SUSTAINABLE MANAGEMENT OF ESTUARINE CROCODILE (*Crocodylus porosus*) IN SARAWAK

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Foreword by the Director of Forests

The population of Estuarine Crocodile (*Crocodylus porosus*) in Sarawak has increased significantly over the last thirty years following the implementation of conservation efforts and enforcement of protection measures by the State Government. This is evident by the presence of the species along many rivers, estuaries, streams, waterways and drainage systems in many parts of the State where such occurrence was hardly encountered in the past. The recent population survey of Estuarine Crocodile was conducted between 2012 and 2015, covering a total distance of about 2,000 km over 50 rivers and tributaries throughout Sarawak. It indicated that the averaged population densities of the species was about 6 individuals/km, as compared to only 1 individual for every 20 km in the early 1980s. Quite unfortunately, our success in conserving the Estuarine Crocodile over the last thirty years has brought about a rather negative repercussion to general public, i.e. 'increase in Human-Crocodile Conflict (HCC), causing injuries and loss of many human lives to the predator'. This makes crocodile to be seen as a nuisance animal and pest by many and create a perception that they should be exterminated, despite the fact that the species is legally protected by law and an important biological asset to the State of Sarawak. Thus, to address this tricky situation and conflicting views on the species a Project entitled "Sustainable Management of Estuarine Crocodile (*Crocodylus porosus*)" was implemented by the Forest Department of Sarawak, through its Nature Conservation & Constitution Division, from 2012 until 2019. The project was headed by the author, Dr. Engkamat Lading, who is also a Wild Life Officer in the Department. With some funding from the Ministry of Energy and Natural Resources which was formally known as the Ministry of Natural Resources and Environment, Malaysia the

Department has conducted several activities under the project which include enhancement of crocodile surveys, conducting Education and Awareness program on crocodile in many places in Sarawak, culling of nuisance crocodiles, down-listing of Estuarine Crocodile from CITES Appendix I to II which consequently allows regulated commercial hunting of the species, and finally the formulation of the Management Plan for Estuarine Crocodile in Sarawak for 2016-2020. The implementation of the above project has increased the level of awareness among the general public towards crocodile, and, eventually, significantly reduce the rate of crocodile attacks on human over the last two years (2018 & 2019). Therefore, to keep the issue on Human-Crocodile Conflict well-addressed, and to keep the species well-conserved, continuous implementation of the above project for many years to come is crucial so that people can live harmoniously with the crocodilian and at the same time, 'tapping out' benefits from the existence of the predator.

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Datu Hamden bin Haji Mohammad

Director of Forests, Sarawak

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I would like to express my gratitude to the former Directors of the Forest Department, Sarawak, Datu Haji Ali bin Yusop and Tuan Haji Sapuan bin Ahmad, the present Director, Datu Hamden bin Mohammad, and the then Assistant Director of Nature Conservation and Constitution Division, Tuan Haji Wan Shardini Wan Salleh, for the kind approvals they have granted to me and our field staff team to carry out the project. I would also like to thank the Ministry of Natural Resources and Environment (NRE), Malaysia for the financial support given to us, particularly for the acquisition of field equipment, including outboard engines, boats, fuel and travelling allowances for those involved in the project. The project could not been successfully completed without the involvement and commitment of our field officers and staff to carry out crocodile surveys during the four long years from 2012 until middle of 2015 along major rivers and its tributaries, and along numerous and treacherous deltas and creeks, looking for Estuarine Crocodile. I would like to thank them all for their high commitment and enthusiasm in the task. Among the officers who have given significant contribution to the project are Mr. Micheal Tupong, Mr. Nixon Grang Mang, Ms. Dayang Nuriza, Ms. Nur Afiza, Ms. Chombi, Mr. Rodgers, Mr. Munau Jawa, Mr. Mohidin Morni, Mr. Ramon Tuton, Mr. Kuye (retired), Mr. Latiff Lay (retired), Mr. Sam Akhbar Jobeli, Mr. Jeffri, Mr. Wan, Mr. Hossen and Mr. Goswin. Apart from these officers a number of field staff from Regional Offices in Sarikei, Sibu, Bintulu and Miri have also involved in one way or the other when the surveys were conducted within their respective regions. I am really grateful and thankful to all of you for your assistance and commitment that you have rendered until the completion of the field work. Without your involvement and high commitment it is highly unlikely that the project could be completed in time. Thank you once again.

EXECUTIVE SUMMARY

The alarming rate of crocodile attacks that occurred in Sarawak for the last 10 years has prompted the State Government to find a friendly solution to address the issue. In addressing the issue, the Forest Department of Sarawak (with some funding from the Federal Government) initiated a project entitled “Sustainable Management of Estuarine Crocodile (*Crocodylus porosus*) in Sarawak” from 2012 until 2015, which was extended until the end of 2019. Among some of the activities carried out under the Project are comprehensive crocodile surveys and research on the species along major rivers Statewide, Education & Awareness Program on Crocodiles, culling of nuisance crocodiles, down-listing of Estuarine Crocodile from CITES App. I to App. II (which eventually leads to commercial harvest of the reptilian species in Sarawak), establishment of Crocodile Removal Zones (CRZs), construction of a Crocodile Sanctuary that serves as a rescue center for crocodiles and the introduction of Crocodile-based tourism activities in a number of regions within the State. The implementation of the project has had a positive impact on the issue of Human-Crocodile Conflict and has remarkably reduced the number of crocodile attacks involving the public, apart from enabling sustainable-use of Estuarine Crocodile and its resources in Sarawak. As it is crucial to have the issue on Human-Crocodile Conflict permanently addressed, continuous funding from the Government is needed to extend implementation of the project to the next Malaysia Plan.

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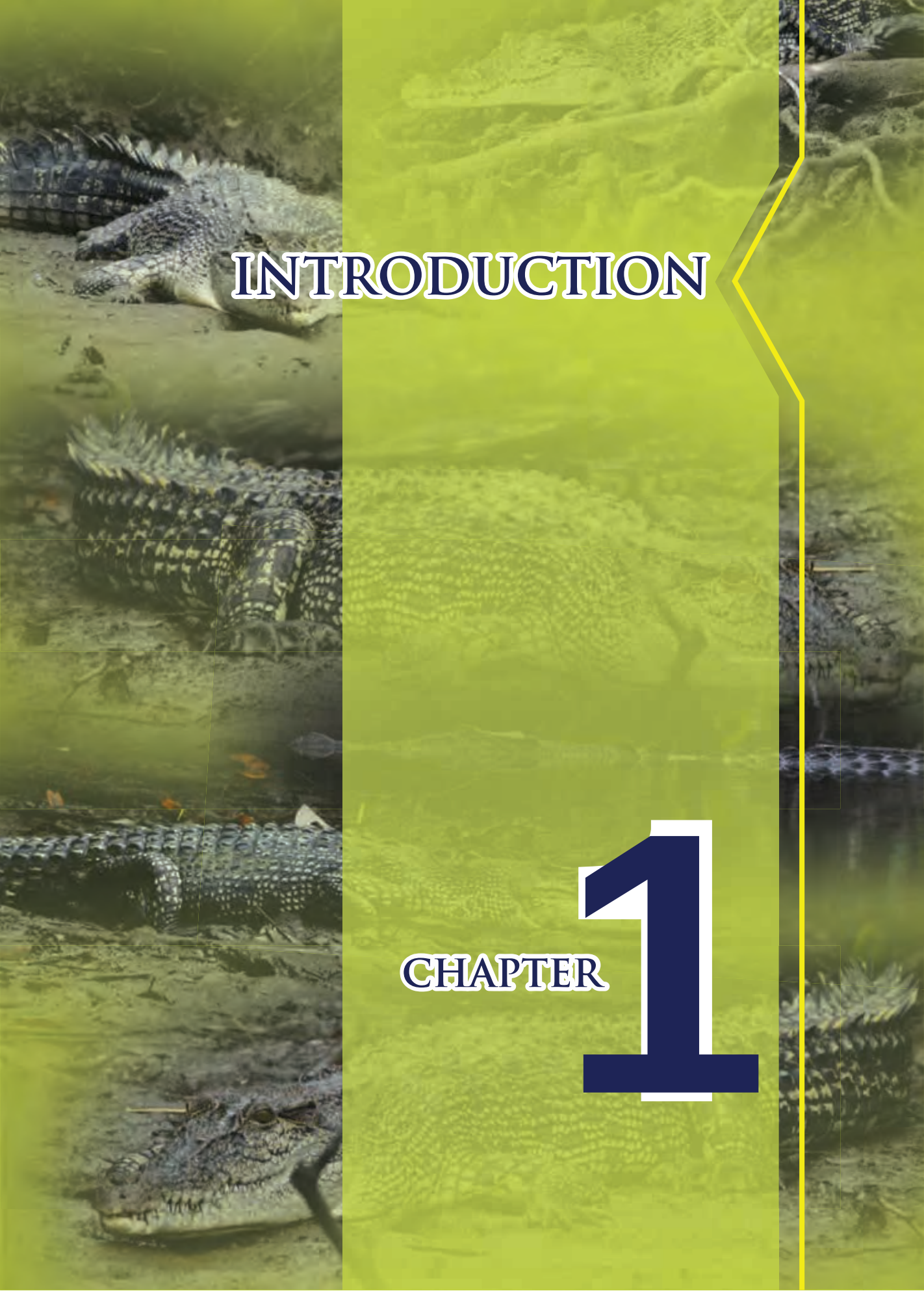


INTRODUCTION

CHAPTER 1

CHAPTER 1: INTRODUCTION

1.0. General Introduction

Though Sarawak is popularly known as the 'Land of Hornbills', some local people describe it as the "land of many rivers" (Ritchie & Jong, 2002). Due to its rugged topography, especially in its interior, rivers have become one of its main modes of transportation for local people. Rivers also provide food and water to the local communities living along riverbanks. At the same time, rivers and its estuaries provide natural habitats for many species, including the Estuarine Crocodile or the Saltwater Crocodile (*Crocodylus porosus*). Locally, the crocodile is known as 'buaya katak' among the Malay communities, while the Ibans called it 'baya' or 'jagu'.

Figure 1.Map of Sarawak showing networks of its main rivers and rivers' system (Engkamat, unpublished report).

The Estuarine Crocodile population is distributed across a wide range of saline and freshwater habitats, including in rivers and creeks, along the coastlines and coastal flood plains as well as in lagoons, swamps, rivers and canal outfalls (Webb & Manolis, 1989). In Sarawak, a high proportionof the crocodile population can be found in freshwater habitats. These habitats include rivers that are not subjected to

tidal influence, freshwater swamps, and oxbow lakes. There are also reports on crocodile sightings in monsoon drains and oxidation ponds in oil palm mills (Engkamat, unpublished report).

The Estuarine Crocodiles are the largest living reptile on Earth – they can grow up to 6–7 m long (Webb et al., 1978; Erickson et al., 2012). Similar to other crocodilian species, Estuarine Crocodiles are opportunistic feeders where they use the active hunting or 'sit-and-wait' strategy to forage for food (Cooper & Jenkins, 1993). Estuarine crocodile hatchlings, yearlings and young juveniles have been found to consume smaller animals, such as insects, fishes, amphibians, and small reptiles. Meanwhile, larger juveniles and adults are known to feed on larger preys such as monkeys, wild boars, buffalos and even human being (Kumar et al., 2012; Engkamat, unpublished report).

1.1. Evolution

Crocodilians are the world's largest living reptiles which have been around for about 240 million years (Webb & Manolis, 1989). Their anatomical and physiological adaptations have allowed them to become one of the most dangerous aquatic-predators. The Estuarine Crocodile (Fig. 2) is one of 24 species of crocodilians found in the world (Webb & Manolis, 1989) and has been distributed successfully within its range. Crocodilians like the Estuarine crocodiles, alligators, the American caimans and the gharials are known as living relicts of the dinosaurs. These crocodile species have diversified considerably over the past 200 million years, spreading to many parts of the world and adapting to a wide variety of ecological niches (Messel et al., 1981; Webb & Manolis, 1989; Campbell et al., 2010; Brazaitis & Watanabe, 2011). The Estuarine Crocodile is the largest of all among the crocodilian species. In some cases, matured males could reach to 7 meters in length and weighing over a ton (Webb & Manolis, 1993). In this light, male crocodilians can grow larger and often faster than females, although they may reach sexual maturity at the same age in their natural environment.

Figure 2. An adult Estuarine Crocodile (*Crocodylus porosus* Schneider) basking on a riverbank.

1.2. Biology and General Ecology

The survival of the Estuarine Crocodiles is attributed to their heavily armored skin which is made of numerous large and small bony plates or 'osteoderms' (Cogger, 1993; Grigg & Gans, 1993). The species has a broad and rounded snout, while their teeth are set in an irregular row. Their mouths possess a tissue that can arise from the floor of their lower jaws to overlap a bony fold on the roof of their mouth. This tissue completely isolates the mouth from the pharynx to allow the Estuarine Crocodile to keep its mouth open in the water without flooding its lungs and stomach. Thus, an Estuarian Crocodile can breathe through its valve nostrils even when its mouth is filled with water (Webb & Manolis, 1998). Furthermore, valves in the crocodiles' nostrils prevent water from flooding the nasal tube when they are submerged.

The skin of these crocodiles is covered with keratinized scales bearing a pore that is generally thought to be a sensory organ. The high density of scales, particularly on the upper and lower jaws, allows these crocodiles to sense movement underwater (Grigg & Gans, 1993). They can also choose to expose a minimum portion of their body with only eyes, ears and nostrils being above water, while the bulk of their body remains submerged.

Crocodiles, in general, have a superior perception of sound. They also have an advance sense of smell and have a more complex brain compared to other living reptiles (Webb & Manolis, 1998). Estuarine Crocodiles can remain underwater for an extended period to conceal themselves. An average-sized crocodile can remain submerged for about 15 minutes per dive, and larger individuals (> 4 m in length) can stay underwater for up to 2–3 hours (Caldecott et al., 2005). Larger crocodiles usually have a higher amount of hemoglobin, which carries oxygen from the lungs to the rest of the body in their blood than smaller individuals. At the same time, they can use the waste product of metabolism, the bicarbonate ions, as the trigger to unload the oxygen it carries (Vines, 1995; Caldecott et al., 2005).

Estuarine Crocodiles reproduce by internal fertilization. Males reach sexual maturity at around 16 years of age while females are sexually mature at 10–12 years (Webb et al., 1977; Webb & Manolis, 1998; Magnusson et al., 1981). Mating usually takes place during the wet season when water levels are the highest (Webb & Manolis, 1998). However, a study conducted in Kuching Wetland National Park (KWNP) (Engkamat, 2020) observed a higher number of hatchlings between October and February. This finding suggests that the major breeding season for Estuarine Crocodile is likely to begin in August and females start to lay eggs between September and early October. This finding is consistent with the breeding season of the species observed in Sungai Klias, Sabah, where numerous hatchlings were reported to be sighted between December and February (Shahrul & Stuebing, 1996).

Besides the period between November and February, the emergence of numerous hatchlings was observed in KWNP from April and June. This observation further suggests that the breeding and hatching seasons for the species may occur twice a year, specifically, from September to November, and between March and April. This finding is also consistent with the report by Stuebing et al. (1985) on Estuarine Crocodiles in Jong's Crocodile Farm. According to the report, breeding activities appeared to take place either between March and May or from October to

November. Eggs are laid during two discrete periods in the year. Females are said to start nesting within two weeks before, or following the previous year's season (Jong, pers. comm.). Although crocodiles' nesting behavior has been well documented (Webb et al., 1977; Whitaker, 1984), there are still limited studies on the environmental factors that trigger the breeding activity (Stuebing et al., 1985). Both Webb (1989) and Whitaker (1984) indicated that seasonal or monsoon rains trigger the breeding response of *Crocodylus porosus*, but exactly how or when, remains unresolved. Johnson Jong (per. comm.) stated that males are usually found to copulate more actively during thunderstorms, but this fact is yet to be substantiated on individual crocodiles in their natural habitat (Engkamat, 2020).

Like most reptiles, Estuarine Crocodiles lay eggs for approximately five months after fertilization with a clutch size varying from 16 to over 80 cm (Webb & Manolis, 1998). A female crocodile will select a nesting site and bury the eggs under a mound of leaves. The female will remain in the nest or within immediate vicinity to defend a fairly large territory around the nest for about 75 to 106 days (Anonymous, 2001), specifically throughout the incubation period of between 80–90 days. As in all crocodilians, the sex of the hatchlings is determined by the temperature of the nest. At the temperature of 28–30°C, all hatchlings will be females, while temperature between 30–32°C will produce male hatchlings (Webb & Manolis, 1998). At the temperature of 33°C or more, hatchlings will either be females or suffer mortality (Lang et al., 1994). Studies have also indicated that if the temperature in the central part of the nest rises above 33–34°C or plummets to 26–28°C for a long period of time, the embryos can be killed or experience deformities, such as misalignment of the jaws, deformities of the spine, curling of the tail and an inability to absorb the yolk once it is enclosed within the body cavity (Webb & Manolis, 1989). While adult crocodiles are formidable animals with few natural threats, their eggs, hatchlings, and juveniles are vulnerable to threats. In the wild, only an estimated 54% of hatchlings will survive their first year (Webb et al., 1983; Webb & Manolis, 1989).

Apart from floods, the mortality of eggs and death of hatchlings are partly due to predation by other animals such as monitor lizards, goannas, raccoons, large fish and other crocodiles (Webb & Manolis, 1998). In term of growth pattern, an Estuarine Crocodile hatchling is about 29.3 cm in length, and it can reach a total length of 73.0 cm in its first year. It will grow to a length of around 107.7 cm in the second year and will be able to attain a total length of 169.8 cm in five years (Webb & Manolis,

1998). The life span of crocodilians is at least 25 years and could exceed 50 years (Webb & Manolis, 1998).

Another behavioral adaptation that contributes to the success of the crocodiles is basking (Messel et al., 1989), which makes Estuarine Crocodiles active throughout the year. In this regard, reptiles have a low metabolic rate and need to conserve energy. Hence, crocodiles bask in the sun to raise their body temperature. They come out of the water at sunrise, lie on the banks to bask in the sun.

When their bodies have warmed up, these crocodiles will move to shadier areas or go back into the water. Crocodiles stay underwater at night to conserve heat because water holds heat better than air. This direct use of solar energy enables large crocodiles to survive even when food is scarce (Messel et al., 1989). Studies have suggested that Estuarine Crocodiles rarely let their body temperatures rise to 35°C before moving to a cooler location in the water or under the shade.

Adult Estuarine Crocodiles have a strong sense of territory (Webb & Messel, 1978; Webb & Manolis, 1989). During the first or second year of their lives, young crocodiles will be within the proximity of their mother's territorial den pool. Once they are grown, they will leave the den and start travelling. Subsequently, they will make their dens and presumably defend their territory from encroachment by conspecifics of either sex (Webb & Messel, 1978). It is this habit of exploiting its environment that has allowed crocodilian species to survive. Crocodiles will consider either a nest, a pool, a den or a system of trails as their home. They will live in a specific site for a long time, and some will live there for generations (Webb & Messel, 1978; Campbell et al., 2013).

Estuarine Crocodiles communicate with each other using visual, sound and chemical signals (Webb & Manolis, 1989; Brazaitis & Watanabe, 2011). Hatchlings 'chirp' to signal the attention of their mother and to keep members of the 'creche' together (Webb & Manolis, 1989). After helping to dig out the hatchlings from the eggs, the female, or usually the mother, will carry them in her mouth down to the water where she will continue to protect them for some time (Brazaitis and Watanabe, 2011). As mentioned before, the survival rate for young Estuarine Crocodiles is very low. It is estimated that up to 75% of eggs laid in a season fail to hatch (Webb & Manolis, 1989). This could be due to several reasons, including infertility, flooding, overheating, poor gas exchange, and desiccation. Furthermore, young hatchlings were reported to fall victims to predators like birds of prey, large fish, otters, and

other crocodiles. Only a few will make it to adulthood, but once they do, they have little fear as they have no natural predators besides other larger crocodiles. However, over the years, human activities have caused the population to dwindle considerably. In many cases, crocodiles have been known to get caught in fishing nets. As a result, the crocodiles become entangled in the nets and drown.

Adults and juvenile crocodiles emit a low rumbling growl when they feel threatened by a predator. Male crocodiles will also growl to mark their presence during the mating season (Webb & Manolis, 1989). They also use their body posture as a visual form of communication, e.g., by raising their snout to signal submission and arching their tail to signify a threat (Brazaitis & Watanabe, 2011). Estuarine Crocodiles could also communicate via chemical signals, but the extent of this mean of communication is still unknown. Furthermore, glands underneath their chin and within the cloaca exude a type of musk which plays an important role in courtship and for territorial marking (Webb & Manolis, 1989).

The build-up to the wet season stimulates courtship and mating behavior. As the mating season approaches, males advertise themselves inconspicuous displays intended to drive off rival males and stimulate receptive females. Male interactions include chasing, head-slapping, and growling, and can escalate to full-blown combat leading to serious injury and death (Webb & Manolis, 1989). Females also become intolerant of other females and will jostle for dominance. Courtship observed in captive crocodiles involve snout contact and rubbing, body-riding, vocalizing, bubbling and circling, with both partners will constantly submerge their body and resurface. Copulation lasts up to 15 minutes and may take place while totally submerged (Webb & Manolis, 1989).

Females usually nest throughout the wet season from late October to May or June (Webb & Manolis, 1989). They often select a secluded area to build their nest. These areas are typically close to permanent water, basking site or wallows which are usually within 20 m from the site. Usually, the nests are constructed by first making a clearing and scraping piles of vegetation and earth together to form an elliptical mound up to 130–250 cm long, 120–225 cm wide and 33–80 cm high (Webb & Manolis, 1989). Some nests are built on floating mats of vegetation that extend out from the riverbank. Once the mound is constructed, the nesting female will dig an egg chamber and lays between 50 to 71 hard-shelled eggs (Webb & Manolis, 1989). The eggs are covered with leaves and other debris. It is important to cover the eggs probably as they will be incubated by the heat generated by the

rotting vegetation and by solar radiation. In the Northern Territory of Australia, most nests have an adjacent "wallow", which is a muddy depression where the female will stay to guard the nest (Webb et al., 1977). Observations in Kuching Wetland National Park found many wallows and couples of nests but did not find any eggs (Engkamat, 2020). The absence of eggs could be due to predation by animals like monitor lizards, long-tailed macaques and otters that were found to be in abundance within the area.

1.3. Diet

All species of crocodilians begin life as opportunistic feeders. At this stage, crocodiles feed by foraging on insects (Grenard, 1991). During their first year of life, young crocodiles or juveniles will rapidly gain access to a wider range of small preys, such as shrimps (Atyidae), crabs (Ocypodidae), insects and small fishes, mostly of the family Hemiramphidae (Shahrul & Stuebing, 1996; Britton, 2012), small reptiles and crustaceans. Crocodile surveys found that between November and February has shown that small shrimps (*Caridina* sp.) are plentiful along the lower part of rivers, river mouths and deltas, as indicated by their saltatorial behavior in response tospotlighting. Interestingly, apart from *Caridina* sp., a relatively high percentage (90%) of the diet of hatchlings captured in KWNP consists of another shrimp species, *Penaeus indicus* (Engkamat, 2020). Thus, the abundance of this shrimp species could be one of the environmental cues that regulate breeding cycles in Estuarine Crocodile. Chong (1980) found that along the coast of Peninsular Malaysia, there was a large number of shrimps emigrating from the sea into shallow coastal estuaries starting from March to June, as well as during the North-East Monsoons between November to December where it reaches its peak. The abundance of Estuarine Crocodile hatchlings along rivers and estuaries at the same period may be triggered by the mass inland water migration of the shrimp species (the dietary mainstay of hatchlings) from the surrounding seas. As these crocodiles grow, their jaw and teeth will approach the size of adult individual crocodiles. This growth allows them to consume more robust preys, such as larger fish, mollusks, birds and small mammals. The size of preys eaten by Estuarine Crocodiles is strongly 'bimodal' with a large number of small preys, consisting mainly of crustaceans, and a small number of larger preys, especially rats (Taylor, 1979; Webb et al., 1991; Erickson, 2015; Gignac & O'Brien, 2016; Engkamat, 2020).

Hanson et al. (2014) stated that small crocodiles are generalist feeders while medium and large-sized classes feed on specific preys within the food web. In this regard, their preys may include anything that it could outswim or ambush at the water edge and overpower. These include wallabies, water buffalo, cattle, flying foxes, crabs, turtles, dogs, and even human being (Webb & Manolis, 1989). Odd objects like chunks of wood, pebbles and even rocks are found in crocodile stomach. These are however not proof of accidental ingestion by the crocodiles. The hard objects are taken in as "gizzard stones" or gastroliths to help grind the coarse food (Davenport et al., 1990). The large chunks of food are reduced to digestible forms by the milling or churning action of the "gizzard stones" contained in the crocodiles' stomach that are set in motion by regular contractions of the strong stomach muscles. These "gizzard stones" also serve to stabilize the crocodile body. The "stones" lie in the stomach, below the center of gravity and work as a counterpoise or ballast to the buoyant lungs (Webb & Manolis, 1989; Davenport et al., 1990; Webb et al., 1991).

Unlike fishes, crabs and other aquatic creatures, mammals and birds are usually found sporadically in or next to the water. As a result, crocodiles seem to search for places where these preys are concentrated, such as under a tree hosting a flying fox colony or spots where herds of water buffaloes habitually feed (Bayliss et al., 1986). A sub-adult Estuarine Crocodiles weighing only 8.7–15.8 kg and measuring 1.36–1.79 m long have been recorded killing and eating goats (*Capra aegagrushircus*), weighing 50 to 92% of their own body mass in Orissa, India. This observation indicates that crocodiles are capable of attacking large prey from an early age (Webb & Manolis, 1996). It was also found the diet of a juvenile to sub-adult crocodiles is more diverse than adults, which often ignore preys below a certain size.

As a seagoing species, the Estuarine Crocodile also preys on a variety of saltwater bony fishes and other marine animals, including sea snakes, sea turtles, sea birds, dugongs (*Dugong dugong*), rays (including large sawfish), and small sharks (Webb et al., 1991). The most commonly observed predatory behaviors on marine animals have been spotted along the coastal waters or within sights of the land. These behaviors include hunting for female sea turtles and their hatchlings during the mating or hatching seasons when the turtles are closer to the shore. At the same time, bull sharks are the only large shark with a strong propensity of patrolling brackish and freshwaters. There is also evidence that Estuarine Crocodiles do hunt

while out in the open seas, based on the discovery of the remains of pelagic fishes that only dwell miles away from land in their stomachs (Webb et al., 1991).

All crocodilians are strictly carnivorous. They often ambush possible preys like fish, birds and small mammals that venture near the water's edge. They also prey on larger or non-aquatic animals such as wallabies, water buffalo, cattle, flying foxes and turtles (Webb et al., 1982). While humans are not a regular part of a large crocodile's diet, a crocodile may see a person wading in the water, or washing dishes at water's edge as potential prey. Crocodile attacks on humans usually occur when people disregard the dangers associated with crocodiles. This perception applies to most indigenous people in Sarawak. These people believe that crocodiles would not attack if they are not disturbed. Furthermore, they often associate crocodile attacks with superstitions or bad luck after being '*kempunan*' after 'not touching or eating food offered to them' or when they ignore 'bad dreams' and insist on going to the river for some activities (Engkamat, unpublished). Such superstitions are widely related to the traditional belief of some local communities in Sarawak, even though there is no scientific proof on these claims.

Crocodiles are ambush hunters. They are so well adapted to this method of feeding that their biology has remained largely unchanged for the past 65 million years (Webb & Manolis, 2009). They prefer to hunt during the night when prey animals are most likely to come to the water's edge to drink. They can remain submerged for up to 2–3 hours at a time, watching and waiting for their victims (Caldicott et al., 2005). Crocodiles have transparent eyelids (the nictitating membrane) that cover the eyes when underwater and special magnifying crystals within the eyeballs, which give them excellent vision from within and above water. When they are underwater, only their eyes, ears and nostrils break the surface of the water, giving little hint of the size of the animal sub-aerially. A crocodile advances silently towards its prey, before suddenly lunges at them at terrific speed from the water. It will slam its jaws around the victim with enormous force. The crocodile then drags the prey into deeper waters, rolling (a process often called as the "death roll") and thrashing it until it stops resisting. The whole process is swift and terrifying. This behavior has made Estuarine Crocodile a formidable and opportunistic-hypercarnivorous-apex predator that is capable of prevailing over almost any animals, including other apex predators like sharks, that enter its territory. Due to their size, aggression and distribution, Estuarine Crocodiles are regarded as the most dangerous extant crocodilian species to humans (Bayliss et al., 1986).

The hunting methods utilized by Estuarine Crocodiles are indistinct from any other crocodilians. While hunting, the crocodiles' body will remain submerged as they quietly swim to the direction of their prey. Once close enough, they will pounce upwards to strike the prey suddenly. However, unlike other crocodilians, such as alligators and the Nile crocodile, they are not known to hunt on dry land. Estuarine Crocodiles are also capable of breaching their entire body into the air in a single upward motion while hunting for preys perched on low hanging branches. This act is often seen when the predators were enticed by its prey, which acts as baits. Estuarine Crocodiles have also been seen to knock monkeys off a bank with their tails, forcing them into the water for easy capture. However, whether the crocodiles intentionally use their tail for hunting, or it is just an accidental benefit, is not definitely clear. Similar to other crocodilians, their sharp, peg-like teeth are well-suited to seize and tightly grip prey, but not designed to shear flesh. While small preys are swallowed whole, larger animals are forcibly dragged into deep water and drowned or crushed; the larger prey will be torn into manageable pieces by "death rolling" (spinning to twist off the chunks of meat) or by sudden jerks of the head sideways.

Occasionally, the remains of food will be stored for later consumption once a crocodile has filled up its stomach. However, this can lead to scavenging by interlopers like monitor lizards. Even though large prey animals may be attacked, the capacity of the crocodile's stomach is relatively small compared to the size of the animal; even a fully matured male would have a stomach barely the size of a soccer ball (Magnusson et al., 1987; Webb et al., 1991). Crocodiles swallow stones, which appear to function as ballast. These gastroliths will remain in the stomach and help to break down their food, similar to birds that swallow grits to help grind up food in their gizzard (Taylor, 1979; Webb & Manolis, 1989). The incredible force of the crocodile's powerful jaws and large cone-shaped teeth slamming into a prey will almost certainly kill it outright. After a crocodile has eaten parts of a large animal, the rest of the body will be abandoned. The carcass may drift downstream and become lodged under debris at the water's edge. The carcass could become an accidental bait for the crocodile, which will be more likely to be hunting turtles or fish that are attracted to the rotting carcass when it happens to pass through the area later (Webb & Manolis, 1989).

Like most species in the crocodilian family, the Estuarine Crocodiles are not fastidious in their choice of food. They are known to vary their prey selection according to availability. They are not voracious, as they are able to survive on

relatively little food for a prolonged period (Webb & Manolis, 1989). Due to their size and distribution, Estuarine Crocodiles hunt the broadest range of prey species than other modern crocodilians (Messel et al., 1981). The diet of hatchling, juvenile and sub-adult Estuarine Crocodiles have been subject to extensive scientific study. However, the diet of fully-grown crocodiles has been rarely studied. This is partly due to the aggression, territoriality and size of adults which make it difficult for biologists to handle them without any significant risk to safety for the biologists and the crocodile themselves (Gignac & O'Brien, 2016).

Successful predations among Estuarine Crocodiles are usually associated with its powerful bite. Crocodilians stand out among living vertebrates for their exceptional absolute bite forces. Their bite can reach higher than 16,000 N among the larger *Crocodylus porosus*, far surpassing the highest value recorded by the Spotted Hyena (*Crocuta crocuta*) with 4,500 N (Erikson et al., 2012). Thus, large individuals are capable of crushing animals, even those with thick bony armor-like turtles (Dodson, 1975; Grenard, 1991). The extraordinary bite of crocodilians is a result of their anatomy. Their skull has a larger space for the jaw muscle, which appears as a bulge at each side of their head. The muscle is extremely stiff and appears as a continuum of the skull. Most of the muscle in a crocodile's jaw is arranged for clamping down. In the meantime, despite the presence of strong muscles to close the jaw, crocodiles have extremely small and weak muscles to open the jaw which allow researchers and biologists to use ducts tapes to shut them securely (Grenard, 1991).

ECOLOGY AND DISTRIBUTION

CHAPTER 2

CHAPTER 2: ECOLOGY AND DISTRIBUTION

2.0. Distribution, Habitat Selection and Threats

According to Messel and Vorlicek (1989), the population of Estuarine Crocodiles, *Crocodylus porosus*, are scattered along the western coast of India, the Andaman and Nicobar archipelago, South-east Asia especially in the regions of Indo-china, Malaya, Philippines, Borneo, Indonesia, Papua New Guinea, parts of the Solomon Islands, and northern Australia (Fig. 3).

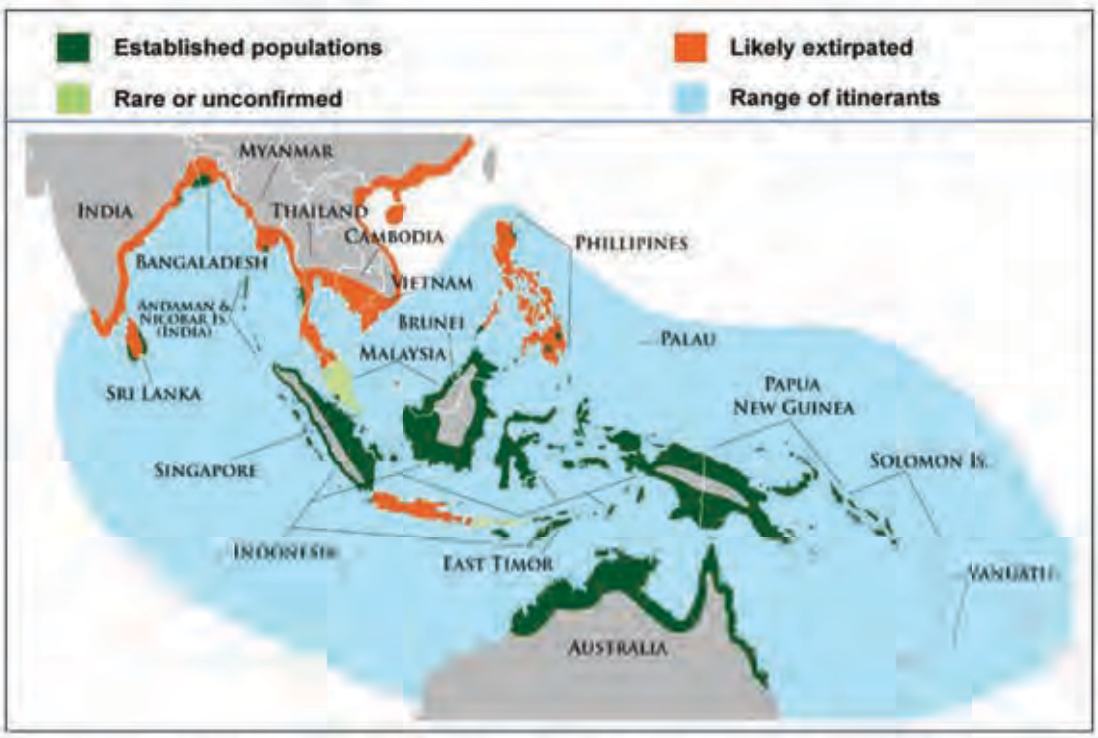


Figure 3. Distribution of Estuarine Crocodile (*Crocodylus porosus* Schneider) worldwide (Britton, 1995–2012).

Their habitats consist of coastal rivers and creeks several hundred kilometers upstream from the sea. While species have been spotted at sea, they have been sighted offshore and moving along the coasts between rivers or to offshore islands in search of suitable habitat. Their tolerance of saltwater has allowed them to occupy coastal waters, offshore islands and rivers that are subject to tidal

impact in the region. Tidal habitats, like estuaries, attract Estuarine Crocodiles because of the brackish water and abundant supply of food sources such as crabs, prawn, mammals, and fish. These areas also offer protection from wind and allow for movement around the coast for new territories. They are also common in rivers under the tidal influence, where salinity ranges between 5–20 % (Messel et al., 1981). Female Estuarine Crocodiles make nests up to a meter high from vegetative debris, such as grass, bark and leaves. The area around the nest often offers seclusion, protection from flooding, a wallow and a quick path to the water (Webb et al., 1983; Webb & Manolis, 1998). Small crocodiles are said to prefer the mangroves area upstream of the river. Undoubtedly, the selection of this location is because it is adjacent to the extensive areas of grassland and shrubs that are well-suited to nesting. These crocodiles also demonstrated a significant preference for brackish water. It was reported that *C. porosus* favors brackish waters, as these waters have an abundant of prawns to feed on. Furthermore, juvenile crocodiles have been found to feed on crustaceans and insects (Taylor, 1979; Engkamat, 2020), and migrate upstream from their nesting sites. However, studies have found that such movements are not correlated with factors like salinity (Magnusson, 1982). This finding needs further clarification as the abundance of main food source, consisting of tiny shrimp, particularly of the genus *Penaeus* sp., is seasonal, and maybe also affected by changes in water salinity. It was also reported that sub-adults (>1.2 m) usually move away from breeding localities or "Type I" habitats due to the aggressive behavior of larger individuals (Messel & Vorlicek, 1987).

While small juveniles *C. porosus* prefer warmer water in the range 31–35°C while feeding, and 25–30°C while fasting (Webb, 1998), larger crocodiles seem to be more wide ranging and may be more inclined to enter freshwater swamps than smaller *C. porosus*. Inland freshwater environments such as rivers, lakes, billabongs, and creeks offer a constant supply of freshwater crocodiles that need to drink. On the other hand, during the dry season, the crocodiles will move back to permanent water areas closer to the coast. Estuarine Crocodiles do not swim much but they drift following ocean current. In Australia, the species can be found in both salty and brackish water habitats, moving from coasts to inland rivers (Kelly, 2006).

Similarly in Sarawak, Estuarine Crocodiles are widely found in a wide range of habitats and niches, ranging from saline habitats such as beaches, deltas, mangrove swamps, rivers and creeks subjected to tidal influence, as well as along freshwater rivers upstream and swamps, oxbow lakes, big drains and sometimes even found inside oxidation ponds of oil palm mill (Engkamat, unpublished report). Kuching

Wetland National Park (KWNP) is one of the many available refuges for hundreds of Estuarine Crocodiles in Sarawak (Engkamat, unpublished) while many rivers that used to be 'crocodile-free' few decades ago have been reported to be infested by the predators.

In contrast to smaller hatchlings with size as small as 20 cm, they are prone to attacks by many other creatures such as otters, large birds, fish and even adult crocodiles (Webb, 1988). Adult crocodiles are protected by their great size, heavy amour and powerful biting power from attacks from other predators in its habitat, except for humans. Human being has become the largest threat for crocodiles. Crocodiles are often slaughtered in response to attacks on humans and their properties, or for commercial purposes.

CONSERVATION STATUS AND MANAGEMENT

CHAPTER 3

CHAPTER 3: CONSERVATION STATUS AND MANAGEMENT

3.0. Conservation Status of Estuarine Crocodile in Sarawak

Estuarine Crocodiles are known to be widely distributed in Sarawak, but prior the year 2000 very little was known concerning the ecology and conservation status of the species along rivers throughout the State. Surveys done along a number of rivers within the State in the early 1980s have indicated that the population of Estuarine Crocodiles is very low with a density of less than a single crocodile for every Km (Cox & Gombek, 1985). However, extensive surveys conducted along more than 45 main rivers and deltas in Sarawak between 2000 and 2002, as well as between 2012 and 2015 indicated that the population of Estuarine Crocodiles throughout the State had increased significantly. Some rivers, including Btg Samarahan, Btg Sadong, Sg Lingga, Sg. Seblak, lower Baram and Sg Bakong were found to have population densities ranging from 9 to 12 individuals per Km. The increase in its population is likely due to the implementation and enforcement of the Wild Life Protection Ordinance, 1990 and the amended 1998 version. This ordinance restricts the hunting, keeping and trading of the species taken from the wild. Under the Ordinance, Estuarine Crocodile is listed as a protected species and no hunting, keeping and trading of the species is allowed without a valid licence from the Controller of Wild Life. Apart from this restriction, rulings from the Convention on International Trade in Endangered Species (CITES), that restricts commercial hunting and trading (export & import) of Estuarine Crocodile from the wild has been strictly enforced and has contributed to the increase of the wild Estuarine Crocodile population in Sarawak. Malaysia (whereby Sarawak is one of its States), is a signatory of the Convention and has to comply with this restriction strictly. It was only after the 17th. CITES COP in October 2016 that wild Estuarine Crocodile could be hunted for export after the down-listing of the species from CITES Appendix I to Appendix II. In this regard, although Estuarine Crocodile has been downgraded into CITES Appendix II for Malaysia as a whole, the permission for commercial hunting (and export) of the species is limited to the State of Sarawak alone and not for the other Malaysia regions (Sabah and Peninsular Malaysia).

Apart from enforcement of the domestic law on wildlife and the use of CITES rulings to restrict commercial hunting of crocodiles from the wild, Stuebing et al. (1993) attributed that the increase in the population of Estuarine Crocodile in Sabah is due to the availability of grassy vegetation materials for nesting along the river banks following the clearing of forest vegetation for agricultural activities, such as

oil palm plantations. This could be another important factor that stimulates drastic growth in the crocodile population in Sarawak since massive vegetation clearings have taken place in many riverine areas throughout the State.

Taboo is another likely factor for the increase in the crocodile population in Sarawak as it hinders and prohibits many of its local communities from killing and hunting of the species, for fearing that they would get bad repercussion from the acts. To most indigenous people in Sarawak, hunting and killing of crocodiles are only be permitted when there is a need for revenge after their family members have been victimized by the reptile (Engkamat, 2020). Myths and superstitions are still widely practiced among most indigenous people in Sarawak, especially among local communities residing along river banks in the interior.

In Sarawak, the previous authority responsible for matters about wildlife and enforcement of the Wild Life Protection Ordinance, 1998 (and its subsequent subsidiary legislation) was the Forest Department of Sarawak, through its Controller of Wild Life. Since February 2020, the function has been handed over to Sarawak Forestry Corporation (SFC) with its present Chief Executive Officer as the new Controller of Wild Life for the State. He is now the sole authority taking care of various aspects pertaining to wildlife management. These aspects include issues on Estuarine Crocodile in Sarawak, such as culling of nuisance crocodiles following attacks on human or removal of crocodiles that pose a danger to the general public and their properties. Culling, when necessary, is part of crocodile management activities as required by the existing ordinance on wildlife. However, this activity requires a licence or permits from the Controller of Wild Life. As crocodiles are protected under the law in Sarawak, other activities involving the species such as research, keeping and farming would also require licenses from the Controller of Wild Life.

3.1. Previous Studies on Estuarine Crocodiles in Sarawak

Crocodiles were and still are, considered as undesired animals by many indigenous people of Sarawak. The perception is simply because crocodiles can become 'man-eaters', leading many people to believe that the crocodilians have the tendency to take revenge on those who have a history in harassing or killing the species in the past. This belief, or rather, myth, is common among the indigenous people of

Sarawak and has been inherited from their forefathers in the past. As such, only a handful of local people in Sarawak are willing to conduct studies on crocodiles, particularly when it involves handling of live animals. Studies on crocodile may involve catching, palpating for its stomach content, tagging for monitoring purposes and collection of the species as scientific voucher specimens. Fear of crocodiles among the indigenous people is likely due to their belief that crocodiles originated from the human being and thus, crocodiles are their descendants (King, 1985; Shim, 2002; Munan, 2006; Datan, 2010). Hostile attitudes among local communities towards crocodiles usually stemmed up as revenge for crocodile attacks on their family members (Engkamat, unpublished report).

Despite the hatred and hostile feeling towards crocodile among most local communities in Sarawak, fatal attacks on human seemed to be inevitable and tend to keep on occurring time and again. The fatal attack on Bangan anak Pali in Batang Lupar in June 1982 managed to attract the attention of a foreign lecturer and his team (Stuebing et al., 1985) from Universiti Kebangsaan Malaysia, Sabah to study on the possible causes of the attack. Their findings indicated that the attacks by Estuarine Crocodiles on human in Batang Lupar seemed to be inconsistent with any animal behavior of hunting humans for flesh. This assertion was made based on the fact that large crocodiles will mostly retreat when approached by humans. Stuebing et al. (1985), however, stated that intentional attacks on human are likely motivated by its aggressive territorial behavior at certain times of the year, rather than due to fear and hunger.

A second study on the species in Sarawak was conducted by Cox et al. (1985) between July–September. This was a follow-up work to a proposal presented by Whitaker (1984). The proposed study aims to determine conservation status and distribution of two crocodilian species (*Crocodylus porosus* and *Tomistoma schlegelii*) in Sarawak, identify the regions and habitats most important for crocodile conservation in the state, assess whether the two species are endangered or vulnerable, and to collect data for management recommendation for the species in the state. The outcome of the study indicated that at that time, the population of Estuarine Crocodiles and the False Gharial were rather low, with an average calculated density of 0.056 individuals per km. They attributed the low density to the rampant poaching activities for crocodile skin during the colonial era. Cox et al. (1985) recommended that Sarawak should work out policies on the legal protection of the crocodilian species, setting up wildlife sanctuaries for the crocodile, introducing re-stocking program for the species into certain rivers, starting up

conservation education program among general public throughout the State, resurveying some of the rivers after a period of times and finally, carrying out culling of nuisance crocodiles wherever and whenever necessary.

Even though there are reports that the crocodile population keep on depleting, it took almost 11 years before the third major surveys and population assessment of the species was done in Sarawak. This is likely due to the lack of interest among local researchers in studying the species (Engkamat, unpublished report). The survey conducted between 1996 and 2006 revealed that the population of Estuarine Crocodile along most rivers in Sarawak had increased significantly. Rivers, such as the Sungai Bako was found to have a density of up to 7.10 individuals per km., Sungai Santubung with a density of 3.31 individuals per km, Batang Lupar (over a stretch of 10 km) was found to have a density of 0.90 individuals per km and Batang Sadong has a population density of 1.40 individuals per km (Engkamat, unpublished). Among the 25 rivers surveyed during the period, Sungai Maludam (over a distance of 15 km) has shown to have the lowest density, with only 0.10 individual per km. In summary, the survey covered a total distance of 760.10 km of rivers has shown an average calculated population density of 0.97 individual per km, an increase of 17.32 times more than what was reported earlier by Cox et al. (1985).

The most recent surveys along 50 rivers and deltas in Sarawak, covering a distance of more than 2000 Km were carried out between 2012 and 2015. The study has proven that the population of Estuarine Crocodile has increased remarkably, with some rivers were found to have population densities of more than 10 individuals per km (Engkamat, unpublished report), thus an increase of about 30 times than that reported in 1985 (Cox et al. 1985). It is a clear indication that the population of Estuarine Crocodiles in Sarawak is now recovering rapidly and comparable with the range of population densities of similar species along several unexploited rivers in Northern Territory of Australia (Caughley, 1980).

3.2. History of Crocodile Management in Sarawak

There is poor documentation on crocodiles before the Brooke era in Sarawak. Crocodile management, mainly on attack incidents in the past and the follow-up efforts to capture the predator, was mainly documented by the Sarawak Museum or recorded as verbal stories passed down from one generation to the next. Crocodiles have been part of the myths and legends of the indigenous people of Sarawak,

including the Ibans, Bidayuh, Malays and the Orang Ulu. To many indigenous people of Sarawak, the killing of crocodile and consumption of its meat are taboo, unless members of the community have fallen victim to the predator (Ritchie & Jong, 2002).

Most early hunting, particularly during the Brooke era, the British Colonial era and the Japanese occupational era (1881–1960), were done using hooks (*alir*). Chicken, monkey, dog or flying fox were used as baits, and the hook was attached to a rattan apparatus anchored to riverine trees. At the same time, other hunters speared crocodiles at night by battery torches and kerosene headlamps with reflective tins (Cox & Gombek, 1985). For centuries, shamans (traditional crocodile catchers), or *pengalir,* have purportedly used spiritual means to charm nuisance crocodiles out of the river, to ensure that justice is meted out especially after every attack on human (Ritchie & Jong, 2002).

Crocodiles are reportedly attracted to decomposing carcasses (Ritchie & Jong, 2002). More often than not, a medium or large crocodile (1.5–4.0 m in total length) would be caught in this manner within several days. In the past, the services of shamans were often used to catch killer crocodiles that most local people believed to be the reincarnation of an evil spirit (Ritchie & Jong, 2002). At that time, crocodiles were also considered as vermin that should be exterminated, and the public was offered bounties for catching every individual crocodile or for collecting of crocodile eggs.

During the reign of the two early Rajahs (James and Charles Brooke) in Sarawak in the 18th century, those who killed crocodiles and brought the skin to the department concerned as evidence, will be paid 36 cents for each foot of the skin. (Ritchie & Jong, 2002). In this light, the government encouraged the people to catch more crocodiles and consequently causing a significant decline in the crocodile population. Apart from commercial hunting, the fate of Estuarine Crocodiles in the wild further deteriorated during the Japanese occupation period (1942–1945) where crocodiles were reportedly hunted for meat by the Japanese armies (Ritchie & Jong, 2002). Thus, as the demand for meat for the occupational forces surged, crocodile hunting was reported to be rampant throughout Borneo, including in Sarawak. At that time, the crocodile skin was not considered an important commercial product for the leather industry; instead, the meat was highly demanded by Japanese soldiers as food. It was at the end of the war that companies were willing to buy any usable animal skins, and the highest price was offered for crocodile skin. Those of high

qualities were exported to other countries. As a result, many people worked actively to catch crocodiles (J. Leong Ipoh *in* Ritchie & Jong, 2002). Thus, the activity eventually leads to the general assumption that the conservation status of Estuarine Crocodiles in Sarawak and throughout its range in south-east Asia as endangered (Groombridge, 1987).

The introduction, or rather, the use of firearms in Sarawak among local hunters in the 1950s, has caused further exploitation of Estuarine Crocodiles (Lading, pers. comm.). Thus, more crocodiles were killed each year for its skin. Crocodile hunting was reported to reach its peak between the year 1954–1960 with the export of its skin from Sarawak reaching 15,000 lbs (6,803.89 kg) in 1960 (Cox & Gombek, 1985). It was conservatively estimated that more than 80,000 crocodiles were harvested over 11 years between 1954 and 1964, particularly for its skin (Cox & Gombek, 1985). Commercial hunting of crocodiles for its skin was not only occurring in Sarawak but was also reported to be similarly rampant throughout its range. Thus, as a result, the population of Estuarine Crocodile, included those in Sarawak was found to be 'crashed' throughout the seventies, and perhaps until early eighties, due to high market demand for its skin. The dire conservation status of the Estuarine Crocodile in Sarawak was supported by the result of the first surveys along several main rivers throughout the State where the density was found to be very low (Cox & Gombek, 1985).

The International Union for Conservation of Nature (IUCN), in its effort to prevent the species from further decline, and may lead to extinction, has listed down the species under Appendix II of the Convention on International Trade of Endangered Species of Flora and Fauna (CITES) (IUCN, 1975). This decision means, as a signatory of the convention, any hunting and commercialization of the species in Malaysia (whereby Sarawak is part of it), including export and import, requires CITES permits. As the wild population of Estuarine Crocodile kept on declining, the species was then further up-listed into CITES Appendix I in 1979 and its hunting and commercialization were banned except for that from Papua New Guinea, Australia and Indonesia, which remained under Appendix II. This inclusion was done to prevent the further decline of the estuarine crocodile wild population (IUCN 1979). With the listing of Estuarine Crocodile under CITES Appendix I in 1979 all commercial hunting, sales, export and import of wild species in and from Sarawak were no longer allowed by the authority.

Due to the alarming decline in the population of Estuarine Crocodile in Sarawak, WWF (in its report) has suggested and recommended the State Government to come up with conservation program for Estuarine Crocodile within the State (Cox & Gombek, 1985). In response to the report, the State Government of Sarawak (through its Forest Department) listed two local crocodilian species (*C. porosus* and *T. schlegelii*) as Protected under its Wildlife Protection Ordinance, 1990. Both species remained as protected under the revised version of the ordinance published in 1998 (Fig. 4a & 4b). This ruling means that anyone found having the animal in their possession, kill, hunt, sell or offer for sale of the species shall be guilty of an offence that carries a penalty of imprisonment for one year and a fine of RM10,000.00 [Section 29(2), Wild Life Protection Ordinance, 1998]. Keeping individual crocodiles in captivity requires a license from the Controller of Wild Life with a yearly license fee of RM10.00 per head (if the number kept is less than 10 individuals), and RM 100.00 with there are ten individuals or more (Rule 13 &16, The Wild Life Protection Rules, 1998). Rule 17 of the Wild Life Protection Rules provides provision for the Controller of Wild Life to regulate keeping and farming of Estuarine Crocodiles.

After about three decades of extensive conservation effort and legal protection given to the species by the State Government of Sarawak, the wild population is now seemed to surge significantly. Crocodiles are badly infesting rivers, streams and other water bodies that have never been reported to inhabit crocodiles in the past. This increase shows the success of the conservation efforts that have been rendered by the Forest Department to address the issue and a kind of achievement that the Government should be proud of (Engkamat, unpublished report).

Though the population status of the crocodilian species in Sarawak has now recovered, the legal status of both the Estuarine Crocodile (*Crocodylus porosus*) and the False gharial (*Tomistoma schlegelii*) remained unchanged at domestic and international level until 15 October 2016 (the 17th. CITES COP in Johannesburg, South Africa). On this day, the Estuarine Crocodile in Malaysia was down-listed from CITES Appendix I to Appendix II for Malaysia, enabling commercial hunting to take place in Sarawak. The hard works and commitment of members of the Forest Department and SFC have successfully convinced the CITES Secretariat on the current issues and problems brought by Estuarine Crocodile to the people of Sarawak, particularly those dwelling along rivers. Following deliberation and justification by the Malaysian delegates, and the voting and support by a majority of member States during the COP, the Secretariat agreed to down-list the species into

CITES Appendix II, giving way for regulated commercial hunting to take place in Sarawak. The approval, however, does not apply to Sabah and Peninsular Malaysia for the time being.

The down-listing of Estuarine Crocodile into CITES Appendix II was approved during the 17th CITES COP partly due to the Sarawak government's success in lobbying the member States, particularly those from the European Union (EU) and Asia-Oceania Regions during the CITES Standing Committee Meeting in Tel Aviv, Israel, before the COP (Conference of Parties) in South Africa. Most member states understand the current status, issues, problem and the suffering brought about by the crocodile to the people of Sarawak and were satisfied with all the mitigation measures being put up by the State of Sarawak to prevent the population from being over-harvested. CITES approval for the regulated commercial hunting of Estuarine Crocodile is hoped to reduce the issues on Human-Crocodile Conflict (HCC) in Sarawak, and at the same time, helps generate revenue to local communities, as well as to the State Government of Sarawak. This presents a new approach undertaken by the State Government of Sarawak in the sustainable management of it Estuarine Crocodile within the State. Similar management approach undertaken by Northern Territory of Australia for several decades has proven to be remarkably successful in conserving the crocodilian species while generating substantial revenue to the local people that have to share the same habitats with the predators.

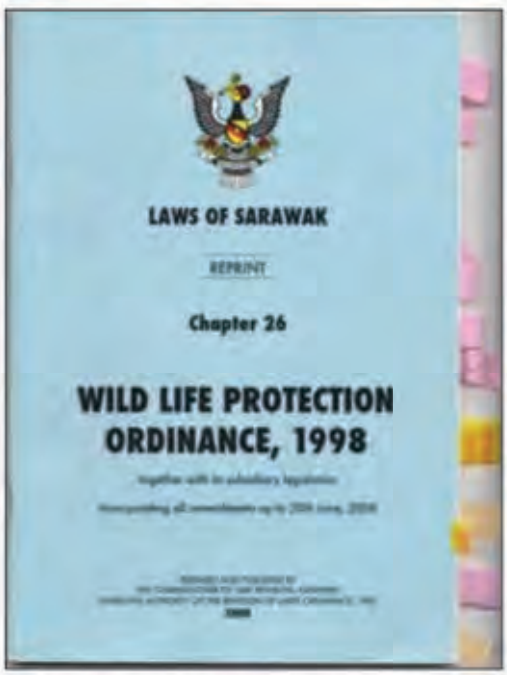


Figure 4a. The Wild Life Protection Ordinance 1998

Figure 4b. A poster on list of wildlife species being protected under the Wild Life Protection Ordinance, 1998

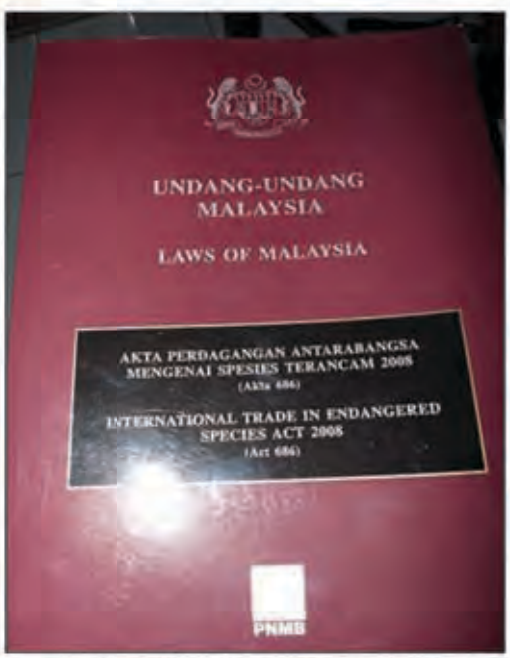
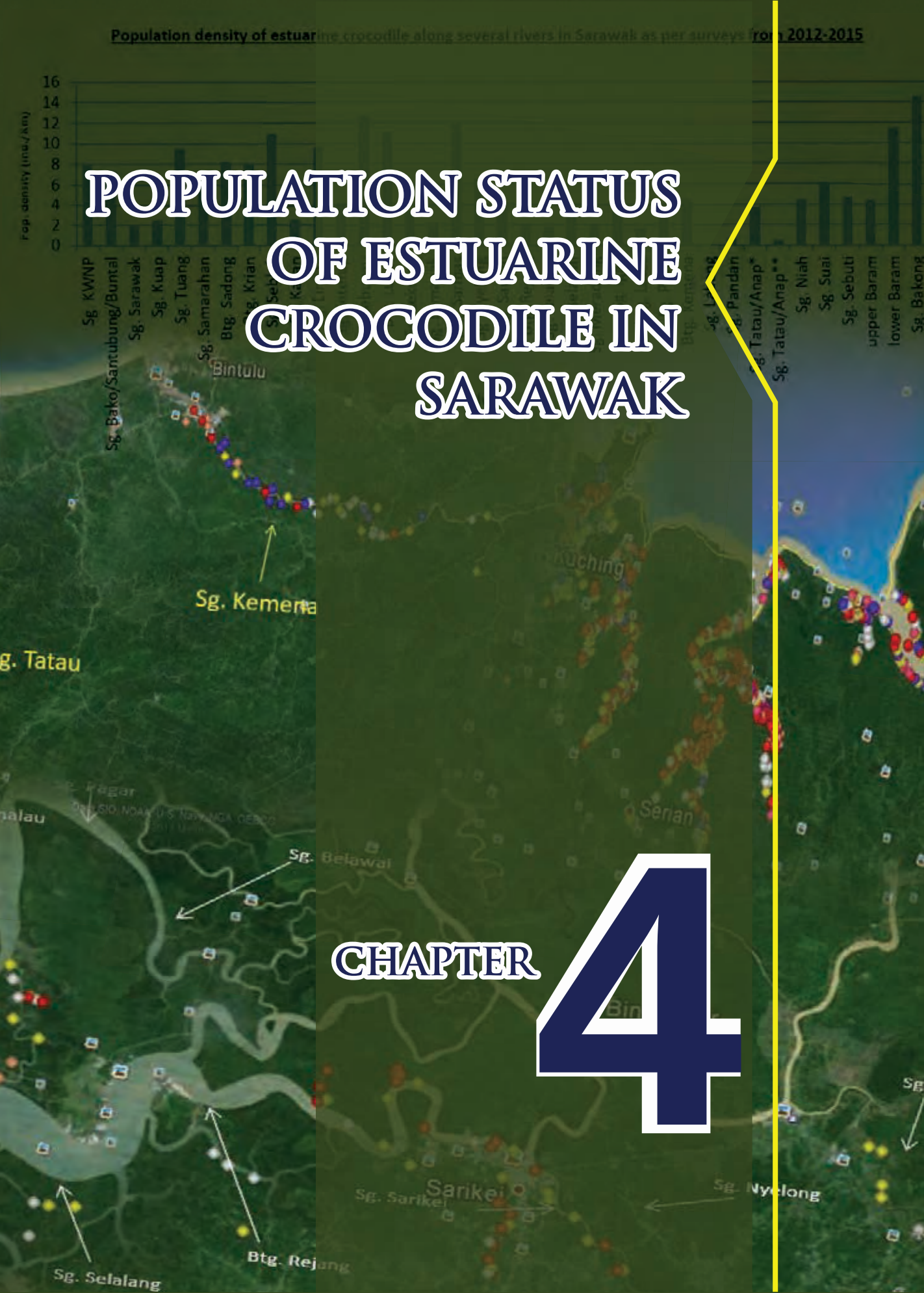


Figure 4c. The International Trade in Endangered Species Act 2008 (Act 686) or 'CITES ACT' for Malaysia.



POPULATION STATUS OF ESTUARINE CROCODILE IN SARAWAK

CHAPTER 4

CHAPTER 4: POPULATION STATUS OF ESTUARINE CROCODILE IN SARAWAK

4.0. Population Status of Estuarine Crocodile in Sarawak

Three decades since the first crocodile survey was conducted in Sarawak, the population of Estuarine Crocodile within the State was found to increase by at least three-fold. Series of comprehensive surveys were done following the methodology for Non-Detriment Finding (NDF), as required by CITES, between 2012 and 2015 along the rivers throughout Sarawak. The results have shown that some sectors of rivers were having considerably high population densities of the species, whereby some sectors of rivers were found to have as many as 10 – 12 individual crocodiles per km. Based on this figure, it could be concluded that the current status of Estuarine Crocodile in Sarawak is well recovering from its 'dark era' that occurred in the 1940s and early 1970s. Therefore, with the speedy population recovery, it can be concluded that the species is now no longer endangered, at least at the local level, provided that its current management approach and its habitat are maintained and conserved.

4.1. Survey Method: Spotlight Counts

Similar to the first crocodile survey done in the 1980s the latest series of crocodile census along rivers in Sarawak, commencing between 2012 and 2015, were conducted during low tide at night from a moving outboard cruising at a speed of 10–15 km/hr. An observer, using a 12V, 300,000 cp. spotlight scanned both sides of the riverbanks and water surface for the presence of crocodiles (Fig. 5). Chemical reflectors in the tapetum of the crocodile eyes, which produce eye-shine at night at the beam of the spotlight, make detection of animals possible during night surveys. Individual crocodiles sighted were approached until they submerged. Their sizes were estimated according to one of five size categories based on its estimated total length (TL): hatchling, H (< 60 cm),yearling, Y (60–120 cm), Sub-adult, SA (120–180 cm), adult, A (> 180 cm) and eyes only, EO. EO or large individuals, often exceeding 3 m in length, were usually submerged almost immediately upon being approached (Webb & Messel, 1997, Engkamat, 2020).

GPS locations of every sighting were recorded and plotted in the google map of the river (Fig. 7–14). Mapping of those sighting localities of different size classes would provide information on the distribution pattern of the Estuarine Crocodiles along the river at different months of the year, as well as indicating the potential breeding site for the species. Sites with a higher concentration of hatchlings are most likely to be used as a nesting ground by the species. A long-term study on the distribution of the species has the potential to help understand the annual distribution pattern of the species along each river and its respective tributaries. Recording the different size classes, however, would provide 'rough ideas' on population structures of the species inhabiting each river at different times of the year. Other environmental and physical factors recorded were the tidal conditions, moon phase, weather condition, vegetation along the river, which includes observation on extend of forest cover, river width and length of the survey coverage. Data were recorded in a standard data form, and some of the raw data are shown in Appendix II.

Population density and population estimates were done using a simplified method adopted by Caughly et al. (1980). Figures on population densities and estimates obtained by using the method would much depend on the ratio of Eyes Only (EO) recorded from the river to that found in Australia (10%). The percentage also depends on figures for Correction Factor (CF) for Australia (1.67). This Correction Factor is derived from the fact that 60% of Estuarine Crocodiles could be found in Australian rivers at any time of the survey (Whitaker, 1984). The Correction Factor for each river surveyed can be derived from the following formula :

$$CF_{(\text{for the river})} = 1.67_{(\text{CF Australia})} \times \%\ EO_{(\text{of the river})} / \%\ EO_{(\text{Australia})}$$

Detail calculation in estimating the population size of the crocodilian was further simplified in an Excel format by multiplying the calculated population estimate by the Correction Factor for each river surveyed.

Note: *differences between monthly counts along one particular river could be caused by the movements of the animals into other nearby rivers and deltas, or creeks and tributaries that are not navigable by survey boat, and not necessarily reflecting the fact of high mortality rate among hatchlings* (Stuebing et al., 1996).

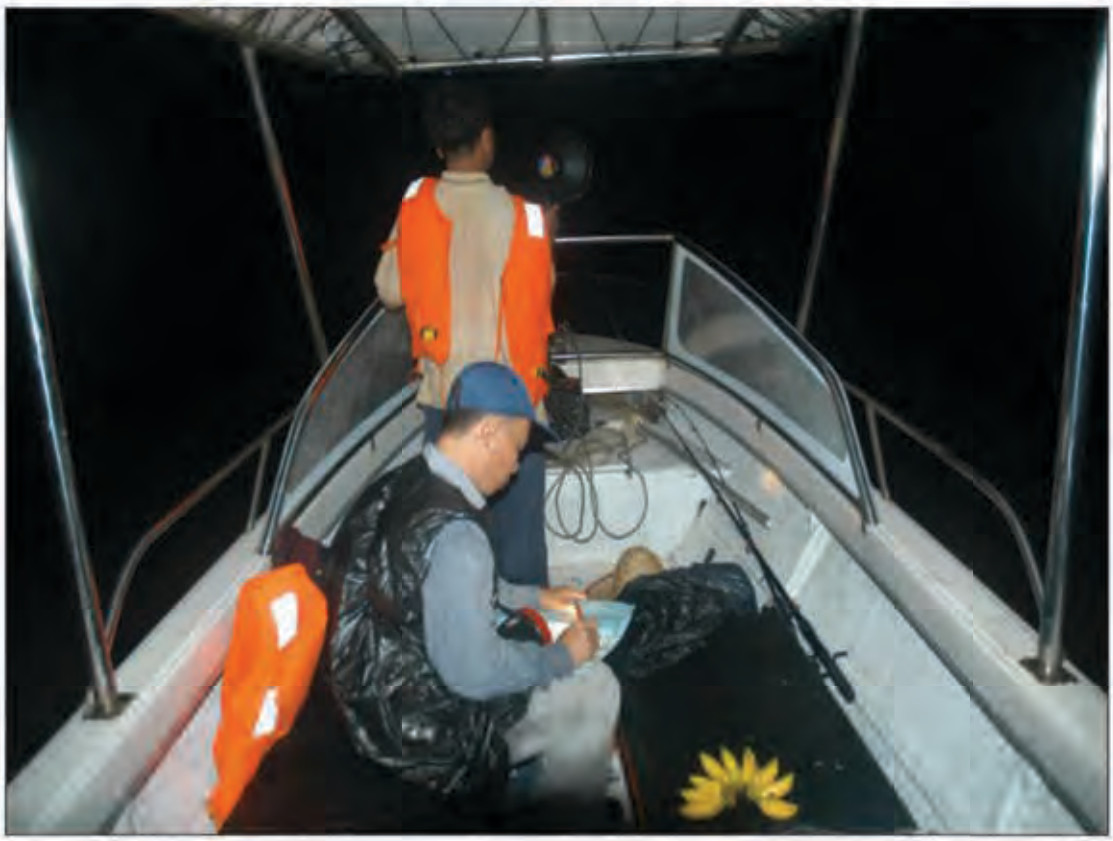


Figure 5. Night survey of Estuarine Crocodile along river

4.2. Survey results: Population densities, estimate, distribution and structure along some major rivers in Sarawak

The survey was funded by the Federal Ministry, as well as the State Govemment. In total, more than 2,000 km of rivers throughout Sarawak were surveyed for its crocodile population between 2012 and early 2015 by a group of researchers from the Nature Conservation and Constitution Division (NCCD) of the Sarawak Forest Department. The main objective of the study was to carry out population assessment

and status of the Estuarine Crocodile so that a sound management action and strategies could be formulated to reduce its attacks on human. One of the ways to achieve the objective is to implement various activities under a 'Sustainable Management Project for Estuarine Crocodile (*Crocodylus porosus*) in Sarawak'. It is believed that a good and effective management strategy would be able to address issues of Human-Crocodile Conflict (HCC) in Sarawak that seems to be on the rise of late. The result of the finding was also intended for justifying proposal to downgrade the species into CITES Appendix II (from CITES Appendix I) so that the surplus population of large individuals could be reduced. The reduction in the number of large individuals could reduce the rate of attacks on human, thus reducing Human-Crocodile Conflict (HCC).

While there were calls from the public to ensure that certain rivers are 'crocodile-free', eliminating crocodiles from these rivers is an uphill task. It may be possible to remove some crocodiles from certain sectors of rivers, but the void left by the harvested individuals would soon be filled up by the newcomers that will establish their territory. On top of that, the unauthorized killing of crocodiles in Sarawak is illegal as it is a protected species under the law, unless with a permit from the Controller of Wild Life. As Estuarine Crocodiles are highly territorial, especially during the breeding season, anything, including human being that intrudes into their territories would face the risk of being attacked (Stuebing et al., 1985; Engkamat, 2020). Due to the pressing need in addressing the issue on Human-Crocodile Conflict, a survey team from the Department, headed by the author, commenced their surveys in April 2012 along major rivers in Kuching Division. This was done in accordance with CITES requirement for the Non-Detriment Finding (NDF) for the species. The survey covered a number of rivers, deltas and creeks within KWNP such as Sg. Samariang, Sg. Sibu and Sg. Matang, and their respective tributaries. The survey was extended to nearby rivers such as Sg. Santubung, Sg. Bako, Sg. Selesong and Sg. Buntal (Table 1). A total of 239 individual crocodiles were recorded over a total distance of 160 km of rivers. This number equals to the population densities (with Correction Factor, CF) ranging from 7.3 to 8.0 individuals for every km of each river and population estimate ranging from 601 to 618 individuals for each of the site/river (Table 1). About 47% of the whole sightings comprised of hatchlings (H).

The survey was extended to Sg. Sarawak and Sg. Kuap, and their respective tributaries in the following month, covering a total distance of about 166 km. Surprisingly, despite a relatively long distance covered during the survey, only 43

sightings were recorded along the two rivers, giving population densities (with CF) of 1.90 and 2.40 individuals per km and a population estimate of 200 and 150 individuals for each of the river (Table 1). 26% of the whole sightings comprised of hatchlings.

The surveys were further extended to Sg. Tuang and Btg. Samarahan, and its respective tributaries in July 2012, covering a total distance of about 114 km. Along the stretch of rivers surveyed, a total of 141 sightings were recorded. This provides the population densities of 9.4 and 6.0 individuals for each of the river and a population estimate of 184 and 568 individuals, respectively (Table 1). Furthermore, about 76% of the whole sightings comprised of hatchlings.

More surveys were carried out towards the third quarter of the year, and these include that of Btg. Sadong, Btg. Krian and Sg. Seblak in August, September and October of the same year, covering a total distance of about 281 km. A total of 603 individuals were recorded along the three rivers, giving population densities of 8.2, 8.0 and 11.0 individuals per km for each of the river and population estimate of 1,136, 701 and 618 individuals respectively (Table 1). The numbers of hatchlings were found to be ranging from 27.9% for Btg. Krian, 45.7% for Sg. Seblak and 60.0% for Btg. Sadong (Table 1).

River	Survey date	Dist (km)	No. sighting	R. Den (ind./km)	Pop. est.
KWNP & its assoc. rivers, deltas & creeks	16–19/4/12	77.72	65 (4.62% H)	0.84 7.95 (CF)	618
Sg. Bako, Sg. Santubung, Sg. Buntal & Sg. Selesong	20–22/4/12	81.92	174 (41.95% H)	2.12 7.34 (CF)	601
Sg. Sarawak & tri.	15–20/5/12	102.84	25 (4.00% H)	0.24 1.90 (CF)	200
Sg. Kuap & tri.	21–23/5/12	62.73	18 (22.22% H)	0.29 2.40 (CF)	150
Sg. Tuang	6–7/7/12	19.50	37 (40.54% H)	1.90 9.42 (CF)	184
Btg. Samarahan & tri.	2–4/7/12	94.51	104 (35.58% H)	1.10 6.01 (CF)	568
Btg. Sadong & tri.	2–10/8/12	137.80	360 (60.00% H)	2.61 8.24 (CF)	1,136
Btg. Krian	28–30/9/12	87.20	140 (27.86% H)	1.61 8.04 (CF)	701
Sg. Seblak	4–6/10/12	56.10	103 (45.63% H)	1.84 11.01 (CF)	618
TOTAL		720.32	1,026	1.39 6.92 (CF)	4,776

Table 1. Results of the crocodile surveys (NDF Phase I) along a number of rivers in Sarawak in 2012.

Phase II of the survey started in February 2013 and ended in October in the same year. 14 rivers and its tributaries were surveyed, covering a distance of 723 km with 896 sightings recorded. In this light, the total population estimate for whole rivers was 4,276 individuals (Table 2a). Among the rivers that revealed remarkably high population densities (with CF) of the Estuarine Crocodiles per km were the Sg. Sebuyau (12.71 ind./km), Btg. Saribas (11.86 ind./km), Btg. Lupar (11.05 ind./km) and Btg. Lingga (9.67 ind./km) (Table 2a). Sg. Kayan in Lundu District, Sg. Sekrang and Sg. Lemanak (tributaries of Btg. Lupar) have shown rather low population densities of the species with each river having less than four (4) individuals for every km (Table 2a). Btg. Lingga, Sg. Seterap (a tributary of Btg. Lingga), and Btg.

Saribas were found to have a remarkably high percentage of hatchlings, with 56.34%, 48.98% and 45.38%, respectively for each river (Table 2). This finding shows that massive breeding and nesting activities must have taken place along the vicinity of the rivers, indicating that the places were among the most favorable breeding sites for the species. Btg. Saribas (over a distance of almost 138 km) and Btg. Lupar (over a distance of 128 km) were each found to have an estimated population of 1,637 and 1,420 individuals respectively while other rivers have much fewer individuals. Sg. Sekrang and Sg. Lemanak were found to have the least number of sightings. It was reported that the number of hatchlings is almost nil during the time of the survey (Table 2). Crocodile attacks that occurred along the two rivers in the past were very likely the works of big individual crocodiles that ventured into the rivers from the main river (Btg. Lupar) to forage for food.

River	Survey date	Dist. (km)	No. sighting	R. Den. (ind./km)	Pop. est.
Sg. Kayan	20–18/2/13	125.66	31 (3.23% H)	0.25 2.53 (CF)	317
Btg. Lingga	18/4/13	20.72	71 (56.34% H)	3.43 9.67 (CF)	200
Sg. Seterap	20/4/13	41.45	49 (48.98% H)	1.18 4.03 (CF)	167
Sg. Sebuyau	27–28/4/13	31.55	98 (24.49% H)	3.11 12.71 (CF)	401
Btg. Lupar	14–24/5/13	128.44	182 (18.68% H)	1.42 11.05 (CF)	1,420
Sg. Sekrang	25/5/13	34.90	10 (0.00% H)	0.29 3.35 (CF)	117
Sg. Lemanak	26/5/13	7.30	4 (0.00% H)	0.55 2.29 (CF)	17
Btg. Saribas & tri.	17–24/7/13	137.96	368 (45.38% H)	2.67 11.86 (CF)	1,637
TOTAL		**527.98**	**813**	**1.61** **7.19 (CF)**	**4,276**

Table 2. Results of the crocodile surveys (NDF stage 1 of Phase II) along a number of rivers in Sarawak in 2013.

Stage 2 of phase II surveys were mainly concentrated along rivers within the Rejang basin, covering a total distance of about 195 km. Over the distance surveyed, only 83 sightings were recorded, giving a total population estimate for all the rivers of only 535 individuals (Table 3). Though, in general, the population densities were found to be rather low, the relatively high percentages of hatchlings along Sg. Sarikei and some sectors of Btg. Rejang near Tg. Manis area is an indication that those places were breeding sites for the species. The relatively low number in its population within the Rejang basin could be due to illegal poaching activities for food in the past by a certain group of people who do not think that catching the 'man-eaters' is taboo.

River	Survey date	Dist. (km)	No. sighting	R. Den. (ind./km)	Pop. est.
Sg. Nyelong	17/10/13	17.96	12 (33.33% H)	0.67 6.51 (CF)	117
Sg. Sarikei	17/10/13	15.88	14 (57.14% H)	0.88 4.21 (CF)	67
Btg. Rejang & tri. (Tg. Manis-pasar S'kei)	19/10/13	46.89	21 (47.62% H)	0.45 2.14 (CF)	100
Sg. Selalang	22–13/10/13	28.61	7 (25.10% H)	0.24 1.74 (CF)	50
Sg. Belawai & tri.	25–26/10/13	23.42	21 (57.14% H)	0.90 3.57 (CF)	84
Sg. Meradong, Tulai & tri.	29/10/13	58.40	8 (0.00% H)	0.14 2.00 (CF)	117
Total		**195.16**	**83**	**0.55 3.36 (CF)**	**535**

Table 3. Results of crocodile surveys (NDF stage 2 of Phase II) along a number of rivers in Sarawak in 2013.

Phase III of the surveys, commencing from 19 May, 2014, were mainly concentrated along rivers in central and northern Sarawak, starting from Sg. Rasau and Sg. Igan in Rejang basin until Sg. Limbang in the Northern part of Sarawak. 314 sightings were recorded during the period, over a total distance of about 669 km along 19 rivers and its associated tributaries. This number provides a whole population

estimate of 2,808 individuals for the surveyed sectors of the rivers. At least eight rivers have shown relatively low densities of the Estuarine Crocodile population (less than 4 ind./km). These rivers include those within the Rejang basin such as Sg. Igan, Btg. Lassa, Sg. Pasin, Sg. Labang, Sg. Pandan, Sg. Tatau/Anap and Sg. Limbang. Surprisingly, most rivers within Miri region were found to have relatively high densities of the crocodilian population. Sg. Bakong, for instance, has about 14.6 ind./km (likely to be the highest density ever recorded in Sarawak thus far), lower Baram having about 11.5 ind./km, Sg. Suai recorded about 6.2 ind./km, Sg. Sebuti 4.6 ind./km and Sg. Niah 4.5 ind./km (Table 4).

River	Survey date	Dist. (km)	No. sighting	R. Den.(ind./km)	Pop. est.
Sg Rasau, Btg Igan, Sg Pasai	19/05/14	52.47	15 (0% H)	0.29 4.46 (CF)	234
Btg. Rejang & Sg Igan sector near Sibu town	20/05/14	19.86	1 (0% H)	0.05 0 (CF)	0
Btg. Rejang, Btg Lassa & Lebaan	21/05/14	84.16	14 (14.29% H)	0.17 1.59 (CF)	134
Sg. Pasin	22/05/14	32.63	9 (0% H)	0.28 3.58 (CF)	117
Btg. Kemena	07/08/14	41.88	43 (13.95% H)	1.03 4.39 (CF)	184
Sg. Labang	08/08/14	22.53	1 (0% H)	0 (CF)	0
Sg. Pandan	09/08/14	25.04	2 (0% H)	0.08 0.67 (CF)	17
Sg. Tatau (Anap)	12/08/14	31.27	29 (27.59% H)	0.93 3.74 (CF)	117
upper Sg. Tatau	13/08/14	35.3	2 (0% H)	0.06 0.47 (CF)	17
Sg. Niah	09/10/14	29.9	9 (11.11% H)	0.30 4.47 (CF)	134
Sg. Suai	10/10/14	32.6	15 (0% H)	0.46 6.15 (CF)	200
Sg. Sebuti	11/10/14	21.8	11 (0% H)	0.41 4.60 (CF)	100
Btg. Baram (K. Tinjar-pasar Marudi)	16/10/14	41.6	40 (12.5% H)	0.96 4.42 (CF)	184
Btg. Baram (lower sector/mouth)	23/10/14	34.89	36 (13.89% H)	1.03 11.49 (CF)	401
Sg. Bakong (Baram)	17/10/14	37.87	46 (8.70% H)	1.21 14.55 (CF)	551
Sg. Limbang	12–13/12/14	125.12	41 (2.44% H)	0.33 3.34 (CF)	418
Total		**668.92**	**314 (0.32% H)**	**4.25 7.68 (CF)**	**2,808**

Table 4. Results of the crocodile surveys Phase III along a number of rivers in Sarawak in 2014.

(**Note**: *there were several other surveys conducted along streams, deltas, estuaries and smaller tributaries of the above rivers in early 2015 and the data has been included in the analysis. With the inclusion of those sites the total numbers of rivers surveyed were 50*).

In summary, between 2012–2014, and until mid-2015, about 50 rivers, tributaries, creeks and deltas were surveyed, covering the distance of 2,108.38 km. A total of 2,236 individuals (inclusive of hatchlings) were recorded, giving a Calculated Relative density of 1.06 individuals for every km of the rivers (Table 5). However, it is not possible to find every single individual crocodile in the rivers during the surveys. This is because some individuals might be submerged while others might be 'hiding' under vegetation, logs and roots of mangroves. Hence, taking figures based on Calculated density alone may not likely portray the actual status of the population. Hence, the figure estimated here is just an index of counting for comparison between rivers at different time periods. Therefore, for better accuracy and more reliable figures, calculation of Relative population densities based on Correction Factor (CF), adopted from Whitaker (1984), was used in this study. The averaged Relative density of the Estuarine Crocodile encountered in the sectors of all the surveyed rivers within the three-and-a-half-year period is 5.6 individuals per km (Table 4), a figure which is comparable to the densities of the species found along unexploited rivers in Northern Territory, Australia. The figure, therefore, gives a population estimate of about **12,000 individuals over slightly more than 2,000 km of the surveyed sectors of the rivers** throughout Sarawak. Assuming that there is 20,000 km of rivers (include freshwater rivers and streams in the interior), and its tributaries, deltas, estuaries, creeks, lakes (include oxbow lakes), swamps, big drains and drainage systems, oxidation ponds of oil palm mills and other water bodies were also inhabited by crocodiles, but were not surveyed due to inaccessibility by the survey boats, then the estimated population of the Estuarine Crocodile in Sarawak can be as high as 120,000 individuals (Table 5). This number is the most conservative estimate because the sectors of rivers and other water bodies not surveyed can be much longer than the distance used in the assumption.

SUMMARY OF CROCODILE SURVEY RESULTS FOR PHASE I, II & III

ITEM	Amount/Number/Distance
Total number of rivers surveyed	45
Total distance (of rivers) covered	2,108.38 Km
Total number of crocodile sightings	2,236 ind.
Population estimate (over sectors of the rivers surveyed)	~12,000 ind.
Calculated (overall) Relative Density	1.06 ind./Km
Relative Density (with Correction Factors, CF)	**5.57 ind./Km atau (6ind./Km)**
(katalah ada 20,000 Km semua panjang sungai/muara di Sarawak yang mempunyai buaya, maka anggaran pop. =	**120,000 individu**
Rivers with high crocodile concentration (≥8-14 ind./Km)	Btg. Sadong, Sg. Tuang, Btg. Krian, Sg. Sebiak, Sg. Lingga, Sg. Sebuyau, Btg. Luper, Btg. Saribas, Btg. Baram, Sg. Bekong.
Rivers installed with Crocodile Warning Signages	Btg. Sadong, Btg. Luper, Sg. Rimbas, Sg. Krian, Sg. Sebiak, Btg. Saribas
Rivers where crocodile attacks occured	Almost all of the rivers surveyed in Phase I, II & III.
Rivers where crocodile cullings were done in the past (following fatal attacks)	Sg. Sarawak, Btg. Samarahan, Sg. Sebuyau, Btg. Sadong, Btg. Saribas, Btg. Lupar & tributaries, Sg. Lingga, Sg. Sebiak, Btg. Belawai, Sg. Nieh, Sg. Bekong, Sg. Beko

Table 5. Summary of survey result of Phase I, II and III on Estuarine Crocodile along 50 rivers, tributaries, creeks and deltas throughout Sarawak in 2012–2014.

Figure 6 presents the summary of the population densities of Estuarine Crocodile (with CF) along the surveyed rivers in Sarawak based on the survey conducted between 2012, and mid-2015. The Figure indicates that some rivers in Sarawak are highly infested by crocodiles, where some of them are comparable to that found along most unexploited rivers in the Northern Territory, Australia. Unexploited rivers in Northern Territory of Australia were reported to have a density of not less than 4 ind./km (Whitaker, 1984).

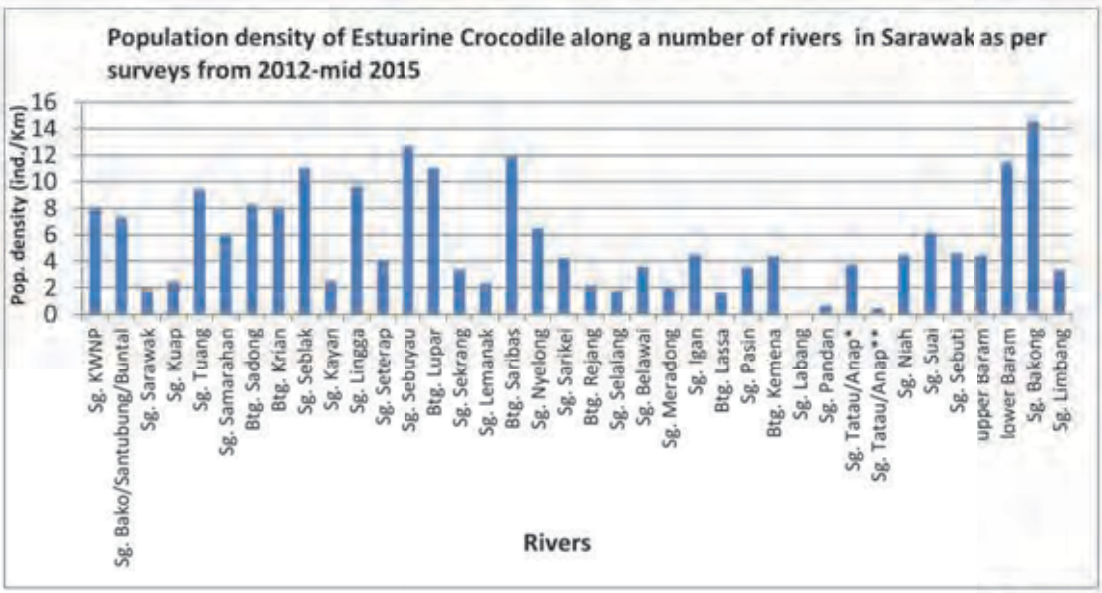


Figure 6. Population densities of Estuarine Crocodile along a number of rivers in Sarawak obtained from surveys conducted during a period from 2012–2014 (which was extended to mid 2015)

4.2.1. Population Structure and Distribution Pattern of Estuarine Crocodile along some major rivers in Sarawak

In term of distribution based on Size Classes, high density of hatchlings and adults were found from lower-middle to upper-middle sectors of rivers, i.e. sectors of rivers affected by brackish water from the incoming tide. The trend of distribution was observed during our surveys along Btg. Samarahan, Btg. Sadong, Btg. Lupar (where the highest concentration of hatchlings-adults was found along Sg. Lingga), Btg. Saribas, Btg. Krian, Sg. Sebelak and Sg. Kemena (Fig. 7–14). The density of hatchlings, however, was found to be relatively low within deltaic areas or sectors of rivers towards its river mouth, and the pattern of the distribution was indicated along rivers and creeks within the Rejang deltas. Relatively more adults (as compared to other Size Classes) were found within deltaic and sectors of rivers near to river mouths, and similar trend of distributions were recorded for most areas beyond upper sectors of rivers hardly reached by the incoming tide (Fig. 7–14). In comparison with other areas, rivers and creeks within the Rejang deltas were

surprisingly found to have a relatively smaller population of Estuarine Crocodile as compared to that found in other rivers surveyed during the period (Fig. 7–14).

Figure 7. Distribution pattern of Estuarine Crocodile (based on Size Classes) along some major rivers in South-Western & Central Regions of Sarawak as per crocodile surveys in 2012 & 2013.

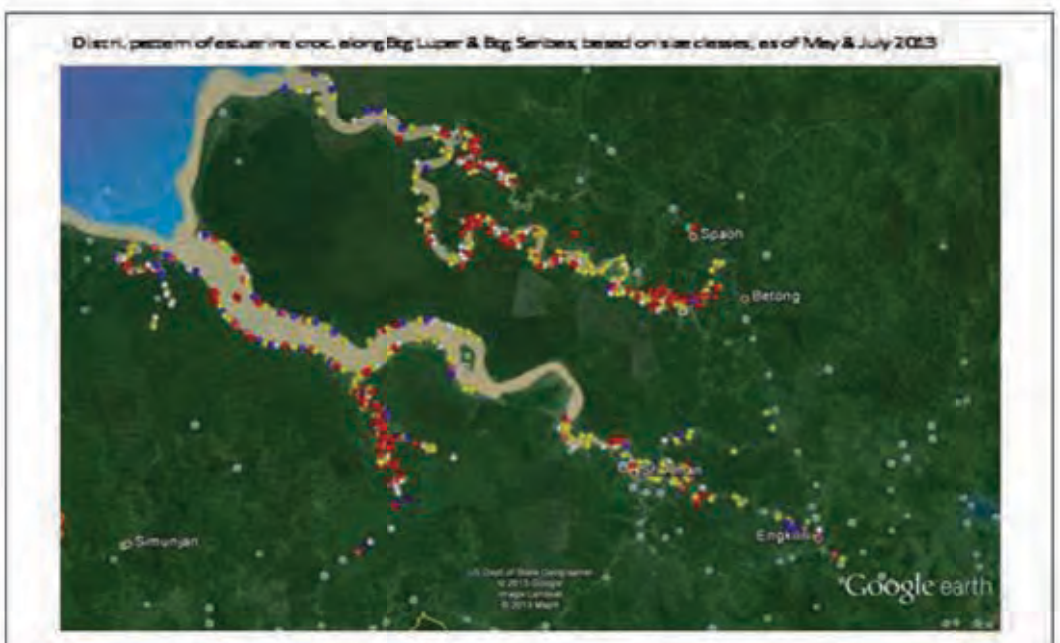


Figure 8. Distribution pattern of Estuarine Crocodile (based on Size Classes) along Btg Lupar and Btg Saribas as per crocodile surveys in May and July, 2013

Figure 9. Distribution pattern of Estuarine Crocodile (based on Size Classes) along Btg Krian and Sg. Seblak as per crocodile surveys in September and October, 2012

Figure 10. Distribution pattern of Estuarine Crocodile (based on Size Classes) along Sg. Santubung, Sg. Bako, Sg. Buntal and Sg. Selesong during crocodile survey in April 2012

Figure 11. Distribution pattern of Estuarine Crocodile (based on Size Classes) along Btg. Sadong as per crocodile survey in August 2012

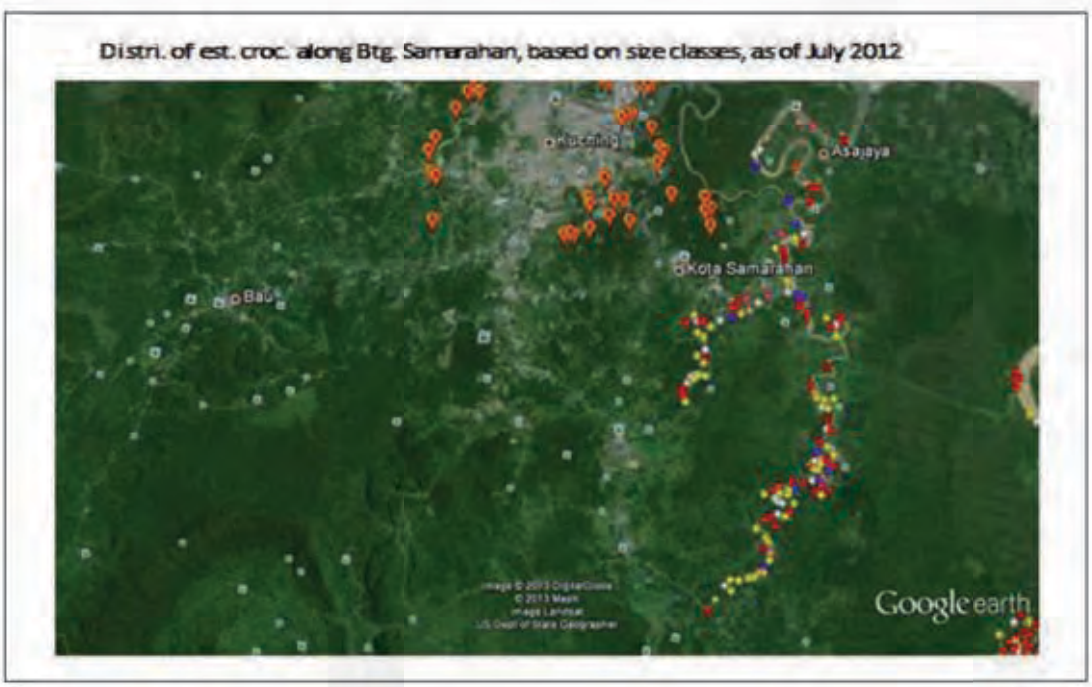


Figure 12. Distribution pattern of Estuarine Crocodile (based on Size Classes) along Btg. Samarahan as per crocodile survey in July 2012

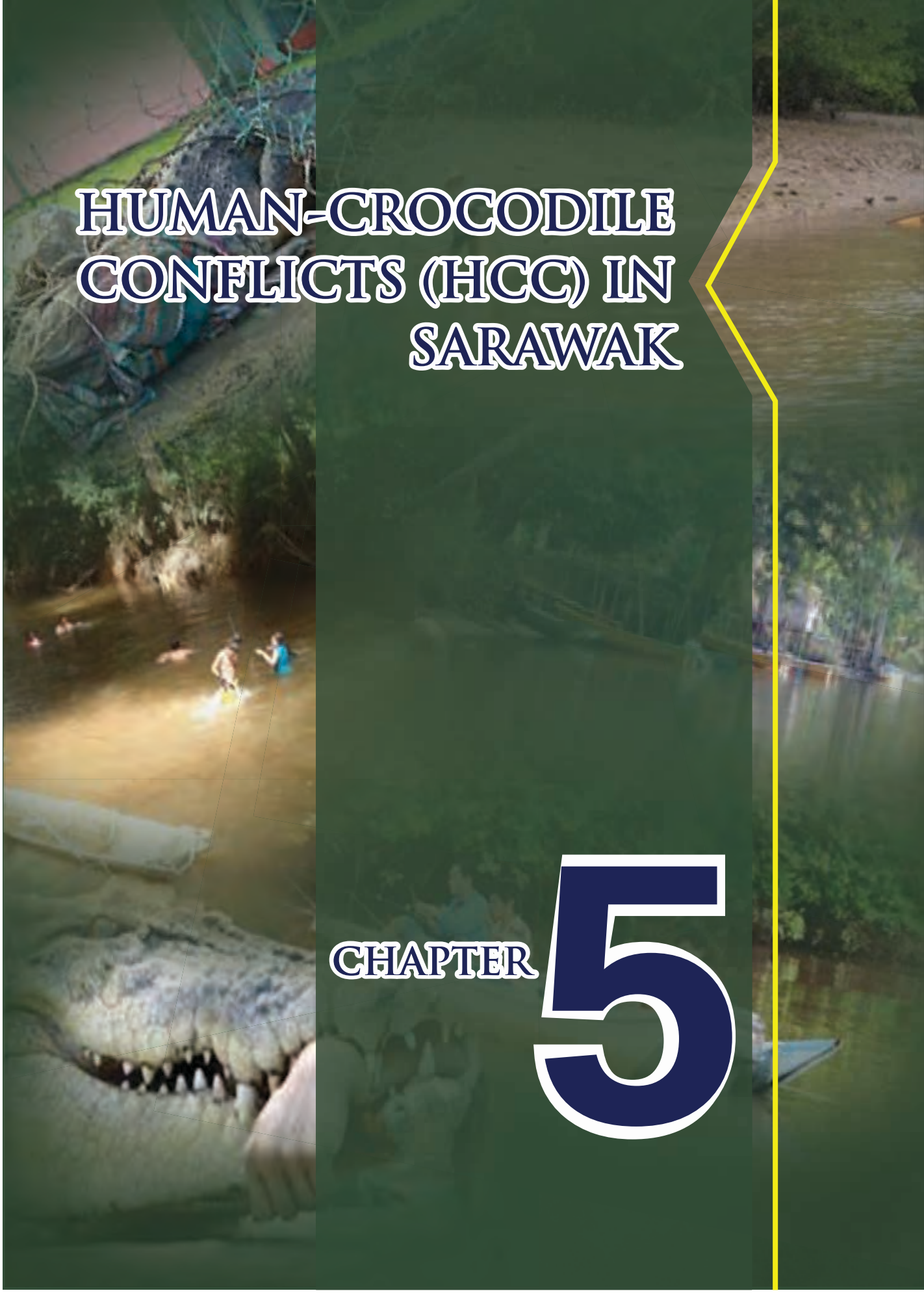
Figure 13. Distribution pattern of Estuarine Crocodile (based on Size Classes) along a number of rivers and deltas within Rejang Basin as per crocodile surveys in October 2013.

Figure 14. Distribution pattern of Estuarine Crocodile (based on Size Classes) along Sg. Kemena and Sg Tatau during crocodile surveys in August 2014.

4.3. Discussion

Surveys conducted along a number of rivers in Sarawak in the mid-1980 concluded that the density of the Estuarine Crocodile within the State was **less than one individual per km** (Cox et al., 1985). However, after decades of protection, the population has recovered rapidly throughout the State. A three-and-a-half-year study (2012–2015) conducted by the Forest Department of Sarawak, vide their Non-Detriment Finding (NDF) project has recorded a tremendous increase in its population where some of the rivers have recorded a density of up to 14 individuals per km. The drastic increase in its population, unfortunately, has led to increasing Human-Crocodile Conflict (HCC), resulting in 18 deaths among local communities in 2016 alone, and 12 attacks (11 of it were fatal) were reported to have occurred in 2017. The figure, however, seems to be declining to five incidents in 2018 and only two in 2019. The reduction in the number of attacks was partly due to the regulated commercial hunting activities of the species throughout the State (which was recently approved by the authority) where at least 30 individual crocodile, consisting of sub-adults and adults, were reportedly captured by licensed hunters. These were in addition to several other large individuals culled by the authorities following attack incidents during the period. The number of attacks seemed to be picking up again towards the beginning of the third quarter of 2020, where five cases were reported until August (Fig. 15 and Appendix I). The high rate of attacks on human remains as there was still considerable numbers of large individual crocodiles lurking in some areas being used by the public.

In term of distribution, more adults and hatchlings were found in the lower and upper-middle sectors of rivers. This finding is most likely due to several environmental factors such as high availability of breeding ground, nesting materials and abundance in food sources for hatchlings. There may be some hatchlings along the lower part of rivers near to river mouth, but due to their tiny size, smaller individual hatchlings could have been washed away by strong current during the incoming tide or that the water salinity is too salty for its food source. On the other hand, the low number of crocodile population within the Rejang deltas, and probably within the whole of Rejang basin, could be due to rampant hunting in the past. To affirm this and to have a better explanation, more surveys and research need to be done on Estuarine Crocodile within the area.



HUMAN-CROCODILE CONFLICTS (HCC) IN SARAWAK

CHAPTER 5

CHAPTER 5: HUMAN-CROCODILE CONFLICTS (HCC) IN SARAWAK

5.1 Introduction

Crocodiles do not necessarily set out to hunt humans. Having said so, one must remember that crocodiles are opportunistic predators, and will even venture onto land to find prey. If that warm-blooded mammal happens to be a human, they will not discriminate. Many areas in which humans and large crocodiles come into contact are remote and sometimes in an impoverished condition. The overlapping use of rivers by crocodiles and local people, unfortunately, often ends up in what has been referred to as "Human-Crocodiles Conflict" (Amarasinghe et al., 2015), and has been reported in many tropical countries worldwide. Human-wildlife conflict is a growing issue around the globe and crocodilians are one of the major group involved (Woodroffe et al., 2005; Lamarque et al., 2009; Amarasinghe et al., 2015). However, most native inhabitants of Sarawak, particularly the Ibans, regard crocodiles with respect, treating them as once great warriors who had fallen victim to headhunting tribes (Ritchie & Jong, 2002). Nevertheless, the Ibans would usually declare war against crocodiles once they have been found responsible for the death of their relatives (Ritchie & Jong, 2002). Accordingly, crocodiles which have killed a human being would be classified as a 'man-eater', and have to be killed (J. Jong, pers. comm.). Amarasinghe et al. (2015), on the other hand, stated that human-wildlife conflict occurs when human requirement encroaches on those of wildlife populations, with potential costs to both humans and wild animals. It has been estimated that about 1,000 people are killed by crocodilians each year (Wikipedia, the free encyclopedia).

As the top predators in most inland waters, crocodilians are involved in human-wildlife conflicts in many countries worldwide. Crocodile attacks occur probably due to a high proportion of large crocodiles in a population. This could also be due to people's increasing reliance towards the water resources that contain crocodiles (Amarasinghe et al., 2015). Human-Crocodile Conflicts (HCCs) are sometimes attributed to overfishing of the crocodile's main food sources, leading crocodiles to hunt other preys, including humans (Uragoda, 1994; Rao, 1996; Anderson & Pariela 2005; Amarasinghe et al., 2015). Depleting wild crocodilian populations are usually managed primarily through conservation, that is, to rebuild the population. However, efforts to help the endangered populations to recover often ends up in Human-Crocodile Conflict, leading to negative public attitudes about those same crocodilian

populations. Human-Crocodile Conflicts could be considered to include "any interaction which results in negative effects on human social, economic or cultural life, on conservation of the species or the environment". These conflicts could also be defined as interactions between crocodiles and humans where they or their livestock are threatened, injured or killed, or livelihoods are affected, such as damage to fishing gear or loss of catches.

In Sarawak, most attacks occur in the shallow parts of rivers, such as along river banks where people tend to bath, swim, wade to set up fishing nets or wash in the late afternoons. This pattern could probably be explained by the fact that it is easier for the crocodile to capture its prey in shallow water with a riverbed providing ground for the predator to launch an attack. Though attacks may occur at any time during the day, more attacks occurred in the period between late afternoons and dusk when it is almost dark. It is believed that at that time, crocodiles cannot easily identify human beings, and confuse them with more regular prey, such as monkeys, dogs or other animal species, suggesting that these attacks are caused by mistaken identity (Caldicott et al., 2005). The above justification may apply to attacks on people walking near water edges of rivers. Meanwhile, Caldicott et al. (2005) mentioned that attacks on a person travelling on small boats could be due to the shape of the boat viewed from underwater is different from that of the actual boat and resembles another crocodile or other animal swimming in the water. Attack by a crocodile on another big crocodile may not be likely to happen regularly. Thus, incidents of crocodile attacks on people on small boats are rarely recorded in Sarawak.

Crocodiles are also opportunistic feeders, eating a wide range of prey. With increasing body size, crocodilians shift to larger prey, and humans are well within the size range of prey that can be eaten by a large Estuarine Crocodile. Studies in Northern Australia indicate that 89% of the attacks were considered as attempts by the crocodiles to find food. However, the possibility of territorial defense cannot be ruled out (Caldicott et al., 2005). In Africa, there are several hundred crocodile attacks on humans per year (Webb et al., 1997). Many of those attacks took place among small communities and are not widely reported. One third to half of the total number of attacks were fatal, comparable to that occurring in Sarawak, where 60% of the attacks are fatal. Thus, for many people, especially those residing along crocodile-infested rivers, the risk of being attacked by a crocodile is part of everyday life. However, knowing more about the patterns and trends involved in

such attacks, for instance in term of timing or activities in rivers, could help to save us from being attacked by the predators.

Crocodile attacks on humans are common in places where large crocodilians are native, and human populations live. Usually, crocodilians of 2.5 meters or more in length represent a danger to humans. This is because these crocodilians are considered capable of killing adults. It has been estimated that about 1,000 people are killed by crocodilians each year. The two species with the most well-known and documented reputation for preying on humans are the Nile Crocodile (*Crocodylus niloticus*) and the Estuarine Crocodile (*C. porosus*), and these are the perpetrators of the–vast majority of both fatal and non-fatal crocodilian attacks(CrocBITE, Worldwide Crocodilian Attack Database: About human-crocodile conflict. Charles Darwin University, Northern Territory, Australia). Reviews indicate that at least half of all attacks by the Nile and Estuarine Crocodiles are fatal (CrocBITE). In Australia, however, only about 25% of Estuarine Crocodile attacks are fatal [IUCN Crocodile Specialist Group (iucncsg.org), retrieved 3 February 2013)]. Though only a few measurements on sizes of crocodile that attacked in Sarawak were recorded, the mean size of crocodiles involved in fatal attacks elsewhere was about or more than 3 m. The majority of fatal attacks are believed to be predatory, hence, the Nile and Estuarine crocodiles can be considered–the most prolific predator of humans among wild animals (IUCN Crocodile Specialist Group, iucncsg.org. Retrieved 3 February 2013).

Although attacks in Sarawak occurred almost every month for the last 23 years, there seems to be a clear pattern of these incidents. Elsewhere, crocodile attacks are often seasonal where it is most prevalent between October and March (CrocBite website) and in between November and June, with a peak occurred in March. Pooley (2014) attributed the attacks to three major factors which include an increase in rainfall, temperature and the breeding season. The abundance in the number of hatchlings found in December until March in KWNP seems to concur with the above findings whereby crocodile become more aggressive during the breeding season, consequently leading to increase in attacks on human. Crocodiles tend to attack when it is warmer due to the fact they are ectotherms. Attacks usually occur when the minimum temperature was higher than usual (Pooley, 2014). According to Pooley (2014) divers in crocodile-rich rivers are said to restrict their diving activities when the water temperature becomes warmer than usual and resume the activities when the temperature goes down to or under 19 degrees Celsius. It is safer to use rivers when the temperature is colder and considered as risky to use crocodile-infested rivers when

the temperature is warmer. Water temperature may be warmer towards the end of the year when the in-flow of seawater into rivers usually occur during the passage of the Northeast Monsoons.

5.2. History and statistic of crocodile attacks in Sarawak and elsewhere in the world.

In Sarawak, crocodile and human have shared the same environments for many millennia, and for most parts, they have coexisted peacefully (Stuebing et al., 1985). In the past, relatively few humans fell victim to the predators, but of late, the number of crocodile attacks has increased dramatically (Engkamat, unpublished). The official record between the year 1941 and 31 August 2020 has shown that a total of 185 attacks have taken place along a number of rivers throughout Sarawak, 111 of which resulted in human fatalities (Fig. 15 and Appendix 1). The number of actual attacks, however, might have been higher as a complete account and full compilation of the attacks were only started in 1990 when the crocodile species was listed as protected species under the State's Wild Life Protection Ordinance. The total number of attacks (185) has given a rate of 2.3 attacks per year. Out of the total figure of the attacks, 111 (60.0%) of it were fatal, giving a rate of 1.3 people killed by the crocodile annually over the last 78 years. The total number of the actual attacks in Sarawak will be higher if the full records of the incidents since the 1940s are available.

The number of previous crocodile attacks that occurred between the 1940s and 1980s in Sarawak was obtained from data and information compiled by the Sarawak Museum whilst most of those occurring from 1990s until 2016 were reported directly to the Sarawak Forest Department, Sarawak Forestry Corporation and/or the police. These complete records after the attacks are useful for the victims and their family members as it could be used to substantiate and expedite 'claims for compensation' from certain Government agency. Some information on non-fatal attacks, or attacks that did not cause any injury to the victims was obtained from the general public through interviews. Statistic and trend of the recorded crocodile attacks in Sarawak that occurred from 1991 until 31 August 2020 are summarized as follows;

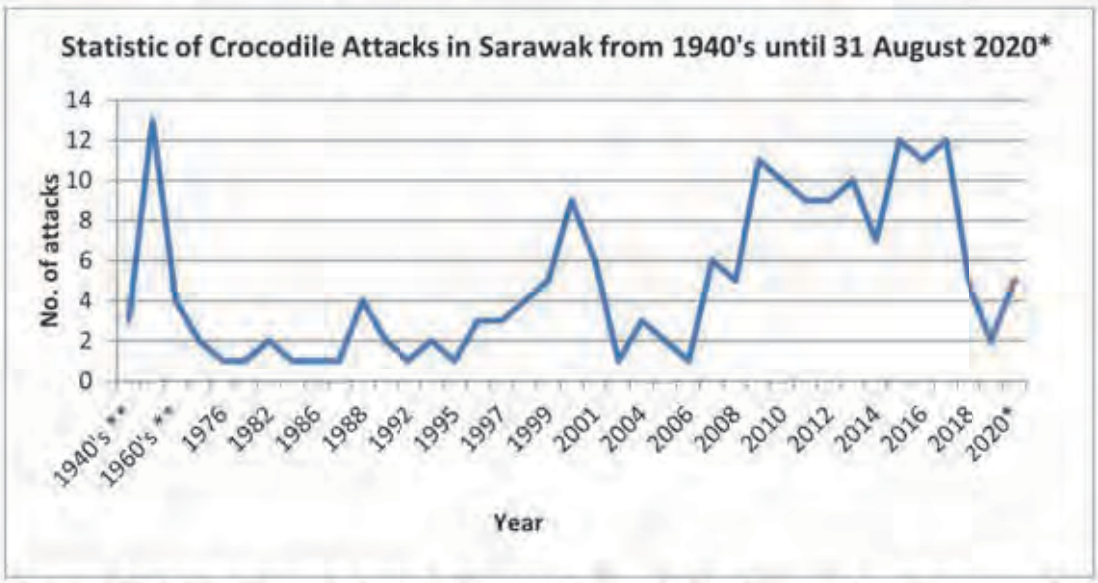


Figure 15. Statistics and trend of crocodile attacks in Sarawak that occurred from 1941 until 31 August 2020* (there was hardly any complete record of attacks prior to 1995).

The figure shows inconsistency in the number of attacks from the 1940s until late 1980s prior to the legal protection given to the species in Sarawak, and most of the data on the attacks were obtained from other government agency, such as the Sarawak Museum. A more proper recording was made by the Department starting from the early 1990s when crocodile species in Sarawak were listed under the protected list of the Wild Life Protection Ordinance 1990. Due to some reasons, the complete records of the attacks from 1992 until 1995 are missing. It is believed that the actual number of attacks must have been more than what is shown in the figure. A more reliable and complete record of the attacks is reflected through the data obtained from 1996 until the present. The record shows a drastic increase in the yearly incidents to up to 12 attacks between 2015 and 2017. The increased number of attacks during the Brooke's era and the British colonization era (1888–1960) caused the general public to perceive crocodiles as 'pests' or 'vermin' (Whitaker, 1984; Cox & Gombek, 1985). This had led to the rampant killing of crocodiles throughout the State, as crocodile hunting, was encouraged. As an incentive, the hunters were given a bounty for each crocodile killed and crocodile eggs gathered (Whitaker, 1984). The price for whole crocodiles in 1937 was rather low: approximately at 36–40 cents/inch of skin and about 50 cents/kg for meat and gallbladders, indicating the presence of good stock (Cox & Gombek, 1985; Ritchie

& Jong, 1993). As a comparison, elsewhere, for instance, in the Ragama-Handala-Wattala area, Sri Lanka, one kilogram of crocodile meat was sold for 300 Sri Lankan Rupees, which is approximately US$2.50 (Amarasinghe et al., 2015), or approximately Ringgit Malaysian (RM) 10.00.

Details analysis and breakdown of the attacks shows that about 60% (111) of it were fatal while only 40% comprising of non-fatal (Fig. 16).

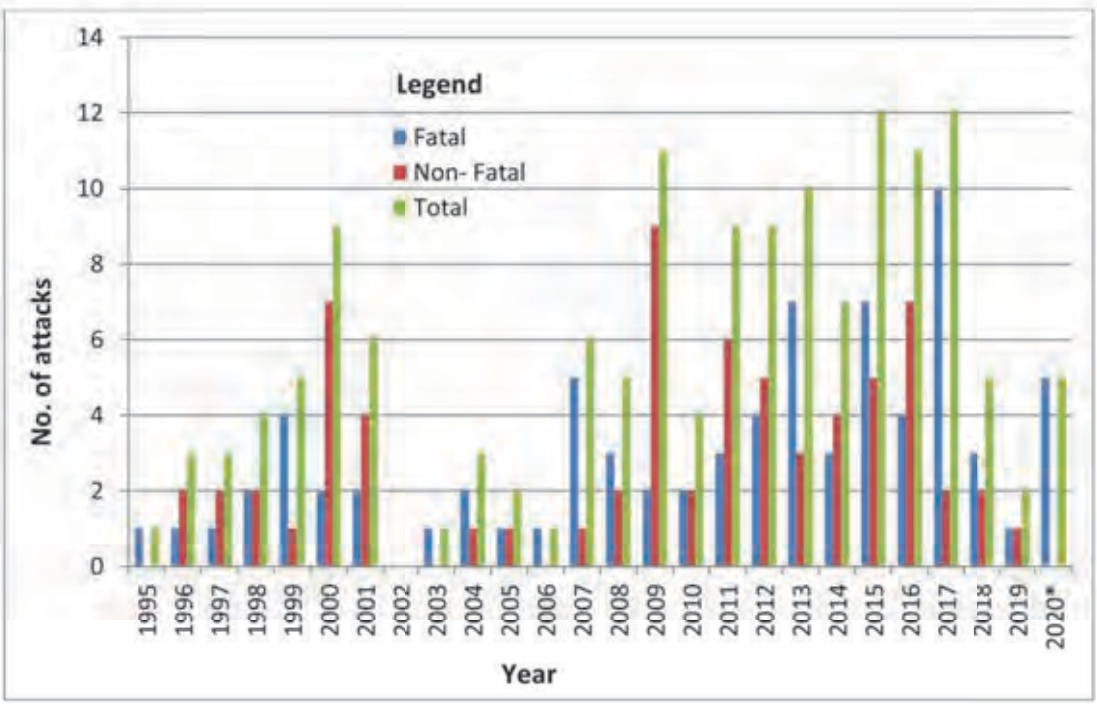


Figure 16. Detail analysis and breakdown of crocodile attacks occurring in Sarawak from 1995 until 31 August 2020 (There was hardly any detailed information of the attacks with the Department prior to the 1995).

As mentioned, apart from Sarawak, crocodile attacks have been documented elsewhere, such as in Sri Lanka since the year 2008, with eight confirmed human fatalities were caused by the Estuarine Crocodile. In addition, three people who were 'disappeared' are believed to have been taken by crocodiles, while 25 people were injured during attacks, with injuries ranging from minor to grievous (Amarasinghe et al., 2015). Most attacks took place in the early mornings, late evenings or by night.

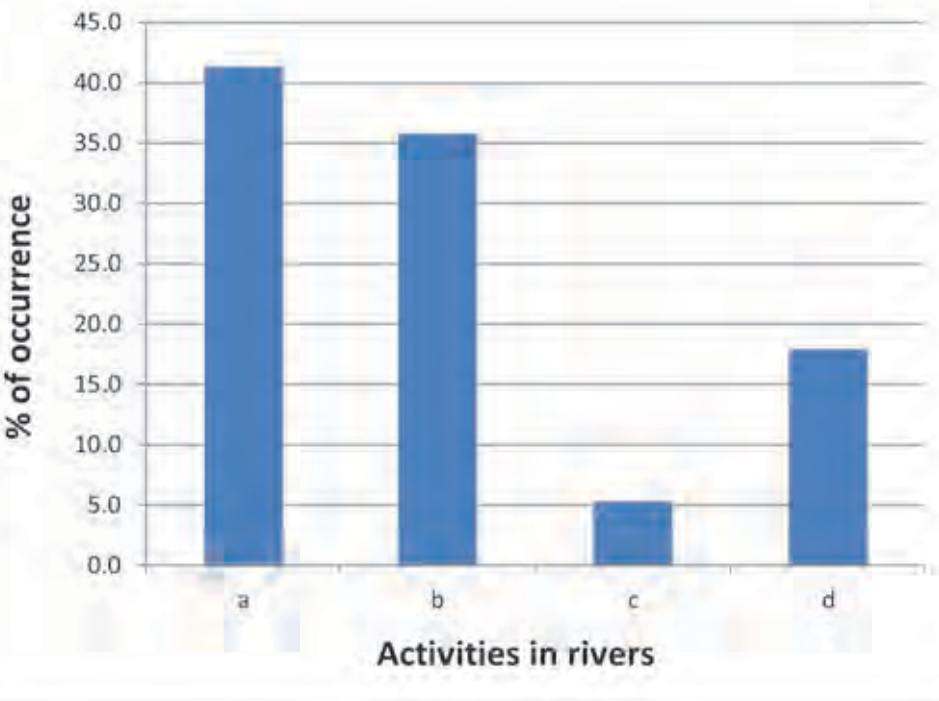
Most of the people who were attacked were males aged over 30 years, and attacks occurred while victims were bathing or carrying out activities in water, such as washing clothes, washing kitchenware, collecting aquatic plants and fishing (Amarasinghe et al., 2015). The similar scenarios were recorded in most of the crocodile attacks that occurred in Sarawak as reflected by the following Table (Table 6).

No.	Activities	No. of Occurrence	% Occurrence
1	Bathing/Swimming/Wading/Washing in rivers (usually in the evening): **(a)**	39	41.0
2	Fishing along rivers (by fishing nets/lines/traps (from boats and sometimes involving going down to water edge): **(b)**	34	35.8
3	Boating along the rivers (sitting on boats or small wooden dinghies, paddling): **(c)**	5	5.3
4	Others (such as walking/strolling along water edges along river banks and beaches near to river mouths): **(d)**	17	17.9
Total	95	100.0	

Table 6. Analysis of activities of crocodile attacked victims (n=95). Note: Activities for the remaining number (61) of the recorded attacks are unknown.

Table 6 shows that out of 95 incidents of crocodile attacks in and along the rivers and water bodies, 41% (39 incidents) occurred on people bathing, swimming, wading, and washing in rivers. Meanwhile, 35.8% (34 incidents) of the attacks occurred on people fishing along the riverbanks and water edge at waist deep to set up and check their fishing nets. Several attacks were also reported to occur on people strolling and walking along riverbanks and beaches near to river mouth, and on people sitting and rowing boats too near to riverbanks. These comprise of 17.9%

(17 incidents) and 5.3% (5 incidents), respectively. The frequency and comparison of the attack incidents related to activities of its victims is reflected in Figure 17.



a: bathing, washing, swimming, wading in rivers (usually in the evening, 17:00-18:30 hours.
b: fishing along rivers (by fishing nets/lines/traps from boats where sometimes require fishermen to go down to the water's edge.
c: boating/paddling along rivers (sitting on boats or small wooden dinghies).
d: others (eg. walking/strolling along water edge or rivers or beaches), or sitting on edge of jetties.

Figure 17. Analysis of the activities of victims of crocodile attacks (n = 95). Note: Activities for the remaining number (61) of recorded attacks are not known.

5.3. Analysis of the temporal patterns of crocodile attacks in Sarawak

In terms of the timing of the attacks (n = 73), 17 of the incidents (23.3%) occurred in the evening between 1800–2000 hours, 14 (19.2%) took place in the late afternoons, between 1400 –1800 hours while eight attacks (11.0%) occurred in early mornings, between 0600–0800 hours. Only seven attacks (9.6%) occurred between

noon and 14:00 hours, while six incidents (8.2%) were reported between 1000–1200 hours and between 1400–1600 hours. Only two to three attacks (2.7–4.1%) were reported to have occurred at night and in the early morning, i.e., between 2000–0400 hours (Figure 18).

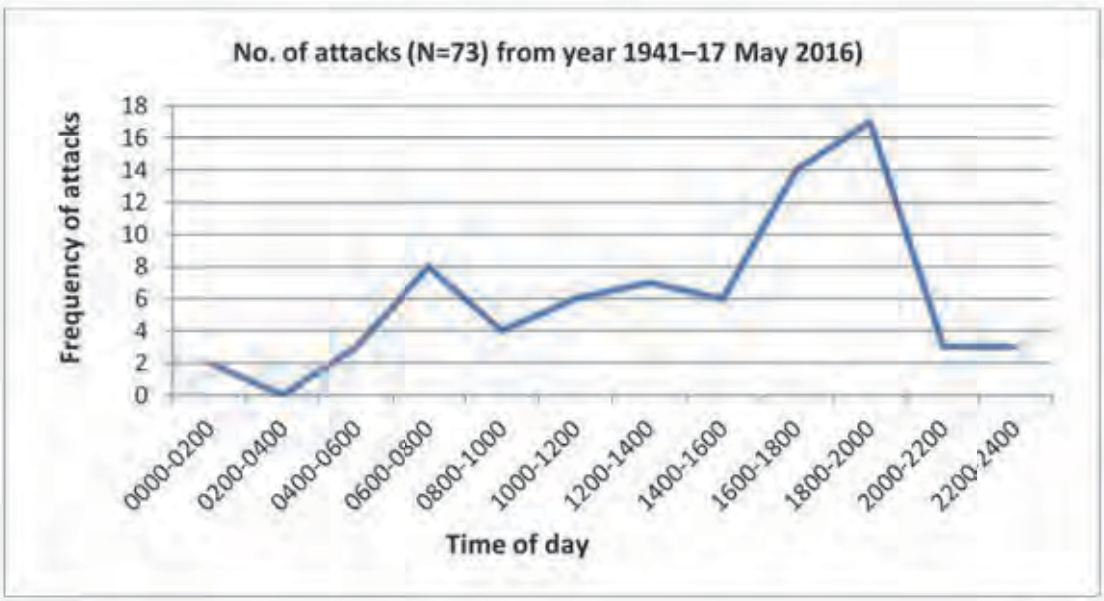


Figure 18. Summary on Trend of crocodile attacks based on time of day (temporal pattern).

5.4. Analysis of crocodile attacks, by months, in Sarawak

The monthly number of crocodile attacks recorded over the past 23 years seems to increase from November and reaching its peak in March. This increase is evidenced by a total of 19 attacks recorded for the period (Fig. 19). The Figure also shows the decline in the number of attacks from June, with only 13 attacks for the past 23 years, while the least number of attacks occurred in August, with only seven reported cases. Increased attacks could be triggered by the monsoon season that usually starts at the end of the year and reaches its peak by January and February. In some cases, the monsoon season could extend to March. Monsoon season is the time when Estuarine Crocodile breeds when the inflow of seawater into riverine systems usually occur and bring in food, particularly tiny shrimps (*Pineus* sp.) for the hatchlings. The situation usually leads to breeding pairs of the crocodilian species getting more territorial and aggressive during the period, and anything that comes

into their territories would likely be in danger of being attacked (Stuebing, 1985; Engkamat, unpublished report). Details account of the attacks by months is reflected by Fig. 19.

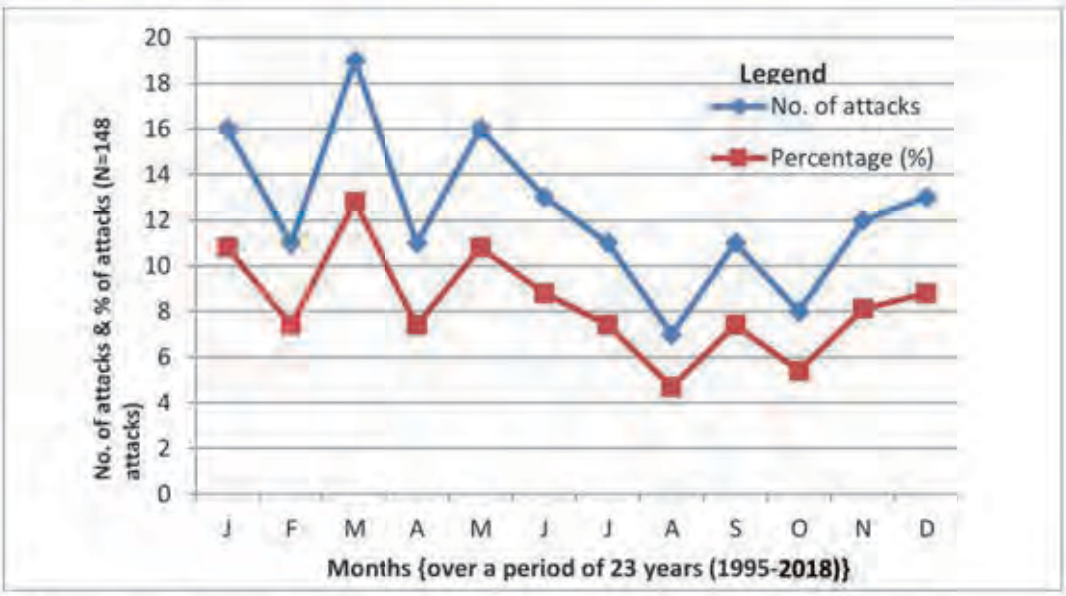


Figure 19. Trend of crocodile attacks on human in Sarawak, by months, over a period of 23 years (1995-2018).

5.5. Analysis on racial patterns of crocodile attacks in Sarawak

In terms of racial composition of crocodile attack victims in Sarawak over the last 77 years, it seems that the majority of the victims are Iban - a total of 85 persons (47.8%), followed by Malay / Melanau - 65 individuals (36.5%). The remaining victims come from other indigenous groups and race, such as Chinese, Orang Ulu and Bidayuh, with less than 10 cases over the same period. A total of 12 Indonesians, mostly construction and plantation workers, had also fallen victims to crocodile attacks (Fig. 10). The attacks on these groups of people are partly due to the belief that crocodile does not attack unless provoked or to take revenge on humans, or do not attack someone who does not take or touch food when offered. Furthermore, some attacks might be caused by ignorance or carelessness when using rivers inhabited by the predators. The breakdown of the attack victims, based on race, is shown in Fig. 20.

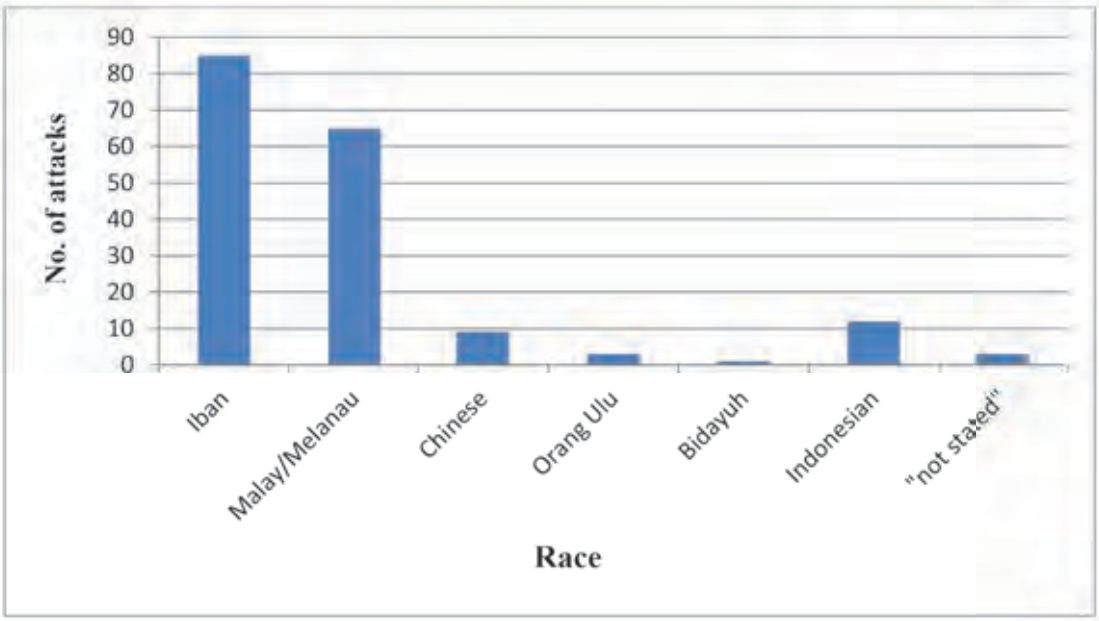


Figure 20. Statistic of recorded crocodile attacks, based on race, in Sarawak from 1941 to 15 November 2018.

5.6. Possible Factors that lead to crocodile attacks

Crocodiles do not necessarily set out to hunt humans. They are opportunistic predators and feeders, and will even venture onto land to find prey. If that warm-blooded mammal happens to be a human, they will not discriminate. An accurate count of annual crocodile attacks on humans is difficult to obtain, especially those that occurred decades or centuries ago. Many of the areas in which humans and large crocodiles come into contact are remote, impoverished and most attacks that did not cause serious injury were not reported to the authorities, making it difficult to verify.

As mentioned earlier, most of the crocodile attacks in Sarawak occurred on people in bathing, swimming, wading to set up fishing nets or washing in the shallow parts of rivers and along riverbanks in the late afternoons. Unlike in deeper parts of the river, crocodile prefers to attack its prey in shallow water with a riverbed providing ground for it to launch an attack. Based on the records, most attacks occurred in late afternoons until dusk, the time when crocodile cannot easily differentiate between human beings and its regular preys such as monkeys, dogs or other animal species. Such a situation could perhaps, be described as mistaken identity (Caldicott et al., 2005). Most attacks at this time occurred on people walking near to water edges or

along riverbanks. On the other hand, Caldicott et al. (2005) stated that attacks on people travelling on small boats as the shape of the boat viewed from underwater may resemble another crocodile or other animal swimming in the water. Attack by a crocodile on another big crocodile may happen, and such an aggressive and territorial act can occur on people sitting on small boats. The rate of such attacks, however, is relatively low compared to the rate of attacks on people doing activities as mentioned earlier (Fig. 17).

Estuarine Crocodiles are opportunistic feeders, as well as opportunistic predators (eating a wide range of preys), thus could easily take on human as its body size increases. In Australia, 89% of the attacks were considered as attempts by the crocodiles to secure food, although the possibility of territorial defense cannot be ruled out (Caldicott et al., 2005). In comparison, Africa recorded several hundred crocodile attacks on humans per year (Webb et al., 1997) where about a third to half of the total number of the attacks were fatal, comparable to the rate (60%) that occurred in Sarawak. Thus, people who reside along crocodile-infested rivers should be aware of the potential risk of being attacked by crocodiles when using rivers. Therefore, one needs to be vigilant and understand the patterns and trends of crocodile attacks. Perhaps by having more knowledge on biology, ecology, patterns and trends in crocodile attacks, one could help to save his/her own life as well as the life of other people from being victimized by the predator.

As stated earlier crocodile attacks on human are common in places where large crocodilians are native to the area while at the same time having human populations living therein. Normally such attacks were the works of large crocodilians of about 2.5 to 3 meters in length or more. Thus individual Estuarine Crocodile with this size, or larger, pose a serious danger to humans, as compared to smaller crocodilians. Among the crocodilian species, the Nile and the Estuarine Crocodile are the most dangerous and notorious crocodile species. This is due to their large body size, and history of both fatal and non-fatal crocodilian attacks (CrocBITE, Worldwide Crocodilian Attack Database: About human-crocodile conflict. Charles Darwin University, Northern Territory, Australia). In Sarawak, most of the recorded fatal attacks are caused by Estuarine Crocodiles with the length of 3-metre (or more). The crocodile is considered by many as the most prolific human predator, as compared to other wild animal species (IUCN Crocodile Specialist Group, iucncsg.org. Retrieved 3 February 2013).

In terms of racial composition among the victims, the Ibans (as mentioned previously) were the most dominant human prey of Estuarine Crocodiles in Sarawak, followed by the Malay/Melanau, compared to the rest of the racial groups. The high number of Iban victims is not because their 'meats are tastier' but because most Iban communities are sharing the same habitat with the 'man-eaters'. Iban communities mostly reside along the river and depend on the riverine habitats, which are also inhabited by the predators, for their livelihood. The competition for food resources along the river usually end up in tragic attacks by the predators, causing endless conflict and hostility between most Ibans and the crocodiles. Iban traditional belief that crocodiles are their forefathers (King, 1985; Shim, 2002; Munan, 2006; Datan, 2010) may also lead to an increase in crocodile attacks among them. Many of them believed that crocodiles were derived from humankind, a termed called 'ancestorship' (Engkamat, 2020) and would not attack them as they are 'relatives'...a kind of destructive belief that misled many of them into tragedies...

The Malay and Melanau also fell victims to the crocodilians, though the number of victims is not as many as the Ibans. This is possibly due to their profession as fishermen in crocodile habitats, and not so much due to belief. The similar reason could also be applied to the other racial groups as most of the attacks on them occurred when they were fishing or doing other activities along crocodile-infested rivers. Therefore, based on the above statements and records described in previous chapters, it can be concluded that the increase in crocodile attacks in recent years in Sarawak was highly likely due to the following factors:

(i) Its protection status under the law, the Wild Life Protection Ordinance, 1998 (where the species is listed as protected) increases its population size, especially among large individuals. This eventually increased the number of attacks on the humans sharing their habitat.

(ii) Clearing of forest along rivers for agricultural activities has resulted in the massive growth of grass and shrubs as succession species. The debris provide excellent nesting materials for gravid females. Breeding individuals tend to establish territories and human intruders into the areas are likely to be attacked by female crocodiles which become aggressive during the breeding period (Stuebing et al., 1985).

(iii) Overlapping use of river habitat by humans and crocodiles. There are still many places in Sarawak where rivers are the source of livelihoods such as for food and water for drinking and bathing, and for transportation of local

communities since road facilities are still lacking. As rivers are also housing the 'man-eaters', the overlapping use of the habitats would consequently lead to Human-crocodile Conflict (HCC). See Appendix III.

(iv) Overfishing has removed potential prey species from the waterways, including fish and shellfish while hunting has significantly reduced large preys, such as monkeys, otters, pigs and deer, the main food of larger crocodilians. Thus, as Estuarine Crocodiles are opportunistic feeders/predators, humans tend to become its victims.

(v) The monsoon season brings excess water from the ocean into rivers, which might be warmer than the minimum water temperature. The change in the water temperature may trigger aggressive behavior of Estuarine Crocodile.

(vi) Defense of territory: Saltwater crocodiles are highly territorial. Males and females establish their territories and defend them against intruders, whether other crocodiles or humans.

(vii) Defense of the nest and/or young: Most crocodilian exhibit some form of nest defense. In the case of Estuarine Crocodiles, females defend their nest against intruders to deter potential egg predators. Crocodilians also react to distress calls of their young (Caldicott et al., 2005; Webb, 2008).

(viii) Hunting for food: Crocodilians are opportunistic feeders and may take suitable-sized animal prey, including humans.

(ix) Mistaken identity: Some attacks may not be directly focused on humans, but the crocodilians may not be able to differentiate between humans and common prey, such as monkeys or dogs at certain times of the day.

(x) Taboo among many local people to kill, capture or harass crocodile, leading to an increase in the population of the species. Taboo among some local communities in Sarawak stemmed out from their belief and myths that crocodiles descended from human beings. Others believe that crocodile effigies could be used to cure some kind of diseases and to get rid of crop pests.

As crocodile attacks on humans have now become an alarming issue in Sarawak, corrective measures need to be put in place through the implementation of recommendations from awareness programs on crocodiles, as well as from recommendations in the Management Plan for Estuarine Crocodile in Sarawak, 2016-2020. Human-Crocodile Conflict (HCC), whereby both humans and crocodiles

would become victims, could be reduced, or even put to a stop if the public could adhere to the given recommendations.

The alarming increase in crocodile attacks in Sarawak, of late, has attracted serious attention from members of State Legislative Assembly and ministers. Subsequently, orders for the culling of nuisance crocodiles were given to reduce its population along certain sectors of rivers. This is part of the effort to reduce Human-Crocodile Conflict (HCC) by bringing down the increasing number in the population of the predators. There are beliefs among some people in Sarawak that once individual crocodiles have preyed upon human being, it would likely target the same prey species again unless it is terminated. As all species of crocodiles in Sarawak are legally protected by local law on wildlife, as well as listed as protected under CITES at the international level, the complete extermination of the species within the State is not quite possible. Thus, proper and sound management of Estuarine Crocodile has to be put in place to turn potential 'risks' to 'opportunities' to benefit the State and its people, as well as to conserve the species sustainably.

The Malaysian Federal Government, through the Ministry of Natural Resources and Environment (NRE), has funded a project called "Sustainable Management of Estuarine Crocodile (*Crocodylus porosus*) in Sarawak" in collaboration with the Nature Conservation and Constitution Division (NCCD) of the Forest Department of Sarawak, to resolve the Human-Crocodile Conflict faced by Sarawakians. The project was implemented from 2012 until 2019. The main objective of the project is to sustainably manage the crocodilian species in Sarawak, facilitate both consumptive and non-consumptive utilization of the species and its resources, and at the same time, conserve the species. Consumptive utilization of the species may include commercial hunting activities while non-consumptive comprises of various activities which include croco-tourism, education & awareness program on crocodile and research. The project incorporates some activities on crocodile conservation undertaken by the Sarawak Forestry Corporation.

MANAGEMENT ACTIVITIES

CHAPTER 6

CHAPTER 6: MANAGEMENT ACTIVITIES

6.0. Management Activities undertaken by the Forest Department of Sarawak

In addressing the increasing incidents of Human-Crocodile Conflict (HCC), haunting the local communities residing along rivers, the State Government of Sarawak, through its Forest Department has implemented various activities as part of the 'Sustainable Management of Estuarine Crocodile (*Crocodylus porosus*) project. These activities are detailed below;

6.1. Down-listing of Estuarine Crocodile from CITES Appendix I to Appendix II

Due to the increase in HCC in Sarawak, the State Government has called upon relevant agencies, particularly the Forest Department and the Sarawak Forestry Corporation (SFC) to address the issues while at the same time putting up some efforts to ensure the sustainability of the protected crocodilian species. In response to the call, the Forests Department and SFC have agreed to request for the down-listing of Estuarine Crocodile in Malaysia from CITES Appendix I to CITES Appendix II. The request was officially granted during the 17th CITES COP in October 2016 in Johannesburg, South Africa. In this light, the regulated commercial hunting and export of the species are strictly confined to Sarawak and not granted to Sabah and Peninsular states. During the Conference, the Malaysian delegation, led by a Federal Minister of Natural Resources and Environment (Fig. 21) managed to convince the State Parties and the CITES Secretariat that HCC in Sarawak could be reduced through regulated commercial hunting of the species within the State. The delegates also argued that regulated hunting could benefit the local people sharing the same habitat with the predators. With the down-listing, regulated commercial trade in Estuarine Crocodiles captured from the wild in Sarawak could now be legalized with a valid license from the Controller of Wild Life. While the regulated hunting and sale of the Estuarine Crocodiles taken from the wild are no longer prohibited, the species remained strictly protected under the Wild Life Protection Ordinance, 1998. Anyone found possessing, killing, hunting, selling and offering the crocodiles for sale without a valid license from the Controller is guilty of an offence with a penalty of imprisonment for one year and a fine of ten thousands

Malaysian Ringgit [Section 27(1), Wild Life Protection Ordinance, 1998]. With the implementation and enforcement of the law provision and its rules, as well as the conditions of the license, regulated hunting would not cause any detrimental impact to the wild population of Estuarine Crocodile in Sarawak.

Figure 21. A Malaysian delegation (with the Malaysian Ambassador to South Africa) attending the 17th. CITES COP, October 2016, Johannesburg, South Africa.

6.2. Establishment of Crocodile-Removal Zones (CRZ)

Certain public areas, including tourism beaches and waterfronts of big cities throughout Sarawak, have now been declared as 'Crocodile-Removal Zones' (CRZ), formerly known as 'Crocodile-Free Zones' (CFZ). These public areas include several recreational sites that cater to activities like swimming, boating, jet skiing and bathing, jetties at longhouses and villages, waterfronts, or areas within places of worship. No crocodile of any size would be tolerated within these areas, and every individual crocodile found encroaching these zones would be expeditiously removed

by any mean deemed appropriate. The task could be carried out by the authority or the general public, following the set Standard Operating Procedures. Live crocodiles removed from the zones could be kept at a wildlife center in Matang, which is about 18 km from Kuching or at the Crocodile Sanctuary in KWNP once its construction is completed. At the moment the wildlife center in Matang serves as a rescue center for wildlife, including crocodiles, taken from various parts of Sarawak. Establishment of rescue centers for wildlife is one of several obligations of the Forest Department and SFC as both are of the agencies are CITES Management Authorities for the State. Alternatively, the task of removing nuisance crocodiles from any areas, including areas already declared as CRZ, could be done by licensed crocodile hunters of the respective area. Some of the areas that have been identified as CRZ in Sarawak are as per Table 7.

Place	Exact location
Kuching City	from Satok Bridge to the Barrage
Santubong, Kuching	Pasir Panjang - Pasir Pandak waters.
Santubong, Kuching	Resort beaches of Damai Peninsula, Santubong.
Bako National Park, Kuching	Telok Asam, Telok Lakei, Telok Tajor and Telok Pandan Kechil at Bako National Park.
Bako, Kuching	Bako Village waters.
Wind Cave National Park, Bau	Wind Cave Nature Reserve recreation waters.
Lundu	Siar Beach and Pandan Beach.
Sri Aman town	Sri Aman Waterfront waters.
Sarikei town	Sarikei Waterfront waters.
Sibu town	Sibu Waterfront waters.
Bintulu town	Bintulu Waterfront waters.
Miri town	Miri Marina - Piasau Bridge area, Sg. Miri.
Batu Niah bazaar	Batu Niah Bazaar Waterfront waters (Sg. Niah).
Sepupok, Niah	Sepupok Waterfront waters (Sg. Niah).
Bakenu	Bekenu Waterfront to Kpg. Dagang waters (Sg. Sibuti)
Marudi town	Marudi Esplanade waters (Btg. Baram)
Long Lama bazaar	Long Lama Esplanade waters (Btg. Baram)
Limbang town	Limbang Waterfront waters (Sg. Limbang)
Lawas town	Lawas Esplanade waters (Sg. Lawas)

Table 7. Showing some of the Crocodile Removal Zones (CRZ) in Sarawak

6.3. Enhancement of crocodile surveys, research, awareness program and population monitoring throughout the State.

Surveys, research, and regular population monitoring of Estuarine Crocodile throughout the State are critical in ensuring effective management of the species. For instance, areas found to be highly inhabited by the predators need to be marked with warning signs. At the same time, education and awareness campaigns on crocodile have to be carried out among the local communities of the area. The task is not confined to the Forest Department, and it should involve other agencies such as SFC, Universities, police, Rivers' Board, Civil Defense Department and of course, local communities. The Forest Department even encourages participation of both under and post-graduate students from local universities to participate in the program.

Figure 22a Figure 22b Figure 22c

Figure 22a – 22c: Some of the surveys and research activities on Estuarine Crocodile conducted by researchers from the Forest Department and students from Unimas.

6.4. Culling of nuisance crocodiles

Culling or selective killing of nuisance crocodiles are normally conducted following attacks on humans or following complaints by the public on the threat by the 'man-eaters' in their areas. As Estuarine Crocodiles are protected by law, any culling activities should obtain a permit from the Controller of Wild Life for Sarawak (Fig. 23a–23f).

Figure 23a Figure 23b Figure 23c

Figure 23a–23c highlighting some of crocodile culling activities done in Sarawak.

Figure 23d Figure 23e Figure 23f

Figure 23d–23f: more crocodile culling activities done in Sarawak.

6.5. Conducting Education and Awareness Program on Crocodile among local communities and other stakeholders from various Gov't agencies throughout the State.

As briefly stated earlier, another important activity implemented by the Forest Department under the project is education and awareness programs on crocodiles. The program involves local communities residing along rivers and officials from government agencies dealing with environment and enforcement. These include those from the Rivers' Board, police, Local Council, Civil Defense and SFC. These agencies are critical and are required to assist in whatever way they can in educating

and giving awareness to the public on the potential danger that may arise from crocodiles, or in rescuing people from being attacked by the predator. Police and Civil Defense forces are usually needed to assist in culling operation of nuisance crocodiles. Figures 24a–24h showcased some of the Education and Awareness activities carried out by the Forest Department among the general public in rural and urban areas. The activities include the dissemination of information on the program to the public through media such as National Television Network and newspapers. Other important messages the authority want to instill among the general public include how to 'live with the predators', specifically all the 'DOs' and the 'DON'Ts' stated in the Management Plan for Estuarine Crocodile in Sarawak, 2016–2020 Appendix III).

Figure 24a. Education and Awareness Program on Crocodile in a longhouse in Julau, Sibu, 2016

Figure 24b. Conducting Education and Awareness Program on Crocodile through mass media (National Television Network & newspapers), 2017

Figure 24c. Education and Awareness Program on Crocodile in Betong, 2017

Figure 24d. Education and Awareness Program on Crocodile in Beluru, Miri, 2019

Figure 24a–24d showing some of the Education and Awareness Program on Crocodile carried out in Sarawak from 2016 –2019.

Figure 24e. Education and Awareness Program on Crocodile in Limbang, 2019

Figure 24f. Education and Awareness Program on Crocodile in Limbang, 2019

Figure 24g. Education and Awareness Program on Crocodile in Marudi, 2019

Figure 24h. Education and Awareness Program on Crocodile in Limbang, 2019

Figure 24e - 24h showing some more Education and Awareness Programs on Crocodile in Sarawak for the year 2019.

6.6. Conducting series of dialogues with crocodile hunters

To ensure that crocodile hunting are done in a sustainable manner, a series of dialogues have been conducted with crocodile hunters in Kuching, Sibu and Miri Regions. Licensed crocodile hunters from all over Sarawak were briefed on conditions of the hunting license and the Standard Procedures for the hunting activities. The hunters were informed on the importance of sustainable crocodile harvest through the use of the quota system, as the species is protected under the Wild Life Protection Ordinance, 1998. The program also warns that hunting without a license from the Controller of Wild Life is an offence, as mentioned in the Ordinance.

Figure 25a Figure 25b Figure 25c

Figure 25a-25c highlighting some of activities done during a dialogue with crocodile hunters in Kuching, 2019

Figure 25d Figure 25e

Figure 25d & 25e showing dialogue sessions with licensed crocodile hunters in Kuching and Sibu regions respectively, 2019

6.7. Installation of crocodile warning signboards in areas infested by crocodiles

Forest Department and the Sarawak Forestry Corporation (SFC) have installed warning signages in public areas such as villages, bathing places, recreational spots, jetties and waterfronts near the rivers infested by Estuarine Crocodiles. This initiative is part of the Education and Awareness program on crocodile conducted throughout the State to remind the public of necessary precaution when they are in the area as an effort to reduce crocodile attacks on people using the rivers. Figure 26a and 26b showcased some of the signages installed in crocodile-infested locations in Sarawak.

Figure 26a

Figure 26b

Figures 26a & 26b: the installation of crocodile warning signboards in Kuching Wetlands National Park and at a jetty point at Lingga bazaar, Sri Aman. (*It was reported that a number of crocodiles were seen lurking around in the area during a flood and at the jetty before the installation of the signages. There are many more places throughout Sarawak already been installed with similar signages*).

6.8. Issuance of license for the commercial hunting of Estuarine Crocodile & monitoring

The downgrading of Estuarine Crocodile from CITES Appendix I to II during CITES COP 17 in Johannesburg, South Africa, has made commercial hunting of the species in Sarawak no longer prohibited. However, the activity has to be properly regulated and only be allowed with a valid license from the Controller of Wild Life. Among the license conditions for hunting are as follows;

i. Hunting of estuarine crocodile is to be confined to certain rivers with certain harvest quota.
ii. The validity period for the license is not more than six months.
iii. Renewal of hunting license would only be approved with the submission of hunting report highlighting the number of catch and other information on crocodile caught.
iv. Slaughtering of live crocodile must not be done in public places.
v. Export of crocodile and its part must be accompanied with CITES permits.
vi. Usage of firearms in crocodile hunting is not encouraged and is only allowed for self defense.

Figure 27. A sample of the hunting license for Estuarine Crocodile, with a fee of RM100/year or part thereof.

Since January 2017 until December 2019 a total of 67 crocodile hunting licenses been issued to hunters for rivers, river tributaries and deltas throughout Sarawak while the annual harvest quota allowed for the crocodilian is 850 for a mixture of various size classes. The figure includes a maximum adult quota of 350 individuals. Due to some difficulties in hunting down the species, particularly the large individuals, our record shows that less than two hundred individuals of various sizes were captured within a two-year period. A sample of hunting license is shown in Fig.27.

6.9. Encouraging local students to conduct research on crocodiles in Sarawak.

Compared to the research on crocodilian species in other regions, local research on crocodiles in Sarawak is still at its infancy. This is partly due to manpower constraint and difficulties in getting someone having interest and passion in the 'man-eating species' that are taboo to some indigenous tribes. Thus, more scientific information on crocodiles in Sarawak could be obtained by encouraging participation of outsiders to conduct research in various aspects of the crocodilian biology and ecology and to provide whatever assistance we could, especially when the study was conducted in Protected Areas. The information would be useful for sound management of the species which generally perceived as a nuisance to the public, particularly for those depending on rivers for their livelihood. The approach managed to attract at least four crocodile researchers from within the Department and the local universities. They have completed their respective dissertations, and three of them have graduated with a PhD., MSc. and a BSc. degree, respectively, between 2016 and mid-2020.

Figure 28a

Figure 28b

Figure 28a. One of the theses on the crocodilian species produced under the project in Sarawak

Figure 28b. A group of researchers from the Forest Department and Unimas setting up camera traps over a crocodile basking site at a river bank

6.10. Formulating a Management Plan for Estuarine Crocodiles (*Crocodylus porosus*) in Sarawak (2016 – 2020).

Another important task undertaken by the Department as part of the project is the formulation of a Management Plan for Estuarine Crocodile (*Crocodylus porosus*) in Sarawak for 2016–2020 (Fig. 29). The Plan is one of the most important requirement by CITES for the downgrading of the species from CITES Appendix I to Appendix II, which consequently allowing regulated commercial hunting of the species in Sarawak. Though it was quite a daunting job to accomplish in such a relatively short period of time, the task was completed when representatives and crocodile researchers from the Department and SFC put their heads together in ensuring the completion of the document. The document has become an important guideline for sustainable management and utilization of the species in Sarawak between 2016 and 2020. Some important information extracted from the Management Plan are shown in Appendix III. This document is a useful tool in regulating commercial hunting of Estuarine Crocodile in Sarawak for the stipulated

Figure 29. Management Plan for Estuarine Crocodile *(Crocodylus porosus)* in Sarawak, 2016-2020.

time period. To ensure continuous and sustainable management of Estuarine Crocodile in Sarawak, the Plan has to be regularly reviewed, updated and renewed for another five years immediately after its expiry date by the end of 2020. The updated and reviewed version of the Management Plan has to be closely formulated based on the result of surveys and studies done after the year 2020 as there might be changes in the population status of the species following commercial hunting activities that have been occurring since 2017. The reviewed version of the Management Plan should be able to address the changes, if any, to ensure that Estuarine Crocodiles in Sarawak are continuously managed sustainably.

6.11. Establishment of a Crocodile Sanctuary in Kuching Wetlands National Park (KWNP).

As a CITES Management Authority that looks after matters pertaining to wildlife management, the Forest Department should have wildlife rescue center to provide refuge for nuisance crocodiles taken from various places in Sarawak or for crocodiles confiscated from and surrendered by the general public. At the same time, the facility provides a venue to enchance research on the species, tourism and serves as an *ex-situ* conservation site for the crocodilian. In taking up the responsibility, the State Government has allocated RM15 million for the purpose of building a wildlife rescue center in the 11th Malaysia Plan. The center is known as 'Crocodile Sanctuary' located in Kuching Wetlands National Park (KWSP). The project has been planned for implementation as early as the beginning of 2016. Unfortunately, due to some technical problems and financial constraint, the construction has to be deferred to the next Malaysia Plan. The Sarawak Forestry Corporation (SFC) has taken over the implementation of the project, and it is hoped that the establishment of the sanctuary would be materialized as soon as possible. The initial layout plan and drawing of the entrance to the Sanctuary is shown in Fig.30.

Figure 30. Initial design of an entrance into the proposed crocodile sanctuary at KWNP

6.12. Setting up a Crocodile Reserve at Pulau Seduku, Btg. Lupar, Sri Aman.

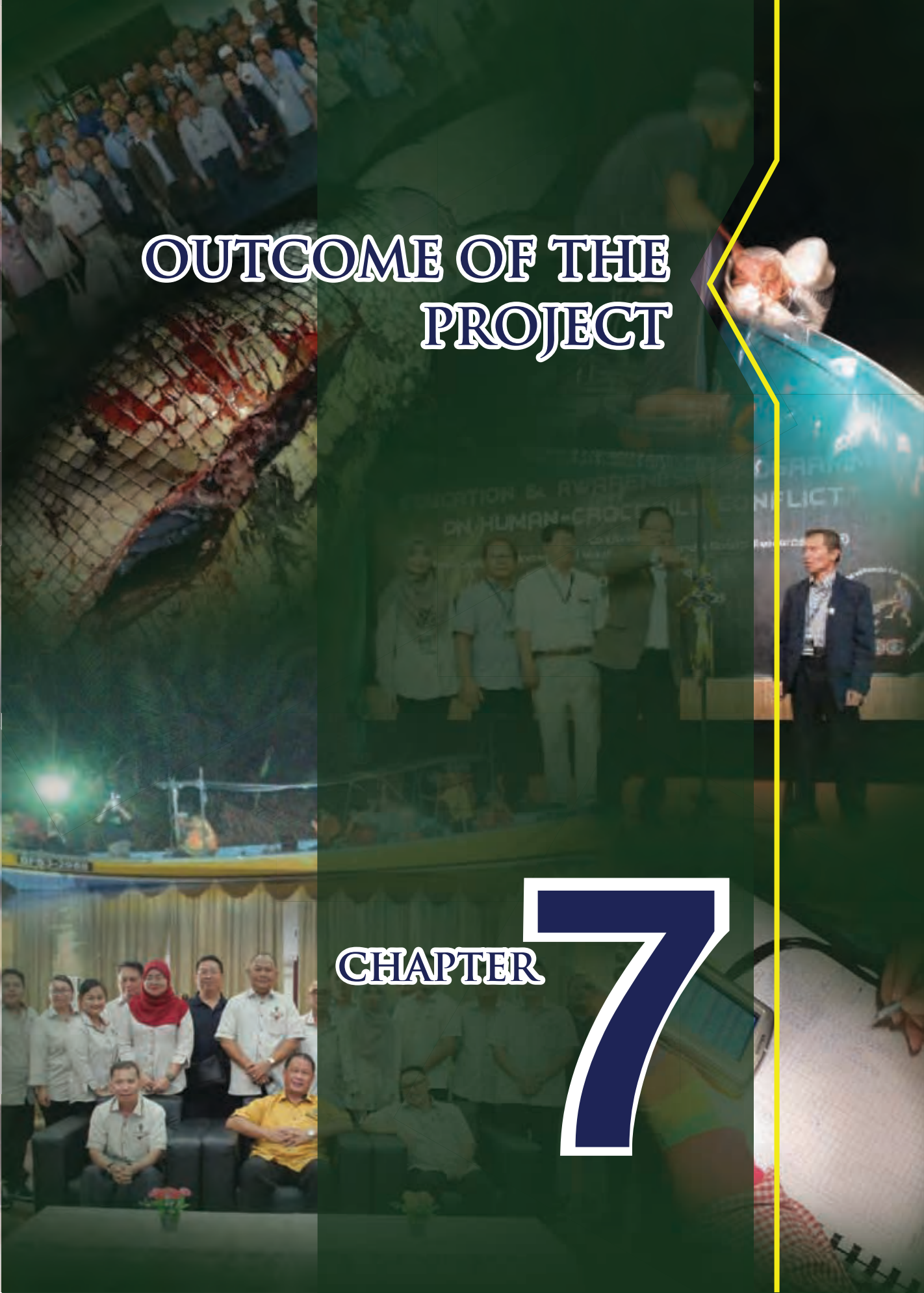
The Sustainable Management of Estuarine Crocodile project also incorporates a proposal by Sarawak Forestry Corporation (SFC) to establish a Crocodile Reserve at Pulau Seduku Nature Reserve, a small island of about 360.8 Ha in size, located in the middle of lower Btg Lupar River near to Lingga bazaar in Sri Aman (Simanggang) Division. The proposal, however, is still at its initial stage at this point of time and there is still no infrastructural facility to serve the purpose. The general objective of the project is for management of Estuarine Crocodile within the area that incorporates tourism activities based on crocodile, enhancement of research work on crocodiles in the area and also to cater for *in situ* conservation of the crocodilian species along the river. The proposed facility is expected to have an office, a laboratory for researchers, staff quarters, boats and boat shed, and accommodation facilities for researchers.

6.13. Introduction of Croco-tourism activities in a number of places in Sarawak, eg. in Samarahan, Btg. Lupar, Bako and Sibuti areas.

This Program was initiated by the respective resident of the Divisions where two meetings have been conducted with various government agencies, including the Forest Department and SFC. The Program would be tied up with 'Home-Stay' program conducted by local communities of the respective areas. Instead of going back to hotels, croco-tourists would have an option to stay with local villagers. Thus the 'spin-off' of tourist expenditures for croco-tourism activities such as crocodile watching would go to local people. This program is among ways and means in getting local communities in helping the authority to conserve the crocodiles through the non-consumptive utilization of crocodile resources. The Croco-tourism industry is one of the opportunities where local people can benefit economically. The local community can take the tourist for crocodile watching, offer boating services and operating their 'home-stays'. Tourists coming back from the crocodile-watching trip do not have to go back and stay at hotel rooms in town as they could stay in local 'Home-Stays' . To attract more tourists, the locals can also organize side-event such as cultural dance. Locally-made handy craft items could also be made available for visitors which could further generate income for local people in

respective areas. In Sarawak, the croco-tourism industry involving local communities and 'Home-Stay Program,' is still at its 'infant stage'. However, the industry is thriving in other regions in Malaysia, particularly in Kinabatangan, Sabah, where the industry has brought in lucrative income to local community and at the same time could help in the sustainable management of crocodiles in the area (Fig. 31).

Figure 31. Crocodile watching along river at night.



OUTCOME OF THE PROJECT

CHAPTER 7

CHAPTER 7: OUTCOME OF THE PROJECT

7.0. General Outcome of the Project

The implementation of various activities under the project since 2012 has become an 'Eye-opener' to the general public on the current status of Estuarine Crocodile in Sarawak and the management of the crocodilian species within the State. Previously, the authority would be blamed for every crocodile attack on humans. However, at present, the negative perception and prejudice are slowly fading out, and more and more people start to be aware of their right to defend themselves from being harmed by the predator, as provisioned under Section 42 of the Wild Life Protection Ordinance, 1998. The higher awareness and knowledge on crocodile acquired from various programs and activities carried out under the project provide hopes among the authority and the State Government that the population of Estuarine Crocodile can be managed sustainably while amicably addressing issues of Human-Crocodile Conflict (HCC). The break-down on some of the outcomes after years of implementation of the Sustainable Management of Estuarine Crocodile Project are described below;

7.1. Down-listing of Estuarine Crocodile species in Malaysia from CITES Appendix I to Appendix II

The down-listing of Estuarine Crocodile from CITES Appendix I to Appendix II has given provision for regulated commercial hunting and export of the species out of Sarawak. The ruling, however, only confine to Sarawak Region and does not apply to Sabah and Peninsular Malaysia. The approval for the regulated commercial hunting of Estuarine Crocodile is seen as an effort to bring down the number of the surplus population of Estuarine Crocodile to reduce crocodile attacks on human.

7.2. Reduction in number of fatal attacks on human

The project is able to reduce the number of crocodile attacks from 12 in 2017 to five in 2018, and further decline to only two incidents in 2019. The lower number of attacks in the past three years could be attributed to the increased awareness among the general public. Thus, the education and Awareness programs carried out between 2014 and 2018 among the general public in Kuching, Samarahan, Serian, Betong, Sri Aman, Sarikei, Sibu, Bintulu, Miri, Marudi, Bakong and Limbang has

been successful in fulfilling the outcomes and expectation of the Government. Based on this positive result, these activities should be continued to the next Malaysia Plan. The program included several CITES Capacity-Building Workshops with various stakeholders throughout the state and the installation of several hundred pieces of crocodile warning signages (signboards) by the Forest Department and SFC in areas with high crocodile density. The figure on crocodile attacks in Sarawak, however, started to surge slightly from the beginning of 2020 until the third quarter of the year to five recorded incidents (Fig.5). This indicates that some large crocodiles are still in the area, lurking into public areas and causing significant danger to the human population. It is a responsibility of SWAT of SFC, the Controller of Wild Life and licensed crocodile hunters of the area to look into this issue.

7.3. Reduction in the number of Human-Crocodile Conflicts (HCC).

The reduction in the number of crocodile attacks from 2017 to 2019 is partly due to crocodile harvests by licensed hunters and culling of nuisance crocodiles by the authorities from certain crocodile-infested areas, during which more than 70 hunting licenses and culling permits were issued. Though there is no accurate figure on the number of catches, it is estimated that no fewer than a hundred animals were captured towards the end of 2018. The figure included individuals that were culled or removed by the authority, eg. by SWAT of SFC or by local communities who were given permits to capture nuisance crocodiles from several places throughout Sarawak.

Due to some reasons, the number of hunting licenses issued in 2020 dropped to almost zero while only a few of the licensed hunters have applied for license renewal. Difficulty in getting buyers for their catch is one of the reasons for the sharp decline in the number of application for new licenses. The situation, however, has led to a slight surge in the number of attacks from the first until the third quarter of 2020 as the population of big individual crocodiles within certain public areas remained abundant. Therefore, to continuously reduce the number of attacks on humans, regulated commercial hunting activities have to go on but with regular monitoring to ensure that it is done sustainably.

7.4. Revenue generation to local people

The involvements of local communities in commercial hunting of crocodile and croco-tourism activities not only contribute to the decline in HCC alone but are also seen as an effort to generate revenue to their communities. With proper monitoring and guidance by the authorities, the activities could easily contribute to the effective and sustainable management of crocodiles in Sarawak. This indicates that something many people perceived as a potential risk to the general public could turn into opportunities for local communities and riverbank dwellers. Though there is no official figure on the amount of public income generated from these activities, unconfirmed reports stated that some crocodile hunters have managed to sell their catch at local markets at a price of up to RM32 per Kg for crocodile meat. The report, however, needs further verification. This is not inclusive of the benefits gained through croco-tourism activities such as from crocodile watching, transportation, home-stay program, and some 'spin-off' benefit gains from the industry. The benefit may include revenue from payment for cultural show and sale of handicraft. For instance, in Kinabatangan, Sabah, a night stay in the homestay cost between RM55–RM70 per night per person. While this kind of crocodile-based tourism industry is still in its infancy stage in Sarawak, it is expected to be picking up with the cooperation and involvement of all the relevant government agencies such as the Forest Department, the Sarawak Forestry Corporation, Resident and District Offices, Sarawak Tourism Board, Ministry of Tourism and local Non-Governmental Agencies (NGOs). These activities could be further developed and maximized while at the same time would further enhance conservation and sustainable use of this last relic of the dinosaur species that have been in existence in this region for many millennia.

7.5. Increase in the number of local scientists/experts on crocodile

Despite potential risks and taboo in dealing with the 'man-eating species' it seems that more and more local researchers are coming forward to conduct studies on various aspects on Estuarine Crocodile in Sarawak. For instance, University Malaysia Sarawak (Unimas) has produced a number of graduates, as well as postgraduate scholars over the last four years. With more research works done on this potentially dangerous species, it is hoped that Estuarine Crocodile could soon be better managed within the State and within its range. With continuous effort and blessing by the authority in extending Education and Awareness program on

crocodile to local communities and other stakeholders throughout the State, this potentially dangerous species could soon be accepted as an important biological asset that serves various purposes and needs. Furthermore, this initiative could bring the awareness that the crocodiles are important biological resources that could significantly generate income to local communities, public entrepreneurs, and the State of Sarawak, in general.

7.6. Enhancing sustainable-use and conservation of Estuarine Crocodiles

As mentioned previously, despite issuing licenses for the commercial hunting of Estuarine Crocodile, the Government, is also encouraging the sustainable use of crocodile and enhance conservation of the species. In line with the initiative, the State Government, through its Resident Offices, has started to introduce crocodile-based tourism program in certain regions in Sarawak such as in Samarahan and Btg. Lupar. This is in addition to various croco-tourism activities already started by various travel agencies and private individuals in Bako, Santubung, Sibuti and Bakong in Marudi. The first two initiatives led by Residents of Samarahan and Sri Aman have received rousing support from the Forest Department and SFC. Several meetings with various government agencies were convened in 2019 to find out ways as to how the activities could be introduced to communities residing along the respective rivers. These two rivers are among the most crocodile-infested areas in Sarawak with a high record of crocodile attacks in the past few years. Among potential activities under the program are crocodile watching along the rivers, which could be done at night. Crocodile watching activities are often paired up with other activities like firefly and egret watching. In some area, the program will be paired with fishing activities. This is because areas with a high population of Estuarine Crocodile are usually rich in fish-prawn fauna. This activity is widely offered by travel agencies in Brunei along the rivers around Bandar Seri Begawan (Engkamat, unpublished report). It is expected that tourists involved in these activities would spend their nights and the rest of their day with local people in their Homestay instead of in hotels in town, which will bring in more tourism dollars to local communities.

7.7. Establishment of Rescue Centers for Crocodiles.

Recently captured nuisance crocodiles are usually kept in small confinement in Matang Wildlife Center, while others that are critically injured or sick when captured are usually put down to sleep by authorized exterminating teams such as SWAT. The practice, however, is seen as wastage to our biological resources, and to address this rather unbeneficial act a holistic management measure has to be put in place. This measure includes the establishment of rescue centers for wildlife, particularly for nuisance crocodiles that are still alive. As a CITES Management Authority (MA), it is an obligation for the Department (and SFC) to provide such facilities to cater for confiscated or captured wildlife species that might cause potential danger to the public in their natural habitats. The center could cater for *ex-situ* conservation for the species, research, education and awareness program for the public as well as for various tourism activities. Due to the pressing need for the center, the State Government has allocated a total of RM15 million for the current Malaysia Plan to build the facility known as the 'Crocodile Sanctuary', in Kuching Wetland National Park (KWNP). However, due to some problems and government requirements, the construction of the Sanctuary is expected to continue to the next Malaysia Plan. The formation of a new Government agency, the Sarawak Forestry Corporation (SFC) which solely looks after matters on wildlife and bio conservation in Sarawak, is expected to speed up the construction of the project.

CHAPTER 8

CONCLUSION

CHAPTER 8: CONCLUSION

For ages, Estuarine Crocodiles have been seen as pests to humans, and in some cases, as vermin that should be eliminated from the earth. This hostile attitude towards crocodiles usually stemmed from the predatory behavior of the species which has taken its toll on human beings, specifically in Sarawak. Though the number of crocodile attacks is not as high as the number of people killed in road accidents, the gruesome nature of these attacks evoked the anger among the general public and politicians. The Government has to render appropriate intervention activities in reducing the conflict and diffuse the hostile perceptions towards the species. In this modern-day, the negative perception towards crocodiles has been slowly eliminated, particularly among animal lovers and wildlife enthusiasts. With more scientific knowledge and understanding on behavior of this predatory species, these negative perceptions and hostility towards crocodiles among the general public would slowly fade out. Having a better understanding of the ecology and biology of crocodiles would make a person realize that the species is an important biological asset that can be made beneficial to humans in many ways. Thus, despite having aggressive and predatory behaviors, many people nowadays aware that Estuarine Crocodiles play an important role in maintaining the health of the river ecosystem. As an apex predator, crocodiles 'clean' rivers by foraging and eating weak and sick animals (animal infected by diseases) residing within its surrounding, thus help cleaning up the ecosystem of the river, leaving out all the healthy marine life behind. This is why crocodile-infested rivers are usually having plenty of healthy fish and prawns.

On top of that, more people nowadays are aware that crocodiles are an important biological resource that can be used to generate income and alleviates the economic status of the public. This can either be done in term of consumptive or/and non-consumptive mean through the sustainable-use approach. Commercial ranching or farming of crocodile for its meat, skin, leather, oil and other parts and derivatives have been proven as a lucrative business in countries where Estuarine Crocodile is listed under CITES Appendix II. These countries include Australia, USA, Thailand and Papua New Guinea Currently. Some states in Malaysia have also follow-suit, putting up commercial crocodile farms for sale of live crocodiles, its meat and skin. With the down-listing of Estuarine Crocodile in Malaysia into CITES Appendix-II it is expected that commercial activities of Estuarine Crocodile would pick up to its full capacity. Proper monitoring and guidance by the authority and by adhering to

the regulations and policies on sustainable-use of crocodile and crocodile resources. Sarawak could become the main producers of crocodile products at both domestic and international level which could significantly contribute to its economy. It is important to note that crocodile leather has gained popularity with a sizeable ladies' handbag, made out of Estuarine Crocodile's leather, recorded prices up to RM37,000 (Engkamat, unpublished).

In term of non-consumptive utilization of crocodile resources, a place such as the Northern Territory of Australia has benefited much from their crocodile-based tourism industry. Croco-tourists do not go down to the river just to watch crocodiles basking on the riverbank but are also allowed to feed wild crocodiles by using baited oars from special-made boats. Wild crocodiles jumping up from its slumber to grab the baits give an indescribable awesome experience to most croco-tourists who do not bother to spend thousands of dollars on the activities. Those tourism dollars do not benefit travel agencies alone but would also benefit local people from its 'spin-off' activities, such as through their home-stay program. Now, since Sarawak is rich in its Estuarine Crocodile species, crocodile-related activities that have been started in some places throughout the State, have to be further developed and improved, in-line with the sustainable-use approach. Experiences in the implementation of Sustainable Management of Estuarine Crocodile Project in Sarawak and guidelines contained in the Management Plan for Estuarine Crocodile in Sarawak, 2016-2020 can be used as references and guidance in enhancing those projects. The guidance and assistance from Government agencies could ensure tourism activities based on crocodiles in the wild could be developed to benefit local communities and the State government. Crocodile-based tourism activities could also change people's mindset and reduce hostile attitudes towards crocodile. This could reduce HCC, eventually leaving people to live in harmony with the species, while at the same time tapping out various benefits from the presence of the last relic of the dinosaur.

The implementation of various programs and activities under a Sustainable Management of Estuarine Crocodile Project is seen as one of the tools that could open public eyes on the importance of sustainable use, proper management and conservation of the crocodilian species. A sound and sustainable management of crocodile incorporating education & awareness programs on the species, regulated commercial harvest and introduction of croco-tourism activities would not only be able to generate revenue to local communities but also to address issues on Human-Crocodile Conflict Statewide. It is an utmost important that continuous funding from the Government be put in place to ensure the continuity of the Sustainable

Management of Estuarine Crocodile Project to the next Malaysia Plan. The extension of the project includes a thorough review of the present Management Plan for Estuarine Crocodile (*Crocodylus porosus*) in Sarawak, which would be expired by the end of 2020. The review of the Management Plan would require new data on the current status of Estuarine Crocodile population along major rivers throughout Sarawak. This has to be done without much delay as the wild population may have been negatively affected by the ongoing commercial hunting activities along a number of rivers throughout the State. Changes in status of its population in the wild would determine as to how the revised management plan for crocodile in Sarawak would be formulated. Only a sound management plan would enable humans to live harmoniously with the potential 'man-eaters' within their shared habitat. It is hoped that Continuous implementation of the project, could ensure the survival of the species while contributing to State's economy and its people, and at the same time reducing, and eventually eliminating, the issue of Human-Crocodile Conflict (HCC) in Sarawak.

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APPENDIX I

Table A. Updated record of crocodile attacks in Sarawak from 1941 to 31 August 2020

No.	Date	Victim	River	Division	Status	Remark
1	1941	Laga ak. Mang	Sg. Baor, Btg. Lupar	Sri Aman	Killed	
2	1944	Wan Auyi	Sg. Palaban, Btg. Lupar	Sri Aman	Killed	
3	1946	Abg. John Abg. Bongsu	Sg. Rawan, Btg. Lupar	Sri Aman	Killed	
4	1950s	Abg. Matuddin	Sg. Meranti, Btg. Lupar	Sri Aman	Killed	
5	1950s	Munan ak. Nyambang	Sg. Stirau, Btg. Lupar	Sri Aman	Killed	
6	1950s	Sanuan	Sg. Meranti, Btg. Lupar	Sri Aman	Killed	
7	1950s	Nanta ak. Busang	Sg. Senang, Btg. Lupar	Sri Aman	Killed	
8	1950s	Jedai	Sg. Senang, Btg. Lupar	Sri Aman	Killed	
9	1950s	Ningkan	Sg. Pelaku, Btg. Lupar	Sri Aman	Killed	
10	NA	Majid	Sg. Sunga, Btg. Lupar	Sri Aman	Killed	
11	NA	Salleh	Sg. Sunga, Btg. Lupar	Sri Aman	Killed	
12	NA	Suwim ak. Nyambang	Sg. Sunga, Btg. Lupar	Sri Aman	Killed	
13	NA	Jemat ak. Kiroh	Sg. Sunga, Btg. Lupar	Sri Aman	Killed	
14	NA	Sah bin Tahir	Pulau Seduku, Lingga, Btg. Lupar	Sri Aman	Killed	
15	NA	Bugau ak. Danggu	Pulau Seduku, Lingga, Btg. Lupar	Sri Aman	Killed	
16	NA	Buah	Pulau Seduku, Lingga, Btg. Lupar	Sri Aman	Killed	
17	1960s	Badon	Sg. Rawan, Lingga, Btg. Lupar	Sri Aman	Killed	
18	1960s	Lindang	Sg. Klauh, Lingga, Btg. Lupar	Sri Aman	Killed	
19	1962	Inchi ak. Tunchun	Sg. Selumbang, Btg. Lupar	Sri Aman	Killed	
20	1965	Chendang ak. Empaling	Sg. Stirau, Btg. Lupar	Sri Aman	Killed	
21	9/5/1975	Minot ak. Kima	Sg. Nibong Besai, Sebuyau	Sebuyau	Killed	
22	1/7/1975	Pilai ak. Mijie	Tg. Bijat, Btg. Lupar	Sri Aman	Killed	
23	1976	Majang ak. Ningkan	Sg. Pelaku, Btg. Lupar	Sri Aman	Killed	
24	14/1/79	Mik bin Ibrahim	Pulau Seduku, Lingga, Btg. Lupar	Sri Aman	Killed	
25	26/6/82	Bangan ak. Pali	Sg. Sunga, Bakong, Lingga, Lupar	Sri Aman	Killed	while catching prawn
26	2/8/1982	Abang ak. Gelayan	Kuala Sg. Tebu, Rejang, Belawai	Sarikei	Killed	dragged out of the boat by croc
27	27/9/84	Badong ak. Apong	Sg. Selumbang, Btg. Lupar	Sri Aman	Killed	while catching prawn
28	14/11/86	Bong Hoi Tau	Sg. Liak, Matang, KWNP	Kuching	Killed	
29	27/5/87	Gilbert Stephen Ali (9)	Sg. Tubau, Ulu Kakus	Bintulu	Killed	swallowed whole
30	Nov-88	Entaril ak. Anyut	Sg. Sunga, Btg. Lupar	Sri Aman	Survived	
31	Nov-88	Elai	Sg. Selumbang, Btg. Lupar	Sri Aman		
32	Nov-88	Materang bin Amit	Sg. Selumbang, Btg. Lupar	Sri Aman	Survived	
33	24/12/88	Mangku ak. Bilas	Sg. Selumbang, Btg. Lupar	Sri Aman	Survived	
34	20/2/89	Berain ak. Tungging	Tg. Bijat, Btg. Lupar	Sri Aman	Killed	while catching prawn
35	13/4/89	Mohamed Sani Apeh	Sesang, Sg. Seblak	Kabong	Killed	
36	21/5/92	Dayang ak. Bayang	Sg. Pelaban, Lingga, Btg. Lupar	Sri Aman	Killed	while crossing the stream by small bridge
37	1/1/1993	Masri bin Bujang	Sg. Semarahar, Semarahan	Semarahan, Kuching	Killed	
38	28/10/93	Abg. Saperi bin Saat	Sg. Semarahar, Semarahan	Semarahan, Kuching	Killed	
39	1995	Manggong ak. Madon	Samulong, Sg. Seterap, Lingga	Sri Aman	killed	

40	Jun-96	Bujang bin Tosen	Sejijak, Batu Kawa, Sg. Sarawak	Kuching	Survived	croc tooth stuck in his knee
41	22/12/96	Ujang ak. Bugak	Sg. Tisak, Sekrang, Btg. Lupar	Sri Aman	Survived	
42	25/12/96	Kayah ak. Enti	Sg. Tisak, Sekrang, Btg. Lupar	Sri Aman	killed	probably by false gharial while taking bath on jetty
43	6/8/1997	TR Sumping ak. Banat	Sg. Kakus, Tatau	Bintulu	Survived	
44	17/8/97	Ahim bin Elok	Beladin, Pusa, Btg. Saribas	Betong	Killed	
45	20/11/97	Mohd. Hamidan Ramlee	Kpg. Sandong, B/Kawa, Sg. Sarawak	Kuching	Survived	
46	1/1/1998	Ibrahim Jakir	R. Panjang, B/Kawa, Sg. Sarawak	Kuching	Killed	
47	27/1/98	Lau ak. Chabu	Dabok, Btg. Layar, Betong	Betong	Survived	
48	15/6/98	Kelly ak. Dudut	Sg. Seterap, Banting, Lingga	Sri Aman	killed	while taking bath in the river
49	13/9/98	Keliong ak. Lipa	Sg. Tisak, Sekrang, Btg. Lupar	Sri Aman	Survived	
50	10/3/1999	Teresa ak. Jaki	Langkang, Engkelili, Btg. Lupar	Engkelili, Sri Aman	killed	
51	21/9/99	a girl (14)	Kg. Sinar Budi, B/Kawa, Sg. Sarawak	Kuching	Survived	
52	1999	a Malay man	Bakong, Lingga, Btg. Lupar	Sri Aman	Killed	
53	11/6/1999	Kadam ak. Kimon	Langkang, Engkelili, Btg. Lupar	Engkelili, Sri Aman	Killed	while taking bath in the river
54	12/7/1999	Marsidek bin Maras	Sg. Sarawak	Kuching	killed	
55	24/1/00	Ros Umba ak. Wat	Kpg. Benat, Gedong	Semunjan	killed	while wading along side of the river
56	2/2/2000	Kapok ak. Merudie	Pak, Engkelili, Btg. Lupar	Engkelili, Sri Aman	Survived	
57	3/3/2000	Sap ak. Enteli	Engkabang, Engkelili, Btg. Lupar	Engkelili, Sri Aman	Survived	
58	19/5/00	Jackson Agi	Tawai, Engkelili, Btg Lupar	Engkelili, Sri Aman	Survived	while taking bath in the river
59	19/5/00	Adam ak. Empeni	Sg. Nyelong, Sarikei	Sarikei	Survived	
60	18/6/00	Chang Senn	Seniawan, Sg. Sarawak	Kuching	Survived	
61	26/7/00	Peli ak. Entoi	Btg. Samarahan	Samarahan, Kuching	Survived	
62	/00	Nurin ak. Briak	Langkang, Engkelili, Btg. Lupar	Engkelili, Sri Aman	Survived	
63	30/12/00	Florence ak. Libin	Banting, Lingga, Btg Lupar	Lingga, Sri Aman	killed	
64	10/2/2001	Jaba ak. Kana (9)	Sg. Niah, Niah, Miri	Niah, Miri	killed	while taking bath in the river
65	9/3/2001	Singkie ak. Agal	Langkang, Engkelili, Btg. Lupar	Engkelili, Sri Aman	Survived	
66	16/3/01	Stephen ak. Kanyan	Engkelili, Btg Lupar	Engkelili, Sri Aman	killed	
67	?/10/2001	Jampong ak. Linggi	Pantu, Lachau, Sg. Seterap, Lingga	Pantu, Sri Aman	Survived	
68	?/12/2001	(a man)	Kpg Pasak, Betong, Sg. Layar	Layar, Betong	Survived	
69	13/5/03	Kadir ak. Lamit	Sg. Bako, Demak Laut	Kuching	killed	
70	17/3/04	John ak. Liong	Btg. Layar	Betong	killed	body not found
71	2004	(a man)	Btg. Layar	Betong	Survived	
72	2004	a boy (15)	Btg. Layar	Betong	killed	body not found
73	2005	(a Malay man)	Sesang, Btg. Seblak, Kabong	Kabong	Survived	
74	1/5/2005	(a man)	Sg. Bakong, Baram	Marudi, Miri	killed	
75	3/9/2006	Mohd. Azuan bin Hatta	Sg. Bako, Kpg. Bako, Kuching	Kpg. Bako, Kuching	killed	swimming across Bako River
76	18/4/07	Jamhari	Sg. Kulat, Bakong, Baram	Marudi, Miri	killed	while taking bath in the river
77	25/4/07	Abd. Hamid Osman	Pulau Seduku, Lingga, Btg. Lupar	Lingga, Sri Aman	killed	while washing his feet in the river
78	11/5/2007	Sangga ak. Megong	Kpg. Sebeba, Similajau	Bintulu	killed	
79	2007	(a man)	Sg. Tisak, Sekrang, Btg. Lupar	Betong/Sri Aman	killed	
80	20/9/07	Yahya Jamali	Sg. Gelugor, Matang, KWNP	Kuching	Survived	while gathering mangrove poles in the rivers
81	2007	Kassim	Empelam, Sg. Seblak	Roban/Kabong	killed	
82	3/6/2008	Rudy Semion Ng	Sg. Seruai, Btg. Saribas	Betong	killed	while catching prawn
83	11/6/2008	Gait ak. Repun	Sg. Tisak, Sekrang, Btg. Lupar	Sri Aman	killed	while taking bath in the river

84	28/7/08	(a man)	Paroh, Sg. Sarawak	Kuching	Survived	while fishing in the river
85	7/10/2008	Lester ak. Japeng	Lubok Ria, Ulu Samarahan	Serian	Survived	while fishing soft-shelled turtle in the river
86	9/11/2008	Chong Ah Khiang	Sg. Sebangan, Samarahan	Serian	killed	
87	6/3/2009	(a man)	Endap, Sg. Seburan	Kuching	Survived	
88	10/3/2009	Paryono (Indonesian)	Demak, Sg. Bako	Bako, Kuching	killed	
89	11/3/2009	Anin ak. Kilum	Kpg. Semeba, Balai Ringin, Sadong	Serian	Survived	while taking bath in the river
90	18/3/09	Putit bin Rosli	Sg. Manik, Sg. Sebangan	Serian	Survived	while taking bath in the river
91	10/4/2009	Roslan bin Jenggi	Btg. Saribas, Spaoh	Spaoh, Betong	Survived	while paddling his sampan in the river
92	26/5/09	Amat ak. Menggong	Sg. Sebuyau	Sebuyau, Sri Aman	Survived	while washing cloth in the river
93	23/6/09	Zainal Arifin	Lingga, Btg. Lupir	Sri Aman	Survived	while scooping out water from his boat
94	6/7/2009	Serbang bin Oppos	Btg. Sadong, Serian	Serian	Survived	while untying his boat in the river
95	10/7/2009	Chee Joon Meng	Batu Angus, Btg. Lupar	Sri Aman	Survived	while taking bath in the river
96	30/9/09	Mhd. Ilham Maulana	Tanah Puteh, Btg. Sadong	Serian	Survived	while taking bath in the river
97	30/9/09	Debelin ak. Nyambong	Rembai, Sekrang, Sg. Sekrang	Sekrang, Btg. Lupar	killed	while taking bath in the river
98	20/1/10	Mathias Winston Felix	Semada, Balai Ringin	Serian	Survived	while taking bath in the river
99	30/1/10	Roslie bin Pori	Kpg Naie Lama, Niup	Samarahan	Survived	while fishing
100	26/6/10	Muhamad Azroy Juti	Sebemban, Spach, Btg. Saribas	Betong	killed	
101	18/12/10	Sidi Samad (66)	Reban, Btg. Samarahan	Samarahan, Serian	killed	
102	12/1/2011	Ilik Intai	Rh. Sibat, Jelukong, Sg. Lemanak	Sri Aman (Btg. Lupar)	Survived	while rowing his boat
103	22/5/11	Mankay bin Goheh (37)	Empelam, Sg. Seblak	Roban/Kabong	killed	Cleaning himself in the river after fishing
104	27/5/11	Nelson Janting (14)	Temelan, Btg. Lupar	Sri Aman	Survived	
105	28/5/11	Jeffryson Sali (26)	Rh. Jangin, Kejemut, Sekrang	Sri Aman/Betong	killed	while taking bath in the river
106	17/9/11	Sulaiman Abdullah	Sg. Seblak, Roban	Roban/Betong	killed	Cleaning himself in the river after fishing
107	14/10/11	Lumeit ak. Entebang(63)	Rh. Empading, Sg. Bakas, Sibuti	Miri	Survived	while taking bath in the river
108	3/11/2011	Johari bin Simoto (23)	Kpg. Bulau, Sibuti	Miri	Survived	while taking bath in the river
109	14/11/11	Ajeng Oyo (Indonesian)	Tengan, Btg Kemena	Bintulu	killed	
110	15/12/11	Dain ak. Kanyon (38)	Rh. Kedu, Kaong Sekrang	Sri Aman	Survived	while fixing a boat in the river
111	25/1/12	Belaja ak. Gadoh	Rh. Sli Merio, Tambak, Engkelili	Engkelili, Sri Aman	Survived	which checking bubu (fish trap)
112	21/3/12	Clay ak. Engkadan	Rh. Phillip, Batu Angus, Engkelili	Engkelili, Sri Aman	Survived	while fishing (with casting net) in the river
113	22/5/12	Peter Heerema Sadan	Linggang Ulu, Tekalong (Sg. Basi?)	Sri Aman	killed	body found sometimes after the attack
114	18/6/12	Siah ak. Munsong	Rh. Embol, Sg. Anak, Seblak, Roban	Roban/Betong	killed	while taking bath at Sg. Anak, Sg. Seblak tributary
115	5/7/2012	Drahman Chali (55)	Kpg. Beladin, Btg. Saribas	Betong	killed	while washing hand in the river
116	22/8/12	Ashley Austin Chin (14)	Sg. Maong, Pasir Panjang, Kuching	Kuching	Survived	while swimming at Pasir Panjang beach
117	24/8/12	Pai (Indon-cons. worker)	Jawa Barat, Indonesia (Sg. Sarawak)	Kuching	Survived	while answering nature call at river bank
118	25/11/12	Mulad Azlan Marzuki	Beach Front (sea), Pasir Panjang	Kuching	Survived	while swimming at Pasir Panjang beach
119	24/12/12	Jerry Apat Angsa	Rh. Sulang, Kpg. Iran, Sg. Suai, Suai,	Suai, Miri	killed	while taking bath in the river
120	18/1/13	Indon. (plant. worker)	Baram Estate, Btg. Baram, Marudi	Marudi, Miri	killed	while fishing in the river
121	5/3/2013	Manja Salman (29)	Sg. Seblak, Kabong	Kabong/Betong	killed	while setting fishing net
122	5/3/2013	Jerry Sylvester Uline(40)	Rumah Girrie, Bengang, Saribas	Betong	killed	
123	16/3/13	Rozaili bin Sabeli (19)	Sg. Lingkau, semunjan, Samarahan	Samarahan	Survived	while doing line fishing from the river bank
124	26/5/13	Irwanshah (Indonesian)	Sg. Karap, Beluru, Bakong, Marudi	Marudi, Miri	killed	while answering nature call at river bank
125	6/7/2013	Julai Melina (34)	Rh. Ngumbang, Pasir Putih, Sg. Suai	Suai, Miri	killed	body missing
126	20/7/13	Anuar b. Sulaiman (59)	Kpg. Melayu, Roban, Sg. Seblak	Roban/Betong	Survived	while fishing in the river

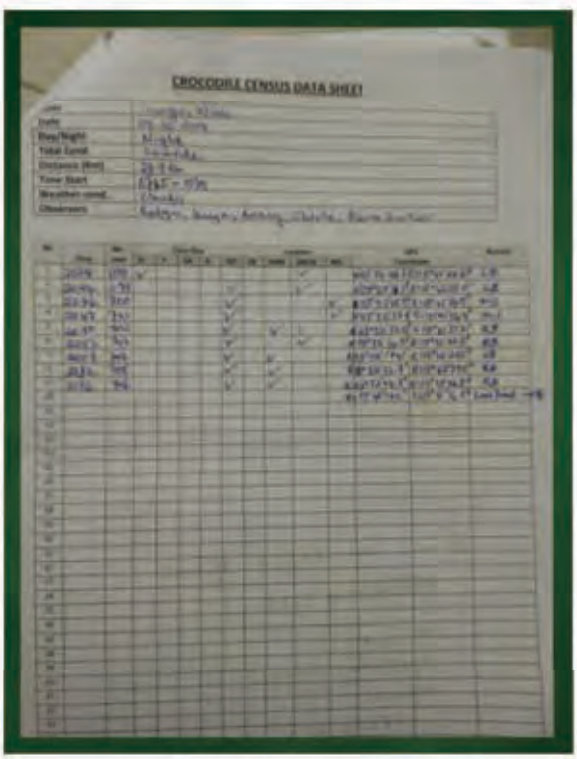
127	13/10/13	Safri bin Kutai	Kpg. Tambak, Pusa, Btg. Saribas	Pusa, Betong	Survived	
128	22/11/13	Adrian ak. Thomas	Lubok Empayak, Sg. Seblak, Roban	Roban/Betong	killed	
129	18/12/13	Alladin bin Sabeli	Kpg. Hulu Lingga (Sg. Enchiap)	Sri Aman	killed	attacked while bathing at Sg. Enchiap, Pantu
130	?/3/14	Indon. (plant worker)	Sg. Benat, Semunjan, Btg. Sadong	Semunjan, Serain	survived	while taking bath in the river
131	7/4/2014	Mos bin Sabeli	Sg. Benat, Semunjan, Btg. Sadong	Semunjan/Serian	survived	prawn fishing by casting net
132	18/5/14	(a sawmill worker)	Baramas Plywood, Kuala Baram	Miri	Survived	
133	14/6/14	Telecson Anclaimang (14)	Sg. Supa, Senyawan, Krian	Saratok	Survived	while doing prawn fishing
134	9/8/2014	Bintayup (Indonesian)	Kpg. Temelan, Btg. Lupar, Sri Aman	Sri Aman	killed	while taking bath in the river
135	30/9/14	Mustapa Bunsu (50)	Kampung Tuie, Debak, Sg. Rimbas	Betong	killed	while tying sago logs in the river
136	2/12/2014	Ramlee ak. Tegalan (29)	Amgreen Gain Plantation, S. Karap	Bakong, Marudi, Miri	killed	while taking bath in the river
137	3/1/2015	Idris bin Yakub (56)	Kpg Soh, Serian, Btg. Samarahan	Samarahan, Serian	killed	while fishing in the river
138	7/1/2015	Munni bin Karun (47)	Kg. Sebemban, Ssaoh, Sg. Belingan	Betong	survived	while fishing in the river
139	?/1/15	Nurfazilah Rahman (26)	Kpg. Binjai, Limbang, Sg. Limbang	Limbang	killed	while taking 'air sembayang' in river early morning
140	?/2/15	(a man)	Sg. Oya, Sibu, Btg. Rejang	Sibu	Survived	
141	26/3/15	Yusman Yusuf (31)	Kpg. Reban, Samarahan	Serian	killed	attacked while fishing-died 8 days later (leg cut)
142	28/3/15	Mulliana Malla (35-Ind.)	Sg. Telong, Suai, Niah	Suai, Miri	survived	while washing cloth in the river
143	15/4/15	Bob Denok (31)	Kampung Babu, Debak, Sg. Rimbas	Betong	killed	wading along Rimbas River to collect 'buah pedada'
144	3/6/2015	Grace ak. Jamar (33)	Rh. Bada, Sg. Sunga, Suai (Sg. Suai)	Suai, Miri	killed	while taking bath in the river
145	6/6/2015	Bera Aun (46)	Rh. Minggu, Sg. Krian, Saratok	Saratok	killed	while doing prawn fishing
146	14/10/15	A man (31)	Sempadi, Lundu, Btg. Kayan	Lundu	survived	while casting fishing net in the river
147	?/12/15	Nurul Wazieyana Yusuf	Pasir Panjang beach, Kuching	Kuching	killed	a nurse-23-body missing-suspected attacked by croc
148	22/12/15	Fakrul bin Dahari (11)	Kpg. Bungin, Spaoh, Btg. Saribas	Betong	killed	taking dip in river-mutilated body found 2 days later
149	11/1/2016	Raziman Razali (16)	Kpg. Santubung, Sg. Santubung	Kuching	killed	taking dip in river-body found 3 days later
150	9/2/2016	Shakawi Suhaili (55)	Kpg. Tupong Ulu, Sg. Sarawak	Kuching	survived	while removing timber under his house during flood
151	26/2/16	A man (40)	Kemena Ind. Estate, Sg. Kemena	Bintulu	Survived	while fishing along the river bank
152	26/2/16	Adi Enchana/Ah Kong	Sg. Maing, Ulu Kakus, Tatau	Tatau, Bintulu	killed	body missing from river-suspected killed by croc
153	?/3/16	Awa ak. Lankau (40)	Engkelili, Btg. Lupar	Engkelili, Sri Aman	survived	while taking bath at jetty
154	6/4/2016	Richard Shutine Tambi	Sg. Nakat, Bakong, Marudi, Baram	Marudi, Miri	killed	while fishing in the river
155	7/4/2016	A.Rahim Maarof (26)*	Kpg. Sg. Mata, Samarahan, Serian	Serian	survived	attacked @ his daughter while taking bath in river
156	7/4/2016	Erlieystha A.Rahim (2½)	Kpg. Sg. Mata, Samarahan, Serian	Serian	killed	attacked @ her father in river (see above)
157	27/4/16	Gadis Seman (43)	Kpg Perepat, Sg. Krango, Krian	Saratok	survived	while washing hand after setting up fishing net
158	11/9/2016	Sylvester Kilat ak. Lee	Kpg. Baru, Samarahan	Samarahan	survived	
159	11/11/2016	Seli Ismail (60)	no detail info available	no info available	no info	no detail info available
160	18/1/17	Aji ak. Inyau (72)	Rh. Jangin, Kejemut, Sekrang	Betong/Sri Aman	killed	while fishing in the river
161	8/2/2017	Selamat bin Raub	Kpg. Santubung, Sg. Santubung	Kuching	killed	his body badly mutilated by croc
162	19/2/17	Atong ak. Kassin (48)	Ulu Selayal, Sg. Rasong, Paloh	Belawai, Sarikei	killed	while collecting firewood along the river (Rejang)
163	21/2/17	Agnes ak. Luang (18)	Rh. Jampang, Peking, Tinjar, Baram	Marudi, Miri	killed	while bathing in the river with parents
164	8/3/2017	Besimillah Rajali (46)	Pusa, Btg. Saribas	Pusa, Betong	killed	while tying sago logs in the river
165	6/4/2017	Nilrizan bin Shapi-ee	Kpg. Hulu Tebelu, Sebuyau	Sebuyau, Sri Aman	survived	while tying boat at jetty
166	22/05/17	Adrian Tan (13)	Rh. Benedict Ego, Sg. Kawi	Bintangor, Sarikei	killed	while sitting on jetty with legs dangling over water
167	13/07/17	Sulaiman Sukku (25-Ind)	Sg. Pulasan, Pusa, Betong	Pusa, Betong	killed	while fishing at the river
168	24/09/17	Bentayan bin Ilah (31)	Kpg. Hilir, Tambak, Sg. Rimbas, Pusa	Betong	killed	while fishing at Sg. Rimbas
169	24/10/17	Nazib bin Abang (33)	Kpg. Tengah, Btg. Sadong, Gedong	Semunjan, Serian	killed	while fishing
170	7/12/2017	Ariff ak. Bagoh (44)	Kpg. Sebemban, Btg. Sadong	Serian	killed	night fishing-body missing-suspected by croc attack

171	5/1/2018	Alaj Mohd. Haikal (13)	Kpg. Melayu Dt, Debak, Saribas	Debak, Betong	killed	body missing-fishing in river, suspected croc attack
172	29/07/18	Effendi Pauil (45)	Kpg. Baru, Lawas, Sg. Lawas	Lawas	killed	attacked while walking along river bank at noon
173	20/08/18	Mangku ak. Sulo	Rh. Benang, Sg. Bakas, Bakong	Bakong, Marudi	survived	while fishing
174	17/10/18	Masnah Inc. Moh (39)	Sg. Sawai, Daro (Rejang)	Daro, Sarikei	killed	attacked while fishing in the morning (9.00am)
175	7/11/18	Minhat Rahmat (Inekan)	Sg. Selalang, Sarikei	Selalang, Sarikei	survived	attacked while attending to fish culture at the river
176	16/1/19	A man	Sg. Suai	Suai, Miri	survived	while bathing in the river
177	25/11/19	Asbullah Daeng Simin	Sg. Telong, Tradewind, Tg. Payung	Suai, Miri	killed	while collecting vegetable along drainage
178	24/1/20	Fairus Latip (37)	Kpg Sempadi, Sg. Kayan, Lundu	Lundu	killed	fishing-mutilated body found a day later
179	22/4/20	Yanlin Malwat (29)	Kpg. Melayu, Sg. Bundung, Tg. Bijat	Sri Aman (Btg. Lupar)	killed	while set up net in river-body found 3 days later
180	5/7/2020	Saukawi Tahip (61)	Kg Tanjung, Pusa, Sg. Undey	Pusa, Betong	killed	gathering & tying sago logs at river bank
181	17/7/20	Kong Gindi (47)	Rh. Tuntun, Sg. Sedaku, B. Lupar	Sri Aman	killed	while washing boat-body found 1 km downriver
182	23/7/20	Ricky Ganya (14)	Rh. Dadat, River near Tg. Manis	Mukah	killed	while collecting snails along river-body missing

APPENDIX II

Some of the crocodile survey data along a number of major rivers in Sarawak, 2012 -2014


CROCODILE CENSUS DATA SHEET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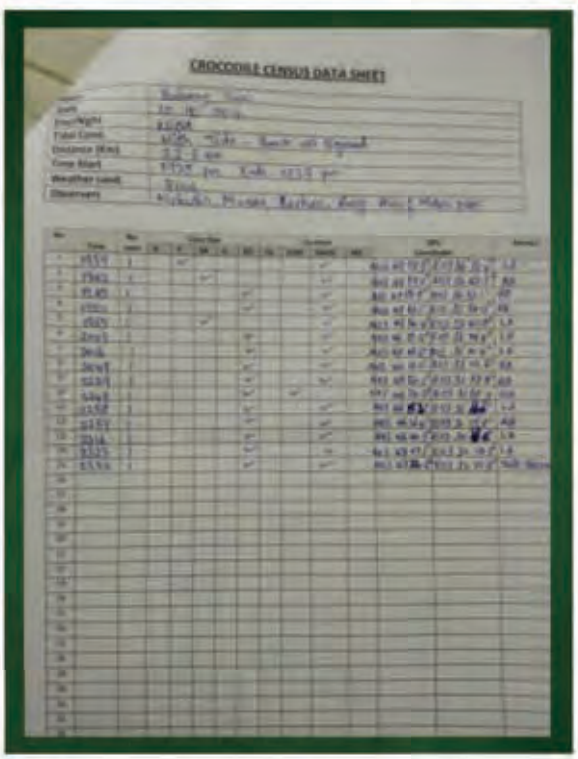
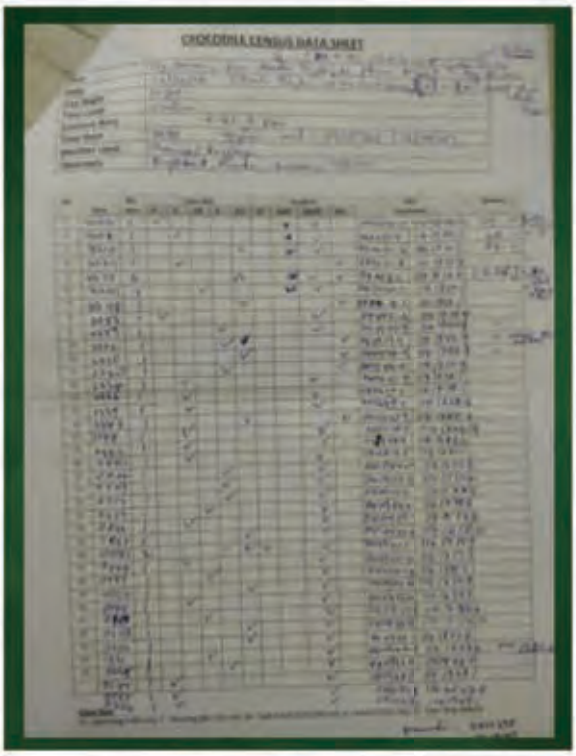

CROCODILE CENSUS DATA SHEET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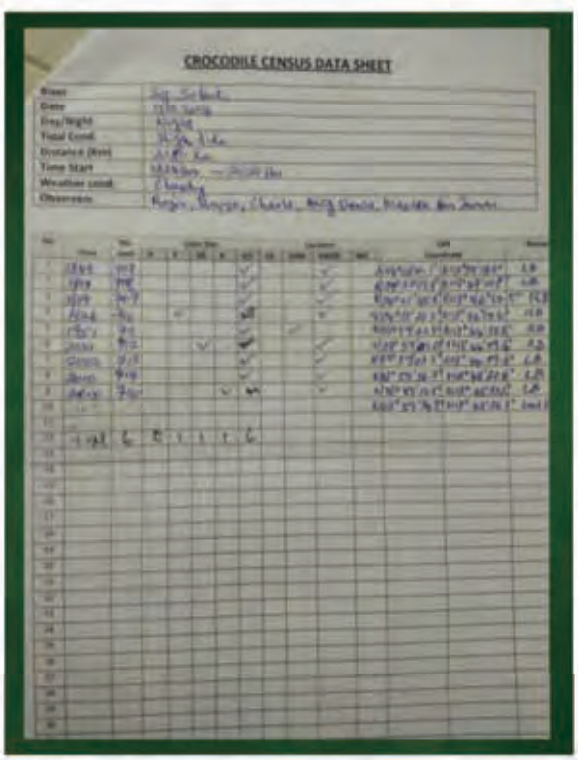
CROCODILE CENSUS DATA SHEET
River
Date
Day/Night
Total Cond.
Distance (Km)
Time Start
Weather cond.
Observers


CROCODILE CENSUS DATA SHEET


CROCODILE CENSUS DATA SHEET

APPENDIX III

Extracts from the Management Plan for Estuarine Crocodile (*Crocodylus porosus*) in Sarawak, 2016-2020

1. Guideline & Policies on crocodile harvesting/hunting

The maximum sustainable yield for wild *C. porosus* populations is not known precisely. Based on experience in the United States and in Australia (Webb, pers. comm.), what is known is that a 5% annual harvest rate for alligators does not interfere with continued population growth, and a selective harvest strategy (males) for *Caiman crocodilus* results in an increasing trend within the harvested wild population rather than decreasing (Webb, pers. comm.). A 5% annual harvest rate for the non-hatchling population estimated to exist along some sectors of the rivers in Sarawak that are accessible for surveys (population = 13,507 individuals; 5% = 675 individuals) is considered to have a high probability of being sustainable. Thus, the actual guidelines for the harvest are as follows,

i. If the monitoring results indicate the non-hatchling of wild population is more or less stable after the first harvest, then the second year's harvest will be unaltered.

ii. If the wild population declines by 20% after year 1 harvest, the harvest levels for year 2 will be reduced to 40%.

iii. If the wild population continues to decline after year 2, the year 3-harvest will be reduced to 60%.

iv. If the decline is not compensated for by an increase in the population the wild harvest program will be abandoned.

v. All harvests must be licensed in person or company.

vi. License fee of RM100 per annum & duplicate copies at RM5 per copy.

vii. Hunting activities must be in accordance with the terms and conditions of a license e.g.

-License to be carried in person by the hunter during harvesting & selling activities.

-License to be surrendered to the Controller of Wild Life upon expiry, with transaction records.

-Hunters are to strictly comply with terms and conditions of the license.

-Hunting activities are river-specific based.

-Hunters are preferably to be among local communities of the area or to engage local people of the affected area

2. Harvest quotas

The proposed harvest quantum will be experimental and restricted to no more than 500 non-hatchlings per year (around 4% of the estimated population) for the first three years of the program. Response of the population to these limited harvests will be quantified through survey work. Harvest rates will then be adjusted up or down, based on the results. It is also intended to harvest less than 2,500 eggs, or their equivalent in hatchlings, i.e., 750 hatchlings based on 25% hatchability, or 375 one-year-old individuals, based on an estimated 50% survival to year 1 as recommended by Webb et al. (1984), with some safeguard measures in the event that the population does not respond as expected. It is an adaptive management approach.

3. Safeguard measures

Harvest of Estuarine Crocodile in Sarawak will be managed and safeguarded by the present law and policies concerning protected species, coupling with continuous monitoring of the crocodile's population.

4. Licenses and permits

Licenses or permits, and CITES export permit are the safeguard measures to ensure that crocodile harvesting is done sustainably. Crocodiles are protected under Section 29 of the Wild

Life Protection Ordinance 1998 in Sarawak. Thus , the removal of crocodile, or its eggs, from the wild must be under and in accordance with the terms and conditions of a license issued by the Controller of Wild Life as per the Wild Life Protection Ordinance, 1998. The license condition requires report for every crocodile capture be submitted to the Controller failing which may may result in the refusal of future permit applications, revocation of license and/or prosecution based on certain provision of the existing ordinance.

5. License to keep or possess

Section 29 of the Wild Life Protection Ordinance, 1998 stated that every possession of individual crocodiles, or its part thereof, require a license to possess, with a fee of RM10.00 per head. Similarly keeping crocodiles in "wild animal farm" alsc requires a license from the Controller with a fee chargeable at RM100/year. Similar charges are subjected to those who operate "commercial wild life farm" which enable the operator to trade the animals.

6. Export and import permits

Import and export of crocodiles is covered under part V of Wild Life Protection Rules, 1998. A license, issued by the Controller, is required to export crocodiles, or their parts or derivatives, from Sarawak. In addition to the export license issued under the Wild Life Protection Ordinance, 1998, CITES permit, issued by the CITES Management Authority, is also required. An import license issued by the Controller is required for the commercial shipment of crocodile's products or their parts entering Sarawak from overseas or from other States in Malaysia. The import or export of wild animals shall be subject to the Public Health (Animals) Regulations contained in Ninth Schedule to the Public Health Ordinance, 1962. Export/import of live animals must be kept separated in compartments to prevent injury to its body and skin while on shipment.

7. Skins

Each skin entering trade will be marked with a non-reusable plastic tag that complies with the provisions of CITES Resolution Conf. 11.12 (Rev. CoP15). Each skin tag is uniquely numbered, and the number serves as an identification number for all subsequent record keeping related to the skin of that particular anima.

8. Meat

Import and export of crocodile meat shall be packed in cartoons and mark with standard CITES tags. Similar marking system applies to export of its parts and derivatives.

9. Manufactured items

Manufactured items are marked to identify the origin of the item and serve to identify items as being legally manufactured from approved farm, state parties or approved program.

10. Performance indicators

Crocodile harvest records are to be updated and are to be consistent with set annual quotas for Sarawak.

11. Standard Operating Procedure (SOP) for Removal and Culling of Nuisance Crocodiles

a. <u>Pre-assessment (river trothing)</u>

Before any culling operation, pre-assessment, and ground trothing in the form of day and night survey during low tide must be conducted at least two or three days prior to the operation. Locations showing the targeted crocodile sighted are marked with GPS and flagging tags (red/yellow). Communities living nearby must be informed on the operation and are to be directed to avoid these locations. The Resident and District Offices and Police must also be notified.

i. Size selection

In a Crocodile Removal Zone, there is no size limit and any crocodile in the areas will be captured and removed. In other areas, only targeted crocodile above 2.1 meter may be captured and removed.

ii. Priority Areas

First priority - to remove crocodile in the Crocodile Removal Zone.
Second Priority - targeted population where crocodile attacks are frequent.
Third Priority - targeted problem or nuisance crocodile.

iii. Active operation

- Active operation will be conducted during low tide (during the nighttime and using power spotlight). If circumstances permit, the active operation can be done in daytime during low tide.
- To use net and pole noose to capture medium size animals (during nighttime especially at CRZ)
- Shooting the crocodile using firearm.

iv. Passive operation

- Setting up trapping cages (size: 25ft Length x 5ft High x 5ft Wide) with dead chicken placed inside the trap to lure crocodile into the trap.
- The traps will be placed at selected sites where there is high frequency of crocodile appearance and sighting.
- The traps will be checked at least twice per day(early in the morning and late afternoon).
- If there is no capture after one week, the trap will either be moved to another location or retained at the same location for another week, with the bait replenished with new and fresh dead chicken.

b. Monitoring process

- To conduct population survey at the affected river system and to formulate a standard monitoring procedure for each river system because each river system may have differences in population profile, habitat composition (e.g., oil palm plantation nearby) and human habitation characteristics.
- To recommend whether further culling operation is to be continued or otherwise.
- Drone technology may be used to survey the profile of the river system.

c. Shooting

Shooting of crocodiles may only be conducted if the following conditions are met:

- Minimum crocodile size of 2.1 meters (other river system) and no limit on size for CRZ areas.
- Crocodiles must be hunted and shot when they are lying out of the water on the banks of waterways.
- Crocodiles cannot be shot while they are in the water. The entire body of a crocodile must be above the watermark before a shot is discharged.
- The shot must be delivered to the cranial platform of the head.

- Conditions at the time of shooting must also allow a high probability of recovery of the carcass to obtain the skin/head trophy.
- Crocodiles should not be shot where there is the possibility that the carcass may slide into the water, or where access to the carcass is restricted e.g. by presence of other crocodiles, by steep banks or by dense vegetation.

d. Trappings protocol

- Trapping data will be collected (GPS location, size of the trap, baits, date of deployment, surrounding habitat condition or vegetation profile).
- Local communities living within the trapping areas should not be allowed to roam near the trapping site.
- The traps must be checked twice daily (morning and afternoon), and this is to avoid more stress on a trapped crocodile if left in the cage for too long.
- Only professional and experienced personnel are allowed to retrieve the crocodile from the trap to avoid injuries to the animal.

12. Guidelines on Sharing habitat/living with Crocodiles

Croc Wise General Facts on Crocodile	*Celek Buaya* *Fakta umum berkaitan buaya*
● Crocodilians are most active by night, but can also hunt by day.	○ *Buaya amat aktif waktu malam tetapi juga memburu waktu siang.*
● Crocodilians prefer smaller prey.	○ *Buaya gemar haiwan/mangsa kecil.*
● Larger crocodilians prefer dogs and goats.	○ *Buaya besar lebih gemar anjing dan kambing.*
● Crocodiles are dangerous and attack can be fatal.	○ *Buaya adalah merbahaya dan serangan boleh menyebabkan kematian.*

● Crocodiles can attack and take people/pet from boat.	○ *Buaya boleh menyerang dan menarik manusia / haiwan daripada bot.*
● The smaller your boat, the greater the risk.	○ *Semakin kecil bot, semakin tinggi risiko.*

Don'ts *Jangan*	Do's *Sentiasa*
Don't walk at the water's edge. *Jangan berjalan di gigi air.* **Do not wade in shallow water.** *Jangan mengharungi air cetek.* **Don't do predictable activities at the water's edge** *Jangan melakukan aktiviti yang dapat diramalkan dipinggir air* **Don't go to areas of crocodilian activity.** *Jangan pergi ke kawasan aktiviti buaya.* **Don't lean over the water from boats, overhanging banks or trees.** *Jangan bersandar keluar dari perahu, tebing sungai atau pokok.* **Don't set up camp too close to the water's edge.** *Jangan membuat kem terlalu dekat dengan pinggir sungai.* **Don't feed wild crocodilians.** *Jangan beri makan buaya liar* **Don't sleep in a boat used for fishing.** *Jangan tidur dalam perahu yang digunakan untuk menangkap ikan*	**Keep a look out for crocodilians.** *Sentiasa perihatin kehadiran buaya.* **Only swim in designated areas.** *Mandi ditempat yang ditetapkan sahaja.* **Observe warning signs.** *Ikut papan tanda amaran.* **Lack of warning signs does not indicate safe swimming.** *Tiada tanda amaran bukan bermaksud tiada buaya.* **Contact local authorities for information.** *Hubungi pihak berkuasa untuk maklumat lanjut.* **Take care when launching or retrieving boats.** *Ambil langkah berjaga-jaga ketika melancar atau mengambil perahu.* **When fishing, use landing nets to retrieve and release fish.** *Bila memancing, gunakan sedok untuk menaik/menurun ikan.*

Don't leave food scraps around when camping. *Jangan biar sampah makanan semasa berkelah.* **Don't tease, capture or interfere with crocodilians.** *Jangan menggusik, menangkap atau menganggu buaya.* **Don't approach wild crocodilians too closely.** *Jangan mendekati buaya terlalu dekat.* **Don't approach a wild crocodilian nest.** *Jangan mendekati sarang buaya liar.* **Don't interfere with baby crocodilians.** *Jangan menganggu anak buaya.*	**Be responsible about cleaning fish and discarding scraps** Berwaspada dan bertanggung jawab bila menyiang dan membuang perut sisa ikan **Be wary during the breeding and nesting season** Berhati hati semasa musim mengawan dan bertelur

APPENDIX IV

The following pictures show some of activities having high risk of being attacked when it is done in crocodile-infested rivers.

Fig. i

Fig. ii

Fig. iii

Fig. i-iii highlights some of river activities that could pose danger of being attacked by crocodile when it is done in crocodile-infested rivers. Do take extra safety precautions (eg. as per the Management Plan for Estuarine Crocodile in Sarawak, 2016-2020) when using rivers with history of crocodile presence.

Fencing up or putting up barricade around bathing places (and jetties) along river, as was done along crocodile-infested rivers during the colonial era, do not seem to be practical especially in fast-flowing river as the facility could easily be washed away by strong current during monsoon and flooding season.

Fig. iv

Figure iv. Most bathing places and jetties during the colonial era were fenced up to prevent from crocodile attack.

Estuarine Crocodile (*Crocodylus porosus*) is one of the 24 species of crocodilians that have been in existence on earth for the last 240 million years. In Sarawak the species is known to inhabit a wide range of water bodies ranging from numerous rivers in coastal areas to drainage systems under human habitation in urban, sub-urban and rural areas. The overlapping use of habitats by the crocodilian and human, unfortunately, has led to the increase in Human-Crocodile Conflict (HCC), prompting the State Government to impose more effective management measures on the species throughout Sarawak. As a management authority for wildlife prior to 2020 the Forest Department of Sarawak, through its Wild Life Officer, Dr. Engkamat Lading, who has been directly involved in managing the species since early 1990s, has led a group of researchers and surveyors from the Department (since 2012) to come up with more comprehensive efforts in managing the species throughout the State. These include conducting extensive crocodile surveys along most of Sarawak's main rivers, carrying out Awareness Programs on crocodile among many local communities dwelling along crocodile-infested rivers, installation of crocodile warning signages at certain localities with human population along rivers infested by crocodiles, doing crocodile culling activities whenever necessary, establishment of crocodile sanctuary and downgrading of Estuarine Crocodiles in Malaysia from CITES Appendix I to Appendix II since October 2016 which eventually lead to regulated commercial hunting of the species in Sarawak since 2017. The approval for downgrading of the species into CITES Appendix II was actually not as easy as one may think of. It requires a number of terms and conditions as have been spelt out in the Management Plan for Estuarine Crocodile (*Crocodylus porosus*) in Sarawak for 2016-2020, of which the Department and the Sarawak Forestry Corporation (SFC) have successfully putting their heads together to come up with the document. With continuous implementation of the various management activities, inline with terms and conditions as stipulated in the Management Plan for Estuarine Crocodile (*Crocodylus porosus*) in Sarawak for 2016-2020, it is the prime hopes of the State Government and the author to see reduction in Human-Crocodile Conflict (HCC) in the State. The approach taken in the management has shown a positive result with significant reduction in number of attacks on human over a period from 2019 to 2020. While allowing regulated commercial hunting of Estuarine Crocodile to take place in Sarawak, particularly to reduce surplus population of the species, the Government, on the other hand, would take every possible measures to ensure that this last relict of the dinosour species would remained in existence as an important biological asset for sustainable utilization (by mean of consumptive and non-consumptive manners) by both local communities (who have to share their habitats with the crocodilian) as well as the State Government, in general.