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## IN QUALIFIED PRAISE OF CAPTAIN F.D. MAXWELL: A PRECIS OF MAXWELL'S 1904 REPORT ON THE TURTLE-BANKS OF THE IRRAWADDY DIVISION OF BURMA (MYANMAR)

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**Abstract.**—In the 19<sup>th</sup> Century, under British Colonial rule, a concession system of leases was established to regulate the annual sea turtle and *Batagur* turtle egg harvests in southeastern Burma (Myanmar). When Maxwell drafted his report in 1897–1898, the harvests had been occurring for decades. The species harvested were the Green Turtle (*Chelonia mydas*), the Olive Ridley (*Lepidochelys olivacea*; incorrectly thought to be the Loggerhead, *Caretta caretta*), the Northern River Terrapin (*Batagur baska*), and the Burmese Roofed Turtle (*Batagur trivittata*). Annual take for Green Turtle eggs at the key site of Diamond (Thameehla) Island was approximately 1.6 M eggs, while for Olive Ridelys, which nest at Thameehla and other islands further east, the annual take was 1.5 M eggs. *Batagur* egg harvests at two key sites were 165,000 (1890–1891) down to 77,000 (1896–1898). This exploitation occurred for nearly a century. Gathering information from concessionaires and fishermen, Maxwell compiled a series of life-history traits, many of which were not generally known until the mid-20<sup>th</sup> Century. He was able to describe natal beach fidelity, reproductive seasonality, clutch intervals, clutch frequencies, individual productivity, and thermal and precipitation impacts on incubation. While Maxwell predicted the over-harvest of the *Batagur* species, he was not insightful on the biology of males, age to maturity, or conservation needs for sea turtles. Most importantly, the continued sea turtle egg exploitation, which he supported at the time, combined with subsequent intensification of nearshore fisheries, has led to the near collapse of all coastal turtle populations in Myanmar.

**Key Words.**—commercial egg harvests; Green Sea Turtle, *Chelonia mydas*; natural history; Olive Ridley Sea Turtle, *Lepidochelys olivacea*; *Batagur*

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### INTRODUCTION

In 2012, during a marine turtle training seminar in Yangon, Myanmar, conducted with Dr. Colin Limpus, the first author was introduced to a remarkable century-old publication (Maxwell 1904). Recognizing its significance (see also Smith 1931 and Thorbjarnarson et al. 2000), the first author borrowed, photographed and transcribed the rare document. The co-authors have now combined their efforts to amplify and present this Precis, which was originally drafted by Douglas Hykle, who coordinated the Indian Ocean - South-East Asia (IOSEA) Marine Turtle Memorandum of Understanding until 2016. Due to the historical nature of the document we believe this summary will be of general value to herpetological conservation.

Captain F.D. Maxwell drafted the 57-page report, innocuously entitled Report on the Turtle-Banks of

the Irrawaddy Division, around 1897–1898 while serving as Deputy Commissioner of the Irrawaddy (now Ayeyarwady) Division, in the British colonial government of Burma (now called Myanmar by most governments). The report also included 27 pages of discussions and opinions by his colleagues and superiors in the colonial administration (Maxwell 1904). Though the purpose and precise details are unknown, the colonial Revenue Secretary appears to have commissioned the report in July 1897. Once completed, his superior formally submitted the report on 18 October 1898 for consideration by higher authorities, and the Lieutenant-Governor of Burma eventually endorsed it in March 1899. The report by Maxwell on the Turtle-Banks of the Irrawaddy Division is a thoroughly captivating document.

We cover a variety of topics in the report (Table 1) and we discuss a map of the primary locations discussed by Maxwell (Fig. 1). The listing of the

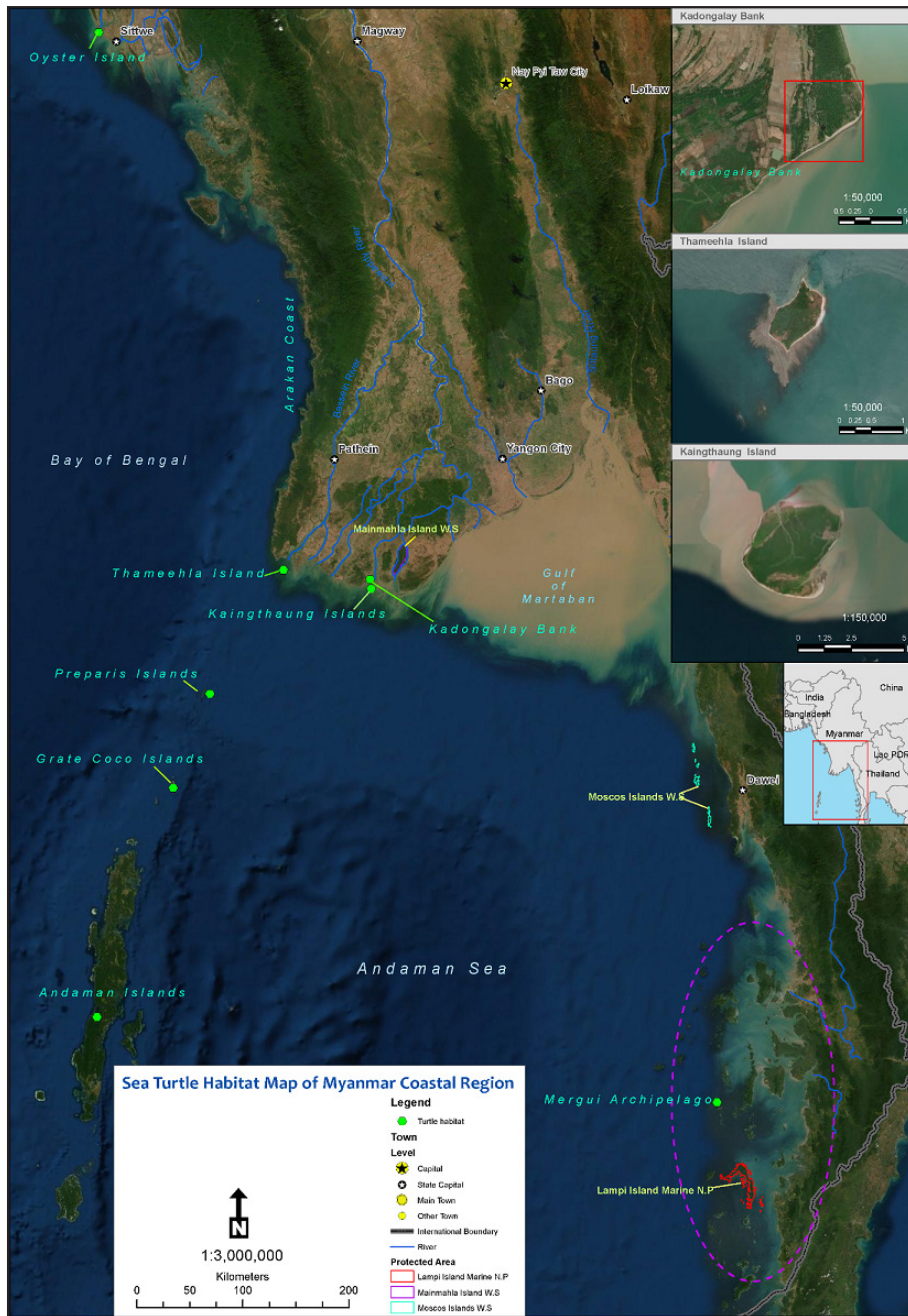


FIGURE 1. Map of southeast coastal Myanmar (historically Burma) showing some of the key locations discussed in Maxwell (1904).

contents of the report might not seem exceptional to present-day readers, until one considers that the meticulous documentation of all of these sea turtle life-history traits was done by a colonial administrator, sitting in the Irrawaddy (Ayeyarwady) delta at the end of the 19<sup>th</sup> Century. This *Precis* serves as a humbling reminder that, despite all of our tremendous advances in knowledge in recent years, it is worth revisiting the pioneering ideas, failures and lessons learned by our forefathers. For aspiring

biologists just beginning their careers, or even well-intentioned conservationists intending to set up a new turtle conservation and research program, the report by Maxwell should be required reading, as an overview of some of the issues they should be prepared to investigate. While a modern techniques manual serves a similar purpose, it is inspiring to realize that a layman thought of all of these things 120 y ago. The report by Maxwell provides an invaluable perspective of the conservation status of

Hykle et al.—A precis of Maxwell’s 1904 coastal turtle report for Burma.

TABLE 1. An ordered sequence of the primary topics covered in the *Precis* by Maxwell (1904).

INTRODUCTION	COMMERCE
Study Site	Egg collection
Nomenclature	Consumption
Species overview	Revenue-generation
LIFE HISTORY ATTRIBUTES	CONSERVATION
Abundance	Traditional knowledge
Feeding	Management
Habitat selection	Site plans
Mating	Regulations
Nesting	Enforcement
Incubation	Socio-economic considerations
Clutch frequency	
Distribution, pelagic phase, natal homing	REPORT OUTCOMES AND UPDATES
Breeding age and fecundity	
Population trends	Official response to the report by Maxwell
Threats	Conclusions
Disturbance	Epilogue
Predators	Literature Cited

turtles and terrapins, as well as their habitat, in the Irrawaddy delta during the decades prior to 1898, a detailed record that present-day researchers can attempt to compare to the current situation. Finally, if ever a decision-maker in government needed cold hard facts to demonstrate that a once-flourishing sea turtle population had been reduced to a tiny fraction of its historical number, and was in need of urgent attention, the report by Maxwell answers the call.

Who exactly was Captain F.D. Maxwell? He appears to have been a highly regarded administrator in the British colonial government in Burma, one who excelled at whatever assignment was handed to him. A few years after the completion of his seminal turtle report, Captain Maxwell was placed on special duty to investigate criminal wrongdoing in the colonial government administration. Jonathan Saha describes Maxwell as follows (partly quoting from other sources): “He was chosen [to head the investigation team] because of his outstanding reputation among the highest echelons of the government of Burma. He was ubiquitously praised. The Irrawaddy Commissioner wrote to the Lieutenant-Governor stating that, ‘It is well known to Government that the late Deputy Commissioner, Captain Maxwell, is an officer who is capable of an immense amount of hard work and that he never spared himself’” (Saha 2013).

Suffice to say that turtles were clearly not the life-long preoccupation of Maxwell. There is some suggestion, however, that he had more than a passing interest in the natural world, given that he quotes a number of times from the writings of Charles Darwin, who had passed away only a couple of decades earlier. He was also very up-to-date and diligent in comparing and contrasting his findings and information derived from local informants (local or traditional ecological knowledge) with the work of critically important zoologists of the time including Gunther (1864), Theobald (1868), and Boulenger (1890).

The fact that the man whose report, a summary of which follows, could be so proficient in completely different fields of endeavor is, we think, testament to his extraordinary abilities. As pointed out in the conclusion of this *Precis*, praise of Captain F.D. Maxwell is hardly unqualified, but we think he should be remembered as someone who has made an immense contribution by capturing an amazingly comprehensive picture of the situation of sea turtles in Burma at the end of the 19<sup>th</sup> Century, as a benchmark against which to measure our progress, or lack thereof, over the following 120 y.

Before continuing, we feel it is necessary to clarify an important point: throughout the report by Maxwell, he refers to the Loggerhead Turtle as being one of

the turtle species nesting in Burma; whereas, based on present-day knowledge, this is considered highly improbable. It is believed that Maxwell was following the taxonomy of his day in referring, throughout his report to the Indian Loggerhead (*Thalassochelys caretta*; now *Caretta caretta*), whereas the species about which he made many of his observations was actually the Olive Ridley (*Lepidochelys olivacea*). For this reason, in the following text, we have substituted all references to Loggerhead with [Olive Ridley], to avoid any confusion, particularly for readers who might read passages in isolation. Recent records of the Fisheries Department of Myanmar and literature reviews indicate that the Loggerhead is actually the rarest sea turtle seen in Myanmar (Maung Maung Lwin, pers. com.; Katherine Holmes et al., unpubl. report). In addition, Maxwell often referred to what he called tortoises in his discussions. He was very likely referring to the Northern River Terrapin (*Batagur baska*), and the Myanmar Roofed Turtle (*Batagur trivittata*), which are now both very rare in Myanmar (Platt et al. 2018). A third estuarine species that could have been in the area in the late 19<sup>th</sup> Century was the Southern Mangrove Terrapin (*Batagur affinis*; Moll et al. 2015).

**Study site.**—Maxwell began his review with a detailed description of the geography of the turtle-banks of the Irrawaddy (Ayeyarwady) Division, situated between the mouth of the To (Toe), or China Bakir, River and the Sandoway (Thandwe) District. His description mentioned the alluvial deposits that continually reshape the coastal region, including its many islands, as well as its vast network of creeks, channels, and jungle habitat. He concluded with an introduction to the island that figures most prominently in his report: “Just off the mouth of the Bassein (Pathein) river and about 5 1/2 miles from the mainland is Diamond Island known to the Burmans as Thamihla (Thameehla) or Meinmahla *kyun*, the island where, according to tradition ... certain beautiful princesses vowed to celibacy but betrothed to royal bridegrooms sought safety and peace. The island is diamond in shape (hence its name), stands well out of the sea, and is surrounded completely, I believe, by a rocky reef some 300 yards from the shore. It is 1,400 yards long, north to south, 700 yards wide, and about 3 miles round. Of the 3 miles about 2 are strewn with rocks and the rest, say, 1,500 yards, is a series of sandbanks. This island is the most valuable turtle-bank possessed by Government and yields larger revenue than all the rest put together” (p. 2).

**Nomenclature.**—Maxwell noted that “considerable confusion exists about the identity of the six

species [of turtles and tortoises laying on the banks of the Irrawaddy (Ayeyarwady) Division]”, leading him to send a number of specimens to the Calcutta (Kolkata) Museum, India, for identification. The Green Turtle, known locally as *leikpyintha* or several variants of *pyinwan*, was said to be edible and much prized; whereas the [Olive Ridley], known locally as *Leikkwe* “has a rank smell and is inedible.” The “hawksbill ... is the only turtle from which tortoise shell of any value is taken and is known by the Burmans as *bi-leik* in consequence.” Interestingly, the description of the leatherback turtle suggests that, although very rare, the species was once observed more frequently in Burmese waters. “About the leathery turtle also there can be no possibility of doubt owing to its extreme rarity, immense size, and peculiar shell, which is ‘covered with a leathery skin of blackish neutral colour above, covered with white spots like splashes of white-wash. Its name in Burmese *saungya*, so called because the shell is like the fruit of that tree *Averrhoa carambola*, points to the identification being correct. On the Arakan (now Rakhine) coast the species is sometimes called *leik-kaba* which may be freely translated longlived or immortal, as it is popularly supposed to live to an immense age” (pp. 2–3).

**Species overview.**—While most of the report by Maxwell focused on the Green Turtle, particularly the commercial value of its egg production, he also commented on the other three species thought to frequent the waters of Burma, to varying degrees. “The [Olive Ridley] lays chiefly on the islands off the mouths of the Irrawaddy (Ayeyarwady) and Dalla (Yangon) rivers and only during the months of September, October, November, and first part of December. Those are her chief resorts, but nevertheless she lays on the mainland from the To (Toe) river right round the coast to the Sandoway (Thandwe) district, the number of turtles laying and the number of eggs laid getting less and less the further the banks are from what is apparently the favorite resort of the reptile, the Kaingthaung (including the modern Gayetgyi and Kadongalay Banks) group.” While noting similarities with the nesting behavior of Green Turtles, he remarked that the Olive Ridley “is even bolder than the green turtle”, to such an extent that “The Burmans call the reptile *kve* (Anglice, dog), because they say she is as foolish as a dog in depositing her eggs with such publicity. During the laying months every turtle comes up three times to the same bank. The first time she lays between 150 and 200 eggs, the next between 100 and 150, and the last time between 70 and 100” (p. 12). Today, we know that in Olive Ridelys, two to three clutches



would be typical (Miller 1997). *Arribada* (mass) nesting occurs when large numbers (hundreds to thousands) of females emerge to nest within a few hours on the same section of beach. For sea turtles it is only seen in Ridelys, genus *Lepidochelys*. Because *arribadas* are very common across the Bay of Bengal at such sites as Gahirmatha in Orissa, India (Dash and Kar 1990), it is very interesting that no such behavior is mentioned by Maxwell, which suggests that the *arribadas* did not occur in Olive Ridelys nesting on Myanmar beaches.

Maxwell concluded his remarks on Olive Ridley turtles with a few suggestions and unanswered questions: “[T]he question as to where he lives is one that I am unable to answer. However, I make the same suggestion, namely, that the species has its *habitat* in the Andamans and only visits the coast of Burma to lay its egg. One curious statement is made by [coastal] residents ... [who] say that the [Olive Ridley] comes in largest numbers when the wind is in the east. If the conclusion to be drawn from this fact is that they come from the east, then their *habitat* would appear to be the Mergui Archipelago. ... If, on the other hand, as may very well be the case, the east wind is only an indication to the turtle that the south-west monsoon is over and their laying season commencing, then they may come from anywhere, so far as the east wind is any indication to the contrary. ... I have met no person who could tell me where the species breeds” (p. 12–13). We now know that the Olive Ridley maintains a huge pelagic foraging population in the Bay of Bengal and nests extensively along the east coast to India. Mating is often observed off the nesting beaches (Dash and Kar 1990).

Maxwell had only a few words to say about the Hawksbill Turtle, which, even in his day, was an infrequent visitor to the country: “[T]he hawksbill turtle or parrot-turtle as the Burmans call it [is] the turtle of commerce, whose epidermal horny shields yield the tortoise-shell. This species only lays here and there, evidently a stranger to these parts, with one single exception. On a small island off the Bawmi circle in the Bassein (Pathein) district about 10,000 eggs of this species it is said are deposited annually during the months of June to September. Burmans whom I have asked cannot tell me how many times the females lay in the year. Apparently over 100 eggs are deposited at a time. According to Boulenger – *Flora (sic, actually Fauna) of British India, Reptilia*, page 49 – the species is plentiful on the coasts of Ceylon and the Maldives. It is with regard to the hawksbill that Dr. Gunther made the statement ... that turtles always resort to the locality where they were born, or where they have been used to lay their eggs, or rather the statement is quoted under the description

of the turtle in *Economic Products*. Anyhow, it is clear that the species is very rare in Burma. ... Of the natural habits of the species I could learn nothing of interest. I have remarked that it lays in the rains and Boulenger states that it is carnivorous”. Interest in the Hawksbill by Maxwell appeared to stem from the potential commercial value of its shell: “I think we might as far as possible preserve the species, if it really proves to be the hawksbill, at all events for some years. It is just possible that the numbers visiting the coast might increase and that Government might realize a revenue from tortoise-shell.” He quotes from another publication (*Economic Products*, Volume VI, Part I, page 433) to indicate that “some specimens sell for as much as £4, the price depending on the quality of the shell” (p. 13). Today, divers report that juvenile Hawksbill Turtles, which feed on sponges, are regularly seen on the coral reefs of western and southern Myanmar and a small amount of nesting does occur annually on Oyster Island in far northwest Myanmar (Howard et al. 2019).

Maxwell had even less to report about the presence of Leatherback Turtles, but he suggested that they might not be quite as rare as believed: “The remaining species is the leathery turtle, so called from its peculiar carapace.” He quotes from another source, which noted that: “A female of this rare species was captured near the mouth of the Ye river in Tenasserim (Tanintharyi) on 1st February 1862, where she had resorted to lay her eggs. ... The shell measured five and a half feet and it took six men to lift the animal. ... The fore paddle ... measured 3 feet 3 inches and the body was 2 feet high. When surprised by Burmese fishermen, she dragged six men along with her nearly into the sea, but was overpowered by others running up.” Maxwell concludes by saying “I do not think that this huge species is quite so rare as is generally supposed. I met several men up the Arakan (Rakhine) coast who have come in contact with the monster. As the species is very rare, it might I think be rigorously preserved. About its habits I know nothing and could learn nothing” (p. 13). We should note that nesting by an individual of this species was recently documented at Lampi Marine National Park in southern Tanintharyi, Myanmar (Platt et al. 2017).

Comparing the two most prevalent species, the Green and the Olive Ridley, Maxwell remarked on their biological similarities and differences: “Both are very similar in appearance: both lay approximately the same number of eggs at one time; the *modus operandi* in the case of both species is the same. Both are equally indifferent to the presence of man, after at all events they have once arrived in the immediate neighborhood of their laying ground, and the period of incubation of the eggs of both species

is probably the same. On the other hand, the average [Olive Ridley] is not more than half the size of the average green turtle, the latter weighing from 150 lbs. to 500 lbs.; the green turtle lays all the year round, the [Olive Ridley] only for two or three months; and the size of the eggs is somewhat different, that of the [Olive Ridley], weighing about three-quarters of an ounce, that of the Green Turtle well over an ounce” (pp. 13–14). We now know that Greens typically lay more than twice as many eggs as Olive Ridleys. These size references once again strongly support the observation that the second species discussed was not *Caretta* but Olive Ridleys, which is about half the size of *Chelonia*, whereas *Caretta* is nearly as large as *Chelonia*.

#### LIFE HISTORY ATTRIBUTES

**Abundance.**—In the following discussion, frequent reference by Maxwell to Local and Traditional Ecological Knowledge (LEK and TEK) is noteworthy: “The annual take of the eggs of the [Olive Ridley] on the banks of the Irrawaddy (Ayeyarwady) division is about a million and a half, whereas the annual take of the eggs of the green turtle on Diamond Island is generally 1,600,000 and frequently more, and in addition the turtle lays a few thousand eggs on the islands of the west coast. I am aware of the danger of assuming that because the number of eggs any two species lay is approximately the same therefore the actual numbers of the species are the same. I have, however, made enquiries from officers in the Mercantile Marine, from a light-house keeper, and from many villagers and all seem agreed that the green turtle is common in the Bay of Bengal. The crews of ships becalmed in the bay frequently meet and spear the green turtle asleep on the surface. I have myself been on spearing expeditions in the Nicobar Islands, where they are extensively killed. The green turtle used to be captured in the Andamans and sent up to Calcutta in fairly large numbers some years ago, and possibly is so still. The light-house keeper above referred to, Mr. F. Stanley, informs me that large numbers of the green turtle lay on Oyster Island and on the Cocos. The present lessee of Diamond Island once sent an expedition to Preparis Island, which brought back large quantities of the eggs of the green turtle and reported that many tens of thousands remained. The [Olive Ridley] is rarely mentioned by officers of the Mercantile Marine to whom I have spoken, and very rarely seen by villagers or by others. I do not remember hearing of the [Olive Ridley] in the Andamans or Nicobars, though no doubt the species laid in the neighborhood of both islands” (p. 4). “Assuming that the annual take of green turtles’

eggs is 2,000,000, [Olive Ridleys] 1,500,000 ... and that the green and [Olive Ridley] turtle lay 400 eggs in a year ... then the number of turtle[s] ... laying annually would be: Green -- 5,000; [Olive Ridley] -- 3,750” (p. 4). We now believe the estimate of 400 eggs would be somewhat low for Greens, but high for Olive Ridleys (Hirth 1980; Miller 1997). A graduate student, Mr. Phone Zaw Oo (pers. com.), has recently confirmed as part of his dissertation work that very low numbers of nests for Green, Olive, and Hawksbill sea turtles were deposited in 2017 and 2018 on Oyster Island (or May Yu Island), which is a Myanmar Navy Base near Sittwe (Fig. 1).

**Feeding.**—Maxwell drew upon the literature of the day, as well as traditional ecological knowledge, to form a view about the foraging habits of Green Turtles. “According to the Flora (sic) of India series, Reptila, page 48 (Boulenger 1890), the Green Turtle is herbivorous, and Theobald, page 344, confirms this. Every villager with whom I spoke on the subject also confirmed the statement” (p. 11). Today there are still vast pastures of sea grasses along Myanmar’s coastline (Katherine Holmes et al., unpubl. report) which would have historically offered, and would still provide, outstanding foraging grounds for the Green Sea Turtle.

**Habitat selection.**—The powers of observation by Maxwell led him to suggest an explanation for the apparent habitat selection of the two species, noting that this warranted further investigation: “[T]he one great difference between the two appears to me to be that, whereas the green turtle apparently prefers the sands of a rocky coast; the [Olive Ridley] prefers the sands of a coast fringed with shoals and flats. Why this curious difference? According to Dr. Anderson both prefer rocky bottoms. I suggest that, whereas the green turtle is algivorous and consequently would find his food in larger quantities and of a more suitable quality amongst rocks the [Olive Ridley] is carnivorous, probably feeding on the small fish and crustacea that swarm, more especially on all mud and sand banks. Whether the suggestion is worthy of careful consideration only naturalists can determine” (p. 14). Immature and adult Greens around the world eat both algae and sea grasses (Hirth, 1971). Olive Ridleys, while their diets are not well studied, prefer invertebrates often living in deep water and foraging on pelagic crabs and tunicates (Dash and Kar 1990; Polovina et al. 2004).

**Mating.**—Maxwell noted the rarity of observations of mating behavior and humorously demonstrated caution about drawing conclusions that are not based

on firm evidence: “[An agent working for 20 years on Diamond Island] informs me that he sometimes sees the male and female copulating. On one occasion I was present, but whether the turtles I saw were male and female or were copulating I could not say. It took place about 300 yards from shore - about 8 A.M. at high tide. What I saw might have been two females settling their differences” (p. 10). This mating location near a nesting beach would be very normal (Hendrickson 1958) and females do occasionally mount other females (Comuzzi and Owens 1990).

*Nesting.*—“Although the [Green] turtle lays all the year round, July to November are the favorite months. The number gradually decreases after December till March and April, and then gradually increases until October, when the maximum number is reached. Roughly July to November, five months, yield [250,000] a month, say, a million and a quarter against 400,000 for the rest of the year and excluding the close season 1st April to 15th May. In the rains, too, the turtles lay more eggs than in the dry weather, the average at the former time hovering about the figure 120, and at the latter varying from 100 to 110, say, 105. Why the rains should be the more favorite time for laying is very difficult to understand” (p. 8)... “Nests are more difficult to find in the rains because a heavy shower washes away all traces of the nest. Monkeys, pigs, man, and other turtles are the less likely to find nests of eggs laid in the monsoon, and it is just possible that turtles hatched in the rains in their turn lay in the rains” (p. 8). “The most noticeable point is that the turtles lay in larger numbers on spring than on neap tides, but this may be as regards Diamond Island only an accidental circumstance. The island is surrounded by a reef of coral, which at low water in February is exposed and never perhaps covered with more than 5 or 6 feet of water. So complete is the ring that large sharks are very rarely seen inside, and Europeans bathe with complete immunity from the shore. Between this reef of coral and the mainland is fairly deep water. I offer as a suggestion for the turtle laying in larger numbers at spring tides, that they fear to cross the reef during the neaps, with the possibility of being confined to a limited area” (pp. 7–8). “The turtles come up exclusively after sunset, sometimes just before dark, generally after dark: it much depends on the state of the tide, the reptiles preferring a flood tide and consequently deep water.” These typical nesting behaviors for Greens were subsequently well documented in Australia by Bustard and Greenham (1969) and in Malaysia by Hendrickson (1958).

Maxwell continued his description of nesting behavior: “Having arrived at the place where she intends to lay - a spot sometimes selected with

difficulty and apparently by caprice - she proceeds to dig a hole 12 inches or 15 inches deep with all four limbs and a curious rotatory motion of the body. In this hole she remains, while with her hind limbs she digs a smaller hole about 9 inches to 1 foot deep and about 3 inches in diameter immediately beneath her copulatory organ. This is probably the most curious part of the whole operation. Two apparently clumsy limbs are curved at their extremities into a ladle and used with wonderful effect in the loose sand. The accuracy and care with which this hole is made defy description. Certainly nature has taught the Green Turtle to ‘plough the sands’ to some advantage. In digging the holes - both the larger one in which to hide her body and the smaller one in which to lay - the turtle scatters the sands with considerable force (it is not pleasant to sit behind her at this time), and with the sand she frequently scatters the eggs of earlier turtles” (p. 9). Maxwell appears not to have noticed that the egg chamber that he described as being about 3 inches in diameter actually broadens out into a rounded flask shape 10–12 inches in diameter at its base (Hendrickson 1958).

Maxwell offered an untested hypothesis as to the selection of a place for nesting: “I have stated above that a turtle selects the locality in which she will lay apparently by caprice, but I suggest that she selects a site with a view of destroying a rival's eggs. That most animals will kill the offspring of a rival is well known” (p. 9). Females do occasionally dig up prior nests but this appears to be density dependent and not purposeful (Bustard and Tognetti 1969). “When the smaller hole is made the turtle proceeds to hide her copulatory organ with her hind limbs. With what purpose this is done I do not know; but suggest that it is to protect the eggs in the act of and after being deposited from the fury of the elements. However this may be, her attempt in this direction may be and probably is from her point of view sufficiently successful, but she leaves a sufficient space between her limbs for an onlooker to witness the actual laying of the eggs. The oviduct is hidden, but the spasms as the eggs are laid and the eggs falling into the hole are both distinctly and clearly visible. At the first ten or fifteen spasms three eggs are laid each time, afterwards two, and last of all one only. While making the hole in which she is to lie and the hole in which she is to deposit her eggs and in laying she exhibits not the slightest sign of fear or modesty. I have three or four times watched the process, always armed with a lantern or a candle - indeed it would be impossible to watch it without a light - and never witnessed any inclination to stop work” (p. 9). While this is generally true, some females will bolt and abort, especially early in the nesting process (Hendrickson 1958).

“When the last of the eggs is laid the turtle proceeds first of all to fill up the hole and then to press the sand down. This is done with her hind feet, and with considerable force, as can be tested by putting one’s finger between her limb and, say, a flat oyster shell. Having pressed the sand into a proper consistency, she with all four limbs fills up the larger hole, and as far as possible, obliterates all marks tending to show the exact locality of her eggs. This latter operation is done principally with her hind limbs as she proceeds to move off her laying ground preparatory to retirement to the sea, and done, from human point of view, clumsily enough, though it is possibly a sufficient protection against her natural enemies, pigs and monkeys. Even an untrained man, however, will find some difficulty in finding the exact locality of a nest” (pp. 9–10).

As for the behavior of male turtles, not surprisingly, Maxwell had much less to report, and he failed to challenge the rather dubious assertion of a trusted informant: “As regards the males of the species Maung Nyu Tun [the egg concession agent] says they come now and again, but only in the rains, make a hole in the sand like the females and then go out to sea. He cannot explain this singular conduct. Perhaps it is evidence of the early androgynous condition of the remote ancestors of the turtle of which many samples are constantly being published...” (p. 11). Male Greens, as well as females, do bask in some remote regions and this is often during the non-nesting season (Spotila et al. 1997).

**Incubation.**—Maxwell challenged various assertions made about the incubation period of eggs, described by some commentators of his day as “about 15 days,” “19 days,” or “roughly three weeks.” He also threw cold water on the notion that “at other periods of the year, when there is less sun, [eggs] have lain more than 30 days before hatching” (p. 10). “While not considering the suspended incubation of turtles’ eggs by any means impossible, I incline to the more popular and common belief that incubation once commenced proceeds regularly. That is the opinion of every Burman to whom I have spoken on the subject, many of whom have constantly watched nests and whose opinions therefore are of weight. Maung Nyo Tun ridicules the idea altogether and his is possibly quite the best opinion to be had. As regards the period of incubation, Maung Nyo Tun puts it at 40 days exactly; others at ‘about 40 or 45 days.’ With all due respect to Maung Nyo Tun and to the others, I suspect that the period is 42 days” (p. 10). To support his contention of an incubation period of precisely seven weeks, Maxwell quoted from the esteemed Charles Darwin, who had observed that various natural phenomena follow lunar periods and

that “many normal as well as abnormal processes [in nature] have one or more whole weeks as their period” (p. 11). While generally correct on the longer incubation times, for the most part 50–70 d is typical depending on rainfall and beach temperature (Hendrickson 1958).

Perhaps unwittingly, Maxwell offered some advice of practical value to modern custodians of turtle nests, who may have been inclined early in their careers to take a peek at the developing clutch of eggs. “[The concessionaire] informed me that in accordance with custom he annually opened four nests, and after satisfying himself that there were eggs closed them again. On being induced to talk freely, he said the custom was useless (*athônmasi*) and humbug (*alaga*), because eggs exposed to the air never under any circumstances hatch. He said that he had carried out the custom for some 15 years, but had never known a nest hatch. ... Moreover, other men who had opened nests told the same story. It is of much interest to enquire why a nest of eggs once opened should never under any circumstances hatch out.” Maxwell attempted an explanation in the following passage. Indeed, his prescient observation, as a layman, about the importance of handling newly laid turtle eggs with great care is almost uncanny. “[W]hen [the female] has finished laying she seals up the nest, pressing the sand to the exactly required consistency. I suspect that incubation commences immediately the eggs are laid, and consequently that any change of temperature, even next morning, a few hours only after the event, is fatal to the vitality of the embryo. However, whatever may be the reason, it is clear that turtles’ egg will not stand removal by villagers to artificially constructed trenches” (p. 20). Concerns by Maxwell foreshadowed the advice contained in modern-day techniques manuals that caution against excessive rotation or movement of eggs, which could prove fatal for the delicate embryo (Eckert et al. 1999). Similarly, his remarks about the viability of “artificially constructed trenches” remind us of the sometimes-controversial, modern-day practice of relocating eggs to hatcheries, often done without practical justification, as an alternative to *in situ* conservation (Eckert et al. 1999). Curiously, though, Maxwell appears adamant in his opposition to what now would be termed community-based, *in situ* conservation, when he stated: “The proposal that reserved nests should be marked and protected by circle *thugyis* [local/village headmen] only needs to be stated to be condemned as absolutely unpractical and impracticable” (p. 20). We assume his negativity here is due to the enormous densities of nesting seen at these beaches 120 y ago, which would render protecting individual nests very difficult.



**Clutch frequency.**—Over a century ago, Maxwell recognized the importance of determining the frequency of nesting for drawing any conclusion about population size and trends: “How often the Green Turtle lays it is impossible to say. Maung Nyo Tun, above referred to, thinks three times a year, but as he has not one single fact to support his hypothesis it may be disregarded. Mr. C. A. Gilbert, Executive Engineer of Bassein, in 1889 wrote a short memorandum on the Diamond Island turtle-bank for Government, in which it was stated that the ‘turtle lays from 80 to 200 eggs at one time, returning three or four times at intervals of ten to fourteen days.’ The evidence on the subject that I have been able to glean is as follows. It is extremely probable that the [Olive Ridley], first cousin to the green turtle, lays three times a year during the months that species lays, September to December. When a Green Turtle is killed and cut open several hundred (400 to 500) eggs in all stages of development are found. It is obvious from this last fact that the green turtle lays more than once during her life, but whether more than once every year is another matter: from the highly developed state of some of the eggs inside her it is probable that she lays oftener than once a year. I do not think any conclusion can be drawn from the fact of the [Olive Ridley] laying three times, as the Green Turtle lays throughout the year, the [Olive Ridley] for only a few months. The point could easily be settled by marking the turtles on Diamond Island as they come up and keeping an accurate record for twelve months” (p. 10). Olive Ridelys typically nest 2.2 times (Miller 1980) while Greens average about six clutches a year (Hirth 1980).

**Distribution, pelagic phase, natal homing.**—Back in the late 1890s, Maxwell was already asking a very germane question that remains unanswered to this day for Myanmar turtles: “Where do the turtle live after getting safely out to sea? No one whom I have met can answer the question, and it is answered in no book to which I have had access” (p. 11). Maxwell goes on to offer a few of his own ideas about the Green Turtles that, in his day, frequented Diamond Island in large numbers, and hinted at differentiation between nesting and foraging habitat: “Surgeon-Captain Anderson in the *Agricultural Ledger* No. 36, states that turtles prefer rocks. That being granted, where do they live? On the coast of Burma, where they are rarely seen, near Preparis or the Cocos or further south? They are, as I stated, constantly met in the Bay of Bengal, and in the Andamans and Nicobars extensively caught. I strongly suspect that the Andaman group is their *habitat* and that Diamond Island is only visited for the purpose of depositing

their eggs. Notwithstanding the hundreds that lay there, the reptile herself is rarely met with off the coast of Burma. It is curious, too, that it is only on the small islands off the west coast that the turtle lays, with the exception of Diamond Island. Diamond Island to Preparis is about 62 miles and Preparis to the Coco is about 45 miles – a total of 170, not a very long distance for a powerful creature to swim – possibly not a day's journey” (p. 11). Today, many populations, even in the Australasian region, have well-documented foraging ranges that have been studied with modern tracking techniques. Because the topic has not been researched in Myanmar, suggestions by Maxwell for foraging grounds are reasonable hypotheses.

Quoting from another publication of his era, Maxwell demonstrated his awareness of the propensity of adult females to return to their natal beaches: “In Dictionary of the Economic Products, [Dr Gunther (1864) states that]: ‘Turtles always resort to the locality where they were born or where they have been used to propagate their kind.’ The fact that Diamond Island is as far as we know very largely used for the purpose of propagating the species would seem to show that Dr. Gunther's statement is literally correct” (p. 11). With an eye to the wider distribution of Green Turtles, Maxwell hypothesized that the turtles nesting on Diamond Island formed part of a larger population that also nested further afield. On the contrary, modern genetic studies elsewhere suggest that natal homing is so tight with the Green Turtle in particular (Fitzsimmons and Limpus 2014), that we can hypothesize that the population that nests at Diamond Island (Thameehla) would likely constitute a distinct genetic entity. Hypotheses by Maxwell would influence his recommendations, elaborated elsewhere, about the potential for Diamond Island to sustain a take of Green Turtles: “I suggest ... that the green turtle uses the Andamans, Cocos, and Preparis for the same purpose [of nesting] and to the same or even to a much larger extent and that therefore perhaps Diamond Island after all only gets the overflow of the islands further south. [I am informed] that twenty and more nests may be seen on the Cocos any morning and half that number on Oyster Island during the springs ... [and that another] expedition found large numbers of nests on Preparis.” ... “Obviously a rocky coast and sandy bays are not to be found everywhere in the Bay of Bengal, and consequently it would seem that the turtle is forced by having only the choice of limited area to come to the coast of Burma” (p. 12). Current research shows mixed genetic populations together on foraging grounds that will separate into specific nesting stocks at the breeding grounds; thus, natal beach homing (Miller 1997).

**Breeding age and fecundity.**—Maxwell admitted to a certain level of common ignorance regarding the age at which sea turtles begin laying eggs as well as the upper limit of their fecundity. As to the first parameter, Maxwell suggested without any certainty that “Some say five, others 10 years. Judging from the size of the smallest green turtle I have seen laying, I should say that the age when they commence to lay is certainly not less than five” (p.16). Great variation is seen in ages to maturity but a useful average for Olive Ridelys is 15 y and for Greens is 35 or more years.

**Population trends.**—Introducing the core argument of his report, which concerned the level of turtle exploitation thought by Maxwell to be sustainable, Maxwell questioned the overall trend for the turtle population of the Bay of Bengal. In so doing, he shed light on the fact that, already more than 150 y ago (and 30 y prior to the report by Maxwell), the conservation of the turtle resource of the Irrawaddy (Ayeyarwady) Delta was in the forefront of some enlightened Fisheries officers: “The sea fisheries of Burma were reported on by the late Surgeon-Major Francis Day, F.Z.S., Inspector-General of Fisheries in 1869. ... [I]t is evident that Day (1869) thought that the banks were being exhausted because he made certain proposals with a view to protect the turtle [which resulted] in a close time being fixed for Diamond Island from 1st April to 15th May annually. [T]he only species benefited by this reservation is the Green Turtle, as the [Olive Ridley] and tortoises do not lay at that time of the year and the tortoises never appear on Diamond Island. ... The close season began in 1874 and has been in force ever since” (p. 16). (Day is cited in Maxwell, but his report was apparently not seen in its original form by Maxwell or by us).

Maxwell then poses the question: “What, then, has been the result of this conservation as regards the green turtle?” He goes on to develop a line of argumentation in support of his personal contention that the population frequenting Diamond Island could sustain a regular take of adult females. Essentially, Maxwell was of the view that Diamond Island was being constantly replenished by an “overflow” of turtles breeding elsewhere in the Bay of Bengal, notably the relatively pristine Andaman Islands. He pointed to egg collection statistics from Diamond Island dating back to 1883 showing, with few exceptions, a fairly constant annual take in the order of 1,600,000 eggs; as well as anecdotal reports from several generations of concessionaires that the take on the island had never been above 2 million eggs. Maxwell argued that “if Diamond Island depended upon its own

resources, the number of turtles would have rapidly decreased and in geometrical progression. But the turtles do not show any reasonable sign of decrease and therefore the argument that the island merely gets the overflow from the Andamans seems to me to be irresistible.” Based on other reports from the Cocos and Oyster Island, Maxwell calculated that some 900,000 eggs were being deposited in those locations alone. He boasted: “I do not think it is a very great exaggeration to say that the number of eggs deposited yearly in the sandy bays of the Bay of Bengal must be at least ten times that number, nine million” (p. 17). In hindsight, Maxwell was clearly wrong when he disagreed with his predecessor: “Dr. Day, whose reports cannot unfortunately be found” (p. 3).

As far as Olive Ridley population trends are concerned, Maxwell contended that “the surest guide to the increase or decrease is the revenue backed by prices.” Maxwell listed each of the banks where Olive Ridelys uniquely laid (interesting also from the standpoint of historical biology), and he enumerated in some detail the historical range in egg prices at each of these locations. Finally, he asserted: “it may be fairly assumed that since the beginning of the eighties [i.e. 1880s] there has been no increase of price. We have then a stationary revenue and stationary price and may fairly conclude that this unconserved species is neither decreasing nor increasing in numbers and that is the very generally expressed opinion of men who have worked the banks for years” (p. 19).

**Threats.**—Maxwell discussed potential man-made disturbance to sea turtles, mainly in the context of compensation offered to egg concessionaires for lost income associated with reduced egg production, supposedly caused by various infrastructure projects around Diamond Island. He largely dismissed these claims and instead attributed the reduction of nesting in certain years to increased ocean traffic, and suggested that the phenomenon is only temporary and that the sea turtles will soon adapt to ship movements. Today we know that Green Turtle populations show wide fluctuations in annual nesting numbers related to their herbivory and *El Niño* events (Limpus and Nicholls, 2000).

**Disturbance.**—“Maung Nyo Tun, the agent of the present lessee, who has been working on the island for nearly 20 years, informs me that a turtle will, if she encounters a man when coming out of the water, turn and retreat, but that after she has once reached her laying place nothing frightens her. That is not altogether my experience, which is that, unless interfered with when coming up, the turtle does not object to the presence of man. If when just out of the

water she is accosted and, as is common, either poked with a stick or critically examined, or an attempt made to turn her over, she will retreat, but she has, I am convinced, no objection to being merely stared at. I saw a turtle come up close to a party of eight Europeans at dinner on the sands, and was informed that another came and interviewed a Christmas' tree duly lighted with children dancing round it. I have frequently watched them come up and never seen any sign of fear" (p. 9).

As further evidence of the kind of disturbance to which the Green Turtles of Diamond Island were occasionally subjected, perhaps relating to the same dinner party on the beach, Maxwell mentioned "a very ordinary sized green-turtle [that] walked away with an Executive Engineer and his wife weighing together some 30 stone [about 125 kg] with a somewhat corpulent Civil Surgeon trying to stop the runaway by adding his weight to the load. It is certain that they can support and move under gigantic weights" (p. 13).

The Colonial government would sometimes pay concessionaires for loss of business allegedly resulting from environmental disturbance. "It is commonly asserted that the turtles are so timid that the appearance of mankind anywhere in their immediate neighborhood frightens them away. On this very ground the present lessee has twice received large remissions of revenue, and on a third occasion made an enormous claim, the very magnitude of which excited suspicion and induced an enquiry. The first alleged major disturbance occurred in early 1885 when 'the Telegraph Department were engaged in picking up a lost cable north of the island and between the island and the mainland'" (p. 7). "The next serious disturbance ... occurred in the open season of 1889-90, when a party of marine surveyors with launches, boats, etc., appeared and stayed on the island surveying the rocks and shoals allround the island and as far out as the Alguada Reef and light house" (p. 7). Maxwell offered his own anthropomorphic explanation to try to account for the fluctuation in nesting from one year to the next: "The Diamond Island telegraph office was opened in December 1877, subsequently closed, and re-opened again. About 1890 the number of steamers and ships using the island as a point of call for orders began to increase and is now about 400 annually, every one of which passes over the very ground, or a part of it, traversed by the turtles *en route* from the Andamans and Preparis. Now it is not a too great stretch of imagination to assume that a young turtle brought up, say, in the Andamans, unused to the luxuries of civilization should somewhat resent the movements of a steamer in its neighborhood and, resenting them,

that she should return to her habitat is but natural. Wild animals, however, of every description are susceptible to education, and it is probable that the turtles are now getting used to the ocean traffic and will in a year or two visit the island in their former numbers. It is in my belief more than probable that the small number of turtles coming in 1890-91 was due to the use of the steam-launches by the Marine Survey in 1889-90 as well as to increased ocean traffic. I think therefore we may conclude that the Green Turtle does not in her natural state approve of steam traffic, but is susceptible to the softening influences of education. And, further, that she has no objection to the Telegraph Department picking up cables between the island and the mainland" (p. 8). We now know that Green Turtle annual nesting numbers can fluctuate wildly from year to year (Chaloupka 2001) so the annual variation they saw was quite normal.

**Predators.**—Long before clever but poorly trained entrepreneurs began keeping hatchlings in holding tanks for display to paying tourists in the name of turtle conservation (thereby depriving the young hatchlings of vital energy reserves needed to escape from predators on land and at sea; Bluvias and Eckert 2010), Maxwell had a keen sense of the nature and extent of hatchling mortality "Immediately the young are hatched they run to the sea, travelling five and six times the pace of their maternal parent at her fastest. Although the water is close (10 yards or so) the effect of this running of the gauntlet is generally most deadly. All the crows and kites in the place assemble in an instant, seemingly from nowhere, and each bird gets a turtle, which is eaten at leisure. Out of, say, 100 small turtles, not more than 50 possibly reach the sea, and then begin the second slaughter of the innocents – small sharks and predatory fishes of every description suddenly put in an appearance, and it is possible to watch the progress of the brood by the snapping of their enemies. In a few seconds all is quiet – either the brood is completely dispatched or the fittest and most lucky have escaped and hidden themselves under the nearest rocks. The young turtle has a particularly bad time of it for the first half-minute because, for some reason that I do not understand, he cannot swim under water but constantly every second or so, puts up his head, evidently to breathe, and consequently his course is limited" (p. 11). Maxwell did not mention that these releases were probably facilitated by men in the daytime; whereas most sea turtle clutches emerge at night, cueing on cooling sand temperatures after midnight (Hendrickson 1958; Mrosovsky 1968), which greatly reduces predator numbers, especially birds. Maxwell noted that adult

turtles are not immune from predators either, natural or otherwise: “[T]here are principally on the west coast, crocodiles, which lie in wait for and destroy the unsuspecting [Olive Ridley]. Then, again, chiefly on the west coast, are thieves, who kill and open the [Olive Ridley] to take the unhatched eggs, and lastly, there is man, who, whether Occidental or Oriental, likes turtle-soup, though I am bound to admit that very little illicit killing of the Green Turtle is done” (p. 16).

#### COMMERCE

**Egg collection.**—“The eggs of the turtle and of the tortoise are laid about 18 inches to 2 feet below the surface, well generally, above highwater level. The turtles’ eggs are taken daily the first thing in the morning. The animals leave their foot-prints in the sand, showing approximately where they have laid. The men, armed with long iron-pointed sticks, poke about until they find the exact locality. The nest is then opened by hand and the eggs taken. As the foot-prints are so recent it is comparatively few nests that escape detection. Maung Nyo Tun, the man who has actually worked Diamond Island for nearly twenty years, thinks that he misses at least five nests a day in the monsoon and after rain...” (p. 5). We surmise that this low level of actual nesting success (five nests per day) may have been sufficient to maintain adequate recruitment of adults at Thameehla (Diamond) Island into the mid-20<sup>th</sup> Century. “The green turtle may be said to lay only on Diamond Island as the few thousand eggs deposited by a few stray members of the species on other parts of the coast may be left out of account altogether (p. 6) ... The lessee’s agent and head servant on the island has daily for many years past kept an accurate account of the number of turtles laying and in even hundreds the number of eggs laid.” ... “[H]ad the accounts in 1883-84 and 1884-85 been complete, the take would have been well over two millions. In 1885-86 and 1886-87 the actual take was over two millions. In 1887-88 it was 1,400,000 rising again in 1888-89 and 1889-90 to two millions and falling in 1890-91 and following years [through to 1898] to an average of about 1,600,000” (p. 6-7). “The Diamond Island lessee has all his eggs sent to Bassein [Pathein]. There he sells what he can retail and the rest he sends to Rangoon [Yangon] and Prome [Pyay] to his agents for sale and distribution in other towns and villages. The other commercial banks ... dispose of what they can on their banks and send the rest to the larger towns in the interior ...”. A considerable number of small boats are engaged in the trade. These go down to the banks, buy what they can afford, generally 10,000 or so, and returning

quickly retail them in the delta villages; but as eggs addle quickly the profits are frequently small or there may even be losses. ... The eggs on the west coast are sometimes bought by local men and carried across the hills to the Bassein (Pathein) River, one man carrying 800 to 1,000 eggs. Salt is largely used for preserving the eggs, and is doubtless better than nothing, though the best antiseptic is ... limewater” (p. 6).

**Consumption.**—Maxwell drew attention to what he perceived as an apparent inconsistency in the practice of Buddhism and the enjoyment of a nutritious source of protein: “...all the rest of the ordinary laborers [on the turtle banks are] Burmans and Arakanese and of course Buddhists. It must be remembered that the disturber and taker of a nest of turtle’s eggs is deserving of as much demerit (*akutho*) as the taker of life; both are in colloquial Burmese (*yetsetthu*). Upon both the pious Buddhist, while content to enjoy the luxuries provided, looks down with horror” (p. 5). “The eggs are consumed all over the delta and in the larger towns of Upper Burma, principally by well-to-do Burmans, though in the former part of the province a family unable to afford the luxury of turtle-eggs is rare. Europeans rarely eat the eggs, for no apparent reason. Ramasawmy makes most excellent buttered eggs out of them and the yokes raw of two or three enable one to travel all day without further sustenance. It is said in Bassein (Pathein) that many thousands are given to the *pongys* (monks) during the Buddhist lent. The Diamond Island lessee confirms this statement and informs me that he can always get rid of his eggs in the rains, fortunately the best time for the turtles and the season of lent” (p. 60).

**Revenue-generation.**—“The prices of eggs vary according to kind and proximity to markets. The eggs of the Green Turtle fetch in Bassein Rs. 1-8-0 per 100 readily. (This notation is for British Indian currency used in Burma at the time with one Rupee (Re or Rs) = to 16 Annas or 64 Paisas. So, the cost for 100 eggs in Bassein was one Rupee, eight Annas and zero Paisas); lower down at the mouth of the river Rs.1-4-0 is paid. The [Olive Ridley] eggs fetch Rs. 1 to Rs. 1-4-0 readily on the banks of the south coast; Rs. 2 per 100 on the southern part of the western coast; 13 annas higher up at Ngayôtkaung and 11 annas at Sinma ; above that local requirements keep up the price. In Rangoon (Yangon) Rs. 2-8-0 to Rs. 3 and sometimes fancy prices, such as Rs. 3-8-0 and even Rs. 4 are paid for eggs retail. The eggs of the tortoise (*Batagur* species) sell readily on the banks for Rs: 3-8-0 to Rs. 4 per 100, being three times the size of the eggs of the Green Turtle and of the



[Olive Ridley]. ... Speaking generally, then, it may be said that the market for the last 17 or 18 years has remained constant, and shows no sign of any change [in the wholesale price approximately Rs. 150 per 10,000 eggs]” (p. 6). In Maxwell’s eyes, Diamond Island provided a virtually infinite, limitless supply of eggs: “The Green-Turtle is a certain visitor and lays regularly, and with hardly any change, the same number of eggs year after year, month after month, and week after week” (p. 26). We are informed that today, in the Sitwee market, clutches are readily available and that three sea turtle eggs sell for about 5,000 Myanmar Kyats, which is approximately \$1US dollar per egg. While this is illegal, a clutch of eggs would provide a huge windfall profit for the poacher.

#### CONSERVATION

As mentioned elsewhere, the report by Maxwell drew attention to the fact that he was not the first to take interest in the sea turtles of the Irrawaddy (Ayeyarwady) Division. Indeed, there is evidence to suggest that Surgeon-Major Francis Day (1869), his predecessor by some three decades, may have been even more enlightened in some respects: According to Maxwell, “the exact nature of [Dr. Day’s] proposals ... is not clear, but from miscellaneous papers I gather they were something as follows:

- (1) As alternatives [to the current harvest regime] –
  - (a) every lessee should be compelled to leave one nest every month, or
  - (b) every lessee should be compelled to reserve some 4,000 to 5,000 eggs at the best season of the year for hatching;
    - (i) the nests to be marked and protected by the circle *thugyi* [local/village headmen], or
    - (ii) the eggs to be removed and buried in artificially constructed trenches and the young turtles liberated at the seashore.
- (2) The capturing of turtles to be made a punishable offence” (p. 20).

Maxwell goes on to discuss how the proposals by Dr. Day were considered by officialdom with some interesting conclusions, on paper, which contained both positive and negative elements; however, it appears likely that none of the proposals was effectively implemented. “The second proposal has been carried out by the Fishery Act by penalizing the capture of turtles in fisheries, *i.e.*, in water, the capture of turtles on dry land is not punishable. The Chief Commissioner did not approve of Dr. Day’s proposals and suggested that banks should only be leased in alternate years. On my visit to the coast and turtle-banks in January I found traces of the first two alternatives and of the Chief Commissioner’s

suggestion. When auctioning the Thaungkadun bank on 8th September 1873, the Deputy Commissioner recorded that the auction purchaser ‘promised to leave some eggs.’ History does not relate whether he did so or not, possibly the latter. The ‘custom’ thus inaugurated has not continued and is now completely forgotten” (p. 20).

Myanmar now has excellent laws in place protecting eggs, adults on the beach and all turtles in the water. Unfortunately, at this writing there is almost no law enforcement in the many important and often remote areas or in the sea where fisheries are largely unchecked. On a more positive note, in many areas of the world conservationists working on nesting beaches, as well as law enforcement people working with specific fisheries (enforcing regulations such as Turtle Excluder Devices [TEDs] on trawls), have facilitated stunning recoveries in some, even rather small turtle populations, which were in dire straits only a few decades ago (Mazaris et al. 2017). Having made this point, however, there are important populations throughout our planet that are still in grave danger of local extinction (Mazaris et al. 2017).

**Traditional knowledge.**—Writings by Maxwell showed an appreciation of the value of traditional ecological knowledge (Platt et al. 2018) in the understanding of turtle biology, and he praised the keen observation skills of local people, as illustrated in the following anecdotes: “[An Olive Ridley] now and again will get a limb bitten off by a shark or get damaged in some other way. The marks made by these unfortunates on the soft sand are consequently different from the marks of the whole and strong; and villagers notice that the same marked species appear three times every season” [thus supporting the notion that Olive Ridleys nest three times per year] (p. 12). To bolster his hypothesis, Maxwell mentioned another informant with an equally astute observation of an Olive Ridley turtle, evidently with a malformed oviduct, which laid nests of a peculiarly shaped oblong egg each year: “That piece of evidence testified to by an intelligent and observant man seems to me particularly good on the point. I think therefore that we may conclude that the [Olive Ridley] lays three times and 350 to 400 eggs in all” (p. 12). Ridleys today often nest three times but the average is closer to two (Miller 1997).

**Management.**—The personal philosophy of Maxwell as regards the turtle resource is perhaps best summarized in the following passage. Maxwell was very clear and definitive in his first recommendation: to do away with the conservation regime of the day. He proposed that the Calcutta (Kolkata) Museum

authorities be consulted and “[i]f they can definitely state that the Green Turtle largely breeds in the Andamans and that Diamond Island gets only the surplus laying population, then clearly the close season should be at once abolished, as it is no part of the duty of Government to supply sharks and crows with young turtles. If, on the other hand, the Museum authorities cannot give any definite information on the subject, I would suggest that Government send down by the Indian Marine vessel visiting the light-houses a small party to examine the Cocos and Preparis. If found a resort for laying turtles and untouched by man, the close season should be abolished.” But Maxwell didn’t stop there, making an even bolder recommendation for Diamond Island: “I go even further than thinking that the “close time” on Diamond Island has done no good. I believe that we might take a considerable number of turtles every year without any danger whatever and with advantage to revenue and people who enjoy turtle-soup and steaks” (p. 17–18). Maxwell conceded that he had no scientific basis for determining a sustainable level of take, but he nonetheless suggested a gradual trial and error approach, which even took account of the sensibilities of turtles that might be disturbed by the sight of “sacrificed friends.” Interestingly, he again invoked the writings of Charles Darwin in defense of his proposal: “The exact number that could be taken I cannot say, but should imagine that, if the number taken was increased gradually 2,000 turtles per annum might come off the island every year, as well as two million eggs. I would suggest a commencement with 150 per annum to be taken from December to March and only early in the morning so that other turtles should not see a fallen friend. After two years, if the number of eggs did not decrease, the number to be taken might be increased to 300 per annum for another two years and similar increases made every two years on a similar condition. To any one who urges that I am recommending almost complete annihilation I would suggest an examination of a map of the Bay of Bengal and a perusal of Chapter III of the *Origin of Species*” (p. 18). Killing this many adult females would have resulted in a much faster demise of the Green Turtle population. There are at least three main reasons for this conjecture: (1) At the time, adults were already being spared in the marine foraging grounds for the most part because they were not commonly consumed, (2) Similarly, Maxwell was underestimating the number of clutches per female (three instead of six most likely) thus they were overestimating the actual size of the female nesting population (e.g., fewer females were actually laying more clutches), and (3) Because of natal beach homing (imprinting), no other population would be likely to replenish the lost nesters over time (Owens et al. 1982).

To his credit, Maxwell recognized that his plan might have implications, at least in the immediate term, for the egg production of Diamond Island: “It is popularly supposed that the Green Turtle comes from the Andamans and lays three times. Does she lay once and then, returning, lay the second and third time there, or does she wait off Diamond Island, where rarely seen, and deposit all her eggs there? If the latter, then by killing her after, say, a first night ashore, we shall be losing the eggs that would be laid on a second and third excursion. ... I think, however, we might make the experiment of allowing a few turtles to be killed yearly; the further killing can easily be stopped if it is found that the number of eggs are decreasing. On this subject also I feel that Government should take the advice of some specialist” (p. 18). Actually, in the 1890s, there were no trained turtle specialists.

Incidentally, lest one gain the impression that Maxwell was interested only in exploiting the turtle resource, he drew a rather different conclusion as regards the tortoises (Terrapins) of the Irrawaddy Division: “I have given reasons for believing that the tortoises (*Batagur* sp.) have very seriously decreased in numbers and stated that they should be protected. The tortoises have to be saved from two classes; from the lessees of the banks, who leave no eggs to replenish the annual waste and from the public, who kill and catch the tortoise whenever they can catch one.” He went on to prescribe a range of detailed protection measures in their favor (p. 19–20).

**Site plans.**—Almost a third of the report by Maxwell comprised appendices in which he set forth his proposals and colleagues provided comments on suggestions to manage the turtle banks of the Irrawaddy Division (p. 33–57). Each of the plans described the location and character of the bank, the extant turtle resource, and relevant considerations associated with the exploitation of that resource (i.e., cost of labor, estimated egg production, past and proposed lease/revenue generation arrangements, etc.). Generally speaking, Maxwell sought to follow an established principle whereby the scale of a given fishery should be reduced as far as possible: “[O]f the turtle-banks of the Irrawaddy (Ayeyarwady) Division there are but five – Thauangkadun, Kaingthaung, Amatgale, Hainggyi, Diamond Island, (and perhaps a sixth Pyinsalu) – capable of being worked by any one man or partnership and of supplying a living to the workers, and may therefore be called the commercial banks. The others consist of a series of small detached banks many miles apart which are and must be sublet to and worked by men residing in the nearest villages” (p. 22). His stated objective, for the

benefit of the colonial government, was “to get the actual workers as tenants of Government and so to divert the profits now received by the landlord into the treasury” (p. 22). If nothing else, the abbreviated plans by Maxwell to manage turtles provide a revealing overview of the wealth of the sea turtle resource that once existed in Burma.

**Regulations.**—Maxwell made another important contribution by drafting proposed rules “to be applied to all turtle-banks and to all licenses issued under the Fishery Act”, as follows (p. 51):

“1. Fishermen who have taken out or who intend to take out licenses for the use of *damin* traps or for nets may use any turtle-bank in the Irrawaddy Division and the waters adjacent thereto other than [certain named areas, including Diamond Island], and the water adjacent thereto without payment, provided that —

a. no net shall be used within 400 fathoms of any bank between sunset and sunrise before the first decrease *Natdaw* [December], and

b. no *damin* trap or net shall be spread out to dry except in some recognized spot near the village or *daminseik* in which the fisherman is residing.

2. No lessee or sub-lessee of a turtle-bank or any part thereof, and no servant of such lessee or sub-lessee or any other person residing under the same roof as either, shall interfere with cattle grazing on any turtle-bank in the Irrawaddy Division, or make any demand in respect of such grazing, provided that no cattle shall be grazed [on certain named turtle banks] between the first decrease *Natdaw* and the time the nests of the *Batagur* tortoises are taken.

3. No lessee or sub-lessee of a turtle-bank or any part thereof, and no servant of such lessee or sub-lessee and no person residing under the same roof as either, shall take or permit or suffer any other person to take, open or interfere with, in any way whatever, any nest of eggs laid by the leathery or hawks-bill turtle, and every such person shall to the utmost of his power preserve the nests of all such turtles.

4. No lessee or sub-lessee of a turtle-bank or any part thereof, and no servant of such lessee or sub-lessee and no person residing under the same roof as either, shall kill, capture or in any way interfere with any of the following: Green turtle, Leathery turtle, [Olive ridley] turtle, Hawksbill turtle, *Batagur* tortoises” (p. 51).

Maxwell elaborated on his motivations behind the draft rules: “Rule 1 permits the use of all (except certain named) banks and the adjacent waters by fishermen, but bars the right of using nets at night, while the [Olive Ridleys] are laying, and the use of any other than recognized drying grounds for drying nets, traps, etc.” (p. 24). He admitted, however, that

this rule had as much to do with controlling blackmail as it did with Olive Ridley turtle conservation, noting that some concessionaires were taxing fishermen for use of their banks even when turtles were not nesting.

He also seemed less concerned about the activities of shrimpers at sea, as compared to the harm they might do while ashore: “As regards the banks not mentioned in Rule 1, shrimping by daylight can do no possible damage at any time of the year, and after the [Olive Ridleys] have done laying, shrimpers should be allowed to use the banks day or night”. We now know Maxwell was wrong on the potential damage caused by incidental capture in shrimp trawls which have been found to be the single most destructive fishery for sea turtles (National Research Council 1990) even regarding Olive Ridleys in the Bay of Bengal (Dash and Kar 1990). He did express concern that fishermen “might assemble in large numbers *on the islands*, and, if they did this, they would almost for certain disturb the turtles at night owing to the very limited area of the islands.” Thus, he noted that “[w]hile actually laying, the turtle should, of course, be left alone” (p. 25).

Interestingly, Maxwell felt compelled to make a concession to cattle-grazing rights on the turtle-banks, “a subject about which there is some dispute on the coast” (p. 25), while including some restrictions aimed at protecting nesting tortoises (terrapins). He also gave particular recognition to the protection needs of Leatherback and Hawksbill turtles, which he stated are “both rare in this part of the world and the former rare everywhere” (p. 25). Modern-day conservationists of Leatherback Turtles can take heart that their concerns about the plight of the species were already shared well over a century ago! Finally, Maxwell sought to address a peculiar inconsistency in the Fisheries Act, as he put it: “to penalize the killing of any of the marine turtles ... not now an offence if done on dry land, whereas penal if committed in the water, an absurd distinction” (p. 25).

**Enforcement.**—With a cautionary insight into what inevitably transpired over the coming decades, Maxwell opined that “Any arrangement that leaves conservation to the lessee and leaves him unchecked and not supervised is bad, and I know of no arrangement by which he could be checked or supervised” (p. 20). He goes on to describe a situation in one particular area that related very well to similar issues faced by modern conservationists in just about any part of the globe: “I was informed that about 25 years ago Government declared all the banks in the neighborhood fallow, but did not enforce the exclusion of the public that consequently villagers got for nothing what they had to pay for before. The

result then of conservation on the part of Government has not been very successful. If conservation is considered necessary ... [i]t will be necessary to reserve a bank every two or, three years and put a guard of men on it to prevent the villagers poaching” (p. 21). This would have been and still is an excellent idea.

Incidentally, Maxwell suggested alternatives for conserving Olive Ridley turtles beyond the reach of the main colonial egg collection regime, but he expressed skepticism as to their potential consideration by the Government: “[Another] group of islands is more favorably situated [for conservation purposes] than any other that I know of being well away from the mainland. If it is considered necessary to protect the [Olive Ridley], I will submit proposals. It is of little use lengthening this report, already unduly long, on the off chance of Government coming to the conclusion that the reptile needs protecting” (p XX).

**Socio-economic considerations.**—It may be construed from writings by Maxwell that he favored the working man over the concessionaires making the profits, whom he considered as absentee landlords. This is apparent in his proposals for reforming the system at Diamond Island: “It might be worth while for Government to consider whether the existing system in vogue for renting Diamond Island is the best that can be devised. At present the lessee hires labor, receives and sells the eggs in Bassein wholesale and retail, and furnishes security. He rarely if ever visits the islands. The real working man is Maung Nyo Tun, who has been on the island 20 years or so. The following plan would certainly answer with him and possibly other men could be found capable of carrying on, and honest enough to carry on, the work. Let Government lease the island to Maung Nyo Tun, the rent to be a percentage of the take...” (p. 28). Maxwell also seemed to have had a soft spot for the dozen or so laborers who toiled on the island under difficult conditions in order to provide the populace with a regular supply of eggs. He sought to ease their burden with a legal source of opium: “The only men who can stand the work and exposure are the west coast men, all or nearly all Arakanese (Rakhine people) and all without exception opium-eaters. Without the drug the men are worthless and helpless. For years past opium has been purchased in fairly large quantities in Bassein (Pathein) and sent down to the islands by the turtle boat. .... This is of course illegal, but without the drug it is next to impossible to work the island and supply the egg-consuming public with a favorite dish. I would therefore suggest that the men actually engaged on the island and in the boats plying between the island and Bassein should be allowed ... under the Opium Act to possess 6 tolas

each, or double the ordinary amount. This proposal legalizes an existing practice” (p. 28).

#### REPORT OUTCOMES AND UPDATES

**Official response to the report by Maxwell.**—How did the superiors of Maxwell react to his report and his detailed proposals for the conservation of turtles and terrapins and their eggs? The appendices to the report include several discussions and opinions on the original report (Maxwell 1904). Evidently supported by the Commissioner of Irrawaddy Division, the report by Maxwell found its way, via the Secretary of the Financial Commissioner, to the Revenue Secretary and eventually the Lieutenant Governor of Burma. The letter by the Secretary of 6 January 1899 outlined the recommendations of the Financial Commissioner as regards each of the proposals (p. 52–54).

The boldest of Maxwell’s proposals, that, subject to further investigation, “the close season for green turtle ... should be abolished and green turtles should be allowed to be caught for food on Diamond Island up to a limited number...” was quickly dispatched. There is some irony in the fact that it was a Financial Commissioner who dismissed the proposals for their lack of strong biological underpinning and on grounds that a take of turtles on Diamond Island might not be sustainable: “The Financial Commissioner is unable to see how either Government or the lessee of the island would benefit much if these proposals were accepted. The argument put forward ... is that under natural conditions the number of eggs deposited would be not more than sufficient to reproduce the species, and as the lessee has been taking the greater share of these eggs for a number of years the Green Turtle must have some other habitat. If not, its numbers would have decreased, whereas, so far as can be ascertained on enquiry, the number has remained almost stationary. [The Financial Commissioner] Mr. Smeaton can hardly consider such an argument convincing. Looking at the matter from a more practical stand-point, it appears ... that March, April, and May are the months in which fewest eggs are deposited on the island, so that to abolish the close season would be of little or no advantage either to the lessee or to Government. The season was started on the recommendation of Dr. Day and should, the Financial Commissioner thinks, be continued. [Moreover] it is not clear what gain there would be in allowing a certain number of turtles to be killed yearly. They would, of course, have some market value, but it would be difficult, perhaps impossible, to prevent more than the prescribed number being taken, and is a dangerous experiment with no very clear object” (p. 52). One may wonder, with the focus



now on national development and an obsession with GDP (Gross Domestic Product) growth, how many ministers of finance would find themselves arguing against a revenue-generation scheme put forward in the framework of sea turtle conservation?

While accepting most of other technical proposals by Maxwell, including his recommendation on the opium allowance, Commissioner Smeaton dispensed with two other key proposals, on legal and operational grounds. Regrettably, the proposal that would have drawn particular attention to the importance of protecting the nests of Leatherback and Hawksbill turtles was rejected for lack of clarity as to which Act might be used to enforce such a provision. Similarly, the progressive recommendation by Maxwell to explicitly extend turtle protection measures to dry land was set aside in favor of a suggestion to make a more generic amendment to the Fisheries Act to prohibit the capture or possession of turtles. Finally, Commissioner Smeaton made it clear that he did not wish to see the Deputy Commissioner or his officers intensively involved in managing and monitoring the egg collection scheme on Diamond Island (p. 53–54).

Ultimately, as reported in the Proceedings of the Government of Burma in the Revenue Department, dated 15 March 1899, the Lieutenant-Governor of Burma accepted the final recommendations of his Financial Commissioner. He also made a few observations of his own, particularly with regard to the feasibility of enforcing a number of the rules proposed by Maxwell. He then handed Maxwell some additional homework: “His Honour does not think that the fishery legislation should be dealt with piece-meal. Captain Maxwell should be asked to forward a draft of the amendments which he advises in the Fisheries Act, and rules on the subject of turtles and tortoises and also for a draft of a form of lease which he considers suitable for turtle-banks” (p. 57). Thus, although the final outcome is unknown, it appears that Maxwell was given another opportunity to rework his proposed legislation.

Curiously, the interpretation by the Lieutenant Governor of the recommendations by Maxwell included a mention of something that Maxwell did not say, at least not explicitly. Whereas Maxwell had simply concluded, from his market-based observations, that the Olive Ridley population was stable, the Lieutenant Governor went further: “In regard to loggerheads [Olive Ridley], Captain Maxwell comes to the conclusion that they are neither increasing nor decreasing *and that no measures are necessary for their protection* [emphasis added]” (p. 56). Of course, the passage of time has proven this implied assertion to be as false as some of the other assumptions made over a century ago.

**Conclusions.**—It is important to note that the Maxwell report provides a very rare and highly specific quantitative picture of the condition of these turtle populations prior to their near complete depletion by the late-20<sup>th</sup> Century. The report issued in the name of the Lieutenant Governor concludes that “The acknowledgments of Government are due to Captain Maxwell for his interesting report, which is evidently the result of much thought and labour” (p. 57). Is this praise justified? We think the remarkable Maxwell report speaks for itself and we are so inclined to agree that it represents an incredibly well-compiled, rich source of information about sea turtles and terrapins in the late-19<sup>th</sup> Century Burma. In addition, his use of and clear respect for Local and Traditional Ecological Knowledge seems to predict important new scientific perspectives from the late-20<sup>th</sup> Century (Platt et al. 2018). We would quickly add the qualification that Maxwell obviously failed to realize that the egg collection scheme to which he fully subscribed was disastrously unsustainable in the long term, and that his proposal to introduce even a limited take of live Green Turtles on Diamond Island would only have accelerated the decline of the turtle populations.

As it happened, the near extirpation of Green Turtles and Olive Ridleys from Diamond (Thameehla) Island was achieved even without the implementation of the latter recommendation to harvest adults; however, this took a long time. A chance conversation on 3 April 2012 with an 86 y old man, U Khin Maung Lay, provided Dr. Colin Limpus and the Fisheries Director U Maung Maung Lwin with additional insights into the status of the egg fishery as it was conducted between 1932 and 1941 (from Colin Limpus, unpubl. report). The father of U Khin Maung Lay had held the egg collecting concession during these years and according to the detailed information he provided, continued collecting and selling both fresh and salted eggs numbering in the many thousands each year. The detail provided by this individual clearly indicated that he had an in-depth and credible knowledge of the turtles and the collection and commercial process. He even noted that the fishery continued to observe the historical closed season for turtle egg collection from 1 April to 15 May, the late dry season, which has naturally lower Green nesting anyway and no Olive Ridley nesting. During the Japanese occupation period of WWII, the formal egg concessions were discontinued by the Japanese and they did not eat eggs or turtles, at least from Thameehla Island. According to Khin Maung Lay, local ethnic groups did continue to go to Thameehla Island from 1942–1944 to harvest both eggs and turtles. After the war, U Khin Maung

Lay and others resumed the egg concession system and continued in business until about 1962–1964. During this post war period and up to 1986, the egg collectors appear to have taken nearly all of the eggs, despite a fisheries rule that they should leave one-third of the eggs in the beach to incubate naturally (Thorbjarnarson et al. 2000; Maung Maung Lwin 2009).

In April 2012, when Dr. Limpus returned to Diamond (Thameehla) Island as part of the Indian Ocean - South-East Asia (IOSEA) training workshop, he called attention to the fact that the number of Green Turtles nesting on the island had declined from the 5,000 or so, estimated by Maxwell, to just a few tens of females per year (Colin Limpus, pers. com.). As Fisheries Director U. Maung Maung Lwin reported (2009), starting occasionally in 1963 and more regularly in 1986, a dedicated staff of the Department of Fisheries have been working hard to try to reverse the continuing downward trend. In 2017–2019 surveys conducted by the Myanmar Department of Fisheries, universities, and citizen colleagues at Thameehla, Oyster, and Lampi islands, have found that Green Turtles have been nesting in low numbers, while similarly on Kadonkalay, Oyster, and Gayetegyi islands, Olive Ridleys have been documented nesting. On Oyster Island low numbers of Hawksbill Turtles are nesting as well. While the numbers are much lower than historical values, they do suggest that viable regionally unique populations of sea turtles are still to be found in Myanmar (Howard et al. 2019). Coastal populations of the *Batagur* species appear to be functionally extinct. At the end of the day, perhaps more praise should have been reserved for Surgeon-Major Francis Day who, around 1869 (cited in Maxwell 1904), three decades prior to Maxwell, seemed to have had a heightened sense of awareness of what the future might hold for the Green Turtles of Diamond Island.

**Epilogue.**—We cite the report by Captain Maxwell as: “Maxwell, F.D. 1904. Report on the Inland and Sea Fisheries in the Thongwa, Myaugmya, and Bassein Districts and Report on the Turtle-Banks of the Irrawaddy Division. Government Printing Office. Rangoon, Burma. 57 p.” which is from the title page of the PDF of the original we received from the New South Wales Library. In addition, on the last page (p. 57) of the Appendices is the notation “G.B.C.P.O.—No. 638, Rev. Secy., 22-7-1904—134.”. We have also seen 1911 used as the publication date as in Smith (1931) and Thorbjarnarson et al. (2000). We do not have an explanation for this inconsistency.

While there is no doubt that the report by Maxwell was completed and formally submitted in 1898, we

do not know why it appears to have taken another 6 y to be published; other than the possibility that official channels took many years to digest its detailed contents and proposals. The fact that the table of contents refers to many appendices, including two titled: “Captain Maxwell’s Fisheries Bill” and “Captain Maxwell’s Fisheries Bill as amended at the Fishery Conference” gives a hint of some not insignificant follow-up work, which materialized after its completion and initial submission in 1898.

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#### LITERATURE CITED

- Bluvias, J.E., and K.L. Eckert. 2010. Marine turtle trauma response procedures: a husbandry manual. Technical Report No. 10, Wider Caribbean Sea Turtle Conservation Network (WIDECAST), Ballwin, Missouri, USA. 100 p.
- Boulenger, G.A. 1890. The Fauna of British India, including Ceylon and Burma. Reptilia and Batrachia. Taylor and Francis, London, U.K.
- Bustard, H.R., and K.P. Tognetti. 1969. Green Sea Turtles: a discrete simulation of density-dependent population regulation. *Science* 163:939–941.
- Chaloupka, M.Y. 2001. Historical trends, seasonality and spatial synchrony in Green Sea Turtle egg production. *Biological Conservation* 101:263–279.
- Comuzzie, D.C., and D.W. Owens. 1990. A quantitative analysis of courtship behavior in captive Green Sea Turtles (*Chelonia mydas*). *Herpetologica* 46:195–202.
- Dash, M.C., and C.H. Kar. 1990. The Turtle Paradise Gahirmatha (An Ecological Analysis and Conservation Strategy). Interprint, New Delhi, India.
- Eckert, K.L., K.A. Bjorndal, F.A. Abreu-Grobois, and M. Donnelly (Eds.). 1999. Research and Management Techniques for the Conservation of Sea Turtles. Publication No. 4, International Union for Conservation of Nature/Species Survival Commission Marine Turtle Specialist Group, Blanchard, Pennsylvania, USA.
- Fitzsimmons, N., and C. Limpus. 2014. Marine turtle genetic stocks of the Indo-Pacific: identifying boundaries and knowledge gaps. *Indian Ocean Turtle*

- Newsletter 20:2–18.
- Gunther, A.C.L.G. 1864. *The Reptiles of British India*. Published for the Ray Society by R. Hardwick, London, UK.
- Hendrickson, J.R. 1958. The Green Sea Turtle, *Chelonia mydas* (Linn.) in Malaya and Sarawak. *Proceedings of the Zoological Society, London* 130:455–535.
- Hirth, H.F. 1971. Synopsis of the biological data on the Green Turtle, *Chelonia mydas* (Linnaeus) 1758. Fisheries Synopsis 85, United Nations Food and Agriculture Organization, Rome, Italy.
- Hirth, H.F. 1980. Some aspects of the nesting behavior and reproductive biology of sea turtles. *American Zoologist* 20:507–524.
- Howard, R., K. Myint, P. Maw, P. Z. Oo, and M. Tiwari. 2019. Improving marine turtle conservation in Myanmar. *Oryx* 53:409.
- Limpus, C.J., and N. Nicholls. 2000. ENSO regulation of Indo-Pacific Green Turtle populations. Pp. 399–408 *In The Australian Experience*. Hammer, G.L., N. Nicholls, and C. Mitchell (Eds.). Kluwer Academic Publishers, Dordrecht, The Netherlands.
- Lwin, M. M. 2009. Green Turtle (*Chelonia mydas*) nesting and conservation activity in Thameehla Island, Myanmar. *Indian Ocean Turtle Newsletter* 10:14–18.
- Maxwell, F.D. 1904. Report on the Inland and Sea Fisheries in the Thongwa, Myaugmya, and Bassein Districts and Report on the Turtle-Banks of the Irrawaddy Division. Government Printing Office, Rangoon, Burma. ([http://www.herpconbio.org/Volume\\_15/Issue\\_2/MaxwellReport-1904.pdf](http://www.herpconbio.org/Volume_15/Issue_2/MaxwellReport-1904.pdf))
- Mazaris, A.D., G. Schofield, C. Gkazinou, V. Almpnidou, and G.C. Hays. 2017. Global sea turtle conservation successes. *Science Advances* 3. <https://doi:10.1126/sciadv.1600730>.
- Miller, J. 1997. Reproduction in sea turtles. Pp. 51–81 *In Biology of Sea Turtles*. Lutz, P.L., and J.A. Musick (Eds.). CRC Press, Inc. Boca Raton, Florida, USA.
- Moll, E.O., S.G. Platt, E.H. Chan, B.D. Horne, K. Platt, P. Praschag, P.N. Chen, and P.P. van Dijk. 2015. *Batagur affinis* (Cantor 1847) - Southern River Terrapin, Tuntong. *Conservation Biology of Fresh water Turtles and Tortoises: A Compilation Project of the IUCN/SSC Tortoise and Freshwater Turtle Specialist Group*. Rhodin, A.G.J., P.C.H. Pritchard, P.P. van Dijk, R.A. Saumure, K.A. Buhlmann, J.B. Iverson, and R.A. Mittermeier (Eds.). *Chelonian Research Monographs No. 5*, doi:10.3854/crm.5.090.affinis.v1.2015
- Mrosovsky, N. 1968. Nocturnal emergence of hatchling sea turtles: control by thermal inhibition of activity. *Nature* 220:1338–1339.
- National Research Council. 1990. *Decline of Sea Turtles: Causes and Prevention*. National Academy Press, Washington, D.C., USA.
- Owens, D.W., M.A. Grassman, and J.R. Hendrickson. 1982. The imprinting hypothesis and sea turtle reproduction. *Herpetologica* 38:124–135.
- Platt, S.G., C. Kingsley, A.U.Z. Latt, K. Platt, and D.W. Owens. 2017. Recent nesting record of the Leatherback in coastal Myanmar. *Indian Ocean Turtle Newsletter* 26:2–5.
- Platt, S.G., K. Platt, M.M. Soe, K.M. Myo, K.E. Holmes, and T.R. Rainwater. 2015. Marine turtles and estuarine crocodiles in Lampi Marine National Park, Myanmar: a conservation and threat assessment with recommendations. *Herpetological Review* 46:319–327.
- Platt, S.G., G.R. Zug, K. Platt, W.K. Ko, K.M. Myo, M.M. Soe, T. Lwin, M.M. Win, S. Htet, N. Aung, et al. 2018. Field records of turtles, snakes and lizards in Myanmar (2009–2017) with natural history observations and notes on folk herpetological knowledge. *Natural History Bulletin of the Siam Society* 63:67–114.
- Polovina, J.J., G.H. Balazs, E.A. Howell, D.M. Parker, M.P. Seki, and P.H. Dutton. 2004. Forage and migration habitat of Loggerhead (*Caretta caretta*) and Olive Ridley (*Lepidochelys olivacea*) sea turtles in the central North Pacific Ocean. *Fisheries Oceanography* 13, 36–51. <http://doi:10.1046/j.1365-2419.2003.00270.x>.
- Saha, J. 2013. *Law, Disorder and the Colonial State: Corruption in Burma c.1900*. Palgrave Macmillan, Basingstoke, U.K.
- Smith, M.A. 1931. *Reptilia and Amphibia*. Volume 1. Loricata, Testudines. *Fauna of British India, including Ceylon and Burma*. Stephenson, J. (Ed.). Taylor and Francis, London, England.
- Spotila, J.R., M.P. O’Connor, and F.V. Paladino. 1997. Thermal biology. Pp. 297–314 *In Biology of Sea Turtles*. Lutz, P.L., and J.A. Musick (Eds.). CRC Press, Inc. Boca Raton, Florida, USA.
- Theobald, W. 1868. Catalogue of the reptiles of British Burma, embracing the provinces of Pegu, Martaban and Tenasserim, with descriptions of new or little-known species. *Journal of the Linnean Society, London* 10:4–68.
- Thorbjarnarson, J.B., S.G. Platt, and S.T. Khaing. 2000. Sea turtles in Myanmar: past and present. *Marine Turtle Newsletter* 88:10–11.





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