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Cover art Karunya Baskar

Our species Homo sapiens emerged approximately 300,000 years ago. That sounds like a long time ago, until you visualise Earth's multi-billion-year history as a 24-hour-day starting at midnight. We-modern humans-showed up a few seconds before 23:59.

We are so much younger than all the species featured in this marine and freshwater-themed issue of Current Conservation. Horseshoe crabs are living fossils who have existed for around 450 million years-outliving dinosaurs and surviving five mass extinctions. Turtles appeared around 220 million years ago, while cetaceans such as whales, dolphins and vaquitas emerged 50 million years ago.

Yet, the pursuit of infinite economic growth and 'development' have wreaked havoc on our rivers and coasts, on the world's oceans -only five percent of which have been explored-on deep sea creatures from ancient lineages as old as life on Earth, and on the delicate balance of nature. As new entrants on a grand geological timeline, I echo John Green's question in The Anthropocene Reviewed: "Are we the period at the end of the very long sentence of Earth life, or a comma somewhere in the middle of that sentence?"

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Of coasts and construction

Author Lakshmi Ravinder Nair | Illustrator Alisha Dutt Islam



I had to squint against the afternoon sun to see the outline of the Vizhinjam International Seaport that was under construction. A couple of my coursemates and I were on our way to meet with local artisanal fishermen in Trivandrum, Kerala.

field note

"Palli-de avde ethittu, vilicha madhi, njan veraam." Call me when you reach the mosque, I will come there.

Our interview facilitator sounded very patient over the phone as we meandered around the harbour, trying to locate the mosque.

A quarter of an hour later, we were in the company of nonchalant fishermen who had finished the day's work and their lunches. Our facilitator informed us that conversation was welcome at this point.

A coursemate and I had undertaken a short field study to understand the impacts of the Adani port construction on the livelihoods of artisanal fishermen at Vizhinjam. This was a part of a wildlife and habitat conservation course that I was doing with an NGO based in Coimbatore. The theme of the course was marine conservation and its challenges, which brought us to the coasts and communities of Kerala and Tamil Nadu.

I was nervous about conducting interviews with the artisanal fishing communities because this came on the heels of some of them violently protesting against the construction of the port about a month earlier. Their gripe was that the port would result in higher rates of coastal erosion, lower catch and community displacement. My desk research confirmed the chronology of this issue, while also throwing up various scientific, political, religious and social perspectives. Most of the news articles were accompanied by the image of the larger-than-life structure of the port sitting where it really did not belong—in the backdrop of numerous colourful fibre boats and the mosque that was our present landmark.

This would be a very sensitive subject to broach, so I consulted my professors and went through my survey questionnaire repeatedly to ensure I would not cross a line. I exchanged apprehensive introductions with my first interviewee and got down to business.

"So, has anything changed for you after the port construction began?"

Fighting reality

The word 'development' has many interpretations.

In 2015, the verdict to modernise India's ports was passed through the National Perspective Plan. Called Sagarmala, the vision of the project was to 'develop' the nation's logistics infrastructure for seamless trade. In southern India, Vizhinjam was one of the many national sites planned for port modernisation.

Vizhinjam is approximately 16 kilometres south of Trivandrum, stretched between Kollam and Kanyakumari, and lies close to major shipping routes. The port construction project was envisioned as a public-private-partnership and the harbour was chosen for development, primarily because of the geomorphological features of this region—Vizhinjam has a natural bay, with a depth of 18-20 metres that would allow the parking of capesize vessels (the largest cargo ships) without additional dredging.

Vizhinjam is home to artisanal fishing communities like the Mukkuvars, who rely on the sea and its bounty for daily living. The seabed in and around the area has rock formations, sandy bottom ridges, floor slopes and sloping ridges, making the space a rich breeding ground for mussels and a variety of marine organisms.

I asked some of my interviewees what 'development' meant to them. They defined it as having enough to eat every day and meeting educational expenses of their children so that in the future, they may take up an occupation apart from fishing.

This is because finding catch in and around Vizhinjam is becoming increasingly difficult as port construction milestones are ticked off on a Gantt chart.

Turn of the tide

Artisanal fishermen use sustainable methods of catching fish as opposed to trawling and gillnet fishing that sweep out species from the seafloor. Some of the most popular regenerative fishing methods at Vizhinjam are hook and line fishing (*chunda*), trammel nets (*konchu vala*), boat seine (*thattumadi*) and variations of these. *Chunda* is used to catch tuna, groupers and snappers, whereas *thattumadi* is used to trap squid, ribbonfish, pomfret and other targeted species.

These methods are regarded as sustainable for it allows fish populations to recover in numbers before the next fishing cycle. Also, the chances of trapping bycatchnon-targeted species—is minimal due to the fishing gear deployed.

The coast of Trivandrum experiences another phenomenon—erosion and accretion. Erosion typically occurs along the northern coast while accretion happens in the south. There are natural checks and balances, but artificial structures such as groynes, reclamations and reefs, interfere with the process, causing disruptions in sediment flows.

Mr. Das (name changed), who fishes about 30 km north of Vizhinjam says that since construction began, he and his friends have visually observed an increased rate of erosion. This has forced them to move their landing centres closer to the mainland.

Regular dredging at the port mixes sediments and leads to muddy waters, which keeps certain fish species away. To add to the problem, there are lights within the construction perimeter that are kept on all the time. According to the men, these lights deter the fish away from the coast as it increases visibility of their fishing gear. This, in turn, has created many disruptions in the way they have to fish.

Mackerel, tuna, sardines and seer fish are the main catch at Vizhinjam. Previously, these were procured within a



distance of 5-10 km from the shore. Now, the average distance travelled for a decent catch is 15 km. Even with subsidies, diesel and kerosene are pricey, especially during periods of low or no catch. In addition to altering their own fishing methods, prevalent destructive practices such as trawling and light fishing put them out of the game by reducing their catch quantity and composition.

Things look bleak on the mainland as well. The upcoming construction work in the hinterland to build port connectivity will impact the fisherfolk living by the shore. In an interview with a retired fisherman at Adimalathura, a 30-minute drive from Vizhinjam, he mentioned that massive boulders had been dumped at Chappath, a town close to Adimalathura. These structures occupied a minimum area of 200 acres by his estimation. The land was being cleared to make way for roads leading to the National Highway 66, which connects major seaports situated in western India.

My interviewees mentioned the blatant apathy from the government in dealing with the matter of community livelihood and displacement. Fisherfolk were instructed to move to a warehouse with a cramped living space of 10 x 10 meters, a significant downgrade from the housing spaces they were used to. The non-availability of basic facilities such as restrooms was of great concern. Proper negotiation channels were not opened to the community, which is what led to the protest at the end of 2022.

Nine out of 10 interviewees said that their children are either willingly opting for non-fishing occupations or are being persuaded to do so. The prime reason for this is the knowledge of depleting fish stocks in the sea. One interviewee knows how bad it is without even reading about biodiversity loss and climate change. Since the 1980s, he has observed that about 33 kinds of fish are not available to catch anymore.

Status quo

Public apathy sets in when there is a certain distance from the epicentre of an issue. While writing my project report, one of my recommendations was having local citizen programmes to build awareness on the livelihood threats to artisanal fishermen. At the back of my mind, I wondered if it is any good because the issue is being viewed through a lopsided lens by key decision-makers, leading to a disregard for scientific recommendations, a lenient environmental impact assessment report and an indifference to concerns of the communities. All of this a great hit to artisanal fishing communities and a massive step back for conserving marine species as well.

I fell silent after my last interview at Adimalathura. My interviewee's concluding remarks echoed in my mind. "They paint us as villains of development. We are not. We only want to know why we are being excluded from development."

I glanced at the Arabian Sea and noticed silhouettes of ships dotted along the horizon. I did not have to squint this time.

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Alisha Dutt Islam is a botanical illustrator and artistic researcher working between India and Switzerland. With a background in teaching Art and Design theory, one of the recurring themes in Dutt Islam's works is a decolonial and eco-feminist approach to the curiosity and fascination that we experienced as children regarding the origins and uniqueness of various species in our habitat.

Mallik | Photographers & Punyashloke Bhaduri **Biswajeet Panda**

Madhumay

Author

Horseshoe crabs Ancient marvels facing modern threats

The horseshoe crab has been around for more than 450 million years. It has survived three mass extinctions, including the Cretaceous-Tertiary extinction event 65 million years ago, when more than 70 percent of all life forms, including dinosaurs, were wiped off the planet. Apart from being one of the oldest, the horseshoe crab is also among the most resilient of animals. Yet, despite being around for so long, not a lot is known about these living fossils.

Contrary to its name, the horseshoe crab is not a true crab nor a crustacean; it is, in fact, closely related to spiders and scorpions. With ten eyes situated all along its protective shell, five pairs of legs hidden underneath the carapace and a protruding spike for a tail, it is a creature that is a perfect ensemble of prehistory. Horseshoe crabs play a crucial role in the coastal food web.



Shorebirds, most of which are migratory, depend on their eggs as a food source, as do several species of fish and invertebrates. The horseshoe crab's blue-coloured blood is an important component of medical research and the health industry, yet its own survival faces an uncertain future.

Horseshoe crabs visit the intertidal mudflats only for the purpose of breeding, spending their first year of life along coastal habitats and shallow waters, before moving deeper into the ocean. Feasting on clams, worms and algae, horseshoe crabs will only begin breeding after they reach adulthood at about 10 years of age. For the next decade, they will return back to the beach every summer, to reproduce. Being largely understudied animals, their return to the beach is the only part of their lifecycle that we have information about.

An eye for survival

The horseshoe crab is nocturnal and possesses some unique adaptations. Cruising along the shallow coastal seabed, it uses moonlight to its favour—to both forage and spawn its next generation. It has a pair of large compound eyes seated laterally, each with 1000 photoreceptors, as its primary visuals. Five more super-eyes, located on top of the shell, detect the ultraviolet spectrum, allowing the animal to navigate its surroundings on dark nights. Two more eyes on the underside, close to the mouth, help maintain a stable orientation against the flowing current. Lastly, an eye situated on the tail helps keep track of the day and night cycle.

The animal not only brings variety into visual engineering, but also possesses a well-defined circadian clock in its brain. The eyes of the horseshoe crab are the reason we have been able to extensively study our own vision.

Double-edged sword

Nevertheless, it was not just the vision of the crab that humans eyed. The baby-blue-coloured blood of horseshoe crabs has been harvested since the early 1600s the colonial times in modern USA—initially to be used as "cancerine fertilisers" and later as a test for bacterial contamination in drugs. An important discovery was made in the 1950s, when Frederick Bang found that horseshoe crab blood contained a chemical called Limulus Amebocyte Lysate (LAL). This compound came to be widely used in the pharmaceutical industry to test for the presence of any bacterial contaminants, because it helped identify endotoxins even at concentrations as low as one part per trillion. The moment LAL comes in contact with any contaminant, the solution turns into a 'gel', immobilising the bacteria within the gel. The LAL test is instantaneous and simple, and creates a sample that remains stable for weeks, even at room temperature, and it replaced unethical testing on rabbits and mice. The test went on to become an important step in the approval of any drug, surgical implant and prosthetic device hoping to get the Food and Drug Administration's approval. The horseshoe crab's blood has helped deliver insulin as well as COVID-19 vaccines.

On account of the presence of this important chemical compound, horseshoe crab blood became one of the

feature

most expensive liquids on earth. According to Business Insider, the price of the blood is valued at \$60,000 per gallon, and the demand is growing. However, this has led to the overexploitation of the species. About 30 percent of all horseshoe crabs collected for drawing blood die in the laboratory, and those that are released have been reported to show diminished chances of survival in the wild.

For the horseshoe crab, this unique chemical defence evolved to help it survive its bacteria-rich habitats. The moment the crab's blood cells detect invaders, they release LAL, thus creating a gel-like physical barrier that immobilises the bacteria. But, what was supposed to protect the animal is now the reason for its demise. In the 1970s, the high demand for LAL led to the start of a severe decline in the horseshoe crab population globally. Despite existing regulations, horseshoe crabs are poached in the thousands to meet the demands of the growing pharmaceutical industry.

Emerging threats in India

Apart from the demand from pharmaceutical companies, horseshoe crabs are also increasingly threatened by pollution and habitat destruction. Delaware Bay in the US, which has the largest population of horseshoe crabs, saw a decline from about 1.24 million Atlantic horseshoe crabs (*Limulus polyphemus*) in 1990 to about 334,000 by the early 2000s.

Among the four species of horseshoe crabs, two are found in India—the mangrove horseshoe crab (*Carcinoscorpius rotundicauda*) and the Indo-Pacific horseshoe crab (*Tachypleus gigas*). A recent study (see Further Reading section) revealed a 64.7 percent decline in the population of the former species and a 72.2 percent decline in the population of the latter between 2000 and 2010. The fourth and largest species, the Japanese horseshoe crab (*Tachypleus tridentatus*), too is in a similar situation. In India, there are additional threats facing the two species of horseshoe crabs. According to Prof. B.C. Chowdhury, a member of the IUCN-SSC Marine Turtle Specialist Group and advisor to the Wildlife Trust of India's (WTI) marine projects, the primary reason for the decline of horseshoe crabs in the country is the destructive fishing practices prevalent along the eastern coast, which is home to these species. Although not targeted, horseshoe crabs form a substantial part of the bycatch along the intertidal flats. Plucking them out of the nets is not easy and causes severe skeletal damage to the animals. Those that are plucked out whole are left scattered on the beach to perish. Moreover, since these are hard-shelled animals, fishermen also blame them for reduced fishing productivity due to the damage caused to their nets by the shells.

Bichitrapur beach located in a mangrove forest reserve in the Balasore district of Odisha used to be an important feeding and spawning ground for the Indo-Pacific horseshoe crab, but sightings have drastically reduced over the years. Dr. Biswajeet Panda, who is conducting a study on horseshoe crabs along the beaches of Balasore, suggests that poaching might be a major threat to the population. This despite both indian species





being protected under Schedule II of the Wildlife (Protection) Act, 1972, where illegal collection/hunting can attract a jail term of up to three years, a fine of up to INR 100,000 or both.

Satyajit Maity, a local fisherman from Dhublagadi village, remembers growing up seeing and playing with horseshoe crabs, saying they have now "vanished" from the coasts of Bichitrapur. Although the exact nature of trade is not known—with traders from places farther away contacting local fishermen to collect the animals and the specifics are kept under wraps—he confirms that it does exist and could be one of the reasons for the decline in numbers. According to Maity, a good-sized adult can sell anywhere between INR 800–1,000 (US\$ 9.61–12.01).

There is also increased pressure from other anthropogenic activities. Increased construction along the beaches like Digha and Sagar Islands in the state of West Bengal has led to a change in the texture and composition of the sand and sediment. This has also led to a shift in the congregation sites of the crabs over the past decade. According to Dr. Panda, more than 400 horseshoe crabs (across both species) were sampled in surveys that date back to the late 1980s. However, during a recent survey, they found less than 10. This tragically illustrates the severity of the decline.

Physiochemical changes in the habitat due to coastal erosion, industrial effluents and increased human activity have led to the loss of long-time spawning grounds for the species. Dr. Punyashloke Bhadury from IISER-Kolkata says that the population of the Indo-Pacific horseshoe crab is severely threatened by changing river systems. Faulty barrage management, like the one in Mahanadi River, has led to less clay sediment flowing into the river mouths compared to what it was a decade ago. The river courses have changed, the water volume has decreased and thus, the nutrient cycle that the crabs depend upon is affected. In addition, increasing amounts of wastewater being dumped into the sea without adequate treatment has led to an increase in nitrogen levels, thereby changing the physiochemical composition of the feeding grounds for the worse.

The aftermath of Cyclone Amphan

In May 2020, Cyclone Amphan caused colossal damage to the coastal habitat along the Bay of Bengal in India. Sagar Islands, a prime breeding ground for these crabs, was one of the most severely affected areas. Huge patches of mangrove and the adjacent mudflats were damaged. The high winds also brought in debris that changed the sediment composition of the banks.

Dr. Bhadury and his team, supported by WTI, led a cleaning drive while simultaneously assessing the sediment texture of the mudflats. With the help of local volunteers from the fishing community, some of these habitats were restored, debris and marine macroplastics were removed, and several horseshoe crabs were rescued and rehabilitated. More than 35 crabs, including gravid females, were rescued alive from ghost nets and released as part of the drive.

Dr. Bhadury's project has helped generate baseline information on horseshoe crabs and their habitats, while paving the way for the first coordinated rescue and release initiative for the species in this landscape. He now calls for urgent collaborative efforts involving state Forest Departments and governments, and NGOs to map the breeding sites and record the status of habitats of horseshoe crabs across their range. According to him, future conservation plans for this species need to ensure the long-term improvement of their habitats by conducting science-based mangrove plantations and sustainable management of debris, with a special focus on the involvement of fishermen communities.

Straddling both water and land, horseshoe crabs are a symbol of adaptability and resourcefulness in several cultures across the globe. It would be a shame if this prehistoric creature that survived mass extinctions is lost to anthropogenic exploitation. The horseshoe crab is a stark reminder of why we should revisit our existing relationship with nature and rethink our overuse of its precious resources

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What will it take to save the vaquita?

Author Sahotra Sarkar, Victor Sanchez-Cordero and Alina Gabriela Monroy-Gamboa Illustrator Karunya Baskar

For half a decade now, biologists have been predicting and fearing the extinction of the critically endangered vaquita (*Phocoena sinus*)—the smallest of the world's seven porpoise species. The vaquita lives in the northern upper end of the Gulf of Mexico between Baja California and the Mexican mainland. In August 2023, the International Whaling Commission, in a first-of-its-kind declaration in its 70-year history, issued an "extinction alert" for the vaquita. What occasioned this alert was a new report that estimated only 8–13 individuals of the species remaining in their natural habitat. Moreover, breeding in captivity has so far not succeeded.

While this population estimate underscores the dire situation the species is in, it nevertheless gives hope for the vaquita's survival. In 1997, the population comprised around 570 individuals. In 2018, it was estimated that fewer than 20 individuals remained, with an annual rate of decline close to 50 percent. Two years later, the estimated population size was down to eight individuals, though healthy calves were sighted. The current estimate also includes the healthy calves. Moreover, a recent analysis suggests that, despite its small size, the population is not prone to inbreeding depression—which is caused by a lack of genetic variation in the population, and which can lead to reduced survivability and fertility of the offspring.

Thus, given the tenacity of this species at the brink of extinction, it is imperative to redouble our conservation efforts. Unfortunately, policy formulation, let alone implementation, is far from straightforward, requiring consideration not only within the Mexican context but also globally, particularly in relation to the medicinal beliefs and food preferences among the wealthier classes of China.

The vaquita is close to extinction because of gillnet fishing of another critically endangered species; the fish totoaba (*Totoaba macdonaldi*), which shares its marine habitat. Between November and May each year huge gillnets—each sometimes over 600 metres long—are dropped into the water to trap the totoaba. The vaquita and many other marine mammals, including whales and dolphins, probably as many as 300,000 of them, are also trapped in these nets as bycatch each year, only to be later discarded. Totoaba fishing has been illegal in Mexico since 1975 and gillnets have been banned since 1998.



to have medicinal value, including increasing longevity and vigour, despite a lack of credible scientific evidence. Highly prized, these swim bladders can fetch up to US\$ 80,000 per kilogram in China.

Local conservationists in Baja California do not blame the fishermen who carry out the illegal gillnet fishing, but rather the organised cartels originating in China, that control the lucrative trade. Gillnets are expensive equipment and fishing with them is also an expensive enterprise; without funding from these cartels, local fishermen cannot afford to engage in this activity. Obtaining gillnets from the cartels engenders debt that the fishermen are then forced to pay off by extracting totoaba swim bladders. For the vaquita—and the totoaba—to survive, this dynamic must be disrupted.

Three recent developments provide some guarded reasons for optimism. The first and most controversial

of them is the permission granted in 2022 by the Standing Committee of the Convention on International Trade in Endangered Species (CITES) to Earth Ocean Farms, a Baja-based aquaculture company to legally trade in captive-bred totoaba. The hope is that the captive harvest will drive down prices and decrease the incentive for illegal fishing. Meanwhile, recently developed technology will make the products traceable and allow for accurate monitoring of the legal trade. However, critics maintain that this technology is far from perfect. The legal trade may as well spawn an even larger market in China and increase the scope of illegal fishing.

Second, there is some indication that the Mexican authorities are finally cracking down on illegal gillnet fishing in the upper Gulf. In 2018, several Chinese nationals involved in the illegal totoaba trade were arrested in Mexico. Since 2020, using information collected by NGOs such as Earth League International, authorities have also arrested several Mexican cartel members. Many, if not most, of the biggest totoaba traffickers are now in jail. Despite the decision to allow fishing again in the former No Tolerance Zone, Mexican authorities, in August 2022, deployed 193 concrete blocks with three-metre metal hooks to entangle gillnets in the upper Gulf. If these efforts continue, there is hope that the reign of the illegal totoaba cartels will be over and both the vaquita and the totoaba can avoid extinction in the immediate future.

Third, there has also been some cooperation from Chinese authorities. In December 2018, Chinese customs authorities confiscated 444 kilograms of totoaba swim bladders illegally smuggled from Mexico and worth an estimated US\$ 26 million. The illegal totoaba market in Mexico immediately collapsed. Though the market subsequently recovered, continued cooperation from China along with the other two measures may well save the vaquita from extinction. Or so we hope.

Sahotra Sarkar is a Professor at the Departments of Integrative Biology and Philosophy at the University of Texas, Austin. Victor Sanchez-Cordero is a Professor and former Director of the Instituto de Biología, Universidad Nacional Autónoma de México (UNAM). Alina Gabriela Monroy-Gamboa is a Postdoctoral and Adjunct Researcher at the Centro de Investigaciones Biológicas del Noroeste, S. C.



In 2017, the Mexican government enacted a small No Tolerance Zone that excluded all fishing activities in part of the upper Gulf of Mexico to create a refuge that comprises the most important habitat for the species. However, in order to appease local fishermen whose livelihoods were supposedly threatened, the government of President López Obrador rescinded the policy in 2021. Meanwhile, conservation NGOs, most notably the Sea Shepherd Conservation Society, have had violent encounters with these fishermen and those behind them.

Beginning in the 1920s, the totoaba was originally fished for its meat. However, that market was soon superseded by the Chinese appetite for its swim bladders, which are considered as status symbols and consumed in multiple ways. The bladders are believed

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PART OF THE BITULABS:

Dolphin decision-making and the fish on your plate

Author Imran Samad | Illustrator Shrobontika Dasgupta

Many of us relish the taste of fish in our cuisines. Some of us speculate where the fish must have come from, but only a handful of us wonder how it was caught at sea. Indeed, human ingenuity, fuelled by our love for seafood, has led to a myriad of ways of catching fish. Crafts can vary depending on the type, shape and size of fish that needs to be caught, and each one of them can be used slightly differently depending on the area, the fisher's knowledge, and the fish that is prized most.

The words 'fishing net' conjure the image of an intricately woven rectangle, similar to pigeon nets in our balconies. Such nets are called gillnets because fish are caught by their gills as they try to travel through the spaces in the net. When you encircle a gillnet around a fish shoal and seal it from the bottom before hauling, it is a purse seine net (resembling a coin pouch more than a purse). And then there is a trawl net—a cone made of fine-sized net dragged underwater by a boat, scooping out fish and all other creatures in its path. Depending on where, when and how much they are used, all fishing gears impact marine ecosystems differently. And some clever animals such as dolphins have learnt to use them to their own advantage.

So, what's the catch?

No fishing gear is perfect. While we intend to fish for particular species, we often end up catching a lot more that may not be of direct use to us. These byproducts of fishing are referred to as 'bycatch' and can include everything from tiny sea stars and corals to colossal whales and turtles. Globally, more than a third of all that we catch may be bycatch and that is inarguably a problem, more so for species that live long and reproduce slowly-like dolphins. So why don't dolphins avoid these treacherous nets and live happily ever after?



As endless as it may seem, the ocean is a finite resource. It is a desert with few ephemeral 'hotspots' of fish aggregations. Therefore, fish-the beloved food of all dolphins-is an extremely prized resource and dolphin pods may travel hundreds of kilometres in search of them. Naturally then, our fishing gears that artificially concentrate fish in small areas before pulling them up to the boat are like an 'all you can eat' buffet, albeit a risky one where entanglement in the fine plastic lines of the gear can be dangerous.

Dolphins, like us, are air-breathing mammals that need to surface regularly to breathe. Getting caught in a heavy net makes it difficult-sometimes impossible-to resurface and so dolphins can die of asphyxiation. Interacting with fishing gear is therefore a 'high risk, high reward' game which needs to be played with utmost caution, and understanding how dolphins make these decisions is of much interest to many like myself. But first, how do dolphins even know where the fishing boats are in the vast open ocean?

For whom the dining bell tolls

Characterised by a conspicuous hump seating the dorsal fin on their grey/white body, humpback dolphins are commonly found along the coasts of India. They occur very close to the shore (less than two kilometres away) and therefore greatly overlap with the diversity of fishing gear in the country. In Palk Bay, Tamil Nadu, fishers state that humpback dolphins appear near their boats as soon as they dip their gillnets into the waters every morning. In fact, stories of these dolphins tearing fishing nets to feed on fish are common from across the country, which is concerning because plastic nets cannot

Close to the Hawaiian Islands, false killer whales have been documented approaching longline fishing vessels as they haul their catch from the sea. It appears that the mechanical sounds of gears grinding as the net is pulled from the sea acts a 'bell' or cue for the animals to approach the ship for food. Similarly, bottlenose dolphins in Australia have learnt to travel inside the conical structure of trawl nets to feed and then escape swiftly. But do all dolphins engage with fishing gears in the same way? Are some individuals more risk-taking than others, or are there some that have perfected the art of fish-taking? Do mothers—who usually occur in groups or pods—engage less frequently in such activities to protect their young? My research in Goa, on the western coast of India, is trying to answer some of these questions.

be digested and are also a huge loss for the fishers. If nets accumulate in a dolphin's stomach the animal may not be able to feed on anything and die of starvation. Humpback dolphins occur in relatively high densities in Goa and are often spotted near fishing boats. But do all of them indulge in the high risk/reward game of bycatch?

Understanding dolphin-fisheries interactions in Goa

In Goa, my team and I use drones to follow dolphin pods from a safe distance as they travel along the coast, and we record how dolphins behave around various objects, including fishing nets. This helps us not only

NET

answer if dolphins prefer particular nets, but also to understand what kind of animals—for example, large versus small pods, mother-calves versus solitary individuals—engage more frequently with nets, and whether they make more risky decisions in the summer, when there are fewer fish in the sea.

Our initial assessments suggest that dolphins are surprisingly averse to fishing nets. In fact, they may also feed in the same area as fishing boats without interacting with them. Perhaps these skilful hunters do not need to play the human risk/reward game to survive, or perhaps there are only a few individuals who have learned the rules and are willing to take their chances. In the rare cases that dolphins interact with nets, they likely tear and ingest them. Several cases of dolphin deaths, presumably due to interactions with and ingestion of fishing nets, have already been documented in Goa.

> Nevertheless, it is exciting to understand why dolphin-fisheries interactions may be rare. Perhaps this is the case worldwide and we haven't looked closely enough—most studies report dolphins foraging near fishing nets but few record whether they interact with nets, simply because it is difficult to do so without using sophisticated tools such as drones. Perhaps not all animals interact equally. Or perhaps different dolphin populations and individuals are unique in their behaviours, which are defined by their history and knowledge.

Conserving the dolphins of Goa

All dolphins found in India are protected by the Wildlife Protection Act of 1972, but whether or not dolphins choose to interact with fishing nets is not governed by the fishers operating the net. Instead, it is likely a choice guided by several environmental factors, including how much fish is available for the dolphins to eat in the sea.

Decades ago, as old fishers of Palk Bay recall, dolphins foraged very close to their boats but rarely took fish from their nets. In the Ashtamudi river mouth of Kerala, cast net fishers use cues from humpback dolphins to understand fish movement patterns and catch more fish. In fact, this synergy between dolphins and fishers has been documented throughout the world, but is corroding away as fish numbers drop, increasing the competition between fishers and dolphins. Perhaps dolphin-fisheries interactions were rare and maybe even beneficial to fishers when there were plenty of fish for all. In the past few decades fish catch has steeply declined throughout India likely due to unregulated large-scale fishing activities fuelled by government agendas to extract as much fish-resources as possible from the ocean. This likely increased the competition for fish between dolphins and fishers leading to severe negative consequences for both.

Still, working in Goa to understand dolphin behaviour has inspired hope. Goa has a strong and vibrant network of researchers, activists, locals and organisations that are dedicated to conserving not only dolphins but the entire coastal ecosystem. Organisations such as Terra Conscious, Reef Watch, Coastal Impact and many more have been working closely with both the government

Imran Samad is a PhD student at the Indian Institute of Science studying marine megafauna bycatch. He combines modern tools and technology to answer species conservation-related questions.

Shrobontika Dasgupta is a storyteller who likes to express herself through art – particularly via illustration and 2D animation. to develop better management strategies for the coasts as well the locals/tourists to explain the workings of a complex system and people's role in protecting it. Since the coast is a multi-group use area, other stakeholders including the fisheries and the tourism unions, their respective departments, the coast guard, and the navy must also band together to develop and implement large-scale plans to protect dolphins.

The journey of a fish from the sea to one's plate is a long and complicated one. And dolphin-fisheries interactions are just as complex and nuanced as human-stock market interactions which are shaped by local, historical and individual-level factors. We are still a long way from understanding them, but I do sometimes wonder how likely it is that the fish on my plate is there because a dolphin decided not to take it from a net.

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THE KASAVS OF KAZIRANGA

Author Anuja Mital



Assam is famous around the world for its tea, handicrafts, food and, of course, the greater one-horned rhinoceros. Kaziranga National Park is one of the last remaining refuges for these endangered rhinos in India. It is a lush, biodiverse landscape that is known for its picturesque views and easy access to rare wildlife. A safari in Kaziranga is replete with sightings of several large species, including elephants and wild water buffaloes, roaming the expansive open landscape, unbothered, unfazed and undaunted. But it's not just majestic mammals that offer up clear views of themselves to visitors. Surprisingly, freshwater turtles—known as 'kasav' in the Assamese language—make appearances too, especially on the 'turtle trail' which runs along the Diffolu River.



On a sunny day, a drive drown this trail will reveal bales of Critically Endangered Assam roofed turtles—yes, a group of turtles is called a bale —basking on the unlikeliest surfaces. They are easily identified by a bright pink spot behind the eyes and pointy shells with jagged ends, resembling a tiled rooftop. These acrobats can balance and position themselves on the narrowest of logs and at acute angles, to catch some sun rays. Basking is an important regimen for turtles in order to thermoregulate, and also to keep their skin and shells healthy and free of parasites. If you're lucky, you can even spot some crafty young ones basking on top of bigger turtles or tumbling into the river as fights break out over prime basking spots.





Kaziranga is nestled in the floodplains of the Brahmaputra River, bounded by the rugged hills of Karbi Anglong in the south and the lofty mountains of the Eastern Himalayas to the north. This protected valley is sustained by the mighty Brahmaputra. The river diverges into hundreds of channels that are teeming with aquatic life, while the forested sand islands punctuating the streams serve as important corridors for elephants and tigers.

While going on a safari in Kaziranga, one experiences this landscape as a mosaic of habitats, from dense forests and ferocious free flowing rivers to lush swamps, muddy wetlands and reedy grasslands. Although the sanctuary is known for its charismatic megafauna, these diverse habitats support a wide range of flora and fauna, including mahseer fish, Gangetic dolphins, and even the occasional gharial finding a quiet retreat in these channels.

The Brahmaputra floodplains are also a hotspot for as many as 19 species of freshwater turtles. Kaziranga serves as a hideaway haven that still supports healthy populations of up to four large softshell turtle species, with these river stretches serving as undisturbed breeding and feeding habitats for them. It's rare to find places to sit and observe turtles for hours on end, yet these wetlands provide several spots to do so. If you are patient enough, you can spot the kasavs when they surface, gliding along peacefully and peering at you curiously amidst water hyacinth clumps and moss-covered logs. It is truly a delight to watch them go about their daily routine, living a simple life in a complex, interconnected natural world.



Page 22-23 (Clockwise from top):

Flowing down the Brahmaputra River, looking for turtles. Photo credit: Saiyam Wakchaure

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Black softshell turtles often use sandy river banks as basking or nesting habitat. Photo credit: Gunjan Menon

Assam roofed turtles basking precariously on a narrow log. Photo credit: Pradeep Hegde

The Kazrianga landscape is a mosaic of forests, grasslands, sand islands and the many channels of the Brahmaputra River. Photo credit: Pradeep Hegde

A view of the turtle trail alongside the serene Diffolu river. Photo credit: Saiyam Wakchaure

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Softshell turtles can often be seen surfacing and floating on the surface of water bodies, with usually just their snouts visible above the water. Photo credit: Pradeep Hegde

This work is supported by the National Geographic Society.

Anuja Mital is a herpetologist and freshwater ecologist, dabbling in river ecology, freshwater turtle conservation, nature education and outreach, and citizen science.

The Southern Residents Author and Illustrator Jacqueline Williams

The Southern Resident killer whales are a genetically distinct population of orcas in the Pacific Northwest. This unique population is on the verge of extinction with only 74 remaining individuals worldwide. One of the major issues is that the multiple threats—including lack of prey, pollution and vessel noise—afflicting the Southern Residents interact together, creating synergistic effects.

Many people are often surprised to learn that there are three different types of orcas within the range of the Salish Sea: resident, Bigg's and offshore killer whales. Each one of these 'ecotypes' — individuals or groups of individuals that share ecological adaptations — have completely different dialects and hunting behaviours, and they do not intermingle nor interbreed.



It's important to note that there isn't a single solution for the recovery of the Southern Residents. We must participate in multiple areas of focus including research, legislation, community outreach and education, in addition to supporting ongoing projects and initiatives.

Jacqueline Williams is a full-time Conversational UX Designer and a self-taught illustrator. She has been drawing for the last seven years and her favourite art topics include food culture, eco art and video games.



Saving the high seas

Author Palak Lunkad and Preksha Lunkad Illustrator Kevin Ilango Commercial activities such as overfishing, dumping of waste and seabed mining have been disturbing the ecological balance of the world's oceans—about 95 percent of which is still unexplored by humans. Constant environmental threat looms over the 'High Seas' in particular because it is the open ocean beyond any single country's jurisdiction, thus making it an international entity. And although it comprises 43 percent of the Earth's surface, only one percent of the High Seas is legally protected against exploitation. A regulation was needed to provide a framework for the protection of such marine areas and their biodiversity. In December 2017, the UN General Assembly decided to convene an Intergovernmental Conference to elaborate the text of an internationally legally binding instrument under the UN Convention on the Law of the Sea (UNCLOS) on the conservation and sustainable use of biodiversity beyond national jurisdiction. This culminated in the **United Nations High Seas Treaty**, which deals with the protection of marine biodiversity in international waters and provides a legal framework to do so.

The treaty, formally adopted on 19 June 2023 at the 78th UN General Assembly in New York, has been making waves all over the world. Also known as the **Biodiversity Beyond National Jurisdiction (BBNJ) Agreement**, its main agenda is to create protected areas in the high seas and prevent exploitation in the form of overfishing, shipping, pollution and potential deep sea mining, all of which when continued unmoderated would lead to severe consequences. With rising ocean temperatures and rapid depletion of marine biodiversity, the enforcement of the treaty is crucial.

First of its kind

The BBNJ treaty is the first legally binding agreement governing the high seas. It is founded upon two main concepts: freedom of the high seas, as outlined in Article 87 of the UNCLOS, and that states have a legal obligation to act in the best interest of all people by preserving biodiversity outside of their borders. The treaty authorises states to create "area-based management tools" in the high seas and deep bottom, such as marine protected areas with restricted activities. These area-based management instruments are important mechanisms for conserving the maritime environment beyond country borders, while taking into account food security, socioeconomic purposes, and cultural values. Previously, there were no global channels for such tools, and control was restricted to small ocean areas and certain businesses. However, the treaty now allows states to employ larger-scale, legally obligatory, multi-sectoral area-based management mechanisms. It also allows signatories to take action in the event of an emergency, whether natural or humanmade.

The treaty's environmental impact assessment provisions allow for the consideration of environmentally detrimental and polluting projects both inside and outside of national boundaries. These regulations require pre-authorisation assessments to determine the potential impact of developmental activities. As an example, Article 28 of the agreement states: "Parties shall ensure that the potential impacts on the marine environment of planned activities under their jurisdiction or control that take place in areas beyond national jurisdiction are assessed as set out in the Treaty before they are authorised."

All global commons require common governance and management by the community, which also means that the international community as a whole is entitled to share the benefits. Thus, unfair aspects of the exploration of the high seas are also covered by the BBNJ agreement, including scientific research conducted by many countries in these areas and experimentation on potentially beneficial DNA retrieved from such marine biodiversity. To ensure equitable distribution of benefits from the aforementioned two activities, the BBNJ treaty prescribes all benefits reaped from the exploration of the high seas as global commons.

The treaty also has major provisions for capacity building and marine technology transfer. And another noteworthy provision is the establishment of a specialised fund to assist developing nations, which will be funded by state contributions and financial advantages from the use of marine genetic resources.

Is the High Seas treaty beneficial for everyone?

An important aspect addressed by the BBNJ agreement is the geo-political economic realities of countries and their disproportionate access to resources. Developed countries continue extracting resources on account of their technological prowess, resulting in the depletion of natural resources and severe damage to the environment over the years. On the other hand, developing and least-developed countries, which have the most need for natural resources in order to 'develop', have limits placed on their levels of resource extraction. The treaty, with its goal of tackling inequality in low-income countries based on a lack of access to resources, has guidelines for usage of the ocean for scientific research and sharing of resources by all member countries equally.

The principle of the 'common heritage of humanity' holds that no state or individual can own common heritage places or resources that are part of the world's heritage and so belong to all humans. Hence, as per the BBNJ treaty which is based on this principle, oceans belong to everyone and must be used for the benefit of all humankind. It establishes a framework for the sustainable use of marine biological diversity in regions outside of national jurisdiction, which are not held by any country, and emphasises benefit sharing, particularly among less affluent and developing countries.

This is crucial because the ocean is a major repository of the world's biodiversity, with over 250,000 known species and countless more still to be discovered. Research on the genetic makeup of this marine biodiversity can help in the development of life-saving medicines and climate change solutions. The legal framework of the treaty ensures that there is a fair sharing of monetary as well as non-monetary benefits of such scientific research by countries who have the means to explore the oceans.

What will enforcement of the treaty do for the High Seas?

The high seas have been subjected to environmental damage due to the lack of formal protection over such expanses of oceans from activities such as unmoderated shipping, pollution, unaccounted fishing, waste disposal, etc. These activities need to be limited, managed and governed. This treaty acknowledges and recognises several forms of environmental damage in its preamble and focuses on tackling problems relating to ocean-human interactions.

While the treaty does not completely prohibit or ban freedoms, it proposes a framework for carrying out such activities sustainably and with regard for the ocean's health. Part IV of the agreement talks about environmental impact assessment (EIA)—a process that evaluates the potential environmental effects of a project or development.

When such an assessment is applied to deep sea mining—a relatively new field of marine exploration we see that, in theory, while this activity may seem enticing and even beneficial, its actual consequences would only worsen the high seas' condition. This led many member states to seek to ban this procedure altogether. However, deep sea mining was exempted from the purview of the EIA—an exemption which is proving to be a major drawback of this treaty and preventing countries from ratifying it. Even though the BBNJ treaty was already adopted and signed by 88 member states, it will only be enforceable once ratified by a minimum of 60 members, of which only 2 have done so. It is expected that once ratified this treaty will be enforceable by 2025.

While it's virtually impossible to know whether the BBNJ agreement will succeed or fail before it is enforced, many wonder whether it can be an all-encompassing solution to the many threats currently facing the world's oceans. Ocean temperatures are being recorded at an all-time high with an average of 21.1°C. This has had severe consequences, such as intense stress on our coral reef ecosystems, resulting in the bleaching and destruction of many reefs, accelerating polar sea ice melt, rapid depletion of fish populations and most importantly, a depletion of global ocean oxygen levels. Additionally, if deep sea mining were to begin, even in the remotest parts of the high seas, it may end up causing irreparable damage to our oceans that they won't be able to bounce back from.

The widespread destruction of marine biodiversity has left gushing wounds on our environment as a whole. The UN High Seas treaty may be the ocean's last hope.

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GETTING MUGGED BY WHALES

Author Laura Torre-Williams | Photographers Geoff Richmond, Janelle Bressow, Tony Taylor, Sea World Cruises Photographers

Working on a whale-watching vessel as a tour guide and researcher, you never know what you're going to see each day. Some days can be absolutely amazing and other days can be hard work in bouncy conditions. Departing from the Southport Seaway, our state-of-theart catamaran the *Spirit of Migaloo* went in search of migrating humpback whales in the Gold Coast Bay, Queensland. It was a lovely, bright sunny morning in July, and the winds were low, and the waters were calm and smooth. We had no idea what enthralling encounter would await us but knew that we would see pods of humpback whales on their long migration past the east Australian coastline.

Marine inspection

After travelling a short distance offshore, we were soon greeted by the blows and spouts of the whales in a classic V shape shooting high up into the air. The sound of a whale blow is very distinct and sounds like a loud "whoosh". It's something that always makes us happy as we begin our visit with these magnificent creatures. We had found our first pod of humpback whales!

After observing them and comparing their overall length against the length of our hull, we could tell that these whales were "juveniles"—not quite fully grown adults, more like young teenagers. Juveniles are not yet involved in the mating activities that older whales



engage in and can be a bit playful and sometimes come over to the boat and take a quick look. Today, however, as the whales approached the vessel, they didn't just swim past us closely and continue on their way, but instead chose to come up to the boat and give us a thorough inspection.

We turned off our engines to ensure their safety near us, and they continued to swim very close and kept approaching the vessel. We were getting 'mugged'! Mugging is a term we use to refer to these very close and sustained intentional approaches to vessels by whales. The whales remained alongside the vessel and began looking at us—first lying on their sides and then bringing their entire heads (or rostrum) out of the water so that their eyes could look intently at the boat and passengers. This behaviour is what we call a 'spy hop', allowing them to focus their eyes and see clearly above the water. It's a rare treat to be eyeballed by a whale, to capture their curiosity and to become the focus of their large, curious brains.

Next, the whales began diving under the boat in what seemed like a game, diving under the port side and swimming right under our hull, and then popping up along the starboard side. Then they would swim under the boat and appear at the stern, lifting their enormous heads clear out of the water, gazing at us intently, before slowly sliding back below the surface. They were checking us out from every position, then diving under the boat and popping up in front of the bow.

Each time they returned to the surface, their loud blows would startle us and everyone on the boat was covered in whale blow—something we refer to as a 'whale blessing'! It seemed to us that they didn't want to leave. This encounter involved the whales repeatedly approaching the vessels and remaining with us for more than 40 minutes, continually diving under the boat, popping up along the sides, spy-hopping and lying belly up just under the water's surface. They appeared not only curious but also exhibited a degree of comfort with the boat. If they were frightened or afraid of the vessel, they certainly would swim away, not lie belly-up next to the boat, which is a very vulnerable position.

Humpback whales are known to be among the most intelligent of all animals, and are sentient or self-aware, possessing large, complex brains with a lot of grey matter to enhance their capacity to store data. Such big brains are capable of well-developed curiosity, advanced wayfinding and navigation, feeling a range of emotions, and engaging in these 'mugging' behaviours.

We are researching the phenomenon of mugging and what behaviours occur during these encounters. Will we ever know why the whales perform this activity? Why are they approaching boats? Are they seeking out the company of humans? That may be a question we leave to the AI experts, but it may have elements of curiosity or boredom or a social component between the whales themselves.

Understanding whale behaviour

Many studies of whales and dolphins discuss how harmful interactions with vessels can be for them. Many research articles cite vessel noise to be intrusive and bothersome. Ship strikes can be possible from proximity to rotating propellers. These impacts are real because their sense of hearing is both sensitive and critical for their survival. Their skin is delicate and soft, and we have seen many, many whales



bearing horrible injuries, wounds and scars from propeller strikes. Boats can attain fast speeds, leaving little time for whales to get out of harm's way, and this is a great concern for our marine species. We have the utmost respect for this body of research and the dedicated researchers performing these critical studies.

All that being said, we have whales approaching and remaining with vessels intentionally, on purpose and of their own free will at this study site. We view this as a learning opportunity, and we conduct research every time these encounters occur. We are slowly learning about what happens during a mugging and are documenting the discrete behaviours exhibited by the whales. So, here's what we've learned so far on the Gold Coast over five years of studying mugging encounters.

First, these encounters can be fleeting and brief or can have a long duration. Most muggings in our study lasted 15 minutes, but some went on for over 40 or 50 minutes. In some cases, the vessel was unable to start its engines and leave because the whales were surrounding the boat so closely that it was unsafe to do so. The intensity level of the mugging can range from low intensity (brief encounters) to high intensity sustained encounters, where the vessel is almost held captive by the whales.

We're also learning that it's not just the juveniles that are exhibiting this mugging behaviour, sometimes it's mixed groups of juveniles and older whales, and other times it's a group of all adults. Very occasionally, we have observed mothers with calves approaching the vessel and remaining alongside the boat or diving under the vessel. Our data suggest that several different age classes engage in mugging activity at this location.

While there is no specific group size for a mugging, they often involve two to three whales together, but occasionally up to five animals can be present around the vessel. Also, sometimes whales interacting with the vessel are joined by more whales, so the number of individuals mugging the vessel grows during the encounter. Even more interesting is that sometimes muggings occur with associated species becoming involved as well. In a few cases, mugging whales have been joined by local bottlenose dolphins, who will also interact and focus on the vessel. In most documented cases, it is typically one or two bottlenose dolphins joining the whales, but one documented encounter included a pod of up to 50 dolphins joining in and interacting with the vessel.

Part of our study is documenting what discrete behaviours occur during a mugging. Data shows that during a mugging, common behaviours include swimming up to and lying alongside the boat, frequent diving under the vessel itself, and pop-ups to either the port side or the starboard side of the vessel. Timed dives under the hull of the vessel may last up to several minutes. Other observed behaviours include head rises and spy hops, rolls, twirls and lying on their sides next to the boat. Often whales are observed resting next to the boat or "logging"—lying motionless just out of hand's reach alongside the hull.

Approaches can be singular with the whales departing after a short time, or several different approaches will be made before they eventually leave the boat. The most common is one to two approaches; however, we have recorded up to seven different discrete approaches to the vessel in one encounter.

Being mindful

As we continue to study and learn about these intentional mugging approaches by the whales, we wish to stress that vessels (recreational, commercial, jet skis, kayaks, etc.) should never purposefully approach them closely, in an effort to entice this type of interaction. All vessels should closely follow the local regulations on approach distances and speeds. Vessels trying purposefully to get up close with whales may place themselves and the whales in danger. These majestic mammals need space and their privacy, and they need to be allowed to exhibit natural behaviours in their wild environment. We always



say "GO SLOW IF YOU SEE A BLOW" because it's important to respect the whales and give them their space. Vessels trying to get too close could cause them to flee, interrupt critical nursing or feeding behaviour or even disturb important resting bouts. (Note: no whales were fed during any of these encounters and vessels should not attempt to feed wild animals.)

The beauty of encountering and experiencing a mugging is that the whale intends to approach and interact with the vessel, not the other way round. It is, indeed, one of the biggest privileges that you can experience out at sea—to capture the imagination of a wild, highly intelligent whale. So, as a responsible boater, it is important that you go slow around marine creatures, be respectful, and follow your local regulations.

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Laura Torre-Williams is a conservation biologist, marine researcher and educator with a passion for communicating science in a simple manner and for all ages. She encourages everyone to play a role in conservation.

Photo credits

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