetened or processed meat (Vidthayanon, 1997; SEAFDEC, 2006a; 2012; Krajangdara, 2014) i.e. fish balls (Vannuccini, 1999; Krajangdara, 2014) and surimi[7] (Musick, 2005). Generally, the fresh meat from the smaller sized sharks is preferred for meat consumption, as it contains lesser concentration of urea and mercury and is easier to process (Rose, 1996; Vannuccini, 1999; Musick, 2005; Dent & Clarke, 2014; 2015); while the larger sized sharks are popularly used for fins, leather goods (Rose, 1996) and low-grade fish balls and surimi (Dent & Clarke, 2015). Tendencies show that in Europe and North America, there is a greater market demand for smaller species, namely dogfish species, while Asian countries display a greater demand for the larger species, likely due to less strict mercury guidelines (Dent & Clarke, 2014) and preference for shark fin soup.

It has commonly been considered a less desired shark-derived product, but in recent decades the meat has become more widely accepted and utilised for human consumption (Vannuccini, 1999). This is possibly a result of improved freezing facilities, limited resources of other preferred food fish (Weber and Fordham, 1997; Vannuccini, 1999; Dent & Clarke, 2015) combined with the introduction of anti-finning laws, encouraging nations to fully utilise the entire shark. This has likely opened up shark to new markets and thus, gradually increased the demand for shark meat (Lack & Sant, 2006; Lack, 2014; Dent &

[7] Miscellaneous minced fish meat, including sharks, e.g. made into imitated crab meat, lobster or shellfish.

Clarke, 2014, 2015). In Thailand most of the meat is consumed domestically and usually traded on local fish markets (SEFDEC, 2006a). Only a small portion is exported, while larger quantities are imported from countries such as the United States, Spain and Norway (SEAFDEC, 2006a). Some of the most preferred shark species for meat consumption is the *Chiloscyllium* spp., while larger sharks, dominantly Carcharhinidae species, are consumed in shark fin soups (SEAFDEC, 2006a).

Fins

Despite a minor drop in the world trade for the past 15 years (Dent & Clarke, 2015), shark fins are the most expensive shark-derived product (Vannuccini, 1999; SEAFDEC, 2006a) and one of the highest priced marine products in the world (Camhi et al., 1998; Dent & Clarke, 2015). In Thailand, all fins are utilised, but the value of the fins differs depending on the size, the species and the shark's current condition (Vidthayanon, 1997; Vannuccini, 1999; SEAFDEC, 2006a). The most popular fins are the pectoral fins, the first dorsal fin and the lower part of the caudal fin, which are typically sold together as a set; the remaining fins including the pelvic fins, the second dorsal fin and the anal fins are less valuable and compiled with other fins of similar size (Musick, 2005). Consuming fins from a 'set' is traditionally more preferred compared to the smaller sized fins in mixed bags (Vannuccini, 1999), while fins from species greater than 1.5 m are in particular commercially valuable - but the level of preferences may differ from country to country (Kreuzer & Ahmed) (as cited in Vannuccini, 1999, pp. 6.2.4 preferred species).

The processing of shark fins requires a longer time with sun drying or smoking methods (Vidthayanon, 1997) which may take weeks before reaching the standard conditions of the products (Vannuccini, 1999). In order to maintain a good quality of the products, the fins should be cut properly when detached from the carcass, with minimal residual meat, regularly turned around in the sun to avoid bending and being kept away from rain and insects (Vannuccini, 1999; Musick, 2005). Sometimes the fins are also salted (Vidthayanon, 1997); this is mainly carried out on fins with high water content, which conversely tend to have a lower value (Musick, 2005). Fins are traded in all sorts of conditions, such as wet (fresh), dried (including denticles), semi-processed (cooked and excluding denticles), fully processed and canned, but mostly the fins are dried and exported to other locations such as Hong Kong, Singapore and Taiwan who will finish the

last level of processing (Vannuccini, 1999; Musick, 2005). In Thailand, there is a limited number of large-scale processing plants, which process fins from start to finish; thus, most of the fins are exported to other international markets for the drying procedures (Vidthayanon, 1997).

In the period from 2007 to 2011, Thailand exported on average 7,560 tons/year of fins, of which 99.6% was prepared/preserved and only 0.4% was exported as dried fins (Dent & Clarke, 2015). The fins from sharks and guitarfishes are typically traded domestically (SEAFDEC, 2006a; 2012) and sold to Chinese restaurants offering shark fin soups (Dent & Clarke, 2015) or exported to countries inside and outside Asia[8] (Vidthayanon, 1997; SEAFDEC, 2012; Krajangdara, 2014; Dent & Clarke, 2015). Based on FAO statistics from 2000-2011, Dent & Clarke (2015) state that Thailand has become one of the world's top exporters of small low-value fins, which generated on average US$ 34.5 million/year in that period, but that the value of the fins is still considerably lower than on many other international markets, which may suggest that Thai fin providers are supplying markets where quality and value are of less importance (Dent & Clarke, 2015).

The most preferred species for shark fin consumption in Thailand are the larger size sharks, which include: the Spot-tail shark (*Carcharhinus sorrah*), the Grey reef shark (*Carcharhinus amblyrhynchos*), the Big nose shark (*Carcharhinus altimus*), the Blacktip reef shark (*Carcharhinus melanopterus*), the Graceful shark (*Carcharhinus amblyrhynchoides*), the Scallop hammerhead (*Sphyrna lewini*), the Thresher sharks (*Alopias* spp.) and the Snaggletooth shark (*Hemipristis elongata*) (Vidthayanon, 1997; SEAFDEC, 2006a).

Skin

Shark skin can be used for various purposes including food, accessories, weapon, sandpaper, etc. (Vannuccini, 1999; Musick, 2005; Krajangdara, 2014). As the skin contains dermal denticles it is often dried followed by a process of removing the denticles, bleaching and a second time drying (Chen et al., 1996). At least since the 1990s, the production of shark skin has been popular in Thailand with a large skin industry in the

[8] Such as: Japan, Russia, the United States of America, Australia, Hong Kong, Myanmar, Singapore and others (Dent & Clarke, 2015).

Samutprakaran province (Vidthayanon, 1997). At this location, the skin is mainly used for shoes, boots, sandals and other footwear (Vidthayanon, 1997), while other businesses may produce belts, wallets, bags and other accessories (Rose, 1996; Vannuccini, 1999; Musick, 2005; Krajangdara, 2014).

Some of the most preferred shark species for leather accessories are the larger size sharks, which include: the Bull shark (*C. leucas*), the Tiger shark (*G. cuvier*), the Scalloped hammerhead shark (*S. lewini),* the Dusky shark (*C. obscurus*), the Sandbar shark (*C. plumbeus*) and the Nurse shark (*Ginglymostoma* spp.).

Other Products

On a wider scale, the shark liver oil can be applied in various products such as cosmetics, pharmaceutical products, health and healing medicaments, act as an antifouling agent on wooden boats, utilised as lamp oil or consumed in traditional food, etc. (Vannuccini, 1999). In Thailand, the liver is often mixed with fishmeal products and typically feed to shrimps in aquaculture (Keong, 1996; Anak, 1997; Krajangdara, 2014). The remaining off-cuts, including cartilage, can be used in the production of fertiliser (Vannuccini, 1999) or likewise turned into animal feed by fishmeal factories (SEAFDEC, 2006a; 2012). A smaller quantity of jaws, teeth and stuffed sharks are mainly sold as souvenirs to tourists, typically in Phuket and Pattaya (Vidthayanon, 1997; SEAFDEC, 2006a; 2012; Krajangdara, 2014). Although, jaws from the larger species are more valued (Vannuccini, 1999), jaws from both small and large *Carcharhinus* spp. are normally sold on the markets (Vidthayanon, 1997; MKS personal observation, 2014). The teeth from larger shark species, which may comprise of up to 150 teeth per species (Vannuccini, 1999), are also sold on markets (Vidthayanon), typically as pendants in leather necklaces (MKS personal observation, 2014).

2.3.4 The Status of Sharks Stocks in Thailand

Several shark species in Thailand are severely threatened due to a number of factors such as uncontrolled overfishing, habitat loss/deterioration, pollution and human-induced impacts (Vidthayanon, 1997).

Overfishing

Since the 1970's, it has been evident with the declining CPUE, especially in the GoT (Boonyubol & Pramokchutima, 1984; Boonwanich & Boonpakdee, 2009), that the resources are overexploited (Pauly, 1979). As a response, commercial fishing vessels are largely operating in coastal and shallow habitats (Vidthayanon, 1997) to compensate for the economic loss from declining fish stocks (Achavanuntakul et al., 2014), which in turn are destroying important nursery grounds for neonate and juvenile sharks (Interviewee G). Sharks appear to use coastal lagoons, mangrove areas and estuaries as birthing grounds or nursery areas (Compagno, 1997), therefore a change in these habitats may alter the shark species' abundance, distribution range as well as reducing the likelihood of survival (Stevens et al., 2005). Sharks are mainly taken as bycatch by trawlers in multispecies fisheries in Thailand (Interviewee G), but since only slight fishing effort can have detrimental impacts on most species, the absence of shark fishery management should eventually lead to comprehensive shark stock collapses and local extinction (Musick, 1999; Stevens et al. 2000; Worm et al., 2013). To illustrate: in recent, previous years, a few artisanal fisheries on the coast of Andaman Sea used to target sharks, but due to population declines caused by overfishing from large-scale fishing vessels, the small-scale shark fisheries were terminated (Interviewee G).

Habitat Loss and Pollution

Habitat loss, in terms of deforestation of mangrove forests to clear space for shrimp farming has also impacted the coastal ecosystems (Vidthayanon, 1997), which can hamper the opportunity for the sharks to grow and reproduce (Walker, 1997; Stevens et al., 2005). Currently, Thailand has cleared approximately 84% of its natural cover of mangrove forests to expand shrimp farming businesses in coastal areas in order to meet the global increasing demand for seafood (Chuenpagdee & Pauly, 2003; Stevens et al., 2005). Another negative side effect from shrimp farming, which may affect sharks in the longer term, is the nutrients released from these practices, which can cause environmental degradation and modification of whole ecosystems and eventually lead to algae blooms, water quality deterioration and anoxia (Eiamsa-Ard & Amornchairojkul, 1997; Piumsombun, 2003; Chuenpagdee & Pauly, 2003; Stevens et al., 2005).

Other Human Induced Impacts

Other potential threats to sharks are human-induced activities i.e. coastal development, increased tourism and climate change. Excavation on mainland for coastal development can lead to silt run-off, which eventually smothers or entirely covers the coral reefs and thus, reduces the fish abundance (Stevens et al., 2005; Larpnun et al., 2011). Intensified and uncontrolled tourism can stress whole ecosystems and reduce the overall health of coral reefs (Lamb et al., 2014), while environmental impacts such as increased temperature, eventually resulting in coral bleaching and ocean acidification will decrease the biodiversity and in due course lead to fish stocks declines (Dearden & Manopawitr, 2010; Dulvy et al., 2014).

Shark Conservation Management

Despite the fact that Thailand has acknowledged the importance of urgently implementing shark conservation and management actions corresponding to the current guidelines of IPOA-sharks in order to preserve the shark stocks (Sattar & Anderson, 2011; See Appendix 1), the Whale shark (*R. typus*) is currently the only protected species of elasmobranch in Thailand. Management initiatives are still exceedingly limited, which is mainly due to lack of information on several areas (SEAFDEC, 2006a; Sattar & Anderson, 2011; SEAFDEC, 2012; Krajangdara, 2014; See Appendix 1). For that reason, it has been difficult to conduct stock assessments due to insufficient data, which has hindered formulation and implementation of any shark conservation management plan for Thailand (SEAFDEC, 2006a; 2012). Some of the major issues in Thailand are:

- Lack of shark biology and catch/fishery data
- Lack of systematic data and baseline assessments
- Insufficient information on shark usage and trade
- Lack of cooperation between stakeholders and government officials
- Non-existent awareness-rising programmes
- Scarcity on shark experts and relevant training
- Inadequate funding for shark fisheries research and policy development

Even though, the first NPOA-sharks draft was introduced in 2005 (Sattar & Anderson, 2011; Fischer et al., 2012; Krajangdara, 2014), Thailand has still not adopted a full NPOA-sharks. The voluntary-based National Plan of Action for the Conservation and Management of Sharks has been developed to encourage shark fishing nations (targeting or regularly catching as bycatch) to follow the aims of the shark-plan that ultimately should help improving shark stocks and ensure long-term sustainable use of the animals. In 2011, a plan was in existence, but due to volatility and general errors within the previous version, the scientists in charge of collecting data and developing an NPOA-shark plan had to make several revisions (Interviewee I). After the revised plan is finished, it has to be approved by higher levels and the FAO, before it can be implemented (Interviewee I). A new, updated version has been developed now, and currently, the officials are reviewing it to determine if it can be approved and, thus, implemented, which is a lengthy process that takes time before reaching the final step (Interviewee I). Currently, the priorities of Thailand's NPOA-sharks plan are to systematically and persistently collect and analyse data on shark and ray biology, fishery and utilisation and to exchange the information gathered with national and international stakeholders. To arrange educational seminars and consultation meeting, while it is expected that vulnerable shark species will receive priority in the plan (Sattar & Anderson, 2011; Fischer et al., 2012; Appendix 1). Figure 6 shows the 10 aims of the shark-plan formulated by the FAO, which should optimally be followed by nations or regions that regularly harvest sharks.

1. "Ensure that shark catches from directed and non-directed fisheries are sustainable.
2. Assess threats to shark populations, determine and protect critical habitats and implement harvesting strategies consistent with the principles of biological sustainability and rational long-term economic use.
3. Identify and provide special attention, in particular to vulnerable or threatened shark stocks.
4. Improve and develop frameworks for establishing and coordinating effective consultation involving all stakeholders in research, management and educational initiatives within and between States.
5. Minimize unutilized incidental catches of sharks.
6. Contribute to the protection of biodiversity and ecosystem structure and function.
7. Minimize waste and discards from shark catches in accordance with article 7.2.2.(g) of the Code of Conduct for Responsible Fisheries (for example, requiring the retention of sharks from which fins are removed).
8. Encourage full use of dead sharks
9. Facilitate improved species-specific catch and landings data and monitoring of shark catches.
10. Facilitate the identification and reporting of species-specific biological and trade data."

Figure 6: *The 10 aims of the IPOA Shark-Plan (FAO, 1999, pp. 14)*

Thailand is also a member of CITES (Convention on International Trade in Endangered Species of Wild Fauna and Flora), an international trade agreement between nations aiming at controlling trade of threatened and potentially threatened animals (Klein, 2014; CITES, 2015). Currently, eight sharks are listed on the CITES appendix II, including the Whale shark (*R. typus*), Basking shark (*Cetorhinus maximus*), the Great white shark (*Carcharodon carcharias*) and more recently (since 2013), over the objection of Thailand (Wipatayotin, 2013), the Oceanic whitetip shark (*Carcharhinus longimanus*), the Scalloped hammerhead shark (*Sphyrna lewini*), the Great hammerhead shark (*Sphyrna mokarran*), the Smooth hammerhead shark (*Sphyrna zigaena*) and the Porbeagle shark (*Lamna nasus*) (Klein, 2014; CITES, 2015). Six of these species inhabit Thai waters. In order to make any international trade with these species, all parties would need a trade permit from CITES, authorising that the species have been harvested sustainably and on legal terms (Klein, 2014; Hepp & Wilson, 2014; CITES, 2015).

Opportunities

Shark diving has become a popular tourist attraction in many countries, which provide an economic incentive to conserve these animals, (Gallagher & Hammerschlag, 2011; Vianna et al., 2011b; Sattar & Anderson, 2011). Thailand has numerous MNPs with fishing restrictions and artificial reefs, which supposedly could provide perfect conditions to discover high biodiversity environments by diving with sharks.

> "Yes, [Shark diving in Thailand] is definitely interesting. For dive tourists it is quite attractive to see sharks and this may have some impact on the fishermen. The tourism industry has a lot of power and they can put a pressure on the fishery. […] A good way to use diving and tourists to conserve and protect sharks" (Interviewee F).

The tourism industry is an important economic sector for Thailand and is currently contributing to around 20% of Thailand's overall Gross Domestic Product (GDP) (WTTC, 2015). The revenue generated from this sector could be used to find a solution to the declining resources and as well providing alternative livelihoods to people needing employment (Chuenpagdee & Pauly, 2003).

2.4 Sharks as a Non-Consumptive Resource

2.4.1 The Diving Industry

South-East Asia is a prime location for diving, as it can offer good and warm water conditions, coral reefs, abundant marine life and well-established infrastructure to access the dive destinations (Dearden & Manopawitr, 2010; Lew, 2013). Diving is one of the most popular water activities in Thailand (TAT, 2015) and is generally highly prioritised among tourists visiting the country (Bennett et al., 2003; Dearden et al., 2006; Worachananant et al., 2008). Estimated numbers show that the influx of divers visiting Thailand has been gradually increasing for at least 10 years, reaching around 1.6 million dive tourists in 2013, which accounted for more than double as many in comparison to 2003 (SMART, 2008). Scuba diving is possible both in the Andaman Sea and in the Gulf of Thailand (Dearden & Manopawitr, 2010). On the west coast, the most popular dive "hub" is Phuket from where divers can go to Koh Similan, Koh Surin and even as north as Burma's Mergui Achipelago.

In beginning of the millennium, it was estimated that dive tourists in Phuket annually contribute with around US$ 150 million to the local economy from expenditures on food, hospitality, retail, transportation, etc., (Bennett et al., 2003). While similarly on the east side, where Koh Tao and Koh Phangan (KTKP) are the more popular dive locations, a study showed that the entire tourism sector on Koh Tao generates on average US$ 62 million per annum, which is largely supported by tourists travelling to the island to take diving instruction and certification (Dearden & Manopawitr, 2010; Larpnun et al., 2011). As a part of the increasingly growing tourism industry in the 1980s, these numbers clearly illustrate that the diving industry in Thailand has become an important, economic contributor to many coastal communities by attracting a regular run of dive tourists which increase the cash flow in the community and similarly financially supports a variety of local businesses including shops, accommodation, tourist and travel agencies, etc. (Newman & Medcraft, 2002; Bennett et al., 2003; Dearden & Manopawitr, 2010; Gallagher & Hammerschlag, 2011).

2.4.2 Shark Diving in Thailand

Since the seasonal Whale shark migrations[9] through the Andaman Sea were initially recorded in the early 1990s, Phuket became a well-favoured dive destination for Whale shark diving (Dearden et al., 2007). At the beginning of the 2000s, it was estimated that the whale shark industry in Phuket could generate at least US$ 3 million in the peak tourist season (Newman & Medcraft, 2002), but with their seasonal migration (Taylor, 1997) and a potential life span of up to 100 years (Taylor, 1994) (as cited in Colman, 1997, pp. 1225), the Whale sharks could in reality revisit for generations and generate economic returns year after year. In spite of its great benefits, much indicate that Whale shark sightings are in dramatic decline along the Andaman Sea. Long-term monitoring data collected by a dive operator in the Andaman Sea showed that Whale Shark sightings have increasingly been reducing and in the period from 1998 to 2001 the sightings had dropped by 96% (Theberge & Dearden, 2006). These trends were largely confirmed by a number of people related to the Phuket diving community. An explanation for these trends was not confirmed, but a number of reasons were considered possible factors to the overall decline (Theberge & Dearden, 2006).

The study mentioned that a potential change of the plankton production could have modified the seasonal migratory behaviour of the Whale sharks or a depletion of the pre-existing population congregating on the west coast of Thailand due to overfishing could have resulted in fewer sights as well as increased disturbance from a higher number of divers in the water (Theberge & Dearden, 2006). This, however, was of greater concern to the diving community in Phuket, as a study later revealed that encountering whale sharks and other shark species in concert with clear water and intact dive sites were given high priority among the divers and one of the main drivers for choosing to dive in Phuket, but due to low shark-sights and pauperised marine environments, divers were increasingly left dissatisfied (Bennett et al., 2003).

The growth curve of dive operators in Phuket (Figure 7) illustrates that there was a vast increase in the establishment of dive companies in the early 1990s until the late 1990s, but around 2000 the curve stagnated and was subsequently followed by a continuous decline.

[9] From October to May

Topelko & Dearden (2005) argue that the high level of customer dissatisfaction due to low shark-sightings may be a consequence from the divergence between the consumptive and non-consumptive use of sharks in Thailand.

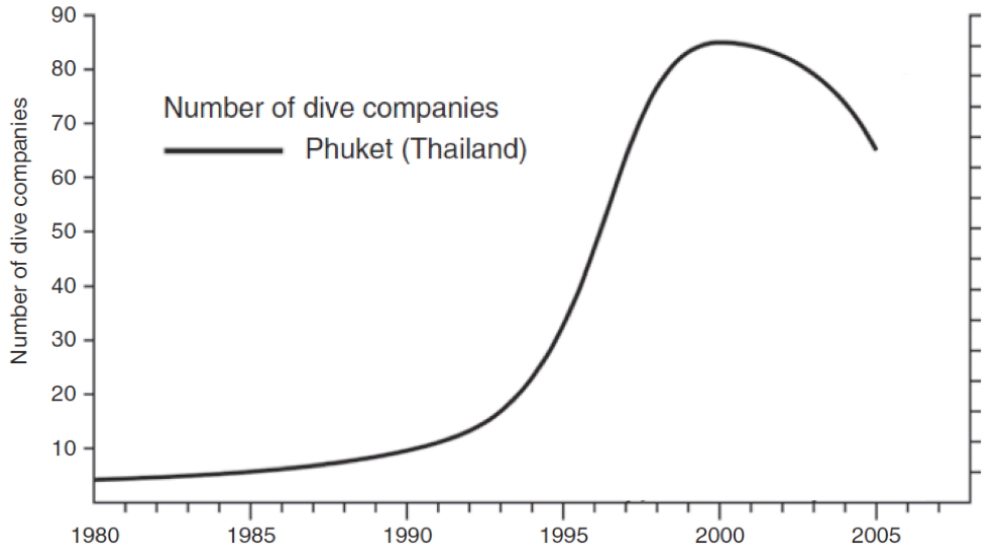


Figure 7: *Number of visitors at different dive operators from 1980-2007.* Source: Dearden *et al.* (2007) (Modified)

Apart from the Whale shark, there are several of other shark species[10] considered commercially significant in the diving industry, which can be observed at dive sites in the Andaman Sea and in the Gulf of Thailand (Ward-Paige & Lotze, 2011; Vianna et al., 2011a; Vianna et al., 2011b; Gallagher & Hammerschlag, 2011; Huveneers & Robbins, 2014). But a more recent study based on dive instructor observations reported that numbers of sharks (and diversity at some sites) had diminished somewhat in the 1990s-2000s and that the current level of abundance was likely only representing a small percentage of the original shark biomass (Ward-Paige & Lotze, 2011). These results correspond to the declining shark stock trends observed in the post-years of the introduction of trawlers, which showed that the CPUE had reduced with almost 75% from 1963-1972 (Pauly, 1979). Thus, even though there still are a few places left to find sharks, much indicates that shark sightings generally are becoming a rarity in Thailand and that often there are

[10] Zebra sharks (*Stegostoma fasciatum*), Blacktip reef sharks (*C. melanopterus*), Bamboo sharks (*Chiloscyllium spp.)*, Whitetip reef shark *(T. obesus*), Blacktip sharks (*C. limbatus*), Oceanic whitetip shark (*C. longimanus*), Tawny nurse sharks (*Nebrius ferrugineus*), Grey reef sharks (*C. amblyrhynchos*) and Bull sharks (*C. leucas*)

insufficient numbers of sharks in the water to justify incorporation of "shark dives" into dive business operations (Interviewee E).

> "From the dive industry point of view, we want more sharks. We would like to be able to see more sharks, [but] we can't do any shark dives here [in Phuket], because we don't have sufficient sharks" (Interviewee E)

2.4.3 Shark Diving Tourism - a Global Perspective

With an increased popularity in particular experienced in the last two decades, shark-based dive tourism has globally become a thriving industry that supplies at least an estimated US$ 327 million to local economies worldwide (Cisneros-Montemayor & Sumaila, 2014). A number of studies have demonstrated that the non-consumptive use of sharks through shark-based diving is a sustainable and attractive, economic alternative to consumptive use of sharks, which under the right conditions and proper management, can benefit multiple businesses across sectors, supply millions of dollars to local economies, create growth in tourism and similarly increase government motivations to implement stricter management measures focussing on the conservation and protection of the existing shark stocks (Quiros, 2005; Brunnschweiler & Earle, 2006; Topelko & Dearden, 2005; Vianna et al., 2011b; Cisneros-Montemayor et al., 2013; Ward-Paige, 2014; Hepp & Wilson, 2014; Huveneers & Robbins, 2014).

In 2009, Palau was the first nation in the world to declare their entire EEZ a shark sanctuary due to the large economic return generated by shark-based diving, which comprised of 8% of the country's total GDP. Besides directly benefitting the shark-based dive operators, the economic benefits from the businesses would also indirectly supply the local communities with different sources of income and yield around US$ 1.5 million through annual tax (Vianna et al., 2011b). Thus, in order to curb the shark fishery in national waters and to promote the diving industry, a comprehensive ban on shark fishing and a prohibition on the trade of all shark-derived products were initiated (Vianna et al., 2011b). This initiative was later followed by several other countries including, Maldives, Honduras, Bahamas, etc. (Hepp & Wilson, 2014; Hoyt, 2014 MCI, 2015). The study based on the economic value of the non-consumptive use of sharks in Palau revealed that if the reef sharks were kept alive in the ocean the economic return would by far outweigh the revenue from the consumed sharks. The results proved that the consumptive use of a group of 100 individual reef sharks would only generate a fraction (0.006%) of the US$ 200

million they contrarily would produce through shark-based tourism over a typical shark life span of 16 years (Vianna et al., 2011b).

Meanwhile, a similar study estimated that 78% of all the divers visiting Fiji travel to the country specifically to dive with sharks. In 2010, the shark diving industry contributed with US$ 17.5 million in government tax, which derived from corporation taxes from the industry itself and taxes paid by the shark-divers (Vianna et al., 2011a). Of the total output, at least US$ 4 million went into local communities through wages supplied by the industry or as 'community levies' paid by dive operators in order for the industry to enter the shark locations - a management tool that contributed greatly to the conservation of the reefs (Vianna et al., 2011a). Based on the contingent valuation method, a number of studies have also highlighted that divers are increasingly becoming more willing to pay additional money on top of their dives in order to explore healthy marine environments with sharks (Waheed, 1998[11]; White, 2008; Cisneros-Montemayor et al., 2013) and provided that management of for example 'marine park fees' is transparent, most customers are willing to contribute to sustainable management of whale shark experiences (Davis & Tisdell, 1999). In 2013, it was estimated that 590,000 divers were engaged in shark diving worldwide but as the global demand for shark diving has been in constant increase since the 1990s (~30%/annum), these trends were expected to be 2.5 times higher in two decades (Cisneros-Montemayor et al., 2013).

In an ideal world, countries where shark diving and shark fishing are simultaneously operating, a full ban on shark fishing should be implemented in favour of the sharks and the diving industry (Topelko & Dearden, 2005), but if unattainable, strict management of the shark fishery must be implemented to ensure the sustainable use of the sharks (Topelko & Dearden, 2005; Cisneros-Montemayor et al., 2013; Huveneers & Robbins, 2014). Shark fishing can hamper the shark diving industry in a few ways, mostly as a result from overfishing of the current shark stocks, normally used by the diving industry and from preventing the shark-based dive industry from expanding and prospering (Topelko &

[11] As cited in Anderson & Waheed, 2001, pp. 2

Dearden, 2005). A case in the Maldives showed as 20 grey reef sharks (*Carcharhinus amblyrhynchos*) disappeared from a local dive site due to overfishing, dive operators in the area could no longer promote the location as a shark site, eventually ending up in annual losses to the dive companies of US$ 500,000, while a single shark produced no more than US$ 1,000 on the market (Anderson & Waheed, 1999). But if the extraction of resources from the fishing grounds is providing a source of income to the fishers, it would seem illogical for them to refrain from fishing there without compensation (Topelko & Dearden, 2005; Lunn & Dearden, 2006; Bennett & Dearden, 2014), therefore, excluding the fishers from an area without any alternatives to replace lost income may exacerbate conflicts and will likely just decrease the will to collaboration (Bennett & Dearden, 2014).

Thailand provides shark diving while on the same time, the local shark population is harvested, which already seems to constrain the shark diving from prospering (at least seen in Phuket) (Topelko & Dearden, 2005; Gallagher & Hammerschlag, 2011; Cisneros-Montemayor et al., 2013; Huveneers & Robbins, 2014). Even if the tourism industry is economically powerful in Thailand (Interviewee F), there will likely still be complications with a future protection of sharks, as the shark fishing industry provides instant revenue, which may seem greater in the moment rather than in the longer term (Topelko & Dearden, 2005; Klein & Techera, 2014). This is, however, different in countries with insignificant shark fishing, where little or nothing has to be "sacrificed" in order to maintain the shark stocks (Topelko & Dearden, 2005). As a result, most shark fishing nations are probably less likely to introduce shark-fishing bans due to the economic uncertainty of the future (Topelko & Dearden, 2005). The stakeholders dependent on the sales of shark products will have to find new sources of income, which may leave many people out of jobs, business or earnings - likewise a situation no government wishes to bring down on the people. Similarly, if the economic profit from shark diving is not significant, it may, from a government point of view, not seem very advantageous to ban shark fishing and instead promote shark diving (Topelko & Dearden, 2005; Klein, 2014). Additionally, in cases where the fishery is considered unsustainable, stakeholders involved in the industry should seek other alternative incomes, which likewise could be supplied by the shark-based dive businesses (Topelko & Dearden, 2005; Klein & Techera, 2014).

However, in order to make a shark-based dive industry a profitable and sustaining business, healthy shark stocks are foremost needed which assures sight-predictability, a general know-how of where and when to locate the sharks, proper management of the resources to avoid exceeding carrying capacity as well as ensuring a balance between gain and maintenance costs (Bennett et al., 2003; Graham, 2004; Topelko & Dearden, 2005; Bennett et al., 2007, Vianna et al., 2011b; Cisneros-Montemayor & Sumaila, 2014). An overwhelming number of papers have provided evidence showing that the non-consumptive use of sharks greatly exceeds the economic value of the consumptive use of sharks but in the absence of effective conservation and fishery management in countries comprising both industries, the shark-based dive industry is likely to suffer as a response to falling numbers of shark-sights (Anderson & Waheed, 1999; Anderson & Waheed, 2001; Graham, 2004; Topelko & Dearden, 2005; Quiros, 2005; Vianna et al., 2011a; Vianna et al., 2011b; Cisneros-Montemayor et al., 2013).

3 Materials and Methods

The thesis approached a multi-method research, which combines two or more data sources to elucidate the presented research questions (Bryman, 2002). A multi-method approach, which increasingly comprises of qualitative and quantitative research (Bryman, 2002), can be helpful for studies involving two different, but interrelated situations (Bryman, 2002), while also adding substance and setting the context into a greater perspective (Esteves & Pastor, 2004). The combination of qualitative and quantitative research methods has given the researcher a broader insight in the fishing and diving industries, which in due course allowed depicting a more inclusive representation of the overall usage and value of sharks in Thailand (Bryman, 2002).

Refinement of Data Gathering

It was necessary to gain some background information from the fishing and diving industries through a thorough literature search. This made it possible to formulate the research hypothesis that in Thailand the profitability of the two industries which rely on sharks shows diverging trends: it is falling for the fishing industry while it is rising for the tourism (diving) industry, provided that the decline in stocks is stopped. The findings from the literature search have been verified by field research, which consisted in personal observations, informal interviews and surveys. A number of semi-structured and unstructured background interviews were also conducted before commencing collecting the primary data to gain a wider perspective of the industries and to get familiar with a new culture. The interviews provided a useful understanding of the current situation and the usage of sharks in Thailand, how to communicate with people and which approaches that would be useful to take in order to avoid causing offence. Each interview was recorded and fully transcribed. One interview was conducted in Thai and subsequently translated into English (Bernard, 2006). Additionally, having a co-advisor living in Thailand was also very important for the entire process and structure of the thesis. The co-advisor could provide relevant insight information and give constructive guidance, make sure that the plans initiated were realistic in a Thai context, as well as arranging interviews significant for the thesis. As a result, the background information and assistance received from the various channels have been an essential precursor of this study, especially in terms of formulating ideas, thoughts and for establishing the course of direction.

Essence of the Study

In its essence, the study comprises of shark landing observations, informal interviews conducted at the port of Songkhla and dive industry surveys to investigate the market for sharks from a consumptive and non-consumptive perspective. The thesis also includes minor parts and management recommendations from the semi-structured and unstructured interviews. In addition, it should be mentioned that the researcher was unexpectedly invited and introduced to the processing area multiple times, which allowed her to observe how the sharks are cut, dried and processed; hence, a more in depth process description of the shark products will also be included in the study as additional information about the industry. To make it clearer which approaches that have been pursued for the study, Table 4 presents an overview of the methods used and the number of people that participated.

Table 4: *An overview of the different stakeholders approached and the methodologies applied in the study. The table is inspired by Vianna et al., 2011b.*

Structure	***N***	**Landing Observations**		**Date**	**Loc***
Landing observations	15	Port of Songkhla		Oct 2014-Jan. 2015	S
Structure	***N***	**Interviewees**	**Alias**	**Date**	**Loc***
Informal interview	3	Boat Owners	A	November 2014	S
Informal interview	1	Middleman	B	November 2014	S
Informal interview	1	Captain	C	November 2014	S
Informal interview	1	Process Manager	D	November 2014	S
Structure (Background)	***N***	**Interviewees**	**Alias**	**Date**	**Loc***
Unstructured interview	1	Operation Manager	E	September 2014	P
Semi-structured interview	1	Fishery Scientist	F	October 2014	S
Unstructured interview	1	Shark Researcher	G	November 2014	HY
Semi-structured interview	1	Retired Fisherman	H	November 2014	S
Semi-structured interview	1	Fishery Biologist	I	January 2015	HY
Structure	***N***	**Respondents**		**Date**	**Loc***
Online questionnaire	36	Operation Managers		Nov. 2014-Jan. 2015	T
Online questionnaire	35	Dive Instructors		Nov. 2014-Jan. 2015	T
Printed Questionnaire	240	Dive Tourists		Nov. 2014-Jan. 2015	KTKP; P

*Locations: HY: Hat Yai; KTKP: Koh Tao and Koh Phangan; P: Phuket; S: Songkhla; T: Thailand

3.1 Study and Distribution Areas

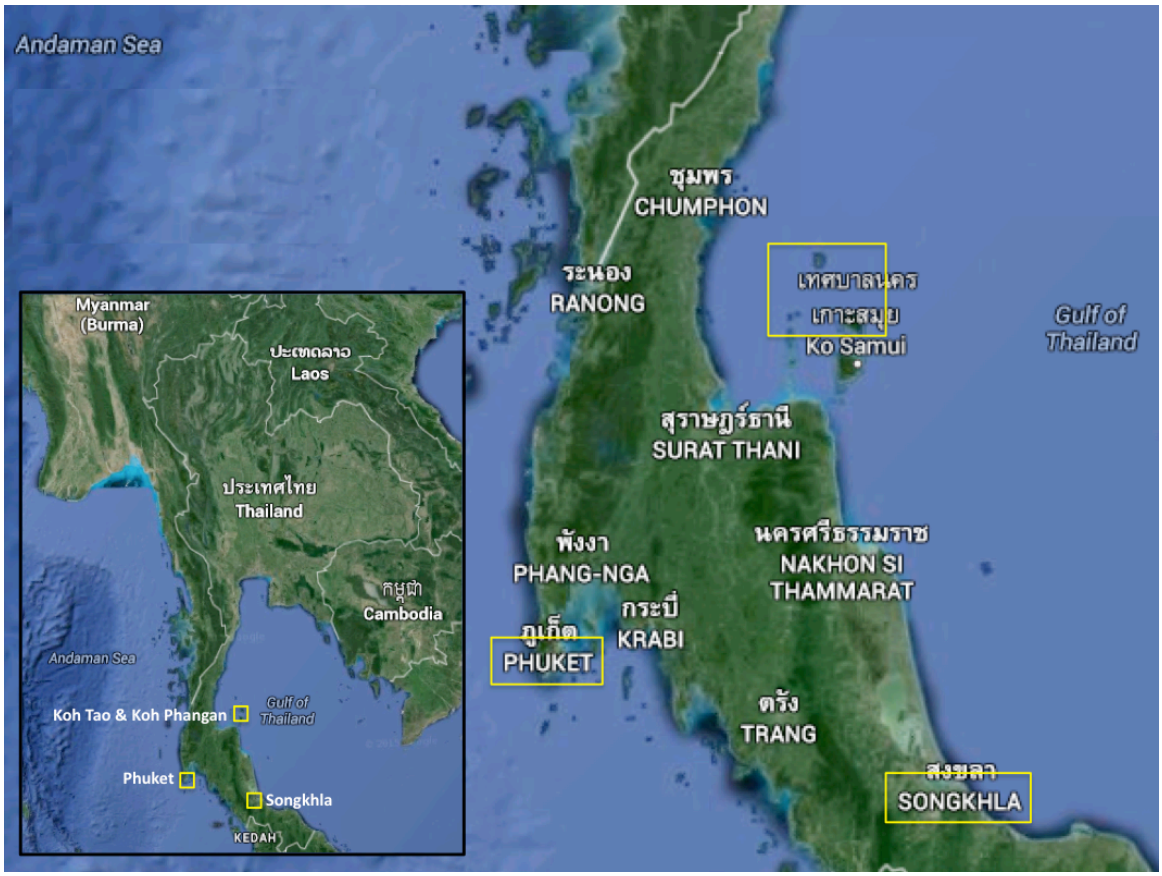


Figure 8: *Map of Southern Thailand showing the study and survey distribution areas: Songkhla, Phuket* and Koh Tao and Koh Phangan (above Koh Samui). Source: Google maps (2015)

Study Area

Data from the fishing industry was collected at the port of Songkhla (7°12′22″N and 100°35′48″E), which is located in the far south of peninsular Thailand, 80 km north of the border with Malaysia in the Gulf of Thailand (GoT). The site is one of the largest shark landing ports in the GoT (SEAFDEC, 2006a) and one of Thailand's most economically important fishing harbours (Keong, 1996; Vidthayanon, 1997; DoF, 2014). The fishing port has three principal landing sites (Achavanuntakul *et al.,* 2014) where fishing vessels like trawlers (otter board, pair and beam), gill netters, purse seiners, push netters, trammel netters, long liners land their catches (SEAFDEC, 2006; DoF, 2015). There are around 60-70 local, medium-scale trawlers (~14 m) that regularly dock at the port, which are owned by 10-15 different boat owners (Interviewee A). The medium-size pair trawlers (and otter board trawlers (12-18m) operate in Songkhla, Pattani, Nakhon Sithammarat, while the larger-size otter board trawlers (16-22m) go offshore to fish in Indonesia and Malaysia (SEAFDEC, 2006a). Several motherships (n=40) (SEFDEC, 2006a), which can carry up to

2000 barrels at the same time, are also docking at the port (Anon, pers. comm., Nov, 2014). They bring landings from the large-scale fishing vessels, mainly trawlers, that operate offshore (SEAFDEC, 2006a; Anon, pers. comm., Nov, 2014), which only dock every one or two years (Anon, pers. comm., Nov, 2014). Motherships can land catches from more than one fishing vessel, so it is not uncommon to have up to 10-15 large-scale fishing vessels unloading their catches to a single mothership (Anon, pers. comm., Nov, 2014).

On busy days, one can see around 300-400 workers arranging and counting the landings. Multiple middlemen are also running their own businesses at the same location. The catch is typically not sold to end users at the port, but a large number of middlemen buy products from multiple fishing boats to aggregate and sell to agents further along the value chain either at the port itself, redistributed to wholesale markets in Songkhla province (SEAFDEC, 2006a) or for shipment to larger markets (closer to Bangkok). The port of Songkhla was chosen as key study area for the fisheries aspect due to its proximity to the writer's main base and the fact that it is an economically important fishing port with large, regular shark landings.

Survey Distribution Areas

The dive tourist survey was distributed on three southern locations in Thailand: Phuket (7°53′24″N and 98°23′54″E), which is located at the Andaman Sea, Koh Phangan (9°43′0″N and 100°0′0″E) and Koh Tao (10°5′24″N and 99°50′17″E) (KTKP) which are islands in the Gulf of Thailand. While both locations offer whale shark diving (Newman & Medcraft, 2002), Phuket has a wide range of diving options for dive tourists (Dearden et al., 2006; Dearden & Manopawitr, 2010), including live-aboard trips (Newman & Medcraft, 2002), while KTKP are well-known for their low-priced dive courses and ideal water conditions for dive students (Larpnun et al., 2011). While being highly popular tourist destinations with well-established infrastructures and ease of accessibility, all three locations are considered some of the most famous dive locations in Thailand, so, each area has numerous dive schools and dive operators, which attract hundreds of thousands of dive tourists annually. In 2014, around 90-100 dive companies were operating in Phuket, while at least 60 and 16 operators were operating on Koh Tao and Koh Phangan, respectively. The audience groups differ somewhat from each other as Phuket tends to have more a

mixed diver clientele with low, medium and high levels of dive experience (Dearden et al., 2006), whereas divers diving at KTKP are typically the backpacker type, who are more inexperienced divers (MKS personal observation; Anon, pers. comm., 2015b). A study showed that the higher specialised divers in Phuket are increasingly more interested in the flora and fauna and shark sightings compared to lower specialised divers in Phuket (Dearden et al., 2006). Therefore, in order to reach the wider target groups, which tend to have different priorities and expectations when diving (Dearden et al., 2006), both areas were included in the survey to better represent the entirety of dive tourists in Southern Thailand.

3.2 Shark Landing Observations

From the end of October 2014 to the end of January 2015, 15 semi-quantitative shark landing observations were conducted at the port of Songkhla. There were no landings on two occasions due to harsh weather conditions, making it impossible for the fishermen to land the catches, thus, this paper only refers to 13 landings. The data was collected sporadically throughout four months: October (*n*=1), November (*n*=5), December (*n*=5) and January *(n*=2) in the period from around 6.30-9.30 am.

At this location, there is only one middleman who manages all the elasmobranches landings (sharks and rays). When the landed sharks have been chased from boat owners, the staff members arrange the smaller-sized sharks (<100 cm) in round laundry baskets (around 47*47*32 cm), while the larger size sharks are kept on the ground (Figure 9D). The smaller sharks are placed in different baskets according to their size (small, medium and large). Often, baskets are somewhat sorted according to species, thus, depending on the size of the shark, the baskets generally contain 10-16 sharks (around 50-100 cm) and weigh between 25-30 kg before they are sent off to the middleman's processing area or purchased directly at the port (Figure 9A). In contrast, baskets with neonates/juveniles (around 20-35 cm), (Figure 9B) may only weigh around 15-20 kg, but instead contain 60-100 small sharks. Where it was not possible to weigh or measure the sharks, some of the landings are estimated using these relationships. Since the weight of the baskets is somewhere between 25-30 kg, the total kilos landed was approximated as the midpoint (27,5kg/basket), if an observer was not present during the weighing process or able to request precise tally from the middleman (Figure 9C).

Figure 9: *A: Multiple baskets (25-30 kg/basket) containing Chilscyllium Spp. in the port of Songkhla. B: Juvenile and smaller sized Chilscyllium Spp., C: Weighing process and D: Six H. elongatus placed on top of baskets filled with H. microstoma on their way to the processing location (Port of Sonkhla, 2014- 2015)*

To reduce potential inaccuracies and data noise, notes and pictures were taken on each trip, along with regularly weighing and measuring of individual sharks landed in Songkhla and Ranong.[12] This was done either alone or together with a Thai shark researcher, with the purpose of improving the estimation and identification skills. It should be noted that if it was impossible to identify a species, the shark researcher went through the pictures and helped identifying the sharks. In an ideal world, the best approach would be to measure and weigh every individual shark, while a shark taxonomist identifies the sharks to species, but the laborious work of measuring and weighing all sharks was constrained by the desire of the fisheries workers to process the catch as rapidly as possible and so, it has not been possible to consistently measure every one of them.

During the landing observations, the researcher could stay in the background most of the time and take notes when the employees weighed the sharks in the baskets on scales, other

[12] A commercially important fishing port in the Andaman Sea.

times weighing was performed by the researcher or as previously mentioned it was wholly based on approximations. The landing estimations in terms of species identification and estimations of length and total biomass in kg were conducted to establish a rate of occurrence of the sharks (f = n/t) in order to calculate the revenue of the landed sharks from harvested to first middleman on a daily and weekly basis to understand the economic value of sharks as consumptive resources. The size estimations of the catches were also used to ballpark the percentage of undersized and small sharks landed to discover how many individuals are actually harvested rather than quantifying their weight in kilos. An identification of the sharks down to species level also allowed the researcher to identify if any of the sharks were listed on the IUCN Red List and if any of them were economically important species in the global diving community.

3.3 **Interviews**

Initially the plan was to survey a significant proportion of the shark fishermen at the port of Songkhla using questionnaires to learn more about shark fishing, product prices and the actors involved. A complete questionnaire was therefore written and translated into Thai. However, as time progressed, it was learned that a questionnaire addressing the fishermen was not an ideal approach to get that sort of information. The approach faltered because it seemed that a questionnaire would appear too institutional and formal or maybe because most fishermen are from Myanmar and Cambodia, nowadays, who do not read or speak Thai sufficiently well. Hence, the questionnaire was dropped and a series of informal interviews initiated (Bernard, 2006).

Four informal interviews were conducted at the port of Songkhla including, one with a middleman specialising in elasmobranchs at the port, one boat captain of a medium-scale trawler (14m) as well as three wives of boat owners, who together owned 22 medium-scale trawlers, and a manager at a nearby processing facility were interviewed. On each occasion, a Thai translator was present to translate the information from Thai into English. In order to make the interviews more open and naturally flowing, none of the interviews were recorded. Instead, the translator explained the findings during the communication, while notes were taken. After each interview ended, all the notes were reviewed with the translator to reduce possible misunderstandings and to increase accuracy. Also, after the

informal interviews had been written in a word document the translator went through the interview once more to confirm the accuracy of the information. During the informal interviews, a laminated prop sheet with pictures of shark species identified in Thai waters was provided to discover which species they potentially see and catch. This also served as a good icebreaker and became an important topic of conversation in many occasions (See appendix 2).

Informal interview: middleman

The goal of the interview with the middleman was to verify data and to collect general business information. To increase the accuracy of the landings estimations and determine if the catch composition is relatively unchanged throughout the year, information about the average kilos achieved per week, species composition and seasonality were obtained. Some information about the supply chain was also obtained, while the level of dependency on selling shark products and previous and current shark abundance were discussed in greater detail by the interviewee. Price information on the various shark products to establish a value chain and to calculate approximate weekly revenues from boat owner to middleman was not revealed during the interview as it was considered a business secret, thus, the researcher had to collect price information from other channels.

Informal interview: captain of a medium-scale trawler

The interview's objective was to obtain price details, but generally the fishermen and captains do not have any insight in the pricing of the sharks, so it was not possible to obtain any information from the interviewee. From this captain, it was possible learn about the previous and current shark abundance from the interviewee's personal observations and the level of economic dependency on catching sharks.

Informal interview: boat owners

The interview with the wives of boat owners aimed mainly to verify data and to acquire general business information. In an effort to increase accuracy of the landing estimations, the boat owners were asked about species composition, seasonality and an approximate number of individuals harvested on a daily basis. Price information, the level of economic dependency on harvesting sharks and factors controlling the prices were also explained

during the interview. The interviewees further shared personal observations of previous and current shark abundances.

Informal interview: processing manager

The interview was arranged in an attempt to get a deeper insight in the fishing business in Songkhla. Some product prices from the first middleman to the next middlemen were obtained during the interview, which assisted in establishing a more precise value chain of the shark products, although not to be considered complete in this paper. Information about the buyers and the supply chain was also shared, but due to a large number of involved parties on both domestic and international markets, a chain representing all the actors involved was unattainable, as it would have required much more time spent in the field. Therefore, this thesis presents the information that was collected and leaves the remaining gaps open for future research.

Additional information and stakeholder recommendations

Some additional information gathered from informal discussions with people in the fishing industry in Ranong and during market visits are also added in the study to fill in the gaps where there was a lack of information to outline a value chain. Management recommendations proposed during the informal, unstructured and semi-structured interviews will also be listed and combined in one overview in order to better illustrate needs and actions to be taken according to the stakeholders, of which some will form the basis of the section on management recommendations.

3.4 Diver Surveys

3.4.1 Dive Industry Surveys

A total of 71 respondents from the diving industry in Thailand participated in the survey from November 2014 to January 2015. The online questionnaires (n=2), which addressed either dive operation managers or dive instructors/guides were written in English and conducted via the web-based survey platform surveymonkey. The answers were downloaded from www.surveymonkey.com and analysed in excel sheets.

About 135 operators located at the coast of the Andaman Sea and 109 operators in the Gulf of Thailand were approached via an email, which included basic information about the researcher, a brief project description and links to the questionnaires. The email addresses were provided by a dive operation manager and retrieved from PADI's online dive shop locator. Follow-up emails were sent out after one week and three weeks later the participation from the dive instructors (*n*=23) and the managers (*n*=28) stagnated. As it was desired to reach a sample size of minimum 30 per target group, it was recommended by a group of individuals related to the diving industry to approach them in person rather than online, hence, a round trip in December 2014 to Phuket, Koh Phangan and Koh Tao was undertaken. During the visits, 60 dive shops were approached on the three locations, which in the end brought in 20 extra responses. By 1 February 2015, 36 dive operation managers and 35 dive instructors had completed the questionnaires.

Outline of the Survey

The questionnaires contained a combination of qualitative and quantitative questions using the Likert scale, closed and open-ended and multiple answer questions (See Appendix 3 and Appendix 4). On one side, this allowed the researcher to gather descriptive, in-depth information on shark diving in Thailand, but also collecting quantifiable data for numerical analysis and to measure the degree of agreement/disagreement.

The surveys were somewhat similar in structure, although with minor variances due to the respondents' different roles in the dive business. An issue with the use of Likert scale questions is that some respondents may potentially state 'agree' or 'disagree' without considering what they are actually asked about (Andersen et al., 2010). However, by adding a middle category such as 'neutral' 'maybe', etc., the risk of forcing respondents to state an opinion, which may result in random selection of the options, is reduced. The option also allows respondents who genuinely do not have an opinion on the given topic to remain neutral and the final result becomes more accurate and closer to reflecting the actual truth (Andersen et al., 2010).

The questions were arranged in an order with semi-difficult questions in the beginning, followed by more difficult ones, which finally lead to more basic and easy to answer questions in order to keep the respondent interested throughout the questionnaire and to

avoid survey fatigue towards the end (Andersen et al., 2010). Before the questionnaires were distributed, the surveys were pre-tested in order to minimise the potential of misunderstandings and to achieve final inputs in the case needed. The overall purpose of the questionnaires has been to investigate if there is a shark diving demand in Thailand, if it is economically viable to pursue shark diving in the current situation and to discover trends in shark abundance and the underwater environment (See Appendices 3 and 4).

3.4.2 Dive Tourist Survey

The estimated sample size necessary for a confidence level of 95% and a margin of error of 5% was 385 completed questionnaires. Due to time constraints, only 240 questionnaires were collected from divers from Phuket (n=126) and KTKP (n=114) from the end of November 2014 to the end of January 2015. This corresponds to a margin of error of 6.32% and a confidence level of 95%.

Survey Distribution

Numerous dive shops in Phuket, Koh Phangan and Koh Tao were contacted via email requesting assistance for questionnaire distribution. Their addresses were randomly retrieved from PADI's online dive shop locator or suggested by an operation manager thus, those who offered help, distributed the questionnaires. The questionnaire, which was distributed by five operators in Phuket, seven operators on Koh Tao and four on Koh Phangan, was handed out to the dive customers on the dive boats after they were finished with their final dives so they could answer the questionnaire partially based on their most recent diving experience in Thailand.

Structure of the Survey

The questionnaire consisted of questions predominantly based on the Likert scale, pictures, multiple choices and closed and open-ended questions (See Appendix 5). On the front page, the respondents could read information about the project, general facts about sharks from both the fishery and the diving industries perspectives and basic contact information about the researcher. The questionnaire had fewer questions and more Likert scale based questions compared to the online questionnaires, which inherently made the questionnaire slightly more quantitative than qualitative. This was a conscious choice because after a dive it is common to be exhausted (particularly so for inexperienced divers), so to

minimise the likeliness of skipped questions or respondent survey fatigue, the questionnaire was kept rather simple and quick to complete. Before the questionnaire was distributed it was pre-tested in order to reduce potential issues and misinterpretations.

Content of the Survey

The survey was based on the contingent valuation method (CVM), which is used to assign an estimated monetary value to an ecosystem service or a natural resource. (King & Mazotta, 2000). This method includes a question asking respondents to state their willingness to pay (WTP) to obtain a specific good/resource, which conversely allows placing an economic value to e.g. a [natural resource] commodity, which is typically not regarded as a market-product with tangible monetary values (FAO, 2000). For this thesis, the WTP method was used to explore if divers in Thailand are willing to pay additional money on top of the standard dive costs, to discover sharks upon diving and likewise to determine a potential "diver fee", which might be used to improve management of shark-prone areas/ Marine National Parks.

The divers were presented with two different hypothetical scenarios: scenario A represented an ecosystem with a high abundance of jellyfish and rays and scenario B represented an ecosystem with higher biodiversity and sharks (Figure 10). In order to estimate the economic value of the sharks as a non-consumptive resource in Thailand, the dive tourists were asked to state how much they were willing to pay (WTP) extra per dive if they selected scenario B. The respondents were then introduced to the idea of letting local communities patrol the areas and the monitors being paid monthly salaries covered by the "dive fees", which in return would allow the divers to continue, exploring and enjoying rich underwater environments with sharks.

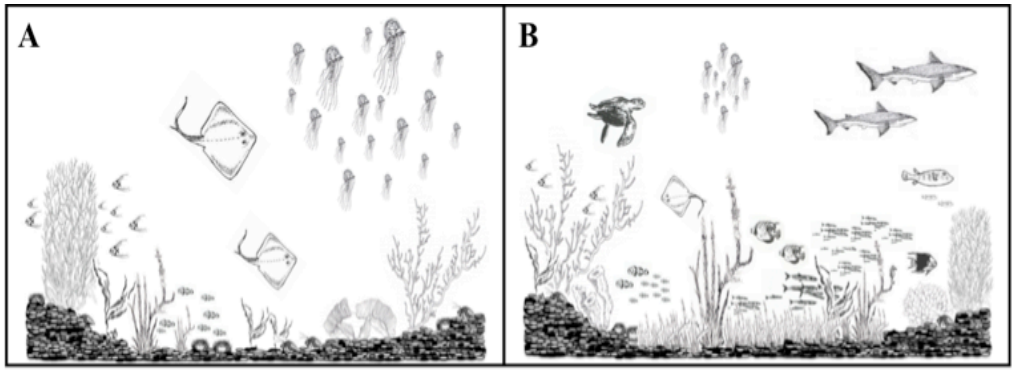


Figure 10: *The two different scenarios pictured in the diver survey*

Despite being one of the best methods to assess the economic value of an ecosystem service, in literature there is much controversy associated with the use of a CVM, especially in terms of representing the reality. Some respondents may give an unrealistic answer, which does not reflect their accurate WTP, thus, the value stated should be carefully interpreted (King & Mazotta. 2000). However, in the survey introduction, the respondents were encouraged to answer the questions as honestly as possible and before choosing the WTP, the divers were reminded to choose an amount that was realistic compared to their current level of income. In addition, a Pearson's r correlation was calculated to measure the level of associations of two independent variables. A t-test was also run to compare the mean WTP between the genders to elucidate if there were any statistical significance between the two groups. To determine if there were any correlation between the choice of WTP and other nominal variables, the following variables were measured, including gender, year of birth, level of income, nationality, and the total number of dives conducted. With the benefit of hindsight, the variable education should also have been included, which likely would have provided some interesting results.

The survey also probed into the divers' motivations for diving at certain locations and the level of importance they attached to sighting sharks during diving. On the first page, pictures were provided of seven different sharks to discover which species respondents were in favour of seeing while diving. The pictures were placed on the first page to stir a certain level of interest in the respondents, which perhaps could encourage more divers to participate. These questions were then followed by CVM related questions, which is the more difficult part of the questionnaire, as the divers would have to reflect on the monetary value they believed Scenario B was worth. The final part of the questionnaire contained information about their current dive(s), questions about shark conservation and finishing with personal, nominal questions (See Appendix 5).

4 Results

4.1 Shark Landing Observations

During 13 days, almost 5 tons of sharks (4,790±25kg) were estimated landed in the port of Songkhla (see Appendix 6). In total, approximately 2,500 individual sharks were observed and at least 10 different species and five families identified, which comprised of Carcharhinidae, Hemiscylliidae, Hemigaleidae, Scyliorhinidae and Sphyrnidae.

The species composition consisted:

1. *Chilscyllium* spp. (71.39%) (*C. punctatum* and *C. plagiosum*)
2. *Hemigaleus microstoma* (19.31%)
3. *Atelomycterus marmoratus* (5.94%)
4. *Hemipristis elongatus* (1.94%)
5. *Sphyrna lewini* (0.87%)
6. *Carcharhinus sorrah* (0.28%)
7. *Carcharhinus leucas* (0.20%)
8. *Sphyrna mokarran* (0.04%)
9. *Galeocerdo cuvier* (0.04%)

The sharks ranged from ~35 cm to ~290 cm and weighed between 0.10g and 295 kg. The data showed that almost all the sharks (97.8%) were less than one meter, 2% were 1-2 meters and only 0.2% was more than 2 meters. Although the small sharks (0-50 cm) took up a smaller percentage of the total biomass (3.71%), it was still the second largest group in terms of number of individuals caught (20.8%).

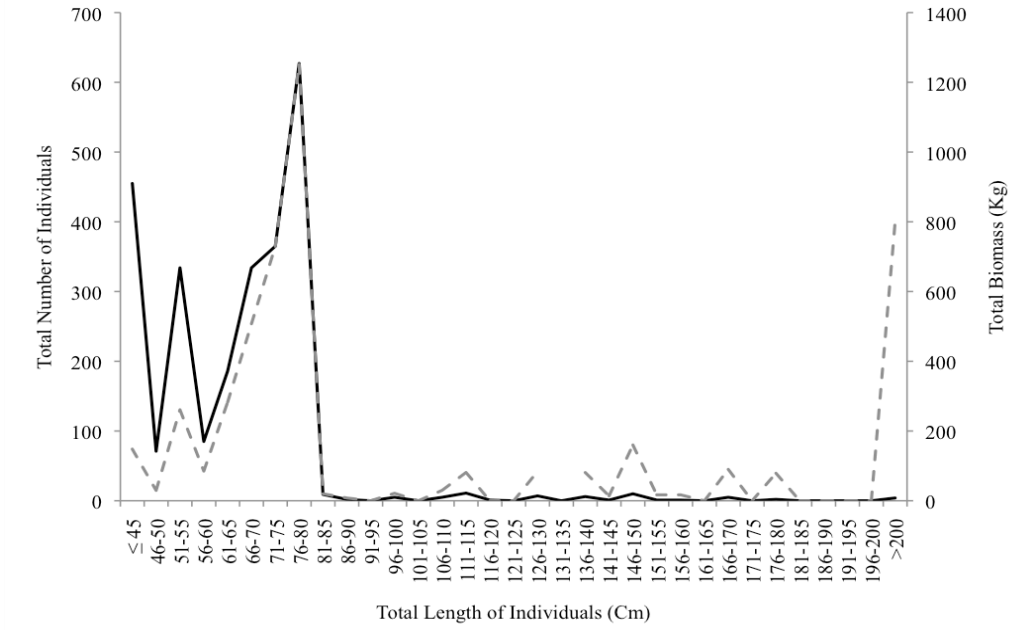


***Figure 11**: Biomass and abundance of landed sharks by size class*

Figure 11 illustrates that the number of individuals and biomass were generally higher among the smaller sharks, but that the biomass from only four large *C. leucas* sharks (800 kg) comprised of ~64% of the total biomass from the most dominant group recorded (76-80 cm), which consisted of ~630 individuals.

No information about the shark's gender or level of maturity was collected due to time and resource constraints, however, sexual maturity can still be estimated based on the size of the shark (Cortés, 2000). There is a difference between the *Chiloscyllium* spp., in terms of reaching sexual maturity. Both sex of the *C. plagiosum* reach sexual maturity around 65 cm (Chen et al., 2007) and *C. punctatum* (male) around 82 cm (Ebert et al., 2013), thus no *Chiloscyllium* spp. longer than 65 cm were included in the maturity estimations, but since *C. punctatum* was considerably more abundant than *C. plagiosum*, it is likely that more *Chiloscyllium* spp., were undersized. Table 5, which includes the 10 species observed in Songkhla, illustrates their different average lengths at 'birth' and at 'sexual maturity' as well as the 'minimum and maximum sizes' observed in the field. Apart from average 'life span' and 'habitat', the table also includes worldwide 'dive locations', where the species can be discovered by divers as well as the 'IUCN Red List Status' to highlight their current conservation status.

Table 5: *Identified species, including length at birth, maturity (cm), IUCN status and sightings on a global scale.*[13]

Scientific name	Common name	Born (cm)	Maturity (cm)		Observed Sizes (cm)	Life span (years)	Habitat	Diving Locations	IUCN Status
			Male	Female					
Atelomycterus marmoratus)	Coral catshark	10-13	47-62	49-57	35-55	-	Coral reefs	South Africa, Indonesia, Philippines	Near Threatened (NT)
Chiloscyllium punctatum	Brownbanded bambooshark	13-18	82	87	35-85	1-14	Coral reefs	Philippines, Singapore, Thailand, Vietnam	Near Threatened (NT)
Chiloscyllium plagiosum	Whitespotted bambooshark	9-12	65	65	35-85	1-14	Coral reefs	Philippines, Singapore, Thailand, Vietnam	Near Threatened (NT)
Carcharhinus leucas	Bull shark	56-81	157-226	180-230	180-290	32	Euryhaline freshwater and inshore	Bahamas, Cuba, Fiji, Florida, Mexico, Seychelles, South Africa	Near Threatened (NT)
Carcharhinus sorrah	Spottail shark	45-60	106	110-118	80-100	5-7	Continental and insular shelf	Maldives, Seychelles	Near Threatened (NT)
Galeocerdo cuvier	Tiger shark	51-76	226-290	250-350	110	20-22 (27-37)	Continental and insular shelf	Bahamas, Egypt, Fiji, Maldives, Mexico, Seychelles, South Africa	Near Threatened (NT)
Hemigaleus microstoma	Sicklefin weasel shark	26-28	75	75-78	45-80	-	Continental shelf	-	Vulnerable (VU)
Hemipristis elongata	Snaggletooth shark	45-53	110-145	110-170	100-180	-	Continental and insular shelf	Egypt, Maldives	Vulnerable (VU)
Sphyrna lewini	Scalloped hammerhead shark	42-55	140-165	212	50-100	35	Continental and insular shelf and adjacent deep water	Bahamas, Belize, Borneo, Costa, Rica, Egypt, Galapagos Islands, Hawaii, Isla Malpelo, Malaysia, Maldives, Mexico, Palau, Philippines, Seychelles, South Africa	Endangered (EN)
Sphyrna Mokarran	Great hammerhead shark	50-70	234-269	250-300	120	-	Continental and insular shelf and adjacent deep water	Bahamas, Belize, Costa Rica, Egypt, Hawaii, Malaysia, Maldives, Mexico, Palau, Philippines, Seychelles, South Africa	Endangered (EN)

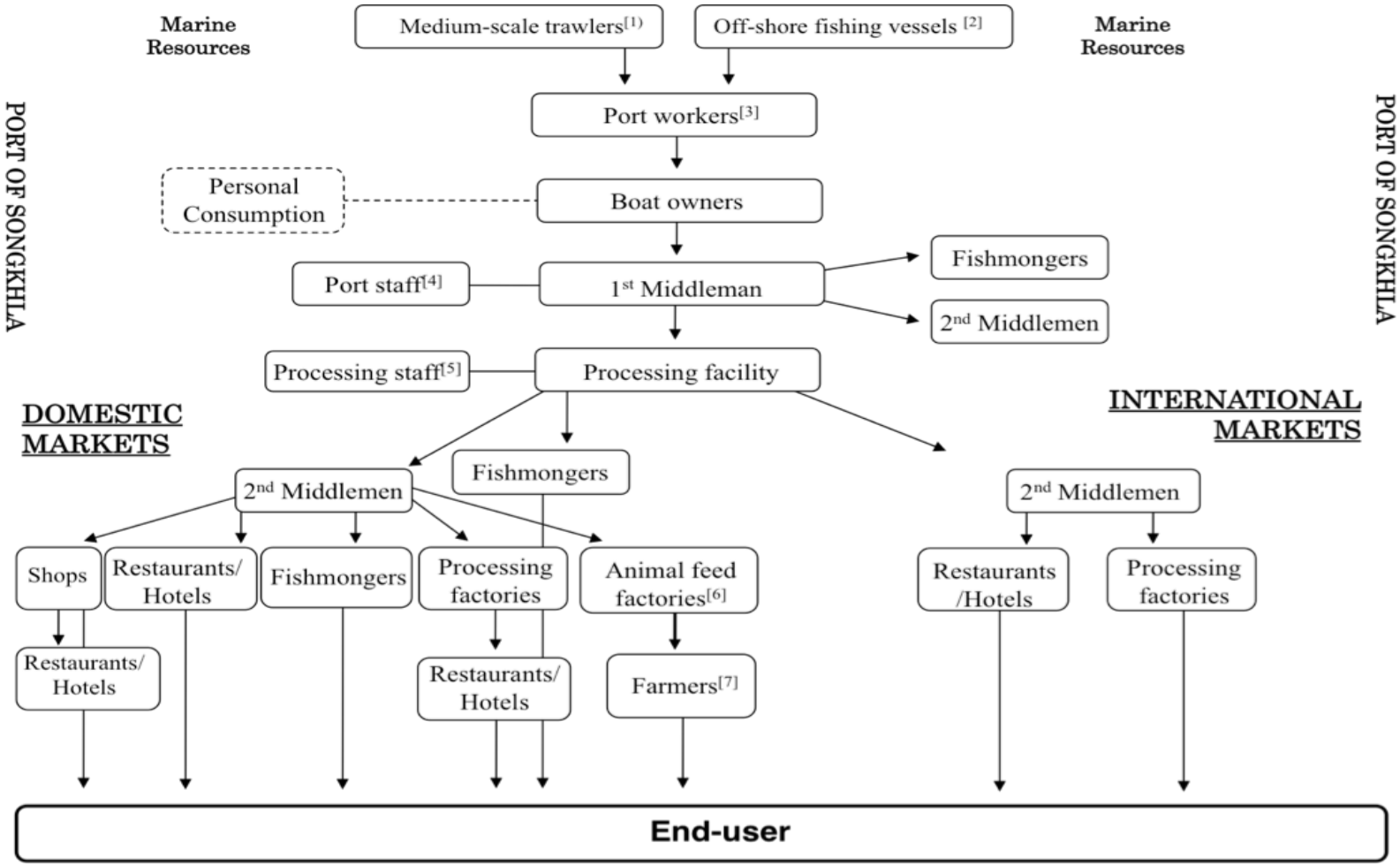
[13] References: Chen et al., 2007; White, 2009; Ebert et al., 2013; IUCN Red List, 2015

4.2 Market Survey

4.2.1 Supply Chain

There are several stakeholders involved in the supply chain of the landed sharks before reaching the end-users. The following section is by no means exhaustive; instead this should be regarded as a first attempt to set up an observed supply chain of the sharks landed in Songkhla. The information has been pieced together from multiple conversations with the first middleman and the manager at the processing area, including personal observations and conversations from market visits. On a market visit to Hat Yai, at least three different labelled bags with shark fins were discovered with two of them being produced in Hat Yai, Songkhla, suggesting that there are a number of manufacturers supplying the market in Hat Yai, while the third 'brand' contained no company label.

In addition, a fishery scientist explained that, in older times, some of the catches were personally consumed on a regular basis, but due to the small catches, nowadays, all landings are up for sale, hence, most of the sharks will probably not be consumed by the owners, friends or relatives, anymore. Therefore, dotted lines will indicate a link in the chain, which may *per se* not happen anymore. However, a number of the levels are entirely unconfirmed, especially the number of middlemen involved, which products are exported, distributed domestically or potentially exported and then re-imported. For these reasons it is not possible to predict what the whole chain structure is. For the most part, the section indicating domestic and international markets is, indisputably, a rough overview, partly based on verified information from stakeholders and partly informed guessing. Arguably, there are more actors involved in the international markets, as well as in the domestic markets, but since limited information was available about the international markets, the supply chain only illustrates the two identified levels (Figure 12).



[1] Catch from the Gulf of Thailand; [2] Catch from Indonesia, Malaysia, Singapore and Vietnam; [3] Up to 200-300 workers; [4] Around five staff members; [5] At least 10 staff members; [6] Higher grade for animals and lower grade for fertilisers [7] Pig, chicken and duck farmers and aquaculture farmers

***Figure 12**: An observed supply chain of the landed sharks in Songkhla, Thailand*

Marine Resources

The most frequently harvested sharks are the brownbanded bamboo shark (*C. punctatum*) and the whitespotted bamboo shark (*C. plagiosum*) as they are rather abundant throughout the entire year. They tend to weigh between one to three kilos, while larger ones may weigh up to five kilos. The coral cat shark (*A. marmoratus*) on the other hand, is not as abundant as the Chiloscyllium spp., but it is still rather abundant, so this species is also caught on a regular basis. The more infrequent and larger size sharks are mainly caught in international waters but, from time to time, large sharks are also caught in the GoT.

Harvested

Except from one observation where four *C. punctatum* were caught with hooks in the Eastern region of the GoT, sharks are either caught in national or international waters by nets and seldom by hooks[14]. However, the sharks are chiefly harvested in Indonesian waters by offshore, large-scale trawlers, while a smaller quantity is caught as bycatch in the GoT by medium-scale trawlers (14-18m). According to a number of stakeholders (n=4)[15], the medium-scale fishermen do not intentionally target sharks. Firstly, because it is not possible to perform deep-sea fishing with a medium-scale trawler, thus, sharks are only occasionally caught as a bycatch in the GoT. Secondly, because there are other much more abundant fish species that are easier to catch and, lastly, due to their relatively low-value. Therefore, targeting sharks is considered an unprofitable business as the economic return is insignificant in comparison to the revenue generated from others catches.

On average, the medium-scale trawlers typically do one to two hauls per day (5 to 6 hours/haul) for 10 whole days in the GoT, while catching approximately one to three sharks (about 40-50 cm) per haul. This means, if the 65 medium-size trawlers trawl two hauls for ten whole days, they should catch around 2,600 sharks, and if they trawl each day, the trawlers could bring in approximately 7,800 sharks on a monthly basis. The larger, off-shore fishing vessels that operate outside Thai waters in Indonesia, Singapore, Malaysia and Vietnam, often harvest the largest shark landings, as they can fish deeper, but also because the abundance of sharks is much greater outside the GoT. It was assumed by a

[14] Previously, sharks were often caught with hooks, but this rarely happens today (Interviewee B).
[15] Interviewees A and C

number of stakeholders (*n*=3) that many offshore trawlers "intentionally" catch sharks as a bycatch, as all catches currently have a market value.

Landings

After the sharks have been unloaded and received by the workers at the port, the boat owners weigh the sharks before selling them to the middleman. After the middleman has purchased the catches, the landings are brought to his business located at the port, where the port staff members weigh and arrange the catches once more. Depending on the quality and customer demand, the middleman either sells the products to local fishmongers and other middlemen straight at the port or processes/cuts the landings, at his family-run processing facility before reselling.

Processing Area

Around a dozen of staff members and a manager are working at the processing area; however, on occasions when larger landings need to be processed, which can take days, more staff may be needed. The staff members are usually skinning, cutting and cleaning the sharks and arranging the fins, meat, jaws/teeth on bamboo mats in an outdoor area for drying. The manager is in charge of the business and controls the daily running of the place.

Second Middlemen and Fishmongers

After the shark products have been cut or dried, second middlemen and fishmongers purchase them. After this level, the products firmly start diverging on either domestic or international markets (Table 6).

Table 6: *Supply chain in domestic and international markets*

Domestic Markets
Fishmongers sell **fresh meat** (perhaps also dried meat) on local and regional fish markets → (Likely) purchased by street food vendors, households, etc. *End-user(s):* Consumed domestically by households, customers, etc.
Second middlemen sell **fresh meat** to buyer(s) in Bangkok → (Likely) purchased by fishmongers, street food vendors, restaurants/hotel owners, etc. *End-user(s):* Consumed domestically by customers, households, etc. → (Likely) purchased by one or more processing factories ▪ (Likely) the processed products are purchased by street food vendors, supermarkets[16], restaurant/hotel owners, etc. *End-user(s):* Consumed domestically by customers, households, etc.
Second middlemen sell **dried meat** nationally (SEAFDEC, 2006a) → (Likely) purchased by shop and restaurant/hotel owners, fishmongers, street food vendors, customers. *End-user(s):* Consumed domestically by customers, households, etc.
Second middlemen purchase **dried, small fins** (<10 cm) and label/pack them at other location(s)[17] → (Likely) some in Songkhla ▪ Shop and (perhaps) restaurant/hotel owners in Hat Yai purchase dried shark fins from Bangkok *End-user(s):* Consumed by Chinese, Malay and Singaporean tourists in Hat Yai including the occasionally important officials
Second middlemen sell **off-cuts** nationally (SEAFDEC, 2006a) → Off-cuts are purchased by animal feed manufacturers ▪ Purchased by livestock and aquaculture farmers *End-user(s):* Consumed by livestock, including pigs, chickens, ducks and farmed fish and shrimps in aquaculture farming
Second middlemen purchase **jaws** and **teeth** → Purchased by souvenir shop owners *End-user(s):* Purchased by western tourists[18] → (Perhaps) also sold online internationally[19] *End-user(s):* North America, South America, Southeast Asia, Western Europe.
Second middlemen purchase **dried skin** → (Likely) purchased by shop and restaurant/hotel owners, fishmongers, street food vendors etc. *End-user(s):* Consumed by households and customers
Second middlemen purchase crude **shark liver oil** → (Likely) purchased by local and regional shop and restaurant/hotel owners, fishmongers, street food vendors. *End-user(s):* (Likely) consumed in Southern Thailand by households and customers
International Markets
Second middlemen sell **fresh meat** to buyer(s) in Malaysia[20] → (Perhaps) purchased by one or more processing factories → Purchased by restaurant owners in Malaysia using fresh meat in fish burgers *End-user(s):* consumed by customers in Malaysia
One middleman buys and resells all the **fresh, larger size fins** (>10 cm) to buyer(s) in Malaysia → Purchased by one or more processing factories in Malaysia ▪ (Likely) purchased by shop and restaurant/hotel owners in Malaysia *End-user(s):* Consumed by customers and households in Malaysia

[16] To the knowledge of the researcher, supermarkets mostly sell fishballs, surimi and imitated crab meat
[17] The processing facility in Songkhla does not label and pack the products.
[18] At least seen in Phuket
[19] http://www.alibaba.com/countrysearch/TH/shark-tooth-necklace.html
[20] Besides Malaysia, a middleman in Ranong also sells products to China

4.2.2 Value Chain

From harvested as a raw resource to finished product, multiple layers of value are added to the products. Especially because of time limitation, non-disclosure of price information, chain complexity and export, it was not possible to identify all the added values throughout the entire value chain. Therefore, due to the sparse price information gathered from the port of Songkhla, available data from Ranong and market visits to Hat Yai and Phuket, will be combined to create a better estimate of the value of the market products. This study only presents the first few steps in the value chain, which have been possible to extract including sporadic prices on products from the end-market. The chain should only be considered as the first effort to set up a value chain, as some levels are incomplete and need further research.

Raw marine resources → Fishermen

As the fishermen (harvesters) do not have any property claims over the harvested sharks, they do not have a say in the first added value, which happens during the exchange between the boat owners and the first middleman in Songkhla. Instead, the boat owners pay the fishermen a daily minimum wage set at a rate of THB 300 (US$ 8.30).

Boat owners → Middleman

At this level of exchange, the boat owners have no influence in the price-setting; the whole sharks are purchased at a fixed kilo price set by the middleman. The price is typically determined by a few factors such as the size and abundance of the shark species, consumers' demand and their economic status (incomes). For example, the *Chiloscyllium* spp. and *A. marmoratus* are smaller shark species, which are relatively abundant; hence, these sharks are less valuable compared to larger sized sharks or the less abundant species. More specifically, the middleman usually sets the price of the products according to the current customer demand and the level of the shark stocks, thus, if consumer demand is low, the prices will consequently fall. It is interesting to mention that prices in Thailand are not uniform, but as a whole there is only a small price variation (Anon, pers. comm., Dec, 2014).

First middleman → Second middlemen/Fishmongers

After the whole sharks have been processed at the processing facility, the middleman adds an additional value to the shark-derived products, which are then sold at higher prices to the next buyers. The second middlemen and fishmongers will add additional values to the products, which may change owners a few times, before finally reaching the retail-market. It should be mentioned, at the time of writing, it was unknown how many middlemen were involved in the chain, but it was assumed that each individual will likely add additional value in order to profit from the sales.

The following examples of a harvested, 2-meter long, 100kg *C. leucas* shark and a 80-100 cm long, 5 kg, *C. sorrah* shark illustrate how multiple layers of value can be added to the many products generated from one "raw" shark, only (see Figures 13 and 14). By the time the products enter the retail-market, the value of most of the products have clearly multiplied. Since it has not been possible to measure every part of the sharks or achieve a complete set of prices, the examples should merely serve as indicators, elucidating the increasing value of the shark products within the marketing processes. The examples present approximate prices on the products, while the dotted boxes denote that there are additional and unidentified values to some of the levels, which should be considered. Moreover, in order to make the estimations as realistic as possible under the given circumstances, the *C leucas* example is based on personal experience from a manager running a processing facility in Ranong, personal observation data as well as additional information on the physiology of the shark. In contrast, the *C. sorrah* example is slightly more approximated, as it does not include personal observations from a processor (See Appendix 7).

Value Chain Example: *C. leucas*

On the first level, the 100 kg raw shark is landed whole and sold for ~15,000 THB to the middleman (See Appendix 9 and Figure 13). In this context, it should be pointed out that a smaller size *C. leucas* will typically sell for ~THB 200-400/kg (US$ 5.60- 11.10), while the same species would have been sold for THB 45-50/kg (US$ 1.20-1.40) post-landing in 2003-2004 (SEAFDEC, 2006a). This shows a price increase of at least 530% in a little bit more than a decade. However, in Ranong, small *C. leucas* (~1m) sharks were observed

multiple times to auction prices of around THB 100[21], which is significantly different compared to the prices from Songkhla; thus, either there is a vast market price difference between Songkhla and Ranong or the THB 200-400/kg is slightly exaggerated.

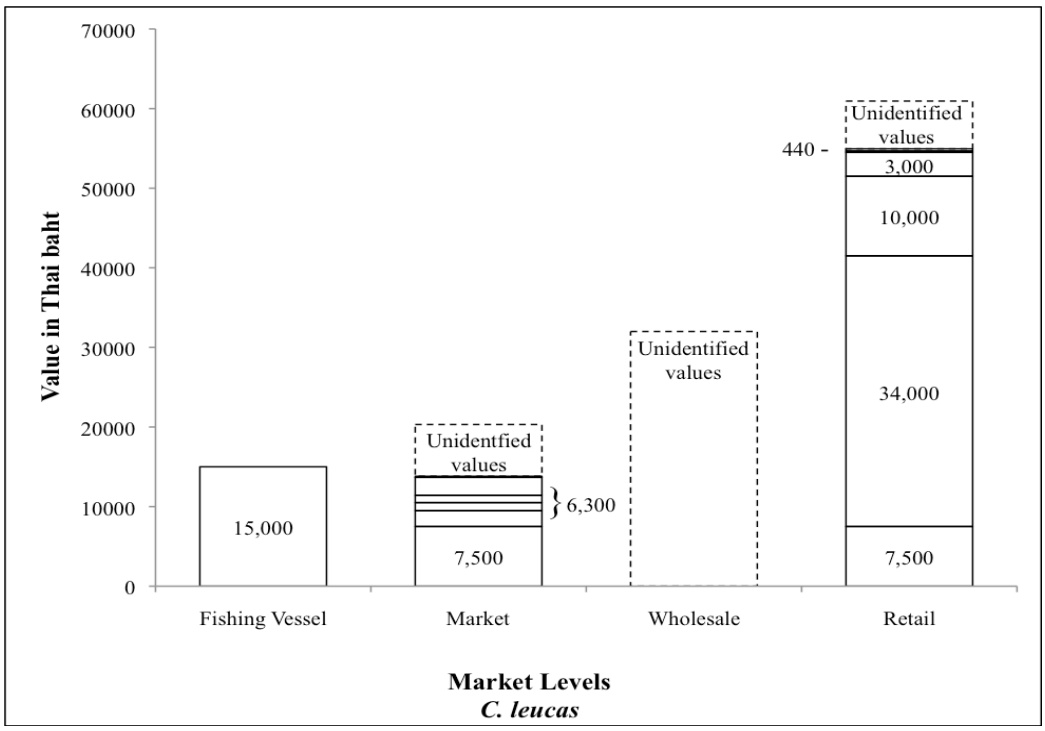


Figure 13: *An observed/estimated value chain for a C. leucas from harvest to end-market sale*

Continuing to next step of the value chain, table 7 shows that on the market level the shark has been cut and dried and will contribute with at least six shark-derived products (See Appendices 8 and 9).

Table 7: *Possible products and prices derived from a 100 kg C. leucas at market level*

Products	Prices at market level
Dried meat	THB ~7,500
Fins	THB ~2,000
Skin	THB ~900
Crude liver oil	THB ~2,300
Jaws	THB ~1,000
Off-cuts[22]	THB ~150
Unidentified values	(THB 6,000)
Total	THB ~14,000 (THB 20,000)

[21] From first middlemen to second middleman/next buyers
[22] Including: liver, head, remaining viscera and cartilage

The value from the presented products was estimated to be THB ~14,000, which noticeably is below the price for the shark post-landing, but due to limitations, it has not been possible to obtain precise information on the additional values added from market level to next agents. It can only be assumed that the shark will generate more revenue on market level than on the first [harvest] level, otherwise the business will lose revenue. Hence, there are evidently values missing, but the generated revenue is probably closer to THB 20,000 or more, as there has to be an economic gain from the processing processes.

The wholesale level remained unexplored, however, it is expected that the values will continue increasing, thus, the entire bar is higher than the previous level and dotted and labelled with unidentified values.

Table 8: *Possible products and prices derived from a 100 kg C. leucas at retail level*

Products	Prices at retail level
Dried meat	THB 7,500
Fins	THB 34,000
Skin	THB 3,000
Jaws	THB 10,000
Off-cuts	THB 280
Crude liver oil	THB 2,300
Unidentified values	-
Total	THB ~57.000

On the retail level the value of shark fins, the skin and jaws has increased a great deal compared to the first few levels. It is likely that the dried meat and the liver oil may also have price increases, but it was not possible to locate the products on the markets, hence, they will appear in the value chain with the estimated value from the market level: THB 7,500 and THB 2,300, respectively. The 5 kg fresh shark fins will be reduced to around 2 kg when dried and will probably bring in at least THB 34,000, the 6 kg skin has halved upon drying and it is worth THB 3,000 due to the shark species and its relatively large size. The jaws are expected to produce at least 10,000 THB, while around 20 kg off-cuts will become around 4 kg animal feed/fishmeal, which should be sold for about THB 280. Based on the current information, the revenue from first level to retail level shows that all the shark products combined may increase in value with at least 280%.

Value Chain Example: *C. sorrah*

Despite the fact that the *C. sorrah* is a smaller shark than *C. leucas,* it is still possible to discover similar value trends, as seen with the *C. leucas*. The *C. sorrah* is harvested and sold for ~ THB 500, but by the time it reaches the retail market, the identified shark-derived products should have increased to at least ~THB 3,250, which is a price increase of more than 550% (see Appendix 8 and Figure 14). It is unknown how large the jaws or the teeth are for a 5 kg *C. sorrah*, but if large enough, a single tooth can be used in a necklace and sold online for US$3 per piece (see Appendix 9).

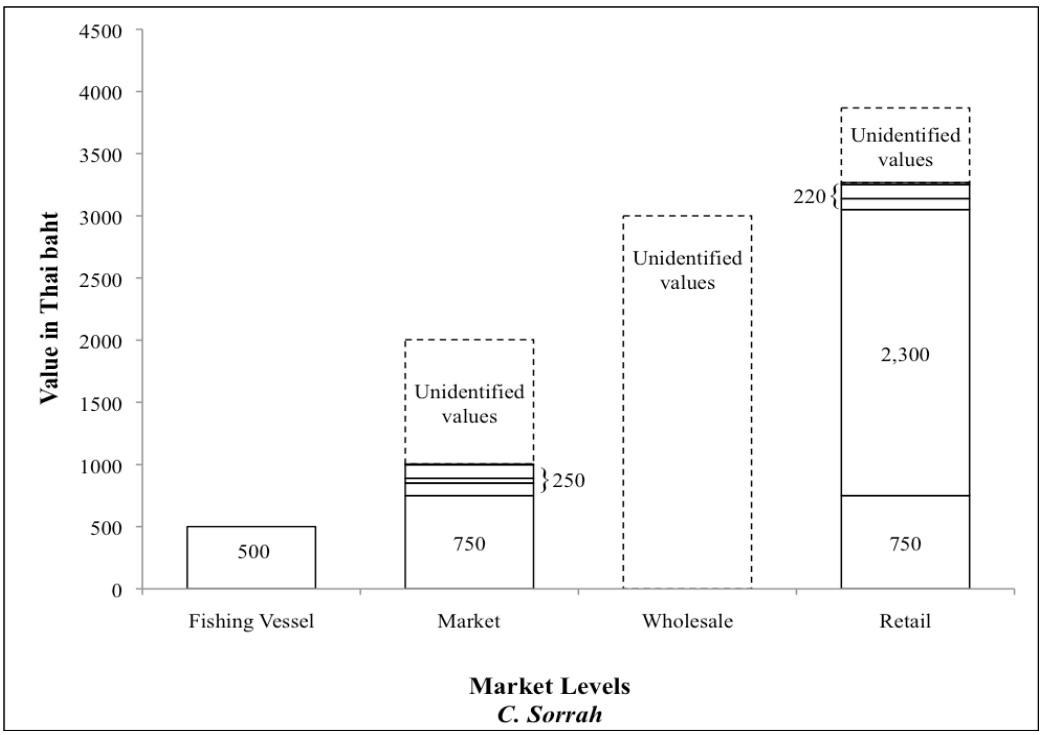


***Figure 14**: An observed/estimated value chain for a C. sorrah from harvest to end-market sale*

Regarding current and previous prices observed on the *C. sorrah*, the tendency shows again comparable price trends compared to the *C. leucas* (SEAFDEC, 2006). Although to a lesser extent, the *C. sorrah* was worth THB THB 45-50/kg (US$ 1.10-1.40) in 2003-2004, while it is now worth around THB 80-120/kg (US$ 2.20-3.30) (See Appendix 9), resulting in a price increase of approximately 110% in just over a decade. [23]

[23] *Additional information:* In 2003-2004, the C*hiloscyllium* spp. was worth THB 10-27/kg, but in 2014 the species was worth THB 25-40.

Clearly, there are shortcomings and deficient details at many levels, including the unknown numbers of middlemen between the different markets and the remaining unidentified values. However, the chains still indicate that there is a vast increase in the value of some of the products, while others are less valuable, especially the "fresh" products and that the prices of the shark-derived products increase in particular when reaching the retail levels. As soon as the first middleman transforms the whole raw shark into multiple products, additional monetary layers are created and added to the commodities. These results clearly underline the large price contrast between the lower valued raw shark as a harvested product opposed to the more costly shark-derived products post-processing.

4.2.3 Utilisation of Sharks

Except from the blood, all the parts from the sharks can be fully utilised, therefore, the action of shark finning does not seem to occur on the vessels that are landing catches in Songkhla, unless discharged on other destinations. The following section presents all the different products, which were introduced and explained during visits at the processing facility. The following results in this section are illustrated with pictures taking by the researcher.

Fresh and dried meat

The smaller sharks (<100 cm) are often sold fresh to other buyers on a daily basis, while the meat of the larger size sharks is typically chopped into smaller pieces and dried. The drying process takes a few days, as the meat first needs to be cut into fillets, and then soaked in salted or non-salted water basins for some hours, followed by a few days of drying on an outdoor terrace. Even though that whole sharks vary in prices, all meat is sold at the same price after being cut into smaller pieces. Local people are mostly interested in the meat rather than the fins; although, everything will be cooked together – even with the fins. Some of the more popular sharks on the market are 'Cha lam hu dams' (black fin sharks) because the meat is more delicious and many restaurants seem to be rather interested in purchasing them. However, it is the quality of the meat that determines whether it will be sold as fresh or dried meat. The fresh meat is typically consumed as fillets or made into fish patties for burgers, surimi, imitated crab meat or minced fish balls, while the dried meat is often used in fried food, barbeques and curries. Although the dried

meat is more expensive than fresh meat, the business still earns more money from selling fresh meat in the long run. This is due to the fact that there are more labour costs associated with the process of drying sharks than selling them fresh, hence, the middleman strives to sell as many of the sharks fresh, because he needs more personnel to work during the processing phase. Yet, this is not always possible. In some cases, the meat that travels from Indonesia is not good enough to be sold fresh, so it has to be processed into dried meat, as opposed to the sharks caught in the Gulf of Thailand, which travel shorter distances. Furthermore, the smaller sharks are often received in large quantities and in the event low demand (some weeks have lower demands), a good way to preserve the meat is by drying it.

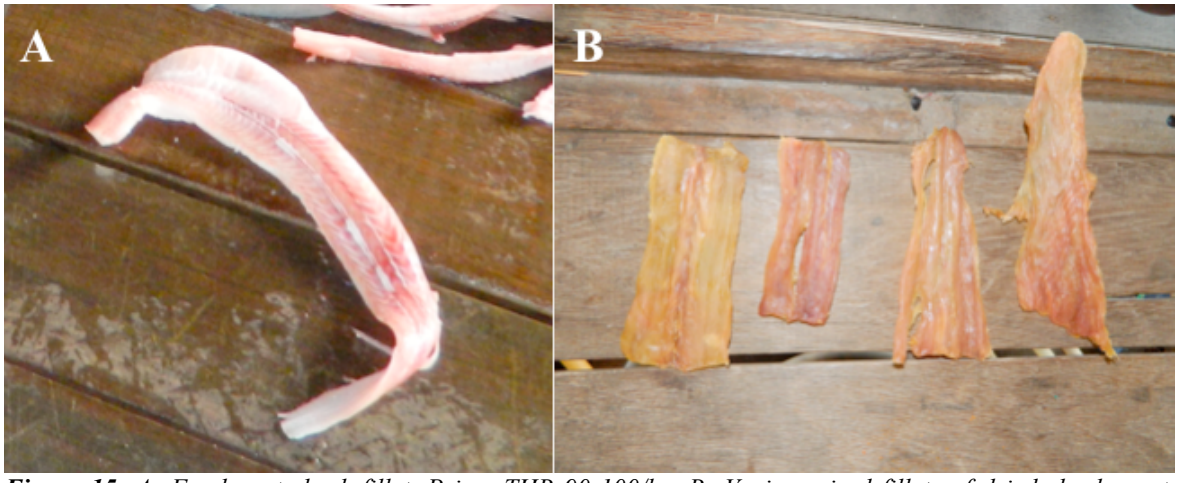


Figure 15: *A: Fresh, cut shark fillet. Price: THB 90-100/kg, B: Various sized fillets of dried shark meat. Price: THB 300/kg (Songkhla, 2014).*

Fins

The small fins are less than 10 cm and usually from the *Chiloscyllium* spp., *Atelomycterus marmoratus* and *H. microstoma*. All the fins are utilised, including the dorsal, pectoral, caudal and pelvic fins, which eventually will be used in shark fin soups. These fins are always dried at the place, and occasionally smoked, as the consumers are not interested in eating them fresh.

Figure 16: *A: In the front: Fins (dorsal, pectoral, pelvic and caudal) from Chiloscyllium spp., drying on the terrace. In the back: Shark fillets drying on bamboo mats, B: Smoked small-sized fins from Chiloscyllium spp. (Songkhla, 2014).*

The larger fins, which are also used in shark fin soups, are always sold fresh and therefore, not dried at this location. As it depends on the size, the price of the fins varies; so the larger the fins are, the more they sell for. It is mostly the fins from sharks that are used in shark fin soups, but occasionally, when caught, the fins from the Guitarfish (*Rhinobatidae* spp.) are sold and utilised for the same purpose. These fins are typically longer than the shark fins and therefore more valuable.

The size of the larger fins ranges from around 10 cm to more than 50 cm. All of the fins are utilised, including the shark's dorsal fins, pectoral fins and the caudal fin. In Thailand, shark fin soup consumption is often considered as a status symbol and a dish that is usually consumed at meetings with important and influential decision makers. But especially in Southern Thailand, it is mostly tourists from Malaysia and Singapore who consume the soup or purchase the dried shark fins from shops, so although consumed by some, Thais do generally not favour this dish.

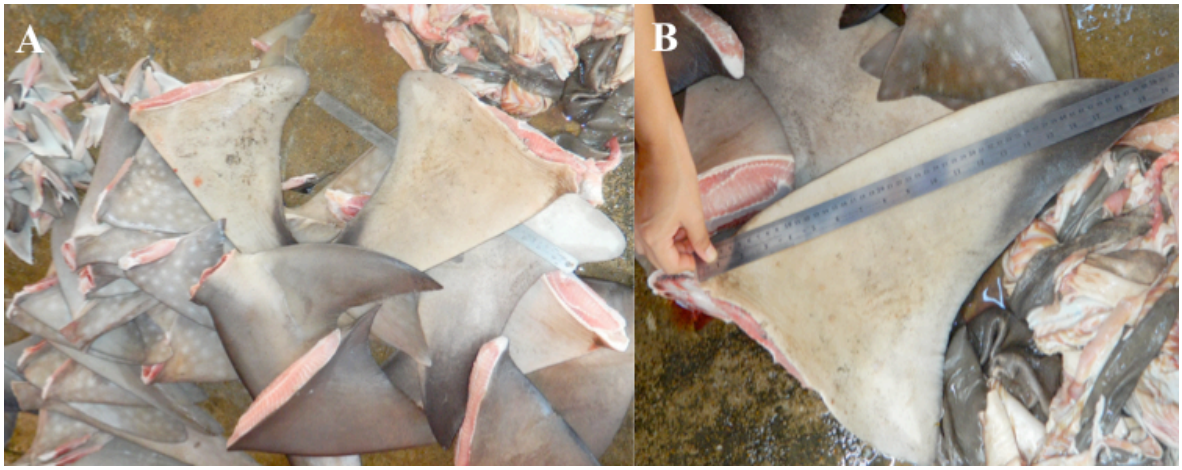


Figure 17: *A: White spotted fins from bowmouth guitarfish (Rhina ancylostoma) and various Carcharhiniformes. Price: THB 500*-600/kg, B: Processing manager *showing how to measure sharks fins. The pictured pectoral fin was around 50 cm. Price: THB 1,000/kg (Songkhla, 2014).*

Dried shark fins

There are at least three different shops in Hat Yai that sell shark fins, but most likely more. The fins are sold in all sizes and grades. Both first grade fins: pectoral fins, first dorsal fin and the lower lobe of the caudal fin and lower grade fins: pelvic fins, anal fin and the second dorsal fin are sold in Thai markets. The customers are typically tourists from Singapore, Malaysia and China and occasionally restaurant owners.

Figure 18: *A: Small-sized dried shark fins. Price: THB 5,800/0.5 kg; B: Small-sized shark fins. Price: THB 28,000/kg; C: A set of pectoral fins. Price: THB 22,000/kg; D: Mixed selection of dried shark fins located in shop in Hat Yai (Hai Yai, 2014).*

Liver and liver oil

At this location, the livers are placed in plastic bags and stored in containers. A way to extract the oil from the liver is by cutting them in smaller pieces and boiling them in suitable containers with water. When all the water has evaporated, the oil will rise to the surface, get skimmed off and strained through a filter (c.f., Haroon, 2010). The oil is mainly used in dishes from the Southern Thai cuisine and not for cosmetic and pharmaceutical products, while the remaining liver is typically minced and mixed with fishmeal to reduce the expenses.

Figure 19: *Liver oil and liver kept in canisters (Songkhla, 2014).*

Skin

The skin is used as a substitute for swim bladders in food. In the famous Chinese dish 'Ka Por Pla' (fish maw soup), swim bladders are a main ingredient, but if the dermal denticles are scraped off the skin, it can be added in the soup and function as good alternative to the swim bladder. At this location, none of the skin is made into leather accessories.

Figure 20: *A: A worker is removing the last bit of meat from the shark skin. Price: THB 100-150/kg, B: 1 kg of dried shark skin in a shop. Price: THB 1,000/kg (Songkhla, 2014).*

Offcuts

Offcuts comprise of parts such as cartilage, viscera and heads, which will get minced and used for animal feed for livestock as well as for fishmeal for shrimp farming.

Figure 21: *Offcuts. Price: THB 7/kg (Songkhla, 2014).*

Jaws and teeth

The jaws are sold as souvenir and used as curios, while the teeth are used for jewelleries such as necklaces and bracelets. The larger the jaws are the more expensive they become.

Figure 22: *A: Teeth, likely from H. elongata, are drying in the sun to remove the last bits of meat, B: Jaws from an adult C. Leucas drying in the sun. Price: at least THB 1,000 (Songkhla, 2014).*

4.2.4 Revenue Estimations

For the past five to ten years, shark products have become more expensive due to declining shark stocks, higher demand on both national and international markets combined with the additional costs of supply in terms of fuel, staff, boat equipment and other necessities. For example, fuelling one boat can easily reach 30,000 litres or more, which will amount to just over THB 1 million (US$27,900), while preparation of food and water provisions are expensive too. In addition, the minimum wage has in recent years increased from THB 200/day (US$ 5.60) to THB 300/day (US$ 8.30), which is also adding up to the overall costs of running a business. The fishing industry is challenging and labour-intensive, which nowadays "force" most fishermen to fish as much as they can for as long as it takes to ensure the value of the catches exceeds the business expenses and that there is enough capital to go out to sea again. At this point it is not the quality that counts, but the quantity.

"According to all the reports, sharks are caught as a bycatch, which I would say is more an incidental catch in more modern species fisheries. So they just get everything. That has been happening for a long time already. They can sell everything because those bycatches can be used for the steadily growing chicken farms and shrimp farms. They need the protein from the trashfish, which are leftover parts from sharks anyway" (Interviewee G).

Currently, all shark products are rather popular, which means the stock will always be sold out. This entirely relies on the economic state of Thailand, however, because with higher prosperity increasing spending power follows. Although, shark products are increasingly popular, the quantity received is rather unstable, as the landings fluctuate from time to time. Some days there are no landings typically due to bad weather, other days some kilos are landed, while other days, landings can reach up to 1,000 kilos and potentially more. On average, the middleman purchases around one to two tons of sharks/week from boat owners, and around 80% is sold fresh while 20% is dried. However, if it came to a point where the fluctuations would be too great and fewer landings, it would not pose an issue for the middleman, since they can readily switch to other fish species.

Based on the estimations conducted during the period, the middleman will on average purchase around 194 sharks/day from the boat owners, which becomes around 370 kg/day (Figure 9). According to these calculations and with the kilos obtained, a boat owner selling the entire catch should at least earn around THB 20,800/day (US$ 581) or THB

145,750/week (US$ 4,068). At the time of writing, the value of *H. elongatus* is unknown, but the species is popular on the market (SEAFDEC, 2006a), and presumably of similar value to *C. sorrah*, thus, in the calculations it will appear with same value as the *C. sorrah.*

As for the *A. marmoratus* and *H. microstoma*, both of them are small sharks, similar to the *Chiloscyllium* spp., and utilised for the same purpose thus, it is believed that the middleman pays similar prices for these species. SEAFDEC (2006a) provides a price list of the sharks landed in Songkhla from 2003-2004, where one can see that the smaller species are equally cheaper than the larger size species such as *H. elongatus*, *C. sorrah, S. lewini*, etc. As the market prices have somewhat increased since then, the prices illustrated are not applicable in this context, although, they do show which species are more valuable than others, which has been useful for this analysis.

Table 9: *Level of occurrence of different landed species in Songkhla on a daily and weekly basis. The following prices are set in THB.*

Species	*A. marmoratus*	*C. leucas*	*C. sorrah*	*Chiloscyllium* spp	*G. cuvier*	*H. microstoma*	*H. elongatus*	*S. lewini*	**Total**
No./day	11.5	0.4	0.5	138.8	0.08	37.5	3.8	1.7	**194**
No./week	80.5	2.8	3.5	971.6	0.56	262.5	26.6	11.9	**1,360**
Cm/species	49.3	234	85.7	63.4	110	74.3	133.4	62.5	
Kg/species	0.38	172	3.3	1.3	6	1.9	12.1	1.1	
Kg/day	4.4	66.2	1.8	177.2	0.46	71.4	45.7	1.9	**369**
Kg/week	30.8	463.4	12.6	1,240.4	3.22	499.5	320.2	13.2	**2,583**
Price/kg	25-40	200-400	80-120	25-40	50	25-40	80-120	50-60	
Price/Species	12.35	20,000	330	42.25	300	61.75	1,210	60.5	
Revenue/day	143	7,692.3	180	5,759	25	2,320.5	4,598	104.5	**20,822**
Revenue/week	1,001	53,846	1,260	40,313	175	16,243.5	32,186	731.5	**145,756**

Table 9 presents price estimations for the whole, raw sharks sold by boat owners to the first middleman and the tables 10 and 11 present revenue estimations for the middleman in Songkhla from daily and weekly sales of fresh/dried meat and fresh/dried shark fins. The calculations are based on personal data collected and insight knowledge from a middleman in Ranong. Evidently, it would have been ideal to have weight data for each shark, but since this was not accessible, the measures obtained from a *C. puntatum* (77.5 cm) will form the baseline of the calculations for the smaller size sharks. For the larger sharks, it will be based on information given by a middleman (See Appendix 10).

In addition, it has not been possible to obtain any prices on the smallest shark fins, however, as they are dried at the location, which requires extra personnel, it could be assumed that the prices for a kg of the smallest shark fins are at least somewhere between THB 150-200 (~THB175). This price is likely higher, as the fins are the most popular and expensive shark-derived product, so they are potentially even more costly than the dried meat (THB 300/kg); however, in the revenue estimation, THB 175 will be applied to the smallest, dried shark fins/kg.

Table 10: *Revenue estimations for fresh/dried meat on a daily and weekly basis from first middleman to second middlemen*

Species	#/day	Meat/Indi.	Meat/Day (kg)	Meat/Week (kg)
A. marmoratus	~12	~186 gr.	~2.2	~15.4
Chiloscyllium spp.,	~139	~637 gr.	~88.5	~619.5
H. microstoma	~38	~910 gr.	~34.6	~242
S. lewini	~2	~539 gr.	~1.08	~7.5
C. leucas	~0,4	~86 kg	~36.8	~257.6
C. sorrah	~0,5	~1650 gr.	~0.9	~6.3
H. elongates	~4	~6 kg.	~24.2	~169.4
G. cuvier	~0,08	~3 kg.	~0.23	~1.61
Total	~196		~188.5	~1,329.3
80% fresh meat			150.8	105.4
20% dried meat			37.7 (18.9 kg*)	263.86 (131.9 kg*)
Revenue from sales				
Fresh meat			~THB 14,326	~THB 100,263
Dried meat			~THB 5,670	~THB 39,570

* The dried meat reduces with ~ 50% from original weight

Table 11: *Revenue estimations for dried/fresh fins on a daily and weekly basis from first middleman to second middlemen*

Species	#/day	Fins/indi.	Fins/day (kg)	Fins/week (kg)
A. marmoratus	~12	~150 gr.	~1.8	~12.6
Chiloscyllium spp.,	~139	~180 gr.	~25	~175.1
H. microstoma	~38	~180 gr.	~6.8	~47.9
S. lewini	~2	~180 gr.	~0.4	~2.5
C. leucas	~0,4	~7,5 kg	~3.2	~22.4
C. sorrah	~0,5	~350 gr.	~0.18	~1.2
H. elongates	~4	~1 kg	~4	~28
G. cuvier	~0,08	~350 gr.	~0.03 kg	~0.2
Total	~196		~41.4	~289.9
Dried fins			34 (13.6 kg*)	238.1 (95.2 kg*)
Fresh fins			7.4	43.4
Revenue from sales				
Dried fins			~THB 2,380	~THB 16,660
Fresh fins			~THB 2,760	~THB 19,320

* The dried fins reduce with ~60% from original weight

Table 12: *An overview of potential expenses for the middleman*

Financial Costs	
Salaries for ~15 employees	THB 300/day/person
Salaries for two employers	-
Rent for two locations	-
Utility bills	Water, electricity, etc.
Necessary Equipment	Fuel, ice, knives, hooks, knife sharpening stones, scales, baskets, wagon, containers/barrels, bamboo mats and salt

It has not been possible to obtain overall costs associated with running a business in terms of rent, utility bills, fuel and equipment costs, etc.: thus, these numbers will not appear, however, in total there are at least 15 people working for the middleman at the port and the manager at the processing area, which likely receive a daily wage of THB 300, but, not all of them are working everyday. On the assumption that seven staff members are on average working on a daily basis for the businesses, the middleman pays THB 14,700 per week in salaries.

By excluding all the additional business costs, the calculations show that the weekly quantity of raw sharks generating ~THB 145,000 (boat owners → middleman) is 20% less than the economic value generated from the sales of fresh and dried products, which should produce at least ~THB 175,000 (middleman → next buyers). Since a number of other shark-derived products are not included in the equation, these figures are expected to be even higher in reality. In conclusion, reliable and detailed information about the total revenue and profit cannot be established, but the available information points to the fact that that middleman makes more money by simply adding value to raw fish, and that the gap in income between the fishers and the middleman is great.

4.2.5 Stakeholder Recommendations

In the 1970s and 1980s, sharks were omnipresent throughout Thai waters and commonly encountered by divers and regularly found entangled in fishing gear. All the stakeholders directly related to the port (n=5) had observed great changes with ongoing declines for the past decades. Thirty years ago, the size and abundance of sharks were much greater but especially during the last 10-15 years, the situation had worsened. Three decades ago, a trawler could catch seven to eight sharks per haul, which is around three to four times more compared with today's catch. A stakeholder estimated that in the last 10 years, the shark

landings had decreased with up to 80%, while a handful of sharks had already disappeared from the landing site.

"Sharks are in decline in Thailand and you can detect a decline every year. The reason for the large decline is the high demand for shark meat, fresh or dried, so the fishermen try to catch as many sharks as they can. Even if, they catch a gravid female, they do not seem to care and will still land the shark for economic incentives" (Interviewee I).

"One year, you may see 30 sharks swimming together and the year after, there are no sharks left. […] The number of sharks is decreasing and the same goes for the biodiversity, some sharks have even disappeared" (Interviewee G).

According to the stakeholders directly related to the port of Songkhla (n=5), there were a few explanations for this trend:

1. No fishing limits or quotas, which forbid the fishing industry from catching sharks and fish every day.
2. Increased number of boats operating in the waters.
3. Advanced fishing technology in terms of sonar systems.
4. Smaller mesh sizes, consequently allowing fishermen to catch more fish, especially juveniles.

As a result, it was deemed almost nearly impossible to increase the shark stocks due to the fishing gear, the advanced technology, the mesh sizes and the supply-side policies. Most of the approached interviewees (n=10)[24] proposed their recommendations concerning restoring the productivity in the sea and thereby the level of sharks, while some also suggested alternative livelihoods for fishermen and other opportunities within the spectrum. Below are the stakeholders' statements, which can be divided into 'Fishery', 'Social' and 'Conservation & Tourism' recommendations (Table 13).

[24] Interviewees included: boat owner wives, captain, middleman, retired fisherman, shark researcher, fishery biologist, fishery scientist and dive operation manager.

Table 13: *Management recommendations list based on suggestions by primary and secondary stakeholders from October 2014 to January 2015*

Fishery Aspects	Social Aspects	Conservation and Tourism Aspects
Increase mesh sizes to at least 4 cm to prevent the neonate and juvenile fishes from getting trapped in the net.	**Stakeholder involvement** to encourage a general ownership of the ocean.	**Artificial reefs** to increase fish stocks, but can also provide as a good basis for tourism and conservation activities
Size regulations: the caught fish should have the length of an adult.	Involve **fishermen** in **data collection**	A successful implementation of **NPOA-sharks**
Release the **juvenile sharks** when caught	Due to challenge and hard work, there is a genuine **interest in leaving the fishing business** for other professions among small-scale fishers	**Shark protection areas** (Conservation and no-take zones)
Shorter trawling hours to increase the value of the catch and to reduce the species getting crushed.	**Increased interest** in the **environment** and **ecology**, especially among small-scale fishers.	A current pilot project: **Shark habilitation programmes** in Chonburi attempting to increase the population
Introduce **fishing quotas/limits**	Explain **benefits** from catching fewer sharks and provide **compensation** for the lost fishes.	Maintain and/or introduce further **marine park closures** to reduce stress and pressure from tourists
Reduce the number of **vessels** and fishing **gear**.	**Shifting from fishing to other jobs**: factory jobs, agriculture, aquaculture, rubber tree and oil palm.	More **enforcement**, **protection** and **patrolling of the marine parks** and the **reefs** to avoid vessels encroaching the zones e.g. in off seasons and night time
A potential **buy-back scheme**.	**Change towards tourist-based activities**, e.g. use the fishing boats for transportation of tourists to islands, recreational fishing grounds and diving locations.	Funding for proper **marine park rangers**.
Increase the 3-kilometre inshore zone to **3 nautical miles** (5,4 km).	**Educate** and **provide evidence** so people will understand the importance of shark diving and the economic gain.	More **transparency** of the money paid for **marine national park fees**.
Continuation and/or expansion of **partial** and **seasonal closures** and **no-take zones** with people patrolling the zones.	Increased focus on **responsible fisheries** to protect local areas from overfishing by introducing crab banks and other activities that serve to protect the resources.	**Conservation** and **awareness programmes** broadcasted through various media.
Bycatch Reduction Device (BRD)	**Include** and **work** in tandem with **local communities**.	Introduce laws/regulations so snorkelling and dive operators that act irresponsibly and mistreat the reefs can be **fined**.
Abolish trawling. Although, considered an extreme method and unlikely to happening.	Run local, **eco projects** and make use of the **local knowledge**, which will reduce bureaucracy and improve the communications.	**Snorkelling trips** with juvenile **blacktip reef sharks** (C. melanopterus) with an initial focus on Koh Phi Phi as they assemble at these locations.
More **transparency** of the long-term operating **offshore vessels**.	Follow Shark Guardians' **Shark educational programmes**	Focus on **long-term planning**.
Species-specific data collection, monitoring programmes and **funding** for fishery and biology research to improve scientific data.	Provide facts explaining the **ecological importance of sharks**	

4.3 Dive Industry Surveys

4.3.1 Demographics

Table 14: *Characteristics of the respondents to the operation manager survey*

Title	*n*	Location	Business Experience	Range
Operation Manager	22	Andaman Sea	10 years	2-25
Operation Manager	13	Gulf of Thailand	14 years	2-30
Operation Manager	1	Nationally based	26 years	-
Both waters	36	Both waters	12 years	2-30

Table 15: *Characteristics of the respondents to the dive instructor survey*

Title	*n*	Location	Diving Experience	Range
Dive Instructor	16	Andaman Sea	6.9 years	1-15
Dive Instructor	19	Gulf of Thailand	7.3 years	0.5-15
Both waters	35	Both waters	7.1 years	0.5-15

Seventy one people working in the diving industry in Thailand participated in the survey, including dive masters/instructors and dive operation managers. A slight majority of the managers (61.1%) were based on the coast of the Andaman Sea, while for instructors the distribution was more equally divided between those from the Andaman Sea (45.7%) and the Gulf of Thailand (54.2%). On the whole, the operation managers had ~12 years of experience as a dive operation manager and the instructors had more than 7 years of dive experience in Thailand.

One-third of the dive centres (33%) had been established in the past 10 years, while the remaining had been established more than 10 years ago (67%), with the oldest established in 1986. All the dive shops are generally open seven days a week all year and they typically offer one to three dives on a daily basis. There is quantity discount on the dives, so the price reduces according to how many dives and days the customer chooses. There is a competition among diving businesses and prices vary a lot from business to business (Table 16). Some businesses might be located at popular dives destinations; others might try to keep the prices low, while others may aim for the rich divers segment, which is usually willing to pay additional for extra service and special treatment.

Table 16: *Observed prices of different dive products offered by the companies*

Prices	Range	Products
1.100 THB	1000 - 1200 THB	1 Dive
2.250 THB	1600 - 3000 THB	2 Dives
4.250 THB	3000 - 5800 THB	3 Dives
30.000 – 49.000 THB*	-	Live-aboard trips
10.000 – 49.000 THB	-	Courses

4.3.2 State of the Diving Industry in Thailand

Increasing Popularity

Almost 60% of the managers considered that the influx of divers had increased within the last five years, with mostly foreign tourists (90-99%) from Europe and Northern America, including, some Asians and Australians. One of the reasons for the rising number of dive tourists was the fact that diving generally had become more popular, which had expanded the industry, and, thus, made it easier and more accessible to dive in Thailand. Altogether, the dive operators could offer various activities such as one-day dive trips and weeklong liveaboard trips to snorkelling, surfing and free diving along with diving courses and reef conservation projects. Some dive operators offered dive trips or courses only, while other businesses had capacity to offer multiple activities. All the dive shops got their main source of revenue through dive tourists and dive students, but a larger percentage also earned revenue from selling merchandise and other water activities, including snorkelling and from providing hospitality services in terms of accommodation, restaurants and bars.

According to the dive instructors, the approximate number of divers diving with their dive company per week varied a lot, as it depended especially on the site locations, the size of the businesses and the seasons. Hence, each comprehensible answer (n=27) has been multiplied by four and then multiplied by the number of months of high season each individual stated. The high seasons typically run from November to May in the Andaman Sea and in the Gulf of Thailand from December to March and from June/July to September. This totalled a little over 600,000 divers during high seasons per annum. The numbers are exclusively based on the instructors' daily estimations, which may not reflect the exact numbers, and therefore, should be used cautiously in this context. However, they still provide a useful indicator of the number of customers that on average dive with the

* It was noticed that some top class liveaboard dive trips: 5 days/6 night cruises to the Similan and Surin Islands can cost up to 87,000 THB/cabin

diving companies, during high seasons. Further, since the participants only constitute a fragment of the entire diving industry businesses in Thailand, it can be assumed that this number is underestimated and, therefore, in reality, it is higher than stated here.

Although the dive shops, in general, had become busier, a few managers had sensed a decline in 2014, which was deemed due to the political turmoil in Bangkok (Corben, 2014). However, most of the respondents thought this situation was only temporary and the customer flow would steadily increase - unless a similar situation occurs again. The remaining 41.7% respondents, who stated a decline in the number of divers, thought this was due to reasons such as: the underwater environment is becoming poorer, with less marine life and disappearing sharks, the negative impacts from the political issues in Bangkok, and the tourists had become less adventurous and more family oriented or party-focussed.

Financial Situation

More than half of the managers (63.9%) deemed their businesses financially stable, with a good flow of customers, and except, for periods with bad publicity[25], many stated a growing number of divers each year. In particular, having a well-established dive business, with years on the market and a good reputation, seemed to attract a lot of customers, who would often later return to dive with them again, but being based in popular tourist destinations also generated a steady stream of customers.

A subset of the managers (36.1%) believed their businesses were financially unstable, for several reasons. According to them, customers were choosing other dive locations due to bad publicity in the media, deterioration of the marine environment, unhealthy reefs and overfishing of the fish populations. Additionally, it was mentioned that the competition was getting harder, as the larger companies made it more difficult for the smaller businesses to survive and, in some cases, competitors had reduced their prices to unsustainable and unrealistic levels, which eventually forced many smaller companies out of business. These factors were only deemed to intensify in the future, with some companies already knowing that they might be forced out of business.

[25] Referring to the political Turmoil in Bangkok and the Koh Tao murders in 2014

Indirect Benefits for Local Communities

Most of the managers (86%) thought that businesses that are not directly in contact with the diving industry were also economically benefitting from the dive tourists through indirect expenditure. They explained how a variety of industries gained from the influx of tourists, as they spend money on all sorts of things, not only on diving. Especially the hospitality sector made up of restaurants, bars, hotels, resorts and other sorts of accommodation were thriving on the basis of the incoming tourists, but also, airlines, taxis, boat operators and transfer services were profiting. While the money inflow also contributes to the infrastructure by providing jobs in the construction industry, it also benefits tourist attractions, tour operators and other businesses including the souvenir, clothes, barber, dive equipment and convenience shops. A respondent said that 95% of all the businesses in Phuket make their money from tourism, while another respondent stated that Khao Lak only exists due to the diving industry. Figure 23 presents an overview of the businesses that typically benefit from the dive tourists, as perceived by the operation managers (in %).

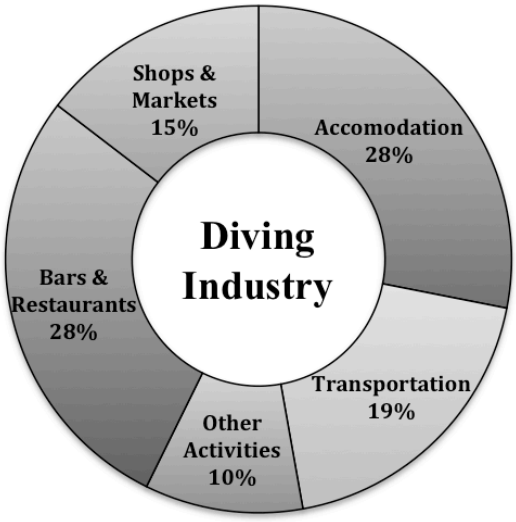


Figure 23: *Local businesses directly benefitting from the diving industry*

A majority of managers (75%) stated that they cooperated with the local communities. Some had engaged the communities and the schools in beach and reef clean ups or raising environmental awareness through local events and programmes, other managers had local people employed in their businesses or had trained local divers to become dive masters. Another group also collaborated with various marine organisations, including Shark Guardian, Turtle Foundation and other eco-programmes or with local businesses by providing diving gear for setting up mooring buoys.

Customer Preferences

Both groups mentioned that divers had expressed various preferences when diving in Thailand. These can be divided into four overall categories: 'Marine Life & Biodiversity', 'Water Conditions,' 'Coral Reefs' and 'Diving Courses'. A vast majority (86%) stated that marine life and biodiversity were a priority for divers, when they came to Thailand to dive and 57.4% said that divers were specifically interested in sharks; of which 34.4% had noted that sightings of Whale sharks (*R. typus*) were in particular a special event for divers. The respondents who stated their customers were interested in sharks represented both the Andaman Sea (57%) and the GoT (43%), thus, there seemed to be a demand existing on both sides.

Table 17: *Customer demand for diving divided into four overall themes*

Themes	% (*n* = 71)	Preferences
Marine Life & Biodiversity	86%	- Macro life - Smaller sized animals - Large schools of fish - Varied and abundant fish species - Larger sized marine species ▪ Turtles ▪ Manta rays ▪ Wrasses ▪ Barracudas ▪ Sharks (57.4%) - Whale sharks (34.4%)
Water Conditions	27%	Many dive customers typically prefer diving in environments including warm water, good visibility and no/little current
Coral Reefs	18%	Divers are interested in diving at locations with healthy, living corals.
Courses	4%	Some divers are especially interested in cheap diving courses, so they can dive all over the world.

Almost three-fourth (73%) had customers who 'often' or 'always' asked if they could dive with sharks, while 23% said it 'sometimes' occurred, only 4% stated that their customers 'rarely' or 'never' asked if they could dive with sharks. However, although customers made requests for shark diving, they ended up not expecting any encounters, as many of the instructors had explained to them that shark sightings are rather rare, so the expectation level was not high.

4.3.3 Marine Resources and Sharks in Thailand

Marine Resources

A strong majority of the respondents (72%, *n*=71) considered that the underwater environment in Thailand had negatively changed for the past 10-15 years and more than half of them (54%) had noticed a general decrease in *biodiversity*, especially in terms of fish stocks, turtles, sharks and other elasmobranch species. Many emphasised that fish stocks and marine life were depleted and the variety was low. Larger species, like sharks, were also in significant decline and had disappeared from numerous areas. A larger part of respondents (42%) also considered that the *corals* had been suffering a great deal, chiefly from the coral bleaching event in 2010 and many of them were either damaged or in decline.

Some respondents (15%) also believed that *fishing related activities*, like overfishing and lack of improved fishing laws and enforcement had resulted in fish stock declines and the removal of larger specimens, including elasmobranchs, from many sites. Most of the respondents had observed increased fishing activity within marine parks and on dive locations after work hours. It was believed that during low season, when the marine parks were closed, fishing was occurring unmonitored for months, which eventually has lead to marine life decline. Some mentioned that, as soon as the dive boats leave after the last dive, the fishermen move onto the dive sites to fish.

Some managers (14%) had noticed an increasing problem from *anchor damage*. Instead of using mooring buoys (installed by both resource managers and local businesses), a number of speedboats, fishing boats and privately owned boats indiscriminately used anchors at dive sites, which damaged the reefs and the marine environment. Some of the respondents (10%) had also observed *water quality issues* such as increased marine debris and pollution, particularly plastic litter, ghost nets, algae and runoffs. A few (6%) explained that *coastal development* such as dredging and excavation for roads, buildings and boat-channels were threatening corals reefs and that the sediment from the rivers flowing into the water was choking the reef. Lastly, 4% had observed an *increase in the number of divers* and *snorkelers* who were unaware of the extent of damage they caused from their behaviour in the water, which was threatening the reefs and its health. Except for two instructors who, ‘often’ encouraged their customers to dive sustainably, thirty-three

instructors (94%) ‘always’ encouraged their customers to dive sustainably by not touching or standing on the reef.

Status of Sharks

More than half of the instructors (57.1%) had noticed a species abundance change, since they had started diving in Thailand. A greater part (42%) used to see Grey reef sharks (*C. amblyrhynchos*) and Bull sharks (*C. leucas*) at Chumphon Pinnacle in the Gulf of Thailand, but these species had entirely disappeared in 2010 and have not been observed since. Twenty years ago, sharks were generally observed on every three dives, and on two locations, in the Andaman Sea, it was guaranteed to see Zebra sharks (*Stegostoma fasciatum*). Many instructors (47%) had also noticed a reduction in Zebra shark encounters, especially within the last 5-7 years and if lucky, one Zebra shark could perhaps be spotted on every ten dives now, while others did not observe them anymore. Guitarfish and Tawny nurse sharks (*Nebrius ferrugineus*) had entirely disappeared, and the somewhat abundant sharks, like the Whitetip reef sharks (*T. obesus*) and Blacktip reef sharks (*Carcharhinus melanopterus*) were additionally lower in numbers and more infrequently spotted during the diving months. Sighting of Whale sharks (*Rhincodon typus*) was also becoming more irregular and no longer seasonal. Some respondents (42%) had noticed fewer sightings of the Whale sharks (*R. typus*.), but these animals were still occasionally seen certain months during the year.

A majority of the instructors (89%) believed the abundance of sharks was changing and it was reduced due to a number of human induced impacts and environmental changes, which can be summarised into fishing activity, ecological factors, increased tourism and marine debris (Table 18).

***Table 18**: Four overall causes of lower abundance of sharks*

Themes	% (*n* =35)	Causes
Fishing Activities	71.4%	Overfishing, shark finning and trawling
Ecological Factors	28.6%	Change of water temperature, habitat loss/destruction and consequences from coral bleaching
Increased Tourism	22.9%	More divers, snorkelers and boat traffic in the water
Marine Debris	11.4%	Ghost fishing and pollution

All the managers expressed concerns about the declining numbers of sharks that could be detected all over Thailand. Some mentioned that, in the past, sharks were regularly spotted around Koh Phi Phi, Koh Similan, Chumphon Pinnacle and other locations within marine parks, whereas now, the encounters were rarer with fewer and smaller size sharks. One respondent stated:

"10 years ago, the question wasn't: "Did you see a shark"? It was: "How many did you see?" [...] Sharks have been gone for about 4 years now" (Operation Owner on Koh Tao).

In addition to the absence of sharks, some also raised concerns about the state of the ecosystems, as taking away apex predators could lead to a "knock-on" effect throughout the entire food chain and eventually decrease the marine biodiversity.

"It is a critical moment for Thailand. Nothing less than strongly enforced NO fishing zones in national park waters will do. We need to get serious about the rate of decline in the quality of diving in Thailand. […] Thailand is risking the future of dive tourism if it does no step up and fight to protect these reefs. Two years of zero fishing in national park waters would have a huge effect.... It is not too late, yet" (Operation Manager in Koh Similan).

4.3.4 Shark Diving

Shark Locations

A smaller group of instructors (28.6%) suggested that sharks, in general, cannot be observed in Thailand anymore, the same way as they used to be around 10 years ago. The majority of respondents (71.4%) stated that sharks can still be observed on certain locations, but it cannot be guaranteed, as shark encounters are becoming a rarity in both the Andaman Sea and the Gulf of Thailand. The respondents pointed out nine different shark species and locations where they may be found. Table 19 presents an overview of the nine shark species observed and where they potentially can be located.

***Table 19**: The most common shark species to encounter during diving in Thailand and the site location*

Common name (*Scientific name*)	**Location**
Bamboo shark *(Chiloscyllium spp.)*	Koh Doc Mai; Koh Lanta; Koh Phi Phi & Koh Similan
Blacktip reef shark *(C. melanopterus)*	Angthong Marine Park; Aow Leuk; Hin Pae; Koh Bida Nok; Koh Haa; Koh Lanta; Koh Phi Phi; Koh Phi Phi Ley; Koh Similan; Koh Surin; Koh Tao; Laem Thien; Loh Samah Bay; Nui Bay; Palong Bay; Palong Wall; Shark Bay; Shark Island & Tao Tong
Bull shark *(C. leucas)*	Angthong Marine Park; Chumphon Pinnacle; Koh Tao; Sail Rock; South West Pinnacles
Grey reef shark *(C. amblyrhynchos)*	Angthong Marine Park; Chumphon Pinnacle; Sail Rock
Oceanic whitetip reef shark *(C. longimanus)*	Koh Similan & Koh Surin

Tawny nurse sharks *(N. ferrugineus)*	Koh Phi Phi
Whale shark *(R. typus)*	Chumphon Pinnacle; Hin Daeng; Hin Luk Bat; Hin Muang; Koh Bida Nok; Koh Bon; Koh Lanta; Koh Phi Phi; Koh Similan; Koh Surin; Koh Tachai; Koh Tao; Richelieu Rock; Sail Rock; Shark Point
Whitetip reef shark (*T. obesus)*	Koh Phi Phi; Koh Similan & Koh Surin
Zebra shark *(S. fasciatum)*	Anemone reef; Hin Bida; Hin Daeng; Hin Muang; Koh Bida Nok; Koh Haa; Koh Lanta; Koh Phi Phi; Koh Similan; Koh Surin; Racha Noi & Shark Point

Shark Diving as a Business

Almost two-third of the managers (63.9%) would not actively promote shark diving in their company, due to unpredictability. Most have stated that there had been a major reduction in shark sightings over the years on Thailand's most popular dive sites, so they could not guarantee their customers any shark encounters.

"No shark dives, specifically as we cannot guarantee them. 14 years ago we could, on certain sites, but now the frequency of sighting is very much reduced" (Operation Manager, Phuket).

There are hardly any sharks left in the Similan National Park and further north" (Managing Director, Khao Lak).

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Some of the managers (36%) did, however, offer shark diving in their business[26]. This involved taking customers to locations where they knew there was a good chance of shark sightings or arranging morning dives. For some businesses, the local shark population was a vital income to their overall revenue.

"If we lost our local population of sharks then our revenues would decline"
(Operation Manager in Krabi/Koh Phi Phi).

The operators offered shark diving with six different species including Blacktip reef sharks (*C. melanopterus*), Whale sharks (*R. typus*), Zebra sharks (*S. fasciatum),* Bamboo sharks (*Chiloscyllium* spp.), Oceanic whitetip (*C. longimanus)* and Whitetip reef sharks (*T. obesus),* which were mostly located in the Andaman Sea (84.6%) (Appendix 11). The prices they charged were not higher than for the other diving operators and the price scale for these operators was ranging from THB 1,200 (1 dive) to THB 5,000 (3 dives).

[26] One manager conducted tag and release studies on the brownbanded bamboo shark (*C. Punctatum*)

In 2014, there was a larger congregation of whale sharks in Thailand, which, according to the respondents, mostly happened in the Andaman Sea. Almost half of the managers (47%) explained that their businesses had benefitted from these sightings and many were still benefitting. The customers were very satisfied and some would even return for the following season. Another 47%, who were mostly based in the Gulf of Thailand, had not benefitted from the whale shark sightings to the same extent. Most of the managers explained that 2014 had been a slow year in regards to whale shark encounters and compared to the past, whale shark sightings were becoming more infrequent.

Future Prospect for Shark Diving

Profitability

Twenty managers (55.6%) said that shark diving could financially become more profitable for Thailand's economy than shark fishing. Many stated that sharks are economically worth more alive than dead, especially, because the live sharks can be revisited time and again, compared to a dead shark, a one-time consumable good. It was also mentioned that divers were already willing to pay more money for shark diving in other countries, and if pursued, it could also contribute to Thailand's overall revenue increase.

"Diving with sharks is sustainable and foreign tourists will pay good money to dive with sharks. Far more tourists want to see sharks than eat them" (Operation Manager, Koh Phi Phi).

"If you fish all the sharks there will be an end to financial profits. If you protect sharks, this can be an increasing financially profitable business" (Managing Director, Koh Lanta).

"More and more divers ask to dive with sharks. It is a new and growing economy" (Operation Manager, Phuket).

Some of the managers (30.6%) could potentially see shark diving become economically more viable than shark fishing, however, most managers were rather sceptical, as the transition would require great changes, with more fish/shark protection and patrolling of national parks and fisheries restrictions. Other managers (13.9%) answered this question with a clear 'no', because, in their opinion, if the present trends continue, there will not be any sharks left in the waters, and this is not a realistic approach.

More than one-third of the managers (36.1%) believed that shark diving could directly increase their overall revenue. Others said that shark diving was already high on demand and if sightings could be guaranteed, more customers would use the service, which eventually would create more revenue for the tourist industry in Thailand. Fifteen managers (41.7%) could potentially see their businesses benefitting from shark diving, if the shark populations recovered, but that would require more protection and fisheries regulations. A respondent mentioned how popular shark diving is in Australia and South Africa and, how, under the right circumstances, it could probably be the same in Thailand. Eight managers (22.2%) said that the sharks had almost or entirely vanished and deemed it unlikely for the populations to rebound, thus, considered unrealistic to integrate shark diving as a significant part of their business.

Shark Diving – a widespread industry

Up to 32.4% of all the respondents (*n*=71) believed it could be possible to establish a more widespread shark diving industry in Thailand, as sharks are fascinating creatures that attract a lot of attention from divers and if there were more sharks. People dive to explore these animals, so if sharks could be spotted more regularly, the message would spread in the media, which eventually would attract more divers. It was explained that Thailand used to be a destination, which had regular shark encounters, but due to various factors, it had become more difficult to offer the same service.

"This is what divers want to see" (Dive Center Manager, Phuket).

"Many divers would like to encounter these animals. If sharks were more often encountered in Thailand it will diffuse on media and divers will come to see them" (Diving Instructor, Phuket).

A subset of respondents (35.2%) was somewhat divided and explained that the chances of seeing sharks need to become more numerous in order to promote the attraction, but on the occasion that sharks could be spotted more regularly, it could be beneficial and attract more tourists, as almost all divers are interested in seeing sharks. It was expressed that a radical change had to happen in order to reverse the dwindling numbers of sharks in Thailand, because with the steadily disappearing sharks, such a goal would be almost impossible to pursue.

"Almost everyone who dives, or would like to dive, would like to see a shark. If there were more sharks, it could be a valuable tourist attraction. However, unless there is some drastic change in the declining numbers of sharks, it is almost impossible for this to become a reality" (Dive Instructor, Koh Tao).

"People will only come if we can increase sighting, and I'm not sure how that can happen naturally" (Dive Centre Manager, Koh Phangan).

Up to 32.4% stated that it was too late to incorporate such tourism attraction due to overfishing. Mostly because there were not enough sharks left on the dive sites to promote this type of business and the population of sharks had been reduced dramatically, reaching a level where it was considered impossible for them to recover sufficiently in order to pursue proper shark dives.

"Fishing vessels will not stop caching sharks inside the Marine Parks. In this area we had 2-3 sites for shark diving. But fishing vessels emptied the sites in the low season and still after 7 years these sites don't have any sharks" (Manager, Krabi and Koh Lanta).

4.3.5 Stakeholder Recommendations

None of the managers said that shark diving was a thriving industry in Thailand and they generally thought more regulation was needed for sharks in Thailand. However, many stated that it was, in reality, more a matter of reinforcement/monitoring rather than regulation, as Marine Park zones do exist, but they are not effectively patrolled. Hence, the problem is not the absence of regulations; it is providing a budget to enforce the regulations, so the marine parks can be protected from people who overfish and infringe on the rules. A respondent said that everyone knows that fishing within marine park areas was happening, but no one has the ability to stop it. Some managers recommended implementation of additional or larger marine park zones coupled with more regulations of the fishing industry, including shark fishing bans, limits on operating fishing boats and an introduction of catch limitations and size control by release of neonate and juvenile sharks. Other managers added additional suggestions in terms of education, awareness-rising activities in local communities, deployment of artificial reefs and charging larger fines to those who violated the restrictions. As an alternative source of income, it was suggested that the fishermen could be offered ranger jobs to uphold the restrictions implemented. In terms of the diving industry, some suggested implementing dive number restrictions in shark prone areas and forcing all dive operators to carry out sustainable diving. It was believed that most dive operators conducted good practices; however, some were engaging in malpractices and causing damage to the environment, which in response created a bad reputation throughout the entire industry.

4.4 Dive Tourists Survey

4.4.1 Demographics

The gender distribution of the 240 divers diving in the Andaman Sea (*n*=126) and the Gulf of Thailand (*n*=114) was slightly different with a minor majority of male divers on both sides.

Table 20: *Gender composition of the divers per location*

Gender	Phuket (*n* = 126)	KTKP (*n* = 114)	Both Areas (*n* = 240)
Female	39.7 %	42.1 %	40.8 %
Male	60.3 %	55.3 %	57.9 %
Unknown	0%	2.6 %	1.3 %
Total	100%	100%	100%

The age range of the participants span from 12 years to 65 years (1950s-2000s) and on both sides combined, the majority of participants were between 21 and 45 years. In Phuket, the majority was between 26 and 45 years, while the majority of the participants in the Gulf of Thailand were somewhat younger, between 21 and 35 years (see figure 24).

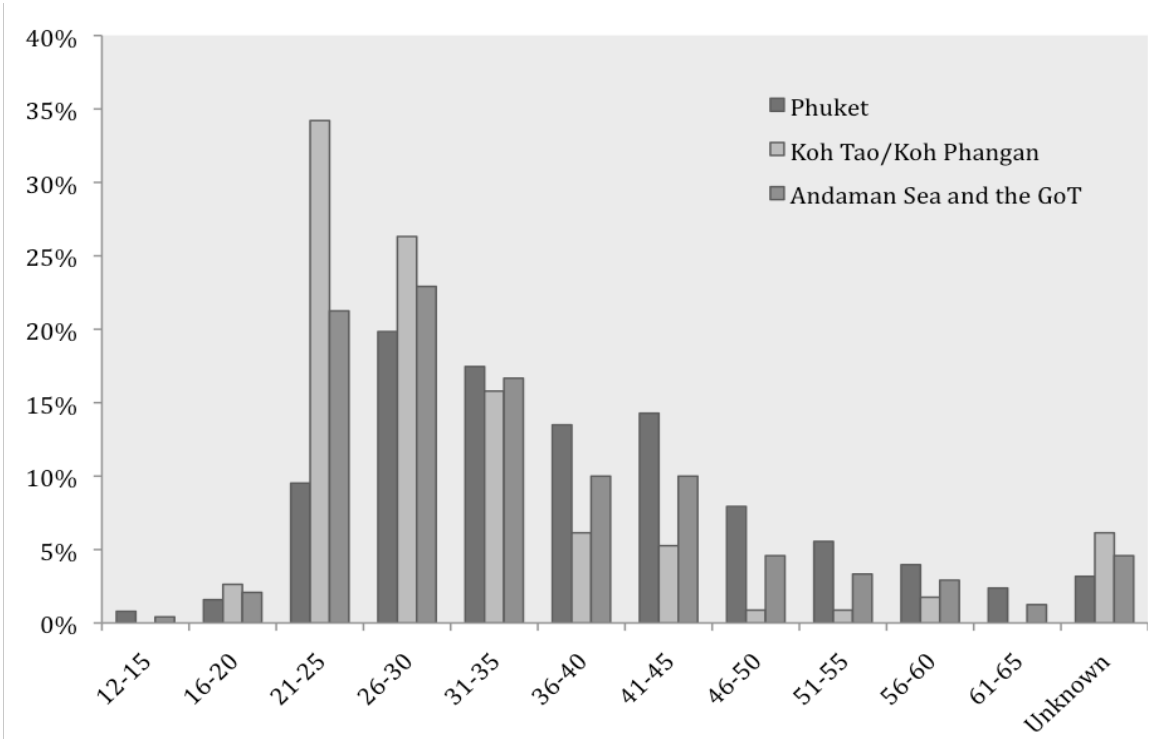

Figure 24*: Age group division of divers at each site (x-axis) and number of respondents in % (y-axis)*

Divers were from five continents and at least 32 different countries. Europe represented the highest percentage (65.8%), followed by Oceania (12.1%), America (11.3%), Asia (7.5%) and Africa (0.8%) while the rest was unknown (2.9%) (Figure 25).

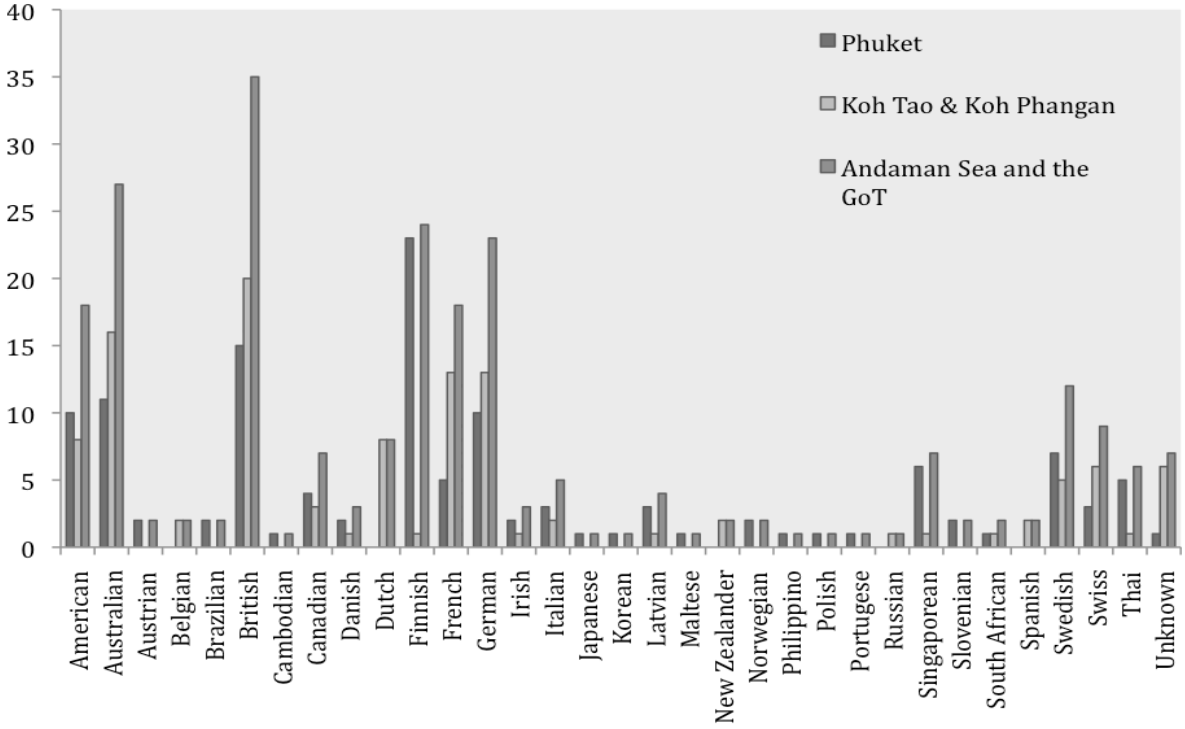

Figure 25: *Nationalities of the divers at each site (x-axis) and number of respondents (y-axis)*

As concerns the level of income, less than 15% earned more than US$ 79,999, while most of the participants (27%) from Phuket earned US$ 20,000 – 59,999/annum. On KTKP the level of income was rather different; the majority (33.3%) earned under US$ 20,000. However, a large percentage (42.9%) on each side combined remained unknown, which yet again could have changed the income distribution.

Table 21: *Annual income per diver and location*

Level of Income	Phuket (*n* = 126)	KTKP (*n* = 114)	Both Areas (*n* = 240)
Under US$ 20,000	6.3%	33.3%	19.2%
US$ 20,000-39,999	14.3%	9.6%	12.1%
US$ 40,000-59,999	12.7%	9.6%	11.3%
US$ 60,000-79,999	8.7%	6.1%	7.5%
US$ 80,000-99,999	3.2%	0.9%	2.1%
US$ 100,000-119,999	2.4%	1.8%	2.1%
>US$ 120,000	4%	1.8%	2.9%
Unknown	48.4%	36.8%	42.9%

On both locations, the majority of the divers were beginners and had dived between 1 and 25 dives; however, a large proportion (31%) from Phuket remained unknown. As it is typically seen that divers choosing Phuket are older, more experienced divers and divers choosing KTKP are the younger and inexperienced divers; it would not be surprising if a larger percentage of the 31% respondents were non-beginners with more diver experience.

Table 22: *Level of skills per diver and location*

Level of Skills	# of dives	Phuket (*n* = 126)	KTKP (*n* = 114)	Both Areas (*n* = 240)
Beginners	1 – 25	27%	47.4%	36.7%
	26 – 50	9.5%	11.4%	10.4%
Advanced	51 – 100	8.7%	11.4%	10%
	101 – 500	9.5%	12.3%	11.3%
Experienced	501 – 999	2.4%	4.4%	2.9%
	≥1000	11,9%	11.4%	11.7%
Unknown	Unknown	31%	1.7%	17%
	Total	100%	100%	100%

The motivation for their choice of dive location was somewhat different, depending on the divers' skills. The top three reasons for the beginners were that they had no influence on the dive location (43%), due to the coral reefs (28.9%) and other reasons (21.9%) such as: participation in conservation projects, dive courses, work relation or due to a specific site or marine species, including Whale Sharks. The advanced divers were diving at the dive site due to the fish species (37.3%), the other reasons (29.4%) as stated above and because they had no influence on the location (27.5%). The 31.4% of the experienced divers were there due to the coral reefs, 31.4% stated they had no influence on the dive location and 28.6% said for other reasons. Apart from the unknown level, the advanced divers were the ones showing the greatest interest in diving with sharks.

Table 23: *Motivation for the choice of dive location*

Motivation	Beginners	Advanced	Experienced	Unkn.	Total
No influence on the location	42.5%	27.5%	31.4%	2.5%	30.8%
Coral reefs	28.3%	27.5%	31.4%	47.5%	31.7%
Fish species	19.5%	37.3%	25.7%	47.5%	28.8%
Sharks	8.8%	17.6%	8.6%	35%	15%
Marine mammals	7.1%	7.8%	2.9%	12.5%	7.5%
Operator had good reviews	16.8%	11.8%	8.6%	30%	16.7%
Random operator	1.8%	5.9%	2.9%	12.5%	4.6%
Other	22.1%	29.4%	28.6%	10%	22.5%

4.4.2 Customer Demand and Conservation Attitudes

Marine Environment Preferences

Almost all divers (97.1%) found it 'very important' or 'important' to dive in marine environments with high biodiversity, 2.1% were 'neutral/undecided', while only 0.8% found biodiversity 'very unimportant' when diving. The same trend was also experienced with the scenario pictures. Again, most of the divers (96.3%) preferred scenario B, which appeared to have a higher biodiversity including sharks; only a minor percentage (1.7%) obted for scenario A due to fright or a dislike of sharks, while 2.1% remained undecided.

The respondents were subsequently asked to explain the reasons behind their choice of scenario, which resulted in nine overall themes. The results showed that biodiversity was evidently the most preferred reason for the selection of scenario B among all the divers, while the remaining reasons started deviating, depending on the skills of the divers. More than 25% of the advanced divers had chosen scenario B due to the presence of sharks, while the beginners and the experienced divers were lying a little bit lower at 16.7% and 8.6%, respectively. The experienced divers' second most preferred choice was a due to appearance of a healthy environment, while turtles' occurrence was the second most chosen reason among the beginners. More specifically, 72.5% of all the divers had chosen scenario B due to biodiversity, 15.8% because of the sharks and 14.2% because of the turtles (Table 24).

***Table 24**: Reasons for choosing scenario B per diver and location*

Reasons for choosing scenario B	Beginners	Advanced	Experienced	Unkn.	Total	#
Biodiversity	76.1%	74.5%	80%	53.7%	72.5%	1
Coral reefs	2.7%	2%	11.4%	2.4%	3.8%	7
Healthy environment	16.8%	7.8%	14.3%	7.3%	12.9%	4
Dislike of jellyfish	4.4%	15.7%	2.9%	7.3%	7.1%	6
Large marine life	2.7%	3.9%	2.9%	4.9%	3.3%	8
More interesting dive	15.9%	5.9%	11.4%	4.9%	11.3%	5
Rays	2.7%	2%	0%	2.4%	2.1%	9
Sharks	16.8%	25.5%	8.6%	7.3%	15.8%	2
Turtles	20.4%	11.8%	2.9%	9.8%	14.2%	3

Shark Species preferences

All the pictured shark species were favoured among the divers, however, some more than others (31.6% - 94.7%) (Table 25). The Whale shark *(R. typus)* was by far the most popular species, which was ranked in the top three by 91.3% of all the divers. In Phuket, the subsequently more favoured sharks were the Blacktip reef shark (*C. melanopterus)* (57.1%) and the Zebra shark (*S. fasciatum)* (57.1%), while on KTKP, the species were the Zebra shark (*S. fasciatum)* (55.3%) and the Bull shark *(C. leucas)* (53.5%). On both locations, the results show that the more unpopular sharks were the Tawny nurse shark *(N. ferrugineus)* and the Whitetip reef shark *(T. obesus),* while the Grey reef shark *(C. amblyrhynchos)* was somewhat partially preferred.

Table 25: *Favoured shark species to dive with per diver and location*

Favoured shark species	Phuket (*n* = 126)	KTKP (*n* = 114)	Both Areas (*n* = 240)	#
Grey reef shark (*C. amblyrhynchos)*	47.6%	44.7%	46.3%	5
Blacktip reef shark (*C. melanopterus)*	57.1%	39.5%	48.8%	4
Whitetip reef shark *(T.obesus)*	43.7%	31.6%	37.9%	7
Bull shark *(C. leucas)*	50%	53.5%	51.7%	3
Zebra shark (*S. fasciatum)*	57.1%	55.3%	56.3%	2
Whale shark *(R. Typus)*	88.1%	94.7%	91.3%	1
Tawny nurse shark *(N. ferrugineus)*	42.1%	37.7%	40%	6

Apart from *R. typus*, it is difficult to decide what seems to determine the divers' choices; however, it is a possibility that beginners prefer diving with sharks which are considered less potentially "dangerous" to humans, as they may not feel experienced enough to deal with such species. The results showed that almost 30% more of the experienced divers preferred diving with Bull sharks, compared to the beginners who ranked it second among the least favoured shark. Further, it was e.g. also noticed that Blacktip reef shark sightings were 12% more favoured in Phuket, while Bull shark sightings were slightly more preferred on KTKP. The largest number of Blacktip reef shark gatherings seems to be confined to the Andaman Sea, especially around Koh Phi Phi, while specific locations in the GoT used to be known for Bull shark sightings. At the time of writing, it is unknown if knowledge by divers that certain species can potentially be located on specific sites shaped the diver's species preferences.

Table 26: *Favoured shark species divided in level of diving skills*

Favoured shark species	Beginners	Advanced	Experienced	Unknown
Grey reef shark	42.5%	47.1%	60%	43.9%
Blacktip reef shark	51.3%	41.2%	54.3%	46.3%
Whitetip reef shark	38.9%	41.2%	37.1%	31.7%
Bull shark	41.6%	66.7%	71.4%	43.9%
Zebra shark	50.4%	68.6%	68.6%	39%
Whale shark	89.4%	98%	100%	80.5%
Tawny nurse shark	41.6%	23.5%	40%	24.4%

The vast majority of divers (83.3%) also showed an interest in returning to Thailand, if they knew Whale sharks would be gathering in Thai waters. More than half of the divers (59.2%) were 'very much interested' in returning to Thailand, if they would encounter whale sharks during diving and 24.6% found it 'somewhat' a strong incentive to return. A smaller group (5.8%) showed 'little' or 'no interest' in returning, while 11% selected the option 'undecided' or left the question blank. The results showing that *R. Typus* was the most desired species is supported by various sources that classify the whale shark as a charismatic mega fauna that is highly favoured by most divers and an economic driver to countries that can guarantee its sightings (Newman & Medcraft, 1997; Graham, 2004).

Shark Encounters

Many divers belived that sharks are beautiful creatues that play an important role in marine ecosystems and it would be great to experience shark encounters, but not essential as there is other marine life to explore. Several stated sharks are rather unpredictable and rare animals, but if they saw one it would be a bonus to their dive.

Table 27: *Level of importance to sight sharks per diver and location*

Level of importance	Phuket (*n* = 126)	KTKP (*n* = 114)	Both Areas (*n* = 240)
Very important	18.3%	23.7%	20.8%
Important	34.9%	27.1%	31.2%
Neutral	39.7%	40.4%	40%
Unimportant	3.1%	7.9%	5.5%
Very unimportant	4%	0.9%	2.5%
Total	100%	100%	100%

As an overall result, 40% of the respondents remained 'neutral' if they did not experience any shark encounters when diving, 52% found it either 'very important' or 'important' to experience shark sightings when diving, while 8% found it 'unimportant' and 'very

unimportant' to encounter sharks. This was chiefly due to fright of the animals and a general satisfaction with whatsoever encountered under water (Table 27).

Less than one-fifth (17.2%) sighted one or more sharks during their dives, while more than three-third (80.3%) reported no encounter during their dives; only 2.5% had observed sharks on very recent dives. In total 39 different shark sigthings were reported from the Andaman Sea and 12 from the GoT, with an overall of six identified species, including the Bamboo shark (*Chiloscyllium* spp.) (17.6%), the Blacktip reef shark (*C. melanopterus*) (45.1%), the Tawny nurse shark (*Nebrius ferrugineus*) (11.8%), the Whale shark (*R. typus*) (5.9%), the Whitetip reef shark (*T. obesus*) (2%) and the Zebra shark (*Stegostoma fasciatum*) (11.8%) and unknown species (5.9%) (see Appendix 12). No Bull sharks (*Carcharhinus leucas*) or Grey reef sharks (*Carcharhinus amblyrhynchos*) were registered and three people reported shark encounters, but were unable to identify the species. Although, the *Chiloscyllium* spp. were not represented in the pictures, this species was the second most observed shark, thus, it would have been useful if it was included in the questionnaire. Of those who spotted sharks, 44 respondents registered one shark species, while two respondents encountered two different species and one person registered three different species seen while diving (Figure 26).

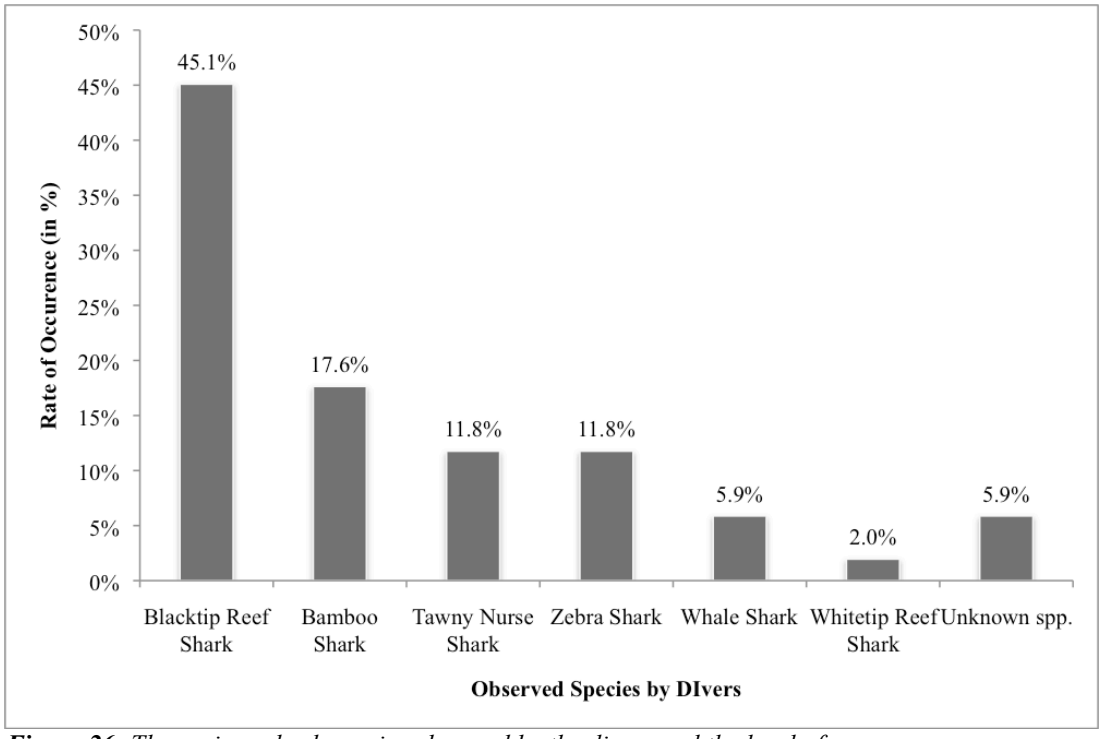

Figure 26: *The various shark species observed by the divers and the level of occurrence.*

In addition, 29.2% of the respondents were very 'disappointed' and 'somewhat disappointed' with not encountering any sharks on their dives in Thailand, while 36.7% were 'neutral'. Up to 25.5% were 'not really' or 'not at all disappointed' and 8.8% did not answer. Again, the general comments were that the respondents were satisfied with encountering other marine life and they were not expecting to sight any sharks, because they were often not observed at the given dive location. It was also stated that, since sharks are wild animals and quite uncommon, many divers did not dive to encounter sharks only, but it would have made the dive more exciting, if they discovered one (Table 28).

Table 28: *Level of disappointment due to absence of sharks during diving per diver and location*

Level of Disappointment	Phuket (*n* = 126)	KTKP (*n* = 114)	Both Areas (*n* = 240)
Very disappointed	12,7%	4,4%	8,8%
Somewhat disappointed	19,8%	21,1%	20,4%
Neutral	38,1%	35,1%	36,7%
Not really disappointed	12,7%	14,9%	13,8%
Not at all disappointed	5,6%	18,4%	11,7%
Unanswered	11,1%	6,1%	8,8%
Total	100,0%	100,0%	100,0%

Shark Conservation

Most of the divers (95%) saw shark conservation as 'important': 62.5% stated that shark conservation was 'extremely important', 26.7% stated 'very important' and 5.8% 'moderately important', 5% remained either neutral or did not define shark conservation as important. Based on the comments regarding shark conservation, two overall themes occurred. First, it is the importance of conservation and protection of sharks, due to their ecological significance; and second, it is the importance of conservation of all marine life, including sharks. The vast majority of those who had commented argued that sharks are at the top of the food chain and they play an important ecological role in ecosystems and if they disappeared in the oceans the marine environment would change. Some stated that protection of these species is needed in order to maintain healthy ecosystems and high biodiversity. A smaller group believed that all aquatic life needed to be conserved, as all marine species have their own individual importance, so this should not be restricted to sharks only but at all living creatures, especially those that needed protection.

4.4.3 Willingness to Pay

Most respondents (96.3%, *n*=231) preferred scenario B, which comprised a high biodiversity environment with a larger variety of marine life, in which multiple trophic levels would interact and sharks would be at the top of the food chain. This was in contrast to scenario A which comprised less complexity, high occurrence of jellyfish and rays as well as fewer, smaller fish species. The majority of responders (92.5%, *n*=222) were willing to pay at least US$ 1.00 or more, if they knew the dives involved surroundings like these, one person (0.4%) was willing to pay extra but was unsure of the amount and 7.1% were not interested in paying additional.

The Willingness to Pay (WTP) ranged from US$ 1.00 to US$ 50.00. The median premium volunteered was US$ 10.00 per dive (34.2%), although almost the same number (32.9%) were willing to pay US$ 20.00 per dive, on the presumption that they would experience conditions similar to those in scenario B (see Appendix 13). A single respondent from KTKP was willing to pay US$ 50.00 per dive, but if this outlier was removed from the data set, the mean (WTP) from KTKP was reduced by US$ 0.30 and the overall mean by US$ 0.20. The mean WTP in KTKP was US$ 11.70 (without outlier US$ 11.40) and the mean WTP in Phuket was US$ 12.00.

Although the sample size of each individual group become too small to demonstrate any statistically significant results, it is still worth to illustrate that the average WTP based on divers nationality (subcategorised into world regions), which showed a vast difference between the world groups. Oceania (*n*=29) and Thailand (*n*=6) showed the highest mean WTP/dive, with US$ 16.60 and US$ 15.80, respectively, while responders from South America (US$ 2.50) (*n*=2) were willing to pay 85% less than the highest mean. Respondents from Africa (*n*=2), Asia (*n*=12), Europe (*n*=157) and North America (*n*=25) were somewhat agreeing in their choice of WTP/dive, with a mean of US$ 11.10/dive (Figure 27).

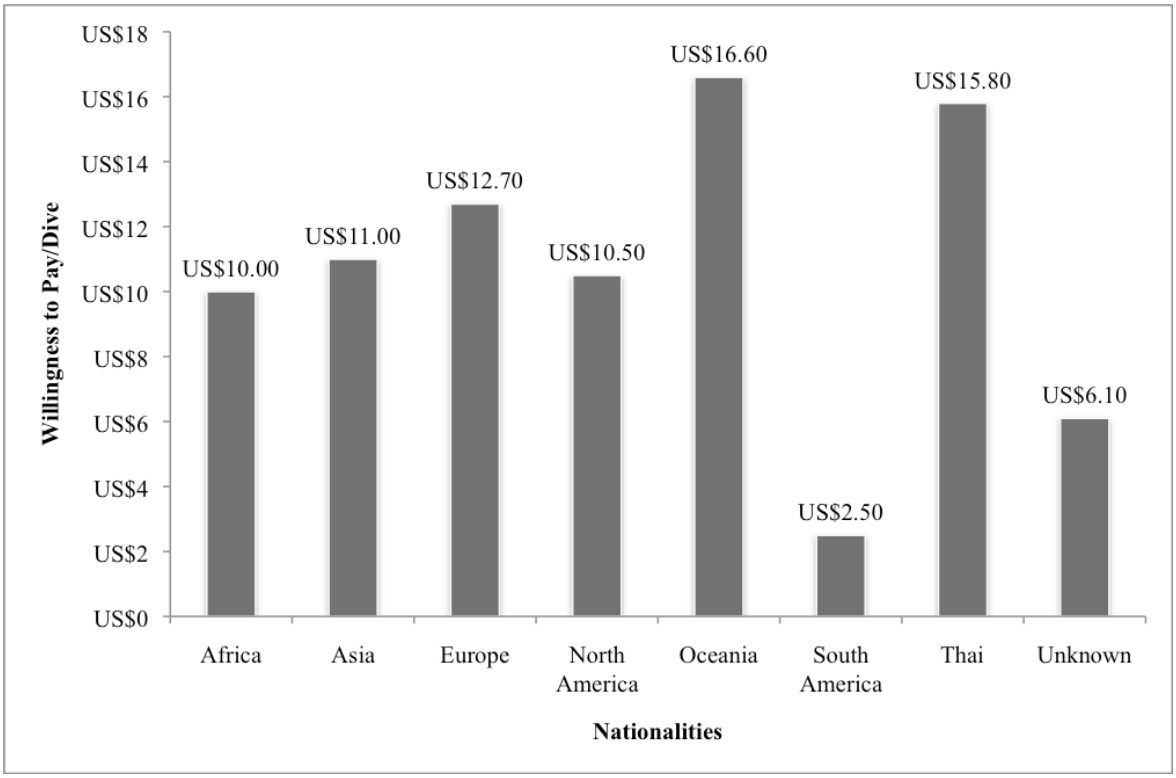

Figure 27: *Mean WTP/dive, based on diver nationality aggregated in world regions*

All in all, divers were willing to pay an overall mean of US$ 11.70 (with an outlier of US$ 11.85) per dive to discover high biodiversity environments. In fact, the data showed that 73% of the respondents selected scenario B due to the high biodiversity in the picture followed by 16% due to the sharks: the vast majority of the divers have therefore likely chosen scenario B due to the general richness in the picture rather than due to the presence of sharks. However, most respondents appeared to agree that sharks play an important ecological role, as they shape and control ecosystems; thus, the absence of sharks is likely to decrease the biodiveristy and the overall health of the marine environments to which they belong.

A Pearson's r correlation was calculated to determine whether there was a correlation between WTP and the following variables, respectively: age, income and number of dives. All the correlations were very weak, thus, it can be concluded that there is no correlation between WTP and these variables.

An independent samples t-test was run to determine whether if there were differences in WTP between genders. The t-test also showed that there were no statistically significant difference in the stated WTP between males and females ($t(234)=-0.834$, $p= 0.405$).

Furthermore, none of the respondents stated a WTP that exceeded their level of income by more than 5%, which potentially can skew the final outcome and therefore should be removed if occuring (FAO, 2000).

The divers would allow that their money potentially could be used to support local communities, for e.g. wages for people to patrol and conserve marine areas/marine reserves with high biodiversity. The double benefit presented in the questionnaire were that locals would get a new source of income and divers could continue to enjoy a biodiverse underwater environment. The vast majority of respondents (72.5%) would 'very much' support this arrangement, 15.8% 'somewhat', 11.5% were 'undecided' or did not answer the question, while one person answered 'not really'. Moreover, the greater part of the divers supported a potential arrangement of hiring people from local communities to monitor/patrol MNPs while they would receive salaries from a potential "diver fee".

5 Discussion

This study has researched the feasibility of the rational long-term economic use of sharks in the shark diving industry compared to the shark fishing. A hypothesis was formulated stating that the profitability of the shark fishing industry is declining both due to decimated/overfished stocks and due to lack of protective regulation, while the profitability of the shark diving industry is rising. In spite of a large customer demand for shark diving in Southern Thailand, the data collected indicated decades of illegal and uncontrolled trawling leading to severe depletion of the shark stocks is now hampering the present and future prospect for a thriving shark-based dive industry in Thailand. On the assumption that Thailand could provide sight-predictability, the gathered data estimated that the economic return from the non-consumptive use of sharks would greatly exceed the economic value of sharks as a consumptive resource by millions of dollars, which similarly could lead to a potential spill over effect to coastal communities. But in order to increase the future chances for shark-sight predictability and to halt and a reverse the decline of the shark stocks, the collected data signalled that strict enforcement and an immediate reduction in fishing effort were needed.

5.1 Shark Landing Observations

Length and Biomass

Sharks were landed on 13 out 15 days of observation at Songkhla Port between October 2014 to January 2015; we observed approximately 2,500 individual sharks (4,800kg) being landed. The average total length of shark species landed at Songkhla has shifted from the <1.5 m reported in the early 1990's (Keong, 1996) to species typically <1 m (see Appendix 6); ~98% of the observed individuals fell under this aggregated length group. The remaining and much smaller group (~2%) comprising species larger than 1 m including immature and mature individuals, represented quite a large proportion of the total biomass (31%) landed, despite the small number of individuals.

In contrast, the total biomass of landed sharks was fairly low among the smallest species (≤ 45-60 cm : 10.9%) although the group constituted more than one-third of the total number of individuals caught (37.4%). It appears likely that the ~450 individuals of ≤ 45 cm

(~150kg) will to be turned into 30 kg fishmeal worth about THB 2,100 (US$ 58.6), but if narrowed down further to individual level, one shark will only be worth ~THB 4.7 (US$ 0.13). This group of individuals comprised around 17-18% of the overall quantity observed, but if individuals measuring 46-50 cm are included (which is quite possible), approximately 20% of the whole quantity is likely going to be processed into fishmeal.

The group of sharks landed at Songkhla also included a disturbing number of immature sharks. None of the individuals landed of *C. sorrah, G. cuvier, Sphyrna lewini* and *Sphyrna mokarran* species were considered mature. The *Sphyrna* spp., in particular, were considered undersized, as approximately 55% was estimated to be neonates and approximately 45% were juveniles far from sexual maturity. Around 50% of *Chiloscyllium* spp. and 66% of *H. microstoma* species were estimated to be juvenile individuals, while the recorded individuals of *A. marmoratus* and the *H. elongatus* species comprised a slightly smaller proportion of juvenile sharks, 27% and 12%, respectively. Based on conservative estimations, around 51% of the entire group of individuals landed could be considered immature, and was represented by all species, except the *C. leucas*.

These results signal that the shark fisheries in Thailand are largely unsustainable as more than half of the overall quantify comprised undersized individuals, where at least 35% or more of the proportion is turned into cheap fishmeal/animal feed to supply the demand from [shrimp] aquaculture and livestock industries. They also indicate that there is a lack of fishing regulations concerning protective measures for juvenile fish and that a considerable portion of sharks are harvested before reaching sexual maturity, thus, preventing them from maintaining a natural reproduction cycle. Intensive fishing effort has now lead to a shortage of wild capture fish, implying that there currently is a market demand for all marine products, regardless of their size and quality, which presumably only encourages fishermen to catch all sizes of fishes.

Species Composition

Out of the 10 different species observed, the data set showed that shark landings in Songkhla are greatly dominated by small species, measuring on average 65 cm in length (96.6%). The most landed species was by far the *Chiloscyllium* spp. (*C. punctatum* and *C. plagiosum*) (71.4%), which comprised of almost three-fourth of the entire quantity landed,

followed by the *H. microstoma* (19.3%) and the *A. marmoratus* (5.9%). The larger neritic species such as *Hemipristis elongatus,* the *Galeocerdo cuvier,* the *Sphyrna* spp., as well as the *Carcharhinus* spp., (which was once the dominant genus of the Thai shark fishery) comprised less than 0.5% of the total quantity of observed landings. If comparing the results of the current study with the overall landing trends observed of *Sphyrna* spp. and *Carcharhinus* spp. from just a decade ago (SEAFDEC, 2006a), the data indicate a significant reduction in landings of both genera of around 83% and 96%, respectively. The observations provided some insights, showing that the proportion of neritic sharks in fisheries landings has diminished, and that of epibenthic sharks has increased, suggesting that populations of the once-plentiful neritic sharks have been depleted.

IUCN Red List Status

None of the 10 species observed in the shark landings at Songkhla were of a conservation status considered of 'Least Concern', which is the IUCN level defining that a given species is abundant in the wild and is under no/potential threat of becoming extinct (IUCN Red List, 2015). Instead, 40% of the landed species were classified as being at "Very High/High Risk" of extinction in the wild, while the other 60% were "Near Threatened" – with high likelihood of coming under extinction risk in the near future (IUCN Red List, 2015). Combining this with the fact that more than 50% of the individuals were considered immature (see Table 6; Appendix 6), once again, underlines that the landed sharks in Songkhla are generally unsustainably harvested and highly emphasises the reality that the shark fishery in Thailand is an extremely pressing issue that must receive immediate attention through allocated resources to make the fishery more sustainable.

5.2 Insights in the Shark Fishing Industry

Current Trends in the Shark Stocks

Since the trawlers were succesfully introduced in Thailand in the 1960s, the shark stocks have been in steady decline, resulting in a continuous reduction in both shark landings and shark sightings. The interview data indicate that trawlers are the main culprit for catching sharks and that a large proportion of the shark landings in Songkhla are now sourced from the more plentiful fishing grounds in Indonesia, since the stakeholders reported that the GoT has been depauperised. Most of the specialised literature states that there are no shark

fisheries in Thailand and that sharks are only occasionally taken as a bycatch by the fishing vessels. This seems to be the case with medium-scale fisheries, which will only catch a few sharks per haul (>1m), as they simply cannot reach the fishing grounds with their type of gear, while small-scale fisheries, on the other hand, seem to harvest no sharks at all[27]. Medium-scale fishers/boat owners are not economically dependent on catching sharks due to their low value, infrequency and inaccessibility; thus, most fishermen/boat owners find it infeasible targeting sharks and therefore exhibit little or no concern about sharks and their future existence.

In contrast, amongst the larger-scale fishing vessels, there seemed to be a general consensus among many stakeholders that these fishing vessels do accidentally "target" the sharks now. The interview data indicated since the large-scale vessels can accesses locations with greater concentrations of sharks, the volumes of bycatch caught by these vessels makes it economically viable for them to accidentally target sharks, despite the relatively low value per kilogram. Thus, the probability that some commercial vessels are "intentionally" catching sharks, while making it appear as "bycatch", only reinforces the perception that implementing shark fishery management measures in Thailand is highly needed and far more urgent than previously anticipated.

There is a strong awareness amongst the industry participants of the occurrence of overfishing. In the last 10 years, it was estimated that the quantity of shark landings had potentially decreased by up to 80%, while a handful of sharks had disappeared and were no longer landed in Songkhla. All the interviewed stakeholders relating to the fishing industry in Songkhla are aware of the fact that the sharks are getting smaller and that they cannot keep up with the level of fishing pressure. They reported that sharks mostly do not reach adulthood anymore, as they are caught while they are still juveniles, eventually driving many species towards local extinction. These comments are also consistent with the shark landing observations, which showed that around 50% of the capture comprised juvenile sharks.

[27] The researcher went to a fishing village in Songkhla that only practices fishing on a small-scale level. The small-scale fishermen explained that they could not attempt any shark fishery, as their boats were too small and that they could not fish that deep, so sharks were not even a bycatch in their fishery. They recommended seeking out larger fisheries that harvest sharks as a bycatch.

Around 71% of the respondents from the diving industry argued that the state of the marine environment had been deteriorating in the last few decades with declines in healthy coral reefs and decreasing biodiversity, especially in terms of fish stock abundance, turtles, sharks and other elasmobranch species. Before the early 2000s, it was customary to sight at least one or more sharks on almost every dive in Thailand, but in the past 10-15 years, there has been a significant change in the overall level of abundance, with some species disappearing from certain sites e.g. the Grey reef sharks (*C. amblyrhynchos*) and the Bull sharks (*C. leucas*) at Chumphon Pinnacle in the Gulf of Thailand. Moreover, the Zebra sharks (*Stegostoma fasciatum*), which used to be locally abundant on a few dive locations in the Andaman Sea, had been noticeably declining, for the past 5-7 years, resulting in only rare sightings now, with a sight predictability of around 0-10% (see also Appendix 11).

The interview and survey data strongly indicate that there has been a great decline in abundance of certain species and the loss of sharks from reef dive sites, over the past few decades. They signal that there is an increased risk of local extinction for a number of reef shark species in the near future, and even the once much abundant *C. melanopterus* can potentially be faced with local extirpation.

Supply Chain

Establishing a detailed and conclusive supply chain of the landed sharks in Songkhla ended up being a rather complex and more comprehensive task than initially perceived due to the many actors involved. The shark products diverge on national and international markets, travel through multiple market levels and several middlemen, before reaching the end-users. Hence, the exact number of middlemen remained unrevealed. The interview data showed that the shark products are intended for human consumption, animal consumption and decorative purposes, and are either sold locally/regionally, nationally or exported and potentially re-imported. At this stage, up to six links between the harvested shark product and the end-consumer could be identified but an additional, unknown number of middlemen are expected to be involved, extending the supply chain and the complexity within. The observed supply chain comprised a number of actors, some of which were identified (Figure 28).

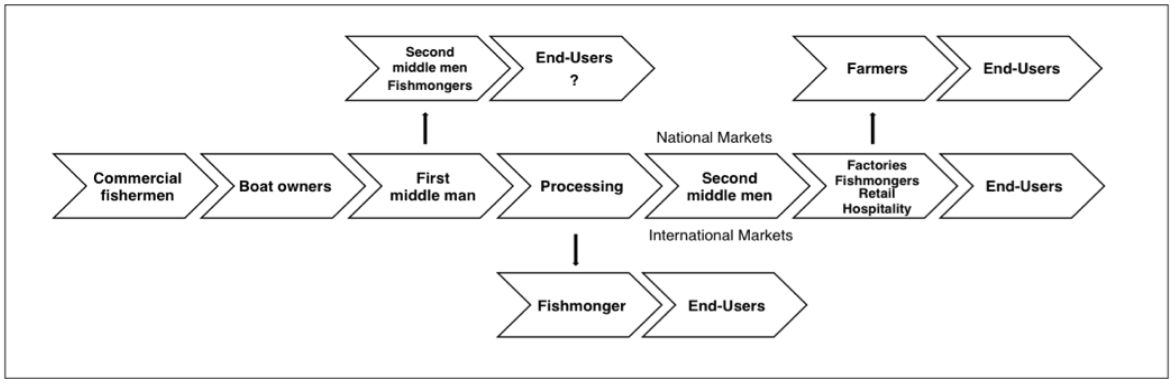

***Figure 28**: Simplified version of the observed supply chain of landed sharks in Songkhla, Thailand*

Value Chain

The highest economic value of shark-derived products is realised towards the end-market rather than on harvest level, where the prices of whole, landed sharks are nearly insignificant, compared to the aggregated end-market values of all the individual products combined. The two different value chain examples, using the more popular *Carcharhinidae* spp., illustrated a likely value increase from harvest level to market level of about 100% for the *C. sorrah*. In both cases, a substantial additional economic value from the harvest level to the retail level was approximated, with an increase of around 280% for the *C. leucas* and 550% for the *C. sorrah*.

When put side by side, it was remarkable to discover that the processed, dried products increase much more in monetary value than the fresh product i.e. meat, off-cuts, etc., denoting that shark-derived products differ hugely in value and that the economic return is highest with the processed products. Large "fresh" shark fins would be sold for ~THB 2,000 on the market level, but when the product reached retail level it has expanded in price by more than 1,600%. Whereas a kilo of fresh meat (market level) that is turned into a kilo of fish balls (retail level), would price increase by only approximately 270%, noticeably to a much lower price (see Appendix 9). The estimations prove that whole sharks are relatively inexpensive on harvest level, but as soon as the first middleman processes the raw sharks, additional values are added to the products; the economic incentive for the perpetuation of the shark "bycatch" industry is quite clear, since it is evident that most sharks of moderate size become rather profitable as soon as the sharks are sold for the second time.

The estimations also showed that Songkhla received around 1,360 individual sharks on a weekly basis, which equals an approximate number of 5,440 individuals per month. A weekly quantity of sharks from harvest to market level would be purchased for around THB 145,000 (~US$ 4,045), which is on average THB 107 (US$ 2.90) per whole shark and represents only around 25% of the mean WTP (US$ 11.70)[28] the divers were willing to pay to explore sharks in marine environments with high biodiversity. Thus, to illustrate the low value of raw landed sharks compared to other marine landed species, the following pictures of different marine products are provided (Figure 29). As illustrated, the 12 whole sharks were sold on auction for a total of 45 THB (US$ 1.2), while four pomfrets (*P. argenteus*) were sold on auction for THB 600 (US$ 16.4), which is 13 times higher than the price of the sharks.

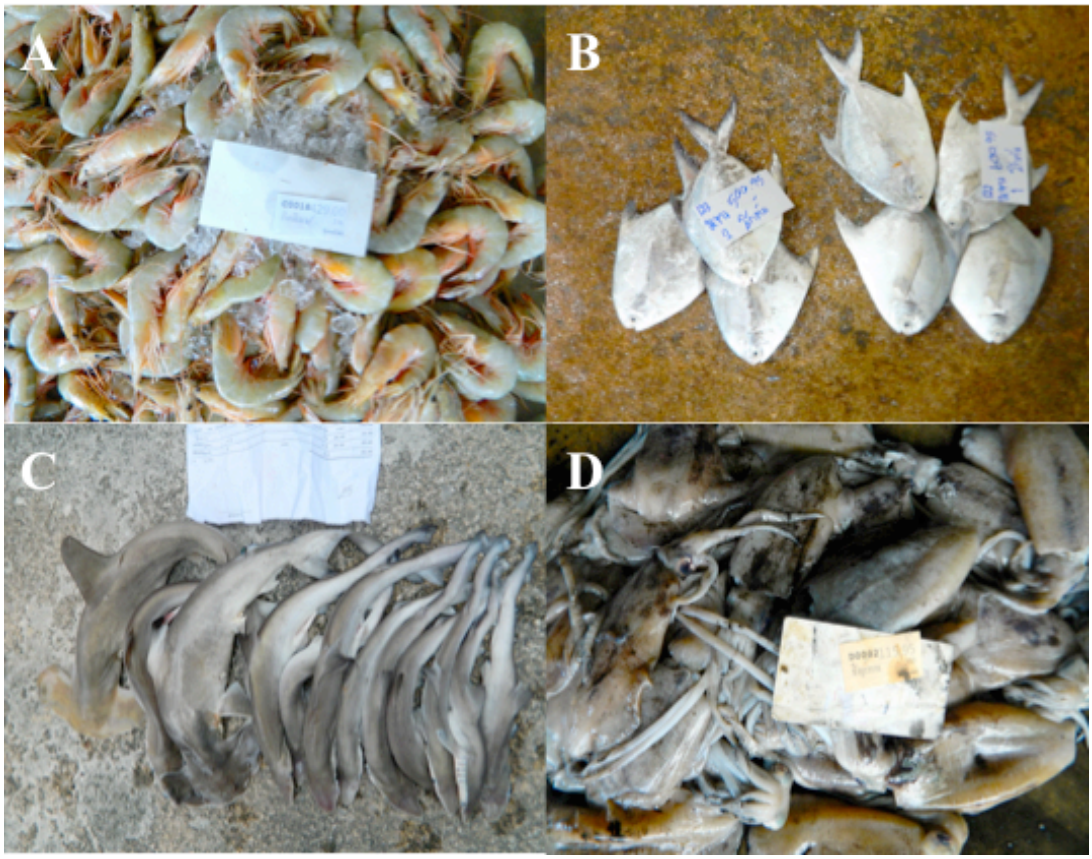

Figure 29: *Various fish species sold on auction in Ranong from first middlemen to second middlemen/buyers. A: Shrimps: THB 429/kg; B: Pomfrets (Pampus argenteus): THB 500-600/kg; C: 12 sharks: In total THB 45; D: Squids: THB 115,95/kg (Ranong, 2015).*

[28] Section 5.4

Based on the data, the shark fishing industry and the market for shark-products seem to have changed significantly in less than 10 years, largely under the increased customer demand combined with a general decline in shark stocks and increased harvesting and processing expenses. Irrespective of the quality, all individual shark-derived products are now highly sought-after, with the fishing industry supplying markets on both national and international levels, while the meat appears to be widely recognised as a well-accepted source of protein - perhaps replacing other diminishing species, as a direct response to the depauperised resources of the GoT, in particular. This also explains the enormous value-adding to the post-landed sharks, highly controlled by increased customer demand and the huge number of middlemen, which may appear insignificant on harvest-level, but eventually may increase prices by more than 1,600%, as the products diverge on the different markets.

The data also signals that the [shrimp] aquaculture and livestock industries have a large, but indirect, impact on the shark stocks, due to the increasing demand for trashfish/off-cuts/fishmeal, which encourages trawlers to conduct biomass fishing (i.e. indiscriminate fishing for harvest quantity alone). In turn, this indicates that the wasteful practice of shark finning is most likely not happening, since there is a market for all the derived products, regardless of the sharks' size and species. As a result, shark finning does not seem to be the main threat to the sharks stocks [in Thailand], but rather the reality of numerous sharks being taken as an "intentional" bycatch in multispecies trawler fisheries with mesh sizes smaller than 25 mm.

5.3 Diver Attitudes and Willingness to Pay

Demographics

It was not possible to localise any detailed tourism records on the demographics of divers in Thailand, but the overall sample results were still considered comparatively representative of reality, based on responses and insights from the dive industry, personal observations and personal communications. Up to 95-98% of the divers were foreigners, mainly from Europe and North America, including a smaller proportion from Asia and Oceania. This result shows dispersion, as different locations attract different tourist groups, compared to one report that stated that 71% of the tourists were, typically from the UK and

Scandinavia (SMART, 2008), while the data from this survey set showed that 77.1% of the respondents were from Northern America/Europe and 19.6% from Asia/Oceania. However, dispersion depends strongly on location and time of the year and, since the sampling was not conducted in peak tourist season, some bias may have occurred in the nationality distribution.

As initially expected, the divers' age range was somewhat different between the Andaman Sea and the Koh Tao and Koh Phangan group (KTKP), which showed that the divers on KTKP were younger than the respondents from Phuket (MKS personal observation; Anon, pers. comm., 2015b). On KTKP, 60.5% of the divers were between 21 years and 30 years, while in Phuket 65.1% were between 26 years and 45 years old. Likewise, the level of income was slightly dissimilar between the two sides. Around one-third of the divers on KTKP (33.3%) earned under US$ 20,000, while 27% earned between US$ 20,000-59,999, indicating that a higher proportion of the respondents from the GoT could be backpackers with a lower level of income. Nonetheless, there was a high rate of non-responses from both the Andaman Sea and the GoT area, as 48.4% and 36.8%, respectively, that did not state their level of income. The gender ratio of males to females was 58:41 (with 1% unknown), which seems to be fairly consistent with the overall gender composition, which is considered to be around 60:40 males to females (Master Divers, 2015).

Diver Attitudes

The data revealed both similarities and dissimilarities between the divers' attitudes based on their level of diving skills and the locations. Irrespective of diving skills, most of the divers did not dive at the chosen sites in order to discover sharks *per se*. Their motivation for diving at a particular site was determined predominantly by other reasons e.g. no influence on the dive location, the coral reefs, the fish species and participation in courses/projects. The survey showed that most of the divers (97.1%) preferred diving in marine environments with high biodiversity, which also corresponds to the dive industry's observation of their customers, when they stated that divers foremost prefer high biodiversity environments, with varied types of marine life. Up to 95% of the respondents regarded shark conservation as at least "somewhat important" and were generally concerned about the state of the sharks and the overall health of the ocean. Many have argued that sharks play a vital role in shaping marine communities and if they disappeared

it will have an effect throughout the entire marine ecosystem, which eventually will lead to decreasing biodiversity. These results demonstrate that divers clearly prefer diverse marine environments, above all else, and that they generally have a substantial interest in the conservation of sharks and a fair knowledge about the consequences of removing apex sharks from ecosystems.

The importance of sighting sharks during diving has revealed two main groups: One diver segment (52%) found it important to sight sharks during diving, while the other diver segment (40%) was neutral. These results could indicate that around 50% of the divers going to Thailand are specifically interested in diving with sharks and that another 40% do not elicit a grand wish to dive with sharks but, if the opportunity was there to discover them, it would add extra value to the whole dive experience. This means that up to 90% of the divers are (in different ways) pleased to observe sharks on dives, which clearly shows that there is a large potential market for shark diving in Thailand, if promoted through the correct channels. This also corresponds to the suggestion of 61% of the managers who requested enhanced promotion of the shark diving in order to make the industry more stable and feasible. However, another important finding is that many of the divers do not expect to see sharks during their dives probably because most instructors have informed them about the poor prospects of seeing sharks in Thailand, or because they knew it from the beginning. Therefore, 62.1% of the respondents were either neutral or expressed no signs of disappointment, if sharks were absent during diving. Under different circumstances, it is, however, likely that the responses would have shown other trends. In a situation with a higher probability of shark sightings, the divers would have probably expected to see at least one or more sharks during their dives, but in case of no shark sightings they would presumably exhibit a higher level of disappointment.

Although 17.2% of the divers observed sharks on their current or recent dives, a percentage similar to the findings of a current operating citizen science project (17.6%) (Shark Guardian, 2015), there are still a few factors that have to be taken into consideration, which may have influenced the total numbers reported. First of all, the questionnaire was only distributed over a quarter of a year, so general seasonlity may have influenced the results. For instance, very few whale sharks were observed in the period, however, the whale shark season is from January to May in Phuket (Newman & Medcraft,

2002), thus, if the questionnaire had been distributed for a longer time, the number of whale shark sightings could potentially had been greater and included other species as well. Also, perhaps some divers did not sight the sharks, because they did not look for them. Maybe the sharks have been scared away by the noise and the large number of divers arriving at the location. Or, perhaps, they may have misidentified the species and, therefore, either reported the wrong species or misunderstood that the animal was a shark. These factors need to be taken ino account, which potentially could have influenced the total reported numbers. Furtermore, it should also be mentioned that one individual shark could potentially have been seen by more than one person, who then reported that one shark, only, which increased the number of sigthtings for the given species. As location was not a prerequisite in the given question, all the dive locations visited by the divers were additionally included (see Appendix 12).

Based on responses to both surveys, it became apparent that most divers (91%) indisputably prefer diving with the Whale sharks (*R. typus*) to any other shark species. This favourite was shared among all the groups of beginners, advanced and experienced divers. Also, knowing that Whale sharks would be migrating through the waters, more than 83% of all the divers expressed a likelihood of returning to Thailand to dive with the Whale sharks. With some species being rather popular still, the following species preferences differed, both according to the level of divers' skills and location, suggesting that there generally was a broad interest in various sharks species in Thailand. Currently, there is a substantial and active customer demand for several different shark species observed in Thai waters (see Tables 19 and 25), which potentially could be turned into a valuable asset for Thailand and, additionally, boost local communities financially. However, due to low and unpredictable numbers of shark sightings, most dive operators consider pursuing this market unfeasible, at least for now.

Willingness to Pay

More than 96% of the divers opted for the scenario which reflected a marine ecosystem with high biodiversity including sharks, compared to a less diverse ecosystem with an increased abundance of jellyfish and rays. The vast majority of the divers (73%) selected the scenario due to the richness and biodiversity in the picture, followed by reasons such as the presence of sharks (15.8%) or turtles (14.2%) and the landscape of a healthy

environment (12.9%). Up to 92.5% of the divers (*n*=222) were willing to pay at least US$ 1.00 or more per dive to experience surroundings like scenario B, which resulted in a average of US$ 11.70. This high mean WTP emphasises the fact that divers in Thailand are willing to pay signifantly more per dive just to experince sharks in the wild.

After running a t-test and calculating Pearson's r, the variables have shown no correlation or a negligible correlation between the choice of WTP and the independent variables. Perhaps this reflects an unconscious preference or a general liking of selecting round numbers, e.g. US$ 10.00 and US$ 20.00 or even the possiblity of some respondents feeling "compelled" to choose a higher WTP due to a "social pressure" from neighbour respondents. If the respondents were given a private space to complete the questionnaire, the latter part could potentially have been avoided/reduced.

5.4 Economic Benefits and Prospect of Shark Diving

Despite the increasing demand from customers in both industries, the businesses are currently in great decline due to over depletion of the shark stocks causing on one hand a low shark-sight predictability for the diving industry, and a growing interest in the capture of juvenile sharks to satisfy the consumer demand on the other. As a result, the data proved that there is significant conflict between the consumptive and the non-consumptive use of sharks in Thailand and that uncontrolled and illegal fishing is largely impeding the chances for a thriving shark-based diving industry in Thailand.

When comparing the estimated economic value of the landed sharks in Songkhla with the average wtp from the divers, it becomes apparent that the accumulated life value of the sharks as a non-consumptive resource greatly outweighs the economic values generated as market products (Table 29). The value of the sharks will differ depending on the popularity of the species[29]. Yet, calculating with the numbers that 51% of a total of 600,000 divers (~838 divers/day) consider shark encounters important (See Section 4.3.2. and Table 27), thus, willing to pay additional US$ 11.70 in order to explore sharks in the wild and then subsequently multiplying the number with the life span of the individual shark species, the results will show that sharks are much more valuable alive than dead, especially, with the

[29] Most preferred sharks in Thailand according to the data collected: (1) Whale sharks, (2) Zebra sharks, (3) Bull sharks and (4) Blacktip reef sharks.

longer-living species. Hence, a country like Thailand could benefit from the non-consumptive use of the shark resources for decades, emphasising the "hidden" gem of sharks as a non-market product. In order to illustrate the significant contrast between the consumptive and non-consumptive use of sharks, Table 29 displays the different species identified during the landing observations with their accumulated and estimated value on harvest, market and end-level as well as their estimated value as a non-market resource based on the average wtp from 306,000 divers (51%).

Table 29: *The observed shark species with estimated value as a market product and as a non-market product with accumulated life value. The values are stated in THB unless otherwise stated.*

Value estimations of the observed species: harvested and non-harvested

Species		**Market Level Values**			**Non-Market Value**
		Harvest	Market	End	Life Value[30]
Bull shark (*C. leucas*)	100kg	~ 15,000	-	(+/-) 57,000	US$ 115 m
Tiger shark (*G. cuvier*)	6kg*50	~ 300	-	Max. 5,000	US$ 75.6 m
Spot tail shark (*C. sorrah*)	5kg* 100	~ 500	-	Max. 5,000	US$ 21.6 m
Scalloped hammerhead (*S. lewini*)	1 kg*55	~ 55	-	Max. 1,000	US$ 126 m
Snaggletooth shark (*H. elongatus*)	12 kg* 100	~ 1,200	-	Max. 10,000	-
Sicklefin weasel shark (*H. microstoma*)	2kg*32.5	~ 65	-	Max. 1,000	-
Bamboo shark (*Chiloscyllium* spp.)	1.5 kg* 32.5	~ 49	-	Max. 1,000	US$ 27 m
Coral cat shark *(A. marmoratus*) *(B.*	0.40kg* 32.5	~ 13	-	Max. 1,000	-
Great hammerhead (*S. mokarran*)	-	-	-	-	-
	Total[31]	**~ 270,690** (US$ 7,550)	**~ 326,500** (US$ 9,100)	**~ 3.3 m** (US$ 92,000)	

[30] Based on total life span of the species (see Table 6) and multiplied with the average wtp (US$ 11.70)
[31] ~2,500 individuals (see table 9)

Over a period of approximately two weeks (*n*=13 days), the total revenue of all the raw sharks landed in Songkhla was estimated to generate around US$ 7,550 on harvest level and US$ 9,100 on market level (Tables 9 & 29). These results were calculated to be between 14-17 times less than the revenue of US$ 127,500 that potentially could be captured from divers (*n*=13 days) willing to pay an additional US$ 11.70 to discover sharks in the wild in high biodiversity suroundings. On the end-market level, however, the accummulated economic value of the shark-derived products had vastly increased in comparison to the two other levels, but the income would still be almost 1.5 times lower than the income gained through the living sharks.

It may differ from site to site and species to species, but a number of studies indicate that around 20 sharks per site are a decent and satisfactory number in order to create a successfully running shark diving business (Anderson & Waheed, 1999; Vianna et al., 2011b). For that reason, 20 large Bull sharks (*C. leucas*) were estimated to have an accumulated one-time value of THB 1.14 million (US$ 31,800), while a group of 20 living Bull sharks, if time-predictable and abundant in numbers, could potentially generate up to THB 4 billion (US$ 115 million) through diving based on their life expectancy. The collected data essentially indicated that all the shark-derived products from the large Bull sharks sold on the end-market would only generate a fraction (0.028%) of the actual economic return that could be harvested through the use of the sharks as a tourist attraction.

Applying this reasoning to a smaller and more specific context, a simple equation will be needed. For example, on Koh Phi Phi, where Blacktip reef shark (*C. melanopterus*) sightings are still somewhat predictable, a dive business based on the island and offering shark dives would have around 245 dive customers per week (Table 30). Assuming that they were all willing to pay US$ 11.70 extra to explore sharks, and further assuming, that the customer flow is constant, the average five Blacktip reef sharks commonly observed around the island (see Appendix 12) would on a weekly, monthly and seasonal basis generate much larger revenues, if they were kept alive (Table 30).

Table 30: *Value examples of five Blacktip reef sharks as harvested and non-harvested resources*

Value estimations of Blacktip reef sharks in Koh Phi Phi (C. melanopterus)

Market Products	5 Blacktip reef sharks: *Harvested*	5 Blacktip reef sharks: *End-market*	5 Blacktip reef sharks: *Accum. life value*[32]
Total	THB 8,700[33] (US$ 243)	THB 75,000 (US$ 2,092)	THB 75,000 (US$ 2,092)
Non-market Products	5 Blacktip reef sharks: 245 divers/week *(wtp)*	5 Blacktip reef sharks: 6869 divers/season *(wtp)*	5 Blacktip reef sharks: *Accum. life value*
Total	THB 103,000 (US$ 2,850)	THB 2,8 m (US$ 80,250)	THB 34,5 m (US$ 962,300)

In comparison to the value of consumable products derived from the five sharks, an aggregated weekly wtp from the dive customers visiting the business could potentially generate an additional economic value spanning from around 36% to 1070% depending on the market level, but if observed throughout their life span, the sharks could bring in approximately 450 times more revenue than the one-time value that they have on the end-market level. This example only refers to the direct revenue generated by one business located at Koh Phi Phi and neither does it include the indirect expenditure which will be several times higher.

The various value examples clearly illustrate that shark-based diving is a better and more sustainable option compared to shark fishing and if shark diving could be incorporated on a higher level in Thailand, this should essentially bring in a higher economic return, which potentially would encourage to improved shark conservation management as well. However, at this stage, it appears to be a critical moment for Thailand's sharks. The results of this analysis indicate that prompt action is needed for lessening the pressure on the shark stocks, especially from overfishing, in order to ensure their survival and growth. As shark diving is becoming a more popular and enduring tourist attraction, the shark-sighting predictability needs to be assured. With the current situation, where only minor shark management measures are implemented, the present downward trend in the stocks will almost certainly continue and eventually lead to an exacerbated likelihood of local extinction of many shark species, and thereby the termination of both industries. The interview data also indicated that stakeholders in the fishing industry are not financially

[32] Life span is around 12 years (Ebert et al., 2013)
[33] 24 kg* THB 72.5/kg =THB 1740/shark

dependent on sharks or could readily switch to other fish species as new source of income, implying that an improved protection of sharks in Thai seas would *per se* not impact these stakeholder segments; thus, pursuing a transition from the consumptive use of sharks to the non-consumptive use is more justified. The diving community is exceptionally devoted to the conservation of the remaining shark stocks and largely interested in providing shark dives, which, given the right conditions, could generate much greater benefits than those related to the shark fishery industries. With the purpose of creating a simplified overview of the two shark-based economies, Table 31 combine elements from the analysis data to illustrate, while simultaneously phasing out overfishing or managing the shark fisheries more intensively, shark diving could be a more economically feasible and sustainable option for Thailand in the long run, which would favour not only the Thai economy, but also the distressed marine environment. By reducing the fishing effort, a positive effect should be expected on the fishermen also, who could profit economically (Squires *et al.,* 2006) from the recovering marine ecosystems and the reduced competition at sea, which is deemed to diminish stakeholder conflicts as well.

Table 31: *Meta-analysis of greater benefits of shark diving rather than fishing*

Perspectives	Dead shark (single use)	Living shark (multiple use)
Economic Value (Profits/WTP)	Based on the market data collected, a single consumptive use of the landed sharks will bring profits ranging from ~THB 1,000 to +/- THB 57,000 on the end-market	Based on the mean WTP, a single individual shark should be able to bring in ~THB 419 (US$ 11.70), but if used multiple times during diving it can potentially bring millions of THB throughout its entire life span (see table 29).
Aggregated/Industry Economic Value (Fishery Statistics/WTP)	In 2013, Thailand generated 131.7 million THB (US$ 3,6 million) from their entire shark fishery production (see Table 2)	600,000 dive tourists x US$ 11.70 (WTP) could potentially generate up to US$ 7 million on a yearly basis, which is an increased revenue of 94% compared to the economic value earned from the entire shark fishery production in 2013.
Livelihood (Direct and indirect benefits)	Creates jobs for many people across several industries: ▪ Fishermen ▪ Boat owners ▪ Port workers ▪ First middlemen and staff ▪ Processing business and staff ▪ A number of other middlemen ▪ Transportation ▪ Labelling factories ▪ Fishmeal/animal feed factories ▪ Aquaculture farmers ▪ Wholesale and retail shops ▪ Restaurants and staff ▪ Actors on international markets	Creates jobs for many people across several industries: ▪ Dive shops ▪ Restaurants ▪ Bars and clubs ▪ Accommodation (hotels, hostels, resorts) ▪ Retail businesses ▪ Local markets ▪ Dive equipment shops ▪ Convenience shops/supermarkets ▪ Transportation (taxis, airplane, bus services, ferry transfer) ▪ Construction work ▪ Marketing, administration and PR ▪ Tourist attractions ▪ Research and Conservation Centres
Utilisation	Sharks are fully utilised including their: ▪ Meat, fins, skin, liver oil, off-cuts and teeth/jaws.	Sharks are observed alive in the ocean: ▪ On sites with sight predictability (see Appendix 11) ▪ On morning dives
Popularity	Most shark-derived products are sought-after in Thailand, implying all harvested sharks/products will be purchased. Especially products i.e. the fins and meat are popular. The prices of the products have increased significantly in the last 5-10 years due to: ▪ Declining wild fish and shark stocks. ▪ A general increased demand on shark-products. ▪ Increased business expenses	There currently is a great demand for shark diving in Thailand, which is likely to: ▪ Increase further in the future, as more divers are getting certified. ▪ Potentially appeal to up 90% of the divers diving in Thailand per annum. ▪ Divers are generally willing to pay almost four times as much compared to the average value of a dead shark.

Level of Interest in sharks	Most stakeholders in the fishing industry generally have little/no interest in the sharks stocks due to: ▪ Low-value ▪ Quantity unpredictability ▪ Difficulties in catching them ▪ Unaware of the sharks ecological role ▪ Traditionally not a fishing target	There is an extremely high interest in keeping the sharks alive among the stakeholders in the diving community due to: ▪ Sharks add a value/bonus to the dive. ▪ Sharks play an important, ecological role in ecosystems. ▪ Sharks are profitable and attracts dive tourists ▪ The presence of sharks is a bioindicator of healthy ecosystems.
Feasibility/infeasibility	Shark fishing is infeasible due to a number of reasons: ▪ Rapidly decreasing in numbers. ▪ Requires a lot of effort to catch them. ▪ Less abundant compared to other fish species. ▪ Difficult to reach the fishing grounds for at least small and medium-scale fishing vessels.	The probability of shark diving becoming a more widespread tourist attraction in the future was around 68:32, however, there is an explicit, fast declining trend resulting in: ▪ Sight unpredictability. ▪ Low abundance. ▪ Divergence of opinion about the feasibility of shark diving.
Sustainable practice	All the landed sharks were either 'Near Threatened' or 'Threatened' species on the IUCN Red List, while 51% was considered immature, indicating that shark fishing in Thailand is greatly unsustainable.	More studies are needed to understand the potential impact from shark diving (Gallagher *et al.,* 2015), but scarce studies signal that interactions with e.g. whale sharks have little impact on their general behaviour and that the aggregation is determined by oceanographic and biological factors (Sanzogni *et al.,* 2015). Taking these results into consideration combined with the fact that the sharks are kept alive rather than killed, clearly exemplifies that shark diving is a more sustainable option than the shark fishing and presumably a crucial driver in the potential conservation of sharks (Topelko & Dearden, 2005).
Ecological Role	Absence of sharks in ecosystems: ▪ Can provoke trophic cascades. ▪ Decreases biodiversity. ▪ Can have detrimental effects on whole ecosystems. ▪ May eventually lead to algae dominated zones. ▪ Likely to decrease the number of dive tourists.	Presence of sharks in ecosystems: ▪ Ensures varied abundance of fish species on all trophic levels. ▪ Increases biodiversity. ▪ Reflects healthy, balanced and resilient marine environments. ▪ Can indirectly economically influence businesses positively. ▪ Likely to increase the number of dive tourists.
Abundance	~2500 individual sharks were landed, greatly dominated by smaller size sharks and juveniles, which at the end of the day only produces a minor quantity of food for human consumption.	~2500 individual sharks comprising of species economic important in the diving community should be able to financially contribute over yearlong periods, implying their higher value and the better use if kept alive.
Cultural Significance	With a few exceptions, shark fin soup consumption is not culturally important among Thais and is more commonly eaten by tourists or Chinese ethnic minorities in the larger cities, i.e. Bangkok, Hat Yai, Phuket, etc.	There is no cultural significance in the living sharks, as for instance seen in some cultures, where sharks represents ancestors or gods and if consumed it will be considered a taboo (Ames, 2013).

Research/Education	Usage of a dead shark i.e.: ▪ Age and growth. ▪ Measure size and length. ▪ Analyse stomach content, etc.	Usage of a living shark i.e. ▪ eShark.org: a citizen science monitoring programme reported by divers, snorkelers and recreational fishers. ▪ Awareness-rising projects. ▪ Tag and release projects, etc.
Overall Reputation	Generally creating: ▪ Bad reputation among all sorts of shark proponents ▪ Commonly clashing with people in touristy cities that thrive on diving or support sharks.	Generally creating: ▪ A positive media attention. ▪ Likely to draw more tourists to the country.

5.5 Study Limitations

Fishing Industry

There are undoubtedly limitations associated with a study, especially when conducted on foreign grounds. The researcher was faced with a lack of consistent and systematic data on shark stocks and their use in Thailand. The thesis is a contribution to filing this gap. It would have been desirable to conduct observations for a longer and more consistent period, preferably at least one year in order to detect seasonal variations, but due to the scope of the project, it was not possible to collect data for more than four months. It would also have been very useful to have local assistants in the field, that could have assisted the researcher in measuring and weighing the sharks; but since there were only limited resources available, the researcher mostly worked alone. This also restricted the scope of the outcome, as some of the landings have been based purely on estimations, which could have been reduced or even avoided with the help from an assistant. More informal stakeholder interviews should have been conducted, which could have assisted in establishing a more accurate picture of the value chain of the landed sharks in Songkhla.

The communication between the researcher and the stakeholders at the port was also limited due to no common language; therefore, a translator was needed in all communication circumstances. This complicated the situation considerably, in cases where the researcher did not have a translator with her in the field. The researcher is aware of the fact that due to language barriers, there is a great risk that useful information may have been lost or remained unrevealed during trips without a translator. Phone calls to Thai colleagues were occasionally pursued, if urgently needed, although it was clearly preferred having a translator by the side, as it allowed more spontaneity and flexibility in communication. Other limiting factors were related to cultural barriers, such as the researcher's Western appearance and her initial lack of knowledge about the Thai culture. In some of the informal interview occasions, the researcher felt that a few of the stakeholders were slightly sceptical or concerned about their existence which potentially also could have restricted the flow of information and the overall outcome. The researcher's lack of cultural insight decreased with time and, towards the end, she had established a fairly good grasp on how to approach the different stakeholders. In order to minimise discomfort and to make the situation progress more naturally, none of the

informal interviews were recorded instead, the translator reported back to the researcher multiple times during the interview, while notes were taken. The potential problem with this approach is that some information could have been lost. As the researcher does not understand Thai, she could not interpret the conversation between the interviewee and the translator, thus, the precision and accuracy of the collected data would solely depend on the translator's skills on delivering the message as precisely and accurately as possible.

Diving Industry

The dive industry was contacted via email. This has given rise to a few drawbacks. Spam filters rejected emails and some recipients could have chosen to ignore the email, consequently, never forwarding the questionnaire to other people in the business. Also, with online questionnaires, the respondents were unable to ask questions, which ultimately can create misunderstandings or misinterpretations, and thereby, potentially skew the final results. The researcher did not distribute the questionnaires in person, this could potentially also have created some issues, because due to her absence she was not able to answer any questions. In order to minimise this, all diving operators were shortly briefed in a previous email explaining the purpose of the project. Some operators explained that their dive tourists did not speak English, hence, other languages could have been considered, but due to time limitations, this option was not pursued.

Ideally, the sample size should have been larger and all the questions completed by the respondents in order to increase the confidence level, which would make the results more precise and minimise potential errors in the sampling. Also, the diver survey was seasonally distributed during three months or a quarter of a year. This could have given rise to bias, especially in terms of diver variances. Some nationalities have shown to be more prone to pay a higher amount (WTP) compared to other nations (Asafu-Adjaye & Sorada, 2008), so in order to retrieve more accurate results and to discover seasonal variations, survey distribution throughout the high seasons on both site locations would have been optimal.

5.6 Future Research

Future research should aspire to focus on all the 10 aims associated with the NPOA-sharks plan (see Figure 6), of which some are currently receiving high priority among decision makers and governmental institutions (Sattar & Anderson, 2011; SEAFDEC, 2012; Chamsai *et al.,* 2013; Krajangdara, 2014; SEAFDEC; 2015; Appendix 1). The data collected for this study confirms that Thailand is following a few of the 10 aims, including (5) "Minimise unutilised incidental catches of sharks", (7) "Minimize waste and discards from shark catches" and (8) "Encourage full use of dead sharks". The remaining aims would, therefore, in particular, be relevant to focus on, with the overall purpose of implementing an NPOA-sharks plan in Thailand, at the first opportunity.

Future research should also concentrate on addressing other related issues which contribute to the general shark stock decline (see Table 18), among others i.e. the consequences of coral bleaching, pollution and habitat loss, effects of noise pollution created by boat traffic and diving activity, as well as the ecological damage caused by a number of inexperienced divers.

Studies dedicated to the value and supply chains of sharks for the whole of Thailand should also be initiated. There is a strong need for more research and transparency on the topic in order to determine the fate of shark-derived products and to elucidate the number of actors involved in the shark supply chain.

The divers and the diving industry provided information on several sites, which are commonly inhabited by sharks (Table 19, Appendices 11 & 12). These locations should represent a good opportunity for future research in relation to monitoring and assessment of shark populations in Thailand, which eventually could assist in determining suitable locations for a potential shark MPA or sanctuary. Another study of the divers' WTP should be launched, as shark stocks rebuild and more shark sightings are feasible in order to revise the level of willingness to pay. The study should also focus on preferences for a potential "diver fee collection" to determine how the divers prefer the fund to be managed, and additionally, to uncover if the fee were to be collected by e.g. the diving industries, local NGOs and conservation centres, governmental agencies or tourist offices, etc.

6 From WTP to Implementation

6.1 Contextualisation of the WTP

The research on the underwater scenario preferences has shown that divers in Thailand are willing to pay an additional US$ 11.70 (± 0.96) per dive provided that the event entails diving at sites with high biodiversity involving the presence of sharks. Based on the estimated 600,000 divers annually visiting Thailand and the average WTP revealed, these numbers suggest that Thailand should be able to generate US$ 6.9 million annually from shark diving and marine biodiversity exploration by the dive customers, which is almost twice the profit earned from the complete shark market production in 2013. However, if the number of divers in reality is even higher and closer to the estimated 1.6 million (SMART, 2008), the suggested US$ 6.9 million only comprises 37.5% of the actual revenue Thailand potentially could generate from shark diving, which instead would be towards US$ 18.4 million. The money raised could be used to support some of the following environmental protection measures or for developing and implementing a strict shark conservation policy, but since the latter option is outside the scope of the thesis it will not be elaborated into further details.

6.1.1 Marine Park Ranger

One average WTP (THB 419) which exceeds one fisherman's whole daily wage of THB 300 by more than 39%; it could be used for better monitoring of Thailand's marine parks to compensate for lost income in the case fishermen become unemployed. For example, a marine park ranger working ~28 days per month and receiving a minimum daily wage of 300 THB (US$ 8.40) could earn ~8,400THB per month (US$ 236). This monthly wage could be supported by 21 divers or by 246 divers for a whole year's salary (Table 32).

Table 32: *A distribution overview of the mean WTP from the divers*

Mean WTP	US$	Salary/Day	Salary/Month	Salary/Year
1 diver	11.70	1 person	-	-
10 divers	117	14 persons	-	-
20 divers	234	28 persons	-	-
50 divers	585	68 persons	2 persons	-
100 divers	1,170	140 persons	4 persons	-
1000 divers	11,700	1,409 persons	49 persons	4 persons
100.000 divers	1.17 million	140,968 persons	4,957 persons	413 persons
600.000 divers	7 million	843,373 persons	29,661 persons	2,471 persons

The data in Table 32 shows that US$ 7.0 million could potentially provide up to 2,471 people with a full time marine park ranger employmen at a minimum wage per annum. This, however, does not include spending on the level of education or traning that likely has to be completed in order to become a marine park ranger. Currently, there are at least 26 established MNPs, which ideally should be monitored 24 hours per day, but by employing around 2,470 ex-fishermen may be a little excessive. As a result, a certain percentage of the fishermen could be hired as marine park rangers, with the purpose of improving the patrolling of the nation's MNPs, as a part of the effort of rebuilding the marine stocks.

6.1.2 Shark Levy

A "shark levy", as implemented in a marine reserve in Fiji, could be collected from divers in Thailand. In Fiji, local communities are paid a daily amount per diver diving in a marine reserve to compensate for their loss of income, financially provided by the diving community (Brunnschweiler & Earle, 2006). This could also be applied as a targeted tax to cover some community level investment in, perhaps, schools, public transportation, water treatment projects or coral reefs sanctuaries. However, since all of the major reef tourism sites on the Andaman Sea are already established within MNPs, a "shark levy" presents a potential management tool. All tourists pay entrance fees to dive in the marine parks, but if the money for a "shark levy" could be transparently linked to an explicit management programme or protection levy, or perhaps allowing dive customers' access to sites otherwise unavailable, it should be possible to implement such a levy over the top of the entrance fee. The survey data proved that many divers were willing to pay an additional amount to the mandatory entrance fee, on the condition that the dive includes possible shark-sightings and high biodiversity environments, thus emphasising the great potential in promoting such management programmes.

6.1.3 Alternative Use of the Fishing Vessels

Tourist-Based Activities

The interview data have shown that it is generally difficult for fishermen to find alternative livelihoods; yet, they have also shown that fishermen increasingly are turning towards tourist-based activities, as an alternative source of income. Given the current situation of

scarce fishery resources, people in the fishing industry are becoming more flexible, as they are aware of the increased likelihood of eventually having to change profession. One suggestion made by survey respondents was to use their fishing vessels as tourist boats that, for example, transported tourists between islands and/or for recreational fishing purposes.

Another option is known *pesca tourism*, which would involve allowing customers on the fishing vessels to learn more about the fishing culture in Thailand. If successfully introduced, this attraction can have multifaceted advantages, such as economic benefits for the fishermen/boat owners, the learning experience about the local fishing culture, which may enhance pride of the profession and the environmental protection aspect due to a reduction of fishing effort (MedPAN, 2012). As a project in the in Mediterranean Sea has shown (MedPAN, 2012), an additional alternative to the latter option could be to allow tourists to embark on a regular boat and follow a fishing vessel out to sea to observe and learn at a distance the practice of fishing in Thailand (MedPAN, 2012). At the start-up stage, the tourist-based activities will need an initial capital investment until this activity creates its own regular cashflow, which for example could be financed by the incoming revenue from diving. Such tourist attractions will also create other job opportunities, including transportation i.e. between hotel and port, administration, marketing, advertisement, catering, translators, etc.

Scientific Monitoring Activities

Another option in regards to alternative boat use could be to encourage fishermen/boat owners to participate in periodic scientific data collection and marine ecological monitoring programmes conducted by teams of scientists and fishers on board the vessels (MedPAN, 2012). The former fishers participants must be compensated for 'lost catches', while instead having spent hours/days on collecting scientific data, which could be supported by the incoming revenue from diving combined with government funding. Further, if properly funded and effectively implemented, such an alternative approach can provide important and valuable results, useful for establishing a shark data base (which is now missing) and to support managers and decision makers in determining future fishery plans (MedPAN, 2012).

6.1.4 Difficulties with Implementation of the WTP

As argued, the WTP is a tool that provides important insights about the value potential consumers place on the non-consumptive use of the shark stocks, which could reduce the pressure on the shark stocks exerted by uncontrolled fishing. But given the current situation (of shark scarcity in Thai waters) that is far from reflecting the actual scenario picture, it will not be recommendable to charge a US$ 11.70 'shark fee' per diver, as Thailand cannot offer shark sightings any longer.

> "Very rare to see sharks in Thailand, now. About 10-15 years ago, there were still many around this area [Racha Yai Island] - totally different from this day's diving" (Experienced Thai diver, 2015).

Provided that the marine resources could be regenerated to a level that reflects the proposed scenario situation more accurately, which should include predictable sightings of sharks, sufficient abundance and increased biodiversity, it would be feasible to charge divers up to US$ 11.70 to dive at shark prone locations. When these conditions have been met, a new WTP questionnaire should be launched to assess the divers' willingness to pay, which might be higher in the future, as the demand for shark diving is deemed to increase.

In the hope that a future shark diving industry will prosper in Thailand, it is deemed advisable to at least develop and enforce a so-called code-of-conduct for diving, similar to the one existing for the Whale shark (Park and Wildlife, 2013), which is likely one of the best approaches in terms of sustainable management of shark diving (Gallagher *et al.,* 2015). As Thailand currently has not implemented any 'shark diving regulations' (Topelko & Dearden, 2005), development of such a code should receive a higher priority. This, in conjunction with a license permit, incorporating a maximum number of operators allowed to conduct shark diving within a certain area will limit the activity, while similarly using trained personnel to evade harmful impacts on the sharks (Graham, 2004; Vianna et al., 2011b).

7 Management Recommendations

A transition towards the non-consumptive use of sharks

The data presented in this thesis indicate strongly that sharks are harvested unsustainably in Thailand, which implies simplistically that the fishing effort targeting the animals must be reduced immediately (FAO, 1999). As the study shows, however, sharks are increasingly "intentionally" targeted by large-scale fishing vessels, indicating that there has been a target-shift towards sharks, probably as a combination of the overall pursuit of catching the diminishing wild fish stocks and the increasing demand for shark-derived products. Sharks should therefore immediately be recognised as a part of Thailand's targeted fisheries and acknowledged as an essential part of the catches. By recognising that many sharks are purposely targeted and not only caught as bycatch should translate into more efficient management of the shark stocks and likely encourage managers and officials to take more management responsibility of the species (Sattar & Anderson, 2011). In recent years, however, the majority of the shark catch has been captured in extra-territorial waters, implying that Thai authorities are free to disavow responsibility of the shark landings.

Even though, the shark production only contributes a minor fraction to the annual marine production, Thailand ranges globally among the most significant shark fishing nations and the world's top exporter of low-grade fins, thus, carrying a great management responsibility in the global fishing and trade industry of sharks (Worm *et al.,* 2014). In the event of a continued absence of shark management, nothing will halt the progressive decline of the shark populations in Thailand, also lowering the future chances for a thriving and economically healthy shark-based diving industry. From the data presented here, it is apparent that the consumptive and non-consumptive exploitation of sharks in Thailand have incompatible goals, since the objective of sustainability applies only to the latter. Therefore, any measure aiming to protect sharks should be embedded in the general fisheries management and conservation measures - as even a successful implementation of the NPOA-sharks will depend on these.

The shark fishing industry in Thailand in its current form is in decline. In favour of increasing the potential use of sharks as a non-consumptive resource through shark-based dive tourism in Thailand and likewise to meet the dive customers' demands for marine environments with high biodiversity with the presence of sharks, the results suggest that the consumptive use of sharks has to be significantly reduced to sustain such businesses. A number of nations have acknowledged the greater benefits extracted from the non-consumptive use of sharks rather than their consumptive-use (MCI, 2015). A long-term sustainable and non-consumptive use of sharks is also possible in Thailand, but this implies that the nation must take action now by addressing a number of management issues in order to reverse the declining stocks trends and to ensure the future existence of sharks.

The chapter presents three overall management approaches with concerted recommendations that are either based on 'strict measures', 'alternative measures' or 'lenient measures', followed by a few 'research-directed measures'. On the whole, the measures have been formulated based on the suggestions proposed by interviewees and respondents and the researcher's insights and conclusions of her analysis, as recommended next-step actions to pursue in order to enhance the shark populations of Thailand which, eventually, should lead to a transition from the consumptive to non-consumptive use of sharks (Table 13 and Chapter 4.3.5.). Supposing that either the 'strict measures' or the 'alternative measures' are implemented, the 'lenient measures' should also be integrated at the side of these, as supporting measures. This applies to the 'research-directed measures' as well. They should be implemented in conjunction with the proposed management measures in an effort to finalise the NPOA-sharks plan. Table 33 displays an overview of the different management recommendations presented according to their level of influence to ensure the long-term sustainable use of sharks, starting with the most recommended (stricter) measures.

Table 33: *Management recommendations from most recommended to least efficient measures, including research measures as a parallel ongoing action*

#	Management Recommendations	Measures
	Strict Measures	Recommended
1	Trawler Ban	
2	Trawler Buyback Plan	
3	Reinforcement of Pre-existing Marine National Parks	
4	Flexible Buffer Zones Around Marine National Parks	
	Alternative Measures	Second Best
1	Partial Trawler Ban Through Zoning	
2	Improved Licensing System	
3	Installation of Bycatch Reduction Devices on Trawlers	
4	Release of Juvenile Sharks and Gravid Females	
5	Limitation on Trawling Hours	
6	Mesh-Size Enlargement of the Cod-End (≥40 mm)	
	Lenient Measures	Softer
1	Continue Implementing Fishing Suspension	
2	Continuance of Pre-existing Fishery Regulations	
3	Community-Based Shark Conservation	
4	Shark Finning Ban	
5	Delegate Fines to Irresponsible Dive Operators	
6	Shark Awareness Campaign	
	Research Measures	Parallel Ongoing Actions
1	Promote the Citizen Science Project in Thailand	
2	Family-Level Reporting → Species-Level Reporting	
3	Additional Biological and Ecological Data Collection	

7.1.1 Stricter Measures

The 'stricter measures' suggesting a combination of a trawler ban and trawler buyback plan in step with stricter MNP enforcement are the most recommended approaches to pursue, which should result in the most ideal transition from a consumptive use of sharks to a non-consumptive use and likewise, assist in increasing the ecosystem health and the shark populations in favour of all the stakeholders daily using the marine resources (Squires *et al.,* 2006).

In Thailand, the fishing effort is far beyond the sustainable yield level and the activity is increasingly occurring within national marine parks, in coastal areas designated to small-scale fishermen and on/around important nursery and breeding grounds. Hence, a *full trawler ban* should prove to be the best and most radical action to pursue in order to curtail the devastating destruction of the bottom habitats. In the Java Sea, a trawling ban was

imposed in the late 1980s, which resulted in rebuilt stocks, greater than prior to the introduction of trawling, and larger sizes of the demersal fish species landings, far more suitable for human consumption (James *et al.,* 1991). In more recent years, Hong Kong, Malaysia and Indonesia have also either initiated or proposed trawling bans in an attempt to reverse further depletion of the marine stocks and to follow a more "green" approach to fishing (Loh & Jaafar, 2015). However, facts denote that implementing a complete trawler ban without any alternatives for the affected parties will only prove unsuccessful and most likely encourage poaching and stakeholder non-compliance (Loh & Jaafar, 2015). As a result, the ban should be accompanied by a *trawler buyback plan,* financed by the government, that will compensate fishermen/trawler owners for surrendering their vessels or, perhaps, give them the opportunity to exchange trawlers for other fishing gear, license or vessels.

In Malaysia and the Maldives, the governments have implemented gear buyback plans that ended up being partially successful. Initially there was a high number of fishers that accepted the buyback offer subsidized by the government, which eventually lead to reduced fishing effort, but ensuring alternative livelihoods to the individuals afterwards was not thoroughly considered, however (Sattar & Anderson, 2011). In Thailand, data collected indicate that a lot of people in the fishing industry want to leave the industry, thus, a trawler buyback plan will likely encourage a lot of trawler owners to seize the opportunity to fully exit the fishing industry and to enter other businesses:

> "If someone wants to take over their business, they want to exit. There is a lot of pressure on the fisheries in Thailand and many try to leave the business*"* (Interviewee I).

In this connection it is advised to involve the fishermen and boat owners in a retraining plan for ease of finding additional income sources and to ensure that they get back to the labour market at the earliest. The purchased vessels could be re-used as patrolling vessels or utilised for tourist and scientific activities (see Chapter 6), or perhaps be deployed as artificial reefs.

In conjunction with the fishery restrictions, *reinforcement of pre-existing marine national parks* must be carried out through strict daily patrolling and monitoring in order to protect

the marine resources from overfishing. This measure should be enforced particularly in offseason and during night-time, where there are no dive operators to prevent or discourage fishing vessels from performing illegal and unreported fishing in the marine parks. In addition, the survey data showed at least 11 overall locations where sharks can be observed, which were either located within a marine park or in close proximity to one (Figure 31) (Sethapun, 2000). These locations are all classified under the IUCN category II, denoting that the parks' main purpose is to protect the ecosystems from overexploitation, while similarly allowing the chance to contribute to local economies through education and recreational tourism without being at the expense of the existing conservation effort (IUCN, 2014).

Both the diving industry and the divers reported the same five shark species at Koh Phi Phi. Most of these species are highly prominent and economically important in the global diving community (Gallagher & Hammerschlag, 2011; Vianna et al., 2011a; Vianna et al., 2011b), but none, however, is considered of 'Least Concern' (implying low risk of extinction). All the species were either listed as 'Vulnerable' or 'Near Threatened' on the IUCN Red List. Around Koh Surin and Koh Similan, the dive instructors reported sighting of the Oceanic Whitetip Shark (*C. longimanus*), which is likewise listed as 'Vulnerable' on the IUCN Red List, but it also included on the CITES Appendix II, which means that the trade of the species has to be closely monitored to minimise the potential risk of the species coming under threat of extinction in the near future.

The term "paper parks" refers to "an area with a name (and often supporting legislation) but no effective protection at all". The current marine reserves certainly fit that bill. Low capacity for enforcement of boundaries and restrictions, coupled with a lack of understanding about the role of MNPs as reservoirs of replenishment means that Thai MNPs largely fail to buffer the impacts on shark populations caused by the depredations of commercial fishers. Indeed, poaching within MPAs appears to have increased as the surrounding ecosystems have been depauperised. As a result, it is highly recommended to intensify MNP enforcement at all the locations illustrated with sharks, as the sites appear to be important living grounds for a number of species that are either under threat of extinction or may soon be facing the risk (Figure 30).

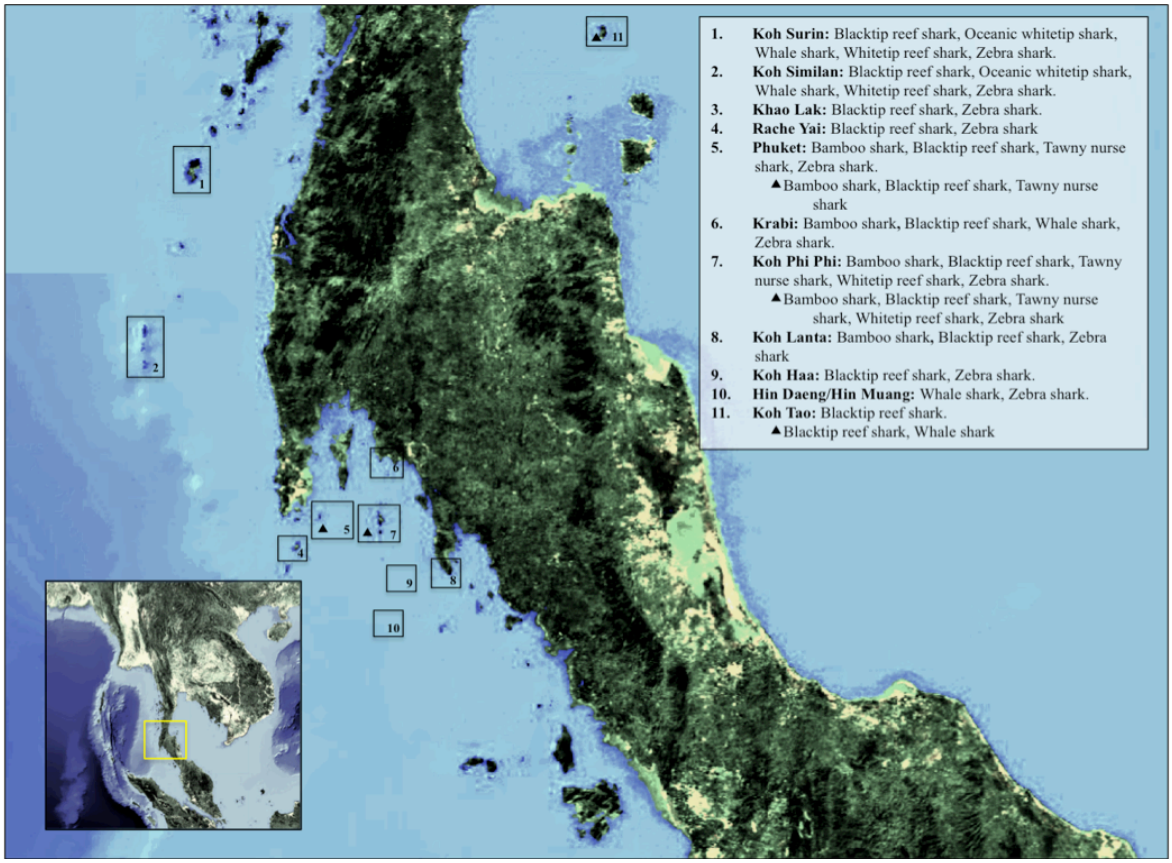

Figure 30: *Dive locations used for shark diving in Thailand, including the observed species (1-11) and dive locations with sharks observed by 17% of the divers (▲) Source: Flash Earth (2015)*

Lastly, the MNPs should additionally be protected by *flexible buffer zones,* which include controlled fishing activity (Figure 30) (Sethapun, 2000) aiming to reduce the overall fishing effort on and around locations favoured by the sharks. Within the buffer zones, small-scale fishermen should still be allowed to operate with no further restriction, while the fishing activity of all medium and large-scale fishing vessels should be restricted to a limited number of fishing days per week or a full fishing ban in the buffer zones every second week. This kind of preventive measures also meets the purpose of the IUCN category II, which states that surrounding waters of a national park should act as buffer zones (IUCN, 2014). This implies that DNP need to cooperate with other agencies such as DoF, the Department of Marine and Coastal Resources (DMCR) and other relevant marine resource institutes to develop effective buffer zone management plans and engage with coastal communities, while following a more decentralised approach, which equally should improve the communication between the parties.

7.1.2 Alternative Measures

If the 'stricter measures' are impracticable, the 'second best option' is recommended including, a partial trawler ban through zoning, concerted with a number of other alternative fishery measures, focussing on limiting the fishing pressure and increasing the gear selectivity are recommended, as part of the overall effort of expediting the transition from consumptive use of sharks to the non-consumptive use.

As many peoples' livelihoods depend on trawler fishing in Thailand, a rapid transition to banning all trawling may be met with a great degree of resentment, thus, an alternative to a complete *trawler ban* could be realised through a *zoning action* within Thailand's EEZ, with the purpose of entirely banning trawling in the future. The pre-existing 3 km inshore zone, which already prohibits all trawling, could be extended to a minimum of 3 nautical miles zone (5.4 km) or potentially increased further to maximise the space for replenishment and to increase the protection of the delicate inshore ecosystems from overexploitation. Like an "onion layer" principle, additional layers of no-trawling zones should then be added to the pre-existing zone(s), in time, in order to allow the fishermen to adapt with the fishery regulation, which eventually should result in a termination of trawling in the Thai seas. The extension of the zone(s) should decided and implemented in close collaboration with all stakeholders: fishermen, boat owners, provisional fishery departments, fishing associations, etc. in order to determine the timeframe and the size of the subsequent layers that should be added to the pre-existing zone.

This should be followed by an *improvement of the trawler licenses*. Although no 'new' trawler licenses are issued, the Fishery Act still allows existing licensees to renew their trawler licenses (Boonyaratpalin, 2002) (as cited in Chuenpagdee & Pauly, 2003), thus as seen with the push netters (Panjarat, 2008), any extension of trawler licenses after expiration should be prohibited to reduce the destructive impact conducted by the fishing gear. The non-transferable trawler licenses should similarly be made non-heritable (Panayotou & Jetanavanich, 1987) and the annual rate of fishery tax should be greatly increased[34] and set in accordance to capacity of the gear (Panjarat, 2008). The retired vessels could be used for similar purposes as mentioned in 7.1.1.

[34] Annual fee on the trawl nets: THB 5 (US$ 0.14)

In addition to a partial trawler ban through zoning and improvement of the trawler licensing, a number of supplementary command and control measures should be put into place. Trawlers accumulate a large quantity of bycatch per haul, which results in a high mortality rate and capture of sharks; installing a *bycatch reduction device (BRD)* on the trawlers should likely assist in reducing the level of shark bycatch (Achavanuntakul *et al.,* 2014; Worm *et al.,* 2014). However, this measure will likely be regarded unfavourably by most fishers and boat owners (Supongpan & Boonchuwong, 2010) due to economic losses from the escaped fish, since the majority engage in biomass fishing. Thus, it will be essential to find a solution to overcome the stakeholder's resistance and their general scepticism of installing BRDs on the fishing gear. The data also showed that a large proportion of the landed sharks in Songkhla were neonates and juveniles and that most fishermen do not release gravid females due to the greater benefits of landing the animal (Interviewee I). As a result, a *size regulation* could be introduced to lower the rate of capture of immature sharks, with the purpose of increasing the percentage of sharks being allowed to reach sexual maturity and to ensure that gravid females successfully deliver the pups they have been carrying.

In the same context, a *limit on the trawling hours* could also be considered, which, at a minimum, should be shorter than the 5-6 hours that the trawlers are currently trawling. This should involve a general reduction of environmental impact and stress on the fish stocks, increase the quality and the economic value of the caught fish, as well as improve the chances of survival for some species, as the pressure in the nets is lessened with the shorter hauls. Another alternative measure is to *enlarge the mesh size* of the cod-end to minimum 40 mm to prevent some juveniles and neonates from getting captured in the net. However, increasing the mesh-size may not have a positive effect on the shark stocks, because most neonate sharks are typically larger than 40 mm meshes, but, from a holistic approach, it should overall promote a healthier marine environment.

In order to achieve stakeholder compliance, it will be necessary to provide evidence that will be beneficial for the fishermen and the boat owners to comply with the alternative measures, as compliance will eventually lead to larger and more fruitful catches. In the case of persistent non-compliance, it may be necessary to regulate the initiatives by law, better monitoring or enforcement through fines. However, the data collected has shown that there is an increasing interest in responsible fishing as well as an improved

understanding of the environment and ecology, thus, indicating there is a good chance to reach the target groups, if the message is presented in a clear and appealing way.

7.1.3 Lenient Measures

The 'lenient' approach, involving enforcement of pre-existing regulations, awareness and teaching/information and a few new approaches, will most likely lead to a very gradual transition towards the non-consumptive use of sharks and, quite possibly will not be enough to reverse the current declining trend in shark stocks. Therefore, the 'lenient measures' should ideally be incorporated alongside with one of the two preceding measures to support the more efficient, fishery protection measures.

The more recent governmental initiative to conserve the marine resources by imposing a 5 to 9 days *fishing suspension* per month (Wipatayotin, 2015) could prove to be a good start in the greater context of rehabilitating the marine resources in Thailand. A limitation on the fishing activity was already recommended by some of the stakeholders in Songkhla, who believed that the uncontrolled fishing activity, occurring every day, was contributing greatly to the overall depletion of the resources. Thus, depending on the number of days suspended, the 65 medium-scale trawlers in Songkhla could presumably reduce the overall catches with ~1,300 to ~2,340 individual sharks per month, based on the catch estimations per haul obtained in Songkhla[35]. In addition to the fishing suspension, the *pre-existing fishery regulations,* implemented by DOF in 1972 and 1984, respectively, including area and seasonal closures and gear restrictions and limited entries should proceed as normal or perhaps be intensified. These fishery regulations were greatly encouraged to remain unchanged among a number of boat owners in Songkhla, as a minor increase in the fish abundance (and to some extent for sharks too) has been detected after seasonal closures, which in response, would slightly drive up the prices of the marine products, resulting in improved revenues for the boat owners.

[35] The large-scale trawlers in Songkhla are owned by very few boat owners, which are often difficult to reach (Anon, pers. comm., Nov, 2014). As it was impossible to retrieve information from large-scale boat owners, the shark catch estimations per haul will only include numbers from medium-scale trawlers.

The survey data showed that all the managers were concerned about the general decline of sharks in Thai waters and most of them believed that more regulation was needed in order to protect the current shark populations. Many dive operators, marine research and conservation centres and NGOs are already actively spreading awareness about marine conservation in local communities and involving divers/students/locals in various conservation and rehabilitation research projects, indicating that there is a great support from the diving community. For this reason, it is deemed desirable to appeal to the stakeholders from the diving community to engage in *marine conservation initiatives,* e.g. scientific involvement, conservation projects or awareness-rising campaigns, as they most likely will show large participation willingness, while hopefully also having the resources to essentially implement a potential initiative. In order to determine the level of interest from the stakeholders, to uncover their capability and perhaps brainstorm ideas about shark conservation projects, nationwide stakeholder meetings could be carried out in the more popular dive tourist destinations such as Phuket, Krabi, Koh Tao, Koh Lanta, etc.

Furthermore, as a common trend previously identified throughout most of the countries in the Bay of Bengal Region[36] (Sattar & Anderson, 2011), there generally is a lack of awareness and understanding of the ecological role most sharks have in marine ecosystems among the stakeholders in the fishing industry; it is important to address this situation in order to reach to the core of the issue and to encourage sustainable fishing. Fishermen and boat owners constitute the first level in the sharks supply chain and are, therefore, directly and (in)directly linked to the harvested sharks, that is why a '*shark awareness campaign',* targeting this particular stakeholder group could be meaningful. Apart from demonstrating the importance of sharks as an "architect" of ecosystems, the campaign could also include general information aspects that can prompt individual stakeholders to take some kind of ownership of the marine resources, while emphasising that everyone shares a collective responsibility in maintaining the welfare of the resources.

A nationwide *shark finning ban* should also be implemented, implying that the sharks must be landed whole, with all their fins attached to avoid any curving of the 'shark fin to

[36] Including the countries: Bangladesh, India, Indonesia, Malaysia, Maldives, Myanmar, Sri Lanka and Thailand.

carcass ratio' restriction (Dulvy *et al.,* 2008; Worm *et al.,* 2014). Similarly, this should send out a positive signal to shark proponents that Thailand is now actively intensifying the effort on shark conservation. Since there are indications, confirmed by collected data, that Thai vessels mostly land whole sharks with their fins attached, a shark finning ban should be fairly uncomplicated to pursue.

In order to decrease the potential impact and disturbance on the sharks and the surrounding marine environment, dive operators conducting mal-practices, e.g. by touching or chasing animals, standing on corals or indiscriminately anchoring on delicate dive sites, could, for instance, be given a reprimand by law enforcers followed by *fines* under non-compliance. In this context, a reporting system where dive operators can submit a complaint if mal-practices are observed could be further explored or star-rating system, as seen in the hospitality industry, can be established to encourage divers to choose the most environmentally-focused dive operator (Gallagher *et al.* 2015).

7.1.4 Research-Directed Measures

In order to implement specific management and conservation plans for the shark species of Thailand combined with the prospect of implementing the NPOA-sharks plan in the future, monitoring and collecting landing data of the shark are some of the integral components for decision makers and managers to apply the most effective management tools for the protection and the long-term sustainable use of sharks. In conjunction, with the suggested management measures, preferably the 'stringent measure approach' at least a number of research measures, aiming at improving the scientific data on sharks should be implemented, on a continuous basis.

Citizen Science Project in Thailand

Currently, there is a nationwide scarcity of scientific studies involving sharks and a lack of funding to allow scientists in the field to conduct comprehensive studies. This issue should be given more attention and be better funded in order to effectively implement the NPOA-sharks plan. Based on these facts, a focus on an existing project that aims at assessing and monitoring the shark populations in Thailand could be a good starting point. The

established Thailand eShark project is a *non-governmental citizen science shark research*[37] appealing to all divers and snorkelers in Thailand, irrespective of the level of dive skills (Ward-Paige & Lotze, 2011), to online report shark sightings/no sightings after all finished dives (eShark.org). The results can provide data on e.g. crucial areas for sharks, i.e. mating and nursery grounds, assessments of the populations to understand the distribution range and abundance, as well as locating and designating areas suitable as no-take sharks zones or sanctuaries (Ward-Paige & Lotze, 2011; Ward-Paige, 2014; eShark, 2015).

Citizen science projects can provide valuable data for scientists, who, accordingly, can formulate nuanced work based on their observations (Ward-Paige & Lotze, 2011; Ward-Paige, 2014; Gallagher *et al.,* 2015). The project was launched in December 2013 and is currently successfully operating, attaining a large number of dives logs every month (Shark Guardian, 2014). The results obtained from the citizen science project could, potentially, in the longer term, aid in addressing at least one or more of the 10 aims of the NPOA-sharks plan. Thus, it would be worthwhile for government officials and decision-makers to consult the scientists and the NGOs behind the project to determine if they can assist in the implementation of the NPOA-sharks plan.

Encourage Family-Level Shark Reporting

Thailand does not report shark landings down to species level, an operation which is essential for establishing appropriate, and effective management measures aiming at preserving the individual shark stocks (Topelko & Dearden, 2005; Sattar & Anderson, 2011; Lack, 2014; Worm *et al.,* 2014). One of the main reasons for the unspecified reporting is due to the fact that it is difficult for most fishermen to identify the different species, thus, all the landed species are aggregated as 'sharks' in annual reports (Krajangdara, 2014). Based on observations from ~25 visits to ports in Songkhla, Ranong and (a few) in Bangkok and Phuket, the patterns showed that the harvested sharks often appear to be arranged somewhat according to species or genus in piles/baskets at landing sites, implying that a number of stakeholders can identify 'some' shark species fairly well. Therefore, it is believed by the researcher that there is huge potential in the people working

[37] The project is led by scientist Christine Ward-Paige and organised through Shark Guardian: a UK founded charity based in Thailand with focus on shark and marine conservation projects worldwide.

directly with the harvested sharks and that a certain amount of data collection could be outsourced to agents at the landing sites. Since 2005, reporting of sharks down to family level has been in place in Indonesia, where at least five families of shark are recorded according to their family including, the Lamnidae, Squalidae, Carcharnidae, Alopiidae and Sphyrnidae (Sattar & Anderson, 2011; Fischer *et al.,* 2012). This approach could also be introduced in Thailand. Experience from field trips indicated that the species composition was somewhat similar to the 25 species identified by SEAFDEC (2006, pp. 123-124), which comprises nine different families, which potentially could be reported by the agents daily operating in the field.

Although there is a lack of proper field guides of shark species in Thai waters and scarcity of specialists in the field (Krajangdara, 2014), the current landing system must be improved to at least, family level, which is deemed possible to achieve, with, assistance from stakeholders, aiming to expanding reporting to the species level in the near future. A partial goal for Thailand could be e.g. that by the end of 2016 a certain percentage of the overall shark landings should be reported down to family level, while by the end of 2018 a certain percentage of the overall shark landings must be reported down to species-level. It is important to set up a realistic number of secondary aims in order to reach the overall aim, which is to report at the species level, this, however may require assistance from other countries that are more advanced on the topic (Davidson *et al.,* 2015).

Additional Biological and Ecological Data Collection

In addition to family level reporting, agents at the landing sites could also be trained in collecting general biological and ecological data to expedite and directly address issues on Thailand's NPOA-sharks plan, e.g. collect data on the species by capture location, gear type and time of year (seasonality), size of maturity, total length and weight, locate pupping and nursery grounds or perhaps collect vertebral columns for age and growth studies or tissue samples to study heavy metal contamination in shark flesh and fin for food safety, etc. (see Appendix 1). A combination of these comprehensive research measures, in comparison to the aforementioned recommendation, would require significantly more work effort from the stakeholders, but yet still deemed realistic to pursue.

8 Conclusions

This thesis sought to shed light on whether the non-consumptive use of sharks, in the longer term, could become more profitable than the consumptive use via a small-scale study of the shark-based industries of Southern Thailand. While an earlier study shows that the shark stocks have been under a steady decline for the last five decades (Pauly, 1979), the results revealed that most shark species in Thailand have shown obvious signs of rapid declines since the beginning of the 2000s, largely as a result of uncontrolled trawling occurring e.g. in poorly monitored marine national parks, during off seasons, night-time and on sensitive inshore habitats considered critically important nursery and breeding grounds for a number of coastal sharks.

Currently, the shark sight predictability is low, making it unachievable for most dive operators to promote shark diving through their businesses, as sight-guarantee cannot be provided any longer. By now, a few popular dive sites in both the Andaman Sea and in the Gulf of Thailand have lost the local population of reef sharks, which shows no sign of returning, while data from other dive sites reveal that the shark populations are steadily diminishing in abundance with detectable changes each year. Unless rapid managerial plans were implemented focussing on the conservation of sharks and the overall reduction of fishing effort, these trends were vastly deemed to result in local extinction of many of the reef shark species, within the near future.

Insights in the shark fishing industry have shown the same tendency, revealing a constant reduction of shark catches in the past 20-30 years, which were three to four times greater in the past in comparison to the current shark landing trends. Stakeholder observations of shark landing trends have revealed that the quantity of shark landings appears to have fallen by around 80% in the past 10 years, while a few shark species had entirely disappeared from the landings. Nowadays, the catch composition of shark landings in Songkhla is dominated by small *Chiloscyllium* spp. (*C. punctatum* and *C. plagiosum*) followed by a few other smaller shark species, such as *H. microstoma* and the *A. marmoratus* (~65cm), while the once-prolific neritic shark species have almost disappeared from the landing sites, indicating a great depletion of these individual species.

The landed sharks in Songkhla are mostly harvested in Indonesian waters by offshore trawlers, as the resources of the Gulf of Thailand have been fully depleted after years of intense fishing effort. Data collected indicate that sharks are unsustainably harvested, with around 50% of the catches estimated to consist of immature sharks and despite the minor contribution to the overall marine production of Thailand, a significant proportion of smaller size sharks are still landed on a daily basis. Due to a combination of sharks' increased economic value on the markets coupled with a general decline in the overall abundance, much signal that large-scale fishing vessels are increasingly "intentionally" targeting the once low-valued sharks. Post-harvest sharks are still, however, relatively inexpensive, but as the raw sharks are processed into shark-derived products, multiple layers of monetary value are added to the individual products, which seem greatly controlled by the vast number of middlemen within the supply chain.

Insights from both shark-based industries revealed that small and medium-scale boat owners and fishermen are not financially depend on sharks and most of them showed minor interest in the species. This was in great contrast to the diving industry, which expressed a huge interest in the protection of sharks and the concept of a shark-based industry to be more enduring in Thailand, as there was a great demand from their current dive customers. On the assumption that shark-sightings could be guaranteed, the results proved that shark diving could ultimately become more profitable than shark fishing under the right conditions. While shark diving potentially appeal to up 90% of the divers visiting Thailand, divers were on average willing to pay an additional of US$ 11.70 on top of every dive, in the case that they would explore high biodiversity and the presence of sharks - which potentially could yield almost twice the revenue generated from the current shark production. But due to the insufficient shark-sightings and deteriorating marine environments, an implementation of the WTP could not be accomplished.

It is apparent that consumptive and non-consumptive exploitation of sharks appeal to contradictory mind-sets and communities in Thailand. The ecological value of sharks is not recognised in any of the key management agencies and any transition to non-consumptive use would be opposed by powerful vested interests. That the economic value of live sharks is orders of magnitude higher than their value as fisheries products (even after up to 1600% inflation via processing) does not diminish the difficulty in establishing arguments that

convince managers and business owners to fish sustainably or to create valuation policies that allow it. Any progress towards sustainable shark fisheries or a transition towards non-consumptive use of sharks in ecosystem-based fisheries management must be incremental and tied to a similar transition away from biomass-focussed fishing. Based on the stakeholders'consultations, a number of recommendations have been developed and presented aiming to reduce shark diminishing fishing effort, and to conserve shark species, in the hope that non-consumptive use of sharks can become a reality in Thailand contributing to both a striving diving industry, and to the sustainable development of coastal communities in Southern Thailand.

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Appendix

Appendix 1: Thailand's National Plan of Action for Conservation and Management of Shark[38].

I. Introduction

Thailand recognized the importance of the Code of Conduct for Responsible Fisheries, the maximization of fishery resource utilization and the conservation of biodiversity. The conservation and management framework of shark[39] is considered as one of the important issue that needed to be implemented urgently. It was known that shark have low growth rate and ling time for maturation, long time for embryo development and few number of newborn. Furthermore, shark is widely utilized in term of shark fin, flesh, skin including other products. There are no specific types of fishing gear to catch sharks as target species in Thailand, generally shark are mainly caught as bycatch. Results of these will affect to the country and global shark population and finally shark will extinct. The Department of Fisheries, Thailand realize that the study on conservation and management of shark need t be implemented in a regular and long term system harmonized to the International Plan of Action for the Conservation and Management of Shark (IPOA-shark). The Department of Fisheries will establish the National Plan of Action for the Conservation and Management of shark (NPOA-shark) to conserve shark sustainability.

II. Objectives

1. Settle a data based system on shark biology, fishery, landing and marketing utilization to conserve and sustainable management of shark.
2. Develop data network, communication, cooperation, stakeholder consultation and other relevance in research works, sustainable management of shark.
3. Capacity building of the officials and other relevance to identify shark species, data collection and shark utilization for more precise data based system.
4. Monitor and control shark fisheries continuously and systematically.
5. Cooperate and harmonize with international agencies on the International Plan of Action for the Conservation and management of Shark (IPOA-shark) for sustainable management of shark.

III. Issues

1. Lack of data on
    - Shark biology e.g. species, spawning season, maturity size, distribution and abundance.
    - Shark statistical data e.g. catch and effort, fishing ground and type of fishing gear.
    - Shark production and value, import and export, processing products e.g. shark fin, fish ball, leather, accessories, souvenirs, including detail on species, type and quality of import and export products and accessories.

[38] Received in a paper version from a Fishery Biologist during an interview in January 2015.
[39] Shark is cartilaginous fish. The term "shark" includes all species of shark, ray and chimaeras (Class Chondricthyes)

2. Unwilling to give data/information and no cooperation between stakeholders and government officials.
3. Government officials are not understood how to collect precise data for management purpose.
4. No assessment on the shark status in the country for systematically monitoring and controlling.
5. No NPOA-shark harmonized with IPOA-shark fir sustainable management of shark.

IV. The National Plan of Action for the Conservation and Management of Shark

1. Formulate standard format for data collection and analysis on shark biology, fishery and utilization. Data will be collected from primary and secondary sources.

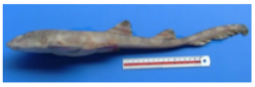
    1.1 Shark biology e.g. species, spawning season, maturity size, distribution and abundance.
    1.2 Shark statistical data e.g. catch and effort; fishing ground and type of fishing gear.
    1.3 Study on shark utilization and value, import and export, processing products, type and quality of import and export products and accessories.
        - Study in the processing process from fishing ground to table and marketing channel.
        - Collect raw material if shark production and value, import and export, processing products incorporate with Fisheries Association, processors, Custom Department, etc.
    1.4 Study heavy metal contamination in shark flesh and fin for food safety.
2. Exchange information and stakeholder consultation within and outside of the countries
        - Seminar/Workshop/Stakeholder Consultation Meeting.
        - Mass media, dissemination, awareness programme for shark conservation building.
        - Produce PVC charts and posters for information dissemination and strengthening awareness.
        - Training for species identification to officers from DoF and other related agencies.
        - Produce field guide for shark identification.
3. Prioritize the status of risk and endanger shark species
4. Collect and analysis data continuously and systematically

Appendix 2: Prop sheet with pictures of most shark species identified in Thailand

Hemiscylliidae (Bamboo shark, cha-lam-kob)

1: *Chiloscyllium punctatum*: Brownbanded bamboo shark

2: *C. Indicum*: Slender bamboo shark



3: *C. griseum*: Grey bamboo shark

4: *C. Hasselti*: Indonesian bamboo shark

5: *C. Plagiosum*: Whitespotted bamboo shark

Scyliorhinidae (Catsharks)

6: *Atelomycterus marmoratus*: Coral catshark

7: *Halaelurus buergeri*: Black spotted catshark

8: *Bythaelurus hispidus*: Bristly catshark

9: *Halaelurus maculosus*: Indonesian speckled catshark

Heterodontidae

10: *Heterodontus zebra*: Zebra bullhead shark

Orectolobidae (Carpet shark)

11: *Orectolobus japonicus*: Japanese wobbegong

12: *Orectolobus leptolineatus*: Indonesian wobbegong

4

Hexanchidae

13: *Heptranchias perlo*: Sharpnose sevengill shark

Squalidae

14: *Squalus megalops*: Shortnose spurdog

15: *Squalus mitsukurii*: Shortspine spurdog

Hemigaleidae (Weasel shark, cha-lam-nu)

16: *Chaenogaleus macrostoma*: Hooktooth shark

17: *Hemipristis elongata*: Snaggletooth shark

18: *Hemigaleus microstoma*: Sickelfin weasel shark

19: *Paragaleus tengi*: Straight-tooth weasel shark

Triakidae (Hound shark, cha-lam-ma)

20: *Mustelus sp.B*: Common smooth-hound (cha-lam-ma-jud-kao)

21: *M. manazo*: Starspotted smooth-hound

22: *M. mosis*: Arabian smoothhound shark (cha-lam-ma)

23: *Iago omanensis*: Bigeye houndshark

Proscylliidae

24: *Proscyllium magnificum*: magnificent catshark or clown catshark

7

Ginglymostomatidae (Tawny nurse shark, cha-lam-ki-sao)

25: *Nebrius ferrugineus:* Tawny nuser shark

Stegostomatidae (Zebra shark, cha-lam-suea-dao)

26: *Stegostoma fasciatum:* Zebra shark

Alopiidae (Thresher shark, cha-lam-hang-yaw)

27: *Alopias superciliosus:* Bigeye thresher shark (cha-lam-hang-yaw-na-nu)

28: *A. Pelagicus:* Pelagic thresher shark (cha-lam-hang-yaw)

Sphyrnidae (Hammerhead shark, cha-lam-hua-kon)

29: *Eusphyra blochii:* Winghead shark

30: *Sphyrna lewini:* Scalloped hammerhead shark

31: *Sphyrna mokarran:* Great hammerhead shark

32: *Sphyrna zygaena:* Smooth hammerhead shark

Carcharhinidae (Ground shark, cha-lam-nu, cha-lam-hu-dam) I

33: *Carcharhinus albimarginatus:* Silvertip shark (cha-lam-hu-kao)

34: *C. Amblyrhynchos:* Grey reef shark (cha-lam-krib-dam-yai)

35: C. altimus: Bignose shark (cha-lam-ja-muk-to)

36: *C. Amboinensis:* Pigeye shark (cha-lam-ta-lek)

37: *C. Amblyrhynchoides:* Graceful shark (cha-lam-hu-dam)

Carcharhinidae (Ground shark, cha-lam-nu, cha-lam-hu-dam) II

38: *C. Brachyurus:* Copper shark/Bronze whaler shark

39: *C. Falciformis:* Silky shark (cha-lam-thao)

40: *C. leucas:* Bull shark

41: *C. Limbatus:* Blacktip shark (cha-lam-hu-dam-lek)

42: *C. brevipinna:* Spinner shark (cha-lam-hu-dam)

Carcharhinidae (Ground shark, cha-lam-nu, cha-lam-hu-dam) III

43: *C. Longimanus:* Oceanic whitetip shark

44: *C. obscurus:* Dusky shark

45: *C. Plumbeus:* Sandbar shark

46: *C. Sealei:* Blackspot shark

47: *C. Melanopterus:* Blacktip reef shark (cha-lam-hu-dam)

Carcharhinidae (Ground shark, cha-lam-nu, cha-lam-hu-dam) IIII

48: *C. Sorrah:* Spottail shark (cha-lam-hu-dam)

49: *Lamiopsis tephrodes:* Borneo broadfin shark

50: *Loxodon macrorhinus:* Sliteye shark

51: *Negaprion acutidens:* Sicklefin lemon shark (cha-lam-krib-kong)

52: *Galeocerdo cuvier:* Tiger shark (cha-lam-suea, ta-phian-tong)

Carcharhinidae (Ground shark, cha-lam-nu, cha-lam-hu-dam) IIIII

53: *Rhizoprionodon acutus:* Milk shark (cha-lam-nu-hua-laem)

54: *Scoliodon laticaudus:* Spadenose shark (cha-lam-nu-hua-laem)

55: *Scoliodon macrorhynchos:* Pacific spadenose shark

56: *Triaenodon obesus:* Whitetip reef shark (cha-lam-krib-kao)

57: *Rhizoprionodon oligolinx:* Grey sharpnose shark

Rhincodontidae

58: *Rhincodon typus:* Whale shark

Odontaspididae

59: *Carcharias taurus:* Sand tiger shark, Grey nurse shark or Spotted ragged-tooth sharks

Megachasmidae

60: *Megachasma pelagios:* Megamouth shark

Lamnidae

61: *Isurus oxyrinchus:* Shortfin mako shark

Appendix 3: Questions in the Dive Instructor Survey

1. Please name your typical dive sites
2. For what reason are they your typical dive sites?
3. On which sites do you tend to see sharks?
4. Throughout Thai waters, in which locations can you in general encounter sharks and which species would they be?
5. What seem to be the divers' general preferences/highlights when diving in Thailand?
6. What is the average number of your divers visiting each site per week?
7. Do many divers ask if they can dive with sharks?
8. On an average week, how many divers expect to see sharks when diving with you.
9. What was the abundance of sharks, when you started diving in Thai waters?
10. What is the abundance of sharks when you dive in Thai waters, today?
11. In regards to the underwater environment in Thailand, have you noticed any changes, declines/increases, etc. throughout the last 10-15 years?
12. If there have been any changes in the abundance of sharks in Thai waters, what do you think are the reasons behind this?
13. Do you think shark diving could become a more widespread tourist attraction in Thailand?
14. Before every dive, do you encourage the divers to dive sustainably by telling them they cannot touch or stand on the reefs as you want to leave as little or no negative impact as possible on the underwater habitats?
15. When is it high season in your diving location?
16. How many years have you been diving in Thai waters?
17. How many years have you been leading/teaching divers?
18. What is your job title?

Appendix 4: Questions in the Operation manager survey

1. What are your main dive attractions or activities?
2. What seem to be the divers' general preferences or highlights when diving in Thai waters?
3. Do many divers ask if they can dive with sharks?
4. Where are the divers from?
5. Do you offer shark dives?
6. Has the number of divers increased in the last five years?
7. What is your source of income?
8. Do you consider your business financially stable?
9. Do you have any regular closing days during the week where you do not offer any dives?
10. On average, how much do you charge per diving trip?
11. In many parts of Thailand, this year was one of the best whale shark seasons in about 45 years. Did your dive business experience any benefits from this?
12. In regards to the underwater environment in Thailand during the last 10-15 years, are there any changes, declines/increases, etc. that have occurred?
13. Do you think shark diving could become a more widespread tourist attraction in Thailand?
14. In the future, do you think shark diving can become more financially profitable for Thailand's economy than shark fishing?
15. In the future, do you think shark diving could become an important part of your overall revenue?
16. Do you think other businesses or sectors that are not directly in contact with the diving industry are benefitting from the diving business too?
17. Do you cooperate with local communities or even support them?
18. Are you concerned about the general decline of sharks in the Thai waters?
19. Do you feel more regulation is needed to protect the sharks?
20. What do you think could be done to make the shark diving industry more successful and prominent in Thailand?
    - ☐ Reduce the effort in shark fishing
    - ☐ Stop fishing sharks, completely
    - ☐ Enhanced promotion of the shark diving industry
    - ☐ More marine parks, sanctuaries, reserves, etc.
    - ☐ Not much, it is a thriving industry
    - ☐ The shark decline is in such a dire state; I don't think it is possible to change this trend.
    - ☐ More support from the government
    - ☐ Other
21. When was your diving operation established
22. Where in Thailand is your diving operation located?
23. How long have you been in the diving business?
24. What is your job title?

Appendix 5: Questions in the diver survey

1. What is the name of the site(s) you dived at today?
2. What was your motivation for diving at this location? Choose one or more options:
   - ☐ I had no influence on the dive location
   - ☐ The coral reefs
   - ☐ The various fish species
   - ☐ The sharks
   - ☐ The marine mammals
   - ☐ The diving operator had good reviews
   - ☐ This is a random diving operator
   - ☐ Other (Pls. specify your answer)

3. To me a biodiverse marine environment when diving is:
   - ☐ Very important
   - ☐ Important
   - ☐ Neutral
   - ☐ Unimportant
   - ☐ Very unimportant

4. How important for you is it to see sharks when diving?
   - ☐ Very important
   - ☐ Important
   - ☐ Neutral
   - ☐ Unimportant
   - ☐ Very unimportant

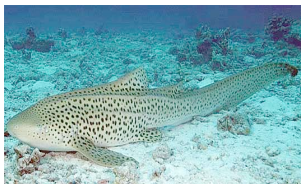
5. In terms of diving with sharks, which of the 7 sharks below would you prefer diving with? (1) is the most favoured shark to dive with, (2) is the second most preferred shark, etc. If you have more than one shark on the same rank, give the shark the same number. (0) Means not interested. If possible, please try and rank them all.

Grey reef shark
Carcharhinus amblyrhynchos
☐

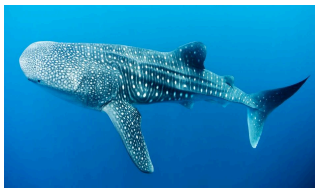
Blacktip reefshark
Carcharhinus melanopterus
☐

Whitetip reefshark
Triaenodon obesus
☐

Bull shark
Carcharhinus leucas
☐



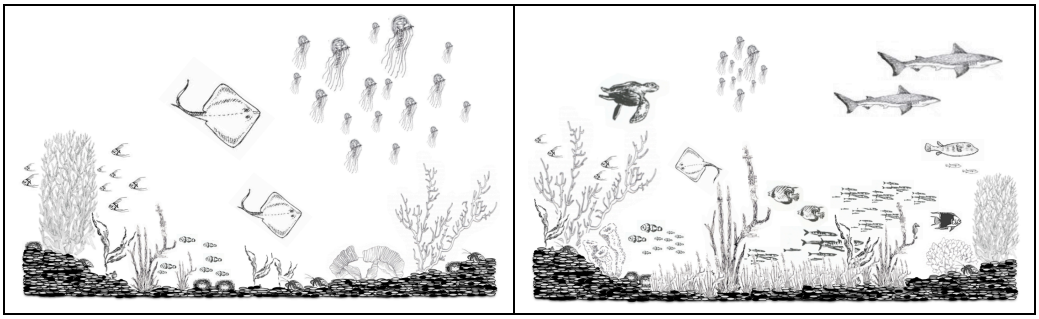
Zebra shark
Stegostoma fasciatum
☐



Whale shark
Rhincodon typus
☐

Tawny nurse shark
Nebrius ferrugineus
☐

6. Which scenario is most appealing to you? Please briefly explain why you chose the scenario as you did and what were the motives behind?



Scenario A Scenario B

7. If you have chosen scenario B, would you be willing to pay additional money per dive to experience such a rich and biodiverse marine environment which includes sharks? If yes, please select the extra amount of money you think it is worth paying per dive from the options below. Make sure that you choose an amount that is realistic compared to your current level of income.
   - ☐ 1 US dollar
   - ☐ 2 US dollars
   - ☐ 5 US dollars
   - ☐ 7 US dollars
   - ☐ 10 US dollars
   - ☐ 20 US dollars
   - ☐ Other amount: _____

8. If you were willing to pay additional money per dive, would you allow that your money could potentially support local communities who e.g. would get paid to patrol and conserve marine areas/marine reserves with high biodiversity? The benefits would be: locals get a new source of income and divers can continue enjoying a biodiverse underwater environment.
   - ☐ Very much
   - ☐ Somewhat
   - ☐ Undecided
   - ☐ Not really
   - ☐ Not all

9. Did you encounter any sharks or manta rays on your dive(s)? If yes and possible to identify, please state the name(s) and the approximate abundance of the sharks or rays on the lines below.

10. If you did not see any sharks on your dive, what did that make you feel? Please briefly explain your statement on the lines below.
    - ☐ Very disappointed
    - ☐ Somewhat Disappointed
    - ☐ Neutral
    - ☐ Not really disappointed
    - ☐ Not at all disappointed

11. In many parts of Thailand, this year was one of the best whale shark seasons in about 45 years. If you knew a season like this would occur again, would that be a strong incentive for you to return to Thailand and dive with them?
    - ☐ Very much
    - ☐ Somewhat
    - ☐ Undecided

☐ Not really
☐ Not all

12. Shark conservation is:. Please briefly explain your statement on the lines below
☐ Extremely important
☐ Very important
☐ Moderately important
☐ Neutral
☐ Slightly important
☐ Not at all important

13. Gender: ☐ Female ☐ Male
14. Year of Birth:
15. On average, what is your annual income pre-tax? (Pls. state the currency)
16. What is your nationality?
17. As a diver, how many dives have you done so far?

Appendix 6: Shark Landing Table

Species	*A.marmoratus*		*C. leucas*		*C. sorrah*		*Chiloscyllium* spp.		*G. cuvier*		*H. microstoma*		*H. elongatus*		*S. lewini*		S. mokarran	
Length (cm)	*N*	wt	*n*	wt	*n*	wt	*n*	wt	*n*	wt	*n*	wt	*n*	wt	*n*	wt	*n*	wt
≤ 45	41	6,6	-	-	-	-	408	138	-	-	6	3,6	-	-			-	-
46-50	53	18,2	-	-	-	-	10	5	-	-	6	4,8	-	-	2	1,6	-	-
51-55	56	32,4	-	-	-	-	238	189,6	-	-	30	30	-	-	10	9	-	-
56-60	-	-	-	-	-	-	79	79	-	-			-	-	6	6	-	-
61-65	-	-	-	-	-	-	167	249	-	-	19	33,8	-	-	-	-	-	-
66-70	-	-	-	-	-	-	321	481,5	-	-	13	26	-	-	-	-	-	-
71-75	-	-	-	-	-	-	118	235	-	-	247	494,5	-	-	-	-	-	-
76-80	-	-	-	-	4	9,5	455	906,8	-	-	167	335	-	-	1	N/A	-	-
81-85	-	-	-	-	-	-	8	20	-	-	-	-	-	-	1	N/A	-	-
86-90	-	-	-	-	2	8	-	-	-	-	-	-	-	-	-	-	-	-
91-95	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-	-
96-100	-	-	-	-	1	5,5	-	-	-	-	-	-	2	8	2	8	-	-
101-105	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-
106-110	-	-	-	-	-	-	-	-	1	6	-	-	4	24	-	-	-	-
111-115	-	-	-	-	-	-	-	-	-	-	-	-	11	81,2	-	-	-	-
116-120	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	N/A
121-125	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
126-130	-	-	-	-	-	-	-	-	-	-	-	-	7	84	-	-	-	-
131-135	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
136-140	-	-	-	-	-	-	-	-	-	-	-	-	6	81	-	-	-	-
141-145	-	-	-	-	-	-	-	-	-	-	-	-	1	14	-	-	-	-
146-150	-	-	-	-	-	-	-	-	-	-	-	-	10	160	-	-	-	-
151-155	-	-	-	-	-	-	-	-	-	-	-	-	1	16,5	-	-	-	-
156-160	-	-	-	-	-	-	-	-	-	-	-	-	1	17	-	-	-	-
161-165	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
166-170	-	-	-	-	-	-	-	-	-	-	-	-	5	90	-	-	-	-
171-175	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
176-180	-	-	1	60	-	-	-	-	-	-	-	-	1	19	-	-	-	-
181-185	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-
186-190	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
191-195	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
196-200	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
>200	-	-	4	800	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	**150**	**57,2kg**	**5**	**860kg**	**7**	**23kg**	**1804**	**2303,9kg**	**1**	**6kg**	**488**	**927,7kg**	**49**	**594,7kg**	**22**	**24,6kg**	**1**	**N/A**

n = number, wt = weight

Appendix 7: Value Chain Example

Experience of a processing manager

From a 100 kg shark:

- Meat typically takes up around 50 kg
- Fins take up 5%
- Skin around 5-7%

- Around 2,5 kg of shark fins turn into 1 kilo of dried shark fins
- Around 2 kg of fresh meat is halved into 1 kg of dried meat.

Personal observations and calculations

A Bull shark weighing a little bit more than 100 kg had:

- 2 x 25 cm (242 mm) pectoral fins
- 1 x 30 cm (298 mm) dorsal fin
- Length of caudal fin – unknown (probably around 40 cm)

Online Information

A bull shark (*C. leucas*) with a body mass of 80 kg has an average liver mass of 9 kg (Davidson & Cliff, 2003), but, as the weight of the sharks' liver differs greatly, which increase in step with the growth of the shark, however sharks' liver weigh between 10-25% of their total body weight (Vannuccini, 1999). The current example is calculating with a liver weight of 10 kg of which 60-70% of the weight contains oil (Vannuccini, 1999). As it was not possible to retrieve any information on crude shark liver oil, the example is using a value mentioned in Guidance on National Plan of Action for Sharks in India (Kizhakudan et al., 2015, pp. 45). Clearly, this is not optimal, but since the cost of living in India is somewhat lower than in Thailand (Numbeo, 2015), the ~350 THB/kg traded for crude liver oil in India should be regarded as at least a minimum price. Moss M.L (1977) explains that sharks cartilages take up around 6% of sharks total body weight (as cited in Lee & Langer, 1983, p. 1185), while around 5 kg trashfish is needed to produce 1 kg of fish meal (De Silva & Anderson, 1995). At the time of writing, the researcher is unaware of the volume of blood and the weight of the off-cuts, including head and remaining viscera, hence, these parts are purely estimated in the value chain.

Keong (1996): 120 kg shark = 30 kg dried salted/unsalted and dried fins around 1-2 kg

Appendix 8: Products developed from a 100 kg *C. leucas* and a 5 kg *C. sorrah*

100 kg bull shark *(C. leucas)*				
Products	**Parts in kg (Approx.)**	**Harvested**	**Market**	**Retail Products**
Fresh, whole shark	100 kg	15,000 THB	-	-
Dried meat	25 kg	-	~THB 7,500	At least ~ THB 7,500
Fins	5 kg	-	~THB 2,000	~ THB 34,000
Skin	6 kg	-	~THB 900	~ THB 3,000
Liver	3,5 kg	-	~THB 24.5	-
Crude liver oil	6,5 kg	-	~THB 2,275	At least ~ THB 2,275
Cartilage	6 kg	-	~THB 42	-
Off-cuts	10 kg	-	~THB 70	-
Jaws	2 kg	-	~THB 1,000	~THB 10,000
Blood	11 kg	-	Not utilised	Not utilised
Animal feed	4 kg	-	-	~ THB 280
Total		**THB 15,000**	**THB 13,811.50**	**~ THB 57,055**

5 kg spot tail shark (C. sorrah)				
Products	**Parts in kg (Approx.)**	**Harvested**	**Market**	**Retail Products**
Fresh, whole shark	5 kg	THB 500	-	-
Dried meat	2.5 kg	-	~THB 750	At least ~ 750
Fins	0.5 kg	-	~THB 100	~ THB 2,300
Skin	0.25 kg	-	~THB 37,5	~ THB 88
Liver	0.175 kg	-	~THB 1	-
Crude liver oil	0.325 kg	-	~THB 113	At least ~ THB 113
Cartilage	0.3 kg	-	~THB 2	-
Off-cuts	0.5 kg	-	~THB 3,5	-
Teeth or jaws	46-60	-	Unknown	Unknown
Blood	0.5 kg	-	Not utilised	Not utilised
Animal feed	0.2 kg	-	-	~ THB 17
Total		**THB 500**	**THB 1,007**	**~ THB 3,268**

A: Fins from a large shark THB 16,888/kg. B: Medium size fins THB 5,800/kg

Appendix 9: Price list of the various shark products

Actors	Products	Prices (THB)	Notes
Fishermen	Whole sharks	N/A	No revenue from the landings, but are paid THB 300 on a daily basis
Boat Owners	*Chiloscyllium* spp. *C. melanopterus*[*] *C. sorrah* *C. leucas* *G. cuvier*[*] *S. lewini*[*]	~25-40/kg ~ 65-80/kg ~ 80-120/kg ~ 200-400/kg, 100/kg[*] ~ 50/kg ~ 50-60/kg	However, large, whole *C. leucas* are purchased for THB 15,000 (~2m) or 20,000 (>2m) by the processor in Ranong
Middle man	Fresh meat Non-fresh meat[*] Dried salted/unsalted meat Extra small fins (<10 cm) Small sized fins (10-15 cm) Medium sized fins (20 cm) Large sized fins (30-40 cm) Extra large fins (50 cm+) Skin[*] Jaws Off-cuts[*] Decayed off-cuts[*] Crude liver oil[***] Liver[*] Cartilage[*]	~ 90-100/kg ~ 50-60/kg ~ 300/kg ?/kg ~ 200/kg ~ 300/kg ~ 500-600/kg ~ 1,000/kg ~ 100-150/kg ~ 1000 + ~ 7/kg ~ 1/kg ~ 160-540/kg ~ 7/kg ~ 7/kg	The liver and cartilage has been labelled with the same price as the off-cuts, as they most likely will get minced and used in animal feed/fish meal
Wholesale level	Fresh meat	~ 130/kg	N/A
Retail level	Fish balls Imitated crab sticks Dried shark fins Dried shark fins (0,75 kg) Dried shark fins (1 kg) Shark tooth necklace[****] Jaws[**] Shark skin Shark Fin Soup (BKK)	= 240, 460/kg = 280/kg = 1,600-12,000/0.5kg = 15,300/0.75kg = 17,000 – 28,000/kg = 100[40] = 2,000-15,000 = 1,000/kg = 500-3,000/bowl	Bull shark and blacktip reef shark jaws are caught and imported from the Andaman Sea. The larger they are, the more expensive they become.

Prices added are from *Ranong, **Phuket, ***Reports, ****Online, No (*) information is from the province of Songkhla

Menu displaying shark fin soup in BKK

[40] http://www.alibaba.com/countrysearch/TH/shark-tooth-necklace.html

Appendix 10:Calculation estimations of daily/weekly revenues of fresh/dried meat and fresh/dried shark fins from 1st middleman to 2nd middlemen

***C. punctatum* (female)**
Total length: 775mm
Weight: 1.86 kg

- Body with head/no guts and fins: 1.45 kg
- Body without head and no guts and fins: 1.05 kg (~ 1kg) (~46% weight reduction)
- First dorsal fin: 25 grams and second dorsal fin: 15 grams
- Pectoral fins: 20 grams/fin = 40 grams
- Pelvic fin: 50 grams
- Caudal fin: 50 grams
- Guts: 230 grams incl, unfertilised eggs
- Eggs: 90 grams (four egg cases)

***C. leucas* (female)**
Total length: 3000 mm
Weight: ~ 300 kg
First dorsal fin: 402 mm
Second dorsal fin: Unknown, but about a third height of first dorsal fin (Borneo SOURCE) ~ 134 mm
Pectoral fins: 567 mm
Pelvic fins: 190 mm
Caudal fin: 750 mm
Fin weight in total = 10-11 kg

Meat estimations:
For the smaller sharks: *Chiloscyllium* spp*., A. marmoratus, H. microstoma* and *S. lewini* (juvenile).

- X amount of kg – 46% meat reduction and 5% of total weight (skin) = fresh fillet
  Example: 1300 gr. *Chiloscyllium* spp.
  46% of 1300 gr. = 702 gr.
  5% of 1300 gr. = 65 gr.
  = ~ 637 gr. fillet in total/shark

For the larger sharks, including *C. sorrah, C. leucas, H. elongatus* and *G. cuvier*

- ~ 50% of total weight = ~ total fillet

Fin estimations:
Hemipristis elongatus: Approx. 130 cm = 12 kg (without fins: 11 kg)
Hemipristis elongatus: Approx. 150 cm = 16 kg (without fins: 15kg)

C. sorrah:
4 fins ~ 10-15 cm (THB 200/kg)
H. elongatus:
4 fins ~ 10-15 cm (THB 200/kg)
G. cuvier:
4 fins ~ 10-15 cm (THB 200/kg)
~ 4.2 kg*THB 200 = ~ THB 840/day
~ 29.4 kg* THB 200 = ~ THB 5880/week

C. leucas (180-250 cm):

- 3* dorsal fins ~ 30-40 cm (THB 500-600/kg)
- 6* pectoral fins ~ 20 cm (THB 300/kg)
- 3* caudal fins ~ 30-40 cm (THB 500-600/kg)

C. leucas (> 250 cm):

- 2* dorsal fins ~ 30-40 cm (THB 500-600/kg)
- 4* pectoral fins ~ > 50 cm (THB 1000/kg)
- 2* caudal fins ~ > 50 cm (THB 1000/kg)

~ THB 600/fin
~ 3.2 kg*THB 600 = ~THB 1,920/day
~ 22.4 kg* THB 600 = ~ THB 13,440/week

Appendix 11: Six different shark species currently used for shark diving by a number of diving operators

# of Managers	Species Sites with sharks	Bamboo sharks (*Chiloscyllium* spp.)	Blacktip reef sharks (*C. melanopterus*)	Oceanic whitetip (*C. longimanus*)	Whale sharks (*R. typus*)	Whitetip reef sharks (*Triaenodon obesus*)	Zebra sharks (*S. fasciatum*)
1	- Shark Point/Anemone reef (Phuket)						x
	- Koh Phi Phi		x				
	- Koh Similan		x	x	x	x	x
	- Koh Surin		x	x	x	x	x
2	- Koh Phi Phi		x				x
	- Hin Daeng/Hin Muang				x		
3	- Phuket		x				x
	- Racha Yai		x				x
	- Koh Lanta		x				x
	- Khao Lak		x				x
4	- Three Rock (Koh Tao)		x*				
5	- Koh Phi Phi		x		[x]		[x]
6	- Shark Point (Phuket)						(x)
	- Koh Phi Phi		x				(x)
	- Koh Similan				x		
7	- Koh Phi Phi		x				x
	- Shark Point (Phuket)						x
	- Hin Bida (Koh Phi Phi)						x
8	- Koh Phi Phi		x				/x/
	- Krabi		x				/x/
9	- Koh Lanta	/x/	x		x		/x/
	- Krabi	/x/	x		x		/x/
10	- Hin Daeng/Hin Muang				x		/x/
	- Koh Phi Phi	x	x				x
	- Koh Haa		x				x
11	- Palong Wall (Koh Phi Phi)		x				
	- Hin Bida (Koh Phi Phi)						x
	- Shark Point (Phuket)						x
	- Koh Dok Mai (Phuket)	x					
12	- Shark Point (Phuket)						(x)
	- Koh Phi Phi						(x)
	- Palong Wall (Koh Phi Phi)		x				
	- Koh Bida Nok (Koh Phi Phi)		x				

(x) Steady decline in the last 5-7 years, [x] Less common/very uncommon, /x/ Sometimes

* The respondent did not specify the species, but it is assumed to be *C. melanopterus*

Appendix 12: Observed shark species by the divers and their dive locations from November 2014 to January 2015

# of divers	Dive locations	Comments	Bamboo shark	Blacktip reef shark	Tawny nurse shark	Whale shark	Whitetip reef shark	Zebra shark	Unknown
1	Phuket and Koh Phi Phi	2 sharks at Palong Bay		x					
2	Phuket and Koh Phi Phi			x					
3	Phuket and Koh Phi Phi		x						
4	Phuket and Koh Phi Phi							x	
5	Phuket and Koh Phi Phi	3 sharks		x					
6	Phuket and Koh Phi Phi	7 sharks			x				
7	Phuket and Koh Phi Phi				x				
8	Phuket and Koh Phi Phi	1 shark at Turtle Rock.		x					
9	Phuket and Koh Phi Phi	1 shark						x	
10	Phuket	3 sharks	x						
11	Phuket	2 sharks	x						
12	Phuket	1 shark at King Cruiser.						x	
13	Phuket								x
14	Phuket	Shark on the seabed						x	
15	Phuket		x					x	
16	Phuket		x		x				
17	Koh Phi Phi	7-8 sharks at Malong dive site near Koh Phi Phi		x					
18	Koh Phi Phi	2 sharks		x					
19	Koh Phi Phi	1 shark		x					
20	Koh Phi Phi			x					

21	Koh Phi Phi	1 shark with a missing eye			x				
22	Koh Phi Phi		x						
23	Koh Phi Phi	Sharks	x						
24	Koh Phi Phi	Sharks	x						
25	Koh Phi Phi	2 sharks at Palong Wall		x					
26	Koh Phi Phi			x					
27	Koh Phi Phi			x			x	x	
28	Koh Phi Phi	4 sharks		x					
29	Koh Phi Phi	6 sharks		x					
30	Koh Phi Phi	5 sharks		x					
31	Koh Phi Phi	2 sharks		x					
32	Koh Phi Phi	6 sharks		x					
33	Gulf of Thailand					x			
34	Gulf of Thailand	Many on a wreck	x						
35	Andaman Sea	2 sharks			x				
36	Andaman Sea								x
37	Andaman Sea	Nurse sharks			x				
38	Koh Tao								x
39	Koh Tao	1 shark		x					
40	Koh Tao	1 shark				x			
41	Koh Tao	1 shark at Sharks Bay		x					
42	Koh Tao	1 shark		x					
43	Koh Tao	Approx. 3-4 blacktip sharks in Shark Bay		x					
44	Koh Tao	15 sharks during snorkelling at Shark Bay		x					
45	Koh Tao	~ 20 sharks during snorkelling in Shark Bay		x					
46	Koh Tao	~ 7 sharks during snorkelling in Shark Bay		x					
47	Koh Phangan	1 shark				x			
		Total **51**	**9**	**23**	**6**	**3**	**1**	**6**	**3**

Appendix 13: Statistical details of willingness to pay for shark sightings

Willingness to Pay Per Dive	
n*	239
Mean	11.8
Standard Error	0.49
Median	10
Mode	10
Standard Deviation	7.66
Kurtosis	1,4
Skewness	0.65
Minimum	0
Maximum	50
Sum	2,841
Confidence Level (95%)	0.96

*Excluding one undecided respondent

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