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Predation by the Saltwater Crocodile (*Crocodylus porosus*) on Sea Turtle Adults, Eggs, and Hatchlings

SCOTT D. WHITING[1,3] AND ANDREA U. WHITING[2]

[1]*Department of Natural Resources, Environment, the Arts and Sport, PO Box 496, Palmerston, NT 0830, Australia [scott.whiting@dec.wa.gov.au];*
[2]*Faculty of Education, Health and Science, Charles Darwin University, NT 0909, Australia [au.whiting@gmail.com];*
[3]*Marine Science Program, Department of Environment and Conservation, Locked Bag 104, Bentley DC, WA 6983, Australia*

ABSTRACT. – This paper describes predation tactics used by the saltwater crocodile (*Crocodylus porosus*) on flatback (*Natator depressus*) and olive ridley (*Lepidochelys olivacea*) sea turtles on nesting beaches in northern Australia. For adult turtles, crocodiles used both a sit-and-wait tactic in which they attacked a turtle at the water's edge after it completed nesting and an active hunting strategy in which crocodiles followed turtle tracks into the dunes to attack turtles at nest sites. Saltwater crocodiles also hunted sea turtle hatchlings in the dunes and excavated a sea turtle nest and consumed the eggs. The protection of saltwater crocodiles in Australia starting in the early 1970s has led to increased population sizes and a greater proportion of larger individuals. This likely has resulted in increased predation rates on sea turtles over several decades, which should be considered as an important mortality component for some tropical nesting aggregations.

KEY WORDS. – Reptilia; Testudines; Cheloniidae; foraging; mortality; behavior; olive ridley turtle; flatback turtle; predator

Once mature, sea turtles have relatively high survivorship (Frazer 1983; Chaloupka and Limpus 2002, 2005) and are relatively well protected from predators by their large size and hard outer shell (Stancyk 1982). In addition, sea turtles are relatively agile in the water, can sustain short fast swimming bursts, and possess somewhat cryptic coloration (Carr et al. 1974). Adult sea turtles, however, are not totally invulnerable to predators while at sea (see Heithaus et al. 2008 for a recent review). Sharks are the most common predators of adult turtles (Fergusson et al. 2000; Heithaus et al. 2005), which also may be taken by marine mammals (Caldwell and Caldwell 1969; Sarti et al. 1994; Margaritoulis et al. 1996; Pitman and Dutton 2004) and saltwater crocodiles (*Crocodylus porosus*) (Hirth et al. 1993).

While on land, sea turtles are slow and cumbersome and are protected only by their size and shell. Their vulnerability to large predators on land is enhanced by the trance-like state they enter during oviposition (Bustard 1972; Jessop et al. 1999; Jessop 2001), exhaustion from physical activity on land, and the considerable time spent out of the water. Nonhuman predators on land include dogs (Márquez 1990), jaguars (Schultz 1975; Autar 1994; Troëng 2000), and crocodiles (American crocodile [*Crocodylus acutus*], Ortiz et al. 1997; saltwater crocodile, Sutherland and Sutherland 2003).

Predation by the saltwater crocodile on sea turtles has rarely been documented (Hirth et al. 1993; Sutherland and Sutherland 2003), despite their extensive areas of sympatry (Groombridge 1987; Webb and Manolis 1989; Márquez 1990; Richardson et al. 2002). The saltwater crocodile is a formidable predator. Males commonly reach 5.5 m in total body length and up to 1 tonne in body mass, with some individuals reaching up to 8 m (Groombridge 1987; Webb and Manolis 1989; Richardson et al. 2002). In general crocodilians appear to be opportunistic feeders with prey size and the proportion of terrestrial prey increasing with the size of the crocodile (Taylor 1979; Cooper-Preston and Jenkins 1993). Large prey can include mammals (dogs, wallabies, kangaroos, cattle, horses, goats, buffalo, and humans), reptiles (other crocodiles, sea turtles, goannas), and birds (Kar and Bustard 1983; Webb and Manolis 1989; Caldicott et al. 2005).

This paper presents the first detailed description of crocodile predatory behavior on 2 species of sea turtles: olive ridley (*Lepidochelys olivacea*) and flatback (*Natator depressus*).

MATERIALS AND METHODS

Predation by the saltwater crocodile on adult sea turtles, hatchling sea turtles, and sea turtle eggs was recorded through direct and indirect observations. Observations were collected during surveys on 2 nesting beaches approximately 450 km apart at Cape Van Diemen, Melville Island (lat 11°10′30″, long 130°22′18″) in the Northern Territory of Australia and at Cape Domett (lat 14°48′06″, long 128°24′30″) on the mainland in northern Western Australia (Fig. 1). The Cape Van Diemen and Cape Domett beaches are 10 km and 2 km long, respectively. The Cape Van Diemen nesting beach comprises olive ridley turtles (95%) and flatback turtles (5%) (Whiting et al. 2007a) while the Cape Domett nesting beach comprises only flatback turtles (Whiting et al. 2008). At both locations, peak nesting occurs during the austral winter or coolest months of the year.

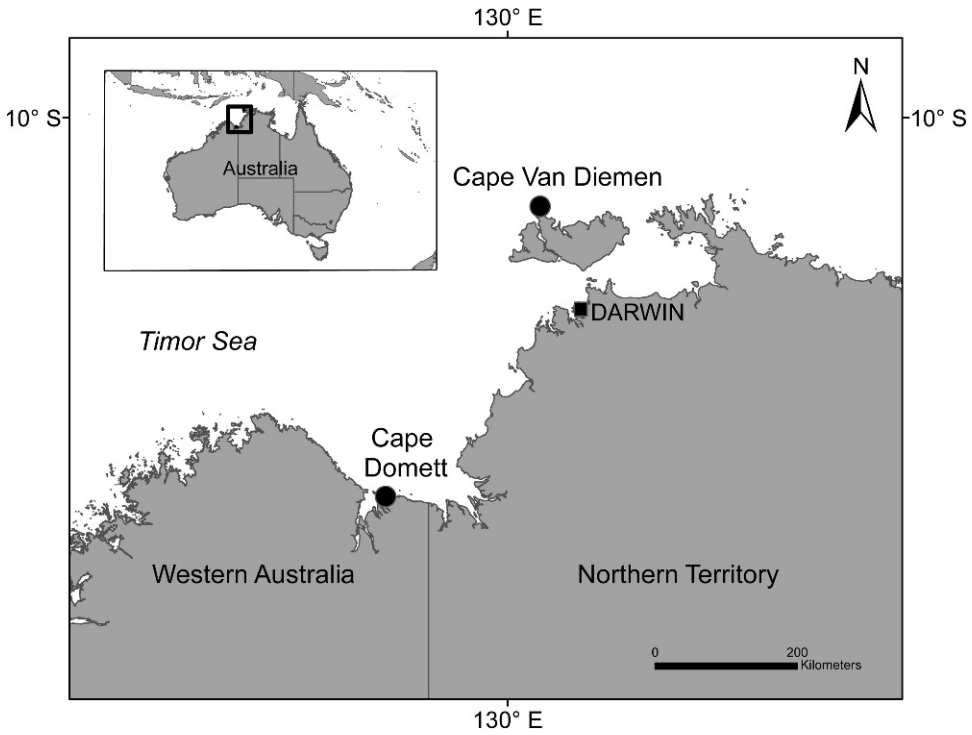

Figure 1. Location of study sites in northern Australia.

All observations were made during nightly beach patrols or early morning turtle track surveys. At Cape Van Diemen a total of 73 survey days were conducted primarily during a 2-week period each year from 2004 to 2009 (see Whiting et al. 2007b) while at Cape Domett, 36 survey days were conducted during 4- to 5-day periods conducted every 7 weeks throughout the 2006 nesting season and during one 13-day period in August 2006 (see Whiting et al. 2008). In both study sites the beaches were patrolled at night for approximately 5 hours around the high tide peak coinciding with turtle nesting period. At Cape Van Diemen patrol group size varied from 1 to 8 people and from patrols entirely on foot or by a combination of foot and quad motor bike. At Cape Domett, patrols were solely on foot in groups of between 2 and 9 people. For the safety of the researchers, groups on foot at Cape Van Diemen used a spotlight to search for the reflective eye shines of crocodiles, while at Cape Domett, researchers used a spotlight with an infrared filter and a night vision scope. The survey methods appeared to cause no disturbance to flatback turtles and minimal disturbance to olive ridley nesting. At each study site as many turtles as possible were intercepted during the night patrols, and each individual was tagged, measured, and inspected for external damage on the dorsal surface including the head and flippers. Only in some cases was the ventral surface inspected. The percentage of turtles intercepted at night at Cape Van Diemen and Cape Domett was 23% and 9%, respectively. At each site, the beach was patrolled during the morning to record any nesting attempts and newly hatched nests that occurred after the nightly patrols ended. Predation of adult sea turtles was recorded through direct and indirect observations. Indirect evidence was gathered from fresh tracks in the sand made by crocodiles and turtles, signs of a struggle, or blood and pieces of turtle flesh and bone. Unsuccessful predation attempts were interpreted from indirect evidence left by tracks in the sand. A crocodile attack on the beach as indicated by struggle marks was deemed unsuccessful if the turtle tracks led back to the water. Evidence of crocodile predation of hatchlings was through direct observation. During morning patrols and routine inspection of nests, crocodile predation on eggs was obtained from the interpretation of turtle and crocodile tracks and evidence of excavation of turtle nests by crocodiles. Turtle tracks were identified to species using criteria from Pritchard and Mortimer (1999).

RESULTS

Saltwater crocodiles were recorded resting on the beaches or in the inshore waters during most nights of surveys at Cape Van Diemen and Cape Domett. Between the 2 study sites, crocodiles preyed upon 3 life stages of sea turtles: adults, hatchlings, and eggs.

Predation of Adult Sea Turtles. — Predation by saltwater crocodiles on nesting turtles was consistently observed at the 2 study sites. Predatory behavior at Cape Van Diemen was dominated by active hunting by

Table 1. Successful and unsuccessful crocodile attacks on olive ridley and flatback turtles along a 10-km section of beach at Cape Van Diemen and 2 km of beach at Cape Domett.

Year	Unsuccessful attacks	Successful attacks	Fresh turtle tracks	No. of days of survey
Cape Van Diemen, olive ridley turtles				
2004	1 (1.0)	2 (2.0)	96	15
2005	0	3 (0.7)	401	13
2006	1 (2.9)	0	34	4
2007	1 (0.6)	3 (1.8)	169	13
2008	4 (1.3)	4 (1.3)	317	14[a]
2009	2 (4.4)	2 (4.4)	343	14
Total	9 (0.7)	14 (1.0)	1360	73
Cape Domett, flatback turtles				
2006	0	6 (0.4)	1497	36
Total	0	6 (0.4)	1497	36

[a] Fourteen days of survey at Cape Van Diemen comprised 8 days of surveys of a 2-km length of beach and 6 days of surveys of the total 11 km of beach. Cape Domett records comprise direct observations only.

crocodiles on turtles while they nested on the beach or sand dunes, whereas at Cape Domett crocodiles used a sit-and-wait behavior and attacked flatback turtles only at the water's edge after the turtles had finished nesting.

Active Hunting Behavior: Interception at the Nest. — At Cape Van Diemen, 14 successful attacks ($n = 13$ olive ridley turtles, $n = 1$ flatback turtle) and 9 unsuccessful attacks were recorded (Table 1). All attacks occurred during the process of nesting (forming the nest, laying eggs, or covering the nest) and all occurred above the spring high water mark. Crocodiles either followed the ascending turtle track from the waters edge, or intercepted the ascending track and followed it to the nest.

On one occasion a large crocodile (estimated to be greater than 4.5 m in length) crawled up the ascending olive ridley track with its belly dragging on the sand until approximately 10 m from the nesting turtle. The track marks of the crocodile indicated that it lifted its belly off the sand and ran the remaining distance to the nesting turtle where the attack occurred, rather than using other common gaits such as ''high-walking'' (Richardson et al. 2002) or ''galloping'' (Webb and Gans 1982). The severe force of the impact was indicated by a piece of carapace, 20 cm in diameter, thrown over 3 m from the point of impact. The track marks indicated that the turtle broke free at one stage but was recaptured 5 m closer to the water and then was carried above the ground to the water. On 8 additional occasions crocodiles had followed the turtle track to the nesting site but must have arrived too late because the tracks indicated a search by the crocodile, but no sign of a capture or of a struggle, only a crocodile track crossing over turtle tracks and a turtle track entering the water. On one occasion, the tracks indicated a struggle, but the turtle tracks heading to the water indicated that the turtle escaped. All successful saltwater crocodile attacks on adult turtles were by large crocodiles estimated to be 4 to 5 m in length. Crocodile tracks were up to 1.4 m in width (measured between the feet) compared with olive ridley and flatback turtle tracks at approximately 0.7 m (Whiting et al. 2007b) and 0.9 m (Whiting et al. 2008), respectively.

Sit-and-Wait Behavior: Interception at Waterline. — Crocodiles at Cape Domett adopted a sit-and-wait behavior in which they remained in the water at the beginning of the ascending turtle track and attacked the turtle at the water's edge as it descended the beach after nesting. Six attacks of flatback turtles were recorded (Table 1). On no occasion did crocodiles follow turtle tracks up the beach, and no large crocodile tracks were seen above the high tide mark during any of the turtle nesting surveys.

One incidence of a crocodile attack on a flatback turtle occurred at dawn and appeared typical of all observed attacks. The crocodile was first seen on the beach approximately 5 m from the water's edge at the beginning of a fresh ascending turtle track, during which time the turtle was on the beach at the base of the first dune laying eggs. As the turtle started crawling down the beach after completing her nesting, the crocodile retreated to the wave-breaking zone within 10 m of the water's edge until the turtle was approximately 1 m away from the water. The crocodile then lunged at the turtle and immediately dragged it into the water and pinned it to the bottom of the ocean floor. There was no sign of the turtle for several minutes and the crocodile's tail was often out of the water as it struggled to keep the turtle on the bottom. The struggle lasted approximately 10 minutes until the crocodile surfaced with the turtle held firmly in its mouth. The turtle was still alive, making weak flipper movements. The crocodile slowly travelled along the surface of the water out to sea and along the coast with the turtle in its mouth until it was out of our sight.

Postcapture Behavior. — At Cape Van Diemen, crocodiles either carried the turtle back to the water's edge or started to break the turtle apart at the site of capture on the beach (Fig. 2a, b). All observed behaviors showed that crocodiles needed to be in shallow water or on dry land to break apart and swallow the turtles. During one night in 2005 at Cape Van Diemen, a large crocodile (> 4.5 m) was observed lying on the beach with a flatback turtle (approximate mass 65–70 kg; Limpus

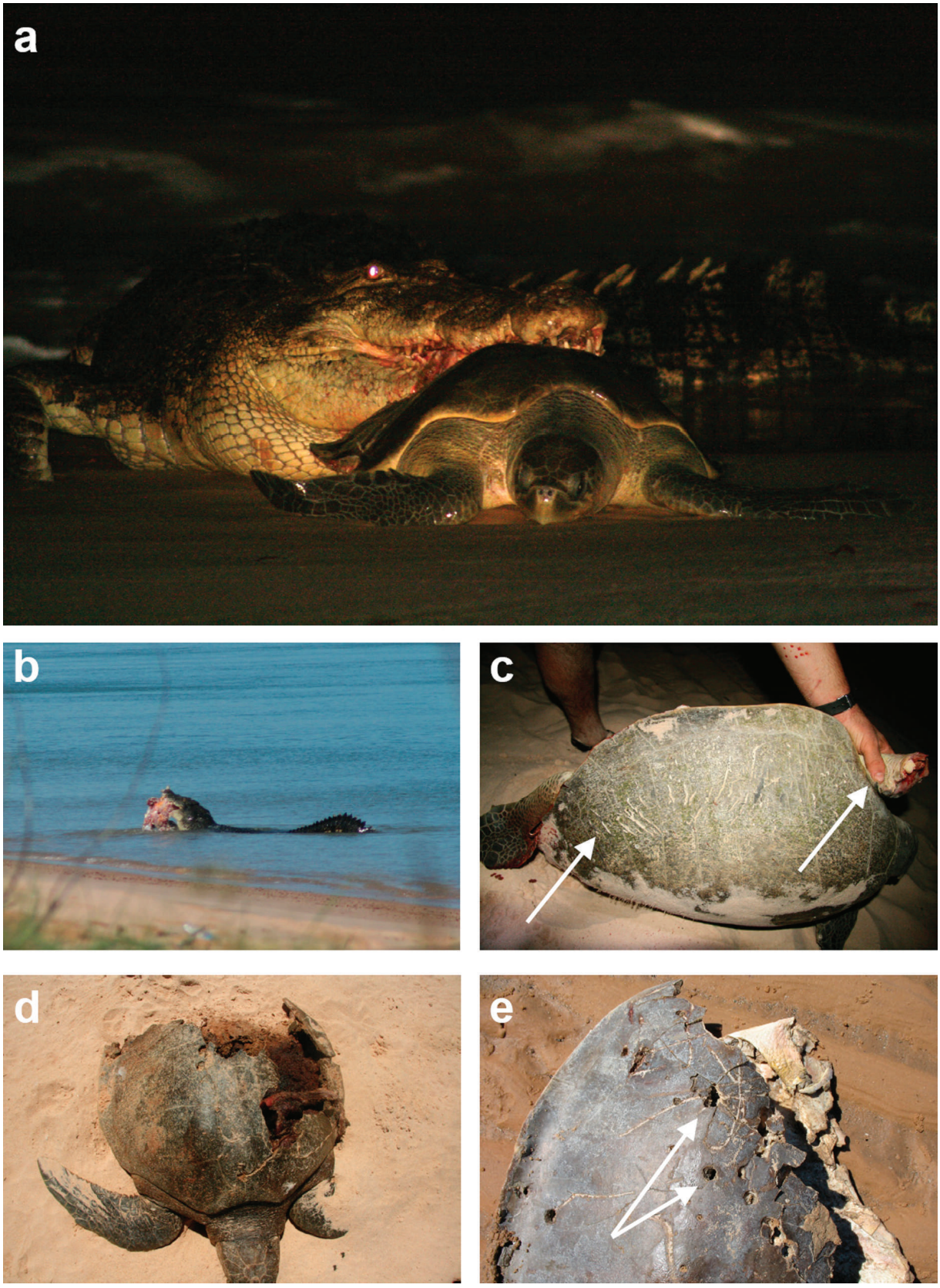

Figure 2. Evidence of predation of turtles by saltwater crocodiles showing a) restraint of an olive ridley turtle in the mouth of a saltwater crocodile; b) a ca. 4-m crocodile swallowing pieces of an olive ridley turtle; c) a live olive ridley turtle showing conical teeth scratch marks across the carapace and almost all of the left front flipper missing from a crocodile attack; d) the remains of an olive ridley turtle left on the beach; e) the remains of a flatback turtle left on the beach with conical teeth puncture holes through the carapace. Photo credits: Scott Whiting (a–c) and Andrea Whiting (d and e).

Table 2. A summary of crocodile damage on olive ridley sea turtles for a 2-km-long section of beach at Cape Van Diemen.

	Year, *n* (%)				
Damage	2005	2006	2007	2008	2009
Carapace scratches only	2 (2.3)	0	1 (2.5)	2 (2.9)	2 (1.4)
Carapace scratches plus soft tissue damage (including missing limbs)	2 (2.3)	0	5 (12.5)	2 (2.9)	2 (1.4)
Total turtles checked	88	5	40	69	141
Total no. of field days	14	3	13	14	14

2009) in its mouth. The crocodile was disturbed by our presence and travelled 30 m along the beach, holding the turtle off the ground from the posterior end with no part of the turtle touching the sand, before entering the water. The same crocodile was seen 1 hour later on the beach without the flatback turtle, but with a live olive ridley turtle in its mouth, again held by the posterior end. The first turtle presumably escaped, based on the time required to subdue, break apart, and consume a large turtle and limited consumption capacities of the crocodiles. Scared off by our presence, the crocodile entered the sea with the second turtle, and re-appeared in the shallows at the waters edge about 30 m along the beach and began cracking the carapace of the turtle with its jaws. Once the turtle's carapace was broken apart and internal organs were released, the crocodile began swallowing small pieces by holding its head almost vertically out of the water. This need to handle the dead turtles in shallow water was again observed in 2007 at Cape Van Diemen after an early morning attack. The crocodile made repeated efforts to bring the turtle into the shallows, despite trying to avoid our observations. After 20 minutes of the observers being well hidden, the crocodile brought the turtle into the shallows where it consumed it by tearing off pieces and then lifting its head out of the water before swallowing (Fig. 2b). On all 4 occasions of direct observations, crocodiles secured live and dead turtles by the posterior end (see Fig. 2a).

Nonfatal Injuries. — In both locations, turtles showed evidence of nonfatal injuries caused by crocodile attacks. Many turtles showed signs of conical teeth scrape marks on the carapace, soft tissue wounds around the pelvic girdles and missing front and hind flippers (Fig. 1c). Examples of conical teeth puncture marks through the bone of the carapace are shown on 2 dead turtles in Fig. 1d and 1e. At Cape Van Diemen, 5% of turtles showed fresh or healed wounds (Table 2) consistent with crocodile attacks.

Predation of Hatchlings. — Predation of flatback hatchlings was observed at Cape Domett during November 2006. A relatively small crocodile (estimated 2 m in length) waited at the top of the high tide mark (ca. 30 m from the waters edge) for 20 minutes before it started tracking back and forth parallel to the water's edge, snapping at the ground, and picking up hatchling flatback sea turtles as they emerged from a nest and ran to the sea. The crocodile regularly raised its head off the sand and displayed characteristic swallowing behavior. The crocodile made 12 attempts at grabbing hatchlings over a 5- to 10-minute interval and, from the tracks left in the sand, was successful in eating all 8 hatchlings in the vicinity during this time. The crocodile remained on the beach until approximately 10 minutes after the last hatchling was taken and then returned to the water. At Cape Domett, several incidences of crocodile hatchling predation were recorded from indirect evidence. Crocodile tracks led in and out of sand depressions left by nesting turtles and tracked along the beach for up to 150 m. This behavior was observed regularly during November 2006, with 2 juvenile crocodiles on the beach each night. No large crocodiles (> 2.5 m in length) were observed using this hunting method. At Cape Van Diemen, there were no observations of predation on olive ridley hatchlings, although a small juvenile crocodile showed similar behavior by running around on the intertidal zone, chasing the abundant ghost crabs (*Ocypode* sp.).

Predation of Eggs. — Only one indirect observation was made of crocodiles consuming sea turtle eggs. A juvenile crocodile (estimated 2.5 m in length) track followed an olive ridley turtle track up the beach to the nest where a small search pattern over an area of < 4 m^2 led it to the turtle nest. The crocodile used its front feet to excavate the top of the nest and to remove part of the clutch of eggs, which it consumed on site. Some broken eggs were visible around the nest. The turtle track was several days older than the crocodile track indicating the crocodile found the nest by using cues other than the presence of the turtle. No egg predation was recorded at Cape Domett.

DISCUSSION

Sea Turtles as Prey for the Saltwater Crocodile. — Nesting sea turtles provide easy prey for crocodiles large enough to restrain, kill, and break through the hard carapace because they are relatively slow and cumbersome on land compared to terrestrial animals and enter into a trance-like state during and immediately after oviposition (Bustard 1972; Jessop et al. 1999; Jessop 2001). In addition, females are usually exhausted after nesting and thus vulnerable to attack. On land their best defensive mechanisms are their relatively large size and protective shell. Both olive ridley and flatback turtles can be quite fast on land, with flatback turtles able to lift their

plastron off the sand and gallop, while olive ridley turtles are one of the lightest sea turtles and use an alternate gait and move quickly compared to other sea turtles. In the water, turtles are agile swimmers and can move fast over short distances. As prey items, nesting sea turtles provide predictability in both time and space as they show fidelity to nesting beaches and have predictable annual nesting seasons. This is ideal for crocodiles, which appear to have the ability to learn prey behavior and include ambushing as one of their hunting strategies (Lang 1987; Caldicott et al. 2005). Despite this predictability, crocodile predation of adult turtles may be limited, because crocodiles would need to reach sizes large enough to restrain the ca. 65–70 kg flatback turtle (Limpus 2009) or the ca. 40-kg olive ridley turtle (Whiting et al. 2007b). The number of large crocodiles at any one beach may be restricted by the size structure of *C. porosus* populations and the behavioral characteristics of *C. porosus*, which show strong site fidelity and territoriality. Territoriality can be displayed by *C. porosus* all year round but does vary with habitat and season. As territoriality is associated with defending resources, it can be relaxed as resources increase (Lang 1987). At Cape Van Diemen, one large crocodile (presumably male) occurred in the same area and was seen on the same nights as 2 large but smaller crocodiles (presumably female). Crocodile damage to nesting sea turtles indicates that sea turtles sometimes escape predation interactions because many turtles come ashore with recognizable injuries. It is presumed that escape probability would be higher for attacks that occur in the water. Similar injuries have also been observed on flatback turtles at Bare Sand Island about 100 km southwest of Cape Van Diemen (Whiting 2000). Severe injuries such as missing flippers may impact reproductive potential of adult females because the front flippers are needed to construct the initial body pit in the sand and the rear flippers are needed to construct the egg chamber. Missing or injured flippers will also impair the turtle's ability to make long migrations and dive for food. Olive ridley turtles from Cape Van Diemen are known to migrate over 1000 km and dive to depths of over 150 m (Whiting et al. 2007a). The injury rate was relatively low in this study when compared with loggerhead turtles, with between 20% and 50% carrying injuries inflicted by sharks (Heithaus et al. 2005).

Predatory Behavior of the Saltwater Crocodile on Sea Turtles. — Predatory behavior by the saltwater crocodile on sea turtles varied between Cape Van Diemen and Cape Domett. Crocodiles at Cape Domett waited for flatback turtles to finish nesting and intercepted them at the water's edge while the crocodiles at Cape Van Diemen followed turtles or their tracks up the beach and attacked them above the high tide line. There are 2 main differences between the 2 locations that could cause differences in attack behavior. Cape Van Diemen is located about 20 km from a small community meaning that crocodiles could be more habituated to people. Cape Domett is remote and several hours drive by boat from the nearest community, and visitors to this beach are rare. Crocodiles from both locations may attack nesting turtles in the dunes, but crocodiles at Cape Domett may be too timid to do so with humans in the area. An alternative scenario may be that the larger sized flatback turtles need to be subdued by drowning and are too large and strong to kill on the beach. Observations from other locations across northern Australia, such as Crab Island, may help to provide answers to these behavioral differences.

The cues used by crocodiles to locate turtles at both locations are not well understood. The crocodilian eye is able to maximize vision in low-light conditions, having a large number of rods, a retinal tapetum within the retina capable of maximizing light hitting the rods, and a pigmented retina able to improve the capture of light (Richardson et al. 2002). This indicates that visual detection of sea turtles or their tracks is the most likely means of prey detection for crocodiles. Sea turtles form a dark silhouette on beaches and their tracks create a dark line in the sand that can even be detected by the human eye on all but the darkest of nights. There was clear evidence that crocodiles followed turtle tracks up the beach at Cape Van Diemen and sometimes employed a search pattern technique, even after the turtle had departed. Other senses such as hearing, olfaction, and mechanoreceptors (Richardson et al. 2002) cannot be discounted and could be used either alone or in combination with any of the other senses. Olive ridley turtles cover their nest and physically compact the sand by repeatedly slamming each side of their body onto the sand (Whiting et al. 2007b). This makes a noise that could be used by crocodiles to home in on the turtle. The smell of turtles could also be used to help crocodiles locate turtles on the beach and would be the most likely sense used to determine the location of turtles eggs buried in the nest in the sand.

The predatory behavior we recorded for saltwater crocodiles on adult turtles may only be a subset of those used by crocodiles to attack adult turtles. Nesting turtles often aggregated in the shallow waters adjacent to nesting beaches, and crocodiles may also hunt turtles in the water. There are many anecdotal reports in northern Australia, of nonnesting turtles in the mouths of crocodiles at sea indicating that crocodiles are also adept at capture of turtles in the water. Unfortunately there are only a few such recorded accounts (Hirth 1993; Whiting 2000).

Predation on Eggs and Hatchlings. — This is the first record of the saltwater crocodile preying on hatchling turtles and turtle eggs. Only juvenile saltwater crocodiles were recorded consuming both eggs and hatchlings. Hatchling turtles would also be vulnerable to attack by crocodiles once they reach the water. Large crocodiles dominated the sightings at both locations indicating that smaller crocodiles may have been excluded from both areas by larger crocodiles. Reduced numbers of smaller crocodiles may have caused the limited observations

of predation eggs and hatchlings. In addition seasonal easterly winds at Cape Van Diemen may have reduced detection of any track evidence in the sand of smaller crocodiles and hatchlings.

Relationships Between Crocodile and Sea Turtle Populations. — The saltwater crocodile suffered significant declines across its range in Australia due to hunting for skins between the 1940s and 1960s (Messel and Vorlicek 1986; Stirrat et al. 2001; Read et al. 2004). Once state legislative protection was formalized in Western Australia (1969), Northern Territory (1971), and Queensland (1974) (Letts 1987) the populations increased in each state and the Northern Territory (Stirrat et al. 2001; Read et al. 2004). This means that crocodile predation on turtles is likely to be increasing or approaching preharvest levels since protection and should be considered in future population modeling of sea turtles in northern Australia. All sea turtles that nest on mainland and coastal island beaches throughout the range of saltwater crocodiles are vulnerable to predation. In Australia, hawksbill (*Eretmochelys imbricata*) and green (*Chelonia mydas*) turtles also inhabit and nest in considerable numbers in northern Australia, while loggerhead (*Caretta caretta*) turtles are mainly subtropical nesters, occurring outside of the saltwater crocodile distribution. Sea turtles nesting on offshore islands of the Great Barrier Reef are less vulnerable to attack as crocodiles are less common in these areas, although the saltwater crocodiles are capable of ocean voyages of up to 1000 km (Richardson et al. 2002).

The predation of sea turtles by crocodiles occurred regularly (1 per 5 days at Cape Van Diemen and 1 per 6 days at Cape Domett) at the 2 study sites which support relatively high-density nesting (Whiting et al. 2007b, 2008). The relationship between nesting density and predation frequency is unknown and would require longer study periods to enable successful modeling. Although the predation rates appear relatively low (ca. 1% of the nesting turtles during the peak of the season), rates could be higher over the whole season based on predation rates remaining relatively constant compared with reduced availability on nesting turtles at the start and end of the nesting seasons. In addition, current numbers may also be an underestimate based on the high probability of observer presence reducing the natural number of interactions. If current predation rates are sustained throughout the nesting season or if additional mortality of nesting turtles occurs in the water, predation by saltwater crocodiles may account for a significant mortality source for adult turtles within each population given that the populations may be under additional anthropogenic pressure across their range. Additional, sublethal impacts may affect turtles by altering the nest location within beaches and between beaches and intraday and intraweek timing of nesting. More information is required to understand the behavior and biology of crocodiles in northern Australia. One extension of this study to elucidate the importance of sea turtles in the diet of crocodiles would be to satellite track individual saltwater crocodiles throughout the year to determine how much time they spend at turtle rookeries in relation to their total time budgets. In addition, this could investigate the level of predation throughout the seasons, particularly at the ends of the season when nesting numbers are lower. A higher proportion of turtles taken during the warmer parts of the nesting season may impact on the number of successful clutches laid that predominantly produce female hatchlings.

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