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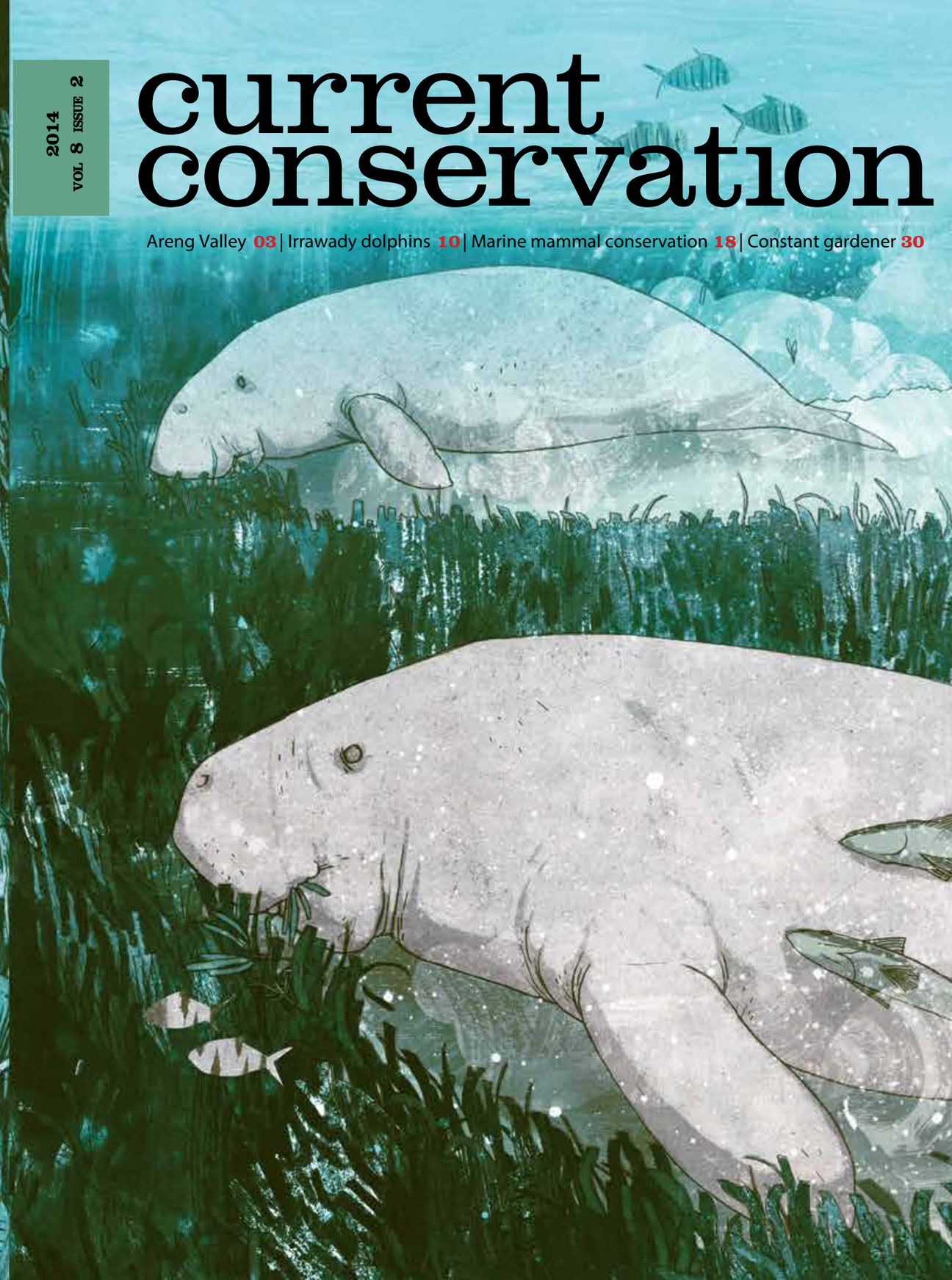

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Cover art by Prabha Mallya

Whales, dolphins and other marine mammals remain at the forefront of our imagination. On the one hand, we would have read about the thousands that were brutally killed in whaling operations. On the other, given their sociality and interaction with humans, many of us have read anecdotal accounts of their 'friendliness' and intelligence. But though they have been part of human folklore and mythology for centuries or even millennia, most of us rarely if ever get to see them in the wild. Personally, a chance encounter with a humpback whale off the west coast of Mexico, slapping the water with its tail fluke less than 50 metres from our boat, is not a sight I am likely to forget.

While marine ecology lags behind terrestrial ecology in many tropical and developing countries, marine mammal research is often even further behind due to logistic constraints and the financial resources required. In India, for example, there has been little in-depth research on marine mammals, with most studies based on strandings, land based sightings and infrequent ship board surveys. In this issue, Dipani Sutaria gives us a perspective of her research in Chilika, tracing the development of her ideas from a focus on biology to the interactions between the people and the dolphins and development, towards finding conservation solutions. Elrika D' Souza writes about her work on the foraging ecology of dugongs in the Andaman Islands, and Diya Das interviews her about a recent publication. Kathleen Stafford and Mark Baumgartner write about methods for studying marine mammals and the role that such research plays in conservation. We also carry a photo-essay on Areng Valley, a biologically rich area in Cambodia, which has recently been threatened by development projects.

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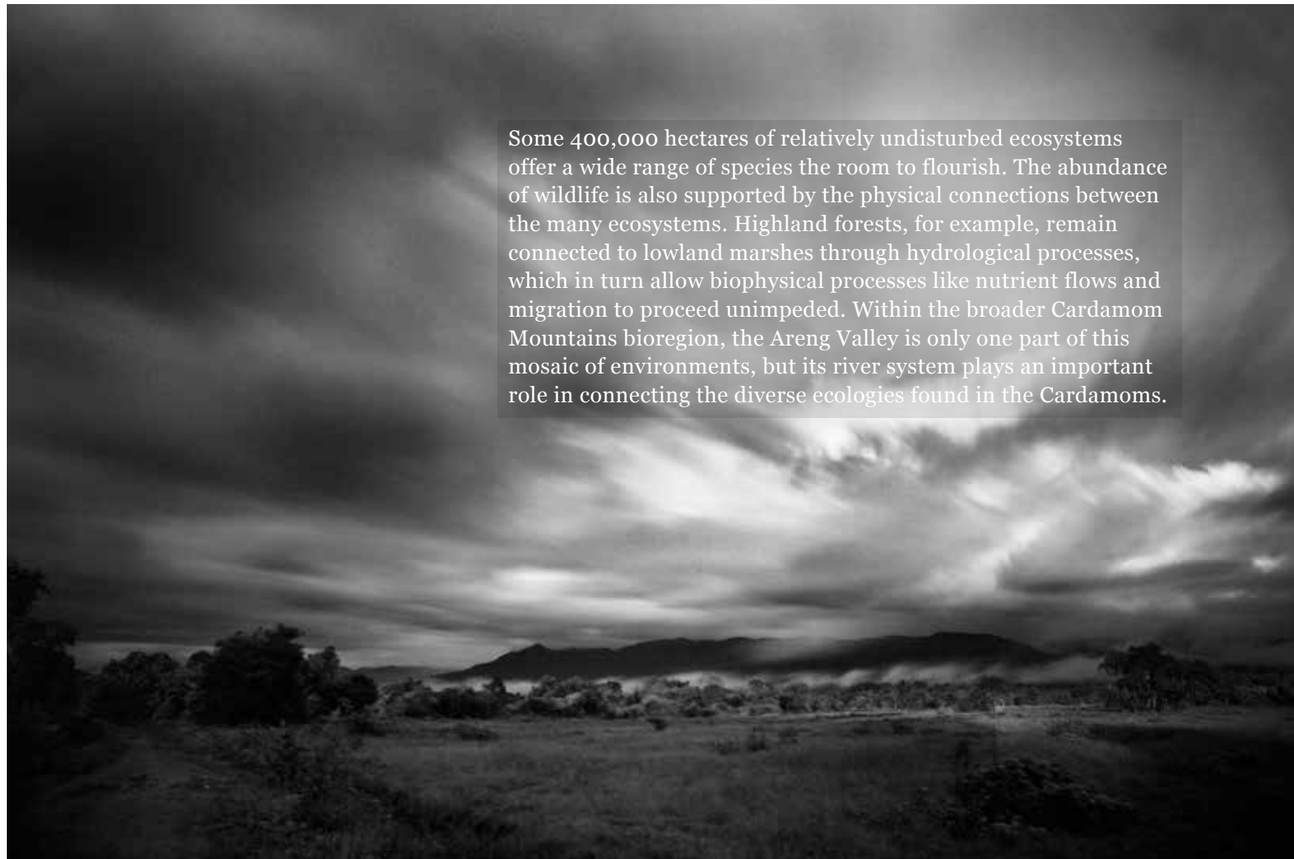
Areng valley

The Areng Valley, one of Cambodia's most socially and ecologically sensitive areas can be found in the depths of the country's southwestern forests. Home to rare and globally endangered wildlife—and to communities that depend on the valley's abundant natural resources—the entire habitat may be flooded if officials proceed with the controversial Chaey Areng hydropower project. In addition to the likely impacts on the environment and communities of the valley, the project is politically sensitive, as it raises questions about how the habitat should managed, and who should have access to the resources of the Areng Valley. The following images provide an introduction to both the Areng Valley and the people who are trying to protect its riches and influence its future.

Located in southwestern Cambodia, the Areng Valley is a roughly 20,000 hectare expanse of evergreen forests, wetlands, farms, and villages that overlap with one of Southeast Asia's most important conservation areas: the Central Cardamom Protected Forest. Designated as a protected area in 2002, the valley and the surrounding mountains are widely recognised as being a part of a broader bioregion that houses significant amounts of biodiversity. The region is host to some of the world's rarest wildlife. Asian elephants, pleated gibbons, clouded leopards, Asiatic black bears and great hornbills are just some of the 31 globally endangered species that have been recorded in the Areng Valley alone. Of notable importance is the presence of the critically endangered Siamese crocodile in the Areng River, a species now extinct across 99% of its historical habitat range. This biological wealth is made possible by the large habitat range provided by the expansive evergreen montane forests of the Cardamom Mountains.



Some 400,000 hectares of relatively undisturbed ecosystems offer a wide range of species the room to flourish. The abundance of wildlife is also supported by the physical connections between the many ecosystems. Highland forests, for example, remain connected to lowland marshes through hydrological processes, which in turn allow biophysical processes like nutrient flows and migration to proceed unimpeded. Within the broader Cardamom Mountains bioregion, the Areng Valley is only one part of this mosaic of environments, but its river system plays an important role in connecting the diverse ecologies found in the Cardamoms.

At the heart of the valley is the Areng River, which fuels both the valley's ecology and its residents. The river's watershed receives an average of 150-200 inches of rainfall per year, with most of the precipitation occurring during the monsoon season (May-October). Seasonal pulses of floodwaters during this time are extremely important in allowing nutrients from the watershed's forests to be distributed throughout the Areng Valley. Not only do these pulses contribute to the river's aquatic biomass, but they also help nourish the valley's agricultural fields. Connected to the river are also networks of seasonal streams, wetlands and ponds that allow many freshwater fish species to perform migrations between the river and the valley's floodplain wetlands. Combined with the river's internal aggregation of interconnected habitats—including deep pools, fast flowing rapids, woody debris and riparian vegetation—the Areng River maintains a level of habitat quality that is becoming increasingly harder to find in the rest of Southeast Asia. Healthy populations of extremely rare Siamese crocodiles, Asian arowana (dragonfish) and "blackfish" attest to the river's ability to support considerable amounts of biological wealth.

Embedded in the Areng Valley and River's ecologies are native residents who rely heavily on the area's environmental resources. While many people living in the valley moved to the area from other parts of Cambodia after the fall of the Khmer Rouge regime, a large portion of the 1500 or so residents are Khmer Daeum, a group of Cambodian natives that include the Chong and Sui indigenous groups. Regardless of ethnic origin, all families in the Areng Valley make their livelihoods through subsistence practices. Rice cultivation, in particular, is an integral part of many people's lives. All the rice, and virtually all other produce grown in the valley, is consumed locally. Cultural interactions also reinforce the locals' connection to, and conception of, the Areng's landscape. Communal agricultural practices, along with communal use of forests and the Areng River, emphasise the shared use of the valley's resources. In addition, animist beliefs in spirit forests and animals such as the Siamese crocodile help sustain a level of conservation by discouraging trespassing and unnecessary encounters.

One place where the intimate knowledge of the environment among valley residents frequently manifests itself is on the surface of the Areng River. Areng Valley fishers, in particular, possess a wealth of place-based knowledge honed by years of experience, and are capable of catching many of the 43 fish species that have been recorded in the river's watershed. The hidden contours and life under the Areng River are as familiar to them as the dirt paths that connect the houses of their village. With such knowledge comes a detailed understanding of the behaviour of aquatic species, including their migration patterns, preferred habitats, and life cycle characteristics. The connections people have with their surrounding environments make them experts on the Areng Valley's ecological systems.

Despite the highly knowledgeable way in which the residents of the Areng Valley engage with their environment, some government officials feel that such knowledge and associated lifestyles are inappropriate for a country that is attempting to rapidly modernise. Both the economic poverty of people living in the Areng Valley and the country's shortage of electricity are noted as being primary reasons necessitating the construction of the Cheay Areng hydropower dam on the Areng River. Since 2006, several foreign companies have offered to lift the valley out of poverty by promising residents generous compensation packages and by sustainably using the valley's water resources through hydropower.

The Cambodian government has embraced these plans as a part of its overall development goals to increase electricity production and to help bring the benefits of development to rural populations. However, a number of prominent environmental organisations, as well as a Japanese aid agency, have countered such claims of prosperity and sustainability with data suggesting that the project offers minimal economic benefits—and will take a considerable toll on local communities and biodiversity. Increasingly, Areng Valley residents are also voicing their opposition to the project. In an attempt to counter what they see as a one-sided project that will strip them of important environmental resources, residents have resorted to forms of protest that allow them to project their voices past the confines of the valley. Their efforts include motorcade marches to provincial government offices, submission of petitions to the national government, and forms of civil disobedience that are physically preventing the hydropower project from moving forward.

The future management of the Areng Valley's environment remains uncertain despite continued efforts by valley residents to stop the dam. Past experience has demonstrated that force is often used against groups that have vehemently opposed large-scale development projects in Cambodia. As a result, it is unclear how the situation will develop from here and how the Cambodian government and the company responsible for the project will respond to the demands of valley residents. For now, with no other functioning mechanism to have their voices heard, Areng Valley villagers will continue their protests.

The Areng Valley communities are not alone in their fight. Starting from a single dedicated local NGO, an expanding network of individuals and groups are rallying to support the efforts of valley residents. Among the supporters are a group of politically active monks who have embarked on an awareness raising campaign for the plight of the Areng Valley, which involves symbolic blessing of the oldest trees in the valley as well as praying for the protection of its people and environment. Other supporters include lawyers, film directors and scientists, each of whom contributes to a campaign seeking to empower valley residents in a way that will allow them to continue to maintain and benefit from the valley's environment.

Ultimately, what the valley residents seek is a way to participate in discussions about how their environmental resources are used for either conservation or development. Much of the dialogue to date has been directed at them rather than with them. Thus, the Chaey Areng hydropower issue offers an opportunity to break new ground in Cambodia, to redefine how stakeholder participation actually influences the planning and implementation of resource use projects. If all sides involved in the resource dispute can listen to the people who will be most affected by a final decision—dam or no dam—then perhaps a path towards a more sustainable and equitable future can be made for the people and environment of the Areng Valley.

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Spoorthy Murali

Of Chilika, dolphins and people

It was a rainy day 12 years ago when we drove alongside fresh green paddy fields, with the smell of moist red earth and the occasional showers of Holi colours, to visit a place that would occupy my mind for the best part of the next decade. It was during that visit in 2002 to Chilika, a brackish water lagoon tucked away in southern Odisha, that I saw my first Irrawaddy dolphin—Scoopfin—with a calf. I kept my eyes on and heart with her all through the next eight years. But I wonder how she is today, how many calves has she had, which other females she is foraging with and if they are still getting enough of mullet, dogfish and popcorn fish. I wonder when and how our paths will cross again. My first visit was just by chance after all. I wonder how Chilika has changed since I left, because the ecological system is dynamic and disturbed, but some interactions remain stable, maintaining the essence of Chilika.

In 1999, while working on a project on olive ridley turtles, I stayed for months on an other-worldly island I fondly call mine—a strip of land in the middle of the Bay of Bengal, several hours from a pay phone, peaceful with its emptiness, its ochre sandy texture against vast grey skies and sultry green seas. The dainty oystercatchers, comic crab dances, and hundreds of olive ridleys right next to the neighbouring island with its missile testing range created a surreal atmosphere on my island home whose only source of light was the stars, the moon and the reflecting sea. It was during those days, while observing the belly rubs and body rolls of Indo-Pacific humpback dolphins encircling our turtle tagging boat that I first considered studying dolphin behaviour. All the more when I realised that they were amongst many ignored groups of marine species—not studied because of logistical issues, because we see them but rarely, because the data from species that are cryptic hardly makes good science and so on. So, when I finally saw the Irrawaddy dolphins in Chilika, I felt a rush of questions, about the nature of tribes, about the cost-benefits of individuals versus groups, about the formation and breakdown of communities and societies. Here was a population of dolphins, which according to fishers spent all its time inside the lagoon. A closed population of well-marked individuals is an absolute treasure for those who study behaviour.

Dipani Sutaria

A misty morning in Chilika

Dipani Sutaria

Scoop fin photographed with a young one by her side in the typical mother-calf position

Irrawaddy dolphins are also special as they have adapted to freshwater systems, brackish water lagoons, estuaries and to coastal areas. In India, they are found in Chilika, in Gahirmatha and in the Sunderbans of West Bengal, and the coastal waters from Gahirmatha to West Bengal. The species is listed as Vulnerable by the IUCN, and is found in small pockets with a discontinuous distribution from Odisha, India till the Philippines. Five of the six partially isolated sub-populations of this species are listed as Critically Endangered by the IUCN. The population in Chilika is the only lagoonal population that has not been assessed by the IUCN Cetacean Red List Authority. Sadly, we still do not know enough about the life history, reproductive biology, genetic viability, and survival rates of the population in Chilika to be able to do a thorough local assessment.

Chilika is the antithesis of my island in the Bay of Bengal. With an area of 800-1000 square kilometres depending on the season, it is surrounded by around 142 villages and more than 200,000 people depending on fishing and agriculture. Chilika is home to long-tailed fishing boats with engines that can reverberate through you, religious mass tourism, limitless unmanaged garbage, agricultural, domestic and aquaculture run-off, illegal shrimp aquaculture, and most importantly a high degree of inter-village conflict. I returned to Chilika in 2004 for my doctoral research with a fuzzy head full of questions, some of which were suggested, some imposed and a few which inspired me. The thesis project had finally received funding from James Cook University, Australia, Wildlife Conservation Society, New York and from Ocean Park Conservation Foundation Hong Kong.

After the first three months though, the journey changed even more. I realised that knowing the people of Chilika was just as important as knowing the dolphins, not just because it would provide a holistic picture for conservationists, but because the people and the dolphins were in fact inseparable. In this crowded space of dolphins and people, I had to choose between remaining an outsider and merging in to understand the social and ecological landscape on which the dolphins depended. I chose the latter and immersed myself into local life. My desire to study Scoopfin and her calves, or M Jagger and his band of rowdy males took a back seat. I instead jumped into unchartered territories and decided to learn the discourse of political ecology—a naïve step at the time.

After finding a family in the village to live with, a stable boat driver, Jagga and local research assistants from the village, Loba and Raja, we slowly started drawing out a plan to understand the various aspects that defined the lives of the people and the dolphins. Over a period of 14 months, we divided our time between interview surveys, shore-based behavioural studies of dolphins in the presence and absence of tourism vessels and dedicated boat transects for population estimation and habitat use by dolphins.

Dipani Sutaria

M Jagger, a commonly sighted adult individual, probably male and part of a group of 11-13 dolphins

We photo-identified a total of 80 individual dolphins based on natural marks and cuts on their dorsal fin along with fin shape and any additional marks on the body. We estimated the population size to be about 119 individuals using less than 400 km² of the water body. We found two core areas in the lagoon, one close to the sea mouth used by around 60% of the population and another in south-central Chilika. The dolphins spent most of their time foraging, milling (an individual, or a group searching for prey in an area with synchronised dives and slow movement but in no particular direction and minimal aerial displays) and socialising, with the predominant behaviour in the core areas being foraging and milling. Depending on prey species, the dolphins exhibited both solitary and group foraging strategies in combination with spitting, sideways flipper slaps and tail slaps. Group foraging (presumably cooperative) was seen mostly for catching schools of mullet and dogfish. Mud-plume feeding, usually solitarily along with spitting sideways was observed mainly in shallower regions of the channels for catching scat fish and small sized prey, while kerplunking (stunning prey using the tail stock and flippers to shoal and catch the fish) with spitting was often observed in dolphins foraging in a group in deeper sections of the channels. Spitting is seen only in two species of delphinids, Irrawaddy dolphins and Belugas. It could be used to either stun prey as explained above or perhaps even as a result of suction feeding in which the dolphin spits out water after filtering in the prey. Dolphins also used shallow sloping shores and stake nets as barriers against which they drove schools of fish. All these behaviours, and new behaviours which may have developed, deserve an in-depth study from a cognitive perspective.

Our dolphins differed largely based on their individual movements and the stability of their associations with each other. The occasional entry of bull sharks or Indo-Pacific humpback dolphins into the lagoon (after a new sea mouth opened) was one of the few sources of predation on the dolphins. Prey availability would otherwise be the main driving factor for presence and movement. We found that some dolphins were rovers and most were homebodies. Quite a few of the individuals, some of whom we saw with calves did not explore more than 10 km², while others had travelled between the outer channel and south-central sector exploring up to 200 km², thus exploring most of the preferred habitat. We hypothesised that the mother-calf pairs stayed close to food sources (Outer channel and Palur channel) and did not venture far even though the Outer channel also brought the risk of bull sharks and larger dolphins. We also found that 14 individuals showed a higher degree of association with each other rather than with others, hypothesising that the population has a stable social structure and does not show fission-fusion (where there is breakdown and movement between groups), and the degree of aggression displayed between individuals was low compared to Bottlenose dolphins and Indo-Pacific humpback dolphins. We do not know if this is a species level difference or a result of adequate space and food. The only time we perceived aggression, intense socialising with chasing and tail slaps was during mating chases, which are most common during February to April each year. The mating chases are intriguing, with a group of males chasing either one or two females, and can be risky if a young one is with the females. When the chase does not get anywhere, the males behave like a football team, forming a circle with all heads inwards, almost as if they were discussing the next strategy.

Dipani Sutaria

Spitting behaviour associated with foraging activity, exhibited only by Belugas and Irrawaddy dolphins

Dipani Sutaria

A group of dolphins forming a circle with all heads facing inwards, as if strategising the next move.

Assuming accidental mortalities in fishing gears are controlled and prey availability and habitat quality are sustained, the Irrawaddy dolphins in Chilika seemed to fare better than most other wildlife, especially given that Chilika is not a protected area. But how do we ensure though that encounters with fishing nets are mitigated and that fish diversity and densities are sustained?

The dolphins spent most of their time foraging, milling (an individual, or a group searching for prey in an area with synchronised dives and slow movement but in no particular direction and minimal aerial displays) and socialising, with the predominant behaviour in the core areas being foraging and milling.

We hoped to find solutions from the people, on how best to protect the small population of Irrawaddy dolphins in Chilika, and to be aware of all ecological or social factors that could influence these solutions. Our work took us to villages all along the periphery of this coastal lagoon. Since we were completely new to the lagoon and its complications, each day came with information that was new, complex and surprising. We found the connection between traditional fishers and Chilika to be one of faith and that 'Chilika Ma' would take care of them. But shrinkage and siltation of the lagoon and reduction in fish catch had become a source of great concern. The intervention by the government to dredge a new mouth to the sea had helped villages in southern and central Chilika, but had created issues in the villages close to the sea. The three fishing associations of Chilika, once a united body, had also undergone some major changes under this pressure. Once a self-managed fishery, where the village panchayats settled fishing areas and fishing seasons, it had now become one of the most conflict torn fisheries in the region. This was largely assumed to be due to the

Dipani Sutaria

Dolphin-watching boats and fishing boats in the Outer channel of Chilika

shift in ownership of Chilika from its people to the administration, and the advent of unsustainable shrimp aquaculture amongst agriculturists or non-traditional fishers via the World Bank and later by the locals themselves. It is not possible to remove a source of income, however destructive, once it has yielded great profits. So while the ecosystem of Chilika was undergoing drastic environmental changes, over-fishing and drop in fish catch, a greater turmoil was playing out in the social landscape. I cannot pretend that none of this affected me. Trying to maintain an academic stance was not always easy and I wondered if it was even necessary if one wanted to grow personally and professionally. It took a while, but remaining aware of the people and the politics, we started looking at how both people of Chilika perceived dolphins amidst all the chaos.

Traditional fishers believed that as long as there were dolphins in Chilika, their well-being and their fisheries would sustain. Our analysis showed that positive perceptions towards dolphins were strongest in people who were most exposed to dolphins during their daily life, that is people living and fishing in the vicinity of dolphin hotspots, those involved in dolphin-watching tourism or those who owned engine boats. We expected age to play a major role in influencing perception, but our sample size was not strong enough to prove or disprove the point. Very interestingly, dolphin-watching tourism grew during the times when fish catch from the lagoon was the lowest. The dolphins that once used to hang around fishers while they were fixing their stake nets soon became an alternate source of livelihood for fishers, buffers to absorb change when externalities had threatened fishing livelihoods, making at least a few of the communities resilient during this time of transformation. At least a few elderly fishers liked this new identity and respect they had derived from being part of the tourism industry.

Earlier, fishers saw dolphins as a blessing from God, as a symbol of ecosystem health, a sign of good fish catch. So if fishers saw dolphins in an area, they would lay out their nets there though gill nets, specially trammel nets, shark nets and hooks-and-lines are the primary cause of mortality in dolphins. And now, dolphins had become a direct source of income, however inequitable, across a range of stakeholders.

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Studying the growth of this community driven dolphin-watching industry in the outer channel from a few boats in the 1980s to about 350 odd boats in 2011, was at first exciting, but later bewildering. It was a self-initiated and self-managed business in the 1980s, and gained support from government agencies in the 1990s. However, the system still had no way to control or limit the number of boats

Dipani Sutaria

A warm sun setting on a winter evening

allowed to approach a group of dolphins, no appropriate guidelines on how to approach and show dolphins, and of course, no cap on the number of villages who could carry out this occupation. But the area they all operated in was just 35 square kilometres. The same people who fished with dolphins, who saw them as a blessing, and asked Chilika Ma (Mother Chilika) for forgiveness when a dolphin got entangled in their nets, apparently did not see what we saw as the effect of uncontrolled tourism.

During our shore based surveys of dolphins around mechanised vessels, we had not witnessed any boat strikes on dolphins, but had observed dolphins changing their behaviour and changing direction of travel if a tourist boat came within 40-60 metres. Managing boat traffic would be of importance in keeping the dolphins healthy. So we asked all the boat drivers at the association to individually fill up questionnaires. The answers were baffling. All the boat drivers mentioned that dolphin watching stressed and disturbed the dolphins, and this affected the quality of experience for the tourist. They were also aware of the fishing gears that were most lethal to dolphins and the gears that could lead to loss of fish diversity and abundance in Chilika. They listed solutions to all these problems, including silent engines and propeller guards. But the only aspect they could not respond to was regarding the management of the number of boats in operation at one time. While we held discussions, drew out different route plans to divert boats, and the government body held workshops for dolphin-watching guidelines, another event occurred. Two new dolphin-watching associations cropped up in adjacent villages. When I returned the following season, the original association had shut down and only one of the new ones was active. This pattern continued with the formation and breakdown of dolphin watching associations in the Outer channel of Chilika. Political conflicts over fishing rights, inter-village rivalries, personal agendas, local workings between the revenue department and the various associations were somehow limiting the growth of the industry. I felt some guilt, but mostly relief over these events, and realised that organisational theory and political ecology had much to offer to our understanding of these situations.

I am not so sure how long this resilience displayed by the people and the dolphins will last. But I have learnt not to worry from Bhalu, a 12-year-old boy then, who had held my hand and walked me home on a bad day. Another 13-year-old boy, a football enthusiast who used to take care of his grandparents, used to row me from one island to another in his dug-out canoe. On the way he used to call out to the dolphins. And every time he did, the M Jagger group would come and circle our little boat. This for me is what Chilika is all about. It is a far cry from serenity, but there are quaint moments, quiet pink sunsets, and fog-covered glassy waters at sunrise. There are dolphins that spit in your face and wiry fishers who smile back at the camera. Amongst all the chaos of those years in Chilika, I actually did find my island of forty-four sunsets. As Exupéry might say, it is hidden, and it is small, and the dolphins that sleep by it, they keep me humble.

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Marine mammal conservation and the role of research

Kalyani Ganapathy

Marine mammals are a diverse and widely distributed group of animals that includes the biggest animal to ever exist (blue whales can be up to 30 metres long), the world-record breath holder (beaked whales can stay under water for over 2 hours), and some fearsome predators (e.g., polar bears, killer whales, leopard seals). Marine mammals are found from the tropics to the poles and from estuaries to the deep ocean. The roughly 125 different species of marine mammals come from three Orders of mammals (Cetaceans, Sirenians and Carnivores) and each has different habitat requirements, prey preferences, and distributions. Our understanding of the role these animals play in their ecosystems and how the ocean influences their distribution and behaviour is hindered by the very environment in which they live. For instance, while pinnipeds (seals and sea lions) are amphibious and give birth and nurse their pups on land, the cetaceans (whales and dolphins) only come to the surface to breathe and spend over 95% of the time underwater. This can make studying these animals, their environment and the potential impacts of human activities on them (e.g., whaling, fishing, climate change) difficult. To overcome these challenges, a suite of new tools has been developed to better understand the role of animals in their environment and how this information can be used in the conservation and management of marine mammal populations. Here we will focus on threats to, and tools for studying, whales and dolphins.

THREATS

When most people think of threats to marine mammals, they likely harken back to commercial whaling. From as early as the 1600s up until late in the 21st century, large whales were the targets of whalers for their baleen (sometimes called whalebone even though it is not bone, but made of keratin like our fingernails and hair) that was used in women's corsets and for umbrellas or riding whips, their blubber that was rendered for lamp oil, industrial lubricants and margarine, and for their meat and bone that was often ground up for fertilizer and dog food, but also used for human consumption. Because of the vast scale of commercial whaling, by the mid-1900s, populations of most species of large whales were nearing extinction. At present, protected by a global moratorium on commercial hunting by the International Whaling Commission, many populations of large whales seem to be recovering, although this is often difficult to accurately assess.

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For populations that are not increasing, other human activities have been implicated in hindering recovery. For instance, ship strikes are one of the key reasons the North Atlantic right whale remains highly endangered. Interactions between humpback, blue and fin whales and commercial cargo and cruise ships are on the rise in the northeast Pacific and the northern Indian Ocean in part because shipping lanes and productive feeding grounds of these species coincidentally overlap. Perhaps the greatest threat to small whales and dolphins today is the accidental entanglement of these animals in fishing gear; as many as 1000 animals per day are caught in nets and on long line gear where they drown because they are unable to surface to breathe. Large whales can usually break free of nets but may end up towing heavy gear or having line trapped in their baleen, impeding feeding.

Kathleen M Stafford

A humpback whale fluke (underside of tail). Each fluke is unique to an individual, much like our fingerprints. Such photos can be used to estimate population size, track individuals over time and space, and provide data on longevity.

Human activities in the ocean, such as commercial shipping and oil and gas exploration, often create a great deal of sound, which can sometimes be harmful to whales and dolphins. Cetaceans rely on their hearing more than any other sense to communicate, navigate and find food, so increases in ambient noise from human sources may interfere with these vital activities or even cause physical harm. Just like a loud party or music concert reduces the distance over which you can effectively communicate with a friend, elevated ambient noise can severely reduce the "communication space" of whales trying to convey information to other whales that are hundreds of meters to tens of kilometers away (sound travels much farther in water than in air). Noise has been shown to increase stress in large whales, and there is evidence that some sonars may even lead to strandings and death in beaked whales.

Finally, climate change may by one of the least understood but most significant threats to marine mammals. Climate change has been underway in the Arctic for the past decade, and changes to the ecosystem related to the disappearance of summer sea ice are readily apparent. The amphibious marine mammals that rely on the ice to rest, such as polar bears and walrus, are spending more time and energy swimming at sea, which impacts body condition, health, and survivorship. "Invasive" sub-Arctic cetaceans, such as humpback, fin and killer whales, are becoming more common in Arctic waters, and will undoubtedly compete with endemic species for prey. With changes in the environment come changes in human activities, and the ice-free Arctic is being increasingly used for industrial activities, like oil and gas production, commercial shipping and eventually fishing. Like in other parts of the world, these human activities will have an impact on marine mammals and will ultimately change what was until only very recently one of the most pristine environments on the planet.

THE RELATIONSHIP BETWEEN SCIENCE AND CONSERVATION

Given such threats, how does one go about "saving the whales"? The anti-whaling movement of the 1970s was part of a broader public awakening to our impact on the environment, and was motivated by the very direct and deliberate killing of marine mammals. Harm to cetaceans today is largely unintentional, simply the cost of doing business in the ocean. Very few fisherman wish whales and dolphins to be caught in their gear (after all, they cause costly damage or even total loss), and very few sea captains wish to hit a whale with their ship. So how can we help, even when it is our way of life (e.g. our consumption of oil, global transportation of goods, fishing practices) that is causing harm? The best solution may be to separate human activities from marine mammals in time and space, or to change marine industrial practices. But to do these, we need a fundamental understanding of the distribution, seasonal occurrence, and behaviour of marine mammals both to identify the risks posed by human activities and to propose solutions that will mitigate those risks. And that is where research and science can contribute to conservation.

Mark F Baumgartner

An oceanographic mooring with a hydrophone coming aboard a ship after being underwater for a year. Acoustic recordings from this instrument can be used to determine what species are in the area and when, even in poor weather and darkness.

Most conservation debates focus on knowledge gaps, and our role as scientists is to inform these debates with meaningful research. Often, scientists can help by answering three fundamental questions: (1) Where do animals go, (2) Why do they go there, and (3) What do they do when they are there? These questions are principally ecological because interactions between animals and their environment have a significant influence on distribution and behaviour. With answers to these questions, a variety of efforts can be employed to remove human activities from important marine mammal habitat, such as designating "areas to be avoided" for shipping traffic, moving shipping lanes around critical habitat, closing fishing grounds during certain times of the year, or establishing marine sanctuaries. If separation in time and space is not possible, then managing activities within critical habitat may be necessary, such as reducing vessel speeds or restricting fishing practices to those deemed whale and dolphin friendly. To obtain industry acceptance of these conservation measures, they must be supported by convincing scientific results so that all stakeholders can see that a problem really exists and that the proposed solution will truly help.

A good example of how science can help conservation is the story of how the shipping lanes approaching St John, New Brunswick, Canada were moved to help North Atlantic right whales. The Bay of Fundy is visited annually by right whales during the late summer, and their presence has been documented by scientists there for over 25 years. Research was able to demonstrate that right whales fed deep in the water column on copepods (tiny crustaceans), and that the local circulation keeps the copepods, and hence the whales, in a discrete area of the Bay. The shipping lanes approaching St John unfortunately travelled directly through this high-use area, but through the hard work of dedicated researchers, conservationists, the International Maritime Organisation, and Irving Oil (the major shipper using the lanes), an agreement was reached in 2003 to shift the lanes to the east. This resulted in a 9-20 kilometres longer trip for the ships, but the risk of a whale being struck by a ship was reduced by 90%. Although it is difficult to assess the efficacy of the change, the right whale population size was 300-350 animals in 2003, and is about 500 today, and there have been no ship strikes in the Bay of Fundy since the adoption of the new lanes. The scientific research demonstrating how and why the whales used this discrete region facilitated recognition of the problem and the development of a viable solution that all stakeholders could endorse.

TOOLS FOR RESEARCH AND CONSERVATION

Marine mammals are challenging to study because their habitat is difficult and expensive for us to access. However, there are several tools that researchers can employ to learn about these elusive creatures. One of the best ways to obtain information about distribution and abundance is via visual shipboard line transect surveys in which observers note the locations, species and numbers of all animals seen along the ship's track line. By incorporating correction factors to estimate how many animals were missed (due to weather conditions or each species' surfacing behaviours), estimates of abundance of multiple species can be obtained for that region and season. When shipboard surveys also include the collection of environmental (sea surface temperature, water salinity, primary productivity) and prey data, an understanding of what cues drive the occurrence of species can be used to establish why animals are present and how they share or divide ecological niches.

Kathleen M Stafford

Researchers on a small boat going out to put a short-term tag on a whale. These tags provide information on dive behaviour, swim speed and orientation of the whale. They can also be used to collect information about the environment.

While shipboard sighting data provide insight into broad scale, multi-species habitat requirements, data collected from individual animals can be equally valuable. Many cetacean species are individually identifiable due to pigment patterns under their flukes (tail) and along their sides, or from body scars or nicks in their dorsal fins. Long-term photo-identification projects in which individuals are documented in numerous instances over different spatial and temporal scales can be used to examine longevity, migratory patterns, site fidelity and determine population-level estimates of abundance. A small skin and blubber sample (biopsy) from an animal can help determine not just the identity and sex of the animal, but also information on diet (from fatty acid analysis), hormone levels (used to assess stress levels or reproductive status), and environmental pollutants can also be obtained. All of these data provide a better understanding of the environment in which animals live and can point to possible sources of stress.

Many of the visual techniques mentioned above provide information from animals at the surface, and at single points in space and time, but more detailed information on the habitat requirements of individual animals can also be obtained by using data-logging tags. These tags can be short term (lasting hours to days) or longer term (months to over a year). Short-term tags are often attached to an animal with suction cups and the data they collect are recovered after the tag has detached. Recent technological advances allow collection of depths, swim speeds and orientation of diving whales. Simultaneous collection of prey, temperature and salinity within the vicinity of the whales allow for a three-dimensional underwater portrait of the animal in its environment and can provide information on what depths and prey are being targeted. Short term tagging has been used to study the effect of man-made noise such as sonars on animals by using playbacks of sounds to tagged animals to study how these sounds change diving, swimming or vocalising behaviour.

Kathleen M Stafford

A researcher looks through "big eye" binoculars on a large-scale survey for marine mammals. Data collected from such surveys can be used to estimate population sizes and determine habitat partitioning for different species.

Longer-term tags, called satellite tags, enable scientists to track animals over longer time periods via satellite telemetry. This movement data can be used to determine swim speeds and migratory movements as well as habitat and home range information. When combined with environmental data from satellites, associations of cetaceans with fronts, eddies or seamounts can show how these ocean features influence marine mammal movement and distribution.

Tagging data often provides information from only one to a few animals in a population. For population-level monitoring, listening to animals can provide a robust overview of what species are present and when. All marine mammals make sounds and these sounds are species-specific. That is, they are relatively straightforward to tell apart. The use of short and long term hydrophones (underwater microphones) has become a robust means of studying marine mammals. The advantages of recording animal sounds is that sound can travel great distances underwater thereby increasing the area over which animals can be monitored. Sounds can be recorded 24 hours a day, all year long in poor weather and light conditions, and areas too remote to feasibly monitor with other means can be studied over long time scales. Because hydrophones record all the sounds in the environment, ambient noise levels in the ocean can be monitored along with multiple species of marine mammals. Passive acoustic monitoring has been used to identify different acoustic populations of blue whales in the Indian Ocean and measure the influence of shipping on the communication space of right whales in the North Atlantic.

The tools and methods used to study marine mammals should be dictated by the research and conservation questions that need to be answered and the resources available to do so (from funding to ship time). Where very little is known about the community composition within a country's exclusive economic zone, a series of shipboard based visual surveys might be the best way to obtain baseline information on geographic and seasonal abundance of multiple species.

The tools and methods used to study marine mammals should be dictated by the research and conservation questions that need to be answered and the resources available to do so (from funding to ship time). Where very little is known about the community composition within a country's exclusive economic zone, a series of shipboard based visual surveys might be the best way to obtain baseline information on geographic and seasonal abundance of multiple species. These data can be used to identify critical habitat and conservation needs. Repeated surveys over time can indicate changes in populations that may be linked to environmental or management changes. Passive acoustic monitoring can also be a helpful tool for understanding the seasonal occurrence of animals and identifying the presence of previously undocumented species, assuming their calls have been documented. From here, finer scale studies can be undertaken to answer conservation questions about region- or species-specific issues. Whatever the scale, coordination amongst researchers, resource and/or expertise sharing and technology transfer are critical to a successful marine mammal conservation program.

Mark F Baumgartner

An Antarctic petrel investigating a biopsy dart with a skin and blubber sample in it. These samples can be used to determine population identity, sex, and diet of the animal from which the sample is taken. The samples taken are about the size of a pencil eraser.

A WAY FORWARD IN THE INDIAN OCEAN

The Indian Ocean contains arguably the highest diversity of cetaceans in the world's oceans, yet research in this region has been extremely limited. Oceanic waters are difficult to access for marine mammal scientists from neighbouring countries because large vessels from which research can be conducted are prohibitively expensive to charter. There are opportunities, however, to partner with the oceanographic community, the members of which routinely conduct marine research on large state-run vessels. Increased training for regional scientists and students is critical to building capacity in marine mammal research in order to take advantage of these excellent survey platforms. We recently participated in a pilot cruise aboard the US research vessel *Roger Revelle* to the oceanic waters of the Bay of Bengal during November and December 2013 to train Indian and Sri Lankan scientists on marine mammal survey methodology. Training included use of both deck-mounted "big-eye" 25X150 binoculars and *Wincruz* marine mammal survey software, as well as rigorous species identification during daytime survey activities and evening at-sea classroom instruction. In total, 52 sightings of 12 different species were recorded, which allowed trainees ample opportunity to practice their new species identification skills. We have plans to continue these training surveys aboard Indian oceanographic vessels that conduct research in the Bay of Bengal, and hope that by doing so, marine mammal expertise and research opportunities will expand in the region.

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Elrika D'Souza

The grass is greener where the seacow feeds!

*The dugong (*Dugong dugon*), fondly called the sea cow, is a marine mammal which occupies Indian waters around the Gulf of Kutch, Gulf of Mannar, and the Andaman and Nicobar (A&N) islands, where it is the anointed state animal. Apart from its voracious feeding on seagrass meadows very little is known about the dugong, making its conservation a challenge. A team of researchers from the Nature Conservation Foundation undertook a study to understand how the dugong is faring in the waters around the Andaman & Nicobar islands and how its status has changed over the last 50 years. Elrika D'Souza, lead author of the paper resulting from this work, spoke to Diya Das about this study.*

Vardhan Patankar

DD: Give us a Just-a-Minute version of your paper.

ED: This paper talks about changes in dugong occurrences in the Andaman & Nicobar islands over five decades. Although there has been an almost 50% reduction in the area used by dugongs over this period because of threats such as hunting, there is still a remarkable persistence of the animal in some areas.

Dugongs are creatures of seagrass meadows and our study found that they like to feed mainly on two kinds of seagrass. They prefer meadows with large, continuous stretches of these kinds. This aspect of dugong ecology is very handy because it makes the job of mapping suitable dugong habitats much easier.

DD: Why dugongs? What makes them important?

ED: Through their selective feeding, dugongs act as gardeners and maintain meadows with certain species of seagrasses. These meadows are then used by a number of fish, turtles and other invertebrate herbivores. It has been observed that meadows that are no longer used by dugongs change in character. The original seagrass species get replaced by species with lower nutritional value, which could, in turn, affect the other animals that are dependent on seagrass meadows. Without dugong grazing, the meadow may also reach a stage of 'die-off' where the shoots become old and the meadow is totally wiped out.

DD: How much do we know about dugongs?

ED: In the Andaman & Nicobar islands, we know the animal only from sporadic sightings, or stranded or dead individuals. There have been no detailed studies looking at its distribution or ecology. So, basically, there is no information. Sighting the dugong is difficult here because they are usually solitary, or in pairs. Besides, they often use remote areas or places where the waters are murky. This makes the dugong a rarely-seen animal around these islands. In contrast, in places like Australia, they occur in herds of 300-400.

DD: Given the rarity of the animal, what was your strategy? How did you go about looking for it?

ED: To find out where dugongs occur currently, we used direct sightings and feeding signs. Dugongs have an interesting feeding habit: they spend a considerable time grazing on seagrasses and leave tell-tale trails on the meadow. Our earlier work has shown that these feeding trails take an average of eight days to disappear. So if we found signs of feeding, it meant a dugong had been there within the last week or so. This is a sure shot sign of the presence of the animal in that area.

We surveyed 57 seagrass meadows around the Andaman and Nicobar islands between 2010 and 2012. During our surveys, we looked for these feeding signs and also recorded other information about the meadow, such as composition of seagrass species, density of shoots, patchiness, etc. This helped us to figure out what exactly causes them to use a particular meadow over others. Though we sighted only seven animals during our study, we were able to get a lot of information from the feeding signs.

We also wanted to see how dugong distribution has changed over the last 50 years. To find out about dugong distribution in the past, we relied on records maintained by various government departments such as the fisheries and forest department, and research institutes, as well as some published information available in journals. The records were very scanty, so we grouped the information into five-year periods to get a better overall picture of how dugong occurrences have changed over the last 50 years.

Vardhan Patankar

A dugong around Ritchie's archipelago

Vardhan Patankar

Feeding trails of dugongs

DD: So what new information has emerged from your study?

ED: We now know where dugongs are most likely to be found around the Andaman & Nicobar islands, and what kinds of meadows they are most likely to use. From the long-term data we learned about persistence - that these animals have been using the same meadows over a long period of time. If certain meadows have ceased to be feeding grounds it is probably because the animal was removed due to hunting or entanglement in fishing nets, or the quality of the meadow had changed. From a management point of view, our study helps prioritise meadows for conservation. It is now possible to identify meadows that contain features that dugongs like, and see whether they are presently used by dugongs or are likely to be feeding grounds in the future.

DD: How do you plan to take this forward?

ED: By working with the government. We are trying to prioritise certain sites for dugong conservation and monitoring, based on its use by the animal and based on how dynamic the particular site is, i.e. how likely it is to change character in the near future. We also want to study direct threats to dugongs in these sites and come up with a priority map for conservation, categorising them as those that require immediate action, only monitoring, or no action as of now.

We've already approached the government, and they are keen to work with us. They take pride in the presence of such a rare animal in their islands, and its conservation is something they are definitely keen on.

Reference:
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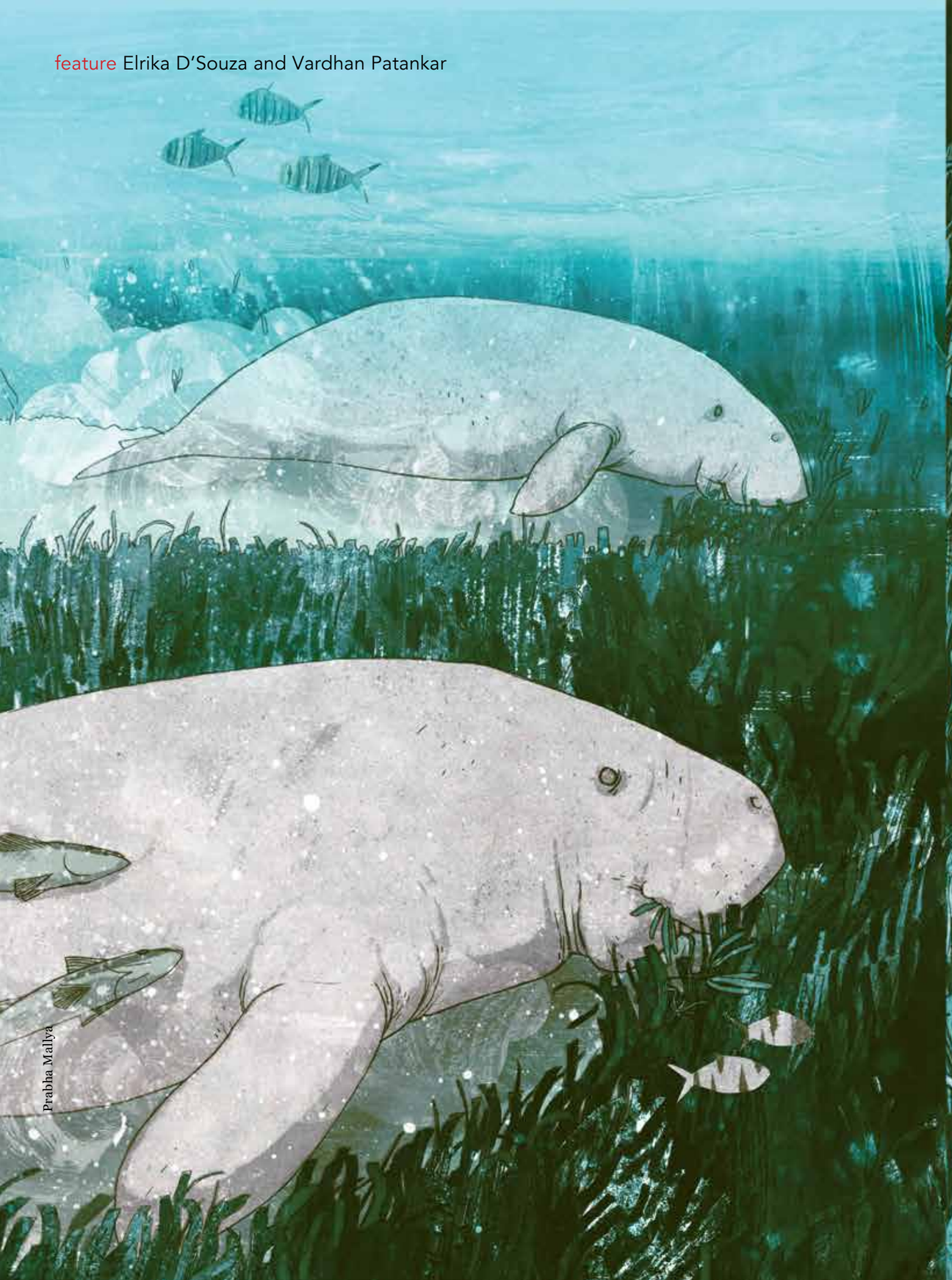

Prabha Mallya

the CONSTANT GARDENER:

dugong feeding behaviour and its implications in the Andaman & Nicobar archipelago

Out in the wonderfully clear azure seas of the Andaman and Nicobar archipelago, we embarked on a quest to study a little known animal, the dugong, commonly known as the sea cow. Spending about seventy percent of their lives below the surface, dugongs come into view only briefly when they rise up to breathe, once every five to seven minutes; no wonder they are still shrouded in mystery!

In India, dugongs inhabit waters around the Gulf of Kutch, Gulf of Mannar, Palk Bay and the Andaman & Nicobar archipelago. Our research has gathered new clues about a crucial part of the dugong's life which occupies much of their time; their feeding habits in seagrass meadows. The search for answers started seven years ago when we sighted two dugongs while snorkeling around an island in Ritchie's archipelago. We observed these two individuals closely for months and found them feeding in the same seagrass meadows through the year. They fed specifically on two species of seagrasses that were relatively small-sized and low in density. This led us to wonder how these animals managed to feed constantly in an area without depleting their resources completely.

Dugongs are known to feed on high-nutrition and low-fibre species of seagrasses, typically pioneer species. Where animals exist in large numbers, such as in Australian waters, they are known to graze down meadows, reducing biomass by almost 80 to 90%. By uprooting entire shoots and then abandoning the meadow to allow them to recover for a period before they return, the dugongs tend the meadows and are therefore considered as 'seagrass gardeners'. The time interval between two visits to a patch is long enough to ensure the recovery of the same species but short enough to prevent the next level of succession which would comprise low-nutrition, high-fibre species that are not optimal for the dugongs' diet. In the Andaman and Nicobar archipelago, populations of dugongs have dwindled considerably in the last five decades and we were observing persistence in habitat use, in contrast to abandoning of over-grazed sites. Hence, we tried to understand this difference in a more systematic manner.

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Vardhan Patankar

A dugong feeding on seagrass around Ritchie's archipelago

We had observed eight seagrass meadows (of the 44 surveyed) that were used by dugongs over a period of four years. We monitored these meadows and found signs of the animals feeding throughout the year at these sites. We also observed that each of these meadows was used either by individuals or pairs of dugongs. To increase our sightings of animals in and around seagrass meadows, we also set up a network of informants comprising fishermen, tourist boat operators and dive operators, who used the waters frequently.

Vardhan Patankar

A dugong around Ritchie's archipelago

From this network's and our personal observations, we estimated a total of fifteen individuals over a period of seven years around Reef, Havelock, Inglis, Neil, Sir Hugh, South Andaman, Nancowry, Trinket and Teressa Islands.

In order to better understand why animals repeatedly used certain seagrass meadows, we measured the magnitude of dugong herbivory in the eight meadows where feeding signs were observed. All these meadows had distinct characteristics—they were all relatively large, unfragmented, continuous in seagrass cover and dominated by the pioneer species *Halophila ovalis*, *Halodule uninervis* and *Halodule pinifolia*. About 15% of the total production of seagrass was consumed by dugongs across these meadows. The recovery of meadows after a feeding event was also quick, taking little longer than a week to return to original shoot densities. Through experimental manipulations, we tried to understand the short term impacts of dugong herbivory on seagrasses. We created cages of fixed sizes in replicates at several meadows where dugongs fed. These cages were such that they allowed seagrasses to grow without altering the natural conditions but prevented them from being consumed by dugongs. We found that when herbivory was excluded for six months and longer, the shoot densities were almost 50% higher within the exclosures than in the surrounding meadow that were actively foraged upon.

About 15% of the total production of seagrass was consumed by dugongs across these meadows. The recovery of meadows after a feeding event was also quick, taking a little longer than a week to return to original shoot densities.

The data obtained from herbivory exclosures when combined with direct observations of animal presence revealed that dugong feeding in the Andaman and Nicobar archipelago is not limited by the availability of suitable resource habitat. The proportion of primary production consumed by dugongs does lead to a reduction in seagrass shoot densities but not to levels that trigger meadow abandonment. The ability of seagrasses to cope with such levels of herbivory perhaps explains the long-term site fidelity shown by individual dugongs in these seagrass meadows.

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Our long term research from the islands has several important implications. Firstly, the low number of dugong sightings implies that conservation of the remnant populations is of utmost significance. Secondly, the dugongs in the Andaman and Nicobar archipelago exhibit feeding behaviour that is probably typical of small populations and was not documented earlier. Taking advantage of the site fidelity of the species, the management

Vardhan Patankar

Another dugong around Ritchie's archipelago

Vardhan Patankar

A typical meadow with mixed seagrass species

can focus on monitoring and protecting these sites and ensuring no further decline in the population. However, the short term movement of dugongs can be governed by other factors too such as male and female mating strategies, escape from predation, calf protection, anthropogenic noise, and oceanography, among others. Therefore, in the future, these factors should be studied and considered while developing long term management plans for species conservation. At present, the dugong populations around the islands are dwindling and any further decline could lead to a level below which species recovery may be unlikely. Therefore, it is critical to safeguard the sites where dugongs occur to allow these wonderful gardeners of the sea to persist.

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