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Marine turtles are amongst the most ubiquitous icons of conservation. More, in fact, than perhaps whales and dolphins, or tigers or pandas. Most countries with a coastline—even very cold ones—have some species of sea turtle along their coast. And a conservation programme to go with it. The fact that over 1000 participants from nearly 80 countries attend the Annual Symposium on Sea Turtle Biology and Conservation is testimony to both the popularity of these flagships, and the threats they face.

In this issue, we take a closer look at some of the concerns in sea turtle conservation today. Sea turtles may be particularly susceptible to climate change as hatchling sex is determined by incubation temperature; hence, rise in temperature could lead to changes in sex ratios or to mortality. Moreover, sea level changes could impact the sandy beaches on which they nest. Mariana Fuentes uses a vulnerability assessment to examine which aspects of climate change will most affect green turtle populations in the Great Barrier Reef. Rebecca Scott examines the oceanic routes of loggerhead turtles using satellite telemetry and ocean models. Jack Frazier asks the critical question: what constitutes success in conservation? Matthew Godfrey takes a closer look at the value of conservation responses to cold-stunned turtles. We also reprint J Nichols' piece from 'Catamaran'—where the ocean and the mind and turtles connect. The illustrations were generously contributed by Smitha Shivaswamy and George Supreeth (Pencil Sauce).

Arribada at dusk *Lepiodochelys olivacea*, Odisha

Kartik Shanker

Olive ridley turtles are known for their arribadas or mass nesting behaviour. Over 50,000 turtles nested on this particular night in February 2013, the most in the last decade of monitoring at this site.

Context adds depth, underwater

An inclusive method to measure impact of noise on marine mammals

Noise from ships and coastal industries is capable of traveling miles underwater and scientists have found that, in many ways, this affects marine mammals. They used to consistently record the amplitude of a sound when produced and drew concentric 'zones of influence' around it, thus measuring the potential effects of the sound on an animal. However, they had not taken into account some other equally important factors (read on to know what they are). Luckily, some scientists have taken the hint from a few earlier studies.

In one study, harbor seals were played sounds of local fish-eating killer whales, and they barely shrugged their shoulders. But when migrant mammal-eating killer whale sounds were played, the seals reacted strongly. In another study, sonar signals were relayed from a stationary ship en route of migrating gray whales. They moved around the ship and avoided it. But when the ship was moved two kilometers away, even though the sound levels remained the same, the whales didn't seem affected and continued on their original path. Clearly there was more to this than just the intensity of sound produced.

So, Ellison and colleagues proposed a new method to better assess the effects of sound on marine mammals. This approach includes contextual factors that were not taken into account earlier, such as the influence of distance between the sound source and the animal, whether the animal had heard the sound before and recognised or learnt it and whether the sound was similar to natural sounds like that of an enemy. They call for similar inclusive assessments that will help in more efficient management of all the noise we create.

Ellison W T, Southall B L, Clark C W & A S Frankel. 2012. A new context-based approach to assess marine mammal behavioral responses to anthropogenic sounds. Conservation Biology 26: 21–28. doi: 10.1111/j.1523-1739.2011.01803.x

Catalina Londono

Harbour seals (*Phoca vitulina*) pick out familiar resting spots, mostly rocky areas where they are protected from adverse weather conditions and predation, near a foraging area.

Snails ride on green turtles

First evidence of green turtles carrying passengers, piggy-back style

Young green turtles on the Uruguayan coast hang around all year at the second largest South American estuary, the Rio de la Plata, as there is plenty of food. Once they become adults, these turtles recruit to adult populations all the way in UK, Venezuela and Africa. And new evidence suggests they might be carrying several passengers with them, riding on their shell!

Lezama and colleagues in Uruguay counted the number of Rapa whelks, large sea snails, on the carapace (upper shell) of 33 green turtles that were stranded or captured on the coast. They also measured the length of the carapace and weight of the turtles, to see if the whelks had detrimental effects on their hosts. Most turtles had severe injuries on their carapaces caused by the attachment of whelks. They found an average of eight to ten whelks on a turtle and up to 49 whelks on a single turtle, causing a 20% increase in weight! It turns out that the whelks take advantage of the turtles when the latter hibernate, and easily clamber on because the carapace is a harder substrate than the ubiquitous soft sand.

The scientists also expected that whelks would be harmful to turtles and reduce the latter's body weight. But they were surprised when they found larger and heavier turtles carried more whelks. May be the healthier a turtle is, the more whelks it can support. The scientists now want to see if the added weight affects buoyancy, the extent of damage to the carapace and also how long they remain on the turtles. Do they take these free rides all the way to Africa and the UK remains to be seen.

Lezama C, Carranza A, Fallabrino A, Estrades A, Scarabino F & M López-Mendilaharsu. 2013. Unintended backpackers: bio-fouling of the invasive gastropod *Rapana venosa* on the green turtle *Chelonia mydas* in the Río de la Plata Estuary, Uruguay. Biological Invasions, 1-5.(2012).

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Rafn Ingi Finnsson

Green sea turtles (*Chelonia mydas*) are found throughout tropical and subtropical seas, with feeding and breeding grounds often separated by thousands of kilometres.

Romulus Whitaker

Sea turtle conservation in India started with turtle walks in Madras (now Chennai) on the east coast in the early 1970s and coincidentally at about the same time in Gahirmatha, Orissa, at one of the largest rookeries for olive ridley turtles in the world. Started by a group of enthusiasts, the turtle walks and conservation activities on the Chennai coast continued through state agencies (Central Marine Fisheries Research Institute and Forest Department) for about a decade.

In 1988, the Students Sea Turtle Conservation Network (SSTCN) was formed and has, for the last 25 years, run a conservation programme centred around its sea turtle hatchery. Kartik Shanker talks to Romulus Whitaker, the founder of the Madras Snake Park and the Madras Crocodile Bank Trusts (MCBT), not to mention the Agumbe Rainforest Research Station (ARRS) and the Andaman and Nicobar Environment Team (ANET). Best known for his work on snakes and crocodiles, Rom played a crucial role in starting the turtle walks and talks about the early days.

KS: I've probably asked you about this many times since we first met when I was working with the SSTCN in Madras in the late 1980s... What was the scene like in the 1970s? Why did you guys decide to do turtle walks and where did the idea come from?

RW: I've probably told you this already that by 1973 or so, the Snake Park was already well-established; almost a million people a year were already coming there. After we moved to Guindy Deer Park in the city, someone brought in a female ridley that they'd found on the beach. I think he was a fisherman. He said, "This is the kind of thing that you guys do, right? I mean, turtles and crocodiles?" So he had it right. We realised of course that we couldn't keep the turtle. But it was kind of a fun thing for all of us to do—to go to Elliot's beach, which was the closest to the Snake Park and release the turtle.

KS: And you didn't know at that point that ridleys nested on this coast?

RW: No idea, no idea at all.

KS: And you guys didn't know about the rookery in Orissa either?

RW: No. Wasn't that later?

KS: Robert Bustard visited Orissa in 1974 and discovered the rookery at Gahirmatha. But, J C Daniels and Hussain of BNHS apparently had heard of a turtle rookery in Orissa and that's 1973.

RW: Yeah, I do know that they—Daniels and Hussain—were the first to mention Gahirmatha.

KS: So when you guys saw that first ridley, you had no idea that ridleys were nesting in Madras or

anywhere else?

RW: No.

KS: That's quite a coincidence, that you were independently discovering ridleys in Orissa and Madras.

RW: If we had known, we would have looked into it and realised that ridleys were one of the main turtles nesting on this coast, but we didn't have any information.

KS: Then you guys started the turtle walks and the hatchery, right?

RW: Yeah, I think it must have coincided with other reports of people from Cholamandalam . We knew some artists there like S.G. Vasudev, Thambi (S. Nandagopal) who would say "Hey man, we saw a turtle!" And then, it sort of started clicking, that from December or January onwards, that's the time the turtles nest. And that's when the turtle walks started. Initially, it was informants—people who were just interested in coming around who went on walks. But then we really did it in a somewhat systematic way... I mean, all the way to Kalpakkam, 50 kilometres away.

KS: So, who were the people who would have been part of the first season?

RW: A bunch of us including my sister, Nina and her (now) husband, Ram Menon, Zai Whitaker, Jean and Janine Delouche, Anne Joseph, Wendy Bland. And Valliappan, who worked in Central Leather Research Institute across the road from the Snake Park. Not only was he on those first turtle walks collecting eggs and dissuading poachers, but he took the first pictures of the sea turtle slaughter at the Tuticorin Market which mobilised the Forest Department to clamp down. The turtle killers then started the "Turtle Blood Drinkers Association" to try to fight the ban—but they failed.

KS: So, what was his connection with you?

RW: He was bored with what he was doing—almost all these guys were. They were just bored with their IIT and CLRI and ABC College and God knows what else, and they just didn't want to do their thing. It was much more fun hanging out with us. They didn't know anything about reptiles.

Valliappan

Turtle slaughter at Tuticorin market

KS: Really? [laughs]

RW: And sea turtle walking, it was more fun than college. I mean, there were few other things you could do. Yeah, we could go snake hunting with Irulas, but this was something that was very cool, you know? There weren't many party scenes happening probably at the time either, so it was a good thing to do in the evening. But, we took it very seriously. And we did sections, you know, from Thiruvanmiyur south, and up to Neelankarai and further. We were doing 10-15 kilometres in one day, then often we'd just get wiped and go to the main road and take a bus back. But sometimes we'd walk all the way back—like 30 kilometers—fairly serious walking. And we dreamed about camels and dune buggies and any number of things, when we were plodding along, stepping on human shit and stuff like that.

KS: Yeah, so there's a paper written in 1973 by Valliappan and Pushparaj. I've never encountered Pushparaj either.

RW: He was one of the kids I hired when he was probably about 15 or 16, out there in Rajakilpakkam, along with Motorcycle Mani who's probably still at the Snake Park or was until recently. Two or three teenage kids started working for me. Pushparaj hung around the Snake Park when it was based in Selaiyur, that's where he lived too. He was hard working, and accompanied me and others on field work. Later, he joined the Tamil Nadu Forest Department as a guard.

In the early 1970s, when the Madras Snake Park moved to Guindy, it became a local hangout for young folks from nearby campuses like Indian Institute of Technology (IIT) Madras, the AC College of Architecture and the Madras Christian College (MCC). Even up to 30 years later, I would run into some of these guys in strange places. They're now mostly as paunchy and balding as I am and we trade a few stories and get into a laughing fit over "the good old days".

KS: Did you have a hatchery the first year you started the walks?

RW: It must have happened right on, because otherwise, why would we be walking? We'd be going to collect eggs before the poachers got them, basically.

KS: And you said that the first hatchery you had was at Jean–

RW: and Janine Deloche's ...in their yard. We built a fence with Casuarina poles and stretched bits of chainlink fencing and chicken mesh we had scrounged from here and there, mainly to keep the dogs out. We found that many nests on the beach were being dug up by dogs and jackals. We were careful to measure the original nest holes, and when we reburied the eggs, we tried to make a nest hole as similar as possible to the original.

Franz Ranacher

Samir Whitaker

KS: How many nests did you collect?

RW: We collected all of 11 nests in the first year. Over the next few years, we rescued about 20,000 ridley eggs from poachers and dogs. We released more than 10,000 hatchings and it made us all feel real good. “This is conservation action”, we thought, as we patted ourselves on the back. In later years, when we learned about temperature sex determination, we realised our approach should have been a bit more scientific.

KS: Of course, you couldn’t have known then that sex was determined by temperature in sea turtles.

RW: Bloody things, like any snake eggs, they’d incubate under the ground, and they’d hatch and you let them go, you know? And then suddenly, these buggers come up with this finding that incubation temperatures determine hatchling sex. That wasn’t till what…mid-80s or late 80s, I think.

KS: Late 1970s, mid-80s

RW: It was so cool to give a talk at that time about it, because anybody who knew anything about genetics or anything else would say [imitating a dissenter] “No, no! It’s not linked to the temperature, you idiot! It’s chromosomally linked, it’s got nothing to do with temperature!”

KS: Yes, I’ve experienced that when giving talks in schools in the late 1980s. Biology teachers were the most suspicious. Anyway, the other seminal event for me and probably for many people, is the fact that Satish Bhaskar got involved. Do you remember your first encounter with Satish?

RW: Actually I don’t. I’d like to make up something like “Sunday! It was a glorious day…it had just rained”, but no.

KS: Well, it’s amazing how people remember him. I’ve had many conversations with fellow students of his from IIT from that time and they say something like “Oh, you work on turtles! You know, back in the 70s when I was in IIT, there was this guy from IIT, who used to go on the beach and look at turtles and I’ve gone out on a turtle walk with him”. I mean, it was Satish, of course—and I keep running into these people from all over.

RW: Satish was already a legendary ‘aquaman.’ He was a soft-spoken engineering student, a non-drinker and non-smoker, a real ascetic compared to the rest of us. His passion was the sea and he spent more time swimming than in the IIT classroom. He’d run from IIT to Elliot’s Beach (a distance of 7 kilometres) every morning, swim for a couple of hours and run back to the campus, ostensibly to attend class. Opportunely (for the turtles), Satish was getting disenchanted with his IIT course and yearned to be a field man with a mission.

The thing I do remember is that when we were talking about what he could do, he said, “I’m really interested in the coast, I’m really interested in marine biology, I’d probably end up doing that.” At that time, I was being quite selfish or autocratic or whatever, and thought that there should be one person for each taxa—and that person should just do everything they can to make that taxa happen, and you know… the conservation of it, or whatever. And I said to him, “If you just concentrate on sea turtles, you’ll become “Mr. Sea Turtle”. Because there’s nobody else doing it. You know, elsewhere there’s Archie Carr and there’s George Hughes and all these great turtle people.” And Satish probably wondered, “What the hell’s this guy ranting about?” But he eventually read all these reprints that we’d started collecting. And I didn’t know it then, but Satish ended up walking almost the entire coastline of India, thousands of kilometers, giving us the very first handle on what turtles were nesting, where and what kind of numbers.

KS: Did you know what others were doing elsewhere?

RW: I have to say we were writing a lot of snail mail in those days to quite a few people around the world who were into sea turtles. As soon as we’d found out a bit about the ridleys and we realised “Shit, man… we don’t know anything, we better find out what other people are doing”. So I guess it had a lot to do with my sister Nina and Brenda, my secretary who eventually married Satish, and all these girls. They were typing all the letters and the posting that you don’t even do nowadays—and getting feedback from all these fantastic, wonderful people from all over the world… who sent their reprints, folded carefully, and their notes—coming all the way to India and stuff… and that was the thing that got us excited about continuing, because there were other people doing things much more seriously than we were.

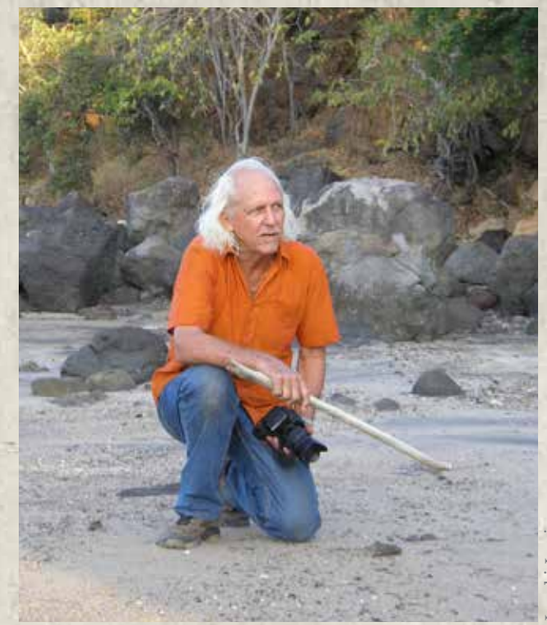
KS: So how did Satish get started?

RW: When he started hanging out at the Snake Park, we talked seriously about doing turtle surveys along other beaches around the country. The Snake Park had a tiny research budget but it was enough to hire Satish as Field Officer and get him out on his first few survey trips. When the fledgling World Wildlife Fund (WWF) saw the good work he was doing for endangered sea turtles, Satish landed his first grant which really set him in motion. After our first visits to the Andamans in the mid-1970s, I encouraged Satish to go there (we raised the funds for his travels) and start what became almost a decade of survey work for him. In 1978, Satish visited the Andaman & Nicobar Islands for the first time and like so many of us, got hooked. Over the next few years, again thanks to WWF and other funds, he visited many of the islands and most of the major sea turtle nesting beaches in the islands.

KS: And the rest of the Indian coast, and the Lakshadweep, and West Papua….

RW: I can’t imagine another human being on the planet who could have achieved what Satish did in those years.

And I didn’t know it then, but Satish ended up walking almost the entire coastline of India, thousands of kilometers, giving us the very first handle on what turtles were nesting, where and what kind of numbers.



Janaki Lenin

KS: Tell us about the Lakshadweep adventure.

RW: In 1977, Satish first went to Lakshadweep and felt that the uninhabited island of Suhelipara was the place for a green sea turtle study. The only problem was that the main nesting period is during the monsoon and no one goes there when the sea is so rough. In 1982, Satish came up with a scheme to maroon himself (with WWF funding) on Suhelipara for the whole monsoon, from May to September. That way he could collect data on green sea turtle nesting for the entire period. It also meant making elaborate preparations, like calculating the amount of food he would need. We sat with Satish and talked about things that could go wrong during this isolation—chronic toothache, appendicitis, malaria were just a few sobering thoughts. The Navy did provide some signal flares and there was talk of a radio, but eventually Satish just set sail and that's the last we heard of him till September. Actually that's not true. A few months after he was dropped on Suhelipara, his wife Brenda back in Madras, received a letter from a Sri Lankan fisherman enclosing a loving note from Satish that the fisherman had found floating in a bottle. We had always speculated whether that would really work! He had launched his message in a bottle on July 3rd. 24 days and 750 kilometres later, the bottle was picked up.

The emergency situation that arose on the deserted isle is something none of us could have predicted: a huge dead whale shark washed up on Satish's little island and started rotting. The nauseous stench became so overpowering that our intrepid sea turtle man had to move to the extreme other end of the tiny island to a somewhat precarious wave-lashed spit of sand.

KS: Remarkable. The only survey of Suheli that has been done since then is a brief survey in the early 2000s by the Wildlife Institute of India. And plenty of adventures in the Andamans too, right?

RW: Yes, another mythological Satish exploit was his many months sojourn, over several years, on tiny South Reef Island on the West coast of North Andaman. He was studying the hawksbill and green turtle population there, but it was tough with no freshwater and of course, no food. He would swim the half kilometre of vicious currents to Interview Island to collect freshwater and swim back with his load. Once though, he ran into one of the notorious feral elephants of Interview which promptly charged. As he ran down the forest path, he threw his shirt down which fortunately distracted the angry pachyderm. Next day, he swam back to Interview to retrieve his jerry can and found his shirt, in three pieces. He posted the pieces back to Brenda with a reassuring note. Bonny, a heavyset Karen who worked for the Andaman Forest Department, was based in Mayabunder. He was so devoted, he delivered rations to Satish braving very choppy monsoon seas. Once he crashed his dhongi and had to repair it to go back to Mayabunder. All these people were so heroic and yet so self-effacing.

KS: Amazing. So, moving on to a slightly later phase in the Madras turtle walks, how did Anne Ahimaz get involved in the turtle walks ?

RW: She was Anne Joseph then, my secretary at the Snake Park. Annie was one of those rare girls who could work with a gang of boys with complete confidence, and she had the energy to keep up on those long grueling beach walks. Plus she had a daytime job at the Snake Park, so it was a tough, but exciting life.

The turtle slaughter was an annual event up there: they were harvested by the hundreds and even thousands, and being trucked up to the Calcutta market from Digha. Published in India Today, these pictures shook the government out of its lethargy and made them protect the turtle populations.

Janaki Lenin

KS: Yes, I've heard Shekar Dattatri talk highly of her enthusiasm in organising the turtle walks in the late 1970s and early 1980s. I think he and Vijaya were really active along with her during that period.

RW: Shekar was deeply involved with Snake Park work from the late 1970s onward and was at the forefront of the sea turtle work, along with Vijaya (Viji). Viji was another star researcher. We were then in touch with freshwater turtle man Ed Moll of Eastern Illinois University in the States. In the mid-80s, Viji assisted Ed in doing freshwater turtle surveys. She went up to Orissa and West Bengal and she got some pretty amazing but terrifying pictures of the ridley harvest with the little Minolta film camera we had given her. The turtle slaughter was an annual event up there: they were harvested by the hundreds and even thousands, and being trucked up to the Calcutta market from Digha. Published in India Today, these pictures shook the government out of its lethargy and made them protect the turtle populations. Ed later encouraged Viji to go to the States to do her Master's degree. Vijaya died tragically when she was still in her twenties.

KS: Quite an amazing cast of characters. Any words of advice for the young enthusiasts going on turtle walks ?

RW: Well, times have changed and perhaps the first inkling was when a small group of turtlers was stopped by a group of 'rowdies' who were pretty drunk and abusive in the early 1980s. Only one of our guys had a watch, which was quickly taken, and they also lost the few rupees they had. But it was a scary event and we were just happy that none of the girls were along that night. It's good to have a savvy local person or two with you on turtle walks. Involving interested local village youth is not only the safest way to do field work, it spreads the word!

Also, while it's very satisfying to have a protected hatchery and to be able to watch all the baby turtles hatch out and take them to the sea, it can be argued that it's better to simply transplant the nest to a place a few metres from where it is found. Chances are animal and human predators won't find the new site and the problem of temperature related sex determination in a hatchery need not be worried about.

I think the work we started back in the early 1970s has had a positive effect on sea turtle conservation in India, mostly by waking us all up to the plight of these wonderful but beleagured creatures. By protecting the breeding base of India's sea turtle population, by waking up people all along India's coast to the problems facing turtles we've seen a lot of dedicated young biologists and naturalists getting seriously involved. I do believe all these efforts have helped save our sea turtles and it's very encouraging to see that the interest persists and that the turtle walks and outreach to coastal villages are still going strong!

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Too hot for sea turtles?

Sea turtles are particularly susceptible to climate change because their behaviour, physiology and life history are affected by environmental changes.

All life stages of sea turtles (e.g. hatchlings, juvenile and adult) can be affected by climatic processes. The more detectable impacts of climate change on sea turtles will occur during their interlude on land (during the laying and incubation of eggs and hatching) because there are clear and relatively straightforward effects of increased temperature, sea level rise and cyclonic activity on their nesting sites and nesting success. For example, predicted increases in sand temperatures will skew sea turtle population sex ratios towards predominantly females, decrease hatching success and alter the size of the hatchlings. Sea-level rise and cyclonic activity will cause loss and/or alteration of nesting beaches and egg mortality. A reduction of available nesting area will decrease the area available for nesting, potentially increasing nest infection and destruction of nests by turtles. Other predicted impacts from climate change include shifts in latitudinal ranges, alteration of reproductive periodicity, changes in hatchling dispersal and migration and indirect effects on food availability. Indeed, research investigating the impacts of climate change on the largest green turtle population in the world, the northern Great Barrier Reef (nGBR) green turtle population, predicts a complete feminisation of annual hatchling output by 2070 and a potential loss of up to 38% of available nesting area across the most important nesting sites for this population.

Ultimately, the risk that climate change poses to sea turtle populations will depend on their ability to adapt. Sea turtles have existed for hundreds of millions of years and during this time, they have survived dramatic climate fluctuations and changes in sea level. It is speculated that sea turtles have historically adapted to environmental changes by redistributing their nesting sites and nesting season, by developing new migratory routes and by changing their behaviour. The extent to which sea turtles will (or can) adapt either behaviorally or physiologically and how these responses may counteract impacts of climate change, remains to be seen. Despite sea turtles' ability to cope with past climatic changes, their ability to do so again is uncertain. Current rates of climate change are much faster than historic rates and at present, they are being simultaneously affected by a variety of anthropogenic activities.

The uncertainty on whether and how sea turtles can adapt to climate change necessitates precautionary actions and adaptive management. A mix of different short-term and long-term approaches have been suggested including: 1) mitigating the threat by reducing global greenhouse emissions; 2) adaptively managing impacts from climate change to increase population persistence; and 3) employing actions that build biodiversity resilience, such as addressing current non-climate-related threats. Reducing emissions is perhaps the biggest challenge, but even immediate reductions will not stop the already apparent and unavoidable impacts of climate change but are still essential to ameliorate threats. Adaptive management is hindered by risks associated with implementing mitigation strategies (e.g. species relocations, manipulations or management actions that improve habitat) and a lack of understanding of how effective and feasible these strategies will be at reducing impacts at relevant temporal and spatial scales.

The more detectable impacts of climate change on sea turtles will occur during their interlude on land (during the laying and incubation of eggs and hatching) because there are clear and relatively straightforward effects of increased temperature, sea level rise and cyclonic activity on their nesting sites and nesting success.

The majority of the suggested strategies, to date, focus on the nesting environment, as this is where most research on sea turtles occurs and baseline knowledge is strongest as well as where implementation and monitoring is logistically easiest. However, even on nesting beaches, the implementation

of these strategies requires an understanding of the thermal profile at different nesting beaches, the current sex ratio of hatchlings entering the population and the proportion of males to females that are ready to mate at any one time for that population; information which is rarely available. Importantly, not many strategies have been suggested for mitigating in-water impacts from climate change or boosting resilience of foraging turtles, presumably because of a lack of data or an understanding of how these systems will be impacted.

Building biodiversity resilience, to date, has focused on reducing non-climatic threats under the rationale that large, healthy and stable populations will help maintain (1) genetic diversity, which can facilitate adaptation to variable conditions; (2) a wide geographic distribution, which can minimise the overall impacts of area-specific threats; and (3) a large breeding population, which can help absorb impacts through an increased ability to recover from population disturbance.

In this context, I conducted a survey with other sea turtle specialists, to explore factors that may influence the resilience of sea turtles to climate change, which indicated that persistence of nesting grounds themselves may also influence the resilience of sea turtle populations. This follows the rationale that optimal nesting areas are necessary for reproduction and therefore the entry of offspring into the population. It also provides buffer areas for sea turtles to redistribute the geographic locations of their current nesting grounds, if necessary, as an adaptive response to deal with environmental or land-use changes. This highlights the need to maintain and protect important nesting beaches and to identify and legally protect areas that will maintain suitable nesting environments in the future, even if they are not major nesting grounds today. This will be particularly difficult in areas where coastal development and beach alteration is widespread and continually expanding. Impacts from climate change are likely to interact with other anthropogenic threats, such as coastal development. Therefore, managers face the challenge of addressing the direct effects of climate change, as well as ongoing threats that sea turtles face throughout their geographic range. For logistical, financial and political reasons, natural resource agencies cannot address all of these drivers or "threats" simultaneously; priorities must be established. For this, there is a need to understand the relative impacts of current and future threats to the overall population dynamics and the variation of those impacts. This is particularly important for sea turtles, since each of their life stages has a different reproductive value (potential for contributing offspring to future generations), and therefore reductions to each life stage will impact population growth rates differently.

As iconic species, sea turtles could be used as flagships to promote understanding of the impacts of climate change on biodiversity, to build community support for conservation action and to provide incentives for effective management and support for research, conservation and changes in policy.

Risk and vulnerability assessments are increasingly being used to help prioritise management of species in the face of climate change and also to investigate the risk of not addressing evident threats. For example, I used a vulnerability assessment to identify which climatic process will cause the most impact on the terrestrial reproductive phase of the nGBR green turtle population and to explore how the vulnerability of this population to climate change will alter if the impacts of different climatic process are mitigated.

Even with innovative decision-support tools, the implementation of management will likely be compromised without the necessary laws and policy. Existing national and international laws might need to be revisited and adapted to ensure that

Mila Zinkova

A green turtle, *Chelonia mydas*, at a foraging ground. Sea turtle can be affected at multiple life stages by climate change

management can address emerging climate change threats. Arguably, many laws are ill-suited to climate change because of their static nature. Many were written to address specific types of threats at a time when climate change was not at the forefront of concerns and are consequently limited in a changing world. Legislative flexibility will be essential, particularly for emergency responses. But changes in legislation require scientific, political, and community support. Public awareness of the links between climate change, the potential impacts to sea turtles, and the need to take action can provide the momentum to do something about it. As iconic species, sea turtles could be used as flagships to promote understanding of the impacts of climate change on biodiversity, to build community support for conservation action and to provide incentives for effective management and support for research, conservation and changes in policy.

Ultimately, an integrated approach comprising several strategies will be needed. Most strategies will require community, government support and voluntary behavioural changes to minimise social and economic impacts and in many cases community consultation to improve the effectiveness and acceptance of new management arrangements. The best set of strategies will likely be site-specific and will depend on environmental, social, economic and cultural conditions at a particular location, yet also will be integrated at the appropriate regional scale. Importantly, targeted research to understand the adaptive capacity of marine turtles, the exposure and sensitivity of populations and key habitat to climatic processes, population-scale thresholds of concern, and synergistic impacts is necessary to help guide future efforts to manage sea turtles and enhance their adaptive capacity.

Suggested reading:

Fuentes MMPB, Pike DA, Dimatteo A & BP Wallace. 2013. Resilience of marine turtle regional management units to climate change. Global Change Biology, 19, 1399–1406.

Fuentes MMPB, Limpus CJ & M Hamann. 2011. Vulnerability of sea turtle nesting grounds to climate change. Global Change Biology, 17, 140-153.

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Found in NEMO

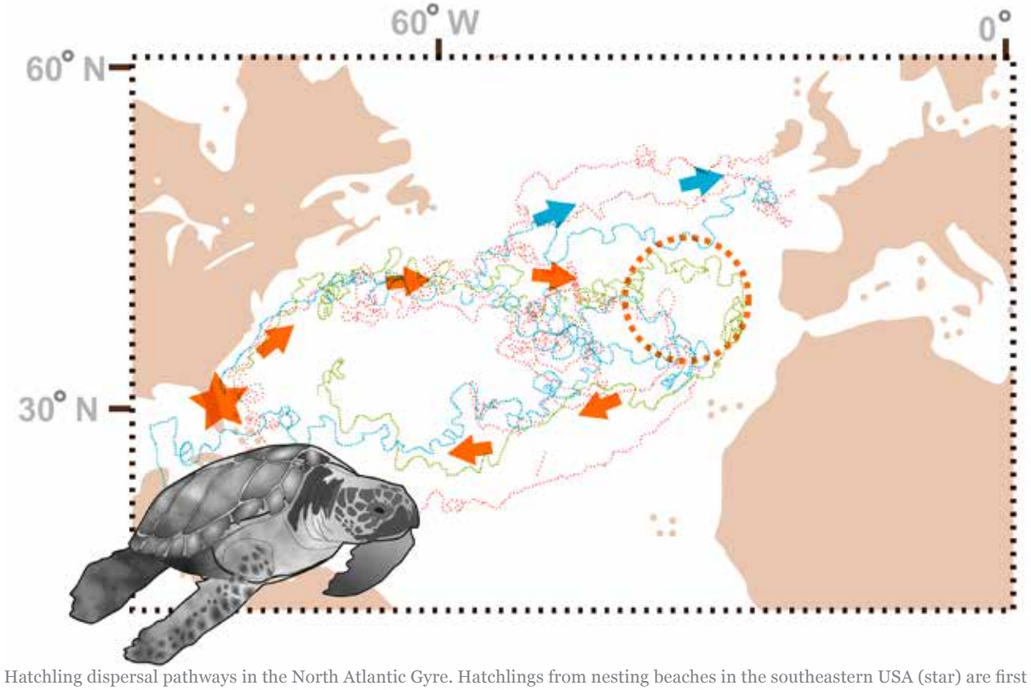
Sea turtle ocean highways tracked through satellite telemetry and the NEMO ocean model.

Many marine organisms travel great distances which presents a variety of research and conservation challenges. The movements of large animals like sharks, marine mammals and sea turtles are now routinely studied with satellite tracking technology. Once attached to an animal, these satellite tracking devices send us regular data on the animal's location. For sea turtles, satellite tracking devices can easily be attached to adults when they come ashore to nest. Consequently, the regular migrations between their breeding and foraging habitats (which can be several 100s to 1000s of kilometres apart) are now well documented. However, one of the biggest challenges in satellite tracking technology is the miniaturisation of these devices. Consequently, many small marine species and juveniles of larger species are too small to be tracked in this way. This is the case for new born hatchling sea turtles which are just a few centimetres when they emerge from their nests; much smaller than the satellite tags currently available. It is thus very difficult to study hatchling sea turtles during their first few years of life (which are commonly referred to as the "lost years") as these small hatchlings disappear into the sea after emerging from their nests.

Nonetheless, it is now well established that surface ocean currents drive the dispersion of hatchling turtles from predator-rich nesting beaches to safer oceanic habitats where they live and grow as juveniles. Indeed, ocean currents can transport hatchlings on journeys that can span entire ocean basins; hence the distances that they travel can be much further than the regular breeding migrations of adult turtles. In the North Atlantic for example, loggerhead turtle hatchlings from nesting beaches in the southeastern USA are transported north with the Gulf Stream current and then east

Rebecca Scott

A green turtle, *Chelonia mydas*, returning to the sea after nesting in Aldabra, Indian Ocean



Hatchling dispersal pathways in the North Atlantic Gyre. Hatchlings from nesting beaches in the southeastern USA (star) are first transported north east with the fast flowing Gulf Stream, hatchlings are then transported east with the northern boundary currents of the clockwise flowing North Atlantic Gyre (depicted with red arrows) towards juvenile development habitats near the Azores (red circle). At the northern boundary of the gyre, hatchlings risk being transported with the North Atlantic Current (blue arrows) towards the cold waters of northern Europe where they will die as the waters in northern Europe are too cold. Hatchlings that successfully remain in the warm North Atlantic Gyre spend several years feeding around the Azores before the westward flowing currents at the southern boundary of the North Atlantic Gyre aid their return trip to coastal development habitats in the southeastern USA. Turtles will spend many years in these coastal development habitats until they reach maturity at c. 45 years and return to beaches close to where they were born to breed. Coloured lines (created from the pathways taken by floating drifter buoys and virtual simulated floats) represent some potential dispersal pathways of hatchlings from nesting beaches in the southeastern USA.

with currents at the northern boundary of a large clockwise flowing ocean circulation system, the North Atlantic gyre. Transported in this gyre, hatchlings are able to reach their oceanic development habitats near the Azores islands > 5000 kms away from where they were born. Hatchlings then remain at the Azores for several years before they return to coastal habitats in the southeastern USA as large juvenile turtles. During their return journeys they are aided by the westerly flowing currents at the southern boundary of the North Atlantic gyre. These large juvenile turtles then remain in these coastal habitats until they reach maturity and return to the area where they were born to breed. Whilst hatchlings are too small to be directly tagged/followed on these long journeys, oceanography approaches can be used to study hatchlings during the "lost years".

Measurements of ocean currents are commonly made by releasing objects e.g. surface drifter buoys, into the ocean and tracking their movement pathways. Thousands of satellite tracked surface drifter buoys have now been deployed throughout the oceans as part of the Global Drifter Programme (GDP). Data from the GDP is freely available online and is a very easy source of information for marine biologists to work with. Additionally, sophisticated global ocean circulation models such as the "NEMO" ocean model can be valuable tools for biologists as they enable us to release "virtual floating objects" anywhere in the ocean and the movements of these virtual floats can be tracked on a computer programme as

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they drift in modelled ocean current simulations. Hence, for small organisms that disperse with ocean currents, drifter buoys and ocean models like NEMO can be used in innovative ways by biologists wanting to study these cryptic animals.

For example, from beaches in the southeastern USA, the loggerhead turtle hatchlings that disperse in the North Atlantic gyre are typically not seen again until they are encountered by fisherman in the Azores. By using drifter buoys and ocean models to study the ocean current flows (and therefore dispersal pathways of hatchlings) between the southeastern USA nesting beaches and juvenile habitats in the Azores, we can get important information about the "lost years". Due to the small size of hatchlings and the huge distances that they disperse, obtaining even very basic information on the biology of hatchlings is difficult. However, by combining data on (1) the size of new born hatchlings when they first emerge from their nests with (2) data on the size of hatchlings that are accidentally caught by fisherman in the Azores with (3) the time we estimated that it takes for hatchlings to drift between these sites, we were able to produce the first robust estimates of the growth rates of hatchlings.

Unlike fish and other marine organisms, for which there are well established techniques to directly determine the age of individual animals and hence the age at which species reach maturity, sea turtles cannot be aged directly with accuracy. Instead, reliable age estimates require information on the natural growth rates of hatchling turtles, larger juvenile turtles and adult turtles. The growth rates of large juvenile and adult turtles can be measured at the breeding grounds and in coastal foraging habitats through mark-recapture programmes where turtles can easily be captured, measured and marked (typically with a metal flipper tag), and then recaptured/measured at a later date. Prior to our estimate, however, the growth rates of hatchling turtles were only well known for hatchlings in captivity. Since these captive individuals are given a lot more food than they would get naturally in the wild, captive growth rates are much higher than natural growth rates. So, by combining our new hatchling growth rate estimates during the "lost years" with direct growth measurements of larger turtles, we were able to produce the most reliable age at maturity estimate to date. In so doing, we revealed that the time these turtles take to reach maturity (c. 45 years) is much longer than other animal species and that past age at maturity estimates based on captive growth rates were underestimated. This has important conservation implications as species, like turtles, which take such a long time to reach maturity, are much more vulnerable to extinction than other species (like fish, marine mammals, birds, lizards etc) that mature at much younger ages.

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A female loggerhead turtle, *Caretta caretta,* returns to her breeding grounds in Zakynthos, Greece

Once offshore, hatchlings are also known to be able to use geomagnetic information from the Earth's magnetic field as a navigational sign post.

Since hatchlings are reliant on ocean currents to reach their oceanic development habitats, we can use oceanography data to study the "lost years" and gain important information on sea turtle biology. However, laboratory observations by American researchers have also shown that hatchlings can undertake in periods of active swimming. For example, when they first enter the sea they embark on a period of intense offshore swimming (the "swimming frenzy") which lasts for about a week. This frenzy period helps hatchlings escape predator-rich coastal waters and reach offshore currents like the Gulf Stream which rapidly transports them towards safer oceanic habitats near to the Azores. Once offshore, hatchlings are also known to be able to use geomagnetic information from the Earth's magnetic field as a navigational sign post. By adding laboratory observations of this swimming behaviour into ocean models we were able to show for the first time that limited amounts of swimming (just 1-3 hrs/day) can (1) help hatchlings to remain within the warm waters of the Gyre/reach safe offshore development habitats like the Azores and (2) avoid drifting towards northern Europe where the cold water would kill them. This is quite remarkable given the limited swimming capabilities of hatchlings (due to their small size) and the fact that these simulations were carried out in a region that contains one of the fastest current flows in the World (the Gulf Stream).

Rebecca Scott

A hatchling loggerhead turtle in the Peloponnese peninsula, Greece

Our work highlights the value of oceanography approaches for studying the biology of species which are difficult to study using conventional techniques and the importance of taking into account the behaviour of animals when using these valuable, albeit currently underexploited, oceanographic tools. Many other marine species, like fish, have juvenile life stages that also disperse with ocean currents and the swimming speed and strength of these juveniles are comparable or greater than those of hatchling sea turtles. The potential conservation applications of these oceanographic tools are thus huge as key information can be gained on the pathways, habitats, survival and biology of a range of species of conservation concern. This information is all crucial for designing effective conservation and management strategies.

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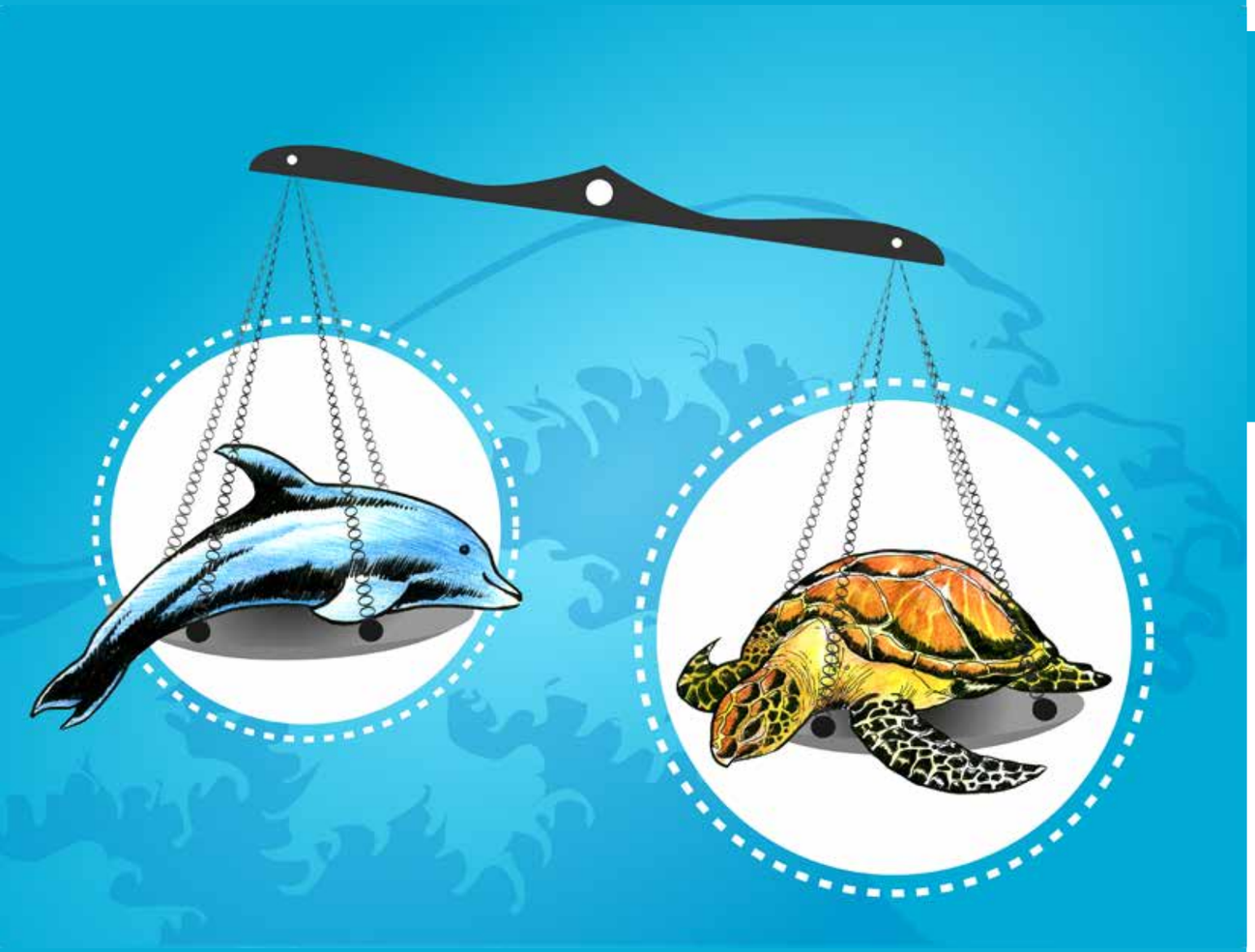
Successful success stories



Conservation biology is routinely built on fears and portents, proclamations of one disaster after another. This species is on the brink of extinction; that habitat has been destroyed; such-and-such environment is in crisis… Prospects like these, routinely derived from biological and ecological studies, are indeed frightening; such forewarnings warrant careful attention and diligent action.

Yet conservationists are accused of promulgating a gross overabundance of bad news, often resorting to scare tactics and doomsday predictions to garner attention and raise support for their activities. There is nothing new about this strategy: environmental disasters have been predicted from the time of Genghis Khan and the Ancient Greeks.

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But the trend of procuring attention and financial support by proclaiming disaster has often resulted in a jaundiced public; as we know from the children's story, crying "wolf" can have dire consequences—not on the wolf but on the person who cries its name in vain. Besides, who wants to support a gloomy enterprise that careens from one catastrophe to another? Not surprisingly, conservationists have identified the pressing need to show success and move away from the constant environmental obituaries.

A more balanced approach is long overdue, and in recent years it has become ever more common to recount success stories. Surely we need more manifestations of success, for after all success in solving complex environmental problems is presumably the object of engaging in the great conservation enterprise in the first place. Clearly, there are some excellent success stories from many projects and diverse lands. Yet as this alternate strategy becomes more fashionable the conservation industry is in danger of drifting back into the same swamp as before, only from a different path. Many conservationists now swing to the other extreme—playing up any little improvement as virtually world-saving. Just as there have been countless hoary predictions of environmental calamities, we are now facing a blitz of success stories and with each one the respective bard expects to be rewarded.

But what constitutes an authentic success story? Who defines "success"? The dictionary tells us that "success" is primarily about fame and fortune: is that what conservation success stories are about?

Take marine turtles: there are few turtle conservationists who would question that more turtles signify more success. But if conservation really is based on robust biological and ecological information, then one needs to look more closely at what exactly "more turtles" means. If these are critically endangered hawksbill turtles, then population recovery and more of them is certainly the desired condition. On the other hand, if the more numerous turtles are, say, olive ridley turtles, then their increased numbers may not necessarily be universally appreciated. If you happen to be struggling to rehabilitate badly decimated populations of critically endangered leatherback turtles and the olive ridleys are competing with them for food, nesting areas or other limited resources, the success of the olive ridleys would be a threat to the leatherbacks.

The point is, not all marine turtles are created equal and measures of success need to be gauged by bearing in mind characteristics and situations of different species—information that is often out of reach.

Alternately, consider that a dolphin is severely threatened by incidental capture in certain fishing operations, and there are, unfortunately, many

The dictionary tells us that "success" is primarily about fame and fortune: is that what conservation success stories are about?

species of dolphins that are in this situation. At the same time, incidental capture and mortality is also a major threat to most marine turtle species. Consequently, there have been diverse attempts to reduce or mitigate incidental capture of marine wildlife. Some of these methods work better for turtles than for dolphins. So more turtles would indicate success in dealing with incidental capture of the reptiles—but if this came at the cost of more dolphin captures, then many people would question if it really is "success" when one endangered species bears the brunt of another species' triumph. In fact, this dilemma has occurred repeatedly, often with specialists of one group of animals focused on protecting "their critters", but oblivious of the consequences of their conservation actions on other endangered species.

So, not all endangered species are created equal.

Another critical consideration is what happens to the environments where the species of conservation concern live. For example, when a depleted population of green turtles increases, consequently there will be more turtles grazing more often, looking for more food; the marine pastures on which they depend will be under increased grazing pressure. This will have important consequences on the plants and animals that live in the marine pastures: some of them will be under increased pressure because the green turtle population is recovering. Indeed, an entire marine pasture ecosystem could be negatively impacted if grazing pressure by threatened green turtles increases too much. While it may be a blasphemous question to some turtle conservationists, could it be that too many threatened green turtles in an ecosystem would actually be endangering to the ecosystem?

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But these deliberations are simple when compared to others that consider the impact of one other species: *Homo sapiens*. Even if it there were consensuses that a conservation action was valuable for an endangered turtle species and it did not cause any problems for other turtles or any other endangered species or ecosystems where the turtles live, we have not necessarily reached a universally acceptable state of "success". More turtles might be celebrated by all conservationists (turtley ones and dolphiny ones), but the situation could still cause distress or annoyance to other people. For example, fishermen are often bothered by turtles getting into their nets, reducing their catch and destroying their gear. In the case of trawlers, the turtles can crush valuable catch and increase drag, lowering efficiency and profitability of the operation. For longlines, with thousands of baited hooks, a few turtles can cause havoc, not only eating the bait and leaving the hooks bare and useless but tangling up and knotting the lines to create terrible messes that take tremendous time and effort to put right: all this denies the fishermen of the ability to fish. Nesting turtles that wander around on beaches at night, knocking over and destroying beach furniture are not welcome for some hoteliers. More turtles grazing on a marine pasture could mean less fish available to the fishermen. And so on...

The point is: not everyone is madly in love with turtles, no matter how endangered they may be or how politically correct it is to show concern for them. For some people the chelonians present clear problems and threats to their livelihood. From their point of view, more turtles mean more problems, less ability to meet their own needs. Although conservationists are adept at arguing their case, providing alluring pictures and marketing cuddly plush animals, in fact, there are far, far more fishermen than conservationists in the world. So, what may be "success" for a few could actually be failure for many.

And we have only considered well-known and innocuous turtles. These reptiles have numerous attractive features, they are central to many cultures the world over and there is no great challenge to get people to identify with these curious animals that live inside a box. In the conservationists' lexicon, these are "flagship" species, relatively easy to attract attention and interest.

What if instead the conservationists' attention were focused on some other endangered species, say some critter that is barely known to biologists, much less to the lay public, something that has no clear redeeming qualities and is not attractive but rather is generally disgusting to people. Would most members of society really agree that more of the "what-do-you-call-them" is success?

Or take some very well-known endangered animals. Does everyone whole heartedly agree that more wolves, more bears, more panthers, more tigers, more elephants is unequivocally a success? If your crops were destroyed, your livestock carried away, your child mauled or your own life threatened by one of these endangered animals, would you want more of them?

Without a doubt, we need more success stories. But just like the fashion of effortlessly stamping some living thing with "brink of extinction" or some landscape with "environmental disaster", conservationists need to be very careful about painting a situation a glowing colour of success. Employing either of these strategies to draw attention and raise support could be counter-productive, not to mention dangerous, if conducted without consideration of the complex ecological, sociological, and political context in which the protected species exists.

It is said that "beauty is in the eyes of the beholder": the vision of success is no less subjective. Truly successful success stories must have many and diverse eyes beholding them.

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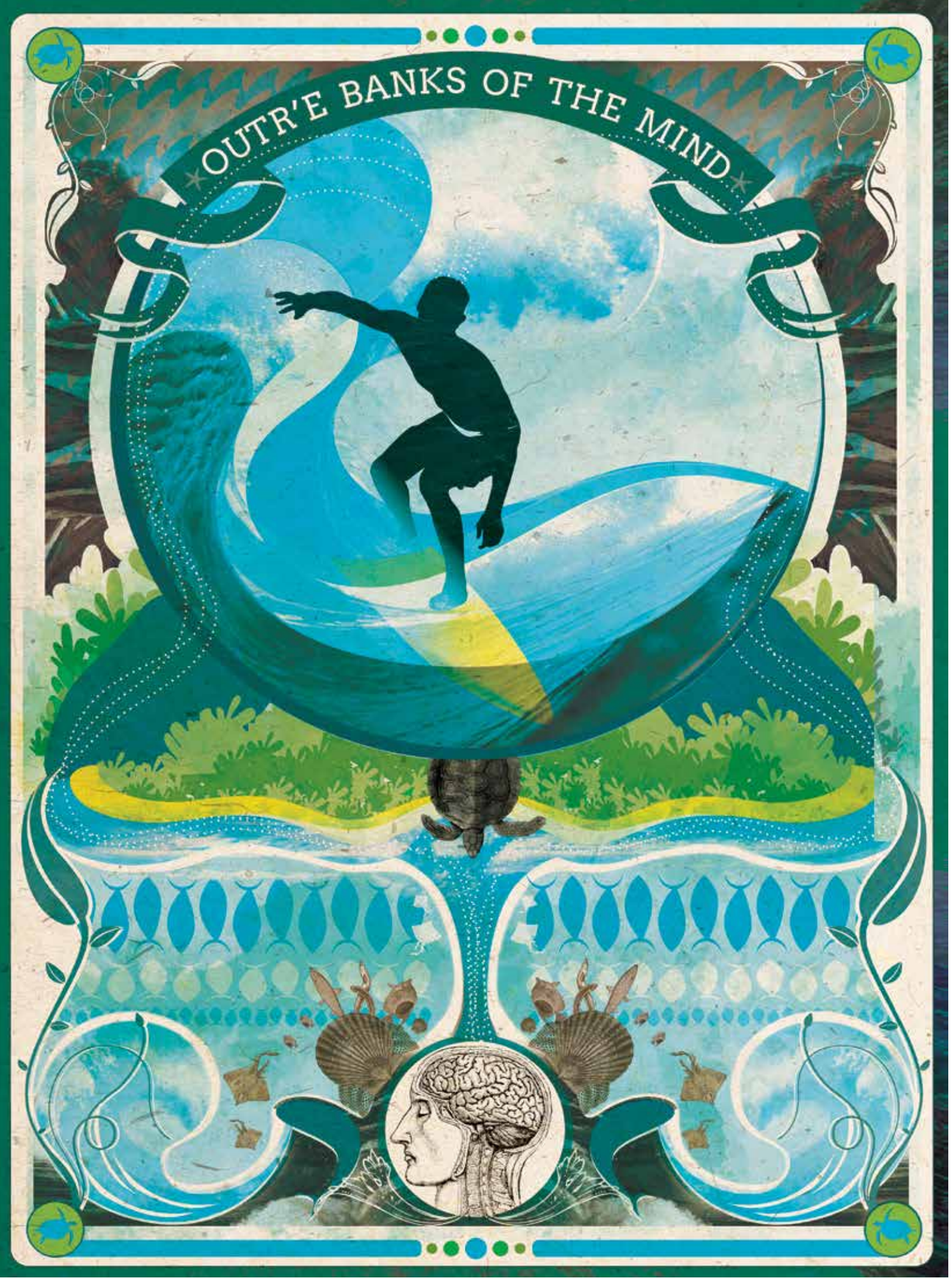

outre' (oo'tre) adjective. Unusual and startling, violating convention or propriety: "in 1975 the suggestion was considered outre'—today it is orthodox." Origin French, literally "exceeded," past participle of outrer (see outrage).

I'm standing on a pier 50 feet above the Atlantic. Ocean to the left and right, forward, back and below. I'm wearing a light blue hat, like a bejeweled swim cap. A heavy black cable snakes down my back like a ponytail. I look like an extra in an Esther Williams swim troupe who wandered into Woody Allen's *Sleeper*.

Water fills the light, the sound, the air, and my mind. Waves steadily arrive under the pier, crashing to the beach and suspending their salt mist and negative ions, which I rhythmically inhale with pleasure. It smells like summer to me.

I'm a human lab rat. The cap is the nerve center of a mobile electroencephalogram (EEG) unit. I'm just trying it on for size. The cap is not yet recording anything, but soon 68 electrodes plugged into my head will measure my every neurological up and down. The sum effect of the cap, the grandeur of nature, our imaginations and the academic and experiential gravitas of those with me is one of beautiful absurdity. A somewhat ridiculous high-tech costume masking some seriously interesting—you might even say revolutionary—scientific potential.

An unlikely agglomeration of talent—neuroscientists, big wave surfers, psychologists, educators, seafood experts, veterans, marketers, realtors, conservationists, evolutionary biologists, filmmakers and writers—have schooled up on Jennette's Pier on the Outer Banks of North Carolina to consider the science behind our emotional connection to water. It's about time we figured out how the words dopamine and amygdala meld with the words, ocean and wave.

The Outer Banks or OBX, are the long, narrow strips of mostly sand separating the Atlantic from the sounds and from the mainland of North Carolina behind that. The Outer Banks are a sandbar, really. Gordon Jones, a realtor for 22 years who knows these edgy dunes as well as anyone, calls them a "speed bump" for the Atlantic hurricanes, squalls and relentless waves that batter her banks. As a result the beaches—literally, the entire place—are inching incrementally westward, grain by grain.

Living on the Outer Banks requires a certain tenacity, but there is a powerful and unmistakable draw to this place. The twin phalanxes of cars coming and going that queue up every summer Saturday and the two hundred percent premium tacked on to the most sought-after homes in the "front row," directly adjacent to the beaches, are ample evidence of the draw. My hunch, as I stand there on the pier, is that hidden beneath the surface of the water we will find massive, yet to be quantified, but irrefutable cognitive benefits. I believe the ocean irresistibly affects our minds. It is a force that for millennia has drawn people all across our watery planet to camp out on windswept bumps of sand like the Outer Banks.

A set of questions and hypotheses has begun to flow from the consilience of neuroscience and water studies and the sharing of personal—sometimes intimate—experiences. It is a conversation I call "Blue Mind."

In 1987, I was a 19 year old biology student at DePauw University, a small liberal arts college in Greencastle, Indiana. On a late summer day, I received a message from Reverend Lamar, the University Chaplain. In his office, he explained that a local nursing home had a special patient the nurses thought might benefit from guitar lessons. DePauw, founded 175 years ago in the Methodist tradition, is known for its community service. Students learn that to be whole one must give generously to those in need. I agreed to the challenge. I was a quiet, introverted teenager. Barbara was a terrible guitar player. She had lost most of her memory in a car wreck 15 years before, when

she was a university music student, herself just 19 years old. I stammered and had a disabling fear of public speaking and performance. I preferred diving in the quiet rock quarries of southern Indiana and the company of my dog and guitar. In a carpeted corner of the institutional lounge, we started in on the standard folk classics of her teens: Dylan; Simon and Garfunkel; Peter, Paul, and Mary. Simple chords, clear lyrics, nothing too demanding. Our Wednesday guitar lessons continued for 8 months. Some days it was agonising work. We would play into dark dead ends. Our hour together would drag with poorly formed thunky chords and start-overs. Other days, a song—or a simple melodic phrase— would open a door into her memory and she would come alive. John Denver, in particular, caused knobs to turn and long-locked memories to flow. On those days we spoke more than we played. Music brought back images, names, stories and other music. The nurses smiled.

"All my memories, gathered 'round her. Miner's lady, stranger to blue water."

This was my first intimation of Blue Mind. These moments enthralled and disturbed me. Late nights in the racks of neuroscience journals failed to provide satisfactory answers to my questions. The requisite formaldehyde-infused dissections in my anatomy courses paled in comparison to the wonder of Barbara's living brain. I began to cherish Wednesday afternoons, strumming my guitar in time with hers and trying to find keys to unlock her memories. In the process, slaking my nostalgia for acoustic three-chord simplicity and swimming holes.

These words from E. E. Cummings haunt me:

"it's always ourselves we find in the sea"

The words connect me to a dozen emotions, a hundred places, a thousand memories, and to the color blue. I prefer to read the lines last to first.

The preceding ten words of the poem are:

"for whatever we lose (like a you or a me)"

And the ten words just before that are:

"as small as a world and as large as alone"

I read them backward and forward, and backward again. I read them that way to myself, to my daughters, to strangers, and to students. I don't know if E. E. cummings meant it that way, but I like to imagine he did; or, at least, that it didn't matter to him which way you read them as he wrote them at his desk, seaside, planning the forward and the backward and the forward again permutations of his paean to the sea.

Have you ever lost a you? Did it happen at the sea? I've lost several me's. So many me's, I've lost count. I used to know the number; it was at least ten. They've mostly been lost in the sea, but one time I lost a me at the bottom of a water-filled quarry. There must be many me's lost in the water. With a backlog of me's-in-waiting, yet to be lost. Sometimes, the me's or the you's lost in the ocean will return. Those lost to rivers have to travel to the sea where one can search for them. Successful searching often requires a guide—a young scientist, perhaps.

August 13, 1996. Martin Arce, a thick-handed lobster- man and I watched Adelita, a loggerhead sea turtle, swim under and away from our small skiff bobbing in the immense Pacific offshore Baja California in Mexico. We stared out across the expanse of blue before us and thought maybe, perhaps, possibly these turtles aren't born in Baja at all. Maybe they migrate here only to return home again—somewhere. We gazed at the horizon. Somewhere out there, across the vast Pacific, was Japan and the nearest known loggerhead nesting beaches, a mere 7,000 miles west. Genetic evidence suggested the possibility of epic ocean-spanning migrations by sea turtles, but in the face of the vastness of the Pacific Ocean, the hypothesis was revolutionary at the time. Too revolutionary, I guess. Unfathomable. absurd even, but also loaded with scientific potential, as the best hypotheses usually are. I was a doctoral student in wildlife ecology and evolutionary biology at the University of Arizona. Debate was rife among scientists about the origins of endangered loggerhead sea turtles swimming along the Pacific coast of the Americas. As most school kids will tell you, the first and perhaps most impressive thing you learn about sea turtles is that they return to the same beaches where they were hatched to nest as adults. With not one single loggerhead nesting beach anywhere on the shores of the eastern Pacific, many questions were unanswered.

Martin and I had attached a small box to Adelita's back. It contained a transmitter. Twentieth-century technology glued to a one-hundred-million-year-old body plan. Each day the box relayed her location to us via satellites linked to a base station in France. Each day we studied the data and then uploaded it to the Internet. Each day tiny dots aligned on a map, surrounded by nothing but blue. Soon, other people took note. Then more. Schoolkids, scientists and turtle lovers the world over were watching Adelita's progress. Alone, but not alone, Adelita stroked on through the deepest, wildest, most humanless expanse of our blue planet.

People would write to me to talk about Adelita: "Hi J., this is Meghan and I was just wondering if you are as excited about this as I am?"

At night, I couldn't sleep. I'd lie awake thinking about Adelita. Praying for her safety. Wondering what was beneath her and above her. Was she hungry? How did it feel to be going home after so many years? I became obsessed with checking my email for the latest position. I'd imagine members of our loosely connected club sitting in front of glowing blue screens all over the world, plotting, calculating, imagining, hoping and dreaming about that vast blue space. We tracked the sea turtle due west out of Baja making a steady 20 miles per day; a healthy walking gait for you or me. By January 1, she was just north of Hawaii. From there, she tracked west and ever so slightly north. Sure enough, she was headed straight for Japan.

Brie, an Internet follower, wrote, "What are you gonna to do when Adelita gets to Japan? I mean are you gonna send a team to get her?" "I'm not really sure," I wrote back.

March 9, 1997. Barbara Garrison, an elementary school teacher in San Diego who was following Adelita's progress with her students, receiving my regular emails and thoughts, wrote this poem during the journey as the turtle neared the International Date Line, which bisects the Pacific:

Adelita sleeps.
Do you ever find yourself
thinking of her
in the middle of the day?

Sister of mercy
adrift in the world
her carapace around her
like a habit
following the liturgy of longitude
like the Stations of the Cross
the draw string of dream
gathering with each dive.

A sea shadow
cradled in the arms
of the great Turtle Mother.

The Virgin of Cobre guiding
through the dangerous sea
the black sand memory
of her natal beach
ringing her course
in peals of instinct.

Cartographer
explorer
world traveler
Adelita sleeps.

A Shinto priestess
leads the way
a goddess path
from Mexico
to the arribada
on a distant Kyushu shore.

August 16, 1997. Three hundred and sixty-eight days and 7,000 miles after we lowered her into the Pacific, Adelita's signal finally went dark—her final location put her transmitter at the end of a fishing pier in Isohama, a village in northern Japan since washed away by the 2011 tsunami.

You can see a simple truth in the eyes of quarry people, river people and sea people. You can hear it in their voices. You can feel it in the way they dance with you. It has to do with the accumulated losing, searching, following, and finding of life. It is a state I call "Blue Mind."

Each day tiny dots aligned on a map, surrounded by nothing but blue. Soon, other people took note. Then more. Schoolkids, scientists and turtle lovers the world over were watching Adelita's progress. Alone, but not alone, Adelita stroked on through the deepest, wildest, most humanless expanse of our blue planet.

Remarkably, the topic of the human brain's emotional interaction with water is a new frontier to science. Neuroscientists, including those that gathered on The Outer Banks, talk a lot about the physiological basis of flow, groove and even chills—those peak moments when we feel we are one with the universe as a response to good work, play or music. Neuroscientists say looking at the colour blue doubles our creativity. They say that simply walking outside helps break apart bad habits and that being seaside can boost happiness and engender a sense of well-being. Practitioners have found that water-related activities such as kayaking, surfing, wildlife viewing, relaxed gazing, and sound bathing, the practice of simply listening in nature can be applied therapeutically to mental disorders, post-traumatic stress, autism and addiction. At meetings like the one on Jennette's Pier neuroscientists are formulating bold new hypotheses about our "Blue Minds" suggesting transformative new ways for humans to relate to water, new possibilities for educating our children, and offering some solace to an increasingly stressed out society. Facing out on the Atlantic, I believe them.

We are learning that the songs that water sings make our memories light up like Barbara's brain on John Denver. Nostalgia glows in the presence of water. By the ocean, along a river or even from the bottom of an inundated quarry, we get a better view of the whole world and of ourselves, and as a result, we feel small but connected. Because we are small in the face of it and we are connected. From a million miles away, the Earth is but a blue marble. From a billion miles, we are just a pale blue dot; a speck in the collective consciousness of the universe. It's far easier to appreciate the little blue marble we live on from the water's edge. Its waves of light and sound can make us feel both small and alone and yet exquisitely connected to the universe and everything in it. Like every little thing we do matters more than we could ever imagine.

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Turtles left out in the cold?

For species of conservation concern, rehabilitation of sick or injured animals is often done with little reflection of where it fits into the larger plan of conservation actions.

The cold wind whipped across the sound, creating little white-capped waves in an area that normally is so calm that the locals often call the waters "slick". I was waiting for a park ranger to arrive with some hypothermic (or cold-stunned) sea turtles that had been found alive but beach-stranded and lethargic. In warmer months, these sheltered waters are often thick with juvenile sea turtles that come to forage on abundant prey. However, when colder winter weather arrives, the turtles sometimes cannot leave quickly enough through the limited number of inlets, and being reptiles, they may easily succumb to hypothermia when the sound's waters drop in temperatures. The boat arrived with 35 turtles and I stacked them in their various containers in the back of my work truck, before driving them to a wildlife veterinarian for assessment and initial treatment with fluids, antibiotics and anything else they may need. Over the course of a few weeks, we will receive over 150 live hypothermic turtles from a small part of the coast.

Not all hypothermic turtles survive, but most do if they receive appropriate care soon after being found. Many turtles will return to full health in 2 weeks or less, while others may need longer, particularly if they had any complications related to the hypothermia, such as pneumonia or eye damage from cold air or wind-blown sand. Often, the most difficult thing in managing hypothermic sea turtles is finding sufficient space for them during their rehabilitation. When several hundred live hypothermic turtles appear in a small area within a few weeks of each other, it can be difficult to find adequate space for them to recover. Often, sea turtle rehabilitation facilities, many of them volunteer-based, will go above and beyond what seems feasible to make room for as many turtles

Matthew Godfrey

Hypothermic juvenile sea turtles recovered from Core Sound, North Carolina, USA

Matthew Godfrey

Public release of rehabilitated cold-stunned loggerhead turtle in North Carolina, USA

as possible. Following this, another major problem is what to do with the turtles that have recovered. Often, coastal water temperatures remain cold for several months, so the turtles cannot be released from the beach without running the risk of more hypothermia. Thus, apart from waiting for late spring or summer to release the animals, the only option is to transport the turtles to warmer waters for release, either by boat to warmer waters far offshore, or by truck or airplane to coastlines closer to the equator. In recent years, some hypothermic turtles from the UK and other European countries have been flown to the Canary Islands or the US for release following rehabilitation.

During the releases of turtles rehabilitated from hypothermia, there is often media attention and the resulting coverage often implicitly or explicitly states that these actions are helping save sea turtles. Strictly speaking, I agree that the individual turtles with hypothermia have been helped, but I wonder about the impacts of these actions on the larger populations of sea turtles. When hypothermic turtles appear on the coast, especially in large numbers, most people involved view it as a crisis that needs immediate response, and there is little time for reflection about what the end goals are (apart from ensuring the animals receive appropriate care). However, given the vast amount of resources expended in responding to and treating cold-stunned sea turtles, it is worth considering whether these are important conservation actions. I do not have the answer, but would encourage the discussion begin with these considerations.

Hypothermia in sea turtles is natural. Although many often consider sea turtles to be tropical or subtropical species, they can and do migrate to more temperate zones, presumably to take advantage of better foraging habitat. Hypothermic turtles regularly appear each year at higher latitudes, and regularly occur every few years even at middle latitudes. There also are historical reports of cold-stunned turtles appearing in various places in the US over the past century (e.g. Witherington & Ehrhart 1989), confirming that it is natural. Should there be an effort to try to reduce a natural source of mortality, such as hypothermia? Or should more effort and energy be focused on anthropogenic sources of mortality or other threats? This type of cost-benefit analysis question could (and should) be applied to any conservation action, although there are few examples where responding to hypothermia is considered. Two notable exceptions are the recent US Recovery Plans for loggerhead and Kemp's ridley turtles, although no specific recommendations are made for whether or how much action is needed in response. Of course, some may argue that treating hypothermic turtles is good because it is a threat that can be mitigated, thereby increasing the resiliency of the population to respond to threats that we cannot mitigate. This may indeed be the best course of action, but it would require a larger discussion about all threats and responses, and include cost-benefit considerations.

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We have little information about the status of cold-stunned sea turtles that have been rehabilitated and released. Some short-term satellite tagging of some turtles has revealed that the individuals appear to survive for at least a few months after release (until the tag stops working or is shed). However, there are no long-term data showing that rehabilitated hypothermic turtles have contributed significantly to larger wild turtle populations. There are anecdotal records of released individual animals subsequently succumbing to hypothermia again at later dates, which reinforces that hypothermia is a natural event and calls into question whether a response is warranted.

Responding to hypothermic turtles does have other types of value. For example, because these events tend to attract media attention, it is an opportunity to increase public awareness and facilitate increased understanding of sea turtle biology and conservation. Cold-stunned turtles offer research opportunities, including health and physiological studies, sampling for foraging ecology, and assessing post-release outcomes (although the latter remain difficult to successfully complete). But none of these actions directly benefit wild populations of sea turtles, and when presenting information to the public, more effort should be made to distinguish between benefits to individual turtles vs. the wild population as a whole (see Loftin 1985). It is likely that many of the current actions in response to hypothermic turtles are driven in part by public perception of sick or injured animals and a general desire to have something "done" about it. If so, then a wider public discussion about threats to populations and impacts of responses is warranted, so that everyone has a better understanding of the different factors influencing turtle population. From there, we can prioritise actions, including responses to cold-stunned turtles. I am not recommending that they simply be left in the cold but rather we need to consider how much time and energy should be spent responding to them and if necessary, divert some of that to other threats that potentially could have greater impacts on wild populations.

Suggested reading:

Loftin, R. W. 1985. The medical treatment of wild animals. Environmental Ethics 7:231-239.

Witherington, B. E., and L. M. Ehrhart. 1989. Hypothermic stunning and mortality of marine turtles in the Indian River Lagoon System, Florida. Copeia 1989:696-703.

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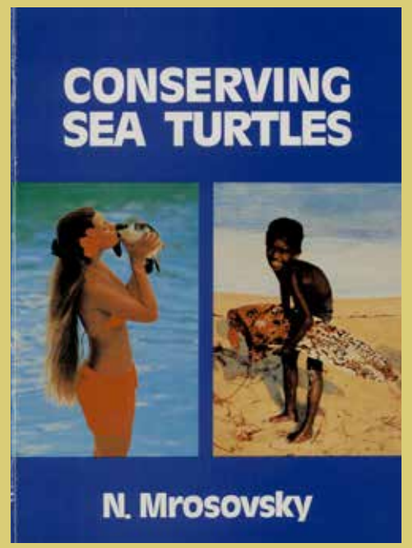
Ongoing critiques of conservation



Conserving Sea Turtles
N. Mrosovsky

ISBN-13: 978-0950737119
British Herpetological Society, London, 176pp, 1st edition (February 1, 1983)

http://www.seaturtle.org/documents/Conserving_Sea_Turtles.pdf

DESPITE ITS AGE, THIS BOOK ON SEA TURTLE CONSERVATION REMAINS RELEVANT TODAY

In 1983, the British Herpetological Society published and printed 1000 copies of a small blue paperback book. The author, Nicholas Mrosovsky, said he wrote this book to analyse various procedures and problems associated with sea turtle research and conservation, and thus facilitate more discussion and eventual improvement in techniques and measures. Prior to this, he already had a reputation as an excellent researcher, publishing seminal work on thermal biology, seafinding behaviour and hatchling sex ratios of sea turtles. He was also the founding editor of the Marine Turtle Newsletter, which was a vehicle to facilitate dialogue and exchange of all points of view on sea turtle conservation. This book, however, established him as someone who wanted to ask difficult questions and create a forum for debate. Even the photos on the book's cover appear designed to stimulate discussion: on the left is someone kissing a live green turtle; on the right is a small child holding a flipper from a butchered leatherback. The book's publication stimulated several long reviews in various journals; some were supportive, others less so. Currently, although this book is still occasionally cited in published papers, it appears to be somewhat forgotten, and was not mentioned in Peter C.H. Pritchard's historical review of sea turtle monographs in his introduction in the recently published book, Sea Turtles of the Eastern Pacific (J.A. Seminoff and B.P. Wallace, eds., University of Arizona Press, Tuscon). This being the 30th anniversary of its publication, it is prudent to reflect on the relevance of this book to current sea turtle conservation.

My first reading of this book was in 1993, and I was greatly influenced by many of its arguments and positions. Reading it now, I find that many of the issues remain highly relevant today. For instance, Chapter 3, entitled "The Tagging Reflex," reveals that many researchers and conservationists were applying flipper tags to sea turtles without considering why they were doing it or how to interpret the tag return data. The same thing is happening today, although it now includes satellite tags, critter-cams and other types of telemetric gadgets. Although there is great potential value of mark-recapture and telemetry data from sea turtles, Mrosovsky clearly articulates the importance of setting up testable research questions before embarking on a tagging project. Chapters 10 and 11 deal with the issue of whether sea turtle species deserve to be considered highly in danger of going extinct. This remains an important question in the sea turtle community (and beyond)—recently an entire issue of the journal Endangered Species Research was devoted to the relevance of placing species, including sea turtles, on the IUCN Red List, the global authority of species in danger of going extinct. One of Mrosovsky's main points is that a defendable scientific approach towards assessing risk would greatly improve the way species are categorized as being threatened with extinction. Chapter 8, on farming of sea turtles, remains topical, particularly with the recent debate over husbandry conditions at the turtle farm in the Cayman Islands. Again, one of Mrosovsky's main points is that analysis based on biological data would greatly enhance discussion and provide room for setting up testable hypotheses and benchmarks.

Of course, given its age, there are some subjects that are no longer "burning issues." For instance, few today would argue that the black turtle, *Chelonia agassizi*, warrants official recognition as the eighth species of sea turtle. Similarly, the chapter on head-starting (captive rearing for the first few years of life before release back into the wild) of Kemp's ridleys is mostly moot, as the program ended in 1993. Yet at the time, these issues engendered debate within the sea turtle community. Rather than take sides, Mrosovsky suggested that the best approach would be to study each problem empirically, and develop testable hypotheses that would serve to resolve the debate. This is exactly what happened in the early 1990s when new molecular biology techniques were applied to green turtles and showed that there was no eighth species of sea turtle. Still, these chapters are of interest, as they provide the historical context of sea turtle conservation.

Upon my latest reading, I found Chapter 14 as riveting today as it was the first time I read it. This chapter addresses the sustainable harvest of sea turtle eggs. Unlike the other issues discussed in the book, such as tagging and tag loss, and hatchling sex ratios, which have generated a fair amount of research and publications by different researchers since the publication of this book, there has been limited research in the area of consumptive use of sea turtles, and policy seems unchanged since 1983. For example, the IUCN Marine Turtle Specialist Group has avoided addressing the topic in two important documents: its Global Strategy for marine turtles and its manual of research and management techniques. Yet, consumptive use of sea turtles continues in various places around the world and has been a major source of debate at international meetings on animal trade (e.g. CITES). Like many of the subjects of this book, sustainable use of sea turtles is contentious, but Mrosovsky argues that the debate would be much improved if scientific data were brought to bear. However, in this case, the lack of widespread debate or discussion impedes progress on this issue.

This was the first small book of three that Nicholas Mrosovsky has written and they all feature constructive commentaries and critiques of various issues in sea turtle conservation. This first book in particular personifies the author's reputation in the past few decades, in that he has rarely shied away from asking challenging questions concerning thorny issues, either at meetings or during online discussions or even during field-site visits. While some may not agree with his ideas, few could say that they have not been influenced by him or his writings. This book in particular remains highly informative and potentially influential—potentially because it is long out of print, so new readers will have to rely on colleagues who may be willing to loan out this book. It is highly worth making the effort to find a copy and regardless of whether you agree with its contents, this book will be sure to make you think.

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