Issues of Exploitation of Sharks by Thai Commercial Fisheries in the Andaman Sea

Sirachai Arunrugstichai

A Thesis Submitted in Partial Fulfillment of the Requirements for the Degree of Master of Science in Ecology (International Program)

Prince of Songkla University

2018

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ABSTRACT

The decline of sharks from the world's oceans has been widely recognized as a major environmental concern by the international conservation communities. This problem is particularly severe in the Southeast Asia region, especially Thailand, which is reported as one of the countries with the greatest declines of shark catches and is now in serious need of management measures. Unfortunately, scientific information concerning this taxon in this region is scarce, presenting a major hindrance to the development of conservation and management strategies. To address this shortage of information, market surveys at major shark landing sites of Thai commercial fisheries in the Andaman Sea were conducted over an entire year in Ranong province of Thailand, after a decade in which the massive declines in the shark catches (>90%) were recorded. In this study, catch composition, landing patterns and biological information of each shark species presented at landing sites were recorded. Of the 64 species previously reported in the existing Thai species list of sharks in the Andaman Sea, only 17 species were observed in this survey, although 1 genetically-confirmed new species, and 2 undescribed species were also recorded.

In terms of species diversity, sharks from the family Carcharhinidae were the most diverse group, being represented by 11 species in this study. By number, the landings were largely dominated by bamboo sharks *Chioloscyllium spp.* from the family Hemiscylliidae, which contributed *c.* 65% of the total landings, followed by requiem sharks from the family Carcharhinidae, which contributed *c.* 30.5% total landings. By biomass, the landings were likewise dominated by carcharhinids, which contributed *c.* 71% to the total landings, followed by hemiscylliids, which contributed *c.* 27% to the total landings. The other sharks, which comprised single species from the families Squalidae, Sphyrnidae, Stegostomatidae and Triakidae, contributed *c.* 45% and *c.* 2% to the remaining percentages by number and biomass respectively.

The study also found that the landing composition is markedly different from that reported by the previous landing survey of 2004, with significant declines of most large shark species with slow life-history characteristics, especially sphyrnid and carcharhinid species, which are likely to be at higher risks than most other species. Moreover, the absence of many species from the landings, coupled with noticeable shifts in life-stage compositions of landed specimens that include larger proportions of juveniles and neonates also suggest that the population of these groups of concern may be close to collapse. Management measures which highlight the urgent need for additional fisheries monitoring efforts and an increase in taxonomic resolution and the requirement of scientific research are urgently required. This is especially critical for analysis of the life-history and spatial ecology of key economic species to conduct accurate stock assessment. This thesis suggests that effective management of shark fisheries in the Andaman Sea needs greater incentives from stakeholder parties to encourage stakeholder buy-in of sustainable practices. Effective stock management may require collaborations with other countries in this region for transboundary management of vagile species. In addition, biological information of each shark species recorded is a key priority, which should prove to be beneficial for additional biological research of this group in the future.

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Sirachai Arunrugstichai

CONTENTS

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SUMMARY OF CONTENTS

1.1 INTRODUCTION

Sharks are ubiquitous in the world's oceans, and are considered apex predators in most ecosystems. Global declines of sharks throughout the world's oceans have been recognized as an international environmental concern (Stevens *et al*., 2000; Stevens *et al*., 2005; Blaber *et al*., 2009). The severity of the decline and the magnitude of the conservation problem for this taxon has become a topic of discussion in major international forums, such as CITES, and WCC, and has spurred the development of an International Plan of Action by the FAO. Recent literature indicates that numerous shark populations have suffered massive declines in the past three decades around the world, with declines exceeding 90% for some species (Baum *et al*., 2007; Baum *et al.,* 2015; Dulvy *et al*., 2008; Ferretti *et al*., 2008; Ferretti *et al*., 2010; Myers & Worm, 2005; Worm *et al*., 2013), although the long-term ecological effects of the global decline remain unclear (Roff *et al*., 2016). The greatest threat to sharks and their elasmobranchs relatives appears to be from overexploitation through fisheries – both targeted and non-targeted (Dulvy & Forrest, 2010). The varied life history parameters of over 500 described species of sharks (Ebert *et a*l., 2013; Weigmann, 2016), make general statements of vulnerability to overfishing problematic. Most species, however, have low reproductive capacity; they have characteristic apex-predator life history characteristics of slow growth, long natural lives, late maturity and low numbers of offspring (Hoenig & Gruber 1990, Camhi *et al.,* 1998; Stevens *et al.,* 2000; Prince, 2005; Goldman *et al.,* 2012). Therefore, sharks and rays (their elasmobranch relatives) can sustain only modest fishing effort prior to stock collapse; population recovery after impacts can take decades (Musick, 2004a). Dulvy *et al.* (2017) report that the exploitation of sharks peaked two decades ago and has been consistently high ever since, with estimated global fishing mortality of approximately 100 million sharks per year (Worm *et al*., 2013). Moreover, stock collapses and local extinctions of some species have been previously documented, where the stocks have not recovered nor returned even after several decades in the previous distribution ranges (Dulvy *et al.,* 2009; Dulvy & Forrest, 2010). Global catch has declined around 20% per year since the peak, on average, reflecting the >80% decline in global shark biomass over that time (Dulvy *et al.,* 2017). For much of the past decade, the rate of change in shark populations has been so alarming that some species are considered at risk of imminent extinction (Herndon *et al.,* 2010; Dulvy *et al.,* 2014).

The intense exploitation and their low capacity for recuperation make sharks and their chondrichthyan relatives being considered to be facing higher risk of extinction than most other vertebrates on Earth (Lucifora, *et al.,* 2011; Dulvy *et al.,* 2014); approximately 30% of shark species are listed as "Threatened" or "Near Threatened" in the IUCN red list, while the status of almost 50% of them are virtually unknown, being listed as "Data Deficient" (Dulvy *et al.,* 2014). However, despite the increasing concerns, only a small number of countries have explicit strategies for managing shark fisheries (Stevens *et al*., 2000), while the existing general fisheries management measures are inadequate to prevent the stock declines (Davidson *et al.,* 2015). Moreover, the information on shark catches essential to crafting appropriate management strategy is usually unavailable, since they are often considered as bycatch and have low management priority, (Hoenig & Gruber, 1990; Musick *et al.*, 2000; Stevens *et al.,* 2000). This is especially so in the Southeast Asia region, the major consumers of shark products (Lam & Sadovy de Mitcheson, 2011). Projections suggest that if the rate of exploitation remain unchanged, it is likely that many shark populations will keep decreasing and eventually many species will be pushed toward extinction (Ebert *et al*., 2013; Worm *et al*., 2013).

Although sharks as a group contribute only a small portion (~0.5%) of the total marine fishery production of Thailand (Krajangdara, 2014), Thailand was listed as the 12th largest shark fishing nation in 2012, with an average of 20,479 metric tons of chondrichthyan landings reported annually to FAO between 2000 and 2009 (Fischer *et al*., 2012). Perhaps confusingly, however, shark fishery management is complicated by the way sharks are viewed by management agencies. Semi-commercial shark fisheries have existed at least since the 1960s in Thailand (Vidthayanon, 1997). Historically, the industry has focused on export of fins for the Chinese market: during the period from 2007 to 2011, Thailand exported on average 7560 tons/year of fins (Dent & Clarke, 2015). Based on FAO statistics from 2000-

2011, Dent & Clarke (2015) regarded Thailand as one of the world's top exporters of small low-value fins, which generated on average US$ 34.5 million/year at that time. According to the country report by the Department of fisheries of Thailand, a *commercial* shark fishery does not exist in Thailand. Instead, sharks in Thailand are caught as bycatch with non-selective fishing gears, which are widely used in commercial fisheries (Krajangdara, 2014) and as bycatch in small-scale fisheries (Keong, 1996; Vidthayanon, 1997; Sattar & Anderson, 2011; Krajangdara, 2014). In modern Thailand, most of the meat is consumed domestically (small sharks are consumed as fresh meat, while larger sharks end up as surimi, although the entire shark is utilized for leather, cartilage or oil: (Schiønning, 2015) and usually traded on local fish markets (SEAFDEC, 2006). In overseas experience, coastal sharks are principally caught by artisanal fishers, mainly for meat (e.g. Martins *et al.* 2018), since trade bans have severely reduced the market accessibility for fins (Tolotti *et al.* 2015, Jaiteh *et al.* 2017). It is almost impossible to gauge the scale of artisanal fishing for sharks in Thailand, since it has become an exercise in opportunism as populations of coastal sharks has declined, and few now deliberately seek them out. Regardless, the ongoing trend suggests that the populations of sharks in Thai and adjacent waters have suffered greatly from intensive fisheries exploitation.

Since the introduction of trawl fisheries in Thailand in the early 1960s, sharks have suffered severe declines in Thai water (Pauly & Chuenpagdee, 2003). In addition, according to Department of Fisheries statistics, the landing of sharks by Thai commercial fisheries have plummeted by over 90% in the past decade, especially with the landings from the Andaman Sea of the Indian Ocean, where declines of 93% in landed biomass have been reported. This represents a decline from 4287 metric tons in 2004 to 292 metric tons in 2013 within a span of only 10 years (DoF, 2007, 2016). Moreover, preliminary surveys at various landing sites along the Andaman coast of Thailand since 2012 and reports from fishers indicate that landings have undergone gradual declines in terms of both species diversity and abundance, suggesting the possibility of population collapses of numerous shark species from the water of Andaman Sea.

There are no specific management policies for sharks in Thailand, excluding the whale shark *Rhincodon typus*, a protected species (Krajangdara, 2014). Despite the growing concerns and signs of heavy exploitation of these predators, catch composition and landing data are limited, creating strong obstacles to effective management of shark populations.

In this thesis, I present data from landing sites in one of the major fishing ports of Andaman Thailand: Ranong. While originally planned to illustrate the life history and biology of a single commercially important species, this thesis focuses on various shark species that have traditionally formed the bulk of landings, and several that have become economically important following the massive declines in landings in a data poor and heavily fished region. In doing so, it provides updated information on shark fisheries in the Andaman Sea and insights into the biology of different shark species. By combining analysis of species diversity and population statistics from landings, insights presented here may eventually lead to improvement conservation efforts and effective fisheries management of sharks in the waters of Andaman sea region in the future.

1.2 LITERATURE REVIEWS

1.2.1 General Biology and Diversity

Sharks, (superorder Selacheii) belong to the subclass Elasmobranchii along with rays, are amongst approximately 1 200 known living and valid species of shark-like fishes, which form the class Chondrichthyes., the cartilaginous fishes (Compagno 2002). They are separated from the other major class, the Osteichthyes which comprise ~95% of modern fishes (Stevens, 2004). The characteristics of sharks are their cartilaginous skeleton, the lack of swim bladders, the 5-7 gill slit openings, the tooth-like dermal denticles on their skins, the teeth that are continuously replaced and embedded in the gum, and one or more dorsal fins (Stevens, 2005; Ebert *et al.*, 2013). With their origins dated back to at least 420 million years ago, sharks are one of the oldest extant groups of vertebrates on Earth, which have survived through all previous mass extinction events (Grogan *et al.,*2012; Worm *et al.,* 2013). Since then, sharks have successfully evolved and diversified into over 500 species from 9 orders, 34 families, and 105 genera (Weigmann, 2016), which are vastly diverse in term of sizes and shapes, ranging from the whale shark *Rhincodon typus*, which can attain the length of 20 m (Chen *et al*., 1997; Ebert *et al.*, 2013), to the dwarf lanternshark *Etmopterus perryi,* with the maximum size of only 21.2 cm (Leandro, 2006), or some flat sharks such as the angel sharks *Squatina spp*. and tasselled wobbegong *Eucrossorhinus dasypogon* with dorso-ventrally flattened bodies, similar to rays. Even in these days, new species of sharks are still constantly being scientifically described, especially with the advancement in molecular techniques, where the greatest peak of species description is within the 2000s (White & Last, 2012).

1.2.2 Habitat and Distribution

Sharks are among the most successful groups of fishes; they inhabit most aquatic habitats, including freshwater ecosystems (Camhi *et al.,* 1998; Ebert *et al.*, 2013). Their distributions widely varied from the tropical sea to the polar region (Ebert & Winton, 2010; White & Sommerville, 2010), from the epipelagic zone (0-200 m), to the bathypelagic depth (1000-4000 m) (Stevens, 2010; Kyne & Simpfendorfer, 2010). In general, most species are restricted to the continental shelves and slopes, however there are exceptions for some species, which are fully oceanic, such as the oceanic whitetip shark *Carcharhinus longimanus,* the blue shark *Prionace glauca,* and the mako shark *Isurus spp.,* while some other species also undergo migrating between coastal zone and oceanic waters, such as the tiger shark *Galeocerdo cuvier*, the silky shark *Carcharhinus falciformis*, the great white shark *Carcharodon carcharias* and the hammerheads, *Sphyrna spp*. (Ferretti *et al.,* 2010).

1.2.3 Ecological Roles as Predators

Sharks are carnivorous, but their diets can be extremely diverse depending on the species, ranging from plankton to benthic invertebrates or even large marine mammals (Ferretti *et al.,* 2010; Heithaus *et al.,* 2010). Some sharks are specific in their diets, but the majority are generalists, which can feed on a vast array of prey animals (Ferretti *et al*., 2010). With some few exceptions (the gigantic filter-feeding species, such as the whale shark *Rhincodon typus*, the basking shark *Cetorhinus* *maximus*, and the megamouth shark *Megachasma pelagios,* and sharks from the order Orectolobiforms), most sharks are considered as upper trophic level predators, occupying places at or near the top of the marine food chains (Stevens *et al.*, 2000; Heithaus *et al.*, 2010). In general, large species with total length over 3metres function as top-predators, while the smaller species with total length less than 1.5metres typically are mesopredators, which are also preyed upon by larger sharks (Ferretti *et al.*, 2010).

In spite of the paucity of detailed analyses on the role of sharks in marine ecosystems, they are considered as an important component in the marine ecosystems. (Camhi *et al.*, 1998; Heithaus *et al.*, 2012; Wetherbee *et al.*, 2012). With over 350 million years of evolutionary history as high order predators, it is likely that sharks and their elasmobranch relatives have been an evolutionary driving force, which has influenced the marine community since the ancient time (Heithaus *et al.*, 2010). As high-order predators, sharks exert top-down control on their prey species via both consumptive and non-consumptive interactions, directly regulate the abundance and influence the behaviors of prey species (Ferretti *et al.,* 2010; Heithaus *et al.,* 2008; Heithaus *et al.*, 2012;), which in turn can greatly affect the marine community as a whole (Ferretti *et al.*, 2010; Heupel *et al.*, 2014). And based on several studies, the removal of sharks, especially the large predatory species could potentially lead to considerable changes in the community structure, causing top-down trophic cascade, which may leave long-lasting ecological and economic impacts (Stevens *et al.*, 2000; Heithaus *et al.,* 2008; Baum & Worm, 2009; Ferretti *et al.*, 2010; Heithaus *et al.*, 2010). The problem of quantifying the effect size of shark removal from an ecosystem is deemed to be challenging and highly unpredictable, due to the limitation of data (Ferretti *et al.*, 2010; Worm *et al.*, 2013) and the complexity of trophic interactions in marine ecosystems (Myers *et al*. 2007), especially the transient effects of migratory species (which operate at different spatial and temporal scales to residents).

1.2.4 Life Histories

Across diversity of over 500 species, shark life histories differ considerably from most fishes; in general. They are much more comparable to marine reptiles and mammals, which have slow life histories, characterized by long life, slow growth, late maturity and low fecundity (Hoenig & Gruber, 1990; Camhi *et al.*, 1998; Dulvy & Forrest, 2010; Ferretti *et al.*, 2010). In terms of the whole group, lifespans of different species vary considerably, but in general sharks are long living, and take many years to reach sexual maturity, while also being considered to be the taxa with lowest reproductive capacity among all vertebrates (Camhi *et al.*, 1998). One particular species, the Greenland shark *Somniosus microcephalus* could potentially be the longest-living vertebrate on Earth, estimated to have lifespans of nearly 400 years, and possibly take ~150 years to mature (Nielsen *et al.*, 2016). In contrast to teleost fishes, which spawn thousands to millions of eggs, sharks reproduce by internal fertilization and produce few, well-developed offspring that may mature to birth *in vivo*, or *in ovo* (Hoenig & Gruber, 1990; Conrath & Musick, 2012).

The diversity of shark reproduction is illustrated by the examples of the tiger shark *Galeocerdo cuvier* Péron & Lesueur, 1822, which although considered a relatively fecund species, gives birth to an average 30-35 young after 13-16 months of pregnancy (Simpfendorfer, 2009). Even more extreme is the blue shark *Prionace glauca* (Linnaeus, 1758), which has been recorded with 135 babies in an average litter size of 35 (Conrath & Musick, 2012; Stevens, 2009). Contrastingly, the species with lower fecundity such as the sandbar shark *Carcharhinus plumbeus* (Nardo, 1827) can potentially give birth to only 1-14 young, after 9-12 months gestation every 2 or 3 years (Musick *et al.*, 2009). With the limited number of offspring produced, recruitment of the population is highly dependent on the number of mature females (Camhi *et al.*, 1998). These life history traits are suitable for their environment as the high order predators, since most sharks need to produce only a few young to maintain their population under normal conditions, with few natural enemies (Camhi *et al.*, 1998; Calliet *et al.*, 2005).

Even a categorization based on maternal contribution in terms of nourishment has been suggested (Conrath & Musick, 2012), reproduction modes of sharks are commonly classified into 3 categories, Oviparity, Aplacental Viviparity, and Placental Viviparity (Ebert *et al.*, 2013).

Oviparous species lay leathery egg cases on the seafloor or attached to underwater crevices, which a portion of embryonic development occurs outside the uterine structure (Conrath & Musick, 2012). The hatching periods are varied between species but may take up to 12 months in some species (Ebert *et al*., 2013). All species of oviparous sharks are demersal and relatively small in sizes (Musick & Ellis, 2005 as cited in Conrath & Musick, 2012, pp. 297), some examples of oviparous are the bamboo sharks *Chiloscyllium spp*., the zebra shark *Stegostoma fasciatum*, and the bullhead sharks *Heterodontus spp.*. Oviparous species are considered to be much more productive than viviparous species with similar sizes, potentially producing approximate 20-100 offspring per year (Conrath & Musick, 2012).

Sharks with aplacental viviparity reproduction mode develop embryos in their uterine structure, prior giving birth to free-swimming live young. The developing embryos received nutrients from yolk sac in the womb, and in numerous species, the embryos also gain additional nourishment from other sources during gestation, ranging from the mucous secretion inside mother's uterus (Mucoid histrotrophy), ingestion of unfertilized eggs (Carcharhiniform oophagy & Lamniform oophagy), or even consuming all other embryos in the uterus (Adelphophagy or intrauterine cannibalism) in the sandtiger shark *Carcharias taurus* (Conrath & Musick, 2012). Gestation time of this mode of reproduction is largely varied, generally they are estimated to be within 4 to 12 months (Conrath & Musick, 2012), but possibly reach up to 24 months in some *Squalus spp.* (Jones & Geen, 1977; Wilson & Seki, 1994 as cited in Conrath & Musick, 2012).

And lastly, in placental viviparity, embryos are connected to the uterine structure with placenta, but contrary to what is commonly believed, there is no hemotrophic transfer of nutrients through placenta from mothers to the embryos as found in mammalian, but the placenta helps in absorption of mucous secretion from the uterus instead (Conrath & Musick, 2012). Sharks with placental viviparity gives birth to well-developed live young, after the gestation period of approximate 1 year or less, even though some exceptions with longest gestation period exists (Conrath & Musick, 2012). Some groups with placental viviparity as their reproductive mode are the hammerheads *Sphyrna spp*. and the whaler sharks *Carcharhinus spp.* (Ebert *et al.*, 2013).

In general, the two modes of viviparity require higher investment from the mother, but the young are better protected during the entire gestation period as a trade-off, in comparison to oviparity with limited maternal investment (Ebert *et al,* 2013).

1.2.5 Vulnerability and Threats

Overfishing is considered to be the greatest threat to sharks and their chondrichtyan relatives (Dulvy & Forrest, 2010; Worm *et al.*, 2013). Based on their life histories characteristics of late maturity, slow growth, long life and limited fecundity, sharks have low resilience to fishing pressure, and are highly sensitive to overfishing (Hoenig & Gruber, 1990; Camhi *et al.*, 1998; Musick *et al.*, 2000; Stevens *et al.*, 2000; Musick, 2004a; Prince, 2005; Blaber *et al.*, 2009), especially when compared with the teleost fishes. With their low resilience to exploitation, sharks population can only withstand a modest amount of fishing pressure prior the stock collapse occurs, and it could take decades for the stock to recover once depleted (Musick, 2004a; Ferretti *et al.*, 2010), since the recruitment of shark populations is highly dependent on the number of the adults (Camhi *et al.*, 1998). Consequently, stock collapses and local extinctions of several shark species has been widely documented in various regions, where the stock have not recovered or returned even after several decades (Dulvy *et al.*, 2009; Dulvy & Forrest, 2010). The group that is considered to be the most threatened are the large species with low rebound potentials in the nearshore habitats, since they can be easily accessible by fisheries (Dulvy *et al.*, 2014) such as the dusky shark *Carcharhinus obscurus*, the sandbar shark *Carchahinus plumbeus*, the bull shark, *Carcharhinus leucas* and the scallopped hammerhead *Sphyrna lewini*. (Smith *et al.*, 1998 as cited in Stevens *et al.*, 2000), while the deep-water species are considered to be the more vulnerable to exploitation with their extreme slow growth and reproductive rates (Stevens *et al.*, 2005; Rigby & Simpfendorfer, 2015). In addition to overexploitation from target fisheries, fishing mortality in mixed fisheries and bycatch for other commercial species is considered to be an even greater threat to sharks, especially for the species with low productivity (Bonfil, 1994; Musick, 2004), since the species with higher productivity can keeps sustaining the fisheries, while the species with low rebound potential are driven to population collapses or local extinction (Stevens *et al.*, 2000; Musick, 2004a).

Considering the vulnerability to exploitation, Holden (1974) has long questioned since the 70's whether sharks can be harvest sustainably (Hoenig & Gruber 1990; Prince, 2005). Fisheries research has indicated that sustainability of shark fisheries is not entirely impossible, especially for the small and fast-growing species with relatively high productivity (Musick, 2004a), with some successful examples from Australia of the fisheries for the gummy shark *Mustelus antarcticus*, (Walker, 1998) and even for the dusky shark *Carcharhinus obscurus* with low rebound potential (Musick, 2004a). In order to sustainably manage shark fisheries, enforcement of effective management strategies based on sufficient scientific information is strictly required (Musick, 2004a), however it is currently not the case in majority of shark fisheries around the globe, where the fisheries are typically unmanaged, while catches information are also generally inadequate (Bonfil, 1994; Lam & Sadovy de Mitcheson, 2011).

In addition to fishing mortalities, habitat degradation is also another significant threat of sharks, especially for the species of coastal, estuarine and riverine ecosystems (Dulvy *et al.*, 2014), and tropical regions (White & Sommerville, 2010). Commercial and residential development, mangrove deforestation, loss of coral reefs and pollution are some major disturbances that are threatening sharks in the nearshore habitats (Dulvy *et al.*, 2014; White & Sommerville., 2010), and could potentially destroy the important nursery areas, and breeding sites, limiting the capacity for the population to sustain or recover from the ongoing threats. The combined effects from overexploitation and habitat degradation and destruction can be especially severe in freshwater ecosystems, with restricted geographical range of the freshwater and euryhaline species, such as the rare and threatened river sharks, *Glyphis spp.* (Dulvy & Forrest, 2010; Dulvy *et al.*, 2014).

1.2.6 Shark Utilization

Humanity is known to have been harvesting sharks throughout history for utilization of various products (Musick, 2004b). For over 5000 years, shark has been a part of diet of the coastal communities in several geographical regions (Vannuccini, 1999), and in the recent decade, the combination of steep growth in demand and economic globalization create a global market of shark products (Dent & Clark, 2015).

Shark fins is one of the most valuable fish products in the World (Camhi *et al.*, 1998; Dent & Clark, 2015), being sought after by Asian countries as the main ingredient in oriental cuisine, shark fin soup. Consumption of shark fins is restricted to a small number of countries in Asia, such as China, Hong Kong, Singapore, Taiwan, Malaysia and Viet Nam (Dent & Clark, 2015). The global trade of shark fins is highly valuable, which according to the FAO trade statistics of 2011 the worldwide trade of shark fins could reach the total value of USD 438.6 for 17154 tons of fins (Dent & Clark, 2015). The most valuable parts are from the first dorsal fin, pectoral fins and the lower caudal lobe, which are regarded as first graded and usually being sold together as a set, while the remaining second dorsal, and pelvic fins are of much lower in terms as value, being lump together from many sharks and considered as second grade (Musick, 2004b). Fins are traded in various stages of processing, from fresh, dried, semi-cooked, and processed, but most of them are exported as dried fins to China, Hong Kong and Singapore for processing (Musick, 2004b). Historically, China and Hong Kong have always been the biggest hub for shark fin trade, until recently which Thailand has grown and surpassed to be the largest exporters of shark fins since 2009 and contributes 43% to the global trade in 2011 with 7723 tons of exported shark fins (Dent & Clark, 2015).

Shark meat can be consumed fresh, smoked, cured, salted, or even processed into surimi (Musick, 2004b; Krajangdara, 2014). The meat of some species is regarded as delicacies such as the spiny dogfish *Squalus acanthias* (Musick, 2004b), which is being marketed as rock salmon in the UK, or Saumonette in France, or the poisonous flesh from the Greenland shark *Somniosus microcephalus* is left fermented in the ground for weeks prior drying as a preparation for the Icelandic national dish, Kæstur Hákarl. However, due to the high urea content in the flesh, which can give off bad stench if not being processed, shark meat is usually low in market value (Camhi *et al.,* 1998), and considered as less desired product. Until recently, based on the FAO trade statistics, it was found that the trade of shark meat is steadily growing since the last decade, where South American and European countries are the largest consumer, possibly driven by the growing demand for seafood with limited production of wild marine fish stocks, or could be the newly emerged market created by finning regulations, which requires the sharks to be landed with their fins intact (Dent & Clark, 2015).

In addition to fins and meat, which are the most-trade shark products (Dent & Clark, 2015), other body parts such as liver, skins, cartilage, jaws and teeth are also being utilized for numerous purposes (Musick, 2004b). Shark livers are consumed as food in some countries such as China and Solomon Islands (Vannuccini, 1999), but the liver extracts, which are rich in hydrocarbon and oils has applications in several industries, such as in agricultural, textile, cosmetic, and even pharmaceutical, which hold the most interest at the present time (Musick, 2004b). Shark liver oil is also rich in vitamin A, which started target fisheries for shark liver oil in the 40's (Musick, 2004b). The industry was short-lived with the development of synthetic vitamin, however it left a long-lasting impact on the stocks of some species, such as the soupfin shark *Galeorhinus galeus* for several decades (Camhi *et al*., 1998; Musick, 2004b). Squalene, another liver extract is widely used as lubricant in cosmetic products such as skin creams and moisturizer, however the growing demand for this hydrocarbon substance raises a concern on the sustainability, since squalene is found primarily in the liver of deepwater dogfish species, which are among the slowest-growing and the latest-maturing group of sharks (Musick, 2004b). Shark skins are used as food in several countries such as Japan, Taiwan, Maldives and Solomon Islands (Vannuccini, 1999; Musick, 2004b), or as sandpaper with its rough dermal denticles on the skins, but the greatest usage is for leather making (Musick, 2004b). Cartilages are traditionally consumed as food in a few East Asian countries such as China or Japan, but since the 90's, there is a rapidly growing market for shark cartilage pills as dietary supplement based from the misconception that sharks do not get cancer (Musick, 2004b). Based from several studies, the effectiveness for cancer treatment with shark cartilage pills is found to be false, however some compound such as chonrdroitin and glucosomine sulfate, which are commonly found in cartilage can be useful in treating arthritis (Musick, 2004b). Wastes from processing can be used in fishmeal production for aquaculture and agriculture, for fish oil extractions for industrial usages, and for making fertilizer (Vannuccini, 1999, Schiønning, 2015), while the remaining jaws and teeth are usually sold as souvenirs (Musick, 2004b; Krajangdara, 2014, Schiønning, 2015).

For Thai market, in exception of blood, every part from sharks is used in various industries, thus the practice of targeted shark finning is unlikely to occurs in the Thai commercial fisheries, especially when consider that everything can be sold for reasonable prices (Krajangdara, 2014; Schiønning, 2015). Smaller sharks are mostly sold whole, while larger sharks are typically butchered, dried and sold as fillets, where the whaler sharks *Carcharhinus spp.* are the most popular in the market (Schiønning, 2015). The different utilization of meat is also largely depending on the quality of the flesh, where fresh meat is typically cooked as fillet or processed into surimi or fish balls, while the lesser quality meat tends to be dried and used in fried food, curries or barbeques (Schiønning, 2015). All shark species caught in Thai commercial fisheries are utilized for their fins, including the small bamboo sharks *Chiloscyllium spp.*, and also from shark-like batoids, the guitarfishes from the family *Rhinobatidae* (Schiønning, 2015). Curiously, Schiønning (2015) also reported that shark livers is processed into oil for human consumption as an ingredient in Southern Thai cuisine or mixed in fishmeal for aquaculture, instead of being used in cosmetic and pharmaceutical industries. Moreover, it was reported that skins are consumed as substitute for fish swim bladders in the Chinese fish maw soup, in addition to the usage for making leather products (Schiønning, 2015). The remaining inedible parts such as jaws and teeth are commonly sold as souvenirs, while cartilage, viscera and heads are used for feeding livestock and aquacultures after being minced (Schiønning, 2015).

1.2.7 Overexploitation and Global Declines

Throughout the last century, most shark fisheries in the World have undergone

Boom and Bust cycles (Camhi *et al.*, 1998; Harry *et al.*, 2011; Lam & Sadovy de Mitcheson, 2011). However, the global landings of sharks and other chondrichthyan fishes had been rising steadily and reached its peak in the 2000's prior gradually declined in the last decade, based from the statistics by FAO (Dulvy *et al.*, 2014; Davidson *et al.*, 2015). The estimated fishing mortality of sharks was calculated to be ranging from 63 and 273 million individuals per year, with an average of ~100 millions of sharks killed each year in the past 2 decades, which is considered to be significantly exceeding the average rebound rates of many shark populations (Worm *et al.*, 2013; Shiffman & Hammerschlag, 2016). Evidently, massive population declines have been documented in many regions throughout the World, based from numerous studies (Baum *et al.*, 2007; Baum *et al.*, 2015; Dulvy *et al.*, 2008; Ferretti et al., 2008; Ferretti e*t al.*, 2010; Myers & Worm, 2005; Worm *et al.*, 2013). In addition, stock collapses and local extinctions at various regions have also been reported, where their populations have not recovered nor returned even after several decades, such as the Angel shark, *Squatina squatina* of the Northeast Atlantic or the Basking shark, *Cetorhinus maximus* of the British Columbia (Dulvy *et al.*, 2009; Dulvy & Forrest, 2010). Considering their vulnerability to fishing pressure, their massive declines, and the rate of exploitation, sharks are facing higher threats to extinction than most other vertebrate groups (Lucifora *et al.*, 2011; Dulvy *et al.*, 2014), where it was assessed in 2014 by Dulvy et al that ~30% of shark species are being "Threatened" (Critically Endangered, Endangered, Vulnerable), or "Near threatened" and almost 50% of the remaining species are virtually unknown (Data Deficient), however their situation could be even worse in reality (Dulvy *et al.*, 2014).

With the worldwide severe declines and the ongoing threats that sharks are being subjugated to, concerns on the overexploitation of sharks have been gaining attention in the international level (Stevens *et al.* 2000; Stevens *et al.*, 2005; Blaber *et al.*, 2009), encouraging efforts to improve the management and conservation of these vulnerable fishes in the past two decades, such as the drafting the International Plan of Action (IPOA) and the National Plan of Action (NPOA), or even the bans of finning or establishment of shark sanctuaries in some nations (Harry *et al.*, 2011; Davidson *et al.*, 2015; Shiffman & Hammerschlag, 2016). However, the progress of implementation remains slow, while the current management measures are still insufficient to cease the global declines of their populations from the current rate of exploitations (Worm *et al.*, 2013; Davidson *et al.*, 2015). Hence, significant improvement in protective measures is required in order to avoid depletion and extinction of sharks from the oceans in the near future (Worm *et al.*, 2013).

1.2.8 Overview of Thai Fisheries

Historically, Thai shark fisheries were relatively small, with basic artisanal fishing gears, such as hook and lines, fishing pots, stow nets, and beach seines. Marine fisheries in general were relatively insubstantial pre-WWII, and only 65 powered boats and 2513 non-powered boats are reported in 1945 (Achavanuntakul *et al.*, 2014). Then, the fishing industries experienced tremendous growth with the introduction of trawlers in the early 60's, where the number of trawlers expanded from 99 in 1960 to 2,695 in 1966 due to its widespread popularity, while marine fisheries production hugely increased by over 600% in the span of only 6 years (Boonwanich & Boonpakdee, 2009 as cited in Achavanuntakul *et al.*, 2014). The Thai fleets then began fishing in the waters of neighbouring countries, such as Vietnam, Cambodia, Myanmar and Malaysia since 1967 and kept on growing continuously prior reaching its peak in 1995, with an annual marine fisheries production of 2,827,400 tons (Achavanuntakul *et al.*, 2014), since then Thailand has grown to become one of the top seafood exporters and producers of the World (Piumsombun, 2003). Nowadays, commercial fisheries largely dominate the entire marine production of the nation with ~90% contribution, where ~70% of the catch was caught by trawlers (Krajangdara, 2014).

Despite the remarkable growth in marine fisheries production, the fisheries itself has largely shifted into "Biomass" fisheries, suggested by the large amount of catches with relatively fairly low economic value (SEAFDEC, 2017). Moreover, the intensive fisheries by the Thai trawlers has taken its heavy toll on the marine resources of the nation, where the Catch Per Unit Effort (CPUE) in the Thai waters has severely declined from ~300 kgs per hour in 1961 to 17.8 kgs per hour in 2010 (Boonwanich & Boonpakdee, 2009 as cited in Achavanuntakul *et al.*, 2014). These suggests that Thai fisheries has long been depending on the resources of neighboring countries for its massive production (Achavanuntakul *et al.*, 2014), while the waters of the Gulf of Thailand and the Andaman Sea is left with stocks depletion and deterioration of marine ecosystems.

1.2.9 Shark Fisheries in Thailand

In Thai fisheries, sharks contribute only a small portion, which is estimated to represent ~0.5% of the total marine fishery production of the nation, yet Thailand is listed as the top 13th shark fishing nation in the World between 2000-2011, with an approximate of 18,532 tons of chondrichthyes landings per year on average (Fischer *et al.*, 2012; Krajangdara, 2014; Dent & Clark, 2015). Yet, according to the recent country report by the Thai Department of Fisheries, target commercial shark fisheries in Thailand do not exist, but instead they are caught as bycatch or incidental catch during trawling operation for valuable species, where ~89% of the total shark landings are caught by otter board trawl, the other 8% are caught by pair trawl, while the remaining 3% are caught with other gears such as longlines or gill nets (Krajangdara, 2014). Sharks are generally landed with their whole body intact, and fully utilized or consumed in various ways, including fresh or processed as salted fish, surimi, fish balls, and also shark fins, where Thailand is a major exporter in the international fin trade (Dent & Clark, 2015). The nation contributes on the average of 18% to the global fins export in the World during 2000 to 2011 and has recently grew to become the top exporter (including re-exporter) from 2007 to 2011 with 7,723 tons of shark fins exported in 2011, specializing in low-value small fins (Krajangdara, 2014; Dent & Clark, 2015). Liver are generally extracted for oils and utilized in cosmetic industry or mixed in fishmeal for aquaculture industry (Krajangdara, 2014). Sharks skins are mainly used for leather (Krajangdara, 2014), where it is mostly harvested from large species, such as the bull shark *Carcharhinus leucas,* according to a shark processing factory owner interviewed in Ranong. Teeth and jaws are cleaned, dried and sold as souvenirs for tourists, where they are common along seaside tourism destinations, such as Phuket, and Pattaya. The remaining body parts such as the head, cartilage, and internal organs processed into fishmeal or used as bait for fish or crab traps (Krajangdara, 2014).

Not surprisingly, considering their vulnerability to exploitation and the massive scale of Thai fisheries, the populations of sharks in Thai and adjacent waters seems to have been greatly suffered from the intensive exploitation, especially with the non-selective biomass fisheries of the nation. Since the early 60's with development of trawl fisheries in Thailand, sharks have been one of the major groups, which subjected to the most severe decline in the Gulf of Thailand (Pauly & Chuenpagdee, 2003). And recently, Thailand has become among the top countries with the greatest declines in shark landings (Davidson *et al.*, 2015), where the total shark landings from commercial fisheries has declined considerably in the past decade, especially with the landings from the Andaman Sea of the Indian Ocean, where ~96% of declines in term of biomass was reported, sharply dropped from 3836 metric tons in 2005 to 157 metric tons in 2014 in a span of only 10 years, (DoF, 2007, DoF, 2016).

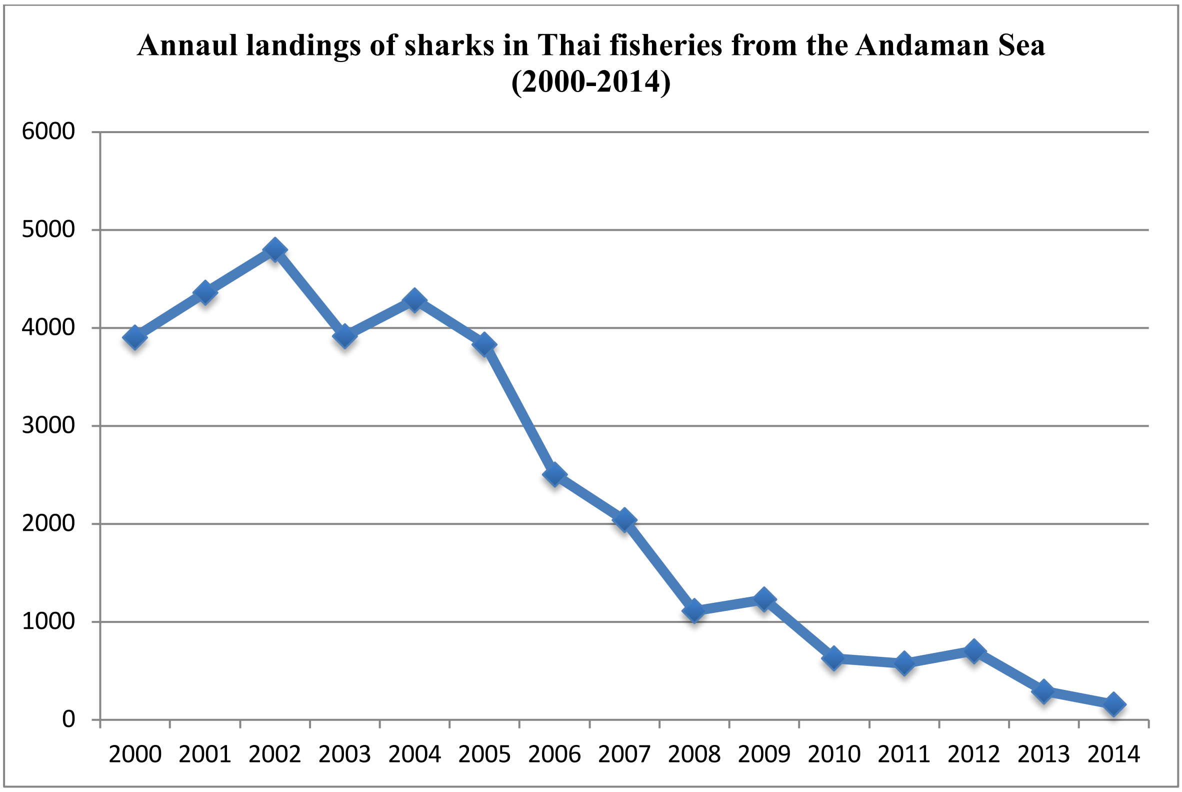

Fig.1.1: Recorded of annual shark landings by Thai fisheries in the Andaman Sea from 2000 to 2014. Source: DoF (2002, 2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012, 213, 2014, 2015, 2016)

Moreover, based from preliminary surveys, conducted since 2012, there have been considerable declines in term of species diversity, and the abundance of the landings observed at various landing sites along the Andaman coast, where large species such as the thresher sharks *Alopias spp*. were completely absent, while the abundance species such as the hammerheads *Sphyrna spp*. declined markedly in terms of number. Fishers and traders at landing sites also reported similar findings of the declines, giving statement such as “There is hardly any shark left in our waters. Majority of the catches these days were not caught in Thailand, but from Myanmar or even from the waters off the coast of India”, “I have not seen those long tail species (*Alopias spp*.) for a long while”, “Sharks are getting rarer and rarer these days.”, with one exceptional statement from an artisanal fisher who said “I used to catch sharks with longline on a small boat, but I quitted a few years ago. Their numbers have gotten too low, which does not make any economic sense to continue catching them anymore.”. Based from anecdotal reports from those fishers and traders, it seems almost certainly that sharks in Thai fisheries were not caught only in the territorial waters of Thailand but includes the waters of many other nations around this region, including Myanmar, Indonesia and India, while the declines of the stocks were also noticed across the vast fishing ground, as reported by Schiønning (2015).

1.2.10 Research, Conservation and Management of Sharks in Thailand

Shark researches in Thailand are focused mostly on the species diversity, which was first initiated by Mongkolprasit in 1977 to compile the first checklist of chondrichthyan fishes in Thai waters and adjacent areas, and eventually updated by Natheewatana and Cheunpan from the Department of Marine and Coastal Resources (DMCR) in 2002 to support the drafting NPOA sharks in Thailand (Krajangdara, 2014). Since then, the Department of Fisheries (DoF) has been the primary agency for shark research in Thailand, which started data collection programs at various landing sites on the Gulf of Thailand and the Andaman Sea in 2004 for supporting the drafting of NPOA-sharks in 2005, thus expanded the checklist to 64 species in 2014 (Krajangdara, 2014), however the actual number of the species in the current checklist of 2016 is possibly different, with potential clarification of some misidentification and resolutions of some cryptic species with the recent taxonomic studies. From the data collections in 2004, Krajangdara (2005) also reported species composition, sexual maturity and fisheries of sharks in the Andaman Sea, which was similarly conducted by Deechum (2009) in 2006 for both of the Andaman Sea and the Gulf of Thailand. The Department of Fisheries also reports the production of marine fisheries in annual fisheries statistics, however the data is reported in weight of the whole group, where different species are aggregated together as "sharks" without finer scale identification.

Out of 64 shark species in the published checklist, 20 of them are listed as "Threatened" (Critically Endangered, Endangered, and Vulnerable) in the IUCN red list of threatened species, with 5 endangered species, the scalloped hammerhead *Sphyrna lewini*, the great hammerhead *Sphyrna mokarran*, with the recent addition of the whale shark *Rhincodon typus*, the winghead shark *Eusphyra blochii,* and the zebra shark *Stegostoma fasciatum* in 2016 (Pierce & Norman, 2016; Smart & Simpfendorfer, 2016; Dudgeon *et al.,* 2016). Moreover, 9 species are also listed in CITES appendix II, namely the whale shark *Rhincodon typus*, the oceanic whitetip shark *Carcharhinus longimanus*, the scalloped hammerhead *Sphyrna lewini*, the great hammerhead *Sphyrna mokarran*, the smooth hammerhead shark *Sphyrna zygaena* with 4 additional species recently listed during CITES CoP 17 in 2016, which are the pelagic thresher shark *Alopias pelagicus*, the common thresher shark *Alopias vulpinus*, the bigeye thresher shark *Alopias superciliosus*, and the silky shark *Carcharhinus falciformis.*

Despite the drafting of NPOA sharks for Thailand has been done in 2005, the plan has not been fully implemented yet, with only the data collection program by the Department of Fisheries has been conducted in 2004, and 2011-2012 (Krajangdara, 2014). At the present time, the NPOA has been revised for improvement and the new version is currently under reviews by the officials, which could possibly take some time prior being approved for the actual implementation (Schiønning, 2015). Currently, Thailand has no fisheries management or conservation measures specifically for sharks, with the exception of the whale shark *Rhincodon typus*, a protected species, which prohibit fishing for this endangered species in the Thai waters (Krajangdara, 2014). However, there are some policies, which may aid protection of sharks indirectly, such as the prohibition of fishing with trawling gears and push nets within 3000-5400 metres from the shoreline, the limitation of new entry of trawler and push netter, and the seasonal closures of some areas from February to May in the Gulf of Thailand, and from April to June in the Andaman Sea (Krajangdara, 2014). Yet, despite its legal protection its received, whale sharks are still occasionally reported being caught by non-selective fishing gears, resulting in their mortalities. In addition, as a CITES member, Thailand is required to regulate the trades of CITES listing species, however a large quantity of the scalloped hammerhead *Sphyrna lewini* were observed being filleted and exported without permit from a shark processing factory in Ranong with Malaysia as the destination during a survey in 2015, after the implementation CoP 16 listing in September 2014, highlighting the shortcomings in the enforcement of trade regulations. Although Thailand has acknowledged the importance of conservation and management of sharks, the progress is still slow, being hindered with numerous limitations, such as the lack of regular data collections, the lack biological and detailed fisheries data, the lack of personnel with capability in species identification, the lack of database systems for stock assessment, the lack of cooperation among different parties, the lack of awareness programs and also the lack of funding (Krajangdara, 2014). And these shortcomings are urgently needed to be address in order to improve research, conservation and management of shark fisheries in Thailand toward sustainability.

1.3 PROJECT OBJECTIVES

The purposes of this study are to

1) Provide up-to-date information on catch composition of sharks caught by Thai commercial fisheries in the Andaman Sea
2) Provide biological information of shark species in the Andaman Sea
3) Provide some management recommendations for shark fisheries in the Andaman Sea

1.4 RESULTS AND DISCUSSIONS

1.4.1 Species Diversity in the Landings

In this study, a total of 2123 sharks (1993 counted and 130 estimated) with a total biomass of 6205 kg were recorded from two major landing locations in Ranong province, Thailand over a period of slightly more than one year. The landings consisted of 17 shark species from six families (Squalidae, Hemiscylliidae, Stegostomatidae, Triakidae, Carcharhinidae and Sphyrnidae), where the Carcharhinidae family was the most diverse all families, being represented by 11 species. The number of species recorded here was markedly lower than a similar study conducted in 2004 on the species diversity and composition at landing sites in Phuket and Ranong provinces by Krajangdara (2005), which reported a total of 41 species from 11 families (over the entire Andaman coast. In this study, sharks from the family Alopiidae and Hemigaleidae were completely absent, despite previously reported as fairly common in the landings of a decade ago (Krajangdara, 2005). Considering the smaller sample sizes of the study presented here compared with the market surveys at two provinces (Phuket and Ranong) conducted by Krajangdara (2005), the absence of some rare species such as the bignose shark *Carcharhinus altimus* (Springer, 1950), the oceanic whitetip shark *Carcharhinus longimanus* (Poey, 1861) and the shortfin mako *Isurus oxyrhincus* Rafinesque 1810 might be expected. It is notable, however that several species that once were present in large numbers in the landings, such as the hooktooth shark *Chaenogaleus macrostoma* (Bleeker, 1852) the straight-tooth weasel shark *Paragaleus tengi* (Chen, 1963) and the Blacktip shark *Carcharhinus limbatus* (Valenciennes 1839) were also totally absent in this study. While the declines of species diversity detected in this study could potentially be reflect the comparatively smaller sample sizes or some unspecific sampling bias, it is also a common pattern attributed to intensive exploitation of large marine predators such as sharks, which are especially vulnerable to overfishing due to their slow life-history traits (Stevens *et al.*, 2000).

Comparison of historical and contemporary species lists is a widely used method to detect disappearance of species and the findings from this study concurs with the trends observed during preliminary visits and also agree with anecdotal reports from fisher and traders at landing sites, where noticeable declines in species diversity, particularly for larger shark species were observed over the year. Considering the fact that Thailand is among the countries with the greatest declines of elasmobranchs landings (Davidson *et al.,* 2015), where the steep declines of over 90% of landing biomass of the landing was recorded throughout the past decade (Krajangdara, 2014), it is unlikely that this observed result is the manifestation of sampling bias alone. Instead, the high intensity of fishing activity in the Andaman Sea is likely to be a sizable factor for this decline in species diversity of sharks, *i.e.* 60%, (Arunrugstichai *et al.*, 2018), although the direct causation is difficult to accurately assess from the available information

1.4.2 New Record & Undescribed Species

Out of 17 species recorded at landing sites, this study yielded three notable species: the Indonesian shortnose spurdog *Squalus hemipinnis* White, Last & Yearsley 2007, the Bengal Smoothhound *Mustelus cf. mosis* and the Bengal Spadenose shark *Scoliodon cf. laticaudus.* The presence of *S. hemipinnis* in the landings recorded represents the first genetically-confirmed record of this species in Thai waters and also a major range extension from the known limited distribution range in the waters of eastern Indonesia (White *et al.,* 2007). The identification was confirmed by using indicative nicotinamide adenine dinucleotide (NADH)2 sequences (G. Naylor, unpubl. data). It is likely that the previous report of the shortnose spurdog *Squalus megalops* (Macley 1881) in Thai waters was actually *S. hemipinnis* due to the fairly recent description of this species in 2007 (White *et al.*, 2007) and the close morphometric similarities of the *megalops* group. The *M. cf. mosis* recorded in this study shares close morphometric similarities with the Arabian smoothhound *Mustelus mosis* Hemprich & Ehrenberg 1899, however the differences in phenotypes and the sequences of NADH2 marker suggest that it may not be conspecific (G. Naylor, unpubl. data) and is likely to be an undescribed species. Similarly, the *S. cf. laticaudus* is likely to be representing a third species of the genus *Scoliodon* as previously suggested by White *et al.* (2010).

The incidental discovery of these three species within a fairly short sampling period emphasizes the limitation of current knowledge of shark diversity in the Andaman Sea region and highlights the importance of using molecular techniques in modern taxonomic studies of sharks. Without the aid of molecular techniques, particularly the usage of NADH2 marker to distinguish between closely related species in addition to the widely used *co*I sequences to distinguish between closely-related species, the hidden diversity of sharks might not have been detected. This is especially true for sharks of the genus *Mustelus*, which could not be reliably distinguished by using the *co*I sequences alone (White & Last, 2012). In addition to the undescribed species found in this study, another interesting note is the uncertainty of the presence of the grey bamboo shark *Chiloscyllium griseum* Müller & Henle 1838 in the landings from the Andaman Sea, due to the complication with close morphometric similarities with *C. hasseltii* as previously noted by White (2009), while all of the sub-sample sent off for verification with NADH2 sequences were identified as *C. hasseltii* (G. Naylor, unpubl. data). Thus, a more details investigation into the *C. hasseltii* and C. *griseum* group is required to determine whether both species are present in the landings from the Andaman Sea (Arunrugstichai *et al.,* 2018)

At the present time, the Southeast Asia region is still aging behind in terms of knowledge of shark diversity in comparison to other regions. At the same time, however, it is also being subjected to intensive exploitation (Arunrugstichai *et al.,* 2018). Considering the biological diversity of the Southeast Asia region in conjunction with the recent knowledge of cryptic species and species complexes issues of this taxon, it is probable that the Andaman Sea may still contains hidden diversity of sharks. Various studies in Indonesia, where numerous shark species, which are new to science were recently described (White *et al.,* 2006), suggest that more species are yet to be uncovered. Thus, a more detailed taxonomic investigation with application of molecular techniques is warranted to provide better understanding the biodiversity of sharks in this heavily exploited region, since it would allow future researchers and managers to accurately identify the subjects and implement conservation measures accordingly (Simpfendorfer *et al.*, 2011). In consideration of signs of overexploitation of sharks in the Andaman Sea (Arunrugstichai & True, in press), without further taxonomic research into this group in the near future, the unknown species could be at risk of disappearance even before being detected, studied and properly managed.

1.4.3 Changes in Species Composition

In terms of abundance, the landing composition recorded in this study is largely dominated by sharks from the family Hemiscylliidae, which contributed *c.* 65% to the total number of sharks recorded, follow by sharks from the family Carcharhinidae, which contributed *c.* 30.5% to the total landings (Arunrugstichai *et al.*, 2018). Sharks from the other families (Squalidae, Sphyrnidae, Stegostomatidae and Triakidae) were presented in low number, contributing only a small fraction of *c.* 4.5%. to the total number of recorded sharks. In terms of biomass, sharks from the family Carcharhinidae contributed c. 71% to the total recorded biomass, dominating the landings, followed by the abundant hemiscylliids, which contributed *c.* 27% to the total biomass of the landings. The remaining four families contributed only *c.* 2% to the total biomass, since they were present in a very low number. Despite the considerably large contribution of the sharks from family Hemiscylliidae, especially *C. hasseltii*, which contributed *c.* 46.3% to the number of recorded sharks, the total recorded biomass primarily consisted of the carcharhinid sharks, where *c.* 48% consisted of only one species, *C. leucas* alone. This finding underlines the importance of sharks from the family Carcharhinidae to shark fishing and related industries, similarly to most other fisheries in tropical regions (White, 2007), particularly the large individuals of *C. leucas*, which generally has the highest market value among shark individuals present at Thai landings sites, *i.e.* ~20,000 THB per a single large adult individual (Schiønning, 2016) and could even reach ~30,000 THB in some instances (pers. obb.).

Comparison of the landing composition data from this study with historical data from 2004 (Krajangdara, 2005) reveals an obvious shift of species composition, with striking declines in terms of relative abundance of larger, slow-growing species and increasing dominance of smaller, faster-growing species (Arunrugstichai *et al.*, 2018). Every shark families recorded the landings in 2004 by Krajangdara (2005) have experienced varying degree of declines from the landings or totally absent, in exception of the hemiscylliids and triakids. On contrary, the hemiscylliids, which was previously reported to contributed *c.* 25.8% to the total landings in terms of number in 2004 (Krajangdara, 2005) largely increased to *c.* 65% in terms of contribution to the total number of sharks recorded in this study. The striking predomination of the hemiscylliids is likely accredited to their relatively much higher fecundity than most other sharks and oviparous reproductive strategy, which allows these small species to withstand fishing pressure with higher resilience than the other groups. Although the carcharhinids declines slightly as the whole group in terms of abundance, from *c.* 36.4% contribution to the total landings in 2004 (Krajangdara, 2005) to the contributions of *c.* 34.5% of the total recorded catches in this study, however the species composition within the Carcharhinidae family also exhibited noticeable shift. Every species of the carchahinids recorded in 2004 have experienced declines in terms of number or totally absent from the landings in exception of *C. brevipinna*, and *C. leucas* (Arunrugstichai *et al.* 2018). The contribution to the total landings of *C. leucas* significantly increased from *c.* 0.2% (Krajangdara, 2005) to *c.* 13.2% and also contributed nearly half of the total biomass recorded in this study. The reason of the notable increases in terms of relative abundance of *C. leucas* in the recent study is not yet well understood, but it could possibly be related to increasing fishing pressures in nearshore coastal environment or the declines of adults in deeper waters, as suggested by the large proportion of neonates, *i.e.* >90% in the total recorded *C. leucas* (Arunrugstichai *et al.* 2018). Another important finding is the severe declines of the hammerheads from the family Sphyrnidae in the recorded landings. In 2004, the scalloped hammerhead Sphyrna lewini (Griffith & Smith 1834) was the most abundant species, dominating the landings with *c.* 20% contribution to the total recorded sharks (Krajangdara, 2005), however the landings of *S. lewini* was almost negligible in this study, contributing only *c.* 1.2% to the total number of recorded sharks (Arunrugstichai *et al.,* 2018). The massive declines of *S. lewini* has been reported throughout the distribution range of this endangered species (Baum *et al.,* 2007), thus it is very likely that the decline in relative abundance of *S. lewini* recorded in this recent study reflects how their population in the Andaman Sea is likely to be subjected to overfishing, similarly to the other regions (Arunrugstichai *et al.,* 2018).

This observed shifts in species composition of sharks in the recent surveys correlate with the common pattern associated to elasmobranchs fisheries under intensive exploitation, where the larger sharks experience population declines, while the more fecund smaller species eventually predominate the community (van der Elst, 1979; Stevens *et al.*, 2000), thus resulting in the shift in assemblages of the landings. It is unlikely that the shift is caused by discard of some particular species, since the Thai commercial fishers tend to keep most of the catches, including bycatch, due to the fact that everything can be sold and utilized (Krajangdara, 2014; Schiønning, 2015). Instead, it is more likely to be the effects from heavy fishing pressure on different shark species with varying degree of resilience in combination with species replacement through complex trophic interactions (Stevens *et al.,* 2000), such as the increase of food availability, reduction of predation or less interspecific competition. However, quantifying how significant overfishing may induce to the changes in shark assemblage is difficult with the current set of data and requires a much more detailed investigation. Still, the trends of the disappearance of species with slower life-history and proliferation of species with faster life-history has been widely reported in other regions (Ferretti *et al.,* 2010), such as in the North Sea (Walker & Heessen, 1996; Walker & Hislop, 1998), in the waters of the Sultanate of Oman (Henderson *et al.,* 2007) and the South China Sea (Lam & Sadovy de Mitcheson, 2011). Considering the massive declines in landings over the years, and the consensus of fishers regarding the noticeable declines in shark abundance and diversity, especially for larger shark species, the changes of species composition within the past years seems to indicate that sharks in the Andaman Sea have been subjected to overexploitation and also suggest the likelihood of population depletion, especially the large species with slow life-history in this water (Arunrugstichai *et al.*, 2018).

1.4.4 Biological Information

This study provides the most detailed information on the biological aspects of sharks from the Andaman sea, which also indicates the difference in biological parameters in a number of species from what has been previously reported in other regions in the existing literatures. The biological information, *i.e.*, the minimum and maximum recorded total length (L_T) is obtained for all shark species in the landings along with additional information on reproductive biology *e.g.* estimated size at maturity and estimated parturition period for some abundant species with reasonable number of individuals in the recent market surveys (Arunrugstichai *et al*., 2018). However, direct comparison of the obtained information with historical data in the Andaman Sea is not possible, due to the limited biological data provided by Krajangdara (2005). Moreover, the limited number of individuals of most shark specie at the study sites and strict restriction to dissect specimens in the field also prohibited some useful additional biological information to be obtained, *i.e.* the litter sizes and the length and weight relationships. The biological information of sharks in the landings is provided in Arunrugstichai *et al*. (2018), which the author hope that it could be useful for research and fisheries management efforts of sharks in this region in the future, however the biological information is discussed in much greater details below, being compared with the available information of each species in the existing literatures.

Family Squalidae

Squalus hemipinnis

The largest individual of *S. hemipinnis* was a female with an L_T of 627 mm, but the species was previously reported to attain the maximum lengths of at least 780 and 522 mm L_T for females and males respectively in Indonesia (White & Dhamadi, 2010). Maturity data from dissection could not be obtained during this study, but length at maturity of female *S. hemipinnis* was reported to be ranging between 600 to 740 mm L_T (Ebert *et al.,* 2013), while White & Dharmadi (2010) also reported the sizes of pregnant females to be ranging between 600 – 735 mm L_T, thus it is likely that the six females recorded in this study with the sizes ranging from 517 to 627 mm L_T consisted of both adolescent and adults (Arunrugstichai *et al*., 2018). The litter size of *S. hemipinnis* could not be obtained due to restriction for dissection, but it was reported to be ranging between 3 to 10 pups per litter with the size at birth ranging between 160 - 220 mm L_T (Ebert *et al*., 2013), after an unknown gestation period (White & Dharmadi, 2010).

Family Hemiscyliidae

Chiloscyllium hasseltii

The recorded maximum lengths of both sexes of *C. hasseltii* recorded in this study were 878 and 900 mm L_T for female and male respectively, which are larger than the maximum lengths of C. *hasselti* previously reported (White, 2009; Ebert *et al.,* 2013), thus these two individuals represented the largest individuals ever reported of both sexes *of C. hasseltii*. The length at maturity of male *C. hasseltii* is estimated to be ranging between 624 to 682 mm L_T, which is also slightly larger than what was previously reported to be at between 440 to 540 mm for *C. hasseltii* by Ebert *et al.*, (2013). This species is oviparous, however the information on number of eggs and incubation period is unknown at the present time. Size at hatching of *C. hasseltii* could not be obtained from the contemporary landings, but the size of the smallest individual recorded is a female with 355 mm L_T. The available information regarding size at hatching of this species has been previously reported to be ranging between 90 to 120 mm $L_{T,}$ where the hatching occurs in around December (Ebert *et al.,* 2013).

Chiloscyllium punctatum

The largest *C. punctatum* recorded in this study was a male individual with the size of 947 mm L_T, which is smaller than the maximum reported size of 1320 mm L_T from Australia (Last & Stevens, 2009). The size at maturity of male *C. punctatum* in this study was estimated to at between 666 to 717 mm L_T, which is marginally different than the size of 680 to 760 mm L_T reported by Compagno (2001) and Yano *et al.,* (2005) as compiled in Dudgeon *et al.* (2016a). The estimated size at maturity of male *C. punctatum* in this this study is considerably smaller than the highest estimated size at maturity for this species of 820 mm L_T reported by Ebert *et al.*, (2013) but still larger than the smallest estimate reported from Indonesian waters at the size ranging between 650 to 660 mm L_T (Dhamadi *et al.*, 2015). It appears that the reported size at maturity from Southeast Asia is considerably different from Australia with the length at maturity of 820 mm L_T (Last & Stevens, 2009), which could be an interspecies or regional difference, considering the possibility that the Australian form might be a cryptic species (Naylor *et al.*, 2012 as cited in Dharmadi *et al.,* 2015; Dudgeon *et al.,* 2016a). The number of egg cases was not thoroughly examined, but 3 egg cases were collected from a single female individual, which agrees with previous study at Andaman landing sites by Krajangdara (2005) of between 2 to 3 egg cases. Size at birth was not recorded, but it was reported to be at between 130 to 180 mm L_T (Last & Stevens, 2009; Ebert *et al*., 2013). The Incubation period in the wild is currently unknown, but hatching period in aquariums was reported to occur after 92 days in Phuket Aquarium, Thailand (Yano *et al.*, 2005 as cited in Dudgeon *et al.,* 2016a), and 153 days in the Underwater World SEA LIFE aquarium in Queensland, Australia (Harahush *et al.,* 2007 as cited in Dudgeon *et al.,* 2016a), which suggests the regional difference between *C. punctatum* in Southeast Asia and Australian waters, supporting the speculation of cryptic species.

<u>Family Stegostomatidae</u>

Stegostoma fasciatum

With the scarcity of *S. fasciatum* recorded in the landings, there is little biological information that can be obtained from this study for comparison with the available information in existing literatures. Based from the length of the immature male measured, the largest male was immature with the length of 1040 mm L_T, which is below the reported size at maturity at between 1470 to 1830 mm L_T by Ebert *et al*., (2013). Additional information of *S. fasciatum* can be found in species information chapter in the appendix or in the assessment by the IUCN Shark Specialist Group by Dudgeon *et al.,* (2016b) and in the book “Sharks of the World” by Ebert *et al.* (2013).

<u>Family Triakidae</u>

Mustelus cf. mosis

Considering that taxonomic investigation is still underway for this potentially undescribed species (Arunrugstichai *et al.,* 2018), the biological information provided below could be the first available for *M. cf. mosis*, thus comparison of biological information is made with *Mustelus mosis* instead. The length at maturity of *Mustelus cf. mosis* is estimated to be over 717 mm L_T, since none of the male individuals possessed fully calcified claspers. However, Compagno *et al.* (2005) and Ebert *et al.* (2013) reported a relatively smaller size at maturity of *M. mosis* at between 630 to 670 mm L_T (Valenti, 2009), which supports the speculation that these two species are not conspecific as suggested by the differences in the sequences of the NADH2 marker (G. Naylor, unpubl. data).

Family Carcharhinidae

Carcharhinus albimarginatus

Based from the smallest neonate recorded in this study, it was estimated that the size at birth of *C. albimarginatus* is close to *c.* <750 mm L_T or less, which falls within the size range reported from Indonesia, *i,e.* 725 - 805 mm L_T by White (2007), and from the waters of southern Africa at between 700 to 800 mm L_T (Bass *et al.*, 1973 as cited in White, 2007), but also considerably larger than the size previously reported by Compagno *et al.* (2005), i.e. 630 to 680 mm L_T (Espinoza *et al*., 2016). With only small juveniles in the recent surveys, the size at maturity of *C. albimarginatus* could not be determined, but it was previously reported to be between 1600 to 1800 for males and 1600 to 1990 for females (Ebert *et al.,* 2013) with possible regional differences. In other regions, the size at maturity was reported to be at between 1930 to 1990 mm L_T for males in Indonesian waters (White, 2007), at between 1700 to 1800 mm L_T in the western Indian Ocean (Stevens, 1984a as cited in White, 2007) and at 1747 mm L_T for males and 2089 mm L_T for females in Papua New Guinea (Smart *et al.*, 2017). Based from the occurrence of neonates with open umbilical scar in the landings, parturition period is estimated to be between December and January, however it is unknown whether this species give birth seasonally or year-round with the limited number of recorded individuals. Also, the litter size could not be obtained, but it was previously reported by White (2007) to be between 5 to 7 pups per litter in Indonesia. Gestation period could not be obtained in this study, but *C. albimarginatus* was reported to give birth biennially after a 12 months gestation period (Compagno *et al.,* 2005; Last & Stevens 2009 as cited in Espinoza *et al.,* 2016; Ebert *et al.,* 2013).

Carcharhinus amblyrhynchos

The size at birth of *C. amblyrhynchos* from this study could not be obtained but it is estimated to be close to *c.* 794 mm L_T or less, based from the measured length of the neonate with visible umbilical scar recorded in this study, it is comparable to what has been reported from Indonesia at between 670 to 700 mm L_T (White, 2007), and slightly larger than the recorded from northern Australia and Hawaii with of *c.* 630 and *c.* 600 mm L_T respectively (Stevens & Mcloughlin, 1991; Wetherbee *et al.,* 1997 as cited in White, 2007). The visible umbilical scar of the neonate suggests its recent birth, thus the parturition period of *C. amblyrhynchos* in the Andaman Sea is likely to at least falls within March and April, however the whole duration of parturition period could not be determined yet, or whether this species give birth seasonally or year-round with the currently available information. In other regions, it has been previously reported that parturition of this species is possibly occur in August in the southern hemisphere after a 9 months gestation period (Stevens & Mcloughlin, 1991 as cited in Smale, 2009) and from March to July in Hawaii after a 12 months gestation period with annual reproductive cycle (Wetherbee *et al.,* 1997 as cited in Smale, 2009). The length at maturity of *C. amblyrhynchos* could not be obtained in this study, but it is commonly reported to be at between 1300 to 1450 mm L_T for males, and 1200 to 1420 mm L_T for females (Ebert *et al.,* 2013), with some regional differences, where it was estimated to be at *c.* 1330 mm L_T for males in Indonesian waters (White, 2007) and at between 1100 to 1200 mm L_T for males from the western Indian ocean (Stevens, 1984a as *C. wheeleri* as cited in White, 2007).

Carcharhinus brevipinna

The largest individual of *C. brevipinna* recorded in this study was a female of 2912 mm L_T, which is considerably larger than the previous record of 2450 mm L_T from the Andaman sea (Krajangdara, 2005), and even larger than the maximum size reported for this species*, i.e.* 2780 mm L_T (Ebert *et al*., 2013), thus it is likely that this is the largest individuals of *C. brevipinna* ever documented. The length at maturity for male *C. brevipinna* could not be determined in this study, but based from existing literatures, there seems to be large regional variations. The length at maturity of male *C. brevipinna* is commonly reported to be at between 1590 to 2030 mm L_T (Ebert *et* *al.*, 2013), with possible regional differences, where it was reported to be at *c.* 1960 mm L_T in the waters of Indonesia (White, 2007), at between 1800 to 2000 mm L_T in Southern Africa (Bass *et al.,* 1973 as cited in White, 2007), at *c.* 2205 mm L_T off Taiwan (Joung *et al.,* 2005), and at 1600 mm L_T around Brazil (Sadowsky, 1967 as cited in White, 2007). For females, the length at maturity was reported to be at between 1700 to 2000 mm L_T (Ebert *et al.,* 2013), with regional differences, where it was reported to be at between 2000 to 2100 mm L_T off southern Africa (Bass *et al.*, 1973 as cited in White, 2007), at 2255 mm L_T off Taiwan (Joung *et al.,* 2005), and at *c.* 1700 mm L_T in Brazil (Sadowsky, 1967 as cited in White, 2007). The size at birth of *C. brevipinna* in this study is estimated to be close to *c*. 900 mm L_T or less, based from the lengths of neonates with open umbilical scars, however it is not likely to be accurate with the lack of L_T data from embryo. The L_T at birth of *C. brevipinna* was previously reported to be between *c.* 600 to 750 mm L_T (Ebert *et al.,* 2013), with some regional difference, where it was estimated to be at between 680 to 810 mm L_T in Indonesia (White, 2007), and at between 600 to 750 mm L_T in the western North Atlantic and Taiwan (Burgess, 2009; Joung *et al.*, 2005). Parturition is estimated to occurs within November to December for the neonates recorded in this study, but it could not be surely determined whether *C. brevipinna* in the Andaman Sea has a longer duration of parturition period or a defined reproductive cycle from the available information. The reproductive cycle of *C. brevipinna* was previously reported to be biennial (Branstetter, 1981 as cited in White, 2007), where birthing was reported to occurs between March to April in eastern Australia (Stevens, 1984b as cited in White, 2007), but this species in Indonesian waters is speculated to has non-seasonal reproductive cycle (White, 2007).

Carcharhinus leucas

The size at birth of *C. leucas* from this study could not be accurately obtained with the lack of embryo examination, but it is estimated to be between *c.* 550 to 800 mm L_T, which agrees with the commonly reported size at birth of this species, *i.e.* 560 - 810 mm L_T (Ebert *et al.*, 2013). With the large abundance of neonates throughout the year, as documented in the recent surveys and preliminary visits (Arunrugstichai pers. obs.), it is likely that *C. leucas* in the Andaman sea may breed and give birth yea-round, as has been previously reported in other tropical areas, such as in Nicaragua (Castro, 1983 as cited in Simpfendorfer & Burgess, 2009). The pregnant females were not dissected due to the strict restriction, however *C. leucas* is reported to give birth to 1 to 13 pups after 10-11 months gestation period (Ebert *et al.*, 2013). The length at maturity of *C. leucas* was not able to be estimated in this study, but it was reported be ranging between 1570 to 2260 mm L_T for males and 1800 to 2300 mm L_T for females (Ebert *et al.,* 2013), with large variations between different regions (White, 2007).

Carcharhinus melanopterus

The length at maturity of male *C. melanopterus* could not be accurately obtained with the lack of maturing individuals in this study, but it is estimated to be over 964 mm L_T, which agrees with the reported size at maturity in existing literatures of this species at the size between 910 to 1000 mm L_T (Ebert *et al.,* 2013), including the information from Indonesia of *c.* 1080 mm L_T (White, 2007). The length at maturity of females was not examined due to the strict restriction, but it has been reported to be ranging from 960 to 1120 mm L_T (Ebert et al., 2013). The size at birth of *C. melanopterus* is estimated to be close to *c.* 585 mm L_T or less, which is still comparable to the reported size at birth of this species in existing literatures, *i.e.* 330 - 520 mm L_T (Ebert *et al.,* 2013), and particularly close to the information reported from Indonesian waters, *i.e.* 500 - 530 mm L_T (White, 2007). The parturition period of the neonate recorded is likely to be between December to January, which differs from what was reported in existing literatures from other regions, where it was estimated to be between August to September in Indonesian waters (White, 2007), around November in northern Australia (Lyle, 1987 as cited in Heupel, 2009) and in October in Aldabra atoll of the Indian Ocean (Stevens, 1984a as cited in Heupel, 2009). The estimated period of birthing of *C. melanopterus* obtained from this study also agrees with anecdotal reports from tourists and tour operators on the presence of large pregnant females in sheltered bays in December and regular sightings of neonates in mangrove forests around nearshore islands of Krabi province of Thailand in January and February. However, the presence of another neonate in April, also suggests that the parturition period of *C. melanopterus* in the Andaman Sea may span over several months, extending from December to March. In addition, the parturition period of *C. melanopterus* in the Gulf of Thailand has been estimated to falls within March to April based from a three years surveys of large aggregation of pregnant females and occurrence of neonates in sheltered bays of Koh Tao, Thailand (Arunrugstichai *et al.* in prep), which suggests the likelihood of difference within the same species from the two seas of Thailand. This study could not obtain the litter size of *C. melanopterus*, but it was reported to be between 2 to 4 pups per litter after a 16 months gestation period (Ebert *et al.,* 2013).

Carcharhinus plumbeus

The size of *C. plumbeus* was reported to vary between different stocks (Ebert *et al.,* 2013). With the single immature *C. plumbeus* recorded in this study, there is hardly any data for comparison with the information reported in existing literatures. The size of this individual is 735 mm L_T, which lies within the reported size at birth of this species*, i.e.* 560 - 750 mm L_T (Ebert *et al.,* 2013). Additional biological information of *C. plumbeus* can be found in the assessment by Musick *et al.* (2009) and in the book "Sharks of the World" by Ebert *et al.* (2013).

Carcharhinus sorrah

The largest individual of *C. sorrah* recorded in this study was a female with the size of 1629 mm L_T, which is considerably larger than the previous largest record of 1450 mm L_T from the Andaman sea (Krajangdara, 2005), and even slightly larger than the maximum size reported for this species at 1600 mm L_T (Ebert *et al.,* 2013), which suggest that this female is the largest *C. sorrah* ever recorded. The L_T at maturity of male *C. sorrah* is estimated to be between 1111 to 1252 mm L_T, which closely agrees with the reported size at maturity from Indonesian waters, *i.e. c.* 1120 mm L_T (White, 2007), and also fairly close to the size of 1060 mm L_T reported by Ebert *et al.* (2013). However, the estimated size at maturity of male *C. sorrah* in the Andaman Sea is still considerably larger than 900 mm L_T reported from Australia (Pillans *et al.,* 2009). The size at maturity of the female *C. sorrah* was not obtained in this study, but it was previously reported to be between 1100 to 1180 mm L_T for this species in most regions (Ebert *et al.,* 2013), and at 950 mm L_T in Australian waters

(Pillans *et al.*, 2009). In this study, the size at birth of *C. sorrah* was estimated to be around *c.* 600 mm L_T or less, which agrees with the commonly reported size at birth of this species, *i.e.* 450 - 600 mm L_T (Ebert *et al.,* 2013) and for the populations in Indonesian waters *i.e.* 520 to 550 mm L_T (White, 2007). Without proper dissection of pregnant females, the litter size of *C. sorrah* was not obtained in this study, but it has been reported to vary between 1 to 8 pups per litters (Ebert *et al.,* 2013). The parturition period of *C. sorrah* in the Andaman Sea is estimated to falls within March to April, which agrees with was previously estimated to be between March to May from the study in Bombay, India (Compagno in prep, as cited in Pillans *et al.,* 2009) but different from the estimated parturition period in Indonesian waters, which was reported to be around September and October (White, 2007).

Galeocerdo cuvier

Only limited amount of biological information of *G. cuvier* could be obtained from this study. The size at maturity of male *G. cuvier* in this study is estimated to be over 2265 mm L_T, which lies within the commonly reported size range for the males of this species to attain sexual maturity, *i.e.* 2260 - 2900 mm L_T (Simpfendorfer, 2009; Ebert *et al*., 2013). The size at maturity of female *G. cuvier* could not be obtained, but it was commonly reported to be ranging between 2500 to 3500 mm L_T in existing literatures (Ebert *et al.,* 2013). There was no neonate of *G. curvier* recorded in the actual surveys, however during preliminary visits in July 2014, there were several small individuals with total lengths lies within the reported range of size at birth in the existing literatures, *i.e.* 510 - 760 mm L_T (Ebert et al., 2013). This finding roughly suggests that the parturition period of *G. cuvier* in the Andaman Sea should be around May to July (Arunrugstichai pers. obs.) and also agrees with the reported parturition period of this species between spring to early summer (Ebert *et al.,* 2013).

Negaprion acutidens

Only one immature male *N. acutidens* was recorded in this study. The size of this individual of 896 mm L_T is very close to the commonly reported size at birth of *N. acutidens*, *i.e.* 450 to 800 mm L_T (Ebert *et al.,* 2013). The size at maturity of N. *acutidens* could not be estimated, but the commonly reported size when this species attain sexual maturity is around 2200 to 2400 mm L_T (Ebert *et al.,* 2013). Additional biological information of *N. acutidens* can be found in the Species Information in the appendix of this thesis or in the book “Sharks of the World” by Ebert *et al.* (2013).

Scoliodon cf. laticaudus

With the deteriorated condition of a large portion of *S. cf. laticaudus* in the landings, accurate measurement could be taken from these individuals, yet this study yields some biological information for this potentially undescribed species (Arunrugstichai *et al.,* 2018). The length at maturity of *S. cf.* l*aticaudus* is roughly estimated to lies within the range of 300 to 449 mm L_T. This is slightly different from the size at maturity at between 240 to 360 mm L_T of *S. laticaudus*, the species that share close similarities with the recorded *Scoliodon* species, as reported by Ebert *et al.*, (2013). Considering that the individuals recorded in this study is not conspecific with *S. laticaudus* (Arunrugstichai *et al.*, 2018), it is likely that biology of *S. cf. laticaudus* could be considerably different and requires detailed investigation in the future.

Triaenodon obesus

The length at maturity of male *T. obesus* recorded in this study is estimated to lies within 1004 - 1212 mm L_T, which closely concurs with the size commonly reported, *i.e.* 1040 - 1212 mm L_T (Ebert *et al.*, 2013), and the estimated length at maturity from from Indonesian waters, i.e. 1130 - 1190 mm L_T (White, 2007), although a smaller mature male with the length of 950 mm L_T was previously recorded in the Maldives (Anderson & Ahmed, 1993). The size at birth was estimated to be close to *c.* 600 mm $\mathrm{L_T}$ or less, which also lies within the range of the commonly reported size at birth of *T. obesus i.e.* 520 - 600 mm L_T (Ebert *et al.,* 2013). Based from the occurrence of neonates in the landings, the parturition period of *T. obesus* in the Andaman Sea is estimated to be between March to April, which is much earlier than the reported parturition period at around August for this species in Indonesian waters (White, 2007). This finding suggests a regional difference in terms of biological parameters, but it requires further study to properly verify this speculation. From the visible mating scars on three large females recorded in April, the mating of

T. obesus in the Andaman Sea was estimated to occurs between February to April, and also suggests that the gestation period should be around *c.* 12 months. With the limited studies on reproductive biology of *T. obesus*, the information on the gestation period of this species was reported with a very wide range from 5 to 12 months (Smale, 2009; White, 2007; Ebert *et al.*, 2013). The gestation period estimated from this study closely agrees with the reported gestation period of c. 12 months of this species from Indonesian waters by White (2007), suggesting that the gestation period of *T. obesus* in the Andaman Sea should also be around 12 months.

Family Sphyrnidae

Sphyrna lewini

The length at birth of *S. lewini* is estimated to be close to *c.* 417 mm L_T, which is similar to the size commonly reported in literatures, *i.e.* 420 - 550 mm L_T (Ebert *et al.,* 2013). Based from the time when a large number of neonates with fresh umbilical scars were recorded, the parturition for *S. lewini* in the Andaman Sea is likely to occur within March to April, which is different from the parturition period previously reported in other regions by Baum *et al.* (2007) including from the Indonesian waters by White (2007). The difference in parturition period of *S. lewini* found in this study could be a regional variation of a distinct stock of this species in the Andaman sea. Due to the fact that most individuals recorded were neonates or juveniles, most other biological information could not be obtained, however information of *S. lewini* from existing literatures are provided in the Species Information in the appendix of this thesis.

1.4.5 Size and Sex Composition

The sex composition of the landings of three abundant species, *C. hasselti*, *C. punctatum* and *S. cf. laticaudus* exhibited significant difference from parity in sex ratios, while the landings of other abundant species do not exhibit this difference. The surveys found that there were significantly more male individuals in the landings of *C. hasselti*, ($\chi 2$ test, $P < 0.05$), while the recorded landings of both *C. punctatum* and

S. cf. laticaudus contained significantly more female individuals. According to the available information of *C. punctatum* from Indonesian waters, which did not exhibit significant difference from parity in sex ratio (Dharmadi *et al.*, 2015), it is uncertain whether there is any regional difference between stocks of this species. Sexual segregation is quite commonly reported in sharks and other elasmobranchs (Springer, 1967 as cited in White, 2007) which could also be an explanation for this finding, however there is no available information in regard to sexual segregation for these three species to support this speculation at the present time.

One of the key findings of this study is the small number or a total absence of adults of most shark species in the landings, in exception of the hemiscylliids, which starkly contrasts with observation during preliminary visits between 2012 and 2013, where adult individuals were present in large numbers, especially the carcharhinids and sphyrnids (Arunrugstichai *et al.*, 2018). The disappearance of large individuals and domination of juvenile sharks in the landings closely correlates with the anecdotal reports from fishers and traders at landing sites, which gave a consensus on the noticeable declines of large sharks during the time period between preliminary visits and the actual surveys. According to the fishers during informal interviews, the disappearance of large sharks began over a decade ago, accompanying the declines of landings over the years. Considering the declines in shark landings and intensive exploitation by commercial fishing activities in the Andaman Sea, overfishing in the waters of this region seems to be the most probable explanation for the absence of large adults in the landings (Arunrugstichai *et al.,* 2018). This pattern is not uncommon in elasmobranch fisheries and has been previously reported from other regions (Lam & Sadovy de Mitcheson, 2011; Jabado *et al.,* 2016.), which raise a grave concern, since the recruitment of shark populations is closely depends on the adults available (Camhi e*t al,* 1998). Moreover, the large proportion of juveniles and neonates in the landings indicates that the nursery areas of most species in the Andaman Sea are also being exploited. Considering the slow life-history characteristics of sharks, especially their low fecundity, fishing in the nursery area could greatly exacerbate the problem by limiting the replenishment potential of the population by removing the neonates from the critical habitat before these sharks can grow and breed. The consequence could be particularly severe if the exploited species are philopatric (Hueter *et al.,* 2005). These findings suggest a high possibility of the situation of recruitment overfishing of most of the large shark species in the Andaman Sea, however this speculation could not be accurately verified with the available information.

1.4.6 Notable Groups of Concern

As there can be large difference in life-history parameters among species, it is likely that the rate of exploitation from fisheries will have a varying degree of effect to different shark species. The disappearance of large shark species is a widespread phenomenon in fisheries in many regions worldwide, which could even cause by light fishing pressure (Ferretti *et al.,* 2010), and the finding in this study closely concurs with this global concerning trend. Based from the marked declines in species diversity and relative abundance from the historical data, it suggests the populations of most large shark species from the family Carcharhinidae and Sphyrnidae have greatly declined and should be considered as the high priority groups of concern, which are in needs of urgent management actions (Arunrugstichai *et al.*, 2018) This finding agree with the assessment of extinction risk of sharks by Garcia *et al.,* (2007), where these two groups are at high risk, based on their viviparous reproductive mode. The hammerheads from the family Sphyrnidae seems to be at the highest risk among all shark species recorded at Andaman landings sites, with massive changes in relative abundance of *S. lewini* from *c.* 20% contributions to the total landings in 2004 (Krajangdara, 2005) to a miniscule contribution of *c.* 1.2% in the present study. It is noteworthy that none of the S. *lewini* individuals in this study had reached the stage of sexual maturity (Arunrugstichai *et al.,* 2018), while the great hammerhead *Sphyrna mokarran* (Rüppell, 1837) was completely absent. The massive declines of *S. lewini* have been reported throughout the distribution range (Baum *et al.*, 2007), similarly to *S. mokarran* (Denham *et al.*, 2007). The findings from this study suggest that the populations of these two sphyrnid species in the Andaman Sea are at similar high risk as has in the other regions.

For the family Carcharhinidae, the 22 species of requiem sharks that were previously reported by Krajangdara (2004) in the recent surveys (Arunrugstichai *et* *al.*, 2018) also exhibited sizable declines in term of relative abundance, if they were not totally absent from the landings. The only exception to this were *C. brevipinna* and *C. leucas.* Comparing the historical and contemporary data, the contribution of *C. leucas* to total landings increased greatly from 0.2% (Krajangdara, 2005) to *c.* 13% of the total recorded individuals of all sharks (Arunrugstichai *et al.*, 2018). Regrettably, there is no size composition information in the available historical data for comparison to be made. It seems highly probably, based from the large dominance of neonates, *(*>90% of *C. leucas*) and young-of-the-year individuals of *C. brevipinna, i.e.* (90% of the total landings of these two species), that this finding is the effect of increasing pressure on inshore and estuarine habitats, which *C. leucas* uses as a parturition ground and nursery area (Simpfendorfer & Burgess, 2009) and nearshore environment, which *C. brevipinna* uses as nursery area (Burgess, 2009) in addition to the disappearance of adult individuals in deeper waters and the overall population declines of the other carcharhinids in the Andaman Sea. With the available information it seems to indicate that the carcharhinids and sphyrnids are at high risk of recruitment overfishing, which can lead to stock collapse in the near future, however it cannot be surely determined with the currently available information and requires further study to conduct yield-per-recruit analysis to properly verify this speculation.

1.4.7 Management Shortcomings

Considering the characteristics of the landings observed in this study and the massive declines of shark catches recorded throughout the past decades, it indicates that the population of many shark species in the Andaman Sea could be at risk of collapse from the intensive exploitation from fisheries, especially for the large species (Arunrugstichai *et al.,* 2018). Despite the inability to conduct population assessment of shark species in the Andaman Sea from the lack of data to accurately do so, mainly from the declining catches, the signs of overexploitation highlight the great urgency to respond to the potential population collapse of a number of shark species in this data-poor yet heavily exploited region in the near future. Although Thailand has acknowledged the importance of conservation and management of sharks, resulting in the drafting of NPOA-sharks, however the actual progress is still slow, being hindered with numerous limitations, especially on scientific information and personnel (Krajangdara, 2014). In order to effectively mitigate this problem, the management strategy needs to be based on good scientific information, which is unfortunately still fairly lacking for sharks in this region, and is a high priority problem to be addressed.

One of the key problems for management is the lack of accurate data collection of different shark species caught by Thai fisheries, which is multispecies in nature. At the present time, the landings data of sharks in Thailand are aggregated into one single group, which could be problematic by limiting the ability to track changes in the landings of different species. Considering that life history of sharks can be vastly different even within the same genus, it is obvious that different species will respond differently to the same fishing pressure also. For example, the slow-growing Sandbar shark *Carcharhinus plumbeus* which reaches sexual maturity at the ranges between 8-16 years will not able to withstand as much fishing pressure as the faster-growing species, such as the Spottail shark *Carcharhinus sorrah*, which reaches maturity in only 2-3 years (Ebert *el al.,* 2013). Therefore, instead of lumping different species into the same group as “sharks”, a greater resolution in data collection regime, ideally as specific to species level could greatly aid the decision-making process for applying conservation and management measures for the species at risk in the future. However, this could be fairly challenging at present, due to the limited personnel working on sharks in Thailand, especially the specialist who can accurately distinguish different species in the field. Particularly for the whaler sharks of the genus *Carcharhinus*, a major group of sharks in most tropical fisheries, which closely resemble each other, making accurate species identification quite challenging even for trained eyes. Capacity building of personnel operating at landing sites to conduct accurate species identification should be a reasonable goal for improvement in long-term catches monitoring of sharks in Thai fisheries. Considering the limited capability of data collection from the lack of experience personnel at the time being, at least starting with separation of “sharks” category into smaller groups based on catch characteristics, body size and life history could be a useful approach to simplify data collection and management process, especially for multispecies fisheries (Harry *et al.,* 2011), as it is in Thailand. Definitely, grouping different species together would not be as ideal as having a regular and systematic data collection regime, which can accurately monitor sharks catches to the species level, however considering the urgency of the current situation, this simplified method could be an effective tool to consider for real world application, which would significantly improve the current practices by a large margin.

In addition to the lack of regular and accurate data collection, the current knowledge of sharks in Thai fisheries in this region is almost non-existence, where most of the previous studies in Thai and adjacent waters were focused on the species diversity of this group, while other data to conduct population assessment such as life-history is lacking. This problem is quite understandable due to the limited research funding and experienced personnel working on sharks in Thailand, however urgent improvement in scientific research would be essential for sustainable management of shark fisheries in the future. Considering that successful resource management requires understanding of the resources and the people who exploit the resources (Hilborn, 2007), additional researches in the future should aim to cover a range of biological, ecological and human aspects (Simpfendorfer *et al*., 2011). For the biological researches, the past literatures in Thailand were focused on species diversity. Although there are still knowledge gaps in the taxonomy of sharks in the Andaman Sea, as suggested by the recent discovery of two undescribed species (Arurugstichai *et al.,* 2018), considering the urgent needs for conservation management of many shark species, the follow up studies in this region should be more focused on life-history to allow population assessment to be made for informed decision making. Life history data are essential for several useful fisheries management techniques, such as stock assessments (Walker, 1992), demographic models (Cailliet, 1992) and ecosystem models (Stevens *et al.,* 2000) that are widely used for setting catch limits in many fisheries (Simpfendorfer *et al.,* 2011). Therefore, further research on important life history information such as age and growth, mortality and reproductive biology should be at high priority in order to improve the management of shark in Thai fisheries, particularly for the species at high risk in the Andaman Sea region, such as the whaler sharks and the hammerheads (Arunrugstichai *et al.,* 2018). For ecological research, perhaps the key priority to focus on at present is spatial ecology to gain better insight on movement and migration pattern and habitat usage of different shark species, which can be extremely useful for spatial management approaches such as time-area closure or marine protected areas (Simpfendorfer *et al.,* 2011). Moreover, considering that the nursery areas of many shark species in the Andaman Sea are under a considerable rate of exploitation (Arunrugstichai *et al.,* 2018), identifying key areas such as nursery and mating ground would also greatly aid the management and protection of critical habitats, especially for the species of concerns. The types of research mentioned above are what the author would like to suggest as high priority at present, given the state of exploitation of sharks in the Andaman Sea, however an in-depth synthesis on different types of research that are needed for the development of effective conservation management of sharks can be looked in much greater details in Simpfendorfer *et al.,* (2011). To effectively collect data for the much-needed research, development of a dedicated onboard observer program, similar to what has been established as a collaboration between the government of Australia and Papua New Guinea, should be essential, since the observer can rapidly collect a tremendous amount of raw biological data in short span of time, if the shark populations still remains in a sufficient number to do so.

Perhaps the greatest obstacle to overcome in order to effectively manage the declining shark populations is the widespread usage of non-selective fishing methods in the waters of this region, considering that majority of the sharks, *i.e.* >90% in Thai fisheries were caught by non-selective fishing gears such as otter board trawl and pair trawl (Krajangdara, 2014). Sharks are usually considered as "bycatch" by the fisheries management authority, which makes them usually be treated as a lower priority group, despite the pressing conservation concern of their population declines, while it also not accurately reflects how sharks are being exploited and utilized by the Thai fisheries in modern time. On contrary to most previous Thai literatures, which stated that there are no target shark fisheries in Thailand and sharks were occasionally caught as bycatch in multispecies fisheries (Krajangdara, 2014), large-scale commercial fishing vessels are reported to be intentionally targeting sharks in some degrees nowadays, based on the consensus among many stakeholders in Thai fishing industry, since catching sharks is still economically viable, despite the lower market value per weight of sharks than the economically important species (Schiønning, 2015). Shark products are widely utilized in a number of different industries and actually quite high on demand, especially for the Carcharhiniformes sharks *e.g. C. leucas*, *C. sorrah* and *Hemipristis elongata*, which have a reasonable market price in Thailand (Schiønning, 2015). In addition, the market price of sharks can significantly increase along the supply chain, *i.e.* >1,600% after being processed into shark fins (Schiønning, 2015), which Thailand is currently the leading exporter (including re-export) of the World (Dent & Clark, 2015) and also for other shark-derived products in different market. With the increasing economic value, sharks are intentionally targeted regardless of sizes and species in multispecies fisheries with tiny mesh size, i.e. <25 mm (Schiønning, 2015), instead of being just an unwanted unintentional bycatch as traditionally perceived, therefore specific attention to regulate the fisheries and trades of sharks is needed in the near future. Considering that sharks were mostly caught in non-selective fishing practices of Thai fisheries, which retain almost if not everything that were caught, since all biomass can be sold, there might be only a few fishing regulations that could effectively address the greatest threat of sharks in this region. Enforcing the usage of Bycatch Reduction Device (BRD) in trawl fisheries might be helpful to reduce the amounts of sharks getting caught in the non-selective fishing gears, however due to the practice of biomass fishing by majority of the commercial fishing vessels, it might be challenging to gain collaboration with fishers due to the loss of other species other than sharks, which would result in less income for the fishers. Increment of mesh size might not be that effective for preventing sharks from getting caught, since the targeted economical species tend to be much smaller in sizes, although it could help reduce the pressure on the stocks of other marine resources. Gradual shifting of fishing strategy from non-selective fisheries toward target fishing for specific high-value species by restriction of usage of bottom trawls or reduction of the number of trawlers via buyback scheme could also be effective long-term strategy to address the depletion of shark populations. In fact, this management measure would not only benefit the declining population of sharks, but also the other stocks of marine resources in Thai waters, which are very likely to be under severe overexploitation from fisheries (Boonwanich & Boonpakdee, 2009 as cited in Achavanuntakul *et al*., 2014). A more compromising alternative would be implementation of a more conservative setpoint for allowable fishing effort, such as limiting trawling hours based on the most sensitive group of species with high vulnerability to fishing pressure, such as large carcharhinids and sphyrnids, since specifically managing different species in multispecies fisheries can be quite challenging (Harry *et al.,* 2011). Nevertheless, any of the mentioned management measures would negatively impact the lucrative seafood-related industries of the nation to a considerable extent once implemented, since the industries have long relied on cheap biomass from unsustainable fishing practices for several decades. Still, in the long run, it should prove to be beneficial to the Thai fisheries and the marine environment as a whole by shifting the industry toward a more sustainable direction.

Specific area-based regulations, such as no-take zones, marine protected areas or time-area closures of nursery grounds or migratory routes could also be a viable management option, given that the nursery areas of many species are being exploited (Arunrugstichai *et al.,* 2018). However, to effectively implement these management measures, it would require a good understanding of habitat usages and migratory patterns of the species of concerns, which is still quite lacking, emphasizing the needs for further spatial-ecology research in this region. Some areas in the Andaman Sea are likely to be the nursery grounds for some coastal carcharhinid species such as Phang-Nga Bay and Trang River for *C. leucas*, and Surin Archipelago and Phi Phi Islands for *C. melanopterus* (S. Arunrugstichai, unpubl. data), however the data of these critical habitats for the other species of concerns is essentially nonexistent in the literatures at the present time. Furthermore, many shark species commonly have a large movement range, which can cover the waters of more than one nation, without being restricted within the established country boundaries (Bradley & Gaines, 2014). Collaborative research effort, joint enforcement and transboundary management between different nations in this region should be a requirement for strengthening the conservation efforts of sharks in the Andaman Sea, especially when considering how majority of sharks were reported to be caught outside of the territorial waters of Thailand (Schiønning, 2015) and it is currently being discussed for the potential of upcoming collaboration with Myanmar at the present time.

A national shark finning ban is arguably the most commonly proposed legal regulation by NGOs and advocated non-specialists but considering how sharks are mostly landed whole by the commercial fishers, while all body parts are traded and utilized in different industries. Essentially, this policy focused on governing how sharks are killed not how many sharks are killed (Shiffman & Hammerschlag, 2016), thus it probably could not effectively address the declining shark populations in this region from the real threat of intensive biomass fishing. Nevertheless, it should be relatively easy to implement based on how sharks are sold and marketed here, while it should help sending a strong message to the general publics on this issue (Schiønning, 2015).

Legal protection of specific species by inclusion into national protected species list is a fairly recent effort to address the declining population of some shark species in Thailand. In addition to the endangered whale shark *Rhincodon typus*, which is already listed in the protected species list of Thailand, three species of the hammerhead (*S. lewini*, *S. mokarran* and *S. zygaena*) and the zebra shark *S. fasciatum* are being considered for inclusion for better protection via legal means. These legal protections of some species of concerns shows the increasing effort by the management authorities to handle the pressing issue of sharks in Thai fisheries, however this is not a silver bullet solution and it is also quite problematic in real world application. First of all, since most sharks are caught in non-selective fishing gears as either incidental or intentional bycatch, it is difficult for the fishers to avoid certain protected species in practice and would risk facing penalties even if they do not intend to catch such species in the first place. To avoid facing such penalties, fishers can just easily discard carcass back into the sea, instead of risk facing penalties, while it does not substantially prevent fishing mortality from the non-selective trawling gears. Moreover, according to anecdotal reports from personal contacts at landing sites, it seems that the pressure from authority and general public has driven the trades of sharks to be well-hidden from sight, where the landings are not openly displayed anymore, and retains in fishing vessels for specialized bidder instead. This obscured trade of sharks makes data collection at landing sites a much more challenging task for both researchers and management authority at the present time, which would greatly hinder accurate catches monitoring and conducting further research to improve shark fisheries management in this region.

Being among the countries with the greatest declines in shark landings, the development of shark fisheries management in Thailand is needed (Davidson *et al.,* 2015) and should be regarded as high priority by the management authorities. Given that shark fisheries have long been known to requires different approaches for management from the teleost fishes due to their high vulnerability to exploitation (Holden, 1974; Harry *et al.,* 2011), the current fisheries management of Thailand is most likely to be inadequate to mitigate the declines of sharks in the Andaman Sea without additional specific strategy to manage this group of conservation concerns. Apparently, the Department of Fisheries of Thailand (DoF) seems to have acknowledged the shark exploitation issue to a certain extent, by developing the National Plan of Action (NPOA-sharks), following the International Plan of Action for the conservation and management of sharks (IPOA-sharks) in 2005 (Krajangdara, 2014), however the NPOA-sharks for Thailand is still in the development phase at this time. Furthermore, efficient communication and collaboration between different management agencies apart from the Department of Fisheries alone should be pursued, since the enforcement of regulations and scientific research of sharks in some angles may also requires cooperation from other agencies such as the Department of National Park (DNP), or the Department of Marine and Coastal Resources (DMCR), *e.g.* increasing protection in specific areas, collaborating in scientific research with the DMCR marine endangered species unit, or making joint decision for drafting new policies. This should greatly influence the successful conservation and management measures in the future, especially with the shortage of experts, resources and funding of the DoF as previously stated in Krajangdara (2014). Considering the current situation in the Andaman Sea with severe catches declines, loss of biodiversity and numerous management shortcomings that needs to be addressed, it is apparent that additional supports and collaborative efforts are needed from various stakeholder parties, such as management agencies and also neighboring nations to effectively manage and conserve shark populations in the Andaman Sea, which would eventually contribute to the overall improvement of fishing industry and marine environment of this region.

1.5 CONCLUDING REMARKS

Overall, this thesis intends to gain insight of the current state of sharks in Thai commercial fisheries in the Andaman Sea after several decades of large-scale exploitation, based on fishery dependent market survey, while also aim to provide biological information of the species present at landing sites and discuss some viable management options for sharks in commercial fisheries in this region. The main findings of this thesis strongly suggest that shark populations in the Andaman Sea are being under severe exploitation from commercial fisheries, as indicated by several signs in the landings characteristics, especially when compared with historical data from 2004. First of all, substantial declines of shark diversity in the landings were recorded, *i.e.* >60%, especially for large species with slow life history characteristics. Secondly, the landings exhibited a massive shift in species composition with marked declines of large sharks and dominations of smaller species. Thirdly, majority of the landings were composed of neonates and juveniles, while the adults of most large species were present in extremely low number or totally absent. These findings closely correspond with anecdotal reports from fishers on declines of catches, lower species diversity and disappearance of large sharks over time. The signs of overexploitation of sharks recorded in this thesis coupled with the striking declines of shark catches, *i.e.* >90% throughout the past few decades raise a pressing concern on the potential collapses of the shark populations in the Andaman Sea in the near future.

Insights from the landings survey also suggest the needs for attention on two groups of concerns, sharks from the families Carcharhinidae and Sphyrnidae. These two groups have experienced massive declines in terms of relative abundance, particularly *S. lewini,* which have suffered the most severe declines, while the adults were totally absent from the landings, suggesting that the population of *S. lewini* is likely to be at higher risk of collapses than all other shark species recorded in the survey. Although, the carcharhinids experienced slight declines in terms of contribution to the total landings as a whole group, only half of the species recorded at Andaman landing sites in 2004 were presented, while majority of the landings consisted of neonates and juveniles almost exclusively. Therefore, it is likely that sphyrnids and carcharhinids are being heavily overfished to near depletion, while the important nursery areas of these groups are also being exploited.

Despite the possibility of population collapses of a number of shark species in the Andaman Sea, it is apparent that there are still many shortcomings to address in order to effectively manage and conserve the declining shark populations. Considering how limited the scientific researches of sharks were conducted in this region, it is unlikely that management and conservation measures for their declining populations could be successful without information to properly conduct stock assessment. Currently there are still many researches area of these groups to filled in including taxonomy, the most fundamental basis of life sciences, as suggested by the unexpected discoveries of two undescribed species in the landings. The biological information of recorded shark species provided in this thesis is intended to add some biological information of sharks in this region to a certain extent, however there are still a considerably large knowledge gap yet to be filled to provide a sufficient scientific basis for developing effective management measures, such as life history information to conduct some fisheries management techniques *e.g.* stock assessment or demographic model or identification of nursery ground to establish protection of critical habitats.

As sharks are increasingly targeted by the commercial “biomass” fisheries, while also being considered as only “bycatch” by the key management authority, a shift in perspective and strong resolution is required from involving parties to tackle this doom and gloom situation. Regular and detailed monitoring program could greatly address the currently missing information gaps. Stronger regulations to control the intensive rate of exploitation from non-selective gears should reduce the fishing pressure on their populations. Protections of critical habitats would also help the stocks to gradually replenish. However, for all of these management measures to happen, sharks cannot be treated as “only” bycatch any longer by the authorities but must be regarded as a group of conservation concerns with high risk of extinction. In order to succeed, a considerable effort is needed to address many existing challenges, which require supports and collaborations from various involving parties in the Andaman Sea region, in the hope that sustainable management of shark fisheries in this water could be archived before it is too late.

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APPENDICES

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Catch composition and aspects of the biology of sharks caught by Thai commercial fisheries in the Andaman Sea

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Catch composition, landing patterns and biological aspects of sharks caught by commercial fishing fleet operating in the Andaman Sea were recorded from landing sites in Ranong province of Thailand over a period of 1 year. Of the 64 species previously reported in the existing Thailand checklist, only 17 species were recorded in this study. Shark landings from the Andaman Sea appear now to be dominated largely by bamboo sharks *Chiloscyllium* spp. (Hemiscylliidae), which contribute *c*. 65% of the total number of sharks recorded. The carcharhinid sharks comprised *c*. 30·5% to the total catch, while the remaining *c*. 4·5% of landings comprised sharks from the families Squalidae, Stegostomatidae, Sphyrnidae and Triakidae. The catch composition is remarkably different from the previous landing survey in 2004, in that the current study found noticeable declines in landings of slow-growing, late-maturing and low-fecundity species (especially sphyrnid and carcharhinid species). The absences of many species and changes in life-stage composition suggest that the populations of these groups may be close to collapse. The results from this study emphasize the urgency for additional research and monitoring efforts and also the need for management incentives in order to manage shark fisheries effectively in the Andaman Sea.

Key words: Carcharhinidae; Hemiscylliidae; population collapse; South-east Asia; species composition.

INTRODUCTION

The global decline of sharks from the world's oceans has been recognized as of significant global environmental concern (Stevens *et al.,* 2000, 2005; Blaber *et al.,* 2009). Over the past two decades, a number of scientific studies have shown that numerous shark populations have suffered massive declines around the world (Myers & Worm, 2005; Ferretti *et al.,* 2008; Ferretti *et al.,* 2010). The severity of the decline and the magnitude of the conservation problem for this group of apex predators has become a key topic of discussion in major international forums, such as Convention on International Trade in Endangered Species (CITES) and World Conservation Congress (WCC) and has spurred the development of an international plan of action for sharks by the Food and Agriculture Organization (FAO). The most significant threatening process

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is overexploitation from both targeted and non-targeted fisheries (Dulvy & Forrest, 2010). Despite varied life-history parameters amongst the more than 500 known species of sharks (Weigmann, 2016, 2017), they typically have slow life-history characteristics such as long natural lives, late maturity and low numbers of offspring (Hoenig & Gruber, 1990; Camhi *et al.,* 1998; Stevens *et al.,* 2000; Prince, 2005). As a result, populations of sharks (and rays) can sustain only modest fishing effort prior to stock collapse and population recovery after such events can take decades (Musick, 2004). Stock collapses and the local extinction of several shark species have been documented in various locations worldwide, where the stocks have not recovered nor returned even after several decades (Dulvy *et al.,* 2009; Dulvy & Forrest, 2010).

To understand global trends in shark catches, it is important to obtain regional level information. Such information is readily available in developed nations, but tends to be either difficult to obtain or is unavailable in many developing nations where shark catches can be much greater. Thailand was listed as the world's 12th largest shark fishing nation in 2012, with an average of 20 479 t of chondrichthyan landings reported annually to FAO between 2000 and 2009 (Fischer *et al.,* 2012) and has also become the leading exporter of shark fins in globally (Dent & Clarke, 2015). Despite this, sharks are not considered as target species in Thai fisheries and catches by both commercial and artisanal fisheries reportedly contribute only *c*. 0·5% of the total marine fishery production of the nation (Krajangdara, 2014). Shark numbers have been in severe decline in Thailand ever since the introduction of commercial trawling in the 1960's (Pauly & Chuenpagdee, 2003). In fact, Thailand has recently been listed amongst the countries recording the greatest declines in shark landings (Davidson *et al.,* 2016). Total shark landings from commercial fisheries have declined catastrophically in the past decade, particularly the landings from the Andaman Sea, which experienced a reported *c*. 96% decline of landed biomass (*i.e*. 3836 t in 2005 to 157 t in 2014: DoF, 2007, 2016).

Surveys at various landing sites along the Andaman coast of Thailand since 2012 and information from local fishers in this area suggest that shark landings have undergone noticeable declines in terms of both species diversity and abundance. This raises grave concerns about the sustainability of the fisheries and the population status of numerous shark species in the Andaman Sea area of Thailand. Unfortunately, there have been very few studies of shark landings in Thai fisheries and information is scant, hindering development of fishery management options. Currently, the official fishery data aggregates all sharks into a single category, with no species-level differentiation. The most recent published study on species composition of sharks in Thai commercial fisheries from the Andaman Sea was by Krajangdara (2005), *i.e*. prior to the substantial declines reported over the past decade. This study provides updated and detailed information on the species, size and sex composition of sharks caught from the Andaman Sea in Thai commercial fisheries. Changes in landing characteristics are also examined by comparison with shark landing data in 2004 from the previous surveys by Krajangdara (2005). Moreover, potential consequences of the changes in shark populations as fisheries continue to exploit stocks are discussed.

MATERIALS AND METHODS

Landing-site surveys were conducted on 17 occasions between December 2014 and April 2015 in Ranong Province of Thailand from two major landing locations, the fishing port operated by the Fish Marketing Organization (9° 56′ 50·1″ N; 98° 35′ 40·3″ E) and privately owned fishing ports (9° 57′ 14·8″ N; 98° 36′ 13·5″ E) that are located along the border of Thailand and Myanmar.

Since sharks are landed whole at these two landing sites, individual sharks could be identified accurately to species level in the field using the keys from White *et al.* (2006) and Last *et al.* (2010). The number of individuals of each shark species was recorded and estimated in one instance. However, owing to the large amount of landings and time constraints encountered during each visit, measurements and biological data could only be collected from a subset of individuals. Where possible, total length (L_T) was measured from the tip of the snout to the tip of the upper lobe of the caudal fin, using a tape measure to the nearest 1 mm, as described by Carpenter & Niem (1998), and total mass (M_T) was measured to the nearest 100 g using approved weighing scales provided at the two landing sites. When large numbers of similar-sized individuals were observed, measurements were taken from a sub-set of individuals randomly picked and used to estimate L_T and M_T for the remaining individuals not measured. In the case of very large sharks, M_T could not be obtained with the available scales in the fish market and thus an estimated mass was recorded based on estimation by the pier owners or shark traders during the auction process.

Where possible, the sex of each individual and, in the case of males, their maturity stage was also recorded. Maturity stage for males was based on the extent of calcification of their claspers based on the criteria described by White (2007), *i.e.* non-calcified (juvenile), partially calcified (adolescent) or fully calcified (adult). Owing to strict limitations in accessing specimens at the landing site, female reproductive data was not recorded. The exception being visibly pregnant females, with a bulging abdomen, or individuals with mating scars, which can be observed without dissection. Individuals with visible umbilical scars were considered as neonate, since the umbilical scars can rapidly disappear in as little as a month, as has been reported for the blacktip reef shark *Carcharhinus melanopterus* (Quoy & Gaimard 1824) (Chin *et al.,* 2015).

Species composition of the landing was expressed as percentage of contribution to the total number of individuals by the recorded number and biomass for each species observed at the landing sites. Minimum and maximum L_T (mm) and M_T (kg) are reported for each species. Size frequency histograms for the most abundant species were produced. Sex ratios were determined for each species and were tested to determine if they vary from parity significantly using the χ^2 goodness-of-fit test described by Zar (1984).

RESULTS

In total, 2123 sharks (1993 counted and 130 estimated) with a total biomass of 6205 kg were recorded. These consisted of 17 species belonging to six families (Squalidae, Hemiscylliidae, Stegostomatidae, Triakidae, Carcharhinidae and Sphyrnidae). By number, the most abundant sharks recorded during the surveys were from the family Hemiscylliidae, *i.e.* 65% of the total landings, followed by sharks from the family Carcharhinidae, *i.e.* 30·5% of the total landings (Fig. 1). By biomass, the landings were dominated by the family Carcharhinidae, *i.e. c.* 71% of the total landings, followed by the family Hemiscylliidae, *i.e.* 27% of the total landings (Fig. 1). The remaining percentages by number and biomass, 4·5 and *c.* 2% respectively, comprise the single species from the families Squalidae, Sphyrnidae, Stegostomatidae and Triakidae.

FAMILY SQUALIDAE

Only one species of squaliform shark was recorded in the landings, the Indonesian shortnose spurdog *Squalus hemipinnis* White, Last & Yearsley 2007. This represents a new record of this species in Thai waters which was also confirmed using

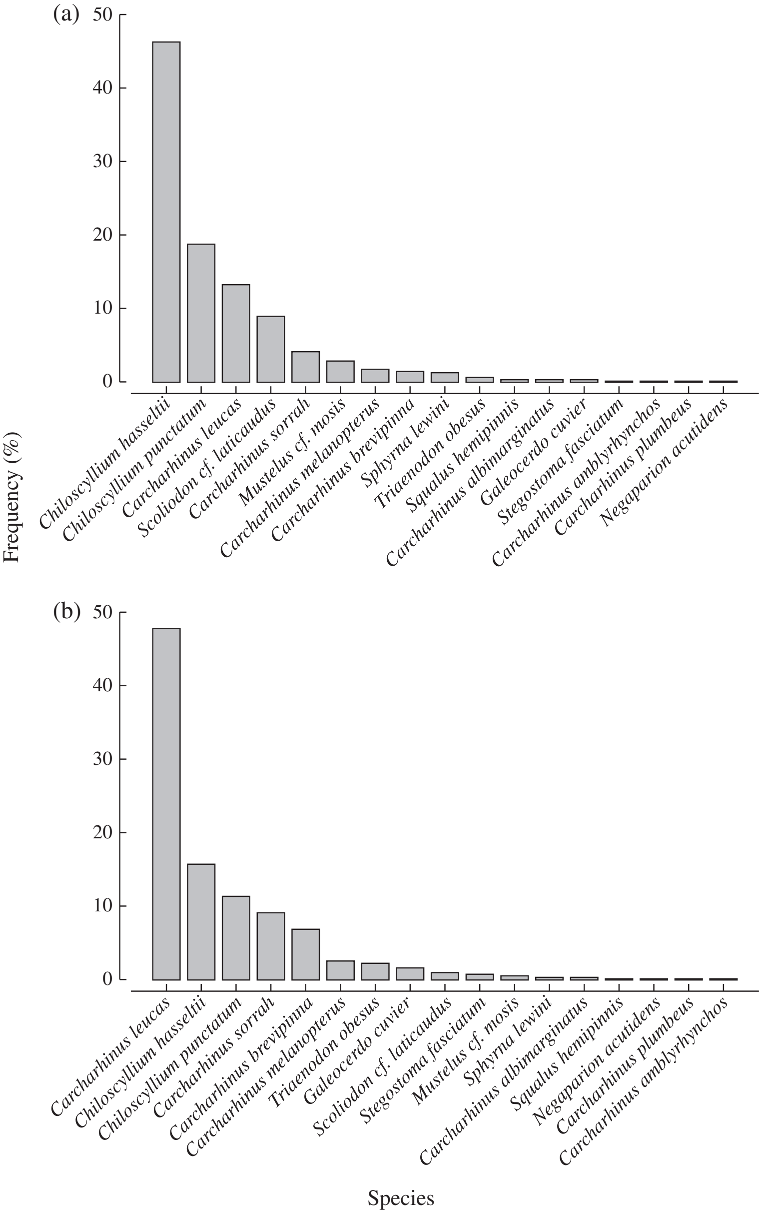

FIG. 1. Frequency distribution by (a) number and (b) mass of 17 shark species recorded during the landing-site surveys in Ranong, Thailand, December 2014–April 2015.

nicotinamide adenine dinucleotide (NADH)2 sequences (G. Naylor, unpubl. data). This species belongs to the *megalops* group within the genus *Squalus* L. 1758, which are characterized by short snouts and a white posterior margin on the caudal fin. It is likely that previous records of the shortnose spurdog *Squalus megalops* (Macleay 1881) from Thai waters relates to this species. Only six individuals, with an average mass of 0·7 kg, were recorded during the surveys.

FAMILY HEMISCYLLIIDAE

Two species of bamboo sharks (Hemiscylliidae) were recorded, the Indonesian bamboo shark *Chiloscyllium hasseltii* Bleeker 1852 and the brown-banded bamboo shark *Chiloscyllium punctatum* Müller & Henle 1838. These two species dominated the landings by number (46·3 and 18·8% respectively) and also contributed greatly to the total biomass of the landings (15·7 and 11·3% respectively). White (2009) noted that *C. hasseltii* is very similar morphologically to the grey bamboo shark *Chiloscyllium griseum* Müller & Henle 1838, which is also considered to occur in Thai waters (Weigmann, 2012; Ebert *et al.,* 2013). Thus, it should be considered that the *C. hasseltii* individuals recorded in this study may have contained some individuals of *C. griseum*. A sub-sample of eight individuals identified as *C. hasseltii–griseum* were sent off for sequencing of the NADH2 marker and were all confirmed as *C. hasseltii* (G. Naylor, unpubl. data). Therefore, for this study, all specimens of *C. hasseltii–griseum* were considered to be *C. hasseltii*, but a more detailed investigation is required in the future to determine if both these species are present in the catches being landed at Ranong.

FAMILY STEGOSTOMATIDAE

Three individuals of the zebra shark *Stegostoma fasciatum* (Hermann 1783) were recorded, with a total mass of 45 kg (Table I).

FAMILY TRIAKIDAE

A single triakid species was represented in the landings, the Bengal smoothhound *Mustelus cf. mosis*. This species closely resembles the Arabian smoothhound *Mustelus mosis* Hemprich & Ehrenberg 1899, but differences in the sequences of the NADH2 marker suggest it may not be conspecific (G. Naylor, unpubl. data). A total of 60 individuals with a total biomass of 31·5 kg were recorded (Table I).

FAMILY CARCHARHINIDAE

Carcharhinid sharks were represented by 11 species from five genera (Table I) with the most abundant species being the bull shark *Carcharhinus leucas* (Valenciennes 1839) which contributed *c*. 13% to the total number and *c*. 48% to the total biomass of sharks (Table I and Fig. 1). By number, the next most abundant species was the Bengal spadenose shark *Scoliodon cf. laticaudus* which contributed *c*. 9% to the total number but only *c*. 1% by mass due to its small size (Table I and Fig. 1). This species of spadenose shark is currently under taxonomic revision (S.A. and W.W.) and probably represents a third species as suggested by White *et al.* (2010). By mass, the second most abundant species was the spottail shark *Carcharhinus sorrah* (Valenciennes 1839) which contributed *c*. 9% to the total biomass and *c*. 4% to the total number of sharks (Table I and Fig. 1).

Carcharhinus melanopterus and the spinner shark *Carcharhinus brevipinna* (Valenciennes 1839) were represented in the landings by 35 and 30 individuals, respectively. The remaining species were represented by less than 12 individuals (Table I).

TABLE I. The abundance, biomass, minimum and maximum total length (L_T) of recorded shark species at the landing sites in Ranong, Thailand, December 2014–April 2015

		Abundance		Biomass		L_T (mm)	
Scientific name	Common name	*n*	%	kg	%	Min.	Max.
Squalidae							
Squalus hemipinnis	Indonesian shortnose spurdog	6	0·3	4·4	0.1	517	627
Hemiscylliidae							
Chiloscyllium hasseltii	Indonesian bamboo shark	982	46·3	974·3	15·7	335	900
Chiloscyllium punctatum	Brownbanded bamboo shark	399	18·8	700·3	11·3	427	947
Subtotal		1381	65·1	1674·6	27		
Stegostomatidae							
Stegostoma fasciatum	Zebra shark	3	0.1	45	0·7	1040	2040
Triakidae							
Mustelus cf. mosis	Bengal smoothhound	60	2·8	31·5	0.5	376	717
Carcharhinidae							
Carcharhinus albimarginatus	Silvertip shark	6	0·3	18	0·3	750	986
Carcharhinus amblyrhynchos	Grey reef shark	1	0.1	2·7	0	794	794
Carcharhinus brevipinna	Spinner shark	30	1·4	420·8	6·8	828	2912
Carcharhinus leucas	Bull shark	280	13·2	2966·1	47·8	559	3000
Carcharhinus melanopterus	Blacktip reef shark	35	1·7	154·4	2·5	585	1543
Carcharhinus plumbeus	Sandbar shark	1	0.1	2.1	0	735	735
Carcharhinus sorrah	Spottail shark	87	4.1	567·2	9·1	600	1629
Galeocerdo cuvier	Tiger shark	6	0·3	101·9	1·6	959	2265
Negaprion acutidens	Sicklefin lemon shark	1	0.1	4·7	0.1	896	896
Scoliodon cf. laticaudus	Bengal spadenose shark	188	8·9	56·2	0·9	278	563
Triaenodon obesus	Whitetip reef shark	12	0·6	133·6	2·2	669	1579
Subtotal		647	30·8	4427·7	71·3		
Sphyrnidae							
Sphyrna lewini	Scalloped hammerhead	26	1·2	21·4	0·3	417	1026
Total, all sharks		2123	100	6024·6	100		

FAMILY SPHYRNIDAE

The single hammerhead species recorded was the scalloped hammerhead *Sphyrna lewini* (Griffith & Smith 1834) which was represented by only 26 individuals weighing a total of *c*. 21 kg.

SIZE AND SEX COMPOSITION

SQUALUS HEMIPINNIS

The six individuals of *S. hemipinnis* were females ranging from 517 to 627 mm L_T. White & Dharmadi (2010) reported on pregnant females at 600–735 mm L_T, thus the specimens recorded from Ranong probably consisted of both adolescent and adult individuals.

CHILOSCYLLIUM HASSELTII

The 982 individuals of *C. hasseltii* comprised 182 females (355–878 L_T), 238 males (363–900 L_T) and 562 unsexed individuals (*c*. 400–800 mm L_T; Fig. 2). The ratio of the sexed individuals differed significantly from parity (χ^2-test, $P < 0{\cdot}05$), with significantly more males than females. L_T was measured or estimated for all but two females and four males. The majority of individuals recorded were in the 600–699 mm L_T classes, contributing *c*. 72% to the total number of individuals with measured or estimate sizes.

CHILOSCYLLIUM PUNCTATUM

A total of 399 *C. punctatum* were recorded at landing sites, comprising 61 females (472–900 mm L_T), 37 males (427–947 mm L_T) and 301 unsexed individuals (*c*. 300–850 mm L_T; Fig. 2). The landings of *C. punctatum* contained significantly more females than male individuals (χ^2-test, $P < 0{\cdot}05$). The majority of individuals recorded were in the 700–899 mm L_T classes.

STEGOSTOMA FASCIATUM

A total of 3 *S. fasciatum* were recorded, comprising a single female (2040 mm L_T), a single juvenile male (1040 mm L_T) and 1 unsexed individual.

MUSTELUS CF. MOSIS

Sixty *Mustelus cf. mosis* were recorded, comprising 32 females (376–621 mm L_T) and 28 males (412–717 mm L_T). The sex ratio of the landings did not differ significantly from parity (χ^2-test, $P < 0{\cdot}05$). The majority of individuals recorded were in the 420–579 mm L_T classes, below the size at maturity for this species. All males possessed non-calcified claspers, thus had not reached sexual maturity.

CARCHARHINUS ALBIMARGINATUS

Six juvenile *Carcharhinus albimarginatus* (Rüppell 1837) were recorded in the landings, comprising two females (750 and 986 mm L_T) and 4 males (750–929 mm L_T). All males were immature, possessing non-calcified claspers.

CARCHARHINUS AMBLYRHYNCHOS

A single neonate female *Carcharhinus amblyrhynchos* (Bleeker 1856) of 794 mm L_T was recorded in the landings. This individual possessed a visible umbilical scar, suggesting recent birth.

CARCHARHINUS BREVIPINNA

A total of 30 *C. brevipinna* were recorded, comprising 14 females (828 to 2912 mm L_T), 2 males (750 and 1062 mm L_T) and 14 unsexed individuals (all *c*. 950 mm L_T). The majority of *C. brevipinna* recorded were young of the year individuals (<1000 mm L_T; Fig. 3). Only two mature, non-pregnant females were recorded in December 2014, 2690 and 2912 mm L_T. All males were immature, possessing non-calcified claspers.

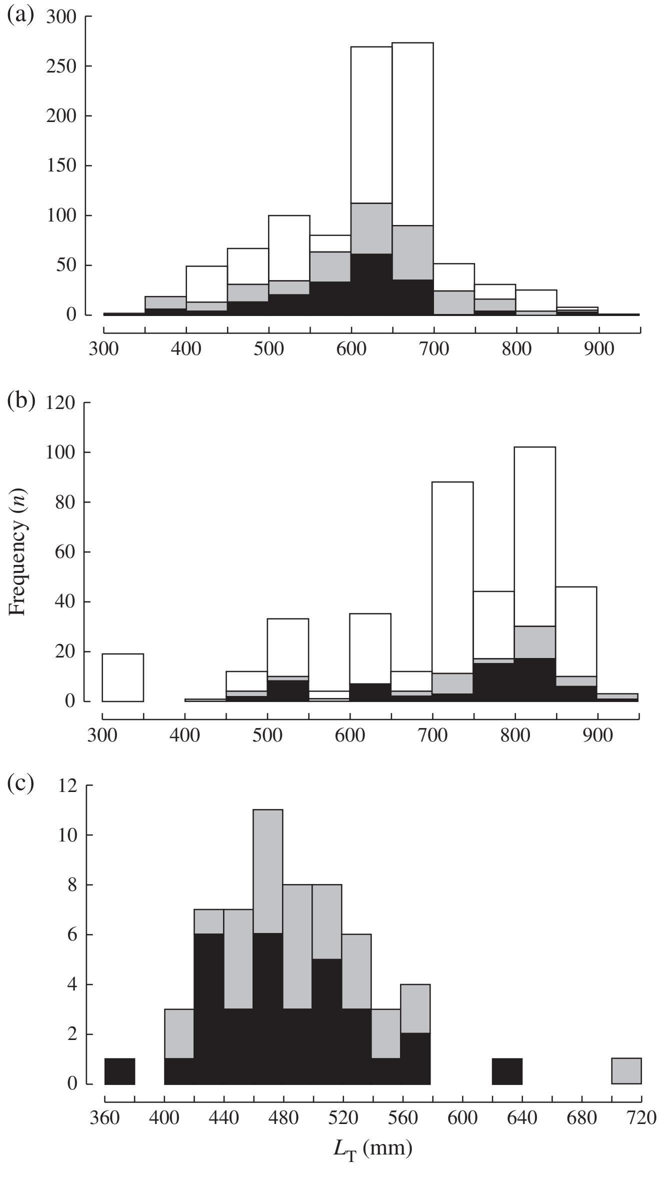

FIG. 2. Total length (L_T) frequency histograms for females, males and unsexed individuals for (a) the combined group of *Chiloscyllium griseum* plus *C. hasseltii*, (b) *Chiloscyllium punctatum* and (c) *Mustelus cf. mosis* recorded during the landing-site surveys in Ranong, Thailand, December 2014–April 2015. (■) Females, (▨) Males, and (□) Unsexed.

CARCHARHINUS LEUCAS

A total of 280 *C. leucas* were recorded, comprising 58 females (707–3000 mm L_T), 76 males (559–2842 mm L_T) and 146 unsexed individuals (*c.* 700–2500 mm L_T; Fig. 3). The sex ratio did not significantly differ from parity (χ^2-test, $P > 0{\cdot}05$). The landings of *C. leucas* were dominated by neonates in the 700–899 mm L_T classes,

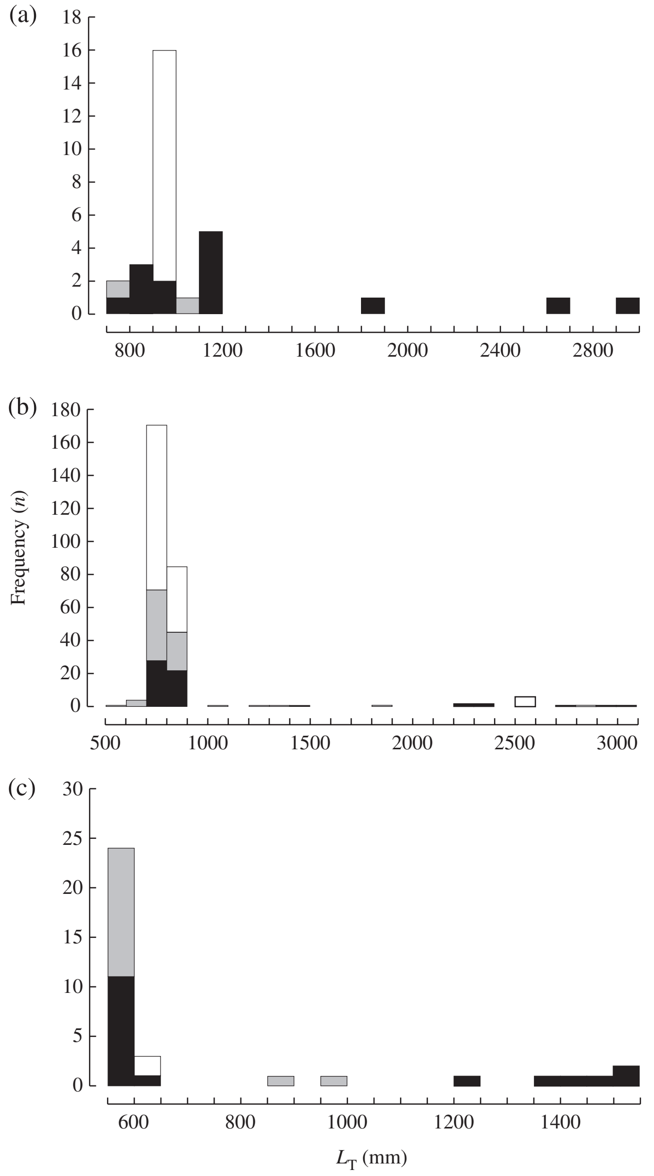

FIG. 3. Total length (L_T) frequency histograms for females, males and unsexed individuals for (a) *Carcharhinus brevipinna*, (b) *Carcharhinus leucas* and (c) *Carcharhinus melanopterus* recorded during the landing-site surveys in Ranong, Thailand, December 2014–April 2015. (■) Females, (▨) Males, and (□) Unsexed.

contributing *c*. 93% to the total number of individuals recorded. A total of 119 of these neonates possessed visible umbilical scars, indicating their recent birth. The neonates were found throughout December 2014 to April 2015, suggesting that parturition was possibly occurring throughout this period, thus may not be synchronous. In December 2014 and January 2015, two mature females with external signs of pregnancy were recorded (*c*. 2300 and 2760 mm L_T), but dissection of these specimens was not permitted. A single mature male with fully calcified claspers was recorded in December 2014, with an L_T of 2842 mm.

CARCHARHINUS MELANOPTERUS

Thirty-five *C. melanopterus* were recorded, comprising 18 females (585–1543 mm L_T), 15 males (594–964 mm L_T) and two unsexed individuals (both *c*. 620 mm L_T (Fig. 3). The sex ratio did not differ significantly from parity (χ^2-test, $P > 0.05$). The majority of the *C. melanopterus* recorded were neonates with $L_T < 600$ mm, which contributed *c*. 69% to the total landings. In total, 25 of these neonates were recorded as having visible umbilical scars. All males were immature, possessing non-calcified claspers.

CARCHARHINUS PLUMBEUS

A single juvenile male *Carcharhinus plumbeus* (Nardo 1827) was recorded in April 2015 with an L_T of 735 mm. The individual did not have a visible umbilical scar, but is close to the known size at birth for this species.

CARCHARHINUS SORRAH

A total of 87 *C. sorrah* were recorded, comprising 31 females (951–1629 L_T), 42 males (600–1252 mm L_T) and 14 unsexed individuals (est. 950–1080 mm L_T). There was no significant difference from parity in sex ratio (χ^2-test, $P > 0.05$). The majority of *C. sorrah* individuals were in the 950–1099 mm L_T classes, just below the known size at maturity for this species (Fig. 4). All males <1111 mm L_T possessed non-calcified or partially-calcified claspers and a single male of 1252 mm L_T possessed fully calcified claspers. Although dissection of large females was not permitted, two pregnant females (1616 and 1629 mm L_T) were apparent in the landings in April 2015. Also in April 2015, two neonates (600 and 649 mm L_T) with fresh umbilical scars were recorded, indicating parturition possibly occurs at this time in these waters.

GALEOCERDO CUVIER

A total of 6 individuals of *Galeocerdo cuvier* (Péron & LeSueur 1822), comprising five females (959–1344 mm L_T) and a single male (2265 mm L_T) were recorded at the landing sites. The male was adolescent, possessing partially calcified claspers.

NEGAPRION ACUTIDENS

A single juvenile male *Negaprion acutidens* (Rüppell 1837) (896 mm L_T) was recorded in April 2015.

SCOLIODON CF. LATICAUDUS

A total of 188 individuals of *S. cf. laticaudus* were recorded at the landing sites, comprising 60 females (360–563 mm L_T), 28 males (353–449 mm L_T) and 100 unsexed

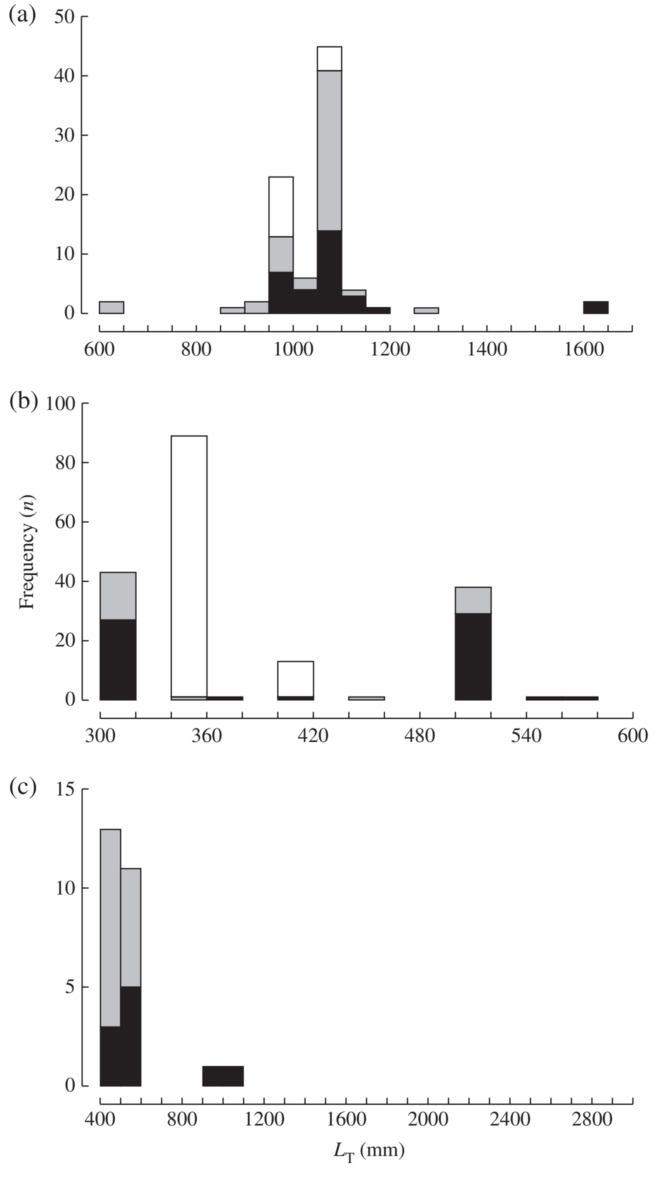

FIG. 4. Total length (L_T) frequency histograms for females, males and unsexed individuals for (a) *Carcharhinus sorrah*, (b) *Scoliodon cf. laticaudus* and (c) *Sphyrna lewini* recorded during the landing-site surveys in Ranong, Thailand, December 2014–April 2015. (■) Females, (▨) Males, and (□) Unsexed.

individuals 340–400 mm L_T; Fig. 4). The sex ratio differed from parity with significantly more females than male individuals (χ^2-test, $P < 0{\cdot}05$). The majority of individuals were in the 300–319 and 340–359 mm L_T classes, however most of these were estimated sizes due to the deteriorated condition of the catches. All males >449 mm L_T possessed fully calcified claspers, while the individuals with the size of ~300 mm L_T possessed non-calcified claspers.

TRIAENODON OBESUS

A total of 12 individuals of *Triaenodon obesus* (Rüppell 1837), comprising four females (919–1579 mm L_T) and eight males (669–1499 mm L_T) were recorded. All males >1212 mm L_T were mature, possessing fully calcified claspers, with three males <1004 mm L_T possessed non-calcified claspers. Two neonates of 600 and 649 mm L_T recorded in April 2015 had fresh umbilical scars, suggesting parturition in this species is possibly occurring around this time in these waters. Two females recorded in April 2015 (1485 and 1579 mm L_T) had visible mating scars on their pectoral fins, indicating a recent copulation event.

SPHYRNA LEWINI

A total of 26 individuals of *S. lewini*, comprising 10 females (472–1027 mm L_T) and 16 males (417–549 mm L_T) were recorded. All but two individuals recorded were neonates in the 400–599 mm L_T classes (Fig. 4). All neonates were recorded in April 2015 and had visible umbilical scars, indicating their recent birth.

DISCUSSION

In this survey, 2123 sharks were recorded comprising 17 species from six families. The diversity of species recorded in this study was considerably lower than recorded by Krajangdara (2005) (Table II). This finding concurs with reports from fishers on declines of large sharks from the Thai coast. Of 41 shark species from 11 families by Krajangdara (2005) from two major landing sites along the Andaman coast of Thailand in 2004. Approximately half of sharks from the family Carcharhinidae recorded by Krajangdara (2005) were present in this study, while sharks from the family Alopiidae and Hemigaleidae were absent in our survey, despite previously being reported as fairly common in Thailand (Krajangdara, 2005) (Table II).

This study provides the first genetically-confirmed record of *S. hemipinnis*, previously only known from a narrow range in eastern Indonesia (White *et al.*, 2007). Previous records of *S. megalops* from Thailand are probably attributable to this species. Both *M. cf. mosis* and *S. cf. laticaudus* recorded in this study differ from the phenotypes described from the type localities of these species and may represent distinct races or subspecies endemic to the Andaman Sea region. Taxonomic investigation of these two species is currently underway.

Prior this study, Krajangdara (2005) and Deechum (2009) conducted similar studies on the species composition of sharks at fishing ports along the Andaman coast of Thailand. Krajangdara (2005) surveyed landing sites in Phuket and Ranong provinces, which are the major landing sites of elasmobranchs by commercial fishing fleets in Thailand, providing a more direct temporal comparison with the current study, whereas Deechum (2009) concentrated on the catch of artisanal fishers. The key finding when comparing across the studies is that landings are becoming noticeably scarcer over the past decade or more, especially for the larger shark species. This study recorded fewer species than Krajangdara (2005), possibly because the Phuket landings source product from an extremely wide area. It is possible however, that the differences are attributable to overexploitation resulting in decreased species richness. The change in

TABLE II. The species of sharks recorded at Andaman landing sites by Krajangdara (2005) with contribution by number (*n*) and percentage, annotation of presence in December 2014–April 2015 survey and note on taxonomic uncertainties

Scientific name	Common name	Number *n*	Number %	Present in this study	Taxonomic uncertainties
Hemiscylliidae					
Chiloscyllium griseum	Grey bamboo shark	1530	9·03	√	Confusion with *C. hasselti*
Chiloscyllium hasseltii	Indonesian bamboo shark	620	3·66	√	Confusion with *C. griseum*
Chiloscyllium indicum	Slender bamboo shark	60	0·35		
Chiloscyllium punctatum	Brownbanded bamboo shark	2152	12·7		
Ginglymostomatidae					
Nebrius ferrugineus	Tawny nurse shark	81	0·48		
Stegostomatidae					
Stegostoma fasciatum	Zebra shark	30	0·18	√	
Rhincodontidae					
Rhincodon typus	Whale shark	4	0.02		
Alopiidae					
Alopias superciliosus	Bigeye thresher shark	8	0·05		
Alopias vulpinus	Thresher shark	2	0.01		Possibly *Alopias pelagicus*
Lamnidae					
Isurus oxyrinchus	Shortfin mako shark	1	0.01		
Scyliorhinidae					
Atelomycterus marmoratus	Marbled cat shark	10	0·06		
Halaelurus buergeri	Brown spotted cat shark	157	0·93		
Hemigaleidae					
Chaenogaleus macrostoma	Hooktooth shark	1391	8·21		
Hemigaleus microstoma	Sicklefin weasel shark	524	3·09		
Hemipristis elongata	Fossil shark	103	0·61		
Paragaleus tengi	Straight-tooth weasel shark	694	4·10		Possibly *P. randalli*
Triakidae					
Mustelus sp.B	White-spotted hound shark	5	0·03		Currently listed as *M. cf. stevensi*
Carcharhinidae					
Carcharhinus albimarginatus	Silvertip shark	113	0·67	√	
Carcharhinus altimus	Bignose shark	1	0.01		
Carcharhinus amblyrhynchos	Grey reef shark	19	0.11	√	
Carcharhinus amblyrhynchoides	Graceful shark	18	0.11		
Carcharhinus amboinensis	Pigeye shark	33	0·19		
Carcharhinus brachyurus	Copper shark	14	0·08		Possibly *C. obscurus*

Table II. Continued

Scientific name	Common name	Number *n*	Number %	Present in this study	Taxonomic uncertainties
Carcharhinus brevipinna	Spinner shark	7	0·04	√	
Carcharhinus dussumieri	Whitecheek shark	78	0·46		Possibly *C. tjutjot*
Carcharhinus leucas	Bull shark	37	0·22	√	
Carcharhinus limbatus	Blacktip shark	521	3·08		
Carcharhinus longimanus	Oceanic whitetip shark	13	0·08		
Carcharhinus melanopterus	Blacktip reef shark	318	1·88	√	
Carcharhinus obscurus	Dusky shark	121	0·71		
Carcharhinus plumbeus	Sandbar shark	33	0·19	√	
Carcharhinus sealei	Blackspot shark	2	0.01		
Carcharhinus sorrah	Spottail shark	1497	8·84	√	
Galeocerdo cuvier	Tiger shark	158	0·93	√	
Negaprion acutidens	Sicklefin lemon shark	20	0·12	√	
Scoliodon laticaudus	Spadenose shark	2322	13·7	√	Most likely *S. cf. laticaudus*
Rhizoprionodon acutus	Milk shark	98	0·58		
Rhizoprionodon oligolinx	Grey sharpnose shark	628	3·71		
Triaenodon obesus	Whitetip reef shark	118	0·70	√	
Sphyrnidae					
Sphyrna lewini	Scalloped hammerhead	3397	20·1	√	
Sphyrna mokarran	Great hammerhead	4	0.02		
Total		2123	100		

assemblage composition described here are consistent with other elasmobranchs fisheries under exploitation, where the larger species decline and are gradually fished out, while smaller and more fecund species proliferate (van der Elst, 1979; Stevens *et al.,* 2000). Accompanying the large declines in landings throughout the past two decades, a change in species composition is evident and corresponds to anecdotal data from fishermen. The landings reveal a noticeable shift in terms of species composition in comparison with Krajangdara (2005), with declines of large species and increasing predominance of smaller species (independent of variation in gear types over the years). In a broader sense, with the exception of the sharks from the family Hemiscylliidae and Triakidae, all shark families recorded in 2004 have experienced some degree of decline in landed biomass or are absent from the landings. The group with the most striking shift in landed biomass between 2004 and 2014–2015 is the bamboo sharks from the family Hemiscylliidae. Thesee species (mainly *C. hasseltii*) previously contributed *c.* 26% to the total landings (Krajangdara, 2005), but had increased in terms of relative abundance to *c*. 65% in in 2016, in terms of the total number of sharks recorded. The recent predominance of the hemiscylliids may be due to their relatively high fecundity, giving these small sharks the resilience to withstand fishing pressure better than other groups, although it is also likely to be affected by a shift in gear types or fishing locations by the fishing fleets to a certain degree. Since sharks are considered as by-catch, there are limited fisheries data available with the exception of landing biomass, thus the shift in assemblage observed in this study may not be able to be explained accurately at this point and should be investigated further in future studies.

Perhaps the most notable group of concern is the *Sphyrna* spp. from the family Sphyrnidae, which experienced drastic declines, declining from *c*. 20% in 2004 (Krajangdara, 2005) to only *c*. 1% of total shark landings in this study. *Sphyrna lewini* was the most abundant species in the Krajangdara (2005) study, but negligible in recent surveys. This finding corresponds with the marked declines of this endangered species reported throughout its range (Baum *et al.,* 2007).

The family Carcharhinidae experienced only slight landing declines, as a group, from *c*. 36% in 2004 (Krajangdara, 2005) to *c*. 30·5% in this study, but there was a strong change in the distribution of species of carcharhinids. With the exception of *C. brevipinna* and *C. leucas*, carcharhinid species either declined in abundance or were absent from the landings. The contribution of *C. leucas* to the total landings increased from 0·2% (Krajangdara, 2005) to *c*. 13% in this study, contributing nearly half of the total landed biomass of all sharks. As with the hemiscylliids, it is likely that increased fishing pressure on inshore and estuarine areas utilized as parturition grounds and nursery areas (Simpfendorfer & Burgess, 2009) has resulted in greatly increased catches of *C. leucas,* since the majority of the landings are now comprised of neonates (year round).

The greater proportion of the landings were immature sharks, while the adults of most species are present in low numbers or are totally absent from the landings especially for the families Carcharhinidae and Sphyrnidae. Since the recruitment of shark populations is closely related to the number of adults available (Camhi *et al.,* 1998), the current rate of exploitation is inimical to replenishment and most likely unsustainable. In addition, the high proportion of juveniles and neonates in the landings indicates exploitation of nursery areas for most shark species recorded. Coastal sharks are especially vulnerable to loss of critical nursery habitat and exploitation in nursery areas, although the greatest reductions in landed biomass and diversity occurred amongst pelagic species.

The findings of this study are similar to that previously reported in another study of shark fisheries in the South-east Asia region, with dominance of small species, large numbers of immature individuals and low occurrence of large sharks in the landings (Lam & Sadovy de Mitcheson, 2011). Although the data obtained through this study cannot accurately assess the population of sharks in Thai waters, it suggests that the stocks of many shark species in the Andaman Sea have probably been under high fishing pressure from the Thai commercial fishing fleets. Local fishermen no longer catch the larger shark species; buyers report that sharks are sourced from ever-more-distant fishing grounds. The key problem for fisheries management in this data-poor yet heavily exploited region is that sharks are regarded as by-catch by the management authority, which diminishes their power to act to conserve shark stocks. The loss of more than 60% of diversity from shark landings in little more than a decade, with massive shifts in the composition of the catch suggest that Andaman Thai shark populations may be perilously close to collapse.

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SHARKS: PREDATORS IN PERIL
NATIONAL GEOGRAPHIC (THAI EDITION)

เมื่อ นักล่า

สิ้นลาย

ครีบหรือ “หู” ของฉลามหูดำและส่วนร่างกายที่หายไปนี้ คือตัวแทนของฉลามมากมายที่กำลังถูกคุกคามจนจำนวนลดลงมาก คาดว่าบางชนิดประชากรอาจลดลงมากกว่าร้อยละ 90 ภัยคุกคามหลักมาจากการทำประมง ปัจจุบัน ฉลามอยู่ในกลุ่มสัตว์มีกระดูกสันหลังที่เสี่ยงต่อการสูญพันธุ์มากที่สุดกลุ่มหนึ่งในโลก

นักท่องเที่ยวถ่ายรูปคู่กับภาพฉลามขาวยักษ์ที่ภูเก็ตทริกอายมิวเซียม พิพิธภัณฑ์ภาพวาดสามมิติในจังหวัดภูเก็ต แม้ทุกวันนี้ความรู้ความเข้าใจเกี่ยวกับฉลามจะดีขึ้นมาก แต่ภาพลักษณ์อันน่าพรั่นพรึงของฉลามจากภาพยนตร์และสื่อกระแสหลักยังคงมีอิทธิพลต่อสังคมไม่เสื่อมคลาย

เรื่องและภาพถ่าย
ศิรชัย อรุณรักษ์ติชัย

[เผชิญหน้า]

สัมผัสจากน้ำเย็นเยียบบนใบหน้าในเวลาเช้ามืด ปลุกผมให้หายง่วงงุนเป็นปลิดทิ้ง ผมว่ายน้ำออกไปจากชายฝั่งอ่าวเทียนออก ซึ่งตั้งอยู่ทางทิศตะวันออกของเกาะเต่า จังหวัดสุราษฎร์ธานี ผ่านแนวซากปะการังผุพังจนมาถึงกลางอ่าว และเริ่มเฝ้ารออยู่กลางท้องน้ำเยียบเย็น อ่าวแห่งนี้เคยอุดมไปด้วยแนวปะการังเขากวางที่สมบูรณ์และเป็นแหล่งอาศัยของสัตว์น้ำหลากหลายชนิด ทว่าเมื่อปี พ.ศ. 2541 เกิดเหตุปะการังฟอกขาวเป็นวงกว้างจากปรากฏการณ์เอลนีโญ ส่งผลให้ความอุดมสมบูรณ์ของแนวปะการังแทบไม่เหลือหลอ

ผมลอยตัวนิ่งอยู่พักใหญ่ท่ามกลางแสงสลัวที่ส่องลอดผ่านผิวน้ำและแนวปะการังที่แทบจะร้างสิ่งมีชีวิต ทันใดนั้น ผมเห็นเงาดำลิบ ๆ เคลื่อนตัวเข้ามาใกล้เรื่อย ๆ ไม่กี่อึดใจ "ฉลามหูดำ" (*Carcharhinus melanopterus*) มากถึงสี่ตัวก็เผยโฉมออกมาจากเวิ้งน้ำขณะฟ้าเริ่มสางราวกับนักแสดงบนเวทีละครเปิดตัวจากฉากม่านกล พวกมันว่ายวนเวียนทิ้งระยะเพื่อสังเกตแขกผู้แปลกหน้าก่อนจะว่ายจากไปหาอาหารเช้าอย่างที่เคยเป็นมาทุกวัน

ฉลามหูดำเป็นฉลามขนาดเล็กที่โตเต็มวัยยาวราว 1.8 เมตร ฉลามชนิดนี้ถือว่าพบเห็นได้ง่าย เมื่อเทียบกับฉลามชนิดอื่น ๆ มากกว่า 60 ชนิดที่พบในน่านน้ำทะเลไทย ส่วนหนึ่งอาจเป็นเพราะถิ่นอาศัยของพวกมันอยู่บริเวณแนวปะการังน้ำตื้นใกล้ชายฝั่ง

แม้ท่วงทีของพวกมันจะดูผ่อนคลาย แต่การถ่ายภาพฉลามกลับไม่ใช่เรื่องง่าย ด้วยเหตุที่พวกมันเรียนรู้ว่าในบริเวณที่มีกิจกรรมประมงหนาแน่นที่สุดแห่งหนึ่งของโลกอย่างกลางอ่าวไทยนี้ พวกมันไม่ควรไว้วางใจสถานการณ์ใด ๆ ที่ผิดปกติวิสัย หรืออย่างน้อยก็ควรอยู่ให้ห่างจากแขกแปลกหน้าอย่างผม

นับตั้งแต่ยุคทศวรรษ 1970 เป็นต้นมา ฉลาม "เปิดตัว" สู่สายตาชาวโลกด้วยบทบาท "นักฆ่าผู้กระหายเลือด" ในภาพยนตร์ฮอลลีวู้ดชื่อดังที่สร้างต่อเนื่องกันหลายภาคอย่าง *จอว์ส* (*Jaws*) ซึ่งกลายเป็นต้นแบบให้ภาพยนตร์อีกหลายเรื่องในยุคหลัง ๆ ที่มีฉลามเป็นวายร้ายของเรื่อง ไม่เว้นแม้แต่ในสารคดีเกี่ยวกับธรรมชาติที่สร้างภาพให้ฉลามเป็นนักล่าผู้น่าพรั่นพรึง นับจากนั้นเป็นต้นมาคนทั้งชั่วรุ่นกระทั่งถึงปัจจุบันยังคงฝังใจกับภาพอันน่าสยดสยองเหล่านั้นไม่มากก็น้อย

ทว่าในความเป็นจริง ในแต่ละปีมีมนุษย์ถูกฉลาม

ทำร้ายน้อยมาก สถิติจากฐานข้อมูลระดับโลกที่เรียกย่อ ๆ ว่า ไอแซฟ (International Shark Attack File: ISAF) ระบุว่า เฉลี่ยแล้วในปีหนึ่ง ๆ มีเหตุการณ์มนุษย์เสียชีวิตจากฉลามทั่วโลกไม่ถึง 10 คน เรียกได้ว่าน้อยกว่าสัตว์ชนิดอื่นที่ทำร้ายมนุษย์หรืออุบัติเหตุบนท้องถนนชนิดเทียบกันไม่ติด อีกทั้งยังมีฉลามเพียงไม่กี่ชนิดที่อาจเป็นภัยคุกคามหรือมีโอกาสทำอันตรายต่อมนุษย์ เช่น ฉลามหัวบาตร ฉลามเสือ และฉลามขาว เป็นต้น ซึ่งทั้งหมดล้วนพบเห็นได้ยาก ไม่เว้นแม้แต่สำหรับนักประดาน้ำหรือกระทั่งนักวิจัยฉลามเอง

ฉลามหัวบาตรถูกลากขึ้นรถซาเล้ง หลังถูกประมูลเพื่อนำไปแปรสภาพเป็นผลิตภัณฑ์ต่าง ๆ ฉลามชนิดนี้อยู่ในบัญชีสิ่งมีชีวิตที่ใกล้ถูกคุกคามโดยสหภาพ-สากลว่าด้วยการอนุรักษ์ธรรมชาติ หรือไอยูซีเอ็น

[สิ่งที่หายไป]

"ฉันไม่เคยเห็นฉลามเยอะขนาดนี้มาก่อนเลย" เมทเทอ ชอนนิง เพื่อนร่วมทีมวิจัยสาวชาวเดนมาร์กของผม เอ่ยด้วยน้ำเสียงตื่นเต้น หลังจากเห็นบรรยากาศที่สะพานปลาจังหวัดระนอง กลิ่นคาวปลาคละคลุ้งไปทั่ว ท่ามกลาง

ลูกเรือชาวพม่ากำลังขนย้ายถังบรรจุปลาที่จับได้
บนเรืออวนลากสัญชาติไทยซึ่งออกทำประมง
ยามค่ำคืนในน่านน้ำของหมู่เกาะมะริด
ประเทศเมียนมาร์ (พม่า) ฉลามส่วนใหญ่ที่จับได้
จากการทำประมงของเรือไทยมักมาจากเครื่องมือ
ประมงประเภทอวนลาก คิดเป็นสัดส่วนเกือบ
ร้อยละ 90 ของฉลามที่จับได้ทั้งหมด

เสียงจอแจและความคึกคักยามเช้า

"จริง ๆ แล้ววันนี้ก็ไม่ได้เยอะเลยนะ เธอน่าจะได้เห็นอย่างที่ฉันเคยเห็น เยอะกว่านี้หลายเท่า" ผมบอกเธอพลางนึกถึงวันแรกที่ผมเริ่มทำงานวิจัยในตลาดแห่งนี้เมื่อสองปีก่อน ผมพบเห็นฉลามหลายสิบชนิดอย่างฉลามหัวค้อน ฉลามหนู ฉลามเสือ และอีกหลายชนิดที่ไม่เคยพบเห็นตัวจริงมาก่อนในธรรมชาติวางกองพะเนินอยู่ตรงหน้า ทว่าในวันนี้จำนวนฉลามที่พบเห็นกลับลดลงอย่างมาก ผมสงสัยว่าเกิดอะไรขึ้นในชั่วระยะเวลาเพียงสองปี

ในช่วง 20 ปีที่ผ่านมา ฉลามถูกจับขึ้นมาราว 107 ล้านตัวต่อปี ภัยคุกคามหลักคืออุตสาหกรรมประมง

อยู่นี่มาจากพม่าหรืออินเดียทั้งนั้นแหละ" พ่อค้าปลาวัยกลางคนที่ตลาดปลาจังหวัดระนองเอ่ยขึ้นเมื่อผมถามถึงที่มาของกองปลาตรงหน้า "มันก็ได้น้อยลงเรื่อย ๆ มานานแล้วนะ จับกันอย่างนี้ทุกวัน เดี๋ยวก็หมดอยู่แล้ว พวกมันออกลูกไม่ทันหรอก" เขาแสดงความเห็นจากประสบการณ์ยาวนานหลายปีในสะพานปลาแห่งนี้

"ลูกฉลามพวกนี้ติดอวนมาหมดเลยหรือครับ" ผมถามพลางชี้ไปที่กองซากปลาฉลามหัวค้อนวัยเยาว์ที่วางระเกะระกะอยู่บนพื้นมากกว่าสิบตัว

บอริส เวิร์ม ผู้เชี่ยวชาญด้านฉลามจากสหภาพสากลว่าด้วยการอนุรักษ์ธรรมชาติ หรือไอยูซีเอ็น (IUCN) ประเมินว่าในช่วง 20 ปีที่ผ่านมา ฉลามถูกจับขึ้นมาราว 107 ล้านตัวต่อปี ภัยคุกคามหลักคืออุตสาหกรรมประมง ประชากรฉลามในธรรมชาติเหลือน้อยมาก จนถูกจัดให้เป็นกลุ่มสัตว์มีกระดูกสันหลังที่ถูกคุกคามจนเสี่ยงต่อการสูญพันธุ์มากที่สุดกลุ่มหนึ่งในโลก

สำหรับสถานการณ์ในประเทศไทย มีรายงานจากกรมประมงว่า ในช่วงระยะเวลาระหว่าง พ.ศ. 2547 - พ.ศ. 2555 จำนวนฉลามที่อุตสาหกรรมประมงไทยจับได้ลดลงถึงร้อยละ 90 สอดคล้องกับรายงานที่เกิดขึ้นทั่วโลก งานวิจัยชิ้นหนึ่งของแดเนียล พอลลี นักวิทยาศาสตร์จากมหาวิทยาลัยบริติชโคลัมเบีย ชี้ว่า ปลากระดูกอ่อนอย่างฉลามและกระเบนเป็นกลุ่มปลาที่สูญหายไปจากท้องทะเลมากที่สุดนับตั้งแต่ยุคทศวรรษ 1970 เป็นต้นมา เนื่องจากเป็นยุคทองของอุตสาหกรรมประมงพาณิชย์และส่งผลกระทบต่อเนื่องยาวนานมาจนถึงปัจจุบัน

"ฉลามแทบไม่เหลือในทะเลไทยแล้วละ ที่เห็น ๆ

"ใช่ แต่ไม่ค่อยเจอตัวใหญ่ ๆ แล้วนะ เดี๋ยวนี้มีแต่ตัวเล็ก ๆ" เขาตอบ

หากคะเนจากสายตา ลูกฉลามหัวค้อนที่เห็นอยู่ตรงหน้ามีความยาวเฉลี่ยราว 40 เซนติเมตร ร่องรอยสายสะดือที่ยังติดอยู่กับร่างบ่งชี้ว่า พวกมันเป็นลูกฉลามหัวค้อนวัยแรกเกิด ภาพนั้นสะท้อนให้เห็นว่า ไม่เพียงฉลามโตเต็มวัยจะถูกล่าอย่างหนัก แต่แหล่งอนุบาลลูกปลาวัยอ่อนยังถูกคุกคามอีกด้วย ฉลามหัวค้อนเป็นหนึ่งในชนิดพันธุ์ฉลามที่ลดจำนวนลงมากที่สุด และถูกจัดให้เป็นสิ่งมีชีวิตที่ถูกคุกคามจนใกล้สูญพันธุ์

ปัจจัยหนึ่งที่ส่งผลให้ฉลามลดจำนวนลงอย่างรวดเร็วคือลักษณะทางชีววิทยาที่แตกต่างจากปลาชนิดอื่น ๆ โดยภาพรวมฉลามแทบทุกชนิดเติบโตช้า อายุยืนยาวและออกลูกในจำนวนที่น้อยมาก เมื่อเทียบกับปลามากมายหลายชนิดที่วางไข่ได้คราวละนับแสนนับล้านฟอง นอกจากนี้ ฉลามหลายชนิดยังตั้งท้องและออกลูกเป็นตัว ดังนั้น การจัดการการประมงที่ออกแบบมาสำหรับจัดการปลาทั่วไป จึงไม่สามารถนำมาใช้กับฉลามซึ่งเป็นปลาที่ฟื้นจำนวนช้าได้เลย

พ่อค้าปลากำลังตัดแต่งเศษเนื้อและกระดูกอ่อนจากครีบอกของฉลามหัวบาตร เพื่อขายเป็นหูฉลามสดก่อนจะนำไปตากแห้งเพื่อเป็นส่วนประกอบหลักของซุปหูฉลาม (บน) ฉลามหัวบาตรที่กองพะเนินเหล่านี้มีจำนวนไม่น้อยที่เป็นลูกอ่อนวัยแรกเกิด

[ค้นหาจิ๊กซอว์]

กลางห้องกว้างนั้นมีถังดองตัวอย่างสัตว์และขวดโหลสารพัดวางเรียงรายอยู่ใต้แสงไฟฟลูออเรสเซนส์สีขาวบาดตา และเมื่อ ดร.วิลเลียม ไวต์ เปิดถังแช่ตัวอย่างที่อัดแน่นไป

พ่อครัวกำลังนำหูฉลามแห้งที่ได้รับการจัดเตรียมอย่างดีไปประกอบอาหารเป็นซุปหูฉลามในภัตตาคารแห่งหนึ่งกลางกรุงเทพฯ อุตสาหกรรมหูฉลามเป็นสาเหตุสำคัญประการหนึ่งที่ทำให้ฉลามถูกล่าอย่างเป็นล่ำเป็นสันเนื่องจากมีราคาสูง โดยตลาดบริโภคใหญ่ที่สุดในโลกอยู่ที่ประเทศจีน

ในช่วงเวลาไม่ถึงสิบปีที่ผ่านมา มีการค้นพบฉลามชนิดใหม่ ๆ จากทะเลแถบเอเชียตะวันออกเฉียงใต้นับสิบชนิด "น่าแปลกใจนะครับว่า สัตว์ที่มีเอกลักษณ์เฉพาะตัวเหล่านี้หลุดรอดสายตาของมนุษย์มาเป็นเวลาหลายร้อยปีได้อย่างไร" เขาตั้งคำถามซึ่งดูจะมีคำตอบในตัวเองอยู่แล้วว่า เรายังต้องศึกษาพวกมันต่อไป

โดยภาพรวม ฉลามแทบทุกชนิดเติบโตช้า อายุยืนยาว และออกลูกในจำนวนที่น้อยมาก

ด้วยฉลามหลายชนิด กลิ่นแอลกอฮอล์ที่ดองซากฉลามเหล่านั้นไว้อย่างดีก็ระเหยโชยเข้าจมูกจนแสบฉุน "ที่นี่รวบรวมและเก็บรักษาตัวอย่างปลาไว้มากกว่าแสนชนิดครับ" เขาบอก ดร.วิลเลียมเป็นนักมีนวิทยาผู้เชี่ยวชาญด้านอนุกรมวิธานฉลามจากองค์การวิจัยด้านวิทยาศาสตร์และอุตสาหกรรมแห่งเครือจักรภพ (Commonwealth Scientific and Industrial Research Organisation: CSIRO) ซึ่งมีสำนักงานใหญ่อยู่ในประเทศออสเตรเลีย "งานอนุกรมวิธานเป็นพื้นฐานของการศึกษาสิ่งมีชีวิตสำหรับฉลามยังมีชิ้นส่วนปริศนาอีกมากที่ยังขาดหายไปซึ่งเราต้องเติมให้เต็มครับ" เขาอธิบาย

ในช่วงไม่กี่ปีที่ผ่านมา ดร.วิลเลียมค้นพบฉลามชนิดใหม่หลายชนิด "คุณดูนั่นสิ ฉลามในโหลตรงนั้นเป็นฉลามชนิดใหม่ของโลกที่ผมเพิ่งเอาตัวอย่างกลับมาจากเกาะบอร์เนียว ประเทศอินโดนีเซีย" เขาว่าพลางชี้ไปยังขวดโหลที่บรรจุตัวอย่างฉลาม พวกมันดูราวกับยังมีชีวิต "ตัวอย่างเหล่านี้จะทำให้เราเข้าใจถึงความหลากหลายของสิ่งมีชีวิต การจำแนกชนิดพันธุ์ที่แตกต่างทั้งยังช่วยให้เราเข้าใจลักษณะทางชีวภาพ หรือโครงสร้างประชากรในแต่ละพื้นที่ ซึ่งจะนำไปสู่การพัฒนาด้านการจัดการประมงและการอนุรักษ์พวกมันได้ครับ" เขาอธิบาย

ปัจจุบัน มนุษย์จำแนกฉลามได้แล้ว 536 ชนิด และยังมีการค้นพบใหม่ ๆ อย่างต่อเนื่อง โดยเฉพาะพื้นที่แถบเอเชียตะวันออกเฉียงใต้ซึ่งบรรดานักวิทยาศาสตร์ด้านฉลามชี้ว่าเป็น "ช่องโหว่" ขนาดใหญ่ขององค์ความรู้ด้านฉลามและยังเป็นพื้นที่ที่ใช้เป็นกรณีศึกษาถึงผลกระทบจากการทำประมงทำลายล้างที่มีต่อฉลามอีกด้วย

"น่านน้ำบริเวณนี้เป็นพื้นที่ตกสำรวจที่ยังไม่เคยมีใครเข้าไปทำงานวิจัยมาก่อน เกาะหลายแห่งมีความพิเศษอยู่ในตัวเอง ทั้งสภาพพื้นที่และสายพันธุ์สัตว์ เช่น ปาปัวนิกินี เกาะฮามาฮีรา และหมู่เกาะที่กระจัดกระจายอยู่ทั่วไปทำให้ฉลามหลายชนิดไม่พบในบริเวณอื่น นอกจากสถานที่ที่มันเพิ่งถูกค้นพบครับ" ดร.วิลเลียมบอกและเสริมว่า

[เปลี่ยนความเชื่อ]

ในบรรดาเมนูขึ้นโต๊ะจีนทั้งหมด "ซุปหูฉลาม" เคยครองตำแหน่งเมนูชูโรงอันดับหนึ่ง ไม่ว่าจะด้วยความเชื่อด้านสรรพคุณบำรุงร่างกาย หรือภาพลักษณ์อันหรูหรา ซุปหูฉลามเป็นเมนูอาหารราคาสูงลิ่ว และยังบ่งบอกถึงฐานะอันมั่งคั่งของเจ้าภาพ รวมทั้งเป็นการให้เกียรติแก่แขกผู้มาร่วมงาน ธรรมเนียมนี้มีมาตั้งแต่สมัยราชวงศ์หมิงของจีน

ด้วยสนนราคาหลักหมื่นบาทต่อกิโลกรัม (แบบแห้ง) ทำให้ฉลามถูกล่าสังหารอย่างหนักเพื่อเอา "ครีบ" ซึ่งเป็นส่วนที่นำมาบริโภค โดยตลาดสำคัญอยู่ที่ประเทศจีน และเมื่อเศรษฐกิจจีนเติบโตอย่างรวดเร็วในช่วงไม่กี่ปีที่ผ่านมา ทำให้ชาวจีนมีรายได้มากขึ้น กองเรือประมงจึงออกล่าฉลามกันอย่างเป็นล่ำเป็นสันเพื่อตอบสนองความต้องการของตลาดที่โตวันโตคืน อุตสาหกรรมล่าฉลามเฟื่องฟูมากแถบแปซิฟิกและแอฟริกา บอริส เวิร์ม และคณะจากไอยูซีเอ็นประเมินว่า ตลอดช่วง 20 ปีที่ผ่านมา ฉลามราว 73 ล้านตัวถูกล่าในแต่ละปีเพื่อเอาครีบเพียงอย่างเดียว

กรรมวิธีล่าฉลามไม่เคยถูกเปิดเผยมาก่อน จนกระทั่งเมื่อสิบกว่าปีที่ผ่านมา องค์กรอนุรักษ์แห่ง

ดร.เจมส์ ทรู นักวิจัยจากสถาบันวิจัยความเป็นเลิศความหลากหลายทางชีวภาพแห่งคาบสมุทรไทย กำลังตรวจสภาพตัวอย่างฉลามที่ถูกจับโดยเรือประมง (บน) ขณะที่การอ่านอายุขัยของฉลามทำได้จาก "วงปี" ที่ฝังอยู่ในกระดูกสันหลัง

แม้จะมีภาพลักษณ์ของความน่ากลัว แต่ฉลามยังคงเป็น "ดารานำ" อยู่เสมอ เมื่อพวกมันปรากฏตัวในส่วนจัดแสดงของพิพิธภัณฑ์สัตว์น้ำอย่างที่ศูนย์แสดงพันธุ์สัตว์น้ำในห้างสรรพสินค้ากลางกรุงเทพฯแห่งนี้

หนึ่งเปิดโปงกรรมวิธีล่าฉลามอันโหดร้ายผ่านทั้งวิดีโอและภาพถ่าย โดยชาวประมงจะจับฉลามขึ้นจากทะเล เลือกตัดเฉพาะครีบและหางจนเลือดนองเต็มพื้นเรือ ก่อนจะโยนร่างที่เหลือทิ้งลงทะเลทั้ง ๆ ที่ยังมีชีวิต ภาพความโหดเหี้ยมนั้นปลุกกระแสเสียงเรียกร้องให้สังคมทบทวนธรรมเนียมการบริโภคหูฉลาม ซึ่งเป็นตลาดหล่อเลี้ยงการทำประมงที่ไร้ความรับผิดชอบ

"ผมว่ามันเป็นขนบธรรมเนียมผิด ๆ นะ ทรมานสัตว์ แถมยังแทบไม่มีสารอาหารอะไรเลย เป็นแค่ความเชื่อล้าสมัย" ติณณ์ อินทพิเชฏฐ์ เจ้าบ่าวหนุ่มวัย 26 ปี กล่าว เขาเลือกที่จะไม่เสิร์ฟเมนูยอดฮิตจานนี้ในคืนวันแต่งงานของตัวเอง "ตอนแรกก็ไม่ได้สนใจครับ คิดว่าเป็นอาหารอย่างหนึ่ง แต่พอได้รับรู้ถึงวิธีการล่าฉลามอันโหดร้าย ก็ไม่คิดว่าจะกินอีกแล้ว พออธิบายเรื่องนี้ให้คนในครอบครัวฟัง ก็ไม่มีใครคัดค้าน" เขาอธิบายด้วย

เหตุผลตามแบบคนรุ่นใหม่

ในช่วงทศวรรษที่ผ่านมา กระแสต่อต้านการบริโภคหูฉลามเริ่มเห็นชัดเจน ไม่เว้นแม้กระทั่งในประเทศจีนซึ่งเป็นผู้บริโภครายใหญ่และขึ้นชื่อว่าเป็นศูนย์กลางอุตสาหกรรมหูฉลามของโลก มีการโฆษณารณรงค์ปฏิเสธการบริโภคหูฉลามนำโดย เหยาหมิง นักบาสเกตบอลชื่อดังของจีน ขณะที่สายการบินใหญ่หลายสายปฏิเสธการขนส่งหูฉลาม โรงแรมหลายแห่งยกเลิกการเสิร์ฟเมนูหูฉลาม หรือแม้กระทั่งรัฐบาลจีนมีคำสั่งห้ามเสิร์ฟหูฉลามในงานเลี้ยงของข้าราชการ เช่นเดียวกับในประเทศไทย ซึ่งเคยมีรายงานว่าภัตตาคารย่านเยาวราชเสิร์ฟซุปหูฉลามกว่า 20,000 ถ้วยต่อเดือน ก็มีการรณรงค์ให้เลิกบริโภคและยกเลิกเมนู ความเคลื่อนไหวเหล่านี้ส่งผลให้มูลค่าตลาดหูฉลามลดฮวบลงมากกว่าครึ่ง

“ถ้าเป็นเมื่อก่อน เธออาจเห็นหูฉลามผึ่งแดดเรียงอยู่ตามข้างถนน แต่ฉันเองก็ไม่เห็นมานานแล้วนะ” แอ๊ปเปิ้ล ชุย นักศึกษาปริญญาเอกด้านวิทยาศาสตร์ทางทะเลจากมหาวิทยาลัยจีนแห่งฮ่องกง ตอบคำถามของผมผ่านโปรแกรมสนทนาข้ามประเทศ “หลัก ๆ คงเป็นเพราะคนรุ่นใหม่เริ่มเข้าใจประเด็นสิ่งแวดล้อมมากขึ้น ดังนั้นถ้าเธออยากจะมาถ่ายภาพหูฉลามที่นี่ คงไม่น่าจะได้เห็นแล้วละ” คำอธิบายของเธอทำให้ผมนึกถึงทัศนคติของคนรุ่นใหม่อย่างติณณ์

อย่างไรก็ตาม แม้ประเทศไทยจะไม่มีอุตสาหกรรมการล่าฉลามโดยตรง ทว่าพวกมันมักจะติดร่างแหมาระหว่างการจับสัตว์น้ำชนิดอื่น หรือที่เรียกว่า Bycatch ที่ตลาดปลาแห่งหนึ่ง แมลงวันฝูงใหญ่กำลังบินตอมเศษชิ้นเนื้อกระจัดกระจายและกองเลือดที่เจิ่งนองบนพื้นปูน คนงานกำลังเร่งขนเศษปลาเล็กปลาน้อยหรือที่เรียกว่า “ปลาเป็ด” ขึ้นรถบรรทุก ปลาเหล่านี้เป็นปลาที่มีมูลค่าทางเศรษฐกิจต่ำและติดมากับอวน พวกมันจะถูกส่งต่อไปยังโรงงานแปรรูปเพื่อทำเป็นอาหารสัตว์

ท่ามกลางปลาหลากหลายชนิด ผมยืนอยู่หน้าซากฉลามหัวบาตร (*Carcharhinus leucas*) ขนาดร่วมสามเมตร “พวกนักอนุรักษ์ไม่เข้าใจผมหรอก พวกเขาคงไม่เคยมาเหยียบที่นี่ด้วยซ้ำ” พ่อค้าปลาคนหนึ่งซึ่งเป็นอดีตช่างเครื่องตัดพ้อ เขาผันตัวมาจับงานแปรรูปฉลามหลังโดนพิษเศรษฐกิจเล่นงาน “ที่นี่เราใช้ฉลามทั้งตัว ไม่ได้ตัดหูทิ้งลงทะเลเป็น ๆ แบบที่เขาพูดกัน” เขาชี้แจง

ด้วยความที่ฉลามมีราคาดีเฉพาะส่วนครีบ จึงส่งผลให้เกิดอุตสาหกรรมแปรรูปชิ้นส่วนอื่น ๆ ตามมาเพื่อไม่ให้สูญเปล่า “ฉลามพวกนี้ถูกรวบรวมมาพร้อมกับปลาอื่น ๆ โดยการทำประมงหลากหลายวิธีครับ เราเลือกไม่ได้หรอกว่าจะเอาปลาอะไรขึ้นมาบ้าง หย่อนเบ็ดบางทีก็ได้ปลาโอปลากระโทงแทง ถ้าอวนล้อมหรืออวนลากยิ่งแล้วใหญ่ เจอตัวอะไรก็กวาดขึ้นมาหมด” พ่อค้าปลาคนเดิมเสริม

ฉลามถูกแปรรูปสารพัด ทั้งดองเกลือทำปลาเค็ม แปรรูปเป็นลูกชิ้น หรือกระทั่งนำมาบริโภคแบบเนื้อปลาทั่วไป ตับฉลามมีขนาดใหญ่และอุดมไปด้วยน้ำมันจึงถูกนำมาใช้เป็นส่วนประกอบของเครื่องสำอางหรือผลิตภัณฑ์เสริมอาหาร "ถ้าจับมาตัวเล็กเกินไปก็จะถูกนำมาตากแห้งเป็นของกินเล่นของสัตว์เลี้ยงแทน ที่จริงแล้วฉลามหนึ่งตัวนี่ทำอะไรได้หลายอย่างนะ มันคือการใช้ประโยชน์จากทรัพยากรรูปแบบหนึ่งนั่นแหละ แล้วก็เป็นอาชีพสุจริตเพื่อยังชีพ พวกเราก็ต้องกินต้องใช้เหมือนกัน" เขาสรุป

ในช่วงเวลาไม่ถึงสิบปีที่ผ่านมา มีการค้นพบฉลามชนิดใหม่ๆ จากทะเลแถบเอเชียตะวันออกเฉียงใต้นับสิบชนิด

[ความหวังเล็ก ๆ]

"ปัจจุบันข้อมูลเรื่องฉลามในประเทศไทยยังมีน้อยมากครับ เพราะพวกมันไม่ใช่ปลาเศรษฐกิจที่คนสนใจ" ดร.เจมส์ ทรู แห่งสถาบันวิจัยความเป็นเลิศความหลากหลายทางชีวภาพแห่งคาบสมุทรไทย (Excellence Center for Biodiversity of Peninsula Thailand) มหาวิทยาลัยสงขลานครินทร์ กล่าวและเสริมว่า ตลอดกว่า 20 ปีที่ผ่านมา ฉลามในน่านน้ำไทยถูกจับเกินขนาดที่ประชากรจะรองรับได้ จนพูดได้ว่าเกือบสูญสิ้นไปจากระบบนิเวศแล้ว

"มีฉลามเพียงไม่กี่ชนิดครับที่สามารถรองรับอุตสาหกรรมประมงขนาดใหญ่ได้ ฉลามที่นำขึ้นมาเทียบท่าเรือในไทยเกือบทั้งหมดถูกจับมาจากน่านน้ำต่างชาติทั้งนั้น อันที่จริง ประชากรฉลามในน่านน้ำไทยสูญหายไปจนล่วงเลยวลีที่ว่าเคยมีการประมงฉลามแล้วด้วยซ้ำครับ" เขาบอกพร้อมรอยยิ้มเศร้า ๆ

ทว่าในช่วงไม่กี่ปีที่ผ่านมา ทิศทางของอุตสาหกรรมการท่องเที่ยวแนวใหม่ อาจเป็นความหวังเล็ก ๆ ของการอนุรักษ์ฉลามก็เป็นได้ การสำรวจเกี่ยวกับฉลามสีเทา (*Carcharhinus amblyrhynchos*) ตามจุดดำน้ำหลายแห่งในประเทศปาเลา (Palau) ซึ่งเป็นประเทศหมู่เกาะเล็ก ๆ ในมหาสมุทรแปซิฟิก พบว่า ตลอดช่วงชีวิตของฉลามตัวหนึ่งสามารถสร้างเม็ดเงินได้ถึงเกือบสองล้านดอลลาร์สหรัฐให้กับอุตสาหกรรมการท่องเที่ยวของหมู่เกาะที่โด่งดังเรื่องการดำน้ำชมฉลามแห่งนี้

"นักดำน้ำส่วนมากอยากเห็นฉลามในท้องทะเล พวกเขายอมจ่ายมากขึ้นเพื่ออนุรักษ์พวกมันไว้ และปรากฏว่ามูลค่าทางเศรษฐกิจจากการท่องเที่ยวเชิงนิเวศตรงนั้นกลับใหญ่โตกว่ารายได้จากการประมงปลาฉลามเสียอีก" ดร.เจมส์อธิบายและชี้ว่านั่นอาจทำให้การอนุรักษ์ฉลามมีความหวังขึ้นมาได้ "ตอนนี้ผู้คนเริ่มเข้าใจถึงความสำคัญของฉลามต่อระบบนิเวศทางทะเล ทั้งในแง่การเป็นตัวชี้วัดความสมบูรณ์และการควบคุมสิ่งมีชีวิตต่าง ๆ ในห่วงโซ่อาหาร แถมยังมีเรื่องมูลค่าทางเศรษฐกิจต่ออุตสาหกรรมการท่องเที่ยวอีกด้วย"

ความก้าวหน้าของแหล่งดำน้ำดูฉลามในประเทศปาเลาส่งผลให้รัฐบาลของประเทศหมู่เกาะเล็ก ๆ แห่งนี้ออกกฎหมายห้ามทำการประมงฉลามอย่างเบ็ดเสร็จเป็นประเทศแรกของโลก เช่นเดียวกับประเทศมัลดีฟส์ที่ประเมินค่าฉลามไว้ในระดับใกล้เคียงกัน

[คืนสู่ท้องทะเล]

แสงสลัวลอดผ่านตู้กระจกในพิพิธภัณฑ์สัตว์น้ำภายในห้างสรรพสินค้าหรูหราแห่งหนึ่งใจกลางกรุงเทพฯ แสงนั้นช่างคลับคล้ายแสงจากผิวน้ำที่ทอดลงมายังซากหมู่ปะการังเมื่อครั้งผมพบเจอฉลามหูดำที่เกาะเต่าในเช้าวันนั้น

พวกมันว่ายน้ำอย่างเรียบเฉย งามสง่า และระแวดระวังท่าทีอยู่ในตัว ในฐานะนักวิจัยและนักดำน้ำ ภาพของฉลามในสายตาผมจึงไม่ใช่นักฆ่าเลือดเย็นหรือฆาตกรแห่งท้องทะเล หากพวกมันคือสิ่งมีชีวิตอัศจรรย์ งดงามและเปี่ยมไปด้วยวิญญาณเสรีที่ท่องไปทั่วท้องน้ำสีมรกต เช้าวันนั้นคงจะมีแต่ผมกระมังที่เป็นสิ่งมีชีวิตแปลกปลอม และเป็นสิ่งมีชีวิตแปลกปลอมเพียงชนิดเดียวที่สามารถคิดค้นวิธีทำลายล้างท้องทะเลและธรรมชาติในเวลาเพียงไม่กี่ทศวรรษในประวัติศาสตร์

ท่ามกลางเสียงเซ็งแซ่อึงอลภายในพิพิธภัณฑ์สัตว์น้ำแห่งนั้น ผู้เข้าชมทั้งเด็กและผู้ใหญ่ต่างตื่นตากับสัตว์ทะเลสีสันสดใส รูปร่างแปลกตา ผมอดคิดไม่ได้ว่า มนุษย์

เราเป็นเพียงเศษเสี้ยวหนึ่งของวิวัฒนาการ จากสิ่งมีชีวิตที่เคยแหวกว่ายกลางท้องทะเลหรือล่องลอยไปตามกระแสน้ำอันไพศาลเมื่อหลายล้านปีก่อน ท้องทะเลก็คงไม่ต่างอะไรกับ "บ้านเกิด" ที่เราจากมา ทว่าทุกวันนี้ เรากลับกำลังทำลายบ้านเกิดด้วยมือของเราเองทีละน้อย

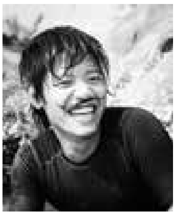
ฉลามเสือทราย (*Carcharias Taurus*) ตัวหนึ่งลอยตัวนิ่ง ๆ อยู่ในตู้กระจก หน้าตาของมันดุดัน ทว่าที่จริงมันขี้อาย ไม่ดุร้าย ตัวเล็กและดูสงบ มันมีท่าทีของความสะโอดสะอง ผมไม่เคยพบเห็นมันมาก่อนในน่านน้ำประเทศไทย ฉลามส่วนใหญ่ในพิพิธภัณฑ์สัตว์น้ำแห่งนี้นำเข้ามาจากประเทศออสเตรเลีย

"ฉลามไม่ได้ชอบกินคนนะลูก" เสียงเล็ก ๆ จากคุณแม่และลูกน้อยดึงดูดผมให้หันไปหาเจ้าของเสียง คำพูดของเธอทำให้ผมอมยิ้ม ผมคิดว่าพวกมันควรได้รับความเข้าใจเสียใหม่ อย่างน้อยก็เริ่มต้นจากในแง่ที่ว่าพวกมันไม่ใช่ "ผู้ร้าย" หรือ "นักฆ่า"

ผมเดินกลับออกมาสู่ท้องถนน พลางคิดถึงเช้าวันนั้นขณะลอยตัวอย่างอิสระในท้องทะเลเพื่อเฝ้ารอพวกมัน □

เมทเทอ ซอนนิง นักวิจัยชาวเดนมาร์ก มองดูกรามตากแห้งของฉลามหัวบาตรที่วางขายอยู่ในร้านของที่ระลึกแห่งหนึ่งบนหาดราไวย์ จังหวัดภูเก็ต นอกจากหูฉลามจะมีราคาแพงลิ่วแล้ว ชิ้นส่วนอื่น ๆ มักได้รับการแปรรูปเป็นผลิตภัณฑ์หลากหลาย

กว่าจะมาเป็นสารคดีเรื่องนี้



ศิรชัย อรุณรักษ์ติชัย *เป็นนักวิจัยทางทะเลและช่างภาพใต้น้ำหนุ่มไฟแรง เขาหลงใหลฉลามและเป็นประจักษ์พยานถึงความโหดร้ายที่มนุษย์กระทำต่อพวกมัน ผลงานภาพถ่ายของศิรชัยเพิ่งคว้ารางวัลชนะเลิศจาก Save Our Seas Foundation ซึ่งเป็นองค์กรด้านอนุรักษ์ทะเลระดับนานาชาติ*

ทำไมคุณถึงสนใจฉลาม

ตั้งแต่เด็ก ๆ เวลาผมเห็นฉลาม ผมจะคิดเสมอว่า "เป็นปลาที่ทั้งทรงพลัง เป็นนักล่า เท่ แถมมีเสน่ห์มาก ๆ ครับ" แต่พอมาทำงานวิจัยจริง ๆ ถึงได้รู้ว่าพวกมันไม่ได้ดุร้ายน่ากลัว แถมกำลังถูกคุกคามอย่างหนักจากอุตสาหกรรมประมง ผมคิดไม่ออกเลยว่าผลกระทบต่อระบบนิเวศจะเลวร้ายขนาดไหนในวันที่โลกไร้ฉลาม

ฉลามวาฬที่ยังไม่โตเต็มวัยขนาดร่วมห้าเมตรแหวกว่ายอยู่ในท้องน้ำนอกเกาะบอน อุทยานแห่งชาติหมู่เกาะสุรินทร์ ขณะที่เหล่านักดำน้ำเร่งว่ายตามเพื่อบันทึกภาพปลาขนาดใหญ่ที่สุดแห่งท้องทะเล งานวิจัยหลายชิ้นบ่งชี้ว่า มูลค่าทางเศรษฐกิจที่เกิดจากกิจกรรมท่องเที่ยวดูฉลามนั้นสูงกว่ามูลค่าที่เกิดจากกิจกรรมประมงชนิดเทียบกันไม่ได้

SHARKS: PREDATORS IN PERIL
WORLD PRESS PHOTO / WITNESS EDITION

Fins and head of a spottail shark *Carcharhinus sorrah* are arranged on a table at a fish market in Ranong, Thailand. According to the recent assessment on extinction risks and conservation of sharks and rays, they are now considered to be one of the most threatened major groups of vertebrates on Earth (Dulvy *et al.,* 2014). © Sirachai Arunrugstichai / National Geographic (Thai Edition)

Encounter

The cold touch of sea water woke me up from my state of half-consciousness. Waking up early before sunrise is not exactly my cup of tea, especially when you need to climb down a rocky cliff with a precious underwater camera housing. I slowly began swimming out alone from the shore of a little bay called Ao Thian Og of Koh Tao, a famous diving destination in the Gulf of Thailand. A large field of dead Staghorn corals *Acropora spp.*, which died off during the mass coral bleaching event in 1998, can be seen covering the bottom of the whole bay, resembling a crumbling field of decomposing bones. There were not many fish around in the degraded reef of Ao

Thian Og, especially when compared with the other bays around the island with better reef conditions. Under the dim light shimmering through the surface, I quietly waited in the blue-green emptiness, scanning my surroundings in anticipation before a group of large shadows slowly approached me from the murk. Within minutes, four adult blacktip reef sharks *Carcharhinus melanopterus* appeared in my sight with the light of dawn. It is not widely known, but this barren bay is one of a few locations in Thailand where these sharks have been documented to aggregate and give birth.

The adult blacktip reef shark can reach a total length of 1.8 meters and are probably the most commonly encountered shark species by beachgoers in Thai waters, due to their near-shore habitat. The group of sharks approached closer, but still kept some distance away from me, a stranger in their realm. I did not feel threatened at all by their presence—on the contrary, it seemed that they were cautious of me being in their feeding ground. The distance was too far for me to take a decent shot with my fisheye lens. The encounter lasted for only a few minutes before the sharks headed off along the reef, minding their business and then disappearing into the blue. I followed them around the bay throughout the morning but could never get a close up shot that I hoped for. And it went that way for the rest of the week. Photographing living sharks in their natural habitat in Thai waters is not easy, since they have largely disappeared from the waters and they are wary of humans, probably with good reason.

A group of visitors take photos with the image of a great white shark *Carcharodon carcharias* at Trick Eye Museum, Phuket, Thailand. Despite the understanding of shark issues gaining momentum among the public, the old perspective of the past still remains. © Sirachai Arunrugstichai / National Geographic (Thai Edition)

Since the 70's, sharks have been painted in a bad light as voracious man-eaters, instilling a fear of these marine predators to the worldwide audiences which still persists to this day. In reality, human and shark incidents do not occur that often, with an average of 82 cases per year throughout the past five years. Fatal cases are even more rare with less than 10 fatalities annually worldwide, according to the International Shark Attack Files (ISAF). There are only three large shark species that contribute to most of the serious incidents: the bull sharks *Carcharhinus leucas*, the tiger sharks *Galeocerdo cuvier*, and the great white shark *Carcharodon carcharias*. Bull sharks and tiger sharks are present in Thai waters, but encountering them is incredibly rare. Throughout a decade of diving all over the seas of Thailand, I can count the number of encounters I've had with these large sharks on one hand. In fact, there have been no reports of any tiger shark or bull shark sightings around Thai dive sites in the past five years.

An adult bull shark *Carcharhinus leucas* is dragged onto a motorcycle trailer by workers at the Fish Marketing Organization landing site after an auction in Ranong, Thailand. Even they are considered as by-catch in non-selective fisheries. As a group, sharks have suffered the most severe declines in Thai waters (Pauly & Chuenpagdee, 2003). © Sirachai Arunrugstichai / National Geographic (Thai Edition)

Disappearance

"I have not seen these many sharks before in my life!" Mette Schiønning, my lab mate from Denmark exclaimed with teary eyes stepping into a large fish landing site in Ranong province and looking through the catches of the day amidst the noises and smells. "Actually, this is not that many. I have seen probably more than twice this amount when I was here last year," I told her while thinking back on my first day conducting a market survey at this site in 2012, just two years prior to this field trip. I have documented many sharks that I have never previously seen in the seas of Thailand: fossil sharks, hammerhead sharks, thresher sharks, and many more. Throughout the years, the amount and diversity of the sharks being landed seems to have continuously declined, which made me wonder: what happened in the seas these past two years?

At depth in the Gulfstream, a silky shark *Carcharhinus falciformis* with a fishing hook in its mouth approaches the camera, while a group of researchers observe them from a distance in Florida, USA. With their long lives, slow growth, low fecundity and late maturity, sharks are highly susceptible to overfishing, which is their primary threat. © Sirachai Arunrugstichai

According to a study by Worm *et al.*, (2013), throughout the past two decades an estimated 100 million sharks died annually from fishing mortality. The populations of many species have severely declined throughout the world's oceans, primarily from both targeted and incidental fisheries, where some species faced population declines of over 90 percent. In some extreme cases, local extinctions of vulnerable species have also been documented, such as the critically endangered common angel shark *Squatina squatina*, which have been extirpated from several regions of European waters. Due to the threats that sharks and their chondrichthyan relatives are facing nowadays in the world's oceans, they have unsurprisingly been assessed as one of the most threatened major vertebrate groups with substantially high risk of extinction (Dulvy *et al.*, 2014).

In the night, commercial fishermen on a Thai trawler move drums of their daily catches on the deck in Mergui Archipelago, Republic of the Union of Myanmar. According to anecdotal data from fishers, most of the landings were caught outside of Thai waters, where the majority were fished in neighboring countries such as Myanmar and India. © Sirachai Arunrugstichai / National Geographic (Thai Edition)

“There are hardly any sharks left in Thai waters, young man. Most of the catches that you see these days were caught by trawlers from the waters of Myanmar or India,” a middle-aged fish trader replied to my question about the locality of the catch. “They have been declining for a long while already, and they will surely disappear in the future, [because] they can’t produce enough offspring with this rate of fishing.” He went on to share insights from his decades of experience at this fish landing site. In Thai waters, population declines of sharks have been recorded since the 60’s with the early introduction of commercial trawling, where sharks and rays are among the groups which suffered the most severe declines (Pauly & Chuenpagdee, 2003). And in the past decade, the situation seems especially grim with alarming declines of approximately 90 percent of landed weight reported in the fisheries statistic by the Thai Department of Fisheries.

A pile of newborn bull sharks *Carcharhinus leucas* arranged for auction at a fish landing site in Ranong, Thailand. Recently it was found that the majority of the landings of most shark species comprise immature individuals or neonates, which suggests the situation of recruitment overfishing. (Arunrugstichai, unpubl. data). © Sirachai Arunrugstichai / National Geographic (Thai Edition)

"I presume that those baby sharks were all caught with trawlers, weren't they?" I asked while pointing toward a pile of scalloped hammerheads *Sphyrna lewini* lying dead on the concrete floor surrounded by a swarm of flies. "Yes, there aren't that many large sharks around these days. Most of the catches are the smaller ones like you are seeing," he replied. The hammerhead sharks in the pile were an average length of 40 centimeters and, from my visual estimation, all had visible umbilical scars indicating that they were newborns. Not only are the adults being fished out, but now the nursery areas of newborn Scalloped hammerhead sharks are also under threat. This species has suffered the greatest decline from the oceans and are also assessed as endangered by the IUCN shark specialist group.

An egg case with an embryo of a brownbanded bamboo shark *Chiloscyllium punctatum* is displayed by a staff member at the hatchery in the Marine Science Institute at Bhurapha University, Chonburi, Thailand. Reproductive modes of sharks are diverse, yet their fecundity is very low in comparison to other fish (Hoenig & Gruber 1990). © Sirachai Arunrugstichai / National Geographic (Thai Edition)

The key factor of why sharks have been doing so poorly with the current threats is their vulnerability to over-exploitation from their slow life-history characteristics. Sharks are generally slow-growing and long-living, taking many years to reach sexual maturity only to produce a low number of offspring in comparison to most other fish. In addition, many species give live-birth with a long pregnancy period, so fishing the reproductively mature adults can greatly affect the future recruitment and hinder the ability of the population to replenish. These characteristics make managing shark fisheries especially challenging, especially for the nations with fishery management strategies designed for other faster-growing marine life.

Missing Pieces

In a clean white room brightly-illuminated by fluorescent lights, bucket and jars containing preserved fish were everywhere, leaving only small spaces to navigate around. Dr. Will White opened buckets filled with sharks of different shapes and sizes, while the sharp smell of alcohol permeated my nostrils. Looking around the room, I was stunned by the tremendous number of specimens being collected at this institution, the Australian National Fish Collection located in Hobart, Tasmania, which houses more than a hundred thousand fish specimens of more than 3,000 species. Dr. White is an ichthyologist at Commonwealth Scientific and Industrial Research Organization and he is one of the world's foremost experts on elasmobranch taxonomy, the science of identifying, naming and classifying sharks, skates, rays and chimaera. He has been involved in describing over 60 new species of sharks and rays. "It is fundamental to the life sciences, however there are many pieces still missing from the puzzles," he told me.

A sectioned vertebral centra of a shark is being examined by Jonathan Smart, a shark scientist from James Cook University, to determine its age for estimation of life history parameters in Townsville, Australia. The information that can be determined from age and growth studies, such as longevity, growth rate, and age at maturity, are critical to ensure effective management of shark populations. © Sirachai Arunrugstichai / National Geographic (Thai Edition)

At the present time, there are more than 500 species of sharks scientifically described, with new species being discovered every year. Within the past decade, Dr.

White has discovered many shark species new to science from Southeast Asia, a hot spot of shark biodiversity with a large knowledge gap for management, while also being the region with high incidence of fishery exploitation. “It is crucial to first distinguish the different species to enable us to learn about their biological aspects and population structure, which in turn helps to improve our management strategies and conservation actions.”

In reality, most shark species which are assessed to be at the highest risk of extinction hardly receive any attention or are even known by the general public, such as the Pondicherry shark *Carcharhinus hemiodon* or the river sharks *Glyphis spp.*, which have been assessed as critically endangered by the IUCN Shark Specialist Group. The more attention these species receives by the general public, the better chance it could lead to stronger efforts to conserve their remaining populations.

Point of View

For Chinese cuisine, shark fin soup has long been perceived as one of the most prestigious dishes with traditional beliefs of health benefits and association with wealth. The dish originated during China’s Song dynasty and gained popularity throughout history until the modern time as a special dish for an event to honor the guests and also as a status symbol for the wealthy host.

Cooks are seen preparing bowls of shark fin soup in the kitchen at a Chinese restaurant in Bangkok, Thailand. Considered as an imperial cuisine, the demand for shark fins fueled by the economic growth in China is a major cause, driving shark fisheries to the world's oceans. © Sirachai Arunrugstichai / National Geographic (Thai Edition)

With the high price tag of sometimes $700 per kilogram for dried fins (according to reports from WildAid), sharks are widely targeted throughout the world's oceans for their fins to fuel the trade for one of the most valuable fish products. Actually, the fin trade is recognized as the major contributor of shark mortality, with an estimate of 73 million sharks killed per year for their fins, according to a study by Worm *et al.* (2013). The practice of *finning* had been relatively out of the general public's sight until the past few decades. Recently surfaced videos of fishermen slicing the fins off of living sharks before throwing their still-thrashing bodies back into the water to die have raised the public's awareness about shark finning and conservation issues, making some rethink the custom.

Tihn Intapichet, a young 26-year-old groom from a Thai-Chinese family, told me, "I don't think this practice should be continued. For me, I think finning is animal cruelty, and there is hardly any nutritional value anyway. Just an old outdated belief." He opted to exclude shark fin soup from the menu for his wedding. "At first, I did not think much about it more than it was just a kind of soup. But after I was aware of what was happening to the sharks, I just decided not to ever have it again. And when I explained this to my family, there was nobody objecting my decision."

Fins from small species of guitarfish (Family Rhinobatidae) are left drying on a net in a shark processing factory in Ranong, Thailand. Despite target shark fisheries not acknowledging the shark catches in Thailand (since they are considered to be bycatch), according to a recent report by FAO, the nation has become the top exporter (including re-export) of the global fin trade since 2007 to 2011, specializing in low-quality small fins from various elasmobranch species (Dent & Clark, 2015). © Sirachai Arunrugstichai

A pile of vertebrae columns and heads of scalloped hammerheads *Sphyrna lewini* in a shark processing factory in Ranong, Thailand, prior to being sold to make fish meal. Despite being listed as endangered by the IUCN red list, this population is still being threatened worldwide, and is speculated to be one of the species with the greatest population declines in Thai waters. © Sirachai Arunrugstichai

Within the past decade, the movement against consumption of shark fins has grown substantially throughout the world, even in China. There are growing campaigns against the dish, notably with the voice of Chinese basketball star Yao Ming for WildAid. In addition, several major airlines have stopped overseas shipment of the fins, major hotel chains have taken the dish out of the menus in their restaurants, and even the Chinese government has banned serving shark fins in their official banquets.

"In the past, you may get to see shark fins being dried on the streets, but I have not seen that for quite a while," wrote Apple Chui, a friend of mine who is now a lecturer at Chinese University of Hong Kong, after I inquired about the situation in her hometown of Hong Kong. "I think that is because the new generations are much more concerned about environmental issues, so I don't think it will be worth your time to fly all the way here to photograph this.” Her insight from Hong Kong made me think of the hope in new generations like the young Chinese groom, Tihn

Nevertheless, in recent years, Thailand has grown to be one of the top exporters of shark fins (including re-export), occupying the top spot during 2007 to 2011, according to a report by FAO (Dent & Clark, 2015), despite the fact that there are no targeted commercial fisheries for sharks. Instead, most sharks landed in Thai fisheries are caught as bycatch, marine life that are incidentally caught in non-selective fisheries for other commercial important species.

A shark fin trader trims cartilage off a pectoral fin of a bull shark *Carcharhinus leucas* in a shark processing factory in Ranong, Thailand. According to a recent report by FAO, which was published in 2015, Thailand has now become the leading exporter of shark fins in the world (Dent & Clark, 2015). © Sirachai Arunrugstichai / National Geographic (Thai Edition)

Being surrounded by piles of catches at the fish landing site in Ranong during the busy auction time, I stared at a 3-meter-long pregnant bull shark lying on the concrete floor with blood dripping from her orifices. “Those conservationists would not understand my point of view; they probably never stepped foot into this place,” a middle-aged shark fin trader expressed his frustration while his workers dragged the sharks onto his old pickup truck. In the past, the shark fin trader was a mechanic, but somehow turned to this business during the 1997 Thailand financial crisis. “We use the whole body of the sharks here! Not cutting the fins and throwing their bodies back into the sea. It is not like how it is shown in those videos,” he added. Since the prices of fins can be as high as over half the value of a whole shark, the remaining body parts are processed into other products once the fins are cut off in factories. “The sharks we have here were caught with other fish, from various sources. We cannot really choose what would be caught, especially from trawlers, which catch everything. We just make the most out of what we get.”

Danish graduate student Mette Schiønning looks at the dried jaw of a bull shark Carcharhinus leucas at a souvenir stall in Phuket, Thailand. Dried jaws from various shark species are common souvenirs among coastal cities in Thailand. © Sirachai Arunrugstichai / National Geographic (Thai Edition)

In Thailand, sharks are processed and marketed as a variety of common products, such as salted fish and fish balls. The livers are extracted for oils and other hydrocarbons to be used in pharmaceutical and cosmetic industries. The jaws are cleaned of flesh and dried, then sold in souvenir shops around seaside tourist destinations. Cartilages are sometimes made into dietary supplements because of the misconception that sharks do not get cancer, an idea which has been proven to be false. The other remaining internal organs are sold at cheap prices to be processed into fishmeal, a major protein source for the aquaculture and poultry industry. "For the baby sharks, their vertebrae columns are dried and sold as pet snacks. Do you see how widely we can utilize the body of a shark? It is how we can make the most out of our resources. It is not a crime," the shark fin trader continued.

Hope

"There is still very limited scientific information of sharks in Thai waters, since they are not the important commercial species," explained Dr. James True, a researcher from Excellence Center for Biodiversity of Peninsular Thailand and my research supervisor at Prince of Songkla University. Over the last 20 years, the massive fishing industries in Thai waters seem to have greatly exceeded the rates for their populations to recover, as suggested by the massive declines of sharks in Thai fisheries. "There are not many species of sharks that can withstand large-scale fishing operations. Since most of the sharks caught in Thai fisheries nowadays are taken from the waters of neighboring nations, their populations seem to have gotten perilously low in Thai waters as the fishermen have been telling you." Projections suggest that if the rate of exploitation remains unchanged, it is likely that many shark populations will keep decreasing and eventually could be driven toward extinction.

Dr. James D. True, a lead researcher at the Centre of Excellence for Biodiversity of Peninsular Thailand with taxonomic specimens being collected at Prince of Songkla University, Thailand. Despite the ongoing overexploitation that has been recorded, there is still limited scientific understanding of sharks in Thailand, which greatly hinders management efforts, similarly to other countries in the Southeast Asia region. © Sirachai Arunrugstichai / National Geographic (Thai Edition)

Despite the fact that there are only a few detailed analyses on the role of sharks as high-order predators occupying the top spots up on the food chain, they are considered to be an important component to a healthy marine community. With more than 350 million years of evolutionary history as high-order predators, it is likely that sharks and their elasmobranch relatives have been an evolutionary driving force, influencing the marine community since the ancient times (Heithaus *et al.*, 2010). Through predation, sharks exert top-down control on their prey species, directly regulating the abundance and influencing the behaviors of their preys, which in turn affects the marine community as a whole (Ferretti *et al.*, 2010; Heupel *et al.*, 2014).

According to several studies, the removal of sharks—especially the large predatory species—could potentially lead to substantial changes in the community structure of marine ecosystems, which could consequently cause long-lasting economic and ecological impacts. However, due to the complexity of trophic interaction in marine food web, it is challenging to quantify the effect that the disappearance of sharks would have. Fortunately, more and more people are becoming aware of the ecological role sharks play in marine ecosystems. The fear from the past may still linger, but it is continuously being replaced by a better understanding.

A volunteer diver lowers a basket containing a brownbanded bamboo shark (chiloscyllium punctatum) into the sea of Chonburi, Thailand. With the limited management in place, most of the conservation efforts of sharks in Thai waters are awareness campaigns led by NGOs and the diving community. © Sirachai Arunrugstichai

In addition, there has been rapid growth in the eco-tourism industry, which may be more hopeful news for sharks. According to a study in Palau by Vienna *et al*. (2011), a single grey reef shark *Carcharhinus amblyrhynchos* could potentially generate $1.9 million USD throughout its lifetime to the tourism industry of Palau, a nation famous for its shark-diving industry, while the same shark could yield an estimate of only $108 USD to the fishing industry. As shown in numbers, the economic value of sharks to tourism are much larger than to fisheries, fueling the growing incentive to conserve them. This is demonstrated by the ban of shark fisheries in nations such as Palau, Maldives, and the Bahamas, which enjoy substantial economic benefits of $18 million, $38.6 million and $113.8 million USD respectively from shark-related tourism (Haas, Fedler & Brooks, 2017; Martin *et al.*, 2006; Vianna *et al.*, 2011).

In the night, a pair of whale sharks Rhincodon typus feed on plankton attracted by the light from a dive boat under the water's surface in Kooddoo Island, Republic of Maldives. Whale sharks in this area have learned to feed on plankton and bait fish that congregate under the light from fishing boats. Dive operators have started using light to attract these giants for tourists, which are now becoming one of the highlight attractions of the southern sea of Maldives. © Sirachai Arunrugstichai

Take me Back to the Sea

In a luxurious mall in downtown Bangkok, dim light penetrated through the acrylic tunnel of an aquarium. The light rays reminded me of those mornings in the old days, when I was out chasing sharks at first light. To me, their graceful movement and cautious nature were far from the widely perceived image of mindless killers of the deep. I saw them as magnificent creatures with an important part to play in their aquatic realm. During my 11 years working at sea, sharks have always left me (the intruder) alone, while my own species decimated their population and destroyed their home within a few decades. Among the deafening noises in the aquarium, visitors both young and old stood in awe of the colourful and bizarre marine life in the acrylic tank. I could not help but think that us humans as a species are only just a tiny fragment at the tip of one evolutionary road, which can be all traced back to the oceans. What we are doing today is simply burning down our oldest home, the home where all life on Earth started.

A child gazes at a captive sand tiger shark *Carcharias taurus* while walking inside the acrylic tunnel at Siam Ocean World, an aquarium located in Bangkok, Thailand. Despite some criticisms in some instances on keeping threatened species in captivity, public aquariums are the main place for public to learn about these marine predators. © Sirachai Arunrugstichai / National Geographic (Thai Edition)

A sand tiger shark *Carcharias taurus* slowly cruised past me on another side of the tank. I have not encountered them in the water before, but I know that the intimidating face is in direct contrast with its docile nature. This particular shark that I was looking at was not from Thai waters, but was imported from Australia. Suddenly, a soft voice spoke behind me, prompting me to look at the source instantly. “Sharks do not like eating people, my dear,” a young mother told her son. Her words made me smile. It has been long overdue for sharks to be looked at as they are: predators with power and grace and an important part of the marine ecosystem—not the mindless man-eaters that they have long been feared. I walked out of the aquarium, reminiscing of the good old days of being in the sea, waiting for them to swim by.

A Caribbean reef shark *Carcharhinus perezi* cruises below the surface with a school of Bermuda chub *Kyphosus sectatrix* in the late evening light in Bimini, Bahamas. As high-order predators of marine ecosystems, sharks are considered to have a critical role in keeping the marine community in balance through predation, and an indicator of biological abundance. © Sirachai Arunrugstichai / Save Our Seas Foundation

SPECIES INFORMATION

1. *Squalus hemipinnis* White, Last & Yearsly, 2007

Common names: Indonesian Shortnose Spurdog, Indonesian Shortsnout Dogfish

Family: Squalidae

Size: Born: ~16-22 cm. Mature: 42 cm (male); 60-72 cm (female) Max: at least 52 cm (male); at least 74 cm (female)

Distribution: Known to be endemic to eastern Indonesia, from Cilacap, Central Java and Tanjung Luar, eastern Lombok. The catch locality of the recorded individuals in this study could not be accurately determined but it was reported to be from the Andaman Sea.

Habitat: Unknown, but likely to be at depths of at least 100 m.

Biology: Viviparous, with yolk-sac dependency; gives birth to litters of 3-10 pups (average of 6-7 pups) with an unknown gestation period. Diet unknown but likely includes small bottom-dwelling fishes, cephalopods and crustaceans.

Conservation status: IUCN Red List: Near Threatened.

References: Ebert *et al.* (2013); White *et al.* (2006); White & Couzens (2009).

2. *Chiloscyllium hasselti* Bleeker, 1852

Common names: Indonesian Bamboo Shark, Hasselt's Bamboo Shark

Family: Hemiscylliidae

Size: Hatch: 9-12 cm. Mature: 44-54 cm (male) Max: at least 61 cm.

Distribution: Tropical Indo-West Pacific. From Burma and Vietnam to Indonesia and New Guinea.

Habitat: Little known, but likely close inshore to the depths of 12 m.

Biology: Oviparous, with eggs hatching in around December. Egg cases are deposited on benthic marine plants. Diet unknown but likely includes small bottom-dwelling invertebrates and possibly small fishes.

Conservation status: IUCN Red List: Near Threatened.

References: Ebert *et al.* (2013); Last *et al.* (2010); White (2009).

3. *Chiloscyllium punctatum* Müller & Henle 1838

Common names: Brownbanded Bamboo Shark; Grey Carpet Shark

Family: Hemiscylliidae

Size: Egg cases: 11-15 cm. Hatch: 13-18 cm. Mature: ~82 cm (male); ~87 cm (female) Max: at least 132 cm.

Distribution: Tropical Indo-West Pacific from east India to north Australia and New Guinea and to Japan.

Habitat: Coral reefs, tidal pools, muddy banks, mangroves and seagrasses bed; from the intertidal zone to a depth of at least 85 m.

Biology: Oviparous, with round egg cases. May deposit up to 153 egg cases, with hatching time approximate 90 days. Diet consists primarily of benthic invertebrates and small fishes.

Conservation status: IUCN Red List: Near Threatened.

References: Dudgeon *et al.* (2016a); Ebert *et al.* (2013); Last *et al.* (2010).

4. *Stegostoma fasciatum* (Hermann 1783)

Common names: Zebra Shark, Leopard Shark

Family: Stegostomatidae

Size: Hatch: 20-36 cm. Mature: 145-185 cm (male); 170 cm (female) Max: at least 235 cm (with report of 354 cm needing validation).

Distribution: Tropical Indo-West to Central Pacific from southeastern Africa to New Caledonia, Japan and Palau.

Habitat: Coral reefs, sands between reef, soft bottoms, ranging from intertidal to 62 m. Juveniles are hardly seen and may live in deeper water of over 50 m.

Biology: Oviparous, with dark brown or purplish-black egg cases, anchored to benthic substrate with masses of fine hair-like fibres. Age at maturity is approximate 6-8 years for female, and ~7 years for males. Diet consists primarily of mollusks, but also includes crustaceans and small fishes, and possibly including sea snakes.

Conservation status: IUCN Red List: Endangered.

References: Dudgeon *et al.* (2016b); Ebert *et al.* (2013); Last *et al.* (2010).

5. *Mustelus cf. mosis*

Common names: Bengal Smoothhound

Family: Triakidae

Size: Born: Unknown; Mature: Unknown; Max: at least 71 cm.

Distribution: Unknown, possibly endemic to the Andaman Sea

Habitat: Unknown

Biology: Reproductive strategy unknown; either viviparous with histotrophy or yolk sac placenta as known in other members of the genus *Mustelus*. Diet unknown, likely consisting of small fishes and invertebrates.

Conservation status: IUCN Red List: Not Evaluated.

References: None

6. *Carcharhinus albimarginatus* (Rüppell 1837)

Common names: Silvertip Shark

Family: Carcharhinidae

Size: Born: 63-80 cm. Mature: 160-180 cm (male); 160-199 cm (female) Max: at least 300 cm.

Distribution: Tropical Indo-Pacific, widespread from southeastern African to central America, but the distribution is fragmented.

Habitat: Continental shelf, offshore islands, coral reefs, offshore banks and inside lagoons. Occurs throughout the water column from the surface to depths of at least 600-800 m. Youngs are known to occur in shallower water near the shore, while the adults are more wide ranging, however it is not an oceanic species.

Biology: Viviparous, with a yolk-sac placenta; gives birth to litters of 1-11 pups (average of 5-6 pups) biennially with approximate 12 months gestation period. Diet consists of a variety of midwater and benthic fishes, including smaller sharks and rays.

Conservation status: IUCN Red List: Vulnerable.

References: Ebert *et al.* (2013); Espinoza *et al.* (2016); Last *et al.* (2010).

7. *Carcharhinus amblyrhynchos* (Bleeker 1856)

Common names: Grey Reef Shark, Losenose Blacktail Shark

Family: Carcharhinidae

Size: Born: 45-60 cm. Mature: 130-145 cm (male); 120-142 cm (female) Max: at least 233-255 cm.

Distribution: Tropical Indo-Pacific, widespread from eastern Africa to the Galapagos Islands.

Habitat: Continental and insular shelves and adjacent oceanic waters. Occurs in coral reefs, near drop-offs or in lagoon passages, from the surface to 140 m depth.

Biology: Viviparous, with a yolk-sac placenta; gives birth to litters of 1-6 pups after an approximate 12 months gestation period. Age at maturity is about 7-11 years. Diet consists primarily of small fishes with some crustaceans and cephalopods.

Conservation status: IUCN Red List: Near Threatened.

References: Ebert *et al.* (2013); Last *et al.* (2010); Smale (2009).

8. *Carcharhinus brevipinna* (Valenciennes 1839)

Common names: Spinner Shark, Longnose Grey Whaler, Inkytail Shark, Smoothfang Shark

Family: Carcharhinidae

Size: Born: 60-75 cm. Mature: 159-203 cm (male); 170-200 cm (female) Max: at least 278 cm.

Distribution: Cosmopolitan in tropical and warm temperate waters of the Indian, Western Pacific and Atlantic Oceans.

Habitat: Continental and insular shelves, coastal-pelagic and common close inshore near beaches, in bays and off river mouths. Occurs from the surface to the depth of 75 m. Nursery grounds are known to be located in nearshore shallow areas.

Biology: Viviparous, with a yolk-sac placenta; gives birth to litters of 3-15 pups (litter size increases with size of the female) with approximate 11-15 months gestation period and 2 years reproductive cycle. Age at maturity is about 5 years for males, and 8-10 years for females. Diet consists mainly of teleost fishes, but also including rays and cephalopods.

Conservation status: IUCN Red List: Near Threatened.

References: Burgess (2009); Ebert *et al.* (2013); Last *et al.* (2010)

9. *Carcharhinus leucas* (Valenciennes 1839)

Common names: Bull Shark, River Whaler, Freshwater Whaler, Zambezi Shark

Family: Carcharhinidae

Size: Born: 56-81 cm. Mature: 157-226 cm (male); 180-230 cm (female) Max: at least 340 cm.

Distribution: Cosmopolitan in tropical and warm temperate waters, also occurring in freshwater, brackish water and in lakes. Usually live near bottom to depths of at least 152 m.

Habitat: Close inshore in lagoons, bays, river mouths, passages between islands, coastal canals, around wharfs and along surf line, also occur far upstream in freshwater rivers and lakes.

Biology: Viviparous, with a yolk-sac placenta; gives birth to litters of 1-13 pups in estuaries and rivers with approximate 10-11 months gestation period. Age at maturity is estimated at 15-20 years for both sexes. Diet consists a very broad range of food, including sea turtles, crocodiles, birds, dolphins, whale offal, terrestrial animals, and invertebrates, but prefer teleost fishes and elasmobranchs.

Conservation status: IUCN Red List: Near Threatened.

References: Ebert *et al.* (2013); Last *et al.* (2010); Simpfendorfer & Burgess (2009).

10. *Chiloscyllium melanopterus* (Quoy & Gaimard 1824)

Common names: Blacktip Reef Shark

Family: Carcharhinidae

Size: Born: 33-52 cm. Mature: 91-100 cm (male); 96-112 cm (female) Max: less than 200 cm.

Distribution: Tropical Indo-West and Central Pacific, from southeastern Africa to the Central Pacific Islands and Mediterranean through Suez Canal.

Habitat: Shallow water on coral reefs, lagoons, reef flats and near drop-offs.

Biology: Viviparous, with a yolk-sac placenta; gives birth to litters of 2-4 pups. Information on reproductive biology are limited and conflicting, with gestation period reported to range between 8-16 months from different locations. Age at maturity is unknown. Diet consists primarily of small fishes, but also including cephalopods, other mollusks and crustaceans.

Conservation status: IUCN Red List: Near Threatened.

References: Ebert *et al.* (2013); Heupel (2009); Last *et al.* (2010).

11. *Carcharhinus plumbeus* (Nardo 1827)

Common names: Sandbar Shark, Thickskin Shark, Brown Shark

Family: Carcharhinidae

Size: Born: 56-75 cm. Mature: 130-180 cm (male); 145-185 cm (female) Max: about 240 cm, but possibly reach 300 cm. Size varies between populations.

Distribution: Cosmopolitan in tropical and warm temperate waters, but the distribution is patchy.

Habitat: Continental and insular shelves and adjacent deep waters and oceanic banks. Commonly occurs in bays, harbours and river mouths

Biology: Viviparous, with a yolk-sac placenta; gives birth to litters of 1-14 pups (commonly 5-12, while litter size also increases with size of the female) every 2-3 years with approximate 8-12 months gestation period. Age at maturity varies between stocks, but generally range between 8-14 years for males, and 7.5-16 years for females. Diet consists primarily of fishes, but including crustaceans and cephalopods.

Conservation status: IUCN Red List: Vulnerable.

References: Ebert *et al.* (2013); Last *et al.* (2010); Musick *et al.* (2009).

12. *Carcharhinus sorrah* (Valenciennes 1839)

Common names: Spottail Shark, Sorrah Shark

Family: Carcharhinidae

Size: Born: 45-60 cm. Mature: 106 cm (male); 110-118 cm (female) Max: at least 160 cm.

Distribution: Tropical Indo-West Pacific, from southeastern Africa to northern Australia, Solomon Islands and China.

Habitat: Continental and insular shelves, including coral reefs. Occurs throughout the water column from the surface to the depth of at least 140 m, but commonly at around 20-50 m.

Biology: Viviparous, with a yolk-sac placenta; gives birth to litters of 3-8 pups each year after 10 months gestation period. Age at maturity is about 2-3 years. Diet consists primarily of teleost fishes, but also including cephalopods and crustaceans.

Conservation status: IUCN Red List: Near Threatened.

References: Ebert *et al.* (2013); Last *et al.* (2010); Pillans *et al.* (2009).

13. *Galeocerdo cuvier* (Péron & LeSueur 1822)

Common names: Tiger Shark

Family: Carcharhinidae

Size: Born: 51-76 cm. Mature: 226-290 cm (male); 250-350 cm (female) Max: at least 550 cm (with one record of 740 cm).

Distribution: Cosmopolitan in tropical and temperate waters.

Habitat: Occurs close inshore to continental and insular shelves, throughout the water columns from the surface to at least 140 m depth.

Biology: Viviparous, with histotrophy (this species is the only non-placental whaler shark); gives birth to litters of 10-82 (average of 33 pups) after a 12-16 months gestation period. Age at maturity is about 7-10 years for males, and 8-10 years for females. Diet consists a very broad range of food, including sea turtles, dugongs, birds, snakes, dolphins, crustaceans, cephalopods, teleost fishes and elasmobranchs.

Conservation status: IUCN Red List: Near Threatened.

References: Ebert *et al.* (2013); Last *et al*. (2010); Simpfendorfer (2009).

14. *Negaprion acutidens* (Rüppell 1837)

Common names: Sicklefin Lemon Shark

Family: Carcharhinidae

Size: Born: 45-80 cm. Mature: 220-240 cm for both sexes Max: at least 310 cm.

Distribution: Tropical Indo-West Pacific and Central Pacific, from southeastern Africa to Pacific Islands.

Habitat: Close inshore around bays, estuaries, sandy plateaus, coral lagoons, reef flats, reef edges and reef shelves. Occurs near bottom, from the surface to 30 m depth.

Biology: Viviparous, with a yolk-sac placenta; gives birth to litters of 1-14 pups (average of 9 pups) after 11 months gestation period with possibly 2 years reproductive cycle. Age at maturity is about 7-11 years. Diet consists primarily of small fishes and rays, but also including crustaceans and cephalopods.

Conservation status: IUCN Red List: Vulnerable (Endangered in southeast Asia)

References: Ebert *et al.* (2013); White *et al.* (2006).

15. *Scoliodon cf. laticaudus*

Common names: Bengal Spadenose Shark

Family: Carcharhinidae

Size: Born: Unknown; Mature: less than ~45 cm (males) Max: at least 56 cm.

Distribution: Unknown, possibly endemic to the Andaman Sea

Habitat: Unknown, but likely to be close inshore in rocky area and river mouth as known in the other members of the genus.

Biology: Reproductive strategy unknown; but likely to be viviparous with unusual columnar placenta and umbilical cord as known in other members of the genus. Diet unknown, likely consisting of small fishes and invertebrates such as shrimps and cuttlefishes.

Conservation status: IUCN Red List: Not Evaluated.

References: None

16. *Triaenodon obesus* (Rüppell 1837)

Common names: Whitetip Reef Shark

Family: Carcharhinidae

Size: Born: 52-60 cm. Mature: 104-116 cm (male); 105-122 cm (female) Max: at least 160 cm (with report of 213 cm).

Distribution: Tropical Indo-Pacific, from eastern Africa to the Central America, including Pacific Islands.

Habitat: Continental shelves and island terraces near coral reefs, coral lagoons and usually resting on or near the bottom, in caves and crevices during day time. Occurs from the surface to 330 m depth, but usually in clear shallow water in depths between 8-40 m.

Biology: Viviparous, with a yolk-sac placenta; gives birth to litters of 1-5 pups (commonly 2-3) after at least a 5 months gestation period. Age at maturity is about 7-8 years for both sexes. Diet consists of bony fishes and cephalopods.

Conservation status: IUCN Red List: Near Threatened.

References: Ebert *et al.* (2013); Last *et al.* (2010); Smale (2005).

17. *Sphyrna lewini* (Griffith & Smith 1834)

Common names: Scalloped Hammerhead

Family: Sphyrnidae

Size: Born: 45-60 cm. Mature: 130-145 cm (male); 120-142 cm (female) Max: at least 233-255 cm.

Distribution: Cosmopolitan in tropical and temperate waters.

Habitat: Coastal-pelagic, semi-oceanic over continental and insular shelves and adjacent deep waters from the surface to the depths greater than 1000 m. This species also commonly occurs close inshore in enclosed bays and estuaries. Juveniles often occur in shallow inshore areas, sub-adults in deeper water, while adults aggregate far offshore around sea mounts.

Biology: Viviparous, with a yolk-sac placenta; gives birth to litters of 13-41 (average of 25 pups) biennially after a 8-12 months gestation period with a following resting period of 1 year. Age at maturity is about 10 years for males and 15 years for females. Diet includes sharks and rays, but primarily consists of bony fishes and cephalopods.

Conservation status: IUCN Red List: Endangered.

References: Baum *et al.* (2007); Ebert *et al.* (2013); Last *et al.* (2010).

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