

# Swimming the Gauntlet

BY DAVID BOOTH

**For sea turtles that nest on coral cays, the most dangerous time in their life is the first few minutes of swimming across the fringing reef while making their way out to the open ocean.**

All sea turtle species have a similar life history pattern. They emerge from nests on their natal beach after 6–8 weeks of incubation and frantically scramble down the beach into the awaiting sea. They then enter a “swimming frenzy” where they swim almost non-stop for approximately 24 hours in order to reach currents that will take them out into the open ocean hundreds and sometimes thousands of kilometres offshore.

Once in the open ocean, hatchlings remain in the top few metres of the water column feeding on plankton for 10–20 years in what has been termed “the lost years”. After this time, once they have reached “dinner plate size”, all species except leatherback turtles (which remain in offshore water throughout their life) move to coastal waters and switch from a pelagic plankton-feeding lifestyle to a bottom-feeding lifestyle.

These juvenile sea turtles then spend a further 10–20 years growing to sexual maturity in the near-shore waters. Sea turtles remain in these localised feeding grounds for the rest of their lives, only migrating once every 4–6 years to mating and nesting grounds in order to breed.

Females usually return to the region of their natal beach to nest. How they are able to do this some 30 years after

leaving as a hatchling is still a great unknown mystery of sea turtle biology.

Once off the nesting beach the females mate, often with several different males. They store the sperm in their oviducts, which will fertilise their eggs over the following weeks. The female then crawls up the beach and constructs nests before laying a clutch of approximately 100 eggs. She returns to the water and stays in the vicinity, returning to the beach at roughly 2-week intervals some two to six times in a nesting season before migrating back to her home feeding grounds.

Female sea turtles lay a large number of eggs in their lifetime – probably somewhere between 1000 and 3000 eggs – so it is clear that most eggs and/or their resultant hatchlings are doomed to perish before reaching adulthood. Indeed, it is estimated that only one hatchling in 1000 survives to be an adult.

On coral cays, which are surrounded by fringing reefs that are the home of thousands of hungry fish, the greatest death rate occurs as the hatchlings frantically swim their first few hundred metres through the shallow waters above these reefs. Green turtle hatchlings (*Chelonia mydas*) have only one strategy when swimming the gauntlet of these fish predators: put your head down and swim as fast as you can. They take no evasive

action when approached by predatory fish.

On Heron Island, which is located on the southern end of Australia’s Great Barrier Reef, one in three hatchlings are eaten by fish before they are able to cross the fringing reef and reach the relative safety of deeper water over the reef’s crest. Once in this deeper water they continue to swim offshore for 24 hours or more, using cues such as swimming perpendicularly to wave fronts to maintain their offshore direction.

Given the great importance of this initial swim to the survival of newborn hatchling green turtles, I became curious about how hatchlings should focus their swimming effort and also how much energy hatchlings used during this period of frantic swimming activity. I hypothesised that hatchlings should use a sprinter’s approach and put their greatest swimming effort and energy expenditure into the first few minutes of swimming after entering the water so they can swim the relative short distance across the predator-rich shallow waters of the fringing reef as quickly as possible.

To test this idea I needed to measure the swimming effort and rate of energy expenditure of hatchlings within minutes of them emerging from their nests. The University of Queensland’s research station on Heron Island was the ideal place to work because the laboratory is only a few hundred metres from where the hatchlings emerge from their nests.



**Figure 1. A corral set up to trap green turtle hatchlings as they emerge from their nest.**

Photo: David Booth



**Figure 2. A green turtle hatchling fitted with a swim suit swims in the test chamber.** Photo: Nick Holmes

The first job was to catch hatchlings as they left the nest. This was done by placing corrals on the sand above nests that were near hatching (Fig. 1). Corrals were visited regularly throughout the night so that a hatchling could be collected within minutes of reaching the sand's surface. The hatchling was transported in a bucket to the laboratory, where it was weighed and its carapace length and width measured. The hatchling was then fitted with a lycra swimsuit that had a tether made of fishing line attached to it (Fig. 2).

The hatchling was then placed into a swimming chamber made of plexiglass filled with seawater maintained at 28°C, a temperature similar to that of the seawater surrounding Heron Island. A lid was fitted to the chamber and the tether threaded through a hole in the lid and connected to an instrument called a force transducer, which measured the forward thrust produced with every swim stroke.

The output of the force transducer was recorded on a computer 40 times per second. At the same time, air was pumped out of the chamber and into an oxygen analyser, which enabled the calculation of the amount of oxygen consumed by the swimming hatchling on a minute-by-minute basis. Oxygen consumption is equivalent to the rate of energy expenditure.

A light at one end of the chamber encouraged the hatchling to swim towards it. Once sealed in the chamber, hatchlings settled down into their regular swimming behaviour... 5–10-second bursts of power-stroking with their large front flippers separated by 2–5 seconds of “dog paddling” (Fig. 3). Hatchlings were swum continuously for 18 hours and then released into the sea.

As predicted, swimming effort was greatest as soon as hatchlings started to swim, and the rate of energy expenditure paralleled their swimming effort (Fig. 4). Swimming effort over the entire 18-hour

monitored period could be divided into three distinct phases:

1. a rapid fatigue phase at 0–2 hours when swim thrust decreased from 45 mN to 30 mN;
2. a slow fatigue phase at 2–12 hours when swim thrust decreased from 30 mN to 25 mN; and
3. a sustainable swimming effort phase between 12–28 hours when swim thrust was maintained at 25 mN.

Clearly it makes sense to concentrate the greatest swimming effort immediately after entering the water because it is during this time that hatchlings are swimming across the predator-rich shallow waters of the fringing reef. The shorter the time spent crossing the fringing reef, the greater are the chances of a hatchling surviving the reef crossing. Once the relatively deep water over the reef crest has been reached by the hatchling, the rate of fish predation decreases dramatically, so it is not so important to swim as fast as possible.

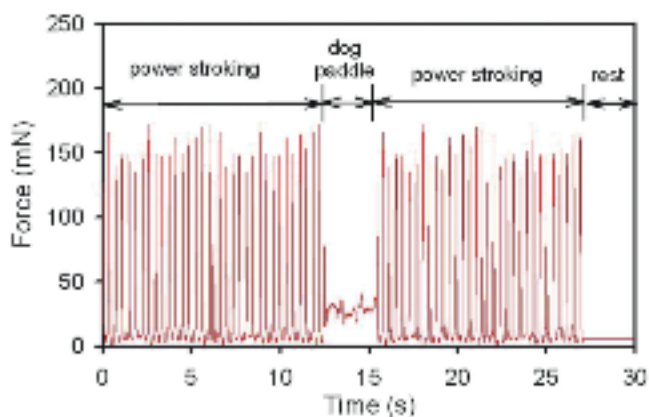


Figure 3. An example of the swim thrust output showing the different swimming activities: power stroking, dogpaddling and resting.

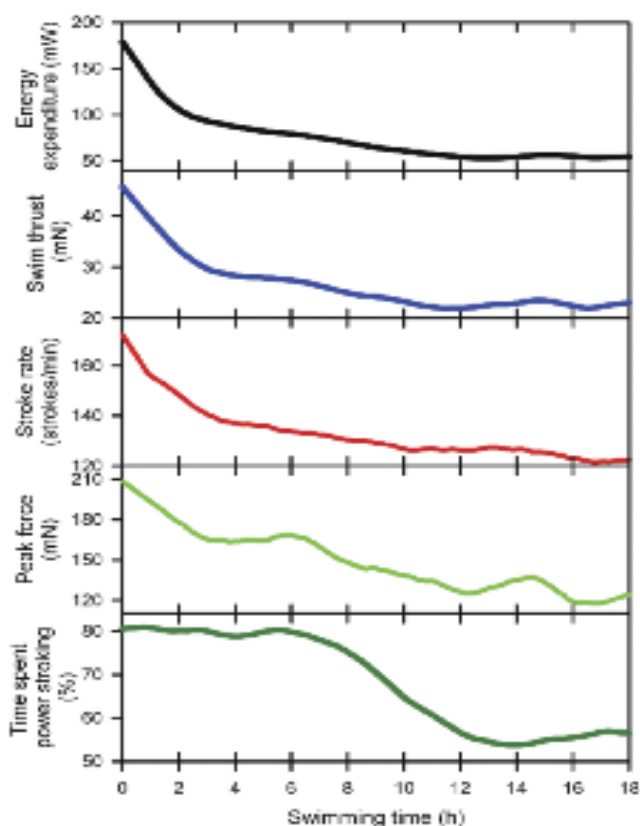


Figure 4. The patterns of rate of energy expenditure, mean swim thrust, rate of power stroking during a power stroking bout, peak thrust during power stroking, and proportion of time spent power stroking during the first 18 hours of swimming in green turtle hatchlings.

It is interesting to note what aspects of a hatchling's swimming contribute to the decline in effort observed during the first 12 hours of swimming. In the first 2 hours of swimming there was a dramatic decrease in the power-stroking rate within a power-stroking bout (from 200 to 145 strokes/minute). This was followed by a slow but steady decrease until the stroke rate stabilised at 130 strokes/minutes from 12 hours onwards.

Likewise, mean maximum thrust per power stroke fell rapidly during the first 2 hours (from 210 mN to 170 mN) and continued to fall steadily until it stabilised at 130 mN from 12

hours onwards.

Surprisingly, the proportion of time spent power stroking remained constant at 80% for the first 6 hours, decreased steadily between 6 hours and 12 hours before stabilising at 55% after 12 hours of swimming.

Calculations from the rate of energy expenditure and the amount of stored energy in the residual egg yolk that is absorbed into the hatchling's abdomen while the hatchling is still in the nest indicated that the decrease in swimming effort during the first 12 hours of swimming is caused by muscle fatigue rather than running out of energy. I calculated that, on average, a green turtle hatchling has about 50 kJ of energy stored in its residual yolk when it enters the water. However, only about 5 kJ of energy is expended during the first 18 hours of swimming, so there is more than enough energy stored in the residual yolk to fuel swimming during the first day.

Indeed, the hatchling has enough energy stored to survive 10–14 days of near-continuous swimming without the need to feed, although hatchlings have been observed to start feeding within 2 days of entering the water. Clearly there is a good safety margin built into the residual yolk energy store in case food is hard to find within the first 2 weeks of hatchlings entering the sea.

Now my research group is exploring what factors may influence a sea turtle hatchling's swimming ability. Laboratory incubation studies have shown that eggs incubated at 26°C (which produces only male hatchlings as sea turtle gender is determined by the incubation temperature during the middle third of embryonic development) produces hatchlings that are much weaker swimmers than eggs that are incubated at 28°C (which produces both male and female hatchlings) or 30°C (which produces only female hatchlings). But is this true for natural nests, where nest temperature changes continuously unlike the laboratory where temperature is kept constant?

To answer this question we are placing miniature temperature data loggers directly into natural nests when the eggs are laid and then measuring the swimming ability of hatchlings when they emerge from the nest. In preliminary results we were surprised to find that there is a wide range in swimming ability of hatchlings emerging from the same nest, and not so surprised to find that there is significant variation in swimming ability between nests.

It is too early to tell yet if differences in nest temperature can explain inter-nest differences in hatchling swimming ability, and what effect the general increase in nest temperatures expected due to global warming may have on sea turtle swimming ability. We hope to be able to answer these questions in the coming years.

David Booth is a senior lecturer in zoology in the School of Biological Sciences at the University of Queensland.