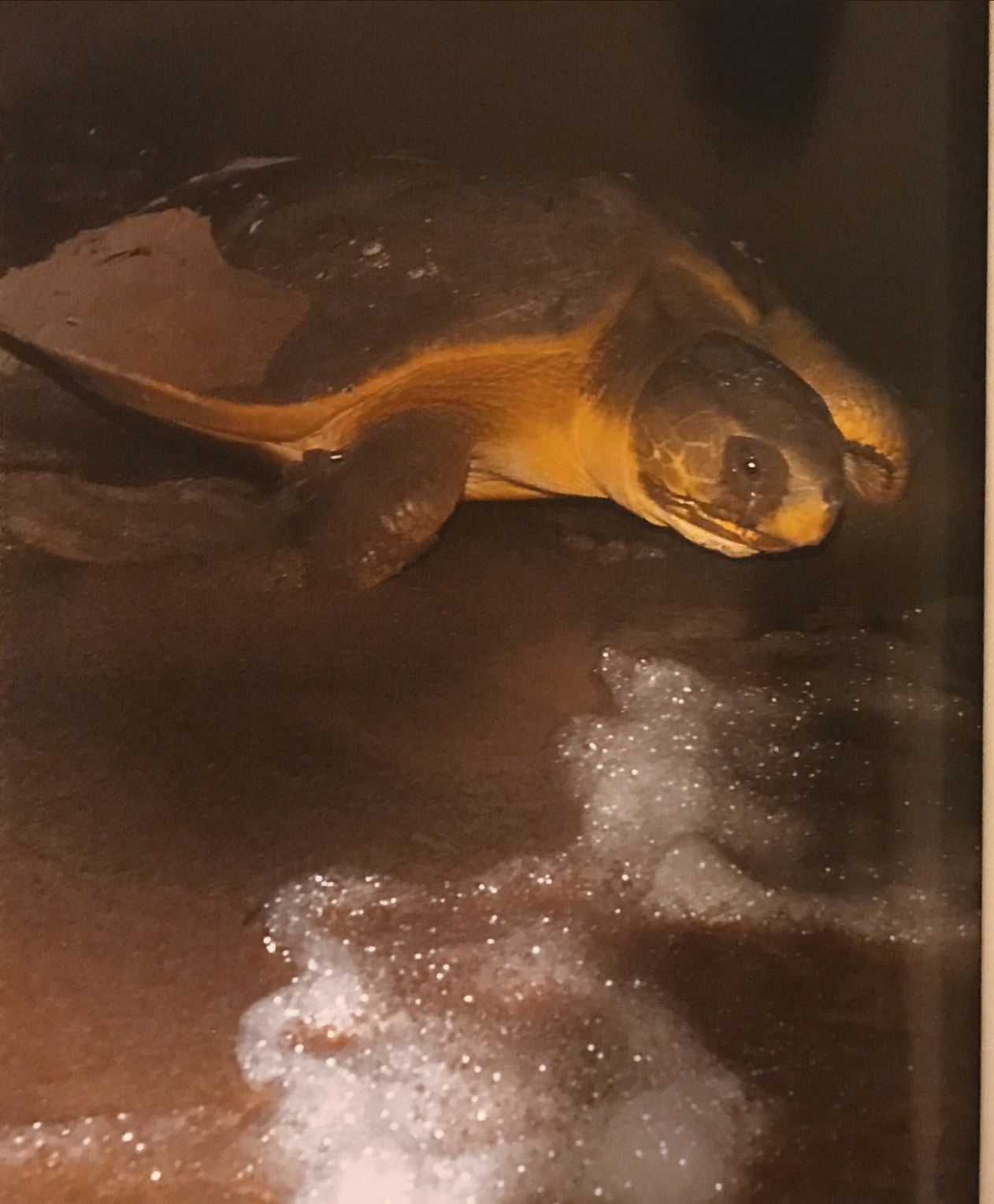


Previous pages: Flatback hatchlings stay close to land after leaving the beach. Unlike other sea turtles, flatbacks remain along the continental shelf for their entire lives.

Opposite: A flatback turtle returns to the sea after nesting on Curtis Island, Queensland, Australia. A result of the nesting process, sand sticks to the salty tears below her eye and has accumulated along the edge of the upturned carapace.

THE FLATBACK, *NATATOR DEPRESSUS*, IS A TURTLE OF MYSTERY. We probably know less about this sea turtle than any of the other six species. It is restricted in distribution primarily to the continental shelf of Australia and its nesting is limited to Australian beaches. We know little about what it eats and no one has tracked its path from nesting beach to foraging ground. In short, we know where they end up but not how they got there. In fact there are only about 100 studies of this species published in the vast scientific literature on sea turtles and many of these are in regional journals of limited distribution. Much of our knowledge on flatbacks is anecdotal and from unpublished reports filed away by government agencies, conservation organizations, and academia.

Famed biologist Samuel Garman first described the flatback turtle as a relative of the green turtle and in 1880 named it *Chelonia depressa*, with *depressa* apparently referring to a shell that looks flat compared to those of other sea turtles. Checking the skeletons on which the original descriptions were based, biologist and taxonomist Peter Pritchard discovered that they actually represented more than one species, and included a green turtle specimen. Perhaps that's why Garman thought the flatback was related and named it *Chelonia*, the genus to which green turtles belong.

As is typical in science, there have been disagreements over the years about how the flatback should be classified. In 1908 Allan R. McCullock thought that he found a new species and gave it the genus name *Natator*, as well as a new species name, *tessellates*. In 1913 D. B. Fry examined a greater range of life history stages and skeletal material. As a result he brought back *Chelonia depressa*. Unfortunately, Fry made mistakes in preparing his hatchling specimens and the broken skulls did look like *Chelonia* skulls.

After that, when flatback skulls were brought into museums scientists saw that they were different and labeled them Kemp's ridleys. The confusion is understandable because they relied on Fry's descriptions and failed to discover his mistake. They did not check the original articles or examine the original specimens used by Garman and McCullock. Shortcuts in science often lead to errors.

By the 1980s Rainer Zangerl and Colin Limpus independently concluded that the flatback was indeed a unique species, that it was more closely related to a log-

gerhead than a green turtle, and that it should have its own name, *Natator depressus*. Their position has been widely accepted and the name confusion seems cleared up, at least for now.

Recent analyses of DNA from mitochondria and cell nuclei indicate that the flatback is widely separated from both the green turtle lineage and the loggerhead-ridley-hawksbill lineage, though it appears to be more closely related to the latter group. The flatback's carapace is indeed "relatively flat" but it is also somewhat soft and flexible and tends to turn up at the margins.

A flatback's skin is soft like that of a leatherback and will bleed if scratched with a fingernail. The carapace is olive gray to pale green, the head and neck are olive gray above and pale yellow below, and the plastron is a yellowish cream color. Flippers are grayish above and cream to yellow below. Hatchlings have a white plastron and a gray or olive green carapace with a white margin. Each scute is outlined in black on its growing edge.

The front flippers of the adult are short and seem quite a bit smaller than one might expect compared to other species of similarly sized sea turtles. Why such small flippers? Flatbacks may be less active swimmers than other species and do not undertake the long oceanic voyages common to other sea turtles. However, the real answer may lie in the day-to-day life of the turtle—where it lives, how big its home range is, and how it forages for food. We don't know much about those things, unfortunately, so we can only speculate.

Natural History

Flatbacks are widespread and abundant in Australia's shallow coastal waters and travel as far north as the Arafura Sea in Indonesia and Gulf of Papua in Papua New Guinea. Occasionally they are also found among the islands of Indonesia. They live in the neritic zone, where bottom depths do not exceed 650 ft (200 m), but mostly inhabit waters less than 200 ft (60 m) deep. Unlike all other species of sea turtles, they lack an oceanic phase. Regular inhabitants of shallow, turbid waters and bays between the Great Barrier Reef and the mainland of Australia, to the northwest they occupy similar habitats in Australia's Gulf of Carpentaria and the Arafura Sea.

Ironically, much of what we know about flatback habitats is from reports of shrimp fishermen who used to catch flatbacks in their trawls before they began to use TEDs. We surmise that flatbacks rarely venture out into the deep ocean because they have never been seen there and have never been caught by trawlers or longline fishermen.

Analysis of the flatback's digestive system and of the contents of a few flatbacks caught in nets or washed up on beaches suggests that this turtle is a carnivore, feeding on a varied diet of invertebrates including sea cucumbers, shrimp, jellyfish, molluscs, sea pens, bryozoans, and others that live on the soft bottom.

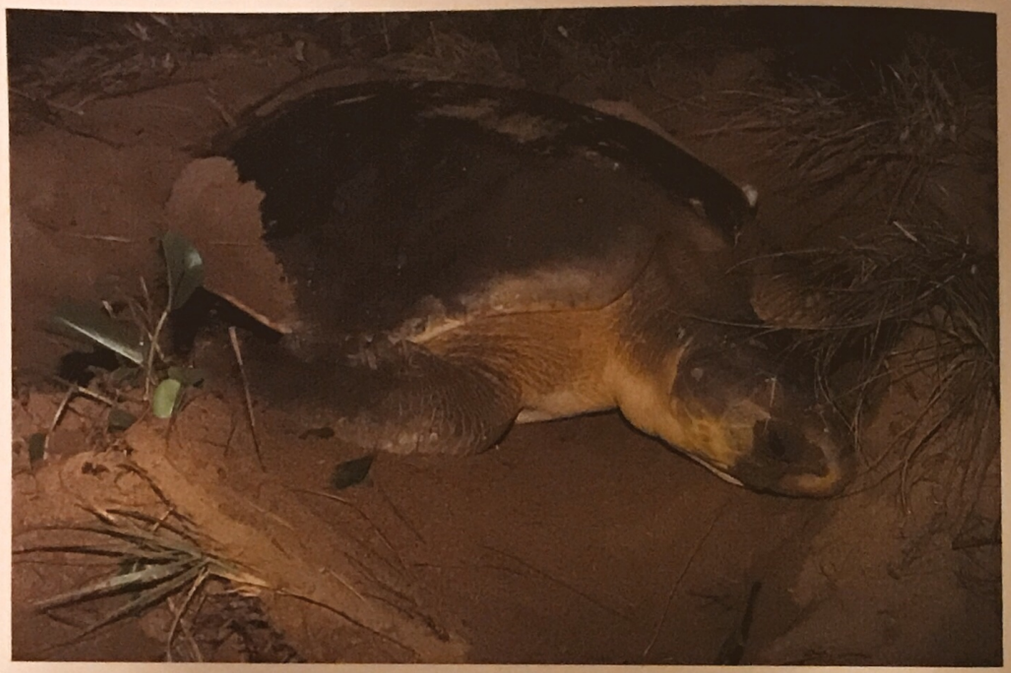
Flatbacks nest on beaches from tropical parts of western Australia eastward around the coast to Mon Repos in Queensland, just outside of the tropics. The

Major Flatback Turtle Nesting Colonies

Population Estimates of Flatback Turtles in Australia

Based on recent estimates from the Indian Ocean sea turtle assessment. There are also many minor colonies that account for hundreds of nesting females annually

Location	Nesting Females per Year	Population Size
Crab Island	3000	1000-5000
Cape Dommett	thousands	1000-5000
Mundabullangana	thousands	1000-5000
Dampier Island	thousands	1000-5000
Monte Bello Islands	thousands	1000-5000
Peak Island	less than 500	750-1300
Wild Duck Island	less than 500	750-1300
Avoid Island	less than 500	750-1300
Deliverance Island	hundreds	100-500
Woody Wallis Island	hundreds	100-500
Bountiful Island	hundreds	100-500
Fog Bay	hundreds	100-500
Eighty Mile Beach	hundreds	100-500
Greenhill Island	50-100	100-260
Curtis island	50	100-130
Aims Beach	tens	10-100
Turu Cay	tens	10-100
Red Wallis Island	tens	10-100
Slade Point	tens	10-100
South of Cape Arnhen	tens	10-100
Bremmer Island	tens	10-100
Field Island	tens	10-100
Mon Repos	10	30
		Total: 8,050- 32,520



A flatback turtle covers her nest on a sparsely vegetated portion of an island sand dune off the coast of Queensland. Flatbacks nest on exposed beaches, sometimes wandering into the vegetation.

largest nesting colony occurs on Crab Island in the northeastern Gulf of Carpentaria in Queensland. Other major nesting colonies occur at: Mundabullangana, southwest of Port Hedland in western Australia; Fog Bay, southwest of Darwin in the Northern Territory; Greenhill Island in the Northern Territory; Deliverance and Keer Islands in the western Torres Strait; and on Curtis, Wild Duck, Peak, and Avoid Islands in Queensland. Nesting in the Sir Edward Pellew Islands, on the Northern Territory's eastern coast in the Gulf of Carpentaria, may also be important. Australian biologists are in the process of describing other extensive nesting distributions.

Nesting

Flatbacks lay fewer eggs than other sea turtles but the eggs are very large considering the species' body size. They're almost as large as leatherback eggs. During a nesting season flatbacks lay two to four clutches of 54 eggs per clutch, each egg weighing 2.7 oz (77 g). Why this turtle lays so few, big eggs is a question that fascinates many sea turtle biologists. Which is the better survival strategy—produce many small eggs in the hope that one or two might make it to adulthood, or produce fewer, larger eggs too large, perhaps, for some smaller predators? It is yet another sea turtle mystery waiting to be solved.

The Advantage of Big Eggs

Scientists often wonder why a species "chooses" fewer larger offspring rather than more but smaller babies. The flatback provides a case in point. Proportional to its body size, the flatback turtle produces the largest egg of any sea turtle. What advantage might there be to this evolutionary strategy? The flatback spends all of its life in shallow coastal waters, unlike other sea turtles that swim out into ocean currents and get carried away into the deep and vast oceanic zones of the oceans. In other words, flatbacks stay close to home. Perhaps the large size of the hatchlings that come out of those eggs protects them from some predators on the beach or perhaps allows them to avoid predators in the nearshore waters where they spend the early part of their lives. In addition, the large egg may give the developing embryo an advantage in the hot sand during the summer on many of their nesting beaches. Flatback eggs experience temperatures as high as 97°F (36°C) during incubation, which is among the hottest temperatures experienced by any sea turtle egg. Larger eggs heat up more slowly.

If a flatback turtle lives 26 years as a reproductive adult under natural conditions (first egg laid to last egg laid—a conservative estimate), then she would likely lay eggs in 10 nesting seasons and lay about 1,512 eggs in a lifetime. If 80% of eggs result in hatchlings reaching the sea, then about 1,210 hatchlings remain. If we assumed that each female replaced herself and one male (a stable population), the odds of survival to maturity would be one out of 756 for each egg and one in 605 for each hatchling that reaches the sea. Apparently, a large size gives a flatback hatchling a better chance of survival to adulthood in its nearshore environment, even though that chance is pretty small.

Flatbacks take about an hour to an hour and a half to lay their eggs. Laying a clutch every 16 days during an individual season, reproductive females will return for the nesting season every two to three years.

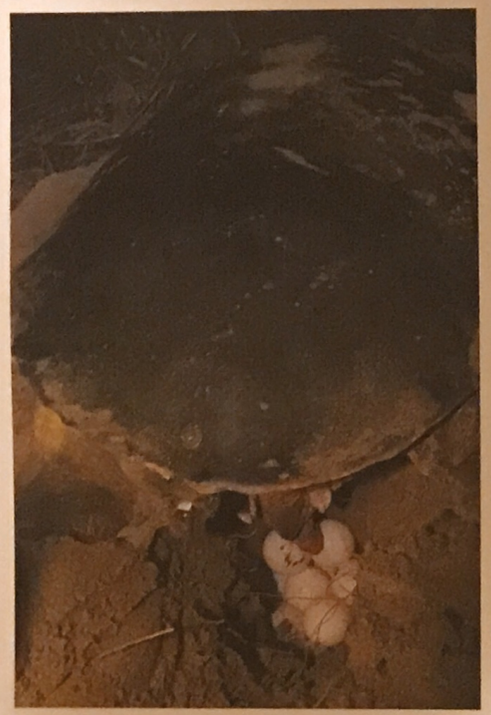
Mating appears to occur shortly before the first nesting. Because the skin is so soft it is easy to see the effects of the males' biting and scratching that is common to turtle courtship. When females come ashore to lay their first clutch they have fresh scratches on their heads and carapaces, but these injuries heal as the nesting season continues and no new scratches appear during the season. Because turtles can store sperm for long periods of time, using it to fertilize many clutches, female flatbacks may need to mate for brief periods (perhaps only once) for an entire season of egg laying.

The nesting season varies. On the southern Queensland coast flatbacks nest primarily between October and January. On Crab Island and elsewhere in the Gulf of Carpentaria they nest year-round, peaking from June to October. At Fog Bay flatbacks nest between March and October during the dry season and at Mundabullangana they nest between October and February during the rainy season.

These variances are probably explained by differences in local climate. For example, in Queensland the sand is too cold for turtle eggs to develop before October. In late July the sand temperature at nest depth is 67°F (19.3°C) and by October it climbs to 80°F

(26.8°C). During the nesting season the temperature within the nest increases to more than 95°F (35°C) in the latter part of the nesting season. At Fog Bay sand temperatures can reach more than 93°F (34°C) during most of the nesting season.

Flatbacks nest on exposed, mostly undeveloped beaches that usually have sand dunes, often with vegetation such as trees (Australian pine, *Casuarina equisitifolia*), coastal dune grass (*Spinefix*), convolvulus or morning glory (*Ipomoea*), and low herbs. Generally nesting at night within a few hours of the high tide, flatbacks sometimes nest in the daytime, often in the late afternoon when the high tide occurs near sunset and the beach is cooling off. This is probably to avoid overheating. Their light-colored carapace helps slow down their heating rate. Cloudy and rainy days should pose no overheating problems. No one has studied flatback daylight nesting sufficiently to address these mysteries of temperature regulation.



Flatbacks lay very large eggs but fewer of them than other sea turtles. The button-like device on the rear of this carapace is a data logger. It will record depth and time of dives.

Flatbacks dig a nest about 20-24 in (50-60 cm) deep at the bottom and about 11-12 inches (28-31 cm) at the top of the eggs. Most nests are placed along the leading edge or at the top of the first dune though some turtles cross over to lay eggs on the secondary dune.

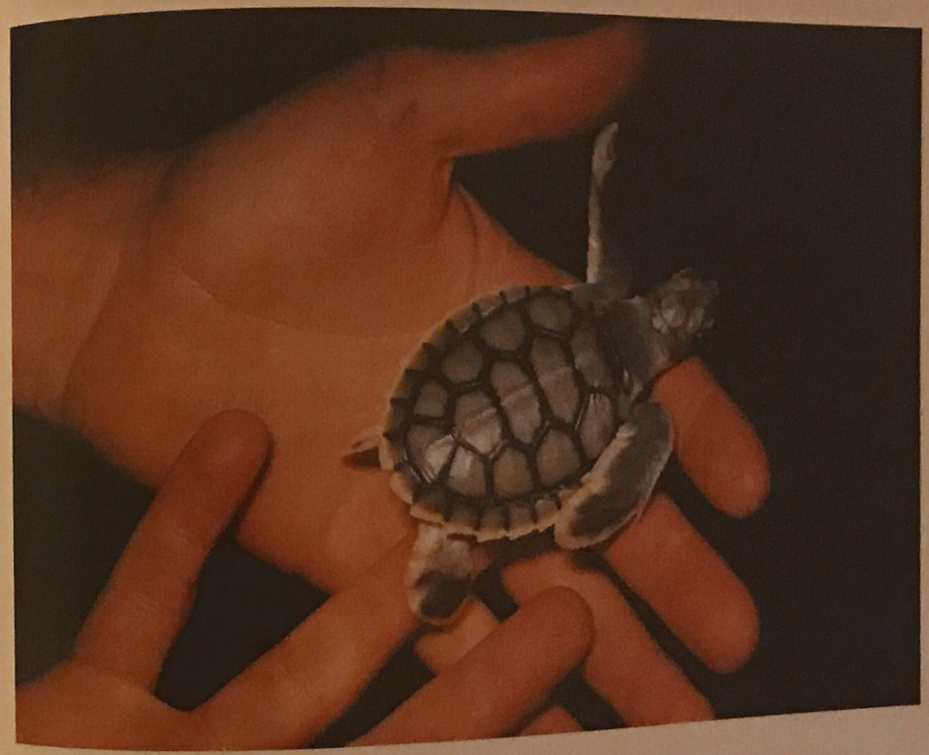
Saltwater crocodiles (*Crocodylus porosus*) eat nesting flatbacks much like those that eat olive ridleys at Playa Nancite, Costa Rica. Crocodiles track down female turtles at night as the flatbacks make their way up the beach to nest. In the morning one can find only the intersecting tracks, some blood, and a few pieces of turtle shell. There has been at least one documented attack on a turtle researcher sleeping atop a sand dune on a flatback nesting beach.

Recently scientists observed a flatback attack on Crab Island, Queensland. A 13-foot crocodile grabbed the turtle in the surf and bit down on it a few times. Then the crocodile rolled over and over until it ripped a flipper off in its mouth, swimming away with its meal. After swallowing the flipper it came back to the edge of the beach, opened its mouth two or three inches, and bared its teeth to the investigators. While it spent the afternoon swimming back and forth along the shore, the scientists stayed on land and kept their distance.

From Egg to Hatchling

Incubation takes about 48-66 days depending upon nest temperature. The pivotal temperature for sex determination is 85°F (29.5°C). On most beaches the temperatures at nest depth are 82-90°F (28-32°C) during most of the nesting season. Temperatures within the nest vary by 0.3-2°F (0.2-1°C) during a 24-hour cycle. The heat created by the eggs' metabolism warms the nests by as much as 13°F (7°C) during incubation. This temperature variation should provide a mixed sex ratio among the hatchlings but we don't yet have quantitative studies of sex ratios on nesting beaches.

Flatback embryos can tolerate very high temperatures during incubation. Some of the hottest temperatures ever recorded in sea turtle nests were in flatback nests (98°F/36.5°C), but these temperatures do not reduce hatching success. When the



This flatback hatchling shows the distinctive coloration of its species and the large size; compare it to the loggerhead hatchling on page 174.

1.5-oz (42-g) hatchlings emerge from the egg they are almost as large as leatherback hatchlings. They may also carry large amounts of undigested yolk, which offers them an extra food supply until they begin eating in their new ocean environment.

Hatching success is generally high on most isolated island beaches, ranging from 70-95 percent. Larger clutches appear to have a higher hatching success. However, on some beaches predators kill a high percentage of the hatchlings. At Fog Bay a large lizard called the sand goanna or sand monitor (*Varanus panoptes*) destroys 52-67 percent of the nests each year. At Crab Island birds such as rufous night herons

Tagging Turtles

Sea turtle biologists have been tagging turtles since Tom Harrison started that practice in Malaysia in the 1950s. Sometimes tagging is done with no particular purpose in mind and we say a person has a "tagging reflex." The new investigator or volunteer tags sea turtles because they do not know what else to do. However, in many cases tagging of sea turtles produces extremely valuable information about their biology. For example, we have learned more about the biology of flatback turtles from tagging them on the nesting beach than from any other method.

Colin Limpus, a researcher with the Queensland National Parks System, has possibly tagged more turtles than anyone alive today. His 30 years of effort have yielded some impressive results as well as some cases where tens of thousands of tags have yielded very little. He actually knows the detailed history of many individual sea turtles because he has tagged them on the nesting beach, captured them on their foraging grounds and recaptured them in subsequent years. He has conducted ultrasounds on the tagged turtles and developed techniques that allow him to predict when they will nest. Studying the same females in the water and on the beach, Colin has taught us much about the reproductive cycles of sea turtles. But it all begins with a little tag that allows him to recognize who's who in Australia.

Top: A Crittercam on a leatherback records the turtle's behavior. Left: Flipper tags are a basic tool used in most sea turtle studies.

How to Tag a Sea Turtle

The tagging of sea turtles involves several types of simple tags. The first is a clip, either metal or plastic, with a number and notification instructions. The metal clips are more common and typically made of Monel or inconel (both alloys) or titanium. The tag is usually clipped on to one of the front flippers. The Monel and inconel tags have been used for years and have the advantage of preventing the growth of marine organisms on the tag. However, these two tag types seem to mildly irritate the flipper and are often shed over time. Titanium tags remain on turtles more reliably but have the disadvantage that barnacles and other marine animals readily grow on them and can add a great mass of material to the tag. This bio-fouling can also cause the tag to rip out of the flipper. The plastic flipper tags seem to fall off and break down quite quickly.

A very different type of tag is the passive integrated transponder or PIT tag. It is a small integrated circuit with a tiny antenna that is encapsulated in a sterile glass capsule. The total size of a PIT tag is somewhere in the range of a grain of rice. The PIT tags are easily attached using a needle and syringe injection to the shoulder of a sea turtle. A special battery-powered reader sends a signal to the tag and energizes it. The reader then captures a numerical code from the tag providing the researcher with a unique ID number. The PIT tags were first tried on Kemp's ridley turtles with mixed success. However, researcher John Parmenter demonstrated the utility of PIT tags during a study of flatback turtles at Wild Duck Island. He found that 40% of the Monel tags and 37% of the titanium tags were lost over a five-year period and by eight years 100% of the Monel tags and 40% of the titanium tags were missing. The failure rate of PIT tags was less than 1% over nine years. Donna McDonald and Peter Dutton were inspired by Parmenter's success and employed the method on leatherbacks at St. Croix in the U.S. Virgin Islands. Their results and that of others since suggest the PIT tags have been over 98% reliable. The disadvantage of PIT tags is that one needs not only a reader, but also one that is compatible with the inserted tags. Luckily people tagging turtles are making an effort to standardize, but some government laws restrict bias in favor of a single company.

(*Nycticorax caledonicus*) kill up to 38 percent of the hatchlings during some periods of the year. These herons cannot swallow the entire hatchling so they peck out the soft body parts and leave the shell. Other avian predators include Australian pelicans (*Pelecanus conspicillatus*), black-necked storks (*Xenorhynchus asiaticus*), white-bellied sea eagles (*Haliaeetus leucogaster*), brahminy kites (*Haliastur indus*), whistling kites (*Haliastur sphenurus*), and ospreys (*Pandion haliaetus*).

Ghost crabs (*Ocypoda cordimana* and *Ocypoda ceratophthalma*) capture only a few hatchlings because the young turtles are too large for the crabs to handle effectively. On the mainland beaches of eastern Queensland, introduced red foxes (*Vulpes vulpes*) used to dig into nests at all stages of incubation and eat hatchlings crossing the beach at night. Dingos (*Canis familiaris dingo*) also raided nests by day and night. Baiting programs, however, have reduced these threats in many areas. On some mainland beaches, however, wild pigs dig up many flatback nests.

We know very little about the early life of flatback turtles. Once they leave the beach, hatchlings disappear into the coastal waters. Instead of swimming off to an oceanic stage like other sea turtle species, they stay in shallow coastal waters and feed on small jellyfish and other floating objects. It's surprising that we know so little about a sea turtle that remains so close to the land all of its life.

Migrations

Although flatbacks do not seem to venture beyond the continental shelf, they do migrate great distances after nesting. They also seem to return to particular feeding areas after nesting. Two turtles from Mon Repos were recaptured at feeding areas 134 miles (216 km) and 789 miles (1,270 km) north, respectively. Two Peak Island nesters traveled north 807 miles (1,300 km) to Princess Charlotte Bay along the York Peninsula. Another flatback migrated 640 miles (1,030 km) to Cape Bedford. A fourth swam 217 miles (350 km) north to Newry Island where it was caught in a trawl and released 235 days after nesting. She returned to Peak Island 16 months later and nested again. In contrast, flatbacks that nest in Queensland do not migrate through the deep oceanic waters of the Coral Sea.

Flatbacks, like olive ridleys and loggerheads, spend considerable time floating on the surface of the water in a manner that suggests they are basking in the sun. Sea birds take advantage of the situation and rest on the turtles' backs. At times the turtles appear to be asleep. Perhaps they are warming up to digest their food.

A Remarkable Turtle

One flatback that nested at Mon Repos beach in Queensland during 2003 had a very interesting story to tell. Australian biologist Colin Limpus tagged her (number X8473) in 1977 and reported on her in a scientific article published in 1984. Now, 26 years later, she is still returning to lay eggs on the same beach. She has returned to nest 12 times (about every other year, occasionally skipping two years), generally in a 1-mile (1.5-km) stretch of beach. Turtle X8473 lays 2-4 clutches per season and does not show any signs of slowing down her reproductive output. She is still growing, but very slowly—less than 0.1 in (2 mm) annually.

When Limpus examined her ovaries with his laparoscope in December 1982 he confirmed that she had not laid eggs in 1981, a year he also did not see her at Mon Repos. When she returned in 1987 several recent fractures were seen in her carapace, probably from a collision with a vessel or from being hauled up in a shrimp trawl and thrown on the deck. She still has scars from that incident.

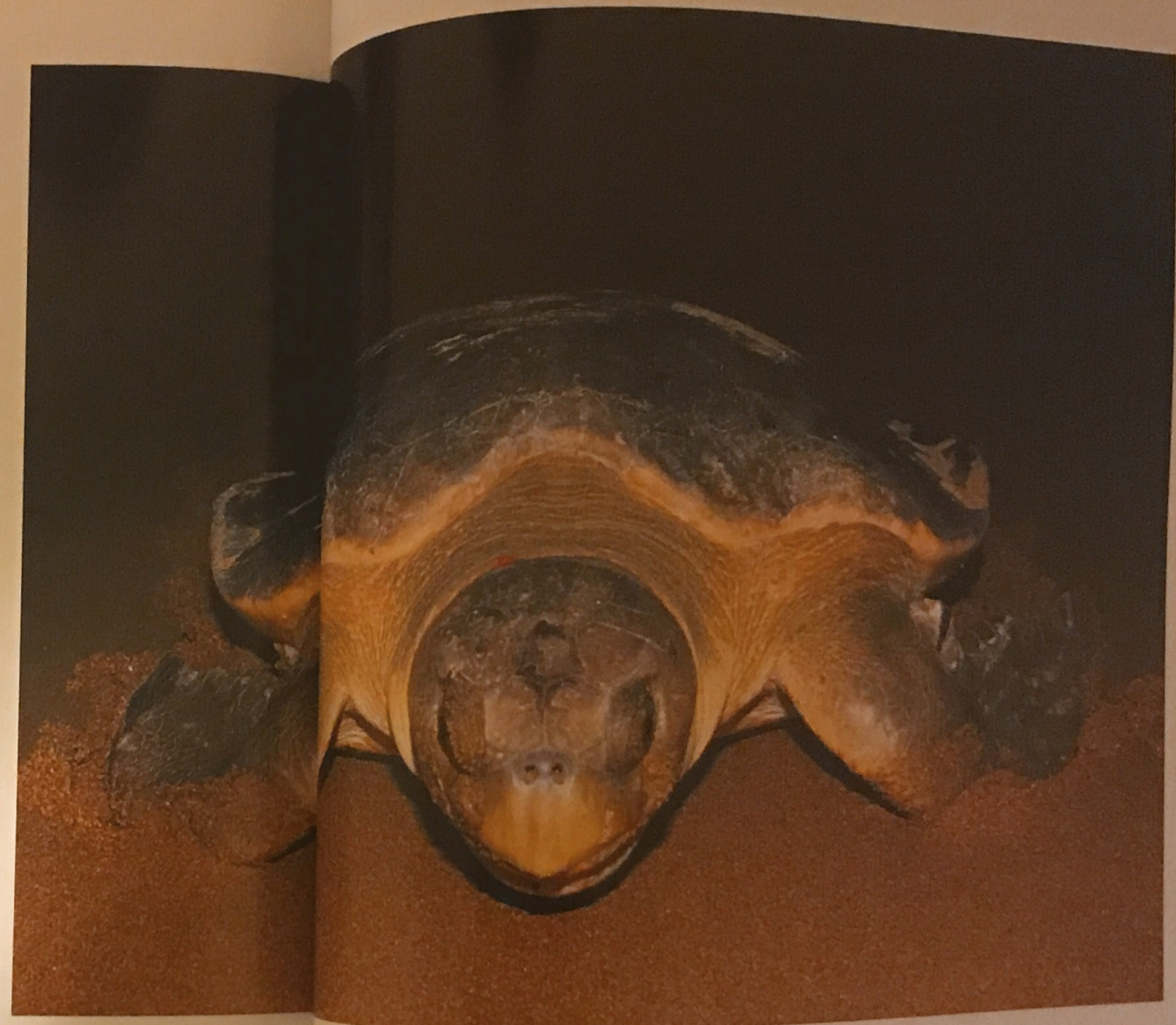
Dr. Limpus has spent the better part of his career with X8473, and although he has learned much about her we still do not know where she lives when she is not nesting or what she does when she is in her home waters. We hope she will survive so that we can continue the long-term studies that are needed to unravel her story and those of her species.

How Many Flatbacks Are There?

Most sea turtle species are in serious trouble because they are being collected on beaches, caught in gill nets and trawls, or hooked on longlines. The flatback is an exception. Because its range is restricted to Australian waters, protecting the flatback presents fewer challenges than those of the other species. No international treaties are needed for its conservation.

The Australian government, to its great credit, protects nesting beaches and turtles at sea. Although in the past many flatbacks were killed in shrimp trawls, since 2000 all trawlers in two of the three largest trawl fisheries in Australian waters have had to use TEDs. There are ongoing discussions about the need for TED use in the third.

Today there are about 10,000 flatback turtles nesting in Australia each year, and some 25,000-30,000 mature females overall. Yet all is not well with the flatback turtle. The Australian government and the Queensland state government have listed flatbacks as "Vulnerable" and the Australian Marine Turtle Recovery Plan considers northern Australian flatback populations to be at significant risk from predation. More work is needed to learn about and protect this unique sea turtle.



The flatback turtle has relatively soft skin on its carapace which shows the scratches from mating for several weeks. This turtle carries a barnacle on the right edge of its carapace. Even though vigorously protected, this species is still threatened in some areas by trawling.