

Some Aquatic Reptiles in Culture Fisheries Management

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Abstract: Aquatic reptiles are major challenge in culture fisheries. These animals feed on culture fish. Adequate knowledge on them is essential for effective culture fisheries management. Marine iguana, aquatic snakes, crocodiles and sea turtles are some aquatic reptiles reviewed in this study.

Keywords: Aquatic snakes, crocodiles and sea turtles, marine iguana

INTRODUCTION

Aquatic reptiles are reptiles which have become secondarily adapted for an aquatic or semi-aquatic life in the aquatic environment (Campbell and Lamar, 2004). The earliest marine reptiles arose in the Permian period during the Paleozoic era (Darwin, 2001). During the Mesozoic era, many groups of reptiles became adapted to life in the seas, including such familiar clades as the ichthyosaurs, plesiosaurs (these two orders were once thought united in the group "Enaliosauria," a classification now cladistically obsolete), mosasaurs, nothosaurs, placodonts, thalattosaurs and thalattosuchians. After the mass extinction at the end of the Cretaceous period, marine reptiles were less numerous (Rasmussen, 1997). Extant marine reptiles include marine iguanas, sea snakes, sea turtles and saltwater crocodiles (Graham et al., 1987). Some marine reptiles, such as ichthyosaurs and mosasaurs, rarely ventured onto land and gave birth in the water (U.S. Navy, 1991). Others, such as sea turtles and saltwater crocodiles, return to shore to lay their eggs. Some marine reptiles also occasionally rest and bask on land (Rassman, et al., 1997).

The reptiles that feed on pond fish are snakes, lizards, crocodiles and alligators. The commonest aquatic snake is the *Anoscopus* sp (Parker and Grandison, 1977). The Nile monitor, *Varanus niloticus* and *Iguana iguana* are two lizards. Three species of crocodiles, *Crocodylus niloticus*, *Crocodylus cataphractus* (Alligator) and *Osteolaemus tetraspis* are also common. Three species of water turtles: *Kimxys erosa*, *pelomedusa* and *Peliosus* sp are possible fish predators. A review of the biology of aquatic reptiles: marine iguana, aquatic snakes, crocodiles and sea turtles provides adequate knowledge for effective culture fisheries management.

THE MARINE IGUANA

The Marine Iguana (*Amblyrhynchus cristatus*) (Plate 1) is an iguana found only on the Galápagos Islands that has the ability, unique among modern lizards, to live and forage in the sea, making it a marine reptile (Wikelski and Thom, 2000). The Iguana can dive over 30 ft (10 m) into the water. It has spread to all the islands in the archipelago and is sometimes called the Galapagos Marine Iguana. It mainly lives on the rocky Galapagos shore, but can also be spotted in marshes and mangrove beaches. On his visit to the islands, Charles Darwin was revolted by the animals' appearance, writing: The black Lava rocks on the beach are frequented by large (2-3 ft), disgusting clumsy Lizards. They are as black as the porous rocks over which they crawl & seek their prey from the Sea. I call them 'imps of darkness'. They assuredly well become the land they inhabit.

In fact, *Amblyrhynchus cristatus* is not always black; the young have a lighter coloured dorsal stripe and some adult specimens are grey. The reason for the sombre tones is that the species must rapidly absorb heat to minimize the period of lethargy after emerging from the water. They feed almost exclusively on marine algae, expelling the excess salt from nasal glands while basking in the sun and the coating of salt can make their faces appear white. In adult males, coloration varies with the season. Breeding-season adult males on the southern islands (Españaola, Floreana and nearby islets) are the most colorful and will acquire red and teal-green colors, while on Santa Cruz they are brick red and black and on Fernandina they are brick red and dull greenish.

Another difference between the iguanas is size, which is different depending on the island the individual iguana inhabits. The iguanas living on the islands of Fernandina

and Isabela (named for the famous rulers of Spain) are the largest found anywhere in the Galápagos. On the other end of the spectrum, the smallest iguanas are found on the island of Genovesa. Adult males are up to 1.7 m (5.6 ft) long, females 0.6-1 m (2.0-3.3 ft), males weigh up to 1.5 kg (3.3 lb). On land, the marine iguana is rather a clumsy animal, but in the water it is a graceful swimmer.

This is due to the traits it has that allow it to swim and make it different from other species of iguana; its laterally flattened tail and spiky dorsal fins allow it to swim further and faster, while its long, sharp claws allow it to hold onto rocks and other materials around it when there are strong currents so that it doesn't drown or get lost/too far away from land. Its diet consists of seaweed and algae. To make it easier for it to get these, the marine iguana has a flat snout so that it can get closer to rocks that algae is growing on, as well as sharp teeth so that it can scrape off more of the algae. It has a special gland in its snout that filters its blood for excess salt that it may ingest while eating. It sneezes out the excess salt, which often leaves a salty crust around its nostrils, one of the aspects that made it unattractive to Charles Darwin.

As an ectothermic animal, the marine iguana can spend only a limited time in the cold sea, where it dives for algae. However, by swimming only in the shallow waters around the island they are able to survive single dives of up to half an hour at depths of more than 15m. After these dives, they return to their territory to bask in the sun and warm up again. When cold, the iguana is unable to move effectively, making them vulnerable to predation, so they become highly aggressive before heating up (since they are unable to run away they try to bite attackers in this state). During the breeding season, males become highly territorial. The males assemble large groups of females to mate with and guard them against other male iguanas. However, at other times the species is only aggressive when cold.

Marine iguanas have also been found to change their size to adapt to varying food conditions. During El Niño conditions when the algae that the iguanas feed on decreased for a period of two years, some were found to decrease their length by as much as 20%. When food conditions returned to normal, the iguanas returned to their pre-famine size. It is speculated that the bones of the iguanas actually shorten as shrinkage of connective tissue could only account for a 10% length change.

Researchers theorize that land and marine iguanas evolved from a common ancestor since arriving on the islands from South America, presumably by rafting. It is thought that the ancestral species inhabited a part of the volcanic archipelago that is now submerged. Its generic name, *Amblyrhynchus*, is a combination of two Greek words, *Ambly*-from *Amblus* (ἀμβλυ) meaning "blunt" and *rhynchus* (ρυγχος) meaning "snout". Its specific name is the Latin word *cristatus* meaning "crested," and

refers to the low crest of spines along the animals back. *Amblyrhynchus* is a monotypic genus in that *Amblyrhynchus cristatus* is the only species which belongs to it at this point in time.

This species is completely protected under the laws of Ecuador. El Niño effects cause periodic declines in population, with high mortality and the marine iguana is threatened by predation by exotic species. The total population size is unknown, but is, according to IUCN, at least 50,000 and estimates from the Charles Darwin Research Station are in the hundreds of thousands. The marine iguanas have not evolved to combat newer predators. Therefore, cats and dogs both eat the young iguanas and dogs will kill adults due to the iguanas' slow reflex times and tameness. Dogs are especially common around human settlements and can cause tremendous predation. Cats are also common in towns, but they also occur in numbers in remote areas where they take a toll on iguanas.

Aquatic snakes: Aquatic snakes are venomous elapid snakes that inhabit marine environments for most or all of their lives. Though they evolved from terrestrial ancestors, most are extensively adapted to a sound in warm coastal waters from the Indian Ocean to the Pacific. All have paddle-like tails and many have laterally compressed bodies that give them an eel-like appearance. Unlike fish, they do not have gills and must surface regularly to breathe. They are among the most completely aquatic of all air-breathing vertebrates. Among this group are species with some of the most potent venoms of all snakes. Some have gentle dispositions and bite only when provoked, but others are much more aggressive. Currently, 17 genera are described as sea snakes, comprising 62 species.

Adults of most species grow to length range of 120-150 cm (3.9-4.9 ft), with the largest, *Hydrophis spiralis*, reaching a maximum of 3 m (9.8 ft). Their eyes are relatively small with a round pupil and most have nostrils that are located dorsally. The skulls do not differ significantly from terrestrial elapids, although the dentition is relatively primitive with short fangs and (with the exception of *Emydocephalus*) as many as 18 smaller teeth behind them on the maxilla.

Like other land animals that have adapted to life in a marine environment, sea snakes ingest considerably more salt than their terrestrial relatives through their diet and when sea water is inadvertently swallowed. This meant that they had to evolve a more effective means of regulating the salt concentration of their blood. Mammals have the advantage of being able to pass salt in solution, mostly in the urine, but kidney function in birds and reptiles is too weak to remove salt in sufficient amounts. In birds, such as penguins, salt is removed through nasal glands, just as with the marine iguanas of the Galapagos

Islands. Sea turtles have lacrimal glands that allow them to produce very salty tears. In sea snakes, the posterior sublingual glands, located under and around the tongue sheath, evolved to allow them to expel salt with their tongue action.

Scalation among sea snakes is highly variable. As opposed to terrestrial snake species that have imbricate scales to protect against abrasion, the scales of most pelagic sea snakes do not overlap. Reef dwelling species, such as *Aipysurus*, do have imbricate scales to protect against the sharp coral. The scales themselves may be smooth, keeled, spiny or granular, the latter often looking like warts. Pelamis has body scales that are "peg-like", while those on its tail are juxtaposed hexagonal plates. *Aipysurus laevis* has been found to have photoreceptors in the skin of its tail, allowing it to detect light and presumably ensuring that it is completely hidden, including its tail, inside coral holes during the day. While other species have not been tested, it is possible that *A. laevis* is not unique among sea snakes in this respect. Interestingly, dermal light sensitivity is found in all the major animal phyla.

Aquatic snakes are mostly confined to the warm tropical waters of the Indian Ocean and the western Pacific Ocean, with a few species found well out into Oceania. The geographic range of one species, *Pelamis platurus*, is wider than that of any other reptile species, save for a few species of sea turtles. It extends from the east coast of Africa, from Djibouti in the north to Cape Town in the south, across the Indian Ocean, the Pacific, south as far as the northern coast of New Zealand, all the way to the western coast of the Americas, where it occurs from northern Peru in the south (including the Galápagos Islands) to the Gulf of California in the north. Isolated specimens have been found as far north as San Clemente in the United States.

Sea snakes do not occur in the Atlantic Ocean. It is thought that Pelamis would be found there were it not for the cold currents off Namibia and western South Africa that keep it from crossing into the eastern South Atlantic, or south of 5° latitude along the South American west coast. Sea snakes do not occur in the Red Sea, believed to be due to its increased salinity, so there is no danger of them crossing through the Suez Canal. Salinity, or rather a lack thereof, is also thought to be the reason why Pelamis has not crossed into the Caribbean via the Panama Canal. Despite their marine adaptations, most sea snakes prefer shallow waters near land, around islands and especially waters that are somewhat sheltered, as well as near estuaries. They may swim up rivers and have been reported as far as 160 km (99 mi) from the sea. Others, such as *Pelamis platurus*, are pelagic and are found in drift lines; slicks of floating debris brought together by surface currents. Some sea snakes inhabit mangrove



Plate 1: Marine iguana (*amblyrhynchus cristatus*)

swamps and similar brackish water habitats and there are two landlocked fresh water forms: *Hydrophis semperi* occurs in Lake Taal in the Philippines and *Laticauda crockeri* in Lake Te Nggano on Rennell Island in the Solomon Islands.

Stidworthy (1974) describes all sea snake species as being reluctant to bite and Fichter (1982) adds that they are quite docile. Spawls and Branch (1995) also claims they are mainly non-aggressive. The US Navy describes sea snakes as generally mild tempered, although there is variation among species and individuals. Mehrtens (1987) suggests that species such as *Pelamis platurus*, which feed by simply gulping down their prey, are more likely to bite when provoked because they seem to use their venom more for defence. This is in contrast to others, such as *Laticauda*, that use their venom for prey immobilization; these snakes (Plate 2) are frequently handled with impunity by local fishermen (Whitaker, 1978). Species that have been reported as much more aggressive include *Aipysurus laevis*, *Astrotia stokesii*, *Enhydrina schistosa* and *Hydrophis ornatus* (Slaughter et al., 2009).

Ditmars (1933) mentions that when they are taken out of the water, their movements become very erratic. They crawl awkwardly in these situations and can become quite aggressive, striking wildly at anything that moves. Yet they are frequently caught in nets by fishermen, who unravel and throw them back into the water barehanded, usually suffering no harm. On land, sea snakes are unable to coil and strike like terrestrial snakes. Observations suggest that sea snakes are active both day and night. In the morning and sometimes late in the afternoon, they can be seen at the surface basking in the sunlight. When disturbed, they dive below. Sea snakes have been reported swimming at depths of over 90 m (300 ft). They can remain submerged for as long as a few hours, possibly depending on temperature and degree of activity. Huge aggregations of sea snakes have been reported. For example, in 1932 millions of *Astrotia stokesii*, a relative

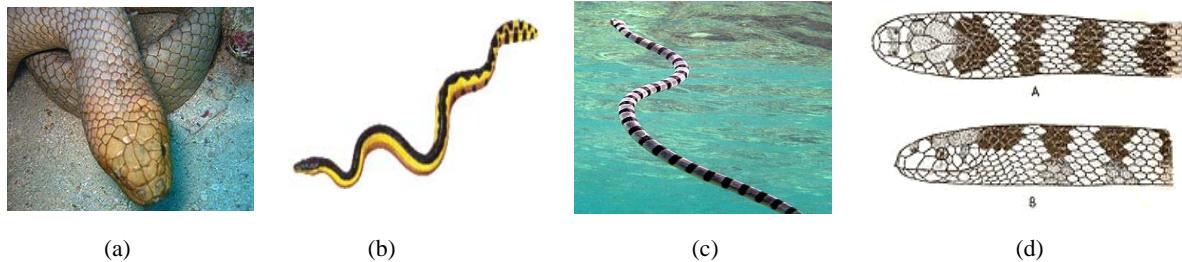


Plate 2: Aquatic snakes, (a) Olive sea snake, *Aipysurus laevis*, (b) Yellow-bellied sea snake, *Pelamisplaturus*, (c) Yellow-lipped sea krait, *Laticauda colubrina*, (d) *Hydrophis cyanocinctus*

of *Pelamis*, were seen from a steamer in the Strait of Malacca, off the coast of Malaysia and formed a line of snakes 3 m (9.8 ft) wide and 100 km (62 mi) long. The cause of this phenomenon is unknown, although it likely has to do with reproduction. Ditmars (1933) mentions that, in that same area, sea snakes can sometimes be seen swimming in schools of several dozen and that after typhoons many dead specimens can be found on the beaches.

Most sea snake species prey on fish, especially eels. The latter stiffens and dies within seconds, when bitten. One species prefers molluscs and crustaceans, such as prawns, while a few others feed only on fish eggs, which is unusual for a venomous snake. Some reef dwelling species have small heads and thin necks, making it possible for them to extract small eels from the soft bottom where they hide. Stidworthy (1974) states that sea snakes will sometimes take bait from a fishing line. Except for a single genus, all sea snakes are ovoviviparous; the young are born alive in the water where they live their entire life cycle. In some species, the young are quite large: up to half as long as the mother. The one exception is the genus *Laticauda*, which is oviparous; its five species all lay their eggs on land.

Like their cousins in the Elapidae family, the majority of sea snakes are highly venomous; however, when bites occur, it is rare for much venom to be injected, so that envenomation symptoms usually seem non-existent or trivial. For example, *Pelamis platurus* has a venom more potent than any terrestrial snake species in Costa Rica based on LD₅₀, but despite its abundance in the waters off its western coast, few human fatalities have been reported. Nevertheless, all sea snakes should be handled with great caution.

Bites in which envenomation does occur are usually painless and may not even be noticed when contact is made. Teeth may remain in the wound. There is usually little or no swelling and it is rare for any nearby lymph nodes to be affected. The most important symptoms are rhabdomyolysis (rapid breakdown of skeletal muscle tissue) and paralysis. Early symptoms include headache, a thick-feeling tongue and thirst, sweating and vomiting. Symptoms that can occur after 30 min to several hours

post-bite include generalized aching, stiffness and tenderness of muscles all over the body. Passive stretching of the muscles is also painful and trismus, which is similar to tetanus, is common. This is followed later on by symptoms typical of other elapid envenomations: a progressive flaccid paralysis, starting with ptosis and paralysis of voluntary muscles. Paralysis of muscles involved in swallowing and respiration can be fatal. After 3-8 h, myoglobin as a result of muscle breakdown may start to show up in the blood plasma, which can cause the urine to turn a dark reddish, brown, or black color and eventually lead to acute renal failure. After 6 to 12 h, severe hyperkalemia, also the result of muscle breakdown, can lead to cardiac arrest.

Sea snakes were at first regarded as a unified and separate family, the Hydrophiidae, that later came to comprise two subfamilies: the Hydrophiinae, or true/aquatic sea snakes (now 16 genera with 57 species) and the more primitive Laticaudinae, or sea kraits (1 genus, *Laticauda*, with 5 species). Eventually, as it became clear just how closely related the sea snakes are to the elapids, the taxonomic situation became less well-defined (Warrell, 2004). Some taxonomists responded by moving the sea snakes to the Elapidae, thereby creating the subfamilies Elapinae, Hydrophiinae and Laticaudinae, although the latter may be omitted if *Laticauda* is included in the Hydrophiinae. No one has yet been able to convincingly work out the phylogenetic relationships between the various elapid subgroups and the situation is still unclear. Therefore, others opted to either continue to work with the older traditional arrangements, if only for practical reasons, or to lump all of the genera together in the Elapidae, with no taxonomic subdivisions, to reflect the work that remains to be done (Voris, 1977).

At best, these snakes make difficult captives. Ditmars (1933) described them as nervous and delicate captives that usually refuse to eat, preferring only to hide in the darkest corner of the tank. Over 50 years later, Mehrtens (1987) wrote that although they were rarely displayed in western zoological parks, some species were regularly on display in Japanese aquariums. Available food supply is one factor that limits the number of species that can be kept in captivity, since some have diets that are too

specialized. Another is that some species appear intolerant of handling, or even being removed from the water. Regarding their requirements in captivity, the *Laticauda* species need to be able to exit the water somewhere and bask, while the other strictly aquatic genera do not, basically requiring only a tank of filtered (synthetic) sea water maintained at about 29°C, along with a submerged shelter. Species that have done relatively well in captivity include the ringed sea snake, *Hydrophis cyanocinctus*, which feed on fish and eels in particular. *Pelamis platurus* has done especially well in captivity, accepting small fish, including goldfish. However, care has to be taken to house them in round or oval tanks or in rectangular tanks with corners that are well-rounded, to prevent the snakes from damaging their snouts by swimming into the sides.

Most sea snakes are not on the CITES protection lists, however, one species, *Laticauda crockeri*, is classified as Vulnerable (Vu), another, *Aipysurus fuscus*, classified as Endangered (En) and two, *Aipysurus foliosquama* and *Aipysurus apraefrontalis*, are classified as Critically Endangered (CE) according to the IUCN Red List of Threatened Species.

The crocodile: The saltwater or estuarine crocodile (*Crocodylus porosus*) (Plate 3) is the largest of all living reptiles. It is found in suitable habitats in Northern Australia, the eastern coast of India and parts of Southeast Asia.

The saltwater crocodile has a longer muzzle than the mugger crocodile: its length is twice its breadth at the base. The saltwater crocodile has fewer armor plates on its neck than other crocodilians and its broad body contrasts with that of most other lean crocodiles, leading to early unverified assumptions that the reptile was an alligator. An adult male saltwater crocodile's weight is 600 to 1,000 kg (1,300-2,200 lb) and length is normally 4.1 to 5.5 m (13-18 ft), although mature males can be 6 m (20 ft) or more and weigh 1,300 kg (2,900 lb) or larger. This species has the greatest sexual dimorphism of any modern crocodilian, with females being much smaller than males. Typical female body lengths range from 2.1 to 3.5 m (7-11 ft). The largest female on record measured about 4.2 m (14 ft). The mean weight of the species as a whole is roughly 450 kg (1,000 lb).

The largest size saltwater crocodiles can reach is the subject of considerable controversy. The longest crocodile ever measured snout-to-tail and verified was the skin of a

Plate 3:
(*crocodylu*



s porosus)

dead which (20 ft) skins tend slightly removal crocodile, was 6.1 m long. As to shrink a feet from the carcass, this crocodile's living length was estimated at 6.3 m (21ft) and it probably weighed well over 1,200 kg (2,600 lb). Incomplete remains (the skull) of a crocodile shot in Orissa have been claimed to come from a 7.6 m (25ft) crocodile, but scholarly examination suggested a length no greater than 7 m (23 ft). There have been numerous claims of crocodiles in the 9 m (30 ft) range: the crocodile shot in the Bay of Bengal in 1840, reported at 10 m (33 ft); another killed in 1823 at Jalajala on the main island of Luzon in the Philippines reported at 8.2 m (27 ft); a reported 7.6 m (25 ft) crocodile killed in the Hooghly River in the Alipore District of Calcutta. However, examinations of these animals' skulls actually indicated animals ranging from 6 to 6.6 m (20-21.7 ft).

With recent restoration of saltwater crocodile habitat and reduced poaching, it is possible that 7 m (23 ft) crocodiles are alive today. Guinness has accepted a claim of a 7 m (23 ft), 2,000 kg (4,400 lb) male saltwater crocodile living within Bhitarkanika Park in the state of Orissa, India, although, due to the difficulty of trapping and measuring a very large live crocodile, the accuracy of these dimensions has yet to be verified. A crocodile shot in Queensland in 1957 was reported to be 8.63 m (28.3 ft) long, but no verified measurements were made and no remains of this crocodile exist. A "replica" of this crocodile has been made as a tourist attraction. Many other unconfirmed reports of crocodiles exceeding 8 m (28+ ft) have been made but these are highly unlikely.

The saltwater crocodile is one of the three crocodilians found in India, the other two being the Mugger crocodile and the Gharial. Apart from the eastern coast of India, the saltwater crocodile is extremely rare in the Indian subcontinent. A huge population of saltwater crocodiles (consisting of many large adults, including a 7 m male) is present within the Bhitarkanika Wildlife Sanctuary of Orissa and they are known to be present in smaller numbers throughout the Indian and Bangladesh portions of the Sundarbans. In northern Australia (which includes the northernmost parts of the Northern Territory, Western Australia and Queensland) the Saltwater Crocodile is thriving, particularly in the multiple river systems near Darwin (such as the Adelaide, Mary and Daly Rivers, along with their adjacent billabongs and estuaries) where large (6 m +) individuals are common.

The Australian Saltwater Crocodile population is

estimated at somewhere between 100,000 and 200,000 adults. Their range extends from Broome in Western Australia through the entire Northern Territory coast all the way down to Rockhampton in Queensland. The Alligator Rivers of Northern Australia are misnamed due to the resemblance of the saltwater crocodile to alligators as compared to freshwater crocodiles, which also inhabit the Northern Territory. In New Guinea they are also common, existing within the coastal reaches of virtually every river system in the country, along with all estuaries and mangroves. They are also present in varying numbers throughout the Bismarck Archipelago, the Kai Islands, the Aru Islands, the Maluku Islands and many other islands within the region including Timor and most islands within the Torres Strait.

The saltwater crocodile was historically found throughout Southeast Asia but is now extinct throughout much of this range. This species has not been reported in the wild for decades in most of Indochina and is extinct in Thailand, Laos, Vietnam and possibly Cambodia. The status of this species is critical within much of Myanmar, but there is a stable population of many large adults present in the Irrawaddy Delta. It is probable that the only country in Indochina still harboring wild populations of this species is Myanmar. Although Saltwater Crocodiles were once very common in the Mekong Delta (from where they disappeared in the 1980s) and other river systems, the future of this species in Indochina is now looking grim. However, it is also the least likely of crocodylians to become globally extinct due to its wide distribution and almost pre-colonial population sizes in Northern Australia and New Guinea.

The population is sporadic in Indonesia and Malaysia with some areas harboring large populations (Borneo and Sumatra, for example) and others with very small, at-risk populations (e.g., Peninsular Malaysia). Despite the close proximity to the crocodile hot-bed of northern Australia, crocodiles no longer exist in Bali. This species is also extinct on Lombok, Komodo and most of Java. A small population may remain within Ujung Kulon National Park in western Java. The saltwater crocodile is also present in very limited parts of the South Pacific, with an average population in the Solomon Islands, a very small and soon to be extinct population in Vanuatu (where the population officially stands at only three) and a decent but at-risk population (which may be rebounding) in Palau. Saltwater crocodiles once ranged as far west as the east coast of Africa at the Seychelles Islands. These crocodiles were once believed to be a population of Nile crocodiles, but they were later proven to be *Crocodylus porosus*.

Due to this species' tendency to travel very long distances at sea, individual saltwater crocodiles occasionally show up in odd locales where they are not native. Vagrant individuals have historically been

reported on New Caledonia, Iwo Jima, Fiji and even in the relatively frigid Sea of Japan (thousands of miles from their native territory). In late 2008/early 2009 a handful of wild saltwater crocodiles were verified to be living within the river systems of Fraser Island, hundreds of kilometers from and in much cooler water than their normal Queensland range. It was discovered that these crocodiles did indeed migrate south to the island from northern Queensland during the warmer wet season and presumably returned to the north upon the seasonal temperature drop. Despite the surprise and shock within the Fraser Island public, this is apparently not new behavior and in the distant past wild crocodiles had been reported occasionally appearing as far south as Brisbane during the warmer wet season.

Saltwater crocodiles generally spend the tropical wet season in freshwater swamps and rivers, moving downstream to estuaries in the dry season and sometimes traveling far out to sea. Crocodiles compete fiercely with each other for territory, with dominant males in particular occupying the most eligible stretches of freshwater creeks and streams. Junior crocodiles are thus forced into the more marginal river systems and sometimes into the ocean. This explains the large distribution of the animal (ranging from the east coast of India to northern Australia) as well as its being found in odd places on occasion (such as the Sea of Japan). Saltwater crocodiles can swim 15 to 18 miles per h (6.7 to 8.0 m/s) in short bursts, but when cruising go 2 to 3 mph (0.9 to 1.3 m/s).

The saltwater crocodile is an opportunistic apex predator capable of taking nearly any animal that enters its territory, either in the water or on dry land. They are known to attack humans who enter the crocodiles' territory. Juveniles are restricted to smaller animals such as insects, amphibians, crustaceans, small reptiles and fish. The larger the animal grows, the greater the variety of animals it includes in the diet, although relatively small prey make up an important part of the diet even in adults. Large adult saltwater crocodiles can potentially eat any animals within their range, including monkeys, kangaroos, wild boar, dingos, goannas, birds, domestic



Plate 4: Sea turtles in different positions

livestock, pets, humans, water buffalo, gaurs, bats and even sharks. Domestic cattle, horses, water buffalo and gaur, all of which may weigh over a ton, are considered the largest prey taken by male crocodiles. Generally very lethargic-a trait which helps it survives months at a time without food-it typically loiters in the water or basks in the sun through much of the day, preferring to hunt at night. Saltwater crocodiles are capable of explosive bursts of speed when launching an attack from the water. Stories of crocodiles being faster than a race horse, for short distances across the ground are little more than urban legend. At the water's edge, however, where they can combine propulsion from both feet and tail, eyewitness accounts are rare.

It usually waits for its prey to get close to the water's edge before striking, using its great strength to drag the animal back into the water. Most prey animals are killed by the great jaw pressure of the crocodile, although some animals may be incidentally drowned. It is an extremely powerful animal. In one case, a 1 tonne Suffolk stallion known to haul over 2 tonnes was pulled into water to its demise by a large male crocodile. A large croc can crush a full-grown bovid's skull between its jaws. Its typical hunting technique is known as the "death roll": it grabs onto the animal and rolls powerfully. This throws any struggling large animal off balance, making it easier to drag it into the water. The "death roll" is also used for tearing apart large animals once they are dead.

Baby saltwater crocodiles may fall prey to monitor lizards, predatory fish, birds, larger crocodiles and many other predators. Juveniles may also fall prey to Bengal tigers and leopards in certain parts of their range, although this is rare. One researcher, Dr. Adam Britton, has been

studying crocodilian intelligence. He has compiled a collection of Australian saltwater crocodile calls and associated them with behaviors. His position is that while crocodilian brains are much smaller than those of mammals (as low as 0.05% of body weight in the saltwater crocodile), they are capable of learning difficult tasks with very little conditioning. He also infers that the crocodile calls hint at a deeper language ability than currently accepted. He suggests that saltwater crocodiles are clever animals that can possibly learn faster than lab rats. They have also learned to track the migratory route of their prey as the seasons change.

Data on attacks is limited outside of Australia. In Australia, attacks are rare and usually appear in national news publications when they do occur. There are approximately one to two fatal attacks reported per year in the country. The low level of attacks may be due to extensive efforts by wildlife officials in Australia to post crocodile warning signs at many at-risk billabongs, rivers, lakes and beaches. In the large Aboriginal community of Arnhem Land, attacks may go unreported. There have also been recent, less-publicized attacks in Borneo, Sumatra, eastern India (Andaman Islands) and in Myanmar.

During the Japanese retreat in the Battle of Ramree Island on February 19, 1945, saltwater crocodiles may have been responsible for the deaths of 400 Japanese

soldiers. British soldiers encircled the swampland through which the Japanese were retreating, condemning the Japanese to a night in the mangroves which was home to thousands of saltwater aquatic life and are unable to even move on land, except for the genus *Laticauda*, which retain ancestral characteristics which allow limited land

movement. They are fater crocodiles. The Ramree crocodile attacks are listed under the heading "The Greatest Disaster Suffered from Animals" in Guinness World Records. Another notorious crocodile attack was in 1985, on eco-feminist Val Plumwood.

Sea turtles: Sea turtles (superfamily: Chelonioidea) (Plate 4) are marine reptiles that inhabit all of the world's oceans except the Arctic. The superfamily: Chelonioidea has a world-wide distribution; sea turtles can be found in all oceans except for the polar regions. Some species travel between oceans. The flatback sea turtle is found solely on the northern coast of Australia.

Sea turtles are almost always submerged in water and, therefore, have developed an anaerobic system of respiration. Although all sea turtles breathe air, under dire circumstances they may divert to anaerobic respiration for long periods of time. When surfacing to breathe, a sea turtle can quickly refill its lungs with a single explosive exhalation and rapid inhalation. Their large lungs have adapted to permit rapid exchange of oxygen and to avoid trapping gases during deep dives. However, sea turtles must emerge while breeding, given the extra level of activity. According to SeaWorld Parks & Entertainment, a lifespan of 80 years is feasible for sea turtles.

It takes decades for sea turtles to reach sexual maturity. After mating at sea, adult female sea turtles return to land to nest at night. Different species of sea turtles exhibit various levels of philopatry. In the extreme case, females return to the beach where they hatched. This can take place every 2 to 4 years in maturity. They make from 1 to 8 nests per season. The mature nesting female hauls herself onto the beach, nearly always at night and finds suitable sand on which to create a nest. Using her hind flippers, she digs a circular hole (40 to 50 cm) (16 to 20 in) deep. After the hole is dug, the female then starts filling the nest with a clutch of soft-shelled eggs one by one until she has deposited around 50 to 200 eggs, depending on the species. Some species have been reported to lay 250 eggs, such as the hawksbill. After laying, she re-fills the nest with sand, re-sculpting and smoothing the surface until it is relatively undetectable visually. The whole process takes 30 to 60 min. She then returns to the ocean, leaving the eggs untended.

The hatchling's gender depends on the sand temperature. Lighter sands maintain higher temperatures, which decreases incubation time and results in more female hatchlings. Incubation takes about 2 months. The eggs in one nest hatch together over a very short period of time. When ready, hatchlings tear their shells apart with their snout and dig through the sand. Again, this usually takes place at night, when predators such as seagulls cannot fly. Once they reach the surface, they instinctively head towards the sea. If, as happens on rare occasions, hatching takes place during daylight, only a very small proportion of each hatch (usually 0.01%) succeed, because local opportunist predators, such as the common seagull, gorge on the new sea turtles. Thus there is an

obvious evolutionary drive to hatch at night, when survival rates on the beach are much higher.

The hatchlings then proceed into the ocean, where a variety of marine predators await them. In 1987, Carr discovered that the young of *Chelonia mydas* and *Caretta caretta* spent a great deal of their pelagic lives in floating sargassum beds, where there are thick mats of unanchored seaweed. Within these beds, they found ample shelter and food. In the absence of sargassum beds, sea turtle young feed in the vicinity of upwelling "fronts". In 2007, Reich determined that green sea turtle hatchlings spend the first three to five years of their lives in pelagic waters. In the open ocean, pre-juveniles of this particular species were found to feed on zooplankton and smaller nekton before they are recruited into inshore seagrass meadows as obligate herbivores.

Instead of nesting individually like the other species, Ridley sea turtles come ashore en masse, known as an "arribada" (arrival). With the Kemp's ridley sea turtles this occurs during the day.

Sea turtles possess a salt excretory gland at the corner of the eye, in the nostrils, or in the tongue, depending on the species; chelonian salt glands are found in the corner of the eyes in leatherback sea turtles. Due to the iso-osmotic makeup of jellyfish and the other gelatinous prey upon which sea turtles subsist, sea turtle diets are high in salt; chelonian salt gland excretions are almost entirely composed of sodium chloride 1500-1800 mosmoll-1 (Zimmerman and Heatwole, 1990).

Marine sea turtles are caught worldwide, although it is illegal to hunt most species in many countries. A great deal of intentional marine sea turtle harvests worldwide are for food.

Many parts of the world have long considered sea turtles to be fine dining. Ancient Chinese texts dating to the fifth century B.C. describe sea turtles as exotic delicacies. Many coastal communities around the world depend on sea turtles as a source of protein, often harvesting several sea turtles at once and keeping them alive on their backs until needed. Coastal peoples gather sea turtle eggs for consumption.

Sea turtles are popular in Mexico as boot material and food. To a much lesser extent, specific species of marine sea turtles are targeted not for their flesh, but for their shells. Tortoiseshell, a traditional decorative ornamental material used in Japan and China, comes from the carapace scutes of the hawksbill sea turtle. Ancient Greeks and ancient Romans processed sea turtle scutes (primarily from the hawksbill) for various articles and ornaments used by their elites, such as combs and brushes. The skin of the flippers is prized for use as shoes and assorted leather goods. The Moche people of ancient Peru worshipped the sea and its animals. They often depicted sea turtles in their art. Sea turtles enjoy immunity from the sting of the deadly box jellyfish and regularly eat them, helping keep tropical beaches safe for humans.

Sea turtles, especially green sea turtles, are one of the few animals that eat sea grass. Sea grass needs to be

constantly cut short to help it grow across the sea floor. Sea turtles act as grazing animals that cut the grass short and help maintain the health of the sea grass beds. Sea grass beds provide breeding and developmental grounds for numerous species of fish, shellfish and crustaceans. Without sea grass beds, many marine species humans harvest would be lost, as would the lower levels of the food chain. The reactions could result in many more marine species eventually becoming endangered or extinct.

Beaches and dune systems do not get many nutrients. Sea turtles use beaches and the lower dunes to nest and lay their eggs. Sea turtles lay around 100 eggs in a nest and lay between 3 and 7 nests during the summer nesting season. Along a 20-mile stretch of beach on the east coast of Florida sea turtles lay over 150,000lbs of eggs in the sand. Dune vegetation is able to grow and become stronger with the presence of nutrients from sea turtle eggs, unhatched nests, eggs and trapped hatchlings. As the dune vegetation grows stronger and healthier, the health of the entire beach/dune ecosystem becomes better. Stronger vegetation and root systems helps to hold the sand in the dunes and helps protect the beach from erosion.

Beach towns, such as Tortuguero, Costa Rica, have transitioned from a tourism industry that made profits from selling sea turtle meat and shells to an ecotourism-based economy. Tortuguero is considered to be the founding location of sea turtle conservation. In the 1960s the cultural demand for sea turtle meat, shells and eggs were quickly killing once abundant sea turtle populations that nested on the beach. The Caribbean Conservation Corporation began working with villagers to promote ecotourism as a permanent substitute to sea turtle hunting. Sea turtle nesting grounds became sustainable. Since the creation of a sea turtle, ecotourism-based economy, Tortuguero annually houses thousands of tourists who visit the protected 22-mile beach that hosts sea turtle walks and nesting grounds. All species of sea turtles are listed as threatened or endangered. The leatherback, Kemp's Ridley and hawksbill sea turtles are critically endangered. The Olive Ridley and green sea turtles are endangered and the loggerhead is threatened. The flatback's conservation

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lining has been identified as a major cause of accidental sea turtle death. There is also black-market demand for tortoiseshell for both decoration and supposed health benefits. Sea turtles must surface to breathe. Caught in a fisherman's net, they are unable to surface and thus suffocate. In early 2007, almost a thousand sea turtles were killed inadvertently in the Bay of Bengal over the course of a few months after netting. However, some relatively inexpensive changes to fishing techniques, such as slightly larger hooks and traps from which sea turtles can escape, can dramatically cut the mortality rate. Turtle Excluder Devices (TEDs) have reduced sea turtle bycatch in shrimp nets by 97%. Another danger comes from marine debris, especially from abandoned fishing nets in which they can become entangled.

Beach development is another area which threatens sea turtles. Since many sea turtles return to the same beach each time to nest, development can disrupt the cycle. There has been a movement to protect these areas, in some cases by special police. In some areas, such as the east coast of Florida, conservationists dig up sea turtle eggs and relocate them to fenced nurseries to protect them from beach traffic (Zimmerman and Heatwole, 1990). Since hatchlings find their way to the ocean by crawling towards the brightest horizon, they can become disoriented on developed stretches of coastline. Lighting restrictions can prevent lights from shining on the beach and confusing hatchlings. Sea turtle-safe lighting uses red or amber LED light, invisible to sea turtles, in place of white light.

Another major threat to sea turtles is black-market trade in eggs and meat. This is a problem throughout the world, but especially a concern in the Philippines, India, Indonesia and the coastal nations of Latin America. Estimates reach as high as 35,000 sea turtles killed a year in Mexico and the same number in Nicaragua (Plate 5). Conservationists in Mexico and the United States have

launched "Don't Eat Sea Turtle" campaigns in order to reduce this trade in sea turtle products. These campaigns have involved figures such as Dorismar, Los Tigres del Norte and Maná. Sea turtles are often consumed during the Catholic season of Lent, even though they are reptiles, not fish. Consequently, conservation organizations have written letters to the Pope asking that he declare sea

Plate 5: Loggerhead sea turtle exits from fishing net through a Turtle Excluder Device (TED)

turtles meat (Zimmerman and Heatwole, 1990).

Climate change may also cause a threat to sea turtles. Since sand temperature at nesting beaches defines the sex of a sea turtle while developing in the egg, there is concern that rising temperatures may produce too many females. However, more research is needed to understand how climate change might affect sea turtle gender distribution and what other possible threats it may pose (Zimmerman and Heatwole, 1990).

Fibropapillomatosis disease causes tumors in sea turtles. Injured sea turtles are sometimes rescued and rehabilitated by professional organizations, such as the Mote Marine Laboratory in Sarasota, Florida, the Marine Mammal Center in Northern California, the Clear Water Marine Aquarium in Clearwater, Florida and the Sea Turtle Inc. organization in South Padre Island, Texas. One such sea turtle, named Nickel for the coin that was found lodged in her throat, lives at the Shedd Aquarium in Chicago. In the Caribbean, researchers are having some success in assisting a comeback. In September 2007, Corpus Christi, Texas, wildlife officials found 128 Kemp's ridley sea turtle nests on Texas beaches, a record number, including 81 on North Padre Island (Padre Island National Seashore) and four on Mustang Island. Wildlife officials released 10,594 Kemp's ridleys hatchlings along the Texas coast this year.

Also in 2007, the U.S. Fish and Wildlife Service and the National Marine Fisheries Service issued a determination that the leatherback, the hawksbill and the Kemp's Ridley populations were endangered while the green sea turtles and olive ridleys were threatened. In Southeast Asia, the Philippines had several initiatives dealing with the issue of sea turtle conservation (Zimmerman and Heatwole, 1990). In 2007, the province of Batangas in the Philippines declared the catching and eating of Pawikans illegal. However, the law seems to have had little effect as Pawikan eggs are still in demand in Batangan markets. In September 2007, several Chinese poachers were apprehended off the Turtle Islands in the country's southernmost province of Tawi-Tawi. The poachers had collected more than a hundred sea turtles, along with 10,000 sea turtle eggs.

Evaluating the progress of conservation programs is difficult, because many sea turtle populations have not been assessed adequately. Most information on sea turtle

populations comes from counting nests on beaches, but this doesn't provide an accurate picture of the whole sea turtle population. A 2010 United States National Research Council report concluded that more detailed information on sea turtles' life cycles, such as birth rates and mortality, is needed.

Sea turtles are very vulnerable to oil pollution, both because of their tendency to linger on the water's surface and because oil can effect them at every stage of their life

cycle. Oil can poison the sea turtles upon entering their digestive system,

Sea turtles play key roles in two ecosystem types that are critical to them as well as to humans-oceans and beaches/dunes. In the oceans, for example, sea turtles, especially green sea turtles, are one of very few creatures (manatees are another) that eat the sea grass that grows on the sea floor. Sea grass must be kept short to remain healthy and beds of healthy sea grass are essential breeding and development areas for many species of fish and other marine life. A decline or loss of sea grass beds would damage these populations, triggering a chain reaction and negatively impacting marine and human life (Zimmerman and Heatwole, 1990).

Beaches and dunes form a fragile ecosystem that depends on vegetation to protect against erosion. Eggs, hatched or not hatched and hatchlings that fail to make it into the ocean are nutrient sources for dune vegetation. Every year, sea turtles lay countless eggs on beaches. Along 120 mile (32 km) stretch of beach in Florida alone, for example, more than 150,000 pounds of eggs are laid each year. Of the seven species of sea turtles, all are listed on the IUCN Red List of Endangered Species as either "endangered" or "critically endangered". Although sea turtles usually lay around 100 eggs at a time, on average only one of the eggs from the nest will survive to adulthood. While many of the things that endanger these hatchlings are natural, such as predators including sharks, raccoons, foxes and seagulls, many new threats to the sea turtle species have recently arrived and increased with the ever-growing presence of humans.

CONCLUSION

Marine iguana, aquatic snakes, crocodiles and sea turtles are some aquatic reptiles threatening culture fisheries management and be managed effectively.

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