

### A Swimming Success

With its big flippers, flexible shell, and insulating layer of blubber, the leatherback turtle (*Dermochelys coriacea*) seems well suited for life in the ocean. Yet we know almost nothing about how these rare reptiles swim

around in the wild. How fast do they go, and how far can they swim in a day? By tracking seven female leatherbacks with radio transmitters and velocity recorders, Scott Eckert, of the Hubbs-Sea World Research Institute, has discovered that contrary to popular belief, momma turtles are outstanding endurance swimmers that travel over great distances with hardly any rest (p. 3689)!

Keeping up with sea turtles can be gruelling, Eckert admits. By day, he's out on the water searching for leatherbacks and monitoring their movements. By night, he's trudging up and down the beaches of St. Croix (US Virgin Islands) looking for nesting females. When he finds one, he puts a simple harness on the animal, attaches his recording instruments, and waits to see what the turtle does once it leaves the beach. "Leatherbacks are pretty easy to deal with," says Eckert. "They don't bite, and they don't run away."

Previously, Eckert had tracked how deep the turtles dived in the ocean, and he found that they spent a lot of time at the surface during midday. This made him think that leatherbacks might be basking in the sun to rest after a long night of diving for food. But he hadn't measured how fast they moved. The only way to really understand how the animals behave in the wild was to track their speed as well as their depth.

But the only previous measurements of leatherback swimming speeds weren't completely reliable, because they were made while animals were being pursued by boat. So, Eckert had a "turtle speedometer" custom-built. When females came to the beach to nest, he attached both the speedometer and a depth meter to their backs and recorded what they did once they returned to the water.

To his surprise, instead of putting their fins up and taking a rest at the surface, the turtles hardly ever stopped swimming, whether it was day or night! And they managed to keep up a high speed too, swimming continuously near the surface at  $0.6 \text{ m s}^{-1}$  and travelling 50 km per day. So rather than being layabouts, leatherbacks are true masters of the marathon. Eckert also noticed that the turtles tended to dive down below 100 m during the day (sometimes exceeding 500 m), but at night the dives were shallower and more frequent, matching the whereabouts of their favourite snack – jellyfish.

Eckert would now like to know how their diet and metabolism help make them such economical swimmers and divers. Ultimately, he hopes that we can use this information to design more effective conservation strategies to protect this endangered species. If we understand the physiology of leatherbacks as well as their migration and feeding patterns, Eckert explains, we can better define how the species uses critical ocean habitats. That would help us reduce the impact of human threats like fishing nets, boats, and plastic bags. Seeing as these majestic creatures have been around for 90 million years, it seems the least we can do.

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### Tryptophan Sweetens Fishes' Temper

Modern life is stressful, and as Svante Winberg explains, living under stress for a long time affects more than just your mood. For fish living in

the cramped conditions of an aquaculture unit there is no escape from the stress. Winberg knew that if he could begin to untangle the stressed-out fishes' physiology, he might be able to help them overcome some of the nastier side effects of stress. Taking a dietary approach to stress relief, Winberg and his team began testing how fish responded to stress after they had been fed a key neurological precursor, tryptophan. To their surprise, they found that a tryptophan supplement changes the way that fish control their hormonal stress response, possibly protecting them from the negative effects of stress (p. 3679).

One of the earliest physiological responses to physical stress is when the neurotransmitter, serotonin, is released deep in the brain, triggering a neurological cascade that culminates several minutes later in the release of the stress hormone, cortisol, into the blood. Animals that suffer continually high levels of stress, live with high levels of cortisol all the time, but the beneficial effects of the hormone begin to fail after several days, and more sinister side effects of the hormone begin to appear. Winberg wondered if he could somehow reduce the cortisol response to stress, and consequently the damaging effects of long-term cortisol exposure.

Winberg already had a clue that tryptophan might help. He knew that fish fed on a tryptophan-supplemented diet for a week became less aggressive, and that tryptophan is the key building block of serotonin. Could tryptophan in the diet affect the fishes' cortisol response too?

Together with Oliver Lepage and Olof Tottmar, Winberg transferred individual trout to the least stressful environment possible for a fish; their own private tanks. Once the fish had adjusted to their solitude, the team began feeding the fish different doses of tryptophan, long enough for the fish to become completely de-stressed. Only then did they raise the stress, by dropping the water level.

Winberg explains that he had expected to see the stressed fishes' cortisol levels rise as the water level fell. To their amazement, these fish hardly changed their cortisol levels at all, even though they were producing and using more serotonin!

But how had the tryptophan diet affected fish that hadn't been stressed? Had the excess amino acid in their diet affected their cortisol levels too? It had. Winberg explains that even though the effect was subtle, the unstressed fish on the tryptophan diet had slightly higher cortisol levels.

At first sight this didn't make sense, why didn't the extra serotonin in the stressed fishes' brains produce a huge cortisol response when the fish needed it? Winberg thinks the answer could be in the way that the hormone levels are controlled.

As well as initiating the release of cortisol, serotonin is thought to switch the response off too. Winberg explains that it is possible that that higher levels of serotonin in the brains of tryptophan-dosed fish might reduce the cortisol response to stress, rather than increasing it. So tryptophan could be an ecological alternative to Prozac for keeping farmed fish calm.



### How the Shark Got its Hammer Head

If Rudyard Kipling was writing a 'Just So' story for the hammerhead shark, he'd surely have come up with a tale of a three way

struggle that produced the fish's distinctive profile. Although Kipling's story would be highly entertaining, Stephen Kajiura has got a much more realistic theory. All sharks are endowed with an electrical sense, that allows them to sense the weak electrical fields that most creatures emit. Kajiura wondered if the hammerhead's

odd shape gave it a head start over other electrosensing sharks. Tempting hammerheads and more classically shaped sharks with decoy dipoles, Kajiura has discovered that the shark's extended head allows it to search for food over much larger areas than its more streamlined relatives (p. 3609).

There are a variety of possible explanations for how the fish's distorted features evolved, ranging from wide angle binocular vision and stereo smell to electroreception. Sharks are one of the few species that specialise in electroreception, and as no other species on the planet has evolved such a distinctive head shape, Kajiura wondered if it had evolved to somehow enhance the fish's electrical sensitivity. He decided to compare the electrical sensitivity of young hammerheads with the sensitivity of a narrow headed shark to see if it might be the clue that explains why the shark went out on this evolutionary branch.

Kajiura set up a seawater enclosure where he could keep the young sharks happy before testing their senses. Collecting the young sharks was also relatively straightforward, but he remembers that building the dipoles to fake a small fish's electric field was far from simple, until he optimised the dipole's strength by applying a  $6 \mu\text{A}$  current across a 1 cm dipole.

Ready to start testing the fish's electrical reflex, Kajiura tempted

individuals towards the dipoles with a whiff of tempting squid essence, before switching on one of the dipoles at random, and videoing each shark attack to see how close the shark had to swim before the dipole sparked its interest. But when he compared the fish's sensitivities, both species seemed to sense the field at the same level. The head's distinctive shape apparently hadn't enhanced its electrical sensitivity! But Kajiura knew that the shark's extended head could bring another benefit; it simply covers more ground. Put in terms of football fields, Kajiura explains that while the electrosensitive head of a 60 cm sandbar can only cover an area the size of half a football field everyday, a better endowed hammerhead's head can cover almost three times as much ground in the same time.

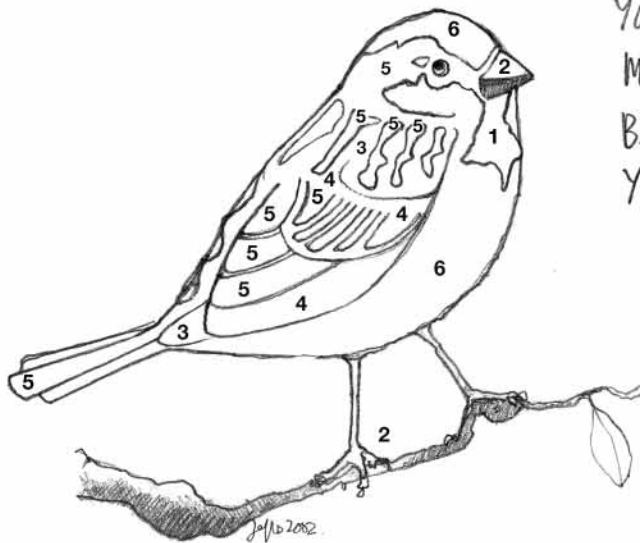
Looking back at the hours of videotaped hunting approaches collected over two field seasons, Kajiura also realised that the hammerheads are significantly more agile than the stockier sandbars. Which has sent him off on his next hypothesis, does the hammerhead help this shark to turn on a pinhead?

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IT'S A D.I.Y. ISSUE THIS MONTH:  
AS THE EDITOR NEEDED THE DRAWING  
IN BLACK AND WHITE...  
YOU'LL JUST HAVE TO ADD THE  
MELANIN AND STRUCTURALLY  
BASED PLUMAGE PIGMENTS  
YOURSELVES...

1= BLACK 2=YELLOW 3=OCHRE 4=SIENNA 5=BURNT UMBER 6=SAND

*Pete Jeffs is an artist living in Paris, France.*

### Paint Your Own Plumage by Numbers

McGraw, K. J., Mackillop, E. A., Dale, J. and Hauber, M. E. (2002). Different colors reveal different information: how nutritional stress affects the expression of melanin- and structurally based ornamental plumage. *J. Exp. Biol.* **205**, 3747-3755.