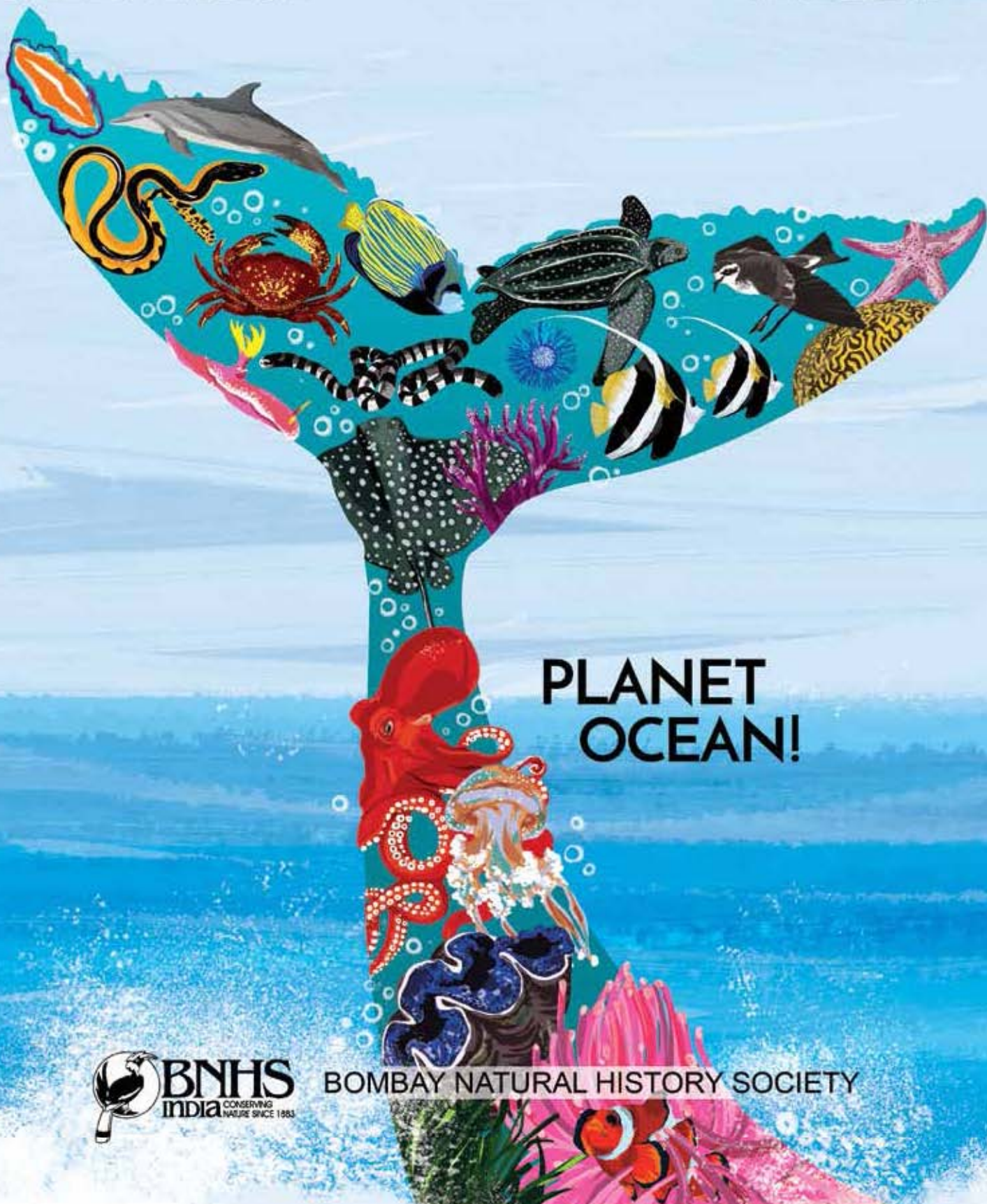


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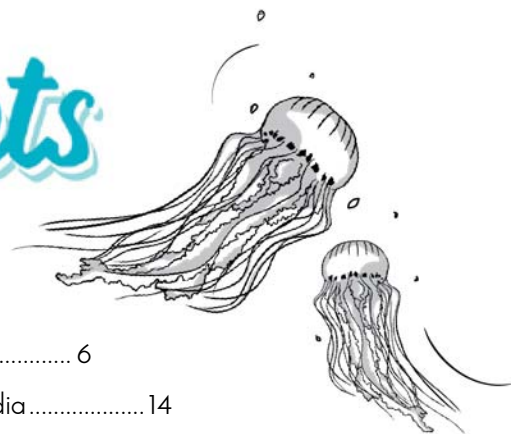
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Contents



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Editorial..... 2

Planet Ocean! 5

Fascinating creatures of the sea..... 6

Coastal and marine hotspots of India 14

Gulf of Kachchh – an unexplored seascape..... 20

Behemoths of the sea 28

Polyclad flatworms – weirdlings of the sea 32

Walking along the shores of Mumbai 36

Fun facts 40

Understanding reef resilience in the Andamans..... 42

Marine fishes..... 46

Tracking the gentle giants..... 56

Marine reptiles..... 62

Tracking a hundred-million-year-old giant..... 66

Serpents of the sea 70

In quest of the ocean wanderers 74

Marine mammals in the Indian seas 78

Conservation of Dugongs in India..... 84

Underwater photography..... 90

The omnipresent photographer..... 100

Upcoming marine photographer..... 104

Adaptations for survival 108

Hidden in the depths 112

A voyage to the last wilderness 118

Frozen waters of the Arctic 124

Obituary 128



Published and printed quarterly
by Mr. Debi Goenka for the
Bombay Natural History Society,
Printed at Akshata Arts Pvt. Ltd.,
Lower Parel, Mumbai.
Reg. No. RN 35749/79, ISSN 0441-2370.

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Editorial



DEEPAK APTE

Almost three-quarters of our planet's surface is covered by water, yet we call it earth, a strange misnomer. The seashore, offshore and pelagic waters, and even the deep sea have a wondrous world within them, which has no parallel on land. From tiny nudibranchs to beds of coral and seagrass, myriad shoals of fish, and to the largest living animal in the world – the gigantic Blue Whale – oceans are home to incredible beauty and diversity. However, more is unknown than known about the wonderworld under water, rather than on land.

Unfortunately, especially in recent decades, the marine ecosystem has been exploited to the extent that our ecosystems are on the brink of ecological collapse. Archbishop William B. Ullathorne of Birmingham, in his autobiography FROM CABIN-BOY TO ARCHBISHOP, talked about his early life on ships that ran from Hull, England, to Scandinavia. On

his voyage to the Baltic, he wrote, “We have been held here in the port for three days, so thick have been the shoals of fish that we cannot leave the harbour.” There cannot be a starker contrast with the experience today, and this story is the same across all continents.

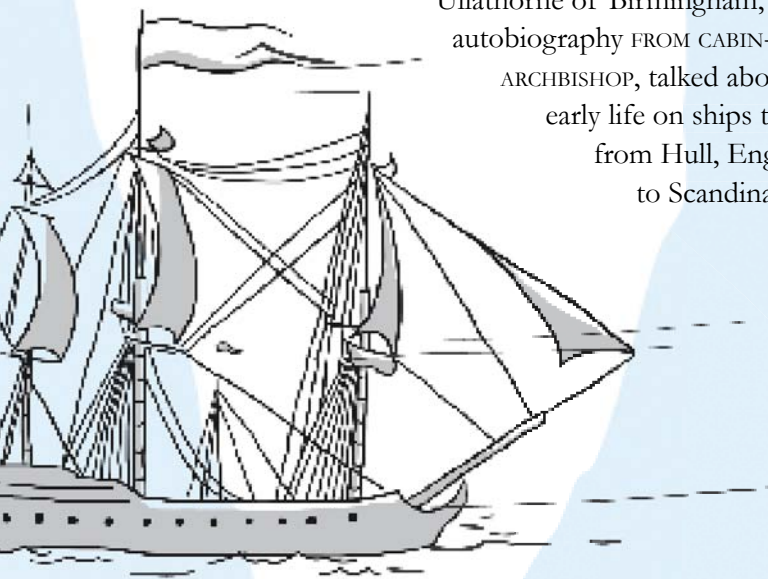
Our oceans are being emptied by greed. We need no more science to tell

Our oceans probably have more plastic and more toxic material now than fish.

us that our fish stocks are diminishing at such a rate that there will be no fish left in the oceans to commercially harvest in the next half century.

Our oceans probably have more plastic and more toxic material now than fish – such is the tragedy of our generation. To add to these woes, climate change and sea level rise stare at us with consequences that we cannot even imagine. And at times, when we need to make firm and stringent policies to insulate and protect our lives and livelihoods, we continue to dilute them further and further.

For example, the draft Coastal Regulation Zone Notification, 2018 is not only regressive, it will also put the



lives of millions of people at risk in the context of climate change and sea level rise, let alone investment risks for housing and developmental projects along coastal areas. Instead of moving away from the shore, the proposed draft takes us closer to it, creating a recipe for disaster. For short-term economic gains, we are undermining the lives and livelihoods of millions of people living along the coast. The state-wise data of changes in shore areas due to accretion/erosion, as provided by Space Applications Centre (SAC), clearly suggest that the shore areas of states like Maharashtra, Andhra Pradesh, Odisha, West Bengal, Lakshadweep, and Andaman & Nicobar have suffered serious depletion. The Indian coast lost a nett area of about 73 sq. km during 1989–1991 and 2004–2006, and as much as 45% of India's 8,414 km long coastline is facing erosion.

A recent paper (Storlazzi et al. 2018) predicts that most of the atolls will be uninhabitable by the mid-21st century because of sea-level rise, exacerbating wave-driven flooding. The entire Lakshadweep Archipelago will face an uncertain future. Under such circumstances, provisions such as reduction in NDZ (No Development Zone) as proposed in the recent coastal draft notification that facilitates infrastructure development in the inter-tidal areas only enhances these risks. Any policy framework must be approached with Precautionary Principle, especially when it comes to unpredictable natural events. It is foolish to believe that sea walls, bunds, and tetrapods can address sea level rise. Climate change is a reality, and by ignoring it we are compromising our lives and the rights of our children and grandchildren.



The draft Coastal Regulation Zone Notification-2018 excluded civil society completely while framing the rules. Any act/law that impacts the lives and livelihoods of millions of its citizens, its ecosystems and biodiversity at large, cannot and should not exclude civil society from the consultation process. Hazard lines should be defined purely by ecological and climatic considerations. The proposed notification has extremely grave consequences on our lives and needs to be redrafted, keeping climate change and sea level rise foremost.

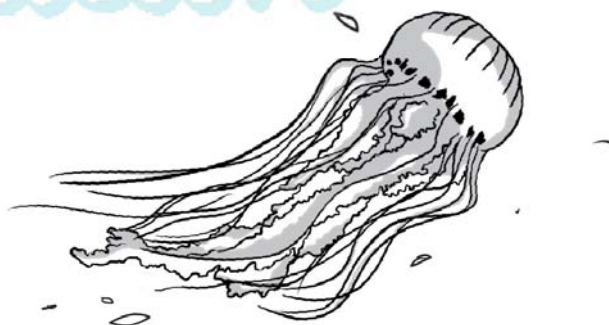
The BNHS marine programme is currently working at several key marine biodiversity areas, such as Lakshadweep, Andaman and Nicobar, Gulf of Kachchh and inter-tidal areas of Maharashtra, Andhra Pradesh, Tamil Nadu, and Gujarat. One of the flagship projects under the marine programme relates to understanding the impact of anomalous sea surface temperature on coral reefs using Giant Clams as surrogate species in Lakshadweep Islands.

This issue of *Hornbill* on life underwater is dedicated to our beloved Dr. B.F. Chhappgar, a marine biologist specializing in carcinology, who has been an inspiration to several marine biologists, including me. A prolific writer, he has authored over 10 books and written hundreds of scientific papers. He was a member of the BNHS Executive Committee for 14 years.

We have attempted to illustrate the spectacular life under water to generate public support for its conservation.



Dedication



We dedicate this issue of *Hornbill* – Planet Ocean! – to Dr. Boman Framji Chhapgar, a globally recognized marine biologist.

“I follow one simple rule in life. Instead of living each day like there is no tomorrow ... live like you have a hundred more years to go.”

B.F. CHHAPGAR



Dr. B.F. Chhapgar is a prolific writer. In a career spanning over six decades, he has described three species of crabs, two mantis shrimps (Stomatopods), co-discovered a jellyfish and a fish, and written hundreds of scientific papers, over 10 books, and innumerable popular articles for magazines under the pen-name “Beefsea”, to popularize science in a style that is appealing to the lay person.

Dr. Chhapgar served as Curator at the Taraporewala Aquarium, Mumbai. He also worked for the Department of Fisheries, Bombay, for over 20 years. He has served on the Board of Governors of the Maharashtra Nature Parks Association and on the Executive Committee of the Bombay Natural History Society. He was elected Life Fellow of the International Oceanographic Foundation for his contributions to the advancement and extension of knowledge in oceanography and marine sciences. His portrait figures in the Gallery of Carcinologists in the Smithsonian Institution National Museum of Natural History in Washington D.C.

Despite failing eyesight he continues to take an interest in the affairs of the Society.

Planet Ocean!

A GARLAND OF CULLED FLOWERS

Nearly three-quarters of our earth is covered by water. Yet we, living on land, usually know more about land creatures than our aquatic denizens. We have a long coastline of some 5,400 km, excluding islands, where live creatures so strange and fantastic that it is difficult to believe that such beings exist. In the sea is to be found a variety of life far unlike that on land – an aggregation of creatures some of which are so unique that we cannot believe in their existence unless we have seen them ourselves.

One of the continuing concerns of man has been to understand and explore this vast watery domain. Yet, being a terrestrial creature, Man has a tendency to know more about the life and phenomena on land ... Yet it has taken immense patience and an arduous task to reach our present level of understanding of the sea. When it comes to marine life, many of us have vague – even wrong – ideas. Man's imagination, from ancient times, has run wild when it came to a study of natural history, whether on land or in the sea.

Unless one actively searches for them, plants and animals in the sea are relegated to the background in our range of conception as compared to the more familiar ones on land. There are no large trees to inspire our awe, nor – as lay people often think – animals comparable to, say, elephants or tigers. Few people are aware of the beauty and grace of marine life. Fewer still try to understand their way of life, or why they behave as they do. Many books on the sea exist. As Aristotle said, "Each of us adds a little to our understanding of Nature, and from all the facts assembled arises a certain grandeur."

I have here only made a garland of culled flowers, and have brought nothing of my own but

the thread that ties them together. And I make no apologies for being selective about the information included.

A word of caution. In the rather ill-considered rush we make to exploit our marine resources, we have taken little trouble to examine the capabilities and possibilities of the sea's wild creatures, save insofar as the findings were of commercial value. Therefore much that is interesting has been overlooked. The kinship between man and the rest of our natural flora and fauna becomes very apparent to those of us who sojourn on the sea for any length of time; alarmingly so to those whose attitude has been governed by the well-worn and much abused phrase that "Man shall dominate over all."

The sea is never conquered; one makes friends with it. Man never dominates it, but belongs there as do the skies, sunshine and other living creatures, keeping time with the seasons, moving in an orderly procession with Nature, holding to the unity of life in all things, seeking no superior place for himself but merely a state of harmony with all created things. Remember, Man is supplicant to, rather than master of Nature.

– From the writings of B.F. Chhapgar



Fascinating creatures

OF THE SEA by Deepak Apte

*"The earth is full of Thy riches;
So is this great and wide sea,
Wherein are things creeping innumerable,
Both small and great beasts.
There go the ships:
There is the Leviathan,
Whom Thou hast made to play therein."*

Psalm 100: 24–26



SEA CUCUMBERS

Sea cucumbers are echinoderms, marine animals characterized by a hard, spiny covering or skin. Echinoderms include sea stars (starfish), sea urchins and sand dollars. Around 1,716 species of sea cucumber are known worldwide. In India, nearly 200 species of sea cucumber are reported. They are commonly found inhabiting rocky shores, sandy beaches, coral reefs, and mudflats. A fascinating ability of sea cucumbers is that they can loosen or tighten their body by contracting or relaxing body tissue; thus they squeeze water out of their body as a defence strategy against threats. Another interesting defence mechanism is evisceration, a process in which the animal can eject its visceral organs (such as intestine, cloaca, and “respiratory trees”).

When under threat, it expels its own guts as sticky filaments that can tangle or injure its aggressor; the organs are regenerated after some days.

Sea cucumbers are detritus feeders. They play an important role in the marine ecosystem, as they help in recycling organic matter and nutrients from the sea. They break down the detritus and make it available to bacteria for further degradation.

Sea cucumbers are highly exploited in the Asian region, being consumed as a delicacy in Japan, China, and Korea in a variety of forms, such as dried, processed, and smoked. All species of sea cucumbers are protected under Schedule I of the Wildlife Protection Act (WLPA), 1972, and harvesting them is illegal, yet large scale illegal harvesting continues in several parts of India.



CRABS & SAND DESIGNS

Tiny balls of sand scattered on the beach, forming intricate designs on sand, often catch our attention. What is more interesting is that these ‘sand artists’ are almost always elusive. They are tiny crabs known as Sand Bubblers of genera *Scopimera* and *Dotilla* in the family Dotillidae going about their mundane diurnal activity, feeding during low tide. These crabs feed on the thin layer of edible organic particles on sand grains. When the tide goes out, the crabs emerge from their burrows and start sifting through the sand, picking up sand grains to scrape up the layer of microscopic food. After they have scraped the sand grains clean, they roll them into little balls and toss them behind. By doing this they avoid sifting the same sand twice. After reaching a certain distance from their burrow, they return to the burrow and start all over again, working radially outwards from the burrow entrance. As they emerge from the burrow as soon as the tide recedes, you can almost tell how long the tide has been out by the pattern of the sand balls. The more intricate the pattern, the longer has the tide been out.

Like the sand bubblers, Fiddler crabs (genus *Uca*) also act similarly but they are highly territorial about their burrows. Hence, their foraging pattern is quite unlike the sand bubblers. Instead of foraging around the entire circumference of its burrow (360°) like the bubbler, the fiddler forages around 180° from its burrow, and in this way it never shows its back to predators.



DEEPAK APTE

HERMIT CRABS

Hermit Crabs, which are decapod crustaceans of superfamily Paguroidea, are known for invading an empty gastropod shell and using it as a shelter. The crab conceals itself in the shell to protect its soft abdomen. The shell is abandoned only when the crab outgrows it. The size and shape of adult hermit crabs varies species-wise, with some being a few millimetres long and others huge enough to be the world's largest terrestrial invertebrate, the Coconut Crab. Juveniles of Coconut Crab use empty gastropod shells as in typical hermit crabs, but adults do not, as they develop a hard, protective exoskeleton.

Various symbiotic associations have been recorded in hermit crab as an obligate associate of other animals for various reasons. A few species are mutualistically associated with sea anemones. In such a case, the crab gets camouflage and protection from the stinging tentacles of the sea anemone, while the anemone gets a substrate for attachment and a mobile home which affords more food options.



DEEPAK APTE

STINGING HYDROIDS

Hydroids are beautiful marine invertebrates of class Hydrozoa in phylum Cnidaria. Hydroids are the polypoid life stage of hydrozoans, which include freshwater jellyfish *Craspedacusta sowerbyi*, freshwater polyps *Hydra*, *Obelia*, Portuguese Man o' War *Physalia physalis*, chondrophores (family Porpitidae), Air Fern *Sertularia argentea*, and pink-hearted hydroids *Tubularia*. Hydroids may be solitary or colonial.

Hydroids are best known for their stinging capacity due to the presence of cnidocytes bearing nematocysts (stinging cells) in their epidermis. All hydroid stings are not fatal, but can cause rashes on the human body for up to a few days. Popularly known stinging hydroids include *Macrorhynchia philippina* which looks like a white fern, *Aglaophenia cupressina* which resembles sea weed, and the free swimming colonial hydroid Portuguese Man o' War mentioned earlier.

CLEANING STATIONS

Every once in a while, fishes small and large make their way to secret spots in the sea and station themselves rather calmly, to be browsed upon by other smaller fishes and shrimps. This behaviour is one of the most marvellous examples of mutualism by various cleaner fish and cleaner shrimps with other fishes. Cleaning Stations, as these spots are generally known, are mostly located around coral reefs. The Blue Streak Wrasse *Labroides dimidiatus*, Cleaner Shrimp *Lysmata amboinensis* runs cleaning stations, feeding on the ectoparasites and dead or infected tissue on fishes, and is visited by several species of fish every day. Along with fishes, sea turtles are common visitors to cleaning stations. Large fishes like manta rays and sharks are generally cleaned up by remoras or suckerfish. The cleaners preferentially eat gnathid isopod larvae, which are the most common ectoparasites in the reefs, and give much needed relief to their 'clients'.



CHRISTMAS-TREE WORMS

Christmas-Tree worms are polychaete worms (family Serpulidae) that bore on corals and are found abundantly in shallow reef areas. The most distinctive feature of these beautiful animals is a pair of 'crowns' shaped like Christmas trees. These are highly modified and specialized mouth appendages. Each spiral is composed of feather-like tentacles called radioles, which are heavily ciliated. While they are primarily feeding structures, the crowns are also used for respiration; hence, they are also called gills.





DIGANT DESAI

SOFT CORALS

Reminiscent of trees, soft corals light up the reefs with the most vibrant of hues and patterns. They may be variously branched, fan-like (gorgonian) or bubble corals with water-filled bubbles of bright colours. True soft corals belong to the order Alcyonacea, although generally all members of the Octocorallia are referred to as soft corals. The name soft coral comes from the fact that unlike their distant relatives the hard corals, very few species of these corals produce substantial amounts of calcium carbonate. And they lack parts like the theca, tabulae, septa, or basal plate. Soft coral colonies host and shelter a variety of other animals and create favourable habitats. Porcelain crabs are known to occupy spaces in the branches of gorgonians. Most of the ovulid gastropods (cowries and their allies or false cowries) are known to feed on coral or gorgonian tissue. Nudibranchs and ophiuroids are also commonly associated with soft corals.



DEEPAK APTE

OCTOPUSES

Octopuses are extremely intelligent invertebrates. About 300 species of octopus inhabit diverse regions of the oceans, including coral reefs, open sea, and the ocean floor. To defend themselves, they resort to camouflage by expelling a cloud of ink by which they escape predators. Species of genus *Hapalochlaena* (Blue-ringed octopuses group) pose a risk to humans due to their neurotoxic venom tetrodotoxin.

Probably the most intelligent among invertebrates, octopuses have proven evidence of short-term and long-term memory systems, to solve problems including going through a maze. The Mimic Octopus (like some other species) can distinguish different shapes and patterns, allowing it to move its arms to emulate other sea creatures.

JELLYFISH

Jellyfish are free swimming, pelagic, marine medusoid Cnidarians found in every ocean, from the surface to the deep sea, with some species recorded also from fresh water. Contact with a jellyfish tentacle can trigger millions of nematocysts to pierce the skin and inject venom. Only some species' venom causes an adverse reaction in humans, but the Box Jellyfish sting can be fatal.

Jellyfish are highly tolerant to adverse environmental conditions, resulting in swarms or bloom formation. They may also benefit from saltier waters rich in iodine, which is necessary for polyps to turn into medusae, the fringed umbrella-shaped form recognized as jellyfish. Rising sea temperatures caused by climate change may also contribute to jellyfish blooms, because many species of jellyfish are relatively better able to survive in warmer waters.



SEA ANEMONES AND ANEMONE FISHES

Sea anemones are the most commonly seen animals of the inter-tidal region. Due to their stinging tentacles, most predators avoid them. However, anemone fish have found a way to live with sea anemones. Symbiont anemone fish are protected from the host toxins by their external inert mucus layer. These fish also show acclimation behaviour, repeatedly going to the host anemone even after being stung, and later entering right inside the host with their developed resistance. Anemone fish have also been reported nibbling on the tentacles of sea anemones to gain immunity.

This symbiosis between anemone fish and their host anemones is highly species-specific. Of about 1,000 species of sea anemones, only 10 harbour symbiont anemone fish. *Amphiprion percula*, a common aquarium anemone fish, is seen specifically in association with sea anemones *Heteractis magnifica* and *Stichodactyla gigantea*. The larvae of *A. percula* use species-specific chemical cues from sea anemones to locate the correct host species.



DEEPAK APTE

PUFFERFISH AND PORCUPINE FISH

As a natural defence against lack of speed, pufferfish have evolved a formidable strategy. They have the ability to puff themselves up (specifically the stomach) into a ball several times their normal size by intake of water on getting alarmed, to scare away predators. With more than 120 species across 20 genera, pufferfish belong to the family Tetraodontidae. They are characterized by two sets of dental plates fused together to give a beak-like appearance to the mouth.

Another incredible defence of pufferfish is the venom tetrodotoxin (TTX), a neurotoxin produced by symbiotic bacteria like *Pseudoalteromonas tetraodonis*, certain *Pseudomonas* spp., and *Vibrio* spp. This toxin makes the fish taste foul and often lethal to predators, including humans. A few fish like sharks are unaffected by the venom of pufferfish. Bottlenose dolphins even take in moderate amounts of the fish in order to get 'high'. As lethal as these fish may be, some species, non-poisonous or not, are eaten in Japan as delicacies, known as *fugu*. Fugu chefs are trained to avoid cooking certain organs like the gall bladder, intestine, and ovaries, which are especially venomous.

Pufferfish are morphologically similar to their relatives, the porcupine fish (family Diodontidae), but differ from them in having hidden spines, which are visible only when the fish is inflated. Porcupine fish, on the other hand, have prominent large spines on the head and body.

Pufferfish are distributed widely in the tropics and subtropics. A few species dwell in brackish habitats, and some inhabit fresh water. They vary widely in size, with the Mbu Pufferfish (or Giant Freshwater Pufferfish) from the Congo basin measuring up to 66 cm, and the Dwarf or Malabar Pufferfish measuring only about 2.2 cm. The latter is endemic to south Karnataka and Kerala.



DIGANT DESAI

SEAHORSES

Seahorses are fascinating marine fish with some myths associated with them and with a variety of astonishing characters. The male seahorse appears to 'give birth' to young. Actually, the female seahorse deposits her fertilized eggs in the brood pouch of the male, and he carefully carries them till they hatch.

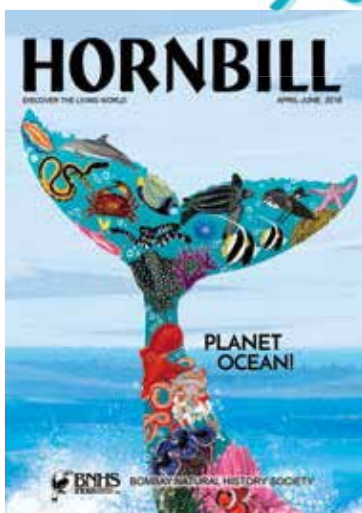
Seahorse species show diverse camouflage strategies. Some exhibit perfect camouflage with gorgonids (soft corals), e.g. pygmy seahorses. Many Asian countries use seahorse in traditional medicine. Dried seahorse was being transported globally from India. By 2001, the population had declined drastically, forcing MoEF&CC to categorize Seahorse under Schedule I, Part II A of the WLP, 1972. Around 54 species of seahorse are known worldwide. They inhabit temperate as well as tropical regions.



DEEPAK APTE

Presently Director of BNHS, Deepak Apte is a scientist of international repute. His specialization is in marine ecology.

Aqua Quiz



HOW MANY SPECIES CAN YOU SPOT AND IDENTIFY FROM THE COVER OF THIS ISSUE?

Sea Snake (2), Dolphin, Sea Slug, and Flatworm
Sea Star, Storm Petrel, Turtle, Angelfish, Blue Button, Crab,
Octopus, Ray Fish, Stony Coral, Bannerfish (2), Brain Coral,
Clownfish, Sea Anemone, Sea Grass, Giant Clam, Jelly Fish,

ANSWERS:



DEEPAK APTE



Rich intertidal fauna of the Andaman coast

Coastal AND marine hotspots OF INDIA

by Deepak Apte

India is blessed with a variety of coastal and marine habitats such as mudflats, estuaries, creeks, bays, mangroves, rocky and sandy shorelines, coral reefs and sea grass beds. These habitats harbour an extraordinarily rich biodiversity. Given below are accounts on some of the important and better known coastal and marine habitats.

EAST COAST

GULF OF MANNAR: This area lies between the southeastern tip of India and the northwest coast of Sri Lanka. Adam's Bridge, also called Ram Sethu, comprising a chain of low islands, reefs, and sea grass beds, separates the Gulf of Mannar from Palk Bay (to the northeast). Gulf of Mannar is known to harbour over 3,600 species of flora



DIGANT DESAI

and fauna, with 117 hard coral species recorded. Sea turtles are frequent visitors to the gulf, also sharks, dugongs, and dolphins. The Gulf of Mannar was known for its pearl fisheries for at least 2,000 years.

In 1986, a stretch between Thoothukudi and Dhanushkodi with 21 islets was declared as the Gulf of Mannar Marine National Park, and in 1989, with an area expansion totalling 10,500 sq. km, it was declared as a biosphere reserve. The reserve, inclusive of the buffer zone, comprises islets, beaches, estuaries, tropical dry broadleaf forests, mangrove forests, and salt marshes.

PALK BAY: An inlet of the Bay of Bengal between southeastern India and northern Sri Lanka, this bay is 64 to 137 km wide, and less than 100 metres deep. The River Vaigai (India) flows into the bay, and there are a number of islands on the Sri Lankan side. The area is rich in corals and sea grasses, with sea turtles, sharks, dugongs, and dolphins being some of the larger fauna.

Diverse fish fauna in a subtidal reef in the Andaman archipelago



DIGANT DESAI

Angria Bank is a shallow, sunken atoll 105 km west of Vijaydurg, Maharashtra



DHIRTIMAN MUKHERJEE

Bhitarkanika is well-known for the largest Saltwater/Estuarine Crocodiles in the world

BHITARKANIKA NATIONAL PARK: Bhitarkanika has the second largest mangrove formation on the Indian mainland, encompassing an area of 650 sq. km in Odisha. It is centred around Kanika Island, lying in the estuarine region of Brahmani-Baitarani. The entire area is criss-crossed with a network of creeks, channels, extensive mudflats, and long sandy beaches, of which Gahirmatha beach is well-known for the highest concentration of nesting Olive Ridley Turtles in India, numbering as many as one million turtles on some occasions. Bhitarkanika is also well-known for its Estuarine Crocodiles. Bhitarkanika has a high diversity of mangrove and mangrove-associate species, with 62 species recorded, including one endemic species, *Sonneratia griffithii*. Bhitarkanika is one of Asia's most spectacular wildlife sanctuaries, and was designated a Ramsar Wetland of International Importance in 2002.

CORINGA: This is another major mangrove habitat on the east coast of India, situated in Andhra Pradesh. The total extent of the mangroves is

316 sq. km, of which 235.7 sq. km come under Coringa Wildlife Sanctuary. Around 35 mangrove species are reported, of which 16 are true mangroves. The mangroves nestle in the deltas of Gouthami and Godavari rivers at Kakinada Bay. Rivers Coringa and Gaderu and other water channels cut into the forests. The avifauna comprises about 120 species, and other major



DEEPAKAPTE

Rocky shores along the Konkan coast harbour a plethora of flora and fauna

fauna includes Golden Jackal, Fishing Cat, and Smooth-coated Otter. Olive Ridley Turtles nest along the beach.

Threats include exploitation of mangroves by locals, who depend on the forest, fisheries, and other natural resources for livelihood. The increasing industrialization of Godavari delta and increasing aquaculture activities are recent threats. Conservation and research initiatives for the Coringa mangroves are being undertaken by Government of India-United Nations Development Programme (UNDP)-Global Environment Facility (GEF)-Ministry of Environment, Forest and Climate Change (MoEFCC)-Andhra Pradesh Forest Department.

SUNDARBAN: Together with the area in Bangladesh, Sundarban is the largest and richest mangrove area in the world, spread over one million hectares. It is situated on the deltas of the Ganga and Brahmaputra rivers. Sundarban has been declared a World Heritage Site.

The Sundarban mangroves have a clear zonation, with bushy and discontinuous thickets of back-mangroves; a second zone of widespread saltwater mangrove forest; and a third major zone dominated by the palm *Phoenix paludosa* that occurs throughout the delta between the water edge and the mangrove proper. Sundarban has diverse fauna, which includes the Tiger, Spotted Deer, Wild Boar, Rhesus Macaque, and Water Monitor. Olive Ridley and Hawksbill turtles are known to nest in the area. Cetaceans include the Bottlenose and Gangetic dolphins.

ANDAMAN & NICOBAR ISLANDS: The Andaman & Nicobar archipelago consists of over 345 islands, islets, and rocky outcrops. The islands are fringed by the second largest reef (11,939 sq. km) in the world. Extensive mangroves also exist on Andaman Island. Among the islands of Andaman & Nicobar, 33 are inhabited, 94 are designated as sanctuaries, including six areas as national parks (two of these are marine national parks; two areas and two islands in the Andamans designated as tribal reserves). The entire Nicobar group is a tribal reserve with four wildlife sanctuaries, two national parks, and one biosphere reserve.

There is a high level of endemism in the archipelago due to its complex geological history and the submergence of land bridges that led to its isolation. The coral diversity is among the highest in Indian reefs, with 133 species under 57 genera, and new species being recorded in recent years. The beaches provide nesting sites for Leatherback, Hawksbill, Olive Ridley and Green sea turtles. The other major marine or terrestrial wildlife includes Dugong, Saltwater Crocodile, Bottlenose Dolphin, Blue Whale, Whale Shark, Coconut Crab, Asian Water Monitor, and Reticulated Python.

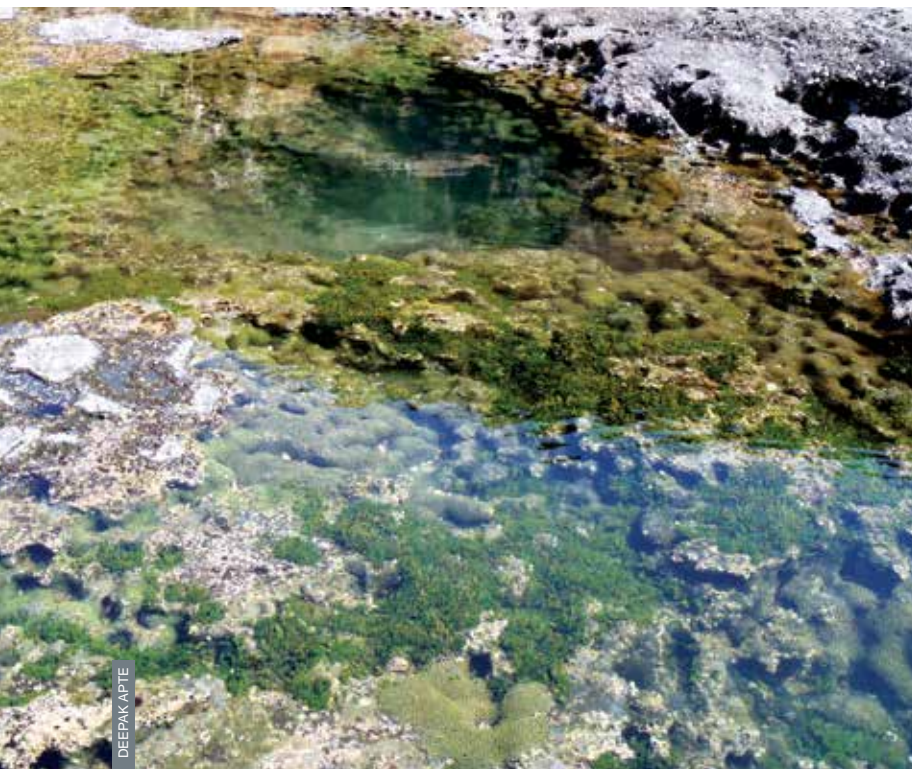


Lakshadweep reefs are the second richest reef formations in India, next only to Andaman & Nicobar



DEEPAK APTE

The diverse natural habitats of coastal Maharashtra support an equally rich biodiversity



DEEPAK APTE

Tidal pools on the Konkan coast are rich in crustaceans and polychaetes

WEST COAST

GULF OF KACHCHH: Gulf of Kachchh is an inlet of the Arabian Sea in Gujarat. The gulf has a maximum width of 60 km at its mouth and its length is about 170 km. The tidal amplitude is very high and large areas of reef get exposed during low tide, offering great opportunities for researchers to explore marine life. The habitat and biodiversity is varied, with the coral reefs of Pirotan, Paga, and Poshitra, mudbanks of Kalubhar; sandbars on both the northern and southern banks; seagrass beds in Poshitra; algal beds of Okha and Dwarka; islands of Lafa, Manmarodi, Dabdada, Kalubhar, Chusna, Bhaidar, and Chhad; mangroves on the southern bank; and the rocky shores of Kuchadi and Beyt Dwarka. An area of about 45,792 ha was declared as a Marine Sanctuary in 1980, and another 16,289 ha as the Marine National Park in 1982.



DEEPAK APTE

Coral formation in the Gulf of Kachchh

POSHITRA REEF: Poshitra Reef is a long stretch of fossil rock substrate along with three water channels, situated in the Saurashtra coast of Gujarat. It is part of Marine National Park in the Gulf of Kachchh. The flora and fauna include corals, algae, shelled molluscs, sponges, and other invertebrates, and also muddy-shore fauna. The area is home to a beautifully coloured, endemic aeolid species, *Sakuraeolis gujaratica*.

LAKSHADWEEP: Lakshadweep is an archipelago of 12 atolls, 3 reefs, and 5 submerged banks, spread across 32 sq. km, lying scattered in the Arabian Sea off the coast of Kerala. It comprises 36 islands, ranging from 0.1 to 4.9 sq. km in size, with only 11 of them inhabited. Lakshadweep reefs are the second richest reef formations in India, next to Andaman & Nicobar. The only atoll formations in India, the lagoons are shallow with maximum depth about 12 m; the outer reefs drop sharply to about 1,000 m. Lakshadweep has a high diversity of reef-associated flora and fauna, including giant clams, Green, Olive, and Hawksbill sea turtles, Whale Shark, and Humpback Whale. About 603 species of fish are reported from Lakshadweep.

NETRANI REEF: Netrani Reef, also called Pigeon Island, is located about 18 km off the Murudeshwar coast of Karnataka. The island has patchy coral reefs with diverse flora and fauna. The reef

supports 14 coral species with their associated fauna. The other fauna includes sponges, coelenterates, molluscs, and crustaceans.

MALVAN MARINE SANCTUARY:

Malvan is a small coastal town in the Sindhudurg district of Maharashtra. The Malvan coast is an interesting composition of submerged islands, sand banks, and rock beds. The diverse natural environment comprising numerous estuaries, sand dunes, and mangroves supports an equally great biodiversity. In 1987, Malvan was declared a marine sanctuary (29 sq. km). The coarse sand, rock pools, and shallow submerged reef provide a great place for studying marine life.

ANGRIA BANK: Known for centuries to fishermen, Angria Bank has recently caught the attention of researchers. Angria is a submerged ocean bank, situated 62 nautical miles (nm) west off Vijaydurg, 75 nm north-west off the Malvan coast, and 75 nm south west off Ratnagiri. It is about 40 km in length and 19 km wide, with steep slopes of up to 200 m. Very little is known about this reef. The site has a good variety of cetacean fauna (whales and dolphins), and a diversity of fish species including angelfish, anemone fish, jacks, and triggerfish among others.

INTERTIDAL WATERS OF COASTAL MAHARASHTRA: Several stretches along the coast of Maharashtra are rich in coastal and marine biodiversity. Among these are seven important clusters: Vengurla-Malvan-Achra, Devgad-Vijaydurg-Kasheli, Ratnagiri-Jaigad, Guhagar-Dabhol, Velas-Dighi, Kashid-Akshi, and Thane-Palghar. These clusters have approximately 30 sites within them that are ecologically sensitive.



DEEPAK APTE

Presently Director of BNHS, Deepak Apte is a scientist of international repute. His specialization is in marine ecology.



Sea Fan Gorgonia, a soft coral

Gulf of Kachchh

AN UNEXPLORED SEASCAPE

by Dishant Parasharya

Oceans are the lifeline of our planet. They cover almost three quarters of the earth's area and hold 97% of its water. Almost 50% of the oxygen that we breathe comes from oceans, which also act as carbon sinks, absorbing most of the carbon from the atmosphere. Oceans also regulate the surface temperature of the earth. Humans have depended on oceans for ages, be it for food, transportation, or even as dumping grounds! Infrastructural development along the coast is increasing rapidly globally; about half of the human population across the world now lives within coastal zones. Human beings are generally more aware about the happenings on land than in the oceans, though they cover 70% of the planet. Like land, oceans are home to an enormous diversity of marine life, ranging from microscopic protozoans to giant whales. Out of 35 animal phyla, the oceans harbour about 32.

The Indian shoreline supports diverse marine ecosystems, such as coral reefs, mangroves, sandy beaches, deltas, rocky shores, lagoons, and so on. Spread across 66 districts of 9 states and 4 union territories, the total coastline of India is 7,500 km, including 2,100 km

island coastlines. Our rich fishing resources are the result of our 3.72 lakh sq. km continental shelf and about 22 lakh sq. km vast Exclusive Economic Zone (EEZ).

The east and west coasts of India are significantly different. The west coast consists of rocky shores and has several small estuaries, whereas the east coast is generally shelving with beaches, lagoons, deltas, and marshes. Islands of the Lakshadweep archipelago on the west coast are oceanic atolls, and those of Andaman & Nicobar are mainly continental in nature. The three major indentations, Gulf of Mannar, Gulf of Kachchh (GoK), and Gulf of Khambhat (GoKh) are unique seascapes of India.

The waters of the Arabian Sea touch the 1,650 km long coast of Gujarat state, making it the longest coastline among all the Indian maritime states. About 60% of the coastline consists of two major gulfs, Gulf of Kachchh and Gulf of Khambhat; and the former is the largest coastal habitat on the west coast of India.

GULF OF KACHCHH

GoK is funnel-shaped, east-west oriented, seismically active, and one of the three macro tidal regions of India. About 125 km long and 75 km wide and with an expanse of around 7,350 sq. km, GoK lies between the mainland of Kachchh to the north and Saurashtra/Kathiawar

peninsula to the south, opening westwards into the Arabian Sea. It also has inlets into the semi-arid and arid regions of Little Rann. The coastline surrounding the gulf consists of low-level coastal plains with inundations, deep inlets, a number of offshore islands, and several small, seasonal river mouths. A cluster of around 42 islands is present in the southern gulf near Jamnagar and Devbhoomi Dwarka coast.

GoK has a highly energetic, macro-tidal system of the north-eastern Arabian Sea, with mixed semi-diurnal type tides having ebbs and high tides occurring twice a day at intervals of six hours. Hence, one should follow the tide table and tide timings before planning a visit to this area. The tidal range at the mouth of the Gulf is about 4 m. In general, the tides are low on the open Arabian Sea coasts of Kachchh and Saurashtra, but due to the funnel shape of the GoK and the semi-enclosed nature at the head, the height of the tides increases tremendously from the mouth to the head region. The tidal amplitude in northern GoK varies from 3 to 8 m, while in the south (i.e. from



Sea Pen *Pennatula* sp., is grouped with Octocorallia or Soft Corals



Cuthona, a nudibranch that feeds on hydroids



Sakuraeolis gujaratica, an endemic sea slug found only in Poshitra



Christmas Tree-Worm, a polychaete which looks like a Christmas tree

Jamnagar to Okha coast), it is 3 to 5 m. The associated tidal currents are fairly strong, reaching 4 to 5 knots in the open gulf near the mouth. The high tidal range and associated tidal currents play a significant role in sedimentation and shaping of the sea floor.

The northern coastline of GoK, lying along Kachchh district, has a mosaic of ecosystems consisting of mangroves, sandy beaches, rocky shores, as well as intertidal and high tidal mudflats, its most significant feature being the vast intertidal zone encompassing a network of creeks and mudflats. The Kachchh coast provides a favourable environment for several maritime trades and occupations like fishing, salt production, and cargo transport.

The Kachchh coast is ecologically important as it supports large areas of mangroves in the Kori Creek region. This area is one of the finest fishing grounds for prawns in the country. The intertidal zones in these mud-dominated marine areas are unique and important because fishermen can land their boats in these creeks during low tide, to keep them safe from strong winds and currents. The finest guides in this area are the local fishing community. They have exceptional knowledge about the geography, tidal fluctuations, and the local flora and fauna.

The sandy beaches from Naliya to Mandvi (in the north) are among the finest nesting habitats of Green Sea Turtle. The state forest department has established

a hatchery at Mandvi to support the conservation of this critically endangered species.

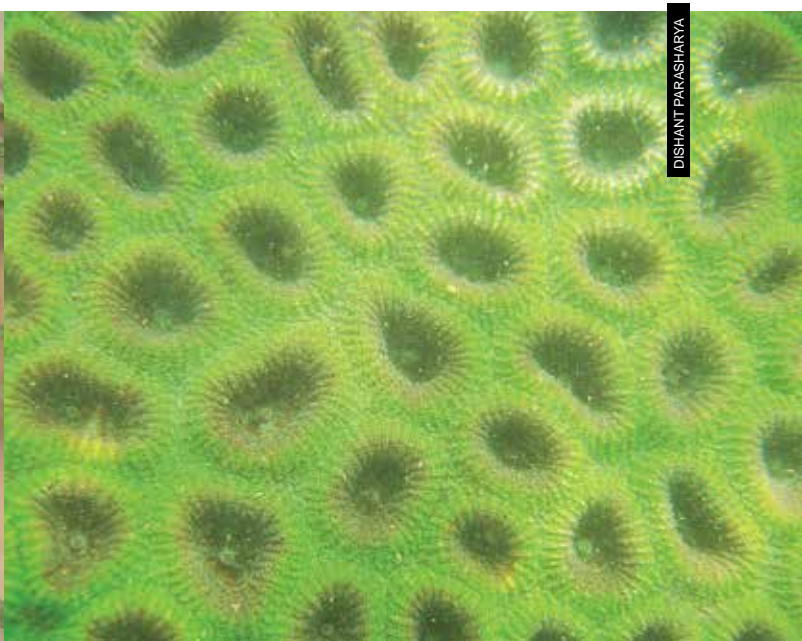
The eastern part of the Kachchh coast is constantly in dispute due to conflicts between port and allied infrastructural development versus the need for mangroves and associated fishery conservation. Development giants have acquired a stronghold in the area.

The southern boundary of the GoK is flanked by three districts – Morbi, Jamnagar, and Devbhoomi Dwarka. This region was declared a Marine Sanctuary (457.92 sq. km) in August, 1980, and Marine National Park and Sanctuary (MNP&S) (162.89 sq. km) in July, 1982. MNP&S of GoK is the first declared Marine Protected Area in India. It is situated in the intertidal zone of the southern coastline of GoK, extending nearly 150 km in Jamnagar, Morbi, and Devbhoomi Dwarka districts.

Out of a total of 42 islands in GoK, the National Park covers 37, while the Sanctuary area covers the remaining five and the inter-tidal zone from Navlakhi to Okha. Since the PAs were constituted under the Wildlife (Protection) Act, 1972, the management of the area is under the jurisdiction of the State Forest Department. MNP&S was initially established for the conservation and protection of a rich and diverse ecosystem, particularly for its intertidal and sub-tidal coral reefs and mangrove habitats. Since 1991, coral reefs and mangroves have additionally been accorded the highest degree of protection under the 1991 Coastal Regulation Zone (CRZ) Notification.



Sea Star is probably among the best known of marine animals



Corals are diverse in colour and pattern

The first scientific document on the flora and fauna of this area was by James Hornell, an English zoologist and seafaring ethnographer, in 1909. After his mammoth work, only patchy reports and half-hearted efforts have been documented till date, on the status of the thriving coral reef, mangroves, and more importantly the associated flora and fauna.

SPLENDID FAUNA

The reefs in MNP&S are mainly patchy or fringing in origin, with a few pinnacles. Scientific literature reveals that about 60 species of hard corals have been reported from the MNP&S area. Of these, only dead specimens were reported for species of the genus *Acropora*, indicating that a reef which flourished in the past is heading towards extinction due to sediment load and other disturbances. Recently, we recorded degradation and loss in the density of plate corals of the

genus *Montipora* also. Species of the genus *Turbinaria* are vulnerable according to the IUCN Red List, and these can be observed on the coastal reefs of Poshitra, Mangunda, Paga, and Boria in MNP&S. Among the 60 species recorded from GoK, generalist species such as *Dipsastraea speciosa*, *Dipsastraea farnus*, *Porites lutea*, *Pseudosiderastrea tayami* are now just surviving in sustainable numbers, while the rest have become sparse. Sedimentation on top of the colony, desiccation



Sponges, a primitive but important component of marine biodiversity



DISHANT PARASHARVA

A flock of Crab-Plovers at Pirotan. The Crab-Plover is monotypic, i.e. the family (Dromadidae) comprises a single genus and single species

during summer, anchoring of boats, and industrial development has caused such declines.

Sponges are primitive multicellular organisms, beautiful in appearance, and about 60 to 70 different species are known from this area. Echinoderms such as feather stars, sea stars, and sea cucumbers are common sightings in the reefs. The Annelid polychaete *Bonellia* found here is a classic example of environmental sex determination. At the time of hatching, the sex of the newborn larvae is not determined. If a hatched larva, while floating, settles

somewhere away from the female, it develops into a female. However, if it comes in contact with a female and settles in the mouth of a female, it develops into a male. Mud Crab *Scylla serrata* and Blue Swimming Crab *Portunus pelagicus* are delicacies with high economic value. Both these species are being harvested from this area and supplied to various local markets and to processing units for export.

More than 300 molluscs are recorded from GoK. During the All India Coordinated Project on Taxonomy of Mollusca (AICOPTAX), Bombay Natural History Society (BNHS) documented more than 70 species of Opisthobranchs, popularly known as sea slugs, from the region. Many of these are first records from the country, and a couple of species new to science have also been described. An aeolid slug *Sakuraeolis gujaratica* is an endemic species found only in less than a 500 sq. m area of Poshitra reef. Discovered by an Australian zoologist



DISHANT PARASHARVA

Blue Ring Angelfish *Pomacanthus annularis*, a beauty on the reef



DISHANT PARASHARVA

Hermit crabs occupy molluscan shells for shelter

Bill Rudman in 1971, it was rediscovered by the BNHS team in 2008–09 during the AICOPTAX project.

GoK is one of the main entry points to India for the birds migrating along the Central Asian Flyway into the Indian subcontinent. More than 300 species of birds including shorebirds and wetland dependent birds regularly visit GoK in huge numbers, and peak counts are recorded in November. Islands like Kalubhar, Bhaider, and Pirotan regularly host more than 20,000 birds during the migratory season. Congregations of Crab Plovers in GoK are among the highest on the west coast of India. Birds like Oriental Darter, Painted Stork, Black-necked Stork, and many species of herons and egrets nest in the mangroves of GoK.

Dugong, the only herbivorous marine mammal, is a rarity, and is mostly reported stranded or washed ashore on the western parts of MNP&S. Indo-Pacific Humpbacked and Bottlenose dolphins are regularly recorded. Olive Ridley and Green sea turtles nest on some of the islands of MNP&S.

NEED FOR CONSERVATION

Being strategically positioned on the west coast of India, major industrial cargo transportation is routed through the waters of GoK. Migrating megafauna such as fish, turtles, dugongs, dolphins, and whales are victims of injuries from propellers of the shipping traffic. This results in disturbances in the local movement patterns of these species. The depth of the gulf ranges from 1 to 60 m, the industries and port authorities have to constantly carry out dredging operations in the navigational channels of the gulf to facilitate the vessel traffic. Dredging and disposal of dredged material add to the natural sedimentation, leading to turbid waters, loss of benthos, and more siltation. Settling of sediments on coral colonies hinder coral calcification (growth) rate, leading to alteration of growth forms and spread of various diseases. They also restrict the recruitment



Lobster, considered a delicacy by many



Pufferfish, the reef inhibitor



Bonellia, a unique worm of class Echiura, phylum Annelida

of new coral colonies, which may affect the survival of various corals and associated fauna and flora that require clear water for survival.

Reclamation of mudflats and cutting of mangroves for coastal infrastructure development is a major threat to the local traditional fishing economy, as numerous fishery species breed in mangroves. New human settlements and increase in the density of coastal population has magnified the problems of waste disposal systems in this seascape. Awareness amongst the settlements is low and their understanding of the value of the marine resources is very limited. In recent years, restoration of ecosystems such as mangroves and coral reefs is being attempted in some parts of GoK. However, restoration requires major scientific studies and large data sets to begin with.

The coral reefs in parts of MNP&S have been neglected for long, despite their status as one of the four

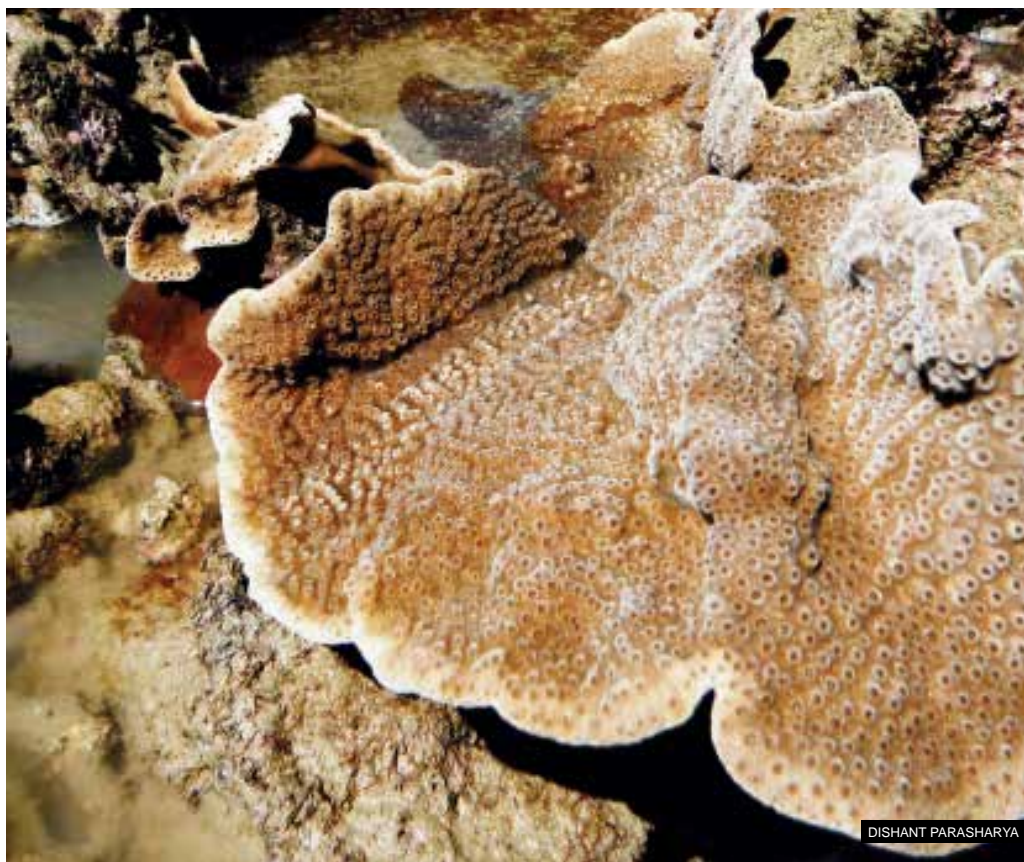


Live cowrie in its habitat



Shallow pools – coral paradise

DISHANT PARASHARYA



Turbinaria mesenterina,
a vulnerable species

major coral reefs in India. In the past, these reefs witnessed dredging for sand and other calcium resources. Such activity was intensive in the eastern and central parts of southern GoK, while the western parts were relatively less disturbed. To restrict calcium exploitation from the area and to help the reefs recover, the state government declared the area as a marine national park. However, industrial development, especially establishment of refineries on the Jamnagar coast, cropped up in the early 1990s, impacting the coral ecosystem. In recent years, industrial pressure has tremendously increased in the central and eastern parts. With a growth rate of 2 mm/year. It is very difficult for coral reefs

to recover within a time span of 10 years, i.e. from 1982 to 1992. In recent times, industrial pressure is highest on the central and eastern parts of the gulf.

The economic value of these marine ecosystems is incomparable, as they provide natural resources with zero or very little investment. Degradation of these marine ecosystems pose a direct threat to the local communities dependent on them. It does not matter whether we are living within coastal areas or far from them, oceans are the lifeline of our existence. Strict and strong vigilance, awareness and support from the local community, and an empowered judiciary are essential to save this seascape.



DISHANT PARASHARYA

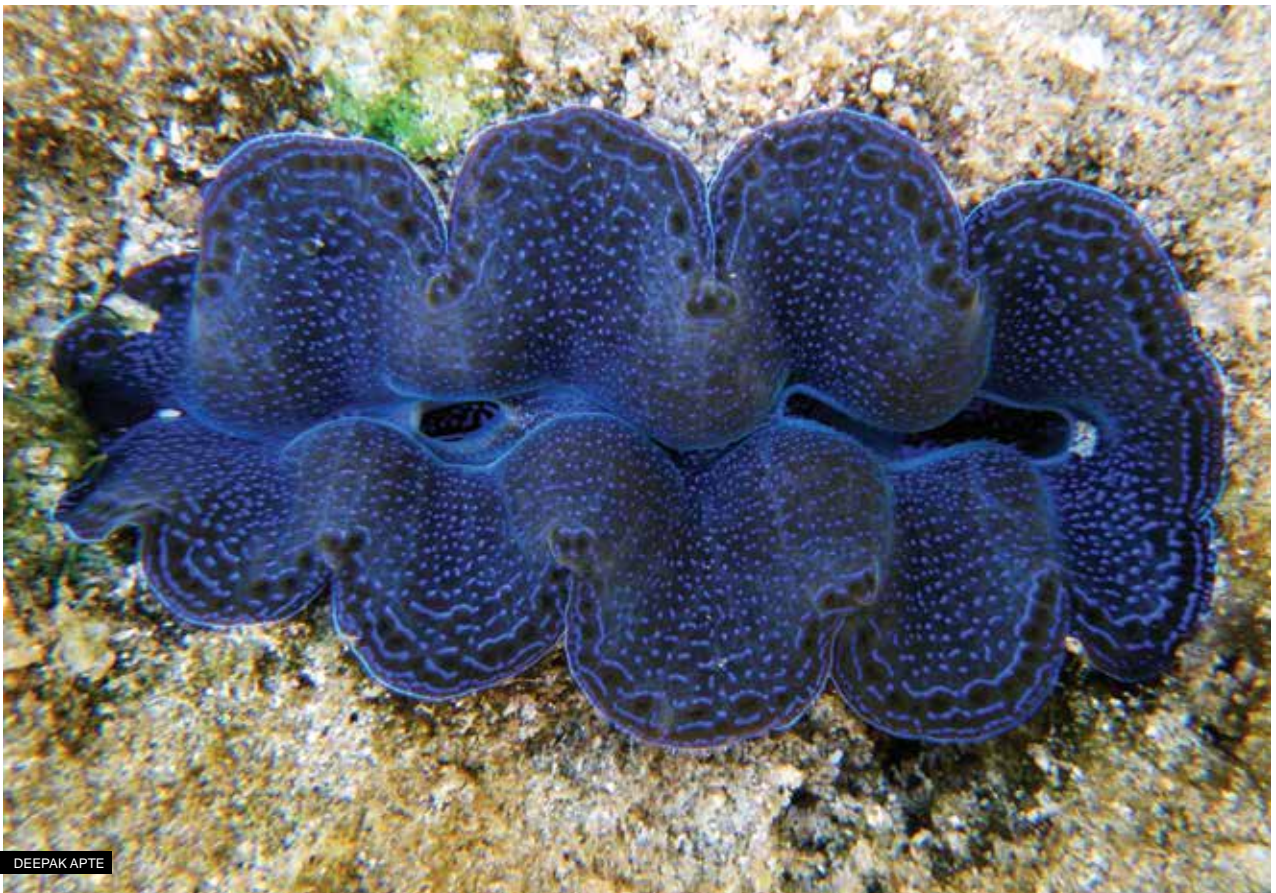
A scientist with BNHS in its marine conservation programme, Dishant's core area of interest is reef ecology.

Behemoths

OF THE SEA

by Deepak Apte

My first ever interaction with marine life was way back in 1970 at our beachfront family home in Sasvane, a small coastal village 120 km from Mumbai. I was just five, when my cousin and I would stroll on the beach, fascinated by sea shells. From then till today, my obsession with the oceans has taken me around the world, ultimately turning me into an ambassador for their conservation. In the past two decades, I have managed to see every coastal state of India, including the islands of Lakshadweep and the Andamans. The unending wealth of our oceans makes me wonder how careless and abusive we are in our attitude towards them. Even after 5,000 dive hours and photographing a few thousand species, I know there is still a lot to be seen. The story of Giant Clams is just one piece of the huge unresolved jigsaw puzzle in the larger picture of the coral reef environment.



DEEPAK APTE

Giant Clams are huge, sessile molluscs inhabiting shallow areas of marine coral reefs. These salt water clams are omnivorous in nature, feeding on both plants and animals. Seen above is the Crocus Clam *Tridacna crocea*

Giant Clams are impressive in numerous ways. These majestic boneless animals are part of the phylum Mollusca (soft bodied, from Latin *mollis* = soft), and are commonly seen in tropical reefs in shallow waters. One among the largest and longest living molluscs, Giant Clams, can grow over a metre and live from 60 to 200 years. Giant Clams are attached to the ocean floor, and reach sexual maturity between 6–20 years, depending on the species. Their fluorescent coloured mantle cannot be missed while diving or snorkeling in shallow coral reefs. These animals have developed the ability to cultivate plants (zooxanthellae or unicellular algae) in their body tissue, demonstrating an unusual phenomenon of endosymbiosis that is also seen in many other animals. However, Giant Clams are unique as they have evolved to cultivate zooxanthellae in a special circulatory system, unlike the others.

The Giant Clam's most remarkable feature is its fluorescent and colourful mantle, which makes it the most sought after of molluscs in the marine aquarium trade. Close observation will reveal tiny iridophores, the eyes of the clam. There is no explanation as to why the mantle shows so much colour variation. Since adult Giant Clams are sedentary, fixed to the substrate, they have adopted a special mode of reproduction called broadcast spawning, i.e. they release eggs and sperms into open water. They are known to release millions of eggs and sperms each year, of which only 2–10 young clams (per hectare) ultimately manage to survive and grow. Of these, probably only one will grow to adulthood. This low rate of reproduction makes them vulnerable to stress.

Twelve species of Giant Clam (ten from genus *Tridacna* and two from genus *Hippopus*) are known worldwide. Of these, five species are known to occur in India (*Tridacna gigas*, *T. squamosa*, *T. maxima*, *T. crocea*, and *Hippopus hippopus*), with only evidence (shell remains) of *H. procellanus* recorded. Among these, three are protected under Schedule I of the Wildlife (Protection) Act, 1972, and these are also protected in over 80 countries where



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DEEPAKAPTE



DEEPAKAPTE

The beautiful, bright colours characteristic of individual Giant Clams are actually a result of the symbiotic algae living within their cells. Seen above are the Maxima Clam *Tridacna maxima*



DEEPAKAPTE



DEEPAKAPTE

Giant Clams are hermaphrodites, but they cannot reproduce on their own.

They release sperms and eggs into the water, where fertilization occurs on contact. The fertilized eggs float in water for around 12 hours before they hatch. A single Giant Clam can release over 500 million eggs at one time. The larvae are planktonic,

i.e. the larvae float on water, but cannot swim against the current.

The larvae start producing shells around themselves within a few days.

They grow rapidly and soon fasten themselves to the floor of the reef for life. Seen here are the Fluted Giant Clam

Tridacna squamosa



DEEPAKAPTE

they occur. Giant Clams are listed in CITES Appendix II (deemed not currently threatened with extinction but at risk of becoming so unless their trade is regulated).

In the western world, Giant Clams were a part of folklore and adventure stories. Several horror movies and novels depicted these animals as dangerous beasts that ambush divers. In truth, Giant Clams have no taste for human flesh. The myth is mainly due to the large size that these animals attain. Freak accidents, due to careless stepping onto one, or uncalled for adventure by divers, resulting in serious damage to fingers or feet are more likely. Giant Clams have powerful adductor muscles and heavy valves (the shell), and they have a natural tendency to snap shut the valves at the slightest touch to the mantle, using the adductor muscles. The best way to avoid such accidents is to watch them from a distance and to not touch the mantle.

UNDER SEVERE THREAT

Like most wildlife, Giant Clams too are under severe threat globally. They are considered a delicacy in Southeast Asia. Due to this demand, their population has crashed beyond recovery in many parts of the world, and has become locally extinct in some areas. The Chinese pay a fortune for the adductor muscle, which is considered to have aphrodisiac properties. Empty shells of Giant Clams are traded in large numbers for sale as souvenirs. Shells of the largest species *Tridacna gigas* were even used as bathtubs for children. Internationally, Giant Clams are used commercially as aquarium specimens and in shell craft. Besides these, there are other biological and ecological stresses that affect them. Rapid deterioration of reefs is one of the important causes of their decline, as are polluted waters.

Giant Clams spawn in a synchronized way with both males and females releasing eggs and sperms simultaneously. Thus, fertilization occurs in water, and if adult clams are distributed far away from each

other due to overharvesting or declines due to other reasons, the chances of fertilization are poor. Giant Clam larvae are free floating and will drift with water currents for up to 70 hours. If a suitable habitat or substrate is not available when they settle on the sea floor, these larvae will die. As mentioned earlier, Giant Clams cultivate zooxanthellae in the mantle. Thus, they need two important environmental conditions: a) shallow waters that allow enough sunlight for zooxanthellae for photosynthesis, and b) water temperature regimes between 18–25 °C for optimal growth of zooxanthellae. In the event of prolonged temperature rise of over 3–4 weeks (e.g. due to El Nino), the zooxanthellae leave the clam, resulting in their death. Sometimes fishing in shallow reefs can uproot Giant Clams, thereby causing mortality. There are also instances of Giant Clam deaths due to boat anchors.

Giant Clams reach maturity very late (over 5 years in the smallest clam *T. crocea* and over 20 years in the case of *T. gigas*). This fact, coupled with the harvesting of juveniles, is a critical factor causing their large scale decline in many parts of the world. Juvenile clams are more beautiful with intricate scales on the valves, and thus sought after as souvenirs. Large populations are harvested even before they reach maturity, resulting in thinning of adult populations.

Since 2004, I have been studying the population ecology, biology, and conservation of Giant Clams in Lakshadweep. This project has now extended to the Andaman & Nicobar Islands. The programme is being executed in collaboration with the Ministry of Environment, Forest and Climate Change, Government of India, and the respective state forest departments with support from Whitley Fund for Nature. There has been a precipitous decline of Giant Clams in Andaman & Nicobar over the past three to four decades, which is a cause of serious concern. Our studies indicate that natural recovery of *Tridacna gigas*, *T. maxima*, and *T. squamosa* is near impossible in these islands. The population of *T. maxima* in the Lakshadweep Islands, on the other hand, is relatively better, while *T. squamosa* continues to decline. Sea ranching is probably a major initiative by which we can bring back populations, as is done in the waters of some countries. It will require exceptional efforts by the government and people to save these majestic giants of coral reefs, otherwise they will remain as no more than folklore stories for the future generations.



DEEPAK APTE

Presently Director of BNHS, Deepak Apte is a scientist of international repute. His specialization is in marine ecology.

Polyclad flatworms

WEIRDLINGS OF THE SEA

by Reshma Pitale



RESHMA PITALE

One of the bright coloured species, *Pseudoceros susanae* originally described from Maldives in 1997, shows distinct colour morphs

Have you ever tried overturning pebbles or poking about with a paintbrush in shady crevices on a rocky shore? If you have, you would have discovered beautifully coloured, spirally pluming Sabellids and other polychaetes, Sipunculids or peanut worms, and Nemerteans or ribbon worms. These are all common worms seen in marine habitats. In addition to these creeping assemblages, there is a community of brightly coloured, flamboyant worms commonly known as flatworms. As the name suggests, these are flat-bodied worms. They belong to the primitive phylum Platyhelminthes and have many-branched intestines (poly = many, clade = branch). The intriguing colour patterns and smooth wave-like movement of these polyclad worms easily steal the attention of a diver or wanderer in the intertidal zone. However, it is not easy to see them as they can be as small as a few millimetres (max. 15–20 cm), and are cryptic, leaf-like, and mostly hiding within shady crevices, or under coral rubble or loose rocks.

The colourful dorsum of these worms showcases a diverse array of colours and patterns, ranging from red, yellow, green, orange, pink, violet, blue, black, grey, cream, to



Rocky coral rubble at Dwarka, Gujarat

white, with streaks, stripes, dots and blotches, and mottling. It is believed that these colours are due to the presence of granules in their skin cells; the granules producing darker shades such as grey or black are situated deep within the cellular region, whereas granules present in the upper layers give rise to other shades of colours. It is also speculated that the colours are pigments derived from the food they ingest. Thus, the network of intestinal branches reflects the colours of the prey consumed, which is visible through the worm's semi-translucent body. One can assume that if the worm appears darker, it has fed recently, as freshly acquired pigments are brighter.

As mentioned earlier, polyclad worms are usually recorded from rocky intertidal to sublittoral areas and coral reefs, but a few species are known to be brackish-water dwellers, and some pelagic; in fact, two species are reported from depths of 2,000–3,000 m.

Flatworms are known to be voracious flesh eaters; they have distinct feeding mechanisms based on the type of



Recently reported cosmopolitan species from India – Gujarat and Maharashtra – *Thysanozoon brocchii* was originally reported from Italy

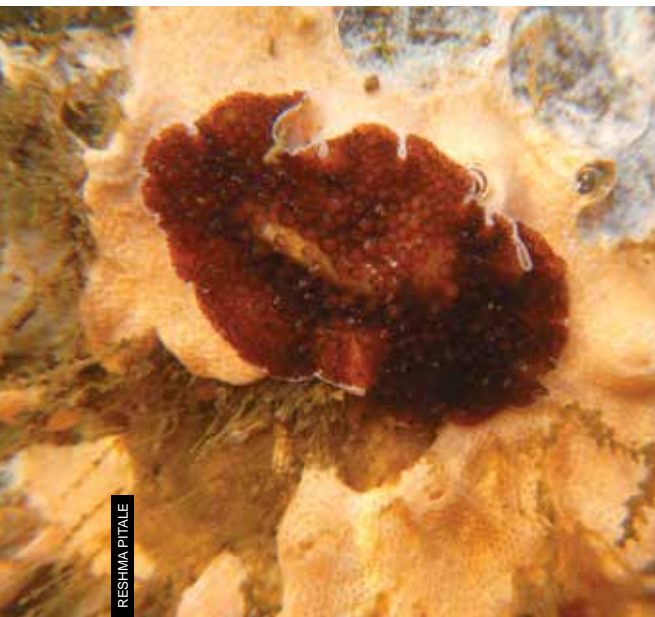


Polyclad *Pseudoceros stimpsoni* commonly found on ascidian *Didemnum psammotodes* along the Ratnagiri coast



Maritigrella fuscopunctata, commonly seen along Lakshadweep and Gulf of Kachchh is frequently associated with an ascidian *Ecteinascidia thurstoni*

RESHMA PITALE



Acanthozoon sp. found dwelling underneath rocky pebbles at Ratnagiri

RESHMA PITALE



Pseudoceros vishnui is a recently described species from Andaman Islands, India

DEEPAK APTE

pharynx. The pharynx may be tubular or ruffled (many-lobed), and can be everted completely through the mouth. These worms either crawl over to grasp the prey by ejecting the pharynx tube, or cover it by expanding the folds of the pharynx to feed on it. Sea squirts (Ascidians) are one of the favourite foods of flatworms, however, some species prefer clams, mussels, corals, and even barnacles.

The feeding habit of flatworms is a bane for aquaculture farmers, especially the acotylean worms, which feed on oysters, mussels, clams, and even pearl oysters. Acotylean flatworms penetrate the pharynx of the prey within the shell or slip into the shell and slowly engulf the tissue. Some species are identified as pests and known as 'oyster leeches'. Destructive attacks are reported from Australia, Japan, North America, Jamaica, Taiwan, Europe, and Korea. Some reports suggest that the empty shells of the prey are later used by polyclads for laying eggs.

Although these worms are free living, some ecological observations indicate their associations with other marine invertebrates. Some species are associated with ascidians, with corals perhaps for feeding, and even Gorgonids, whereas *Imogine* spp. are known to live with gastropod shells occupied by hermit crabs. A study suggests that those associated with hermit crabs eat up the eggs laid by the hermit crab to create space for their own eggs. Similarly, they are observed to live around brittlestars and ship worms (*Teredo* spp.).

Polyclads belong to one of the primitive invertebrate phyla and have a simple nervous system and other anatomical features. However, their defence strategies certainly deserve research on many ecological and biochemical aspects, starting with their coloration and patterns that are, contrastingly, either cryptic or vivid.

A mucus layer surrounding the body, besides toxic derivatives in tissues, makes the flatworm distasteful and unpalatable to predators. These toxic compounds are nerve poisons which are either generated within the body or acquired from food. What happens when a flatworm confronts a predator and escapes with physical injuries? Polyclads are well-known for their



DEEPAK APTE

The royal blue rim of the species *Pseudoceros concinnus* makes it a conspicuous inhabitant of reef areas; it is found commonly within the coral reefs of Andaman, India

excellent capacity for regeneration. In fact, studies report that if the anterior head region is safe, the whole body can be regenerated. This capacity of regeneration by polyclads or even other platyhelminths is a topic of research worth pursuing to understand their nervous mechanisms. Another mysterious aspect is their mimicry with opisthobranch molluscs, e.g. *Pseudoceros* imitates *Phyllidiella pustulosa*; *Pseudoceros gratus* – *Phyllidiopsis striata*; *Tytthosoceros lizardensis* – *Discodoris boboliensis* and some fish species. There are several theories, but no conclusion has been arrived at to explain the driving factors behind this habit of mimicry.

The procreation process of flatworms is equally bizarre. Although the conventional copulation methods like delivering sperm into the female's organ, and internal fertilization and deposition of eggs, are followed by most of the population, there is another way called 'penis fencing', which is followed especially by pseudocerotids and euryleptids. In this ritual, sexually aroused flatworms glide slowly over each other, rear up with the help of tensed muscles, and stab and penetrate an armed structure called stylet (penis). The question is how do the white sperm droplets travel to the female part and fertilize eggs? So far, this process has not been well understood, but for some species ex-situ observations have been made to determine this.

About 1,000 species of polyclad flatworms are known worldwide and some of them are cosmopolitan. Currently only 54 species are known from Indian waters. Molecular studies are currently underway to determine the taxonomic status of the different species, in addition



RESHMA PITALE

Thysanozoon nigropapillosum from Dwarka, Gujarat

to classical taxonomy, yet ambiguities remain in the systematics of polyclads.

FACT FILE:

Flatworms can be found in marine, freshwater, and even damp terrestrial environments. With about 29,000 known species of phylum Platyhelminthes, they are the largest phylum of animals without a body cavity.

Unlike other bilaterians, flatworms have no specialized circulatory and respiratory organs. This restricts body shape, the flattened shape that allows oxygen and nutrients to pass through their bodies by diffusion.



RESHMA PITALE

A scientist at the BNHS, Reshma works on intertidal biodiversity and conservation, with special emphasis on the Maharashtra coastline.



ABISHEK SATAM

A sea sponge, one of Mumbai's little-known marine denizens, against the backdrop of a more familiar form of the city

WALKING ALONG THE *shores* OF *Mumbai* by Pradip Patade

My life has revolved around the ebb and flow of the tides of Girgaum Chowpatty in Mumbai for almost a decade now. My daily routine looks a bit like this – venture out on the beach, go kayaking, windsurfing, reach and observe the treasures that low tide reveals, document our rich marine life through photographs and videos, and occasionally publish this valuable information on social and other mainstream media. All these tasks coexist with my routine job as a water sports instructor and facilitator at Rae Sport Academy. Through all these activities, this stretch of Girgaum beach has begun to feel like an extension of myself.

Some of the most iconic photographs of Mumbai have been taken on this beach during the yearly Ganesh festival. On day 10 of this festival, thousands of devotees converge to enter the waters across the city's main beaches, to immerse the idol of their beloved God with chants of “*Pudbchya varshi laukarya*” (Come back soon next year).



PRADIP PATADE

A young octopus in the intertidal zone of Girgaon Chowpatty



PRADIP PATADE

Mumbai has no shortage of hard and soft corals – pictured here is a cluster of Gorgonian sea fans, a kind of soft coral

In 2013, as part of the official lifeguard team for rescue and relief services to the devotees, I got glimpses of an aspect of the processions that re-imprinted the geography of Mumbai as a coastal city. I vividly remember responding to jellyfish and stingray injuries inflicted on the devotees and panic-stricken crowds as they entered the water. It struck me just how closely we share this city with the Arabian Sea and how little we know about what it hosts.

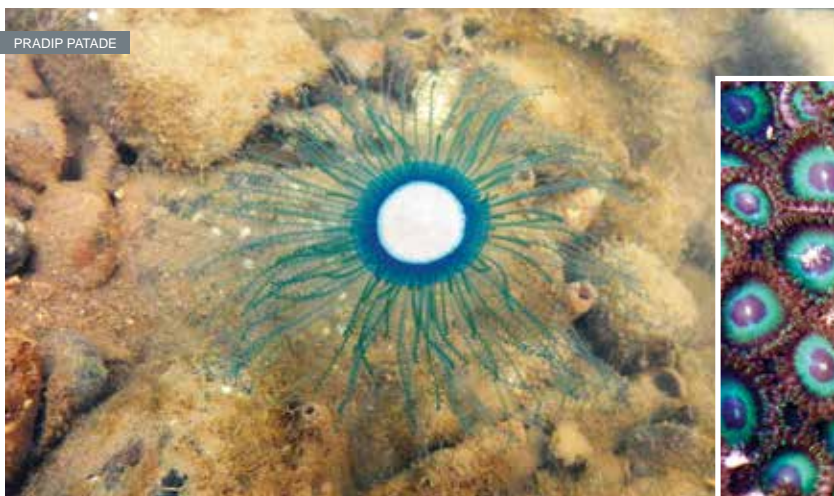
Since then, I have dedicatedly tried to study the marine life that exists along the South Mumbai coast. Besides working to prevent the human-animal conflict I witnessed, I was also enthusiastic to document the precious marine fauna of Mumbai, to popularize this subject from the conservation point of view and to create awareness among Mumbaikars.

Mumbai has a long history of man-made alterations – where seven islands once existed is now the sprawling metropolis of today. It is fascinating that this city's first inhabitants – the

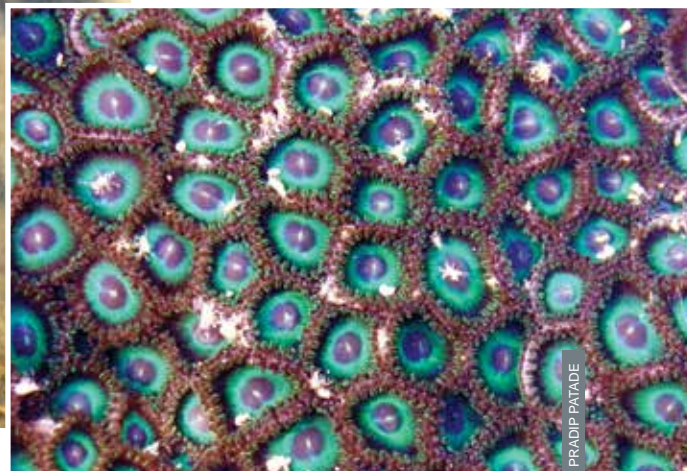


PRADIP PATADE

A carrot anemone – so called because of its carrot-like column, which remains buried in the sand



The jellyfish-like blue button, or blue dollar, washes up on the city's shores in large numbers in windy weather



Vast mats of *Zoanthus* adorn rocks at the deeper edges of some of our rocky shores



Beautiful nudibranch sea slugs, such as this *Bornella stellifer*, are often seen in Mumbai's tide pools



More familiar, popularly known marine creatures, such as this sea star, are also a regular sight at some seashores within the city's urban limits

Kolis – are fisherfolk, and their presence even today is an indication of the rich biodiversity that existed on these shores. Almost everyone who has had a tryst with the city has a connection to the sea, either through the fish they ate, the picnics they enjoyed at the beach, or the walks they took on Marine Drive made famous by Bollywood. And yet when I started out, I found that the general opinion of the people of this city regarding the sea is one of dirt, pollution, and waste. That apathy is one of the reasons why our beaches are degraded with waste, why the city's storm water and nullahs continue to drain into the sea even today, and why most ill-planned development along the shoreline does not anger citizens. What is fascinating is that despite all the neglect and disrespect, the city's shorelines are filled with marine life. And it has become my goal to make this known to as many people as possible.

In 2017, along with a few like-minded people – Siddharth Chakravarty (who studies enforcement policies for marine



ABHISHEK SATAM

The watery edge of Mumbai also serves as an important breeding ground – seen here are egg cases of the Spiral Melongena snail. Each individual case contains several eggs

spaces) and Abhishek Jamalabad (a marine biologist) – I started Marine Life of Mumbai (MLOM), a collective, and our main aim is to take this city’s land dwelling inhabitants (humans) to meet the underwater inhabitants (marine life) on shore walks along the city’s coastline. These walks are cost-free (and will always be) because we believe this is the only way to make the shore walk experience inclusive and accessible to all. Our objective is to use these walks as the medium to collect data and create a database through the avenue of citizen science. A wide range of biologists, researchers, and the general public are now creating a timeline of the city’s marine fauna; in effect, picking up the threads from where this documenting stopped in the 1980s. Our data is open-access and democratized for everyone, which means that across the spectrum of education, impact assessments, and resource management, people can use it for a range of applications. And lastly, we use these walks to train people to become leaders, so that the model can be replicated across the city and further to other cities and states.

In a testament to our goal of encouraging citizen science, even the team, which started with the three

founders, is a growing volunteer-led force today. These team members are an enthusiastic mix of marine biologists and others from the fields of finance, design, publishing, tech – even people who had nothing to do with the study of oceans before this.

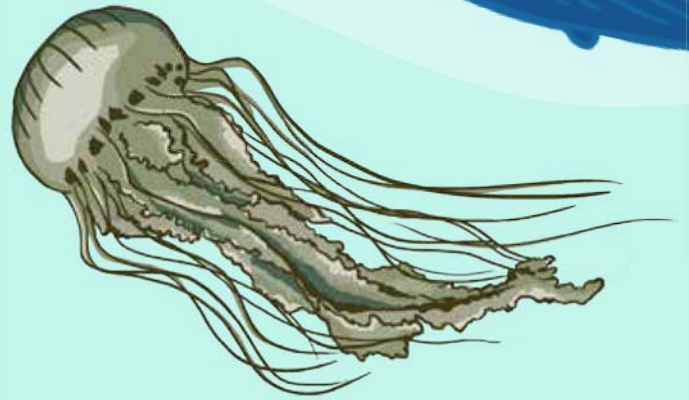
Today India’s 7,500 km coastline is in a state of neglect. Laws are being flouted, people are being displaced, and the ecology is being destroyed. Urban populations have a huge impact on coastal ecosystems and it is important that a sense of wonder and intrigue be instilled in them. With the thousands of people who have joined me on social media, I feel like I no longer walk alone. And nothing can be more joyful and fulfilling than that.



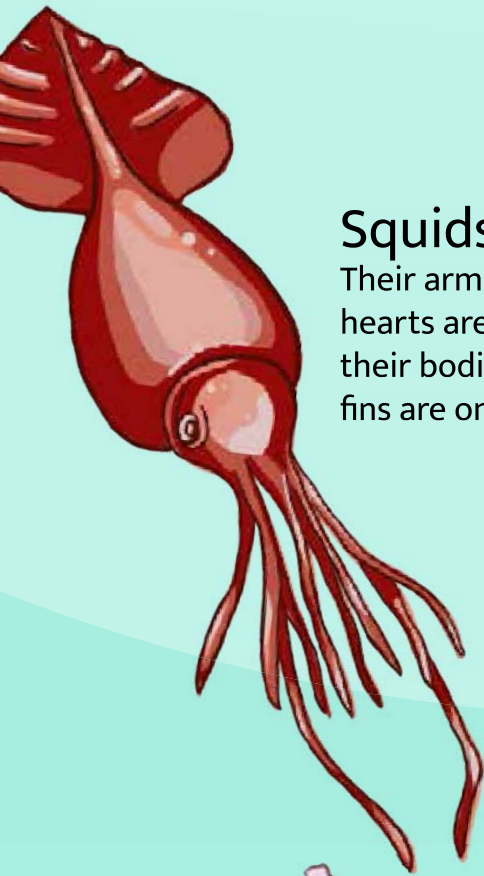
PRADIP PATADE

A wildlife photographer, Pradip has nine years of field experience and leads shore walks to raise awareness about Maharashtra’s marine biodiversity. He is working as a water sports instructor at Rae Sports, Mumbai.

Fun facts



Jellyfish have been around for more than 650 million years, outdating both dinosaurs and sharks.



Squids swim backwards. Their arms, tentacles, and hearts are at the front of their bodies and their fins are on their back.



All **Clownfish** are born male; the male can transform to become a new dominant female.

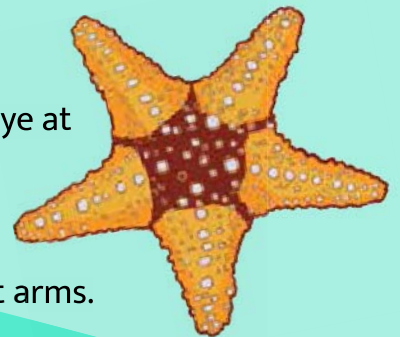


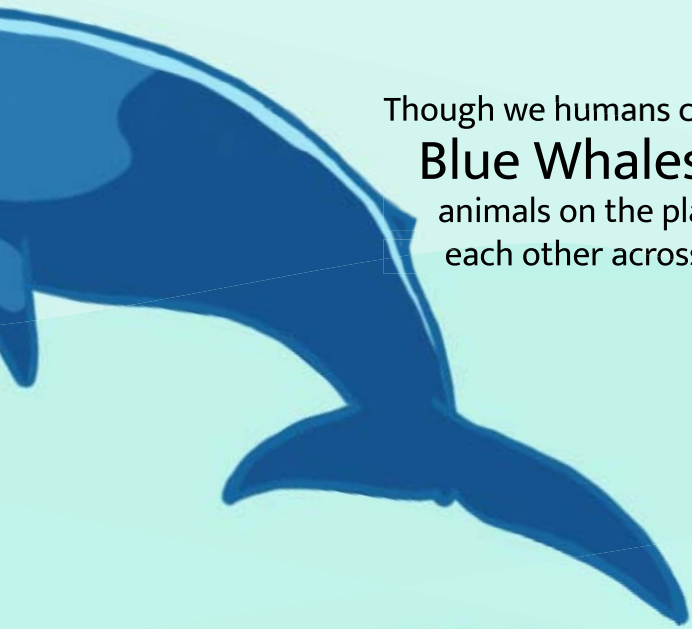
Sea Urchin has a special type of mouth, called "Aristotle's lantern", which is equipped with five sharp teeth that can drill a hole in rocks.



Corals grow very slowly—about 2 cm per year.

Sea Stars have an eye at the end of each arm that allows them to see light, dark, and simple shapes. They can also regrow lost arms.

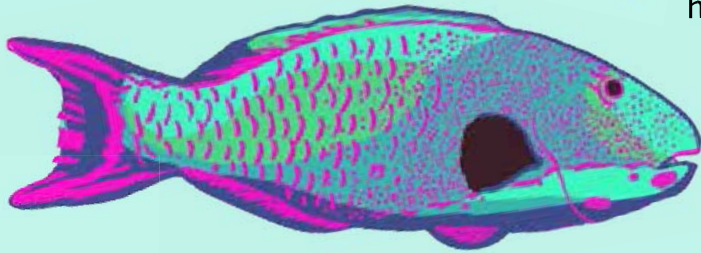




Though we humans cannot hear them, **Blue Whales** are one of the loudest animals on the planet. They can hear each other across distances of up to 1,600 km.



Seahorse is the only animal where the male bears the pregnancy (the female deposits her eggs into his brood pouch) and thus gives birth.



Parrotfish produce mucus which they blow out from the mouth as bubbles, creating a translucent 'nightgown' to protect themselves while in slumber.

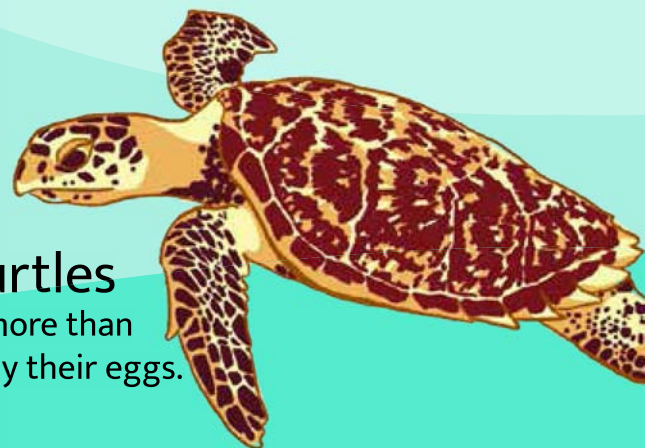


Dolphins sleep with only half their brain shut down and one eye open; that is how they look out for predators and other threats.

Whale Sharks have skin that is 15 cm thick – the thickest skin of any animal species.



Green Turtles can migrate more than 2,250 km to lay their eggs.



*Animal sizes not to scale.

UNDERSTANDING *reef resilience* IN THE ANDAMANS

by Vardhan Patankar



VARDHAN PATANKAR

Vibrant and colourful, coral reefs in the Andaman & Nicobar Islands support a spectacular diversity of marine life

Corals are some of the simplest, yet most complex organisms on the planet. Primitive, yet amazingly ‘modern’; and, unbelievably resilient, yet dramatically vulnerable, corals can be smaller than the size of your nail or bigger than your car.

I fell in love with the reef ecosystem when I observed the colourful and vibrant reefs in the Andaman Islands 15 years back, and it has been my driving force ever since. I was involved in documenting the post-tsunami damage done to reefs and their subsequent recovery during my initial years of research. However, my real quest to study the reef ecosystem began eight years ago, in the summer of 2010, when I got my first opportunity to observe the phenomenon of mass coral bleaching. Until then, I had only heard of coral bleaching, which occurs when coral animals lose their symbiotic algae



Bleaching of corals can directly impact the species that are dependent on corals for food and shelter such as the Sunburst Butterflyfish, *Chaetodon kleinii*

(zooxanthellae) and turn bleached (white) due to increase in sea water temperature¹.

We spent the next one year documenting the impacts of the bleaching phenomenon. Altogether, we surveyed 75 sites along 51 islands in the Andaman archipelago. Every site was different in terms of its location, percentage of live coral cover, and overall fish species composition. Surveying reefs of North Andaman was akin to swimming over a cemetery, whereas in South Andaman and the Nicobar archipelago, only a few corals had been bleached. Why did only certain reefs get bleached while the others survived was the question that baffled us.

In subsequent years, we continued monitoring these sites to understand post-bleaching reef recovery and what we observed took us by surprise. Many sites had succumbed to coral rubble and did not recover, whereas others were hardly bleached and recovered fully. There was significant variation in how much coral

cover was affected by physical and biological disturbances. The question then was, how quickly do coral communities recover after disturbances. This is an age-old question that has intrigued many, including me. I therefore took to assessing reefs of the Andaman with the aim of understanding what makes certain reefs resilient, others resistant, while a few are susceptible in the face of repeated disturbances. A resilient reef is better able to recover from stress events, like bleaching and storms. They are like our immune system. A person with better immunity can recover quickly from illness and viral infections such as cold, whereas a person low on immunity may take longer to recover.

After reviewing and collating past literature and information, it was clear that the Andaman & Nicobar reefs have been grappling with massive coral mortality since time immemorial. According to past records, Andaman Islands have been hit by three tsunamis (the most recent and dramatic being

¹Coral is an animal that secretes an external skeleton of calcium carbonate, typically forming large reefs in warm seas across the Indo-Pacific belt.

the tsunami of 2004), and repeated coral bleaching has affected the island reefs. Just when reefs were beginning to recover from the impact of 2010 bleaching, another natural catastrophe, the El Niño that warms the water in the equatorial Pacific and affects global weather, impacted the corals of the world, including those located in the Andaman Islands. Reefs of several countries were affected by the 2016 bleaching event, which is also believed to be the longest and most intense such event in history. A recent study predicted the local extinction of many reefs in the next 50 years. Other than natural catastrophes, many other types of disturbances or stresses, many of which are human-induced, can kill corals, including cyclones, disease, pollution, overfeeding on coral by crown-of-thorn sea star.

India is not the only country facing this crisis – reefs of several countries have been affected by the 2016 bleaching event.

People often ask that if disturbance and recovery of corals are part of a natural coral reef

ecosystem, then why bother studying reef resilience? My answer to that is: the frequency of disturbances is exponentially higher than previously known, and monitoring coupled with active management is the only hope to save corals. After major natural catastrophes, there are some corals that survive the stress, recover quickly, and recolonize the dead reefs. If we have basic ecological data, collected as part of long-term monitoring programmes, to predict which reefs might bleach, which would survive, and which would bounce back and recover quickly, couldn't we ensure that these reefs were adequately protected? And would not that enable the custodians of marine protected areas to make better decisions to reduce "man-made" stress to give these resilient reefs a better chance of survival?

In order to do this, we have selected 10 sites, and at each site, we collect data on a range of variables that are known to confer resilience to the reefs. My colleagues Zoya Tyabji and Nairika Barucha collect data on invertebrates and coral genera found on different reefs and their relative abundances, while Tanmay Wagh and I collect data on reef fish and different benthic substrate categories, such as percent cover of live coral, dead coral, algae, sand, etc. In addition, in order to understand how herbivorous fish aid in recovery of corals, Tanmay has set up experiments to understand how such fish maintain the coral-algal balance on reefs.

The information collected is consistent with monitoring data collected by other organizations across the world. Our data, therefore, contributes to the global effort to understand reef resilience. As the ocean temperatures continue to rise, we know that it is not only the corals that suffer. Bleaching diminishes the reef (in ways that we are just beginning to understand), thereby reducing the overall health and stability of the entire ecosystem.

For the majority of reefs in the Andaman Islands, there is limited information on their condition and health. A few recent studies suggest that understanding and managing local processes, e.g., local hydrodynamics, ecological and physical factors, and fishing pressure, could play an important



Coral reef at the peak of a bleaching phenomenon



Anemones are susceptible to bleaching, and during a marine heat wave, there could be reduction in the abundance of both anemones and their resident clownfish



VARDHAN PATANKAR

A bleached colony of *Acropora*

role in the recovery of coral reefs. We are now analysing a massive data set and trying to solve the jigsaw puzzle and create a roadmap for how these reefs will respond to repeated disturbances. Hopefully the data will help the Andaman authorities make informed decisions on where to concentrate their resources to maximize efficiency to protect the reefs.

Rather than writing refined obituaries on coral reef degradation, it is important to highlight the success stories of reef resilience. Our preliminary findings indicate that at many sites, reefs are remarkably resilient. These areas should get all attention from reef managers. A good start is to strengthen existing

protected areas and to realise that people's livelihoods in the Andaman Islands are directly or indirectly linked to the reefs' resilience.

Managing coral reefs is complex – it is an unsteady balance of ecosystem, science, politics, and economics. The current situation demands complicated solutions, especially since it involves dealing with global climate change, reducing our carbon footprint, and the lives of thousands who are dependent on reefs. By recognizing that coral reefs and human lives are inherently coupled, we can evolve ecologically sound as well as socio-economically equitable strategies to manage them.



VARDHAN PATANKAR

A marine biologist, Vardhan works on a range of basic and applied studies in marine systems. His current focus is on understanding the impact of humans and climate change on reef ecosystems.

Marine fishes

Fishes form the largest group among vertebrates globally. They exhibit enormous diversity in shape and size [the smallest is the female of the Sumatran freshwater fish *Paedocypris progenetica* (7.9 mm long), and the largest fish is the Whale Shark (~ 40 feet) – Fish known from the marine waters of India are said to comprise 2,443 species, with as many as 91 species of endemic species occurring in coastal waters. Among the fish diversity-rich marine waters of India, the Andaman & Nicobar archipelago has the highest number of species.



Blue-girdled Angelfish
Pomacanthus navarchus

angels
OF THE
reef

Marine angelfish belong to family Pomacanthidae and are found in shallow reefs in the tropical Indo-Pacific, Atlantic, and western Pacific Oceans. The family comprises about 86 highly colourful species, of which 16 are reported from Indian waters.

Some species are solitary in nature while others form harems with a single male dominant over several females. All marine angelfish species are known to be protogynous hermaphrodites. This means that if the dominant male of a harem is removed, a female will turn into a functional male. Another interesting fact about marine angelfish is that juvenile marine angelfish look quite different from the adults (e.g. Blue Ring Angelfish *Pomacanthus annularis* and Emperor Angelfish *Pomacanthus imperator* as illustrated).

Ciguatera poisoning, caused by the consumption of certain reef fish contaminated with a toxin produced by dinoflagellates, has been reported from eating marine angelfish.



(Juvenile)

Blue Ring Angelfish
Pomacanthus annularis
(Adult)



(Juvenile)

Emperor Angelfish
Pomacanthus imperator
(Adult)

Underwater butterflies



DEEPAK APTE

Butterflyfish, along with bannerfish and coralfish, comprise the family Chaetodontidae. Butterflyfish are primarily corallivores (feeding on coral polyps), and thus, are especially territorial, forming pairs and staking claim to a specific coral head. Those that feed on zooplankton form large conspecific groups. There are approximately 130 species of these tropical marine fish known globally.

Schooling Bannerfish
Heniochus diphreutes



Redfin Butterflyfish
Chaetodon lunulatus



Speckled Butterflyfish
Chaetodon cf. andamanensis



Yellowhead Butterflyfish
Chaetodon xanthocephalus



Klein's Butterflyfish
Chaetodon kleinii



Triangular Butterflyfish
Chaetodon triangulum



Copperhead Butterflyfish/Beaked Coral Fish
Chelmon rostratus

Lions OF THE reef



above: Dwarf Lionfish
Dendrochirus brachypterus

below: Zebra Dwarf Lionfish
Dendrochirus zebra



Clearfin Lionfish
Pterois radiata



Spotfin Lionfish
Pterois antennata



Red Lionfish
Pterois volitans

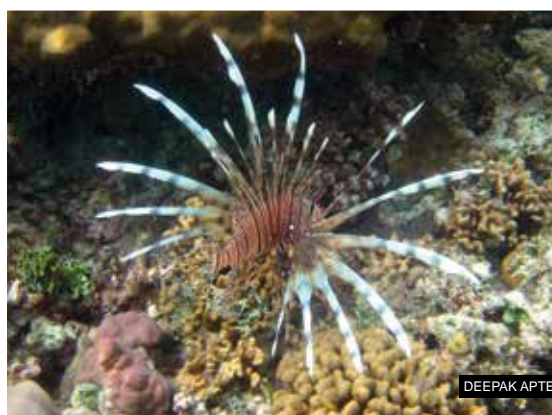
Lionfish are native to the Indo-Pacific and belong to the genus *Pterois*. These are venomous marine fish popularly known by several other names, such as zebrafish, firefish, turkeyfish, and butterfly-cod, but the most commonly used is lionfish.

Lionfish are brilliantly coloured and have elegant pectoral fins with venomous, spiky, frilled fin rays. They usually keep to sheltered ledges of reefs or under large coral boulders. They are territorial and keep patrolling from vantage points in their territories. A few species, including *P. volitans* and *P. miles*, have in recent years invaded the West Atlantic, Caribbean Sea, and Mediterranean Sea.

Some common species found in India are Spotfin Lionfish *Pterois antennata*, Clearfin Lionfish *Pterois radiata*, Red Lionfish *Pterois volitans*, and Zebra Lionfish *Dendrochirus zebra*. The occurrence of Ocellated Lionfish *Dendrochirus biocellatus* in India needs to be confirmed.



Ocellated Lionfish
Dendrochirus biocellatus



Common Lionfish
Pterois miles

sharks



DHRITIMAN MUKHERJEE

The Tiger Shark gets its name from the dark stripes down its body, but these fade as the shark matures

Sharks have adapted to living in a wide range of aquatic habitats at various temperatures. While some species inhabit shallow coastal regions, others live in deep waters, on the ocean floor and in the open ocean. Though they are most common in salt water, there are some species like the Bull Shark that are able to adapt to fresh waters. Sharks mature slowly, and reach reproductive age anywhere from 12 to 15 years. This, combined with the fact that many species only give birth to one or two pups at a time, means that sharks have great difficulty recovering after their populations have declined.

As apex predators, sharks are known to regulate prey populations. The biggest predator of sharks is us humans, and millions are killed each year for meat, leather, and the demand for their teeth and dorsal fins. A paper published in *Marine Policy* revealed that an estimated 100 million sharks are killed by humans every year. In stark contrast, only 12 humans were killed worldwide by sharks in 2011. According to National Geographic, massive depletion of sharks will have cascading effects throughout the world's ocean ecosystems.

Sharks are one of the oldest extant predators, having been around in the oceans over the last 450 million years! That makes them an evolutionary predecessor of the dinosaurs by at least 200 million years. They are among the most advanced predatory creatures, and one of the few creatures to have survived all the five mass extinctions that occurred on our planet.



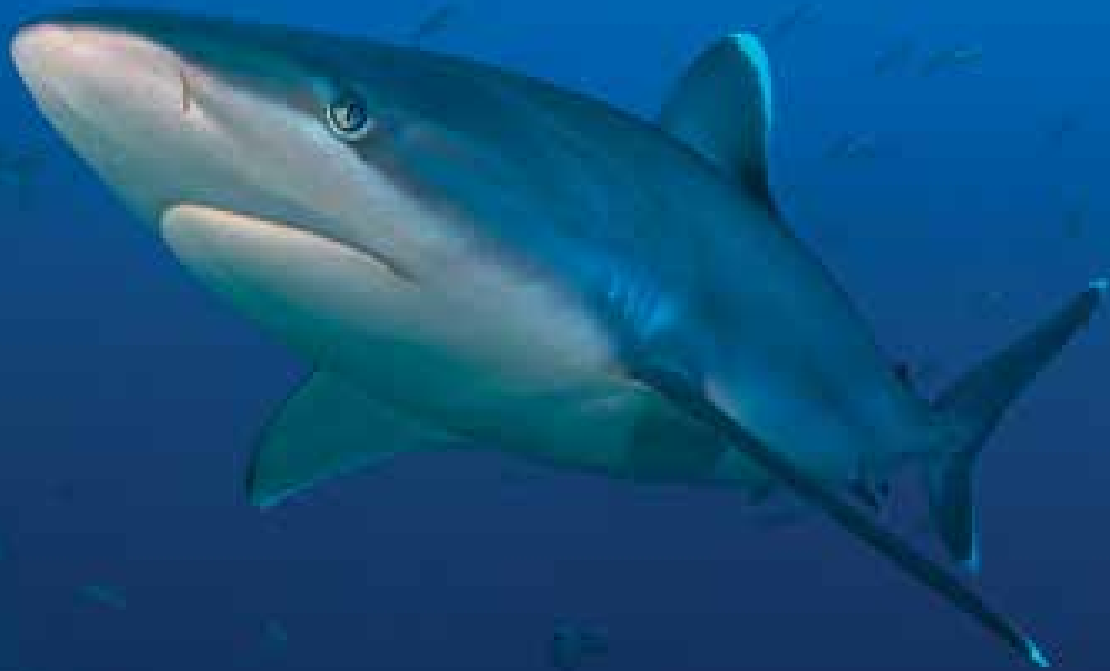
DHRITIMAN MUKHERJEE

Great whites can live as long as 70 years. It is ranked first in attacks on humans; it is this species that was the 'star' in the movie Jaws



DHRITIMAN MUKHERJEE

Oceanic Whitetip Sharks prefer the deeper ocean waters. They hunt in groups, and are not diurnal. Their deep water habitat keeps them from being a threat to humans



Silvertip Sharks get their name from the white outline on all their fins. These sharks are considered to be aggressive and known to follow boats and approach divers and swimmers silently and at close proximity

Seen here is the Scalloped Hammerhead:
As is evident, Hammerhead sharks get their name from the distinctive, hammer-shaped head. They have a 360-degree range of vision, i.e. they can see all around them at all times, whether in front, behind, above or below, which helps during hunting and also helps them get away from predators





DHRITIMAN MUKHERJEE

The White-tipped Reef Shark is a nocturnal, bottom dwelling shark. It is not aggressive and will generally swim away if disturbed. At night it hunts among crevices in the reef



DHRITIMAN MUKHERJEE

Nurse sharks are nocturnal, inshore bottom-dwelling species that feed primarily on small fish and invertebrates



TRACKING THE

gentle giants

by B.C. Choudhury & Sajan John

Whale Shark – the gentle giant – is it a whale or a shark? With no mammary glands and no placenta, the Whale Shark is not a mammal – it is the largest fish (and shark) on earth. It can weigh as much as 21 metric tonnes and grow to a length around 14 m (that's a little longer than a Volvo bus). Although Whale Shark is distributed widely across the tropical and warm temperate seas, we have limited information on its population status and trends, especially along the Indian coastline. The International Union for Conservation of Nature (IUCN) has listed the Whale Shark as Endangered.

Whale Sharks are solitary animals – they do not move around in groups. Though they are seen aggregating in the waters off the Gujarat coast every year; no one really knows



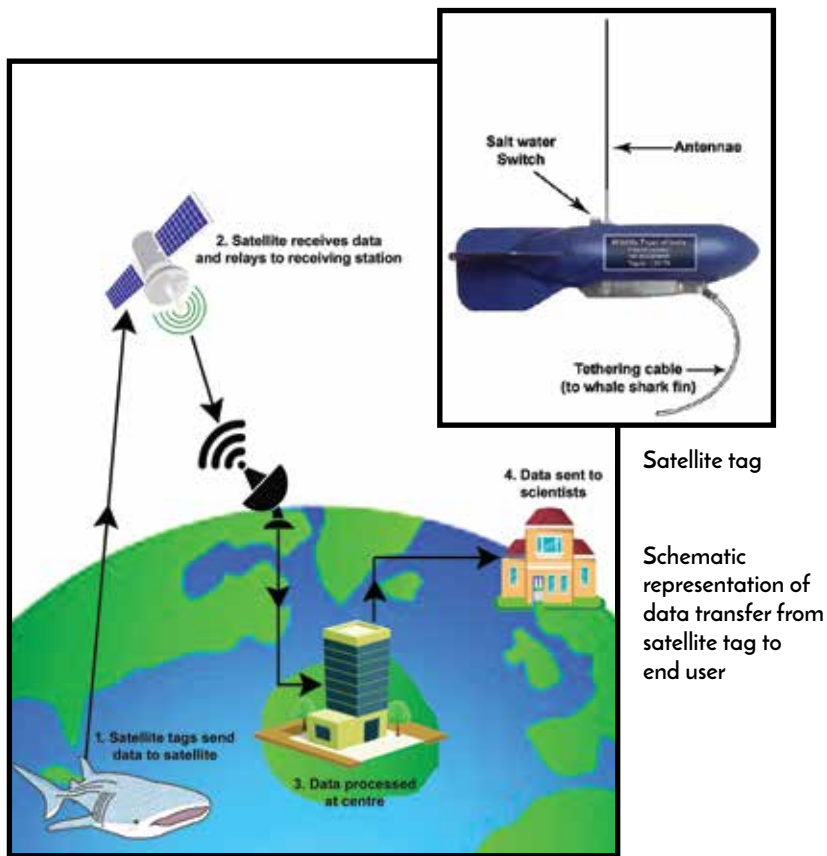
The largest fish on our planet, the Whale Shark can weigh up to 21 metric tonnes; it migrates thousands of miles to different feeding grounds

why they migrate to this area. From September to March, they are present along the Saurashtra coast and due to lack of legal protection, they were, until 2001, hunted and brutally slaughtered on an extensive scale.

FROM "SHORES OF SILENCE" TO "SHORES OF SAVIOURS"

The little known plight of Whale Sharks along the Gujarat coast was brought into the limelight by renowned filmmaker Mike Pandey in 2000. His movie "Shores of Silence" gave a vivid insight into the grim reality faced by this species in Gujarat. As a result of this perceptive film and intensive lobbying by the Wildlife Trust of India (WTI), the Ministry of Environment and Forests (MoEF, now MoEFCC) listed the Whale Shark under Schedule I of the Indian Wildlife (Protection) Act, 1972, in 2001. It was the first fish in India to get protected status.

Yet, legal protection on paper was not enough to save the species. For greater public involvement, WTI launched a campaign to save the Whale Shark, with the support of Tata Chemicals Limited (TCL) and International Fund for Animal Welfare (IFAW) in 2004. As a result of the campaign, the targeted killing of Whale Sharks was almost eliminated on the Saurashtra coast. Fishermen who once killed them became their proud protectors. They also started to rescue and release any Whale Shark that got accidentally entangled in their nets, even to the point of cutting



the net to do so. From 2005 till April 2018, a total of 697 Whale Sharks were voluntarily released by fishermen along the Gujarat coast, setting an example not only for India, but for the whole world. Today, Gujarat has become a safe haven for Whale Sharks.

CONSERVATION SCIENCE

Other than the campaign to save the Whale Shark, WTI turned to investigate the mystery of its migration. The questions were: Where are they coming from? Where do they go? Why do they aggregate around the Saurashtra coast? Are there more such Whale Shark aggregating sites along the Indian coast? The major objective was to track its migratory route. For this, WTI initiated the first-ever satellite tracking study on Whale Sharks in the Indian subcontinent, using satellite tags.

The WTI-TCL-GFD Whale Shark project team tagged eight animals between 2011 and 2018





Whale Shark conservation project biologist tagging the fish

SATELLITE TAGS

Satellite tags are invasive scientific instruments attached to many species of animals (birds, reptiles, mammals, fishes etc) by biologists to collect information about the location of the animals, their habitat preferences, to learn about the migratory patterns and behaviour of endangered animals on a day to day basis. The satellite tags used on aquatic animals are a little different from the transmitters used on terrestrial animals.

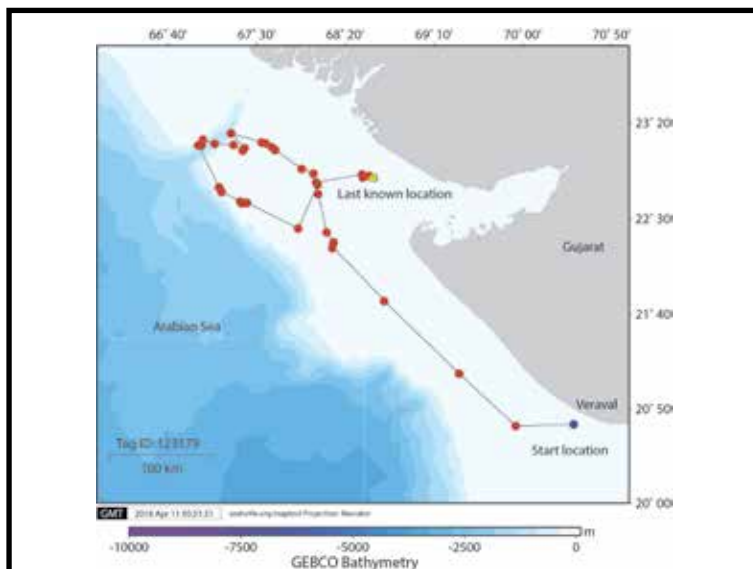
WHAT COMPRISES AN AQUATIC SATELLITE TAG?

An aquatic satellite tag has an antenna, which is responsible for sending a signal each time the animal surfaces. Information relayed includes time, date, latitude, longitude, and quality of the transmission. There is a switch named “salt water switch” which turns on the transmitter when the Whale Shark surfaces, and sends a signal to the satellite. The tag also has the details and contact information of the organization that has deployed it. In case a tag gets detached from the animal or the animal gets caught in fishing gear, the person who retrieves it can contact the organization that has tagged the animal.

Satellite tags come in many sizes. However, all such tags used in marine animals are small (compared to the body size of the animal which is tagged) and smooth to reduce drag. These small satellite tags are packed with sensors that send signals to satellites orbiting 1,000 km above the earth’s surface. The signal is relayed by the satellite to a data processing centre back on earth, from where it can be transferred electronically to the recipient (end-user). The WTI-TCL-GFD Whale Shark project uses satellite tags that send signals to satellites maintained by the ARGOS System in France.

HOW AND WHERE THE TAG IS APPLIED?

The tag is applied using a hand-held applicator. It is attached close to the first dorsal fin of the Whale Shark, by partially implanting a barb into the skin layer at a slight angle, to a depth of about



Top: Whale Shark tagged on May 09, 2015 moved into Pakistan waters and returned to India. Total tracking days were 17

Centre: Whale Shark tagged on December 30, 2016 moved close to Somalian waters and started its return migration. Total tracking days were 306

Bottom: Whale Shark tagged on March 30, 2018 was near Oman waters when contact was lost. Total tracking days were 138

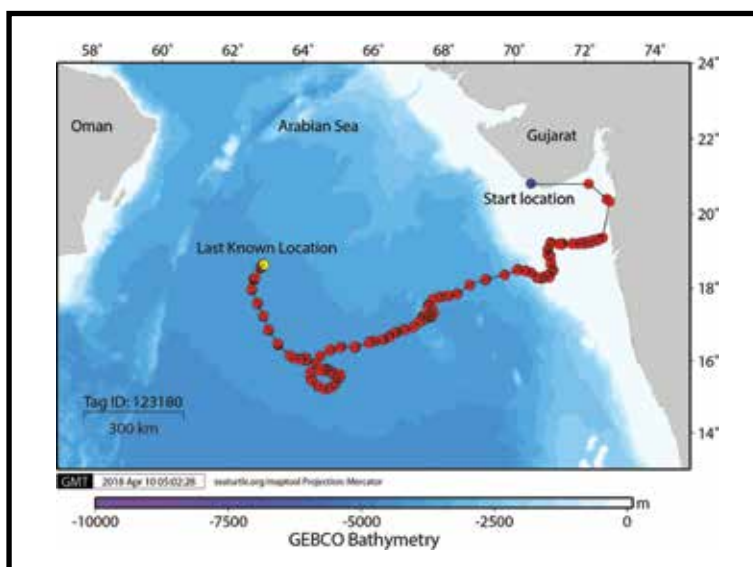
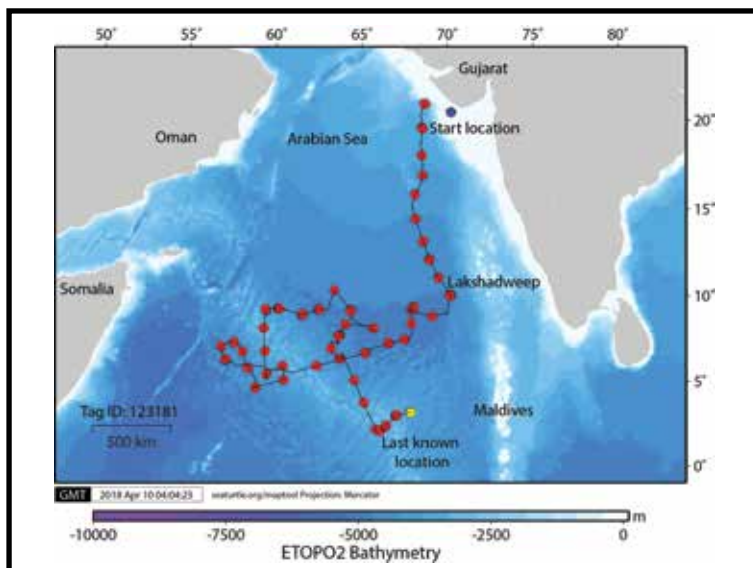
10 cm. Tag designers are also working on developing better hydrodynamic shapes, and on increasing the durability of tags and antennae.

WHAT INFORMATION DID THE TAGGED WHALE SHARKS GIVE ?

The WTI-TCL-GFD Whale Shark Conservation Project is the only whale shark satellite tagging project in India and the project team has tagged eight Whale Sharks between 2011 and 2018. A female Whale Shark tagged near Sutrapada fishing village on December 30, 2016, became the longest tracked Whale Shark (306 days) from the Indian subcontinent. The Whale Shark travelled a distance of 7,500 km and was heading towards the Somalian coast before it turned and started its return migration. Unfortunately, the transmitter stopped responding when the Whale Shark reached Maldivian waters. The eighth tagged Whale Shark travelled a distance of 2,500 km in 138 days. This is the second longest Whale Shark tracking record from the Indian subcontinent. The animal was close to Oman waters when contact was lost. The information provided by the satellite tags is vital to chalk out conservation management strategies for these mega fauna, especially those using a large marine spatial area under different geopolitical jurisdictions.

A HAPPY ENDING?

The Whale Shark Conservation Project is the most successful conservation action project undertaken by WTI. This





Satellite tags are applied using a hand-held applicator; the tag is attached close to the first dorsal fin of the Whale Shark

participatory project has won several laurels, including the BNHS Green Governance Award for Tata Chemicals Ltd in 2005, and the UNDP-MoEF Indian Biodiversity Award for the Junagad Forest Division in 2014. The project also won international acclaim at the 4th International Whale Shark Conservation Conference at Doha, Qatar, in May 2016, where experts noted that the approach deployed by WTI and TCL serves as a role model for other developing nations where traditional values are strong.

The Gujarat waters might be safe for the Whale Shark, but the larger picture is not rosy. Other coastal states of India are not as affable towards this species as Gujarat. Unfortunately, Whale Sharks that accidentally get entangled in fishing nets are still being landed and killed. As in all conservation efforts, greater stakeholder participation is the key to the sustained success of Whale Shark conservation along the Indian coast.



B.C. CHOUDHURY

Prof. Choudhury is an Executive Trustee and the Principal Investigator of Aquatic Projects at WTI, the Regional (Asia) Co-chair of the IUCN-SSC Marine Turtle Specialist Group (MTSG) and Crocodile Specialist Group (CSG).



SAJAN JOHN

A marine biologist, Sajan John works at the Wildlife Trust of India. He heads the Marine Conservation Projects of WTI, which include the Whale Shark and Mangrove Conservation Projects and Coral Reef Recovery Project.

Marine reptiles

Three groups of marine reptiles are known from Indian waters, these comprising the Saltwater Crocodile *Crocodylus porosus* (also known as the Estuarine or Indo-Pacific crocodile), turtles (Green, Olive Ridley, Hawksbill, Leatherback, and the rarely seen Loggerhead), and more than 20 sea snakes species.

In Indian waters, the Saltwater Crocodile is distributed from Vembanad lake in Kerala on the west coast through the estuaries on the east coast (Tamil Nadu, Odisha) to the Sunderbans in West Bengal; and also in the Andaman & Nicobar Islands. Among the sea turtles, the most common is the omnivorous Olive Ridley, which is known to feed on crustaceans, jellyfish, and fish; the largest living reptile and the largest sea turtle – the Leatherback and the Green that has a rounded head, and Hawksbill that has a prominent hawk-like “bill”. Sea snakes are adapted to a fully aquatic life and are unable to move on land, except for the genus *Laticauda*, which has limited land movement. Unlike fish, sea snakes do not have gills and must surface regularly to breathe.



The Green Turtle is the only herbivore among the sea turtles. It gets its name from the greenish colour of their cartilage and fat, not its shell



DIGANT DESAI

Hawksbill is a critically endangered sea turtle. It gets its name from the beak-like bill, and feeds mainly on sponges. Many cultures use the shell for decoration



ADHITH SWAMINATHAN

Olive Ridley is the commonest turtle along the Indian coast. Up to a million turtles have been recorded to nest in Gahirmatha beach in Odisha



ADHITH SWAMINATHAN

Leatherback is the largest of all living turtles, and subsists almost entirely on jellyfish. A serious new threat for the species is from plastic bags, which the turtles mistake for jellyfish and eat



Sea kraits are amphibious and lay their eggs on land, unlike the true sea snakes that give 'birth' to young from eggs that hatch within the body of the parent

DHRITIMAN MUKHERJEE

Short Sea Snake is susceptible to fishing-related stress and suffers high mortality, as recorded in Malvan coast, Maharashtra



CHETAN RAO

Persian Sea Snake is native to the Indian Ocean, it ranges from the Persian Gulf to the coast of Thailand



YOGESH PATEL

File Snake or Little Wart Snake is a species of non-venomous marine snake which brings its prey down by constriction, similar to boas and pythons. It is found in all major estuaries/brackish water habitats in South and Southeast Asia. The specimen was photographed in Malvan



SHAWN D'SOUZA

Saltwater Crocodile, or Estuarine Crocodile, is the largest of all living reptiles, and has the widest distribution of all crocodiles, ranging from the eastern coast of India throughout most of Southeast Asia and northern Australia



ASIF N. KHAN

Tracking A HUNDRED-MILLION-YEAR-OLD giant

by Adhith Swaminathan

Even on a dark moonless night, it is impossible to miss this giant living relic emerging on the white sandy shores of Little Andaman Island. Leatherback sea turtles *Dermochelys coriacea* sometimes grow over six feet in length, which is larger than an average human body. They are the largest of all sea turtle species, weighing up to a tonne, maintaining this massive physique solely on a diet of jellyfish. They are named from their leathery, flexible back, which is unlike the hard shell of other turtles. Perhaps



In India, the nesting of leatherback turtles is currently restricted to the Andaman & Nicobar Islands where 1,000 nests are found annually

unsurprisingly, Leatherbacks are found in every ocean except the Arctic and Antarctic, ranging longer than any other reptile. Sri Lanka and India are currently the only sites in South Asia that are known to host large nesting populations.

Leatherbacks were known to nest sporadically on the Indian mainland up to the late 1960s. However, current nesting populations are restricted to the Andaman & Nicobar Islands. Leatherback nesting was first reported from this archipelago of 500-odd islands in 1979, and research over the last three decades has confirmed the importance of the Islands as Leatherback rookeries. Known for their untouched and picturesque beaches, the Andaman

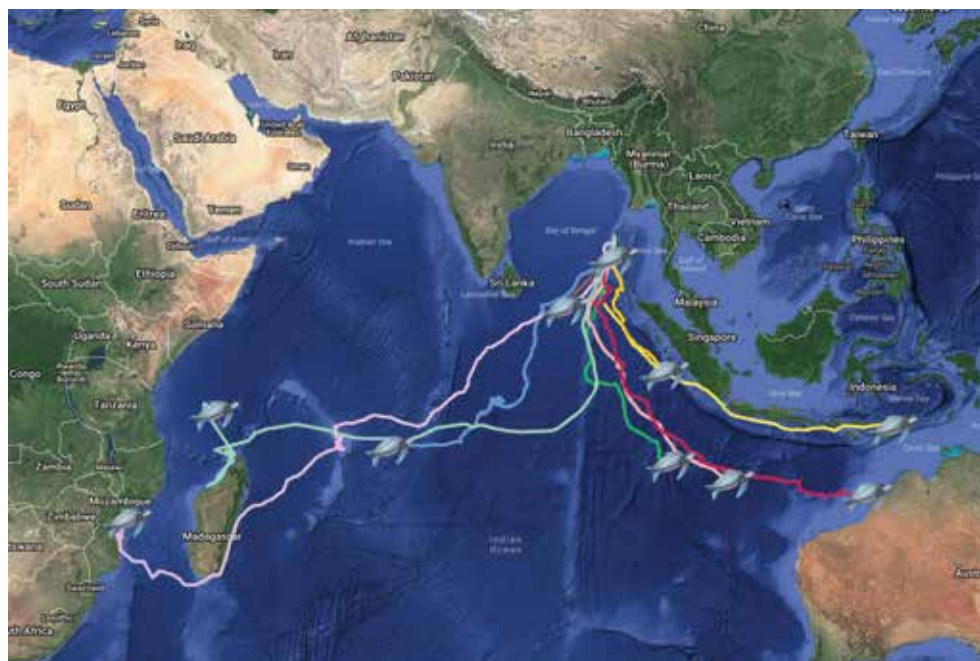


ADHITH SWAMINATHAN

& Nicobar Islands underwent drastic changes in 2004 when an earthquake and the resulting tsunami swept across the ocean; these islands, lying close to the epicenter, bore the brunt of the tidal onslaught. Most of the coastal plates of the Nicobar group got submerged, while some of those in the Andaman group were uplifted.

In the wake of such large scale alteration of the shore topography of the archipelago, a collaborative monitoring programme was initiated in 2008 on Little Andaman Island by Dakshin Foundation, Madras Crocodile Bank Trust, Andaman Nicobar Environment Team (ANET), Centre for Ecological Science, Indian Institute of Science, Bangalore, and the Department of Environment and Forests, Andaman & Nicobar Islands. Since the initiation of the programme, two nesting sites, South Bay and West Bay of Little Andaman Island, have been monitored annually and serve as representative sites for Leatherback nesting in the region.

One of the turtles tagged with a satellite tracker in 2014 covered over 13,000 km from West Bay, Little Andaman, to the coast of Mozambique in 266 days. The turtle traversed close to about 50 km a day



Post nesting migratory route of Leatherback Turtles fitted with satellite trackers in West Bay, Little Andaman



ADHITH SWAMINATHAN

The eggs take about two months to hatch. The hatchlings are only 5–8 cm long

Every nesting season, between December and March, a team of six field staff sets up temporary camps at the two nesting sites. During these months, the team is cut off from the outside world, without access to mobile network or electricity. Coming across people is a rare event at these sites which are inaccessible to most people as they fall within the Onge Tribal Reserve.

Our monitoring efforts have focused on West Bay beach and the main task during the nesting season is to patrol the 7 km beach daily, looking for tracks and evidence of nesting. In the last decade, more than 100 nesting females have been tagged with Passive Integrated Transponders (PIT) and external metal flipper tags to help identify individual turtles. When turtles are encountered, biometric measurements and



ADHITH SWAMINATHAN

Leatherback Turtles can nest 4 to 7 times in a nesting season; at West Bay, an average of 30–35 females nest annually

information on time of nesting, egg-laying duration, tidal activity, and clutch size are collected. The recapture of tagged individuals over the years indicates a minimum nesting interval of one year. These turtles are known to migrate over 10,000 km between their foraging and nesting grounds. They seem to make it back, remarkably, to the same stretch of the beach. All the recaptured turtles in the last decade were initially tagged at the same beach.



The primary threat faced by leatherback turtles in the region is fishery-associated mortality. Though they are not usually hunted for their meat, other threats include predation of nests and hatchlings by dogs, water monitor lizard, and feral pigs

To understand long distance migration of leatherbacks, 10 females were tagged with satellite transmitters at West Bay between 2010 and 2014. The turtles travelled in two directions across the Indian Ocean, southeast towards the western coast of Australia and southwest towards the eastern coast of Africa. While we have identified two main migratory routes, more satellite telemetry studies need to be carried out to assess if there are other migratory routes taken by the turtles and to identify areas where they are most susceptible to fishing-related mortality in the high seas.

Globally, in recent years, many leatherback populations have been stable or are increasing, leading to downlisting of the species from Critically Endangered to Vulnerable by the International Union for Conservation of Nature (IUCN). The data from South and West Bay reveals a steady increase of leatherback nesting in comparison to the period following the December 2004 tsunami. Although the number of nests recorded dips in certain years, these fluctuations can be attributed to variations in reproductive cycles, food supply, and environmental conditions. Our recent survey of the Nicobar Islands in 2016 also confirmed the recovery of previously known nesting beaches and nesting numbers, which are comparable to the surveys conducted before the 2004 tsunami. With more than 1,000 nests located per season across the region, the Andaman & Nicobar Islands are a stronghold for leatherback populations of the South Asian region. Though we have successfully monitored the nesting population in Little Andaman for more than a decade, we still need to fully understand an animal whose lifespan exceeds ours.



ADHITH SWAMINATHAN

A researcher at Dakshin Foundation since 2008, Adhith has worked on marine turtles since the age of 10. He has been working on the Leatherback Sea Turtle monitoring project based in Little Andaman for the last eight years.



DIGANT DESAI

Yellow-lipped Sea Krait *Laticauda colubrina*: sea kraits move easily on land where they find mates or a resting place; they swim underwater hunting for food with the help of their oar shaped tails

Serpents OF THE sea

by Chetan Rao

Snakes have always evoked a sense of mystery in humans. Many cultures, including ours, revere them as signs of vitality and symbols of productivity. A lot has been written about terrestrial snakes, but not much is written or said about their brethren that have made water their home, and especially those of the sea.

Sea snakes are marine reptiles, and largely found in the seas between Australia and east of Africa – there are no sea snakes in the Atlantic Ocean or the Caribbean Sea. The maximum sea snake diversity exists in the Indian Ocean, with one species, the Yellow-bellied Sea Snake *Hydrophis platurus* moving over to the Pacific, making it one of the most widely distributed snakes in the world.

Sea snakes belong to the family Elapidae, that also includes cobras, mambas, and coral

snakes. Sea snakes have evolved from the Australian elapids, such as tiger snakes and taipans. Not all sea snakes spend their entire life in the ocean. Sea snakes include the fully aquatic snakes or 'true' sea snakes, and the amphibious sea kraits, which can live on land or in water. They are adapted to a life in water, and their laterally compressed body is an adaptation for swimming; they are clumsy or slow when cast ashore.

Unlike sea kraits, which are oviparous (species that produce young from eggs laid on land; this limits their range because they need to stay near land to reproduce), 'true' sea snakes are ovoviviparous (species that produce young from eggs which are hatched within the body of the parent) and hence have become independent of the need for land to lay eggs. Ecologically, sea snakes are mid-trophic level (middle of the food chain) predators. They primarily hunt fish and marine invertebrates, and in turn, they are prey to larger marine predators.

SEA SNAKES OF INDIAN WATERS

Two species of sea kraits are found in the Andaman & Nicobar Islands, and 22 species of hydrophiine snakes have been recorded from shallow waters near shores, estuarine habitats and coral reefs of the Indian coast. Despite their ubiquitous presence, sea snakes have hardly been a subject of systematic studies. Studies in India date back to the colonial era, followed by sporadic studies post-Independence through surveys by the Zoological Survey of India. In 1926, Malcolm Smith, a British herpetologist, had prepared a monograph on sea



Short Sea Snake *Hydrophis curtus*
(inset): Juvenile



CHETAN RAO

Hook-nosed Sea Snake *Hydrophis schistosus* is a widespread species found in the Indian Ocean from the Persian Gulf to Australia

(inset): The Hook-nosed is frequently caught in all types of fishing gear



CHETAN RAO

snakes from the Subcontinent, with taxonomic descriptions. More recently, Aaron Lobo conducted a detailed study of sea snakes in Goa and the Gulf of Mannar, Tamil Nadu. He found the diversity of sea snakes to be higher on the east coast, but with low abundance, while sea snakes were fairly abundant on the west coast, but low in diversity.

SEA SNAKE EVOLUTION

Studies from Australia and Southeast Asia have revealed fascinating insights into their ability to colonize and diversify within the marine realm on multiple instances. Sea snake evolution dates back six to eight million years ago around Australia, making them a relatively young lineage compared to terrestrial snakes. The centre of speciation of sea snakes is in Southeast Asia that occurred around two to three million years ago. The volatile sea level changes that occurred during the last glacial climatic event triggered multiple speciation events amongst sea snakes, leading to high diversity in Southeast Asia. With over 70 species, sea snakes are the most diverse of all marine reptiles, preceding sea turtles and marine iguanas.

Sea snakes are air breathing organisms, and cannot stay underwater for prolonged periods of time; they often drown after getting entangled in fishing

nets when they surface to breathe. They are frequently encountered in fishing nets as a bycatch (catch with no value) throughout their distribution range in India. Fishermen physically remove the trapped snakes from the nets, resulting in undesired contact with the animal. Though this can pose a major hazard, as sea snakes are highly venomous and no anti-venom for them is currently available in India, sea snakes hardly tend to bite.

Considering the paucity of information on sea snakes in India, Dakshin Foundation, a non-governmental organization from Bengaluru, collaborated with the Maharashtra Forest Department to investigate the effects of



SIDDHARTH WARADKAR

Yellow-bellied Sea Snake *Hydrophis platurus* is one of the most widely distributed snakes globally

different fishing practices on sea snake assemblages at Malvan in Sindhudurg district. We began a monitoring exercise to record accidental catch of snakes from mechanized gill net boats and fishing trawlers, under the GoI-GEF-UNDP Sindhudurg Project. Our study revealed that two species of sea snakes were frequently caught in all types of fishing gear: Hook-nosed or Beaked Sea Snake *Hydrophis schistosus* and Short Sea Snake *Hydrophis curtus*. The former species was more resilient with fewer individuals found dead on capture. The Short Sea Snake is less tolerant to fishing-related stress and suffered higher mortality. Trawler nets seem to cause the most deaths and are also a grave threat to marine fauna globally.

Sea snakes are harvested for food in Southeast Asia, where they are caught in large numbers. In Australia, the Short Sea Snake and Elegant Sea Snake *Hydrophis elegans* are harvested for the leather industry. In one study from New Caledonia in the southwest Pacific Ocean, a population of sea snakes underwent industrial melanism – an entire population of snakes turned black due to heavy metal pollution, highlighting the risk of bio-magnification, as larger predators fed on these snakes, which can be detrimental to ecosystems in the long run.

Sea snakes, among other marine fauna, mirror the vitality and productivity of our oceans and help us to understand the state of our blue planet.



CHETAN RAO

A Senior Research Assistant with Dakshin Foundation, Bengaluru, Chetan's research interests lie in understanding the ecology and evolution of reptiles, particularly snakes.



UDAYAKUMAR BALASUBRAMANIAM

Flesh-footed Shearwater in flight

IN QUEST OF THE *ocean wanderers*

by Subramanian Sankar

Pelagic birds are those that spend a significant portion of their life in open oceans, returning to land only to rest on rare occasions or to breed. Pelagic birds stay aloft for hours, days or weeks while gliding or soaring, and may be found hundreds or thousands of kilometres offshore. Some even sleep on the wing! Many pelagic birds have salt-secreting nasal glands that help excrete the excess salt from their bodies. This allows them to drink seawater and ingest water from their oceanic prey without accumulating toxic levels of salt in their bloodstream.



SHIVA SHANKAR

Parasitic Jaeger



RAMA NEELAMEGAM

Common Tern

The true or typical pelagic birds are those belonging to the families Diomedidae (albatrosses), Procellariidae (fulmars, petrels, and shearwaters), Fregatidae (frigatebirds), Hydrobatidae (storm-petrels), and Phaethontidae (tropicbirds). They feed primarily on fish, squids, and shrimps. Other seabirds that are highly dependent on the sea, but are not pelagic birds in the true sense, are the boobies, sea terns, gulls, sea-ducks, and skuas, among others.

Till recently, what little was known about pelagic birds from the Indian subcontinent came from storm-driven birds blown ashore, and observations from ships. This despite the Indian subcontinent being bounded by the Arabian and Laccadive seas to the west, Gulf of Mannar, Palk Strait, and Palk Bay to the south, Bay of Bengal to the east, and the Andaman Sea around the Andaman & Nicobar Islands.

In recent times, notably in Kerala since 2010, journeys into the sea were undertaken in quest of pelagic birds. The sightings from these trips excited birdwatchers so much that requests for conducting similar voyages into the sea in Tamil Nadu took strength, and in the period between September 2012 and September 2017, 15 trips were undertaken from Tamil Nadu, most of them from the Chennai coast. Permission for conducting



RAMA NEELAMEGAM

Bridled Tern



RAMA NEELAMEGAM

Wilson's Storm-Petrel



MURUGAN MOHAN

Sooty Tern

these periodical pelagic bird surveys was obtained from the concerned authorities, notably bodies responsible for coastal security. As in the case of Tamil Nadu, surveys of pelagic birds have also been initiated from the Karnataka coast.

The logistical challenges in undertaking such trips were many. The trips were self-funded and the cost-effective fishing trawler was the boat of choice. This meant that journeys into the sea were not pleasure trips for the weak-hearted. Each visit into the sea is a new experience. Nevertheless, those 15 trips off the Tamil Nadu shore elicited considerable data on pelagic birds (and other sea frequenting species) and marine mammals. These were pilot surveys and did not strictly follow a pelagic protocol for estimating numbers. Photographs were used to record and identify species, as some were overlooked in the field. Our field identification skills for pelagic birds are improving, with increasing trips into the sea. Pictures of our field expeditions and images of some of the species sighted are provided here.

Around 38 species of birds have been recorded from pelagic trips in India in recent years belonging to families Sulidae (Boobies), Procellariidae (Petrels and Shearwaters), Hydrobatidae (Storm-Petrels), Fregatidae (Frigatebirds), Phaethontidae (Tropicbirds), Stercorariidae (Skuas and Jaegers), Laridae (Terns and Gulls), and Scolopacidae (Phalaropes).



Caspian Tern

RAMA NEELAMEGAM



Streaked Shearwater



South Polar Skua



Greater Crested Tern

The most common birds in the region were the terns, often found trailing behind the fishing trawlers. Some notable sightings were: 522 Flesh-footed Shearwaters *Puffinus carneipes* on June 26, 2016 in the Bay of Bengal off Chennai coast; Lesser Noddy *Anous tenuirostris* and Sooty Tern *Onychoprion fuscatus* in the Indian Ocean off the coast of Kanyakumari on September 7, 2013; South Polar Skua *Stercorarius maccormicki* on September 18, 2016; Brown Skua *Stercorarius antarcticus* on June 26, 2016; Roseate Tern *Sterna dougallii* on July 8, 2017, off the Chennai coast; and a solitary Red-necked Phalarope *Phalaropus lobatus* in the high seas off the Chennai coast on September 13, 2014.

Among the truly pelagic birds sighted, Flesh-footed Shearwater were the most abundant. They return to their breeding grounds near Australia and New Zealand between October and May every year after spending their winter near the tropics.

Seasnakes, flying fish, cuttlefish, jellyfish, and sea-turtles were regularly sighted during the trips. On August 06, 2016, a super-pod (more than 1,000) of Pantropical Spotted Dolphin *Stenella attenuata* was sighted 22 km off the Chennai coast.



SUBRAMANIAN SANKAR



A birdwatcher from Chennai, Subramanian is interested in the natural history of India, environmental consciousness, bio-acoustics and creating soundscapes.



Marine mammals

IN THE INDIAN SEAS

by Kumaran Sathasivam

The Sperm Whale is the largest of the toothed whales and is usually seen in small parties, which occasionally join up to form large schools

INTRODUCTION

Marine mammals are an interesting group of mammals that rely on the ocean or other marine ecosystems entirely for their existence. They are classified into four groups: cetaceans, (whales, dolphins, and porpoises), pinnipeds (seals, sea lions, and walruses), sirenians (manatees and the sole surviving species of dugong), and marine fissipeds (polar bears and sea otters).

Till recently, relatively few records were available of marine mammals from India. Most of these records were of dead animals cast ashore or of live ones that were caught accidentally in fishing nets. This was not just because it is very challenging to locate and observe living marine mammals in their environment, the sea. The problem was that there was practically no one going out to sea looking for marine mammals.

Over the last decade or so, things have changed. Researchers and enthusiasts have been conducting surveys in different parts

of the Indian coast (For a list of these researchers, visit <http://marinemammals.in/index.php/about-us>). They are reporting more animals that have washed ashore, but more importantly, they are also reporting sightings of live animals. It also happens that they are making very interesting discoveries.

MARINE MAMMALS OF INDIAN WATERS

The marine mammals found in Indian waters are members of the orders Cetacea and Sirenia.

The cetaceans are the more diverse among these two groups. There are some 30 species in the Indian seas, with the world total being around 70. Cetaceans are in turn divided into two groups, the Odontoceti (toothed whales) and the Mysticeti (baleen whales).

Twenty-five of the 60 species of toothed whales in the world occur in Indian seas. They range in size from the Finless Porpoise, which attains a length of around 1.8 m and weight of around 40 kg, to the Sperm Whale, the male of which may be 20 m long and weigh around 45,000 kg. Representatives of four families of toothed whale are found in India: Delphinidae (marine dolphins),

The Beluga Whale is a cetacean that is found in Arctic waters. The term 'whale' is generally used for larger cetaceans. But some marine mammals referred to as whales, such as the Dwarf Sperm Whale, may be smaller than the larger dolphins



DHRITIMAN MUKHERJEE



MAHI MANKESHWAR

The False Killer Whale is a large dolphin that prefers to live in warm temperate or tropical waters. It looks like the Orca (Killer Whale) and also attacks and kills other marine mammals



Spinner Dolphins hunt in organized groups. They communicate via clicks and whistles. Their vocalizations are used for echolocation and possibly for coordination

Phocoenidae (porpoises), Physeteridae (sperm whales), and Ziphiidae (beaked whales). As for baleen whales, there are confirmed records of four species out of the world total of 10 species. Baleen whales are all very large, ranging in length from 10 m to 30 m. All the baleen whales of India belong to one family, the Balaenopteridae, commonly known as rorquals.

The second marine mammal group that occurs in Indian waters, the Sirenia, is represented by just one species, the Dugong. Sirenians are entirely herbivorous, feeding on sea grasses and algae. The closest relatives of the Dugong (other than manatees) among the extant animals are probably elephants.

Researchers have recently confirmed the occurrence of some little-known marine mammals from Indian waters. One is Omura's Whale, which was described to science 15 years back. Another is Longman's Beaked Whale, which was for long known only from a couple of skulls and was considered the world's rarest whale. A third species is Fraser's Dolphin, a stocky dolphin that is known to swim in large groups and feed at depths where there is no light.



DHIRTIMAN MUKHERJEE

Male Humpbacks produce complex sounds known as songs for up to 15 minutes at a time. The songs are audible up to 20 miles away. The whales are known to repeat the same song over and over again for hours. Like other cetaceans, Humpback Whale mothers and their young swim close together, often touching one another with their flippers with what appear to be gestures of affection



DHIRTIMAN MUKHERJEE

Blue whales are the largest animals (c. 30 m) ever known to have lived on Earth. The waters around India and Sri Lanka are important to Blue Whales. Taxonomic research needs to be carried out on the Blue Whales of this region



SAGAR RAJPUKAR

Fraser's Dolphins are highly sociable mammals that swim around in tightly-bonded schools of 100 to 1,000 individuals



RAMA NEELAMEGAM

Pantropical Spotted Dolphin is a small dolphin found in most of the world's tropical oceans. Differences in form have been identified between Spotted Dolphins that live near the coast and those from offshore populations

Accidental trapping in fishing nets is one of the major threats faced by marine mammals



THREATS

Fortunately, all the marine mammals of India are protected by law. And historically, there has not been a tradition of hunting marine mammals in India, except for the Dugong.

The Dugong is now found in three widely separated areas along the Indian coast – in the Gulf of Kachchh, the Palk Bay-Gulf of Mannar and the Andaman & Nicobar Islands. All these populations are believed to be precariously small. It is known that the Dugong had a wider Indian distribution and that its numbers along the Tamil Nadu coast in particular were much greater in the past. This drastic decline may be attributed to the demand that existed for its meat. Hunting of the Dugong to meet this demand persisted illegally over the years. Dugong sightings from the Gulf of Mannar are very rare today. There is evidence that this rare marine mammal is holding on in what was once its stronghold, but depressingly enough, records are usually in the form of dead animals found washed ashore.

Other marine mammals too face threats. The best known of these threats is euphemistically referred to as 'incidental bycatches', wherein these animals, notably dolphins, get accidentally trapped in fishing nets. Hundreds of thousands of nets, each 2 km long on an average, are deployed along the Indian coast. Statistics collected on incidental bycatches suggest that each year tens of thousands of animals die after getting entangled accidentally in fishing nets.

Data relating to other threats are not available. These threats include pollution of different kinds – chemical pollution, plastic waste pollution, and noise pollution. The effects of pollution on marine mammals in India have not been studied. Whales, dolphins, and porpoises all produce a variety of sounds. They use sound for communication and, in the case of toothed whales, for prey location and capture. Since sound is so important for these marine mammals, they have a highly developed sense of hearing. Therefore, they probably suffer great disturbance on account of manmade noises in the marine environment. The noises include those produced by shipping traffic and seismic prospecting for oil and natural gas.

One hopes that these threats will be eliminated through the development and use of new technologies, and by marine mammal researchers and conservationists working together with engineers and policy makers.



KUMARAN SATHASIVAM

A naturalist and writer, Kumaran is involved in coordinating the Marine Mammal Conservation Network of India (www.marinemammals.in)

Conservation OF *Dugongs* IN INDIA

by K. Sivakumar



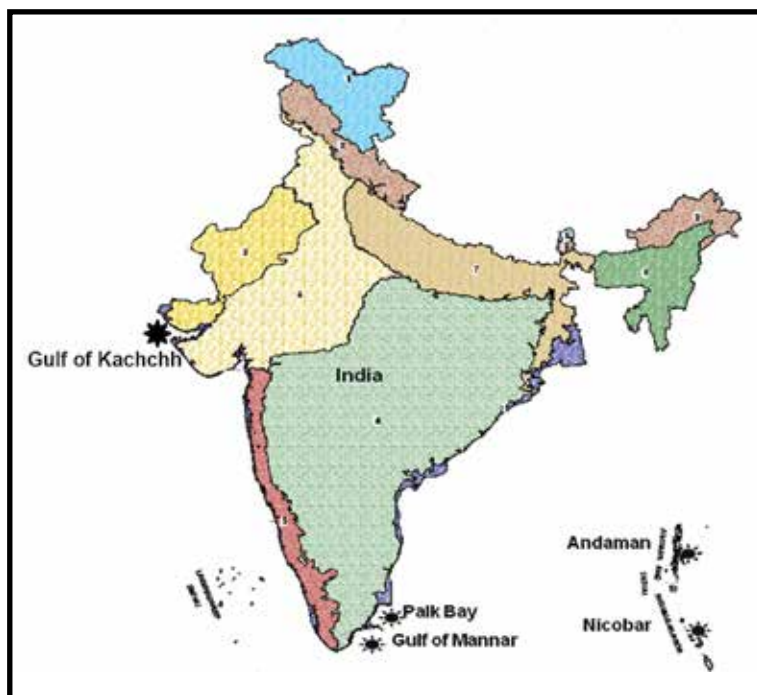
Dugong is a large mammal that can reach a length of about 3 m and weigh up to 900 kg

Dugong *Dugong dugon*, also called Sea Cow, is one of the four surviving species in the Order Sirenia and the only existing species of herbivorous mammals that live exclusively in the sea. Dugongs are usually found in calm, sheltered, and nutrient-rich waters, generally in bays, shallow islands, and reef areas that are protected against strong wind and heavy seas with extensive seagrass beds. Such habitats are still available in the Gulf of Mannar, Palk Bay, Gulf of Kachchh, and the Andaman & Nicobar Islands in India. However, dugongs are not confined to inshore waters but have also been recorded near reefs up to 80 km offshore in waters up to 37 m deep.

Dugongs are classified on the global Red List of IUCN as 'Vulnerable to extinction' (IUCN, 2006) and are included (like all Sirenia) in Appendix I of the Convention on International Trade in Endangered Species of Wild Fauna and



Dugong has a flat tail and flippers like a whale, but it is more closely related to elephants. Dugongs are believed to have evolved 50 to 60 million years ago, when an elephant-like creature entered the water



Present distribution of Dugong in India

Flora (CITES). Based on resolutions during the World Conservation Congress in Buenos Aires (1995), a Global Dugong Status Report and Action Plan was developed and published in 2002. Several countries and territories have already started working on national or regional dugong conservation strategies.

Dugongs continue to occur in the Gulf of Mannar and Palk Bay along the east coast, the Andaman & Nicobar Islands, and Gulf of Kachchh along the west coast of India. In 2009, the population of dugong in India was estimated between 131 and 254 individuals using an interview based survey conducted by the GEER Foundation. Of these, about 77 to 158 individuals were suspected to be occurring in the Gulf of Mannar, 44 to 81 individuals in the Andaman & Nicobar Islands, and 10 to 15 dugongs were estimated in the Gulf of Kachchh. At present, it seems that the largest populations of dugong in India are in the Gulf of Mannar and Palk Bay region, followed by Andaman & Nicobar Islands, though the population

size is presumed to be very small. The Gulf of Kachchh population is already critically endangered. A dugong (dead) was sighted in February, 2018, on Ajad Island, Gulf of Kachchh after a gap of 10 years. The tsunami of 2004 damaged much of the dugong habitat in the Nicobar region, further threatening the dugong population in India.

CONSERVATION ISSUES

Region-specific threats to the dugong and its habitats were identified by the Wildlife Institute of India through a study sponsored by MoEFCC, Government of India and it was carried out from July 2012 to June 2013. Indiscriminate fishing was found to be a major threat to these mammals in the Gulf of Mannar, Palk Bay, and Gulf of Kachchh. Poaching and hunting is prevalent in Andaman & Nicobar Is., and pollution seems to be a major threat in Gulf of Kachchh. Dugong occupancy was found to be greatest in the Gulf of Mannar and Palk Bay, followed by Andaman & Nicobar Is., and lowest in the Gulf of Kachchh. The overall occupancy of the dugong in Indian waters was estimated to

be 11% of its historical distribution area (from 1950s). Only 21% of the area sampled in Tamil Nadu recorded dugongs. The corresponding proportion was 12% in Andaman & Nicobar, and 1% in the Gulf of Kachchh. Status of dugong in some inaccessible areas such as the west coast of South and Middle Andaman is not known as these areas are tribal reserves. Overall, the dugong distribution range has decreased significantly by about 85% in India. Another observation by the Nature Conservation Foundation and ANET estimated a 60% decline in dugong distribution range in last 20 years in Andaman & Nicobar.

PROTECTION STATUS

Dugongs are protected under Schedule-I of the Wildlife (Protection) Act, 1972, which provides the maximum protection to a species in India, and also prohibits any kind of trade in this species. Dugong has been declared as Vulnerable by IUCN and the species is listed in Appendix-I of CITES, which prevents international trade in this species. Being a signatory, Government of India strictly adheres to the CITES rules and regulations



Dugongs need to surface every six minutes to breathe atmospheric oxygen



DHRITIMAN MUKHERJEE

Clumsy and sluggish in habit, dugongs are not particularly adapted to rapid motion

to prevent trade in protected endangered species, including the dugong. Moreover, large portions of dugong habitats in India have been included in the existing Wildlife Protected Areas Network, such as Gulf of Mannar Marine National Park, Gulf of Kachchh Marine National Park, and M.G. Marine National Park. A study jointly carried out by both Sri Lankan and Indian researchers during 2004 revealed that the incidental catch of dugong by fishermen is significantly lower in the Indian part of Gulf of Mannar than in Sri Lanka, due to awareness and protection provided by joint efforts of Government of India and Tamil

Nadu Forest Department. Government of India has also signed a Memorandum of Understanding on the conservation and management of dugongs and their habitats throughout their range in April 2008, to strengthen the ongoing protection and management of dugongs and their habitats in Indian waters with the support of the international community. Additionally, Government of India along with State Forest Departments has initiated awareness programmes among fishing communities to minimize incidental capture of this species and also to protect their seagrass habitats. Further, the National Board for



Dugong can survive up to 70 years in protected habitats with sufficient food resources

Wildlife under the Chairmanship of the Hon'ble Prime Minister constituted two subcommittees comprising conservation experts for recovery of threatened terrestrial and aquatic species in India. These committees have already developed guidelines for the Threatened Species Recovery Plan and selected certain threatened species on priority basis, which includes the dugong.

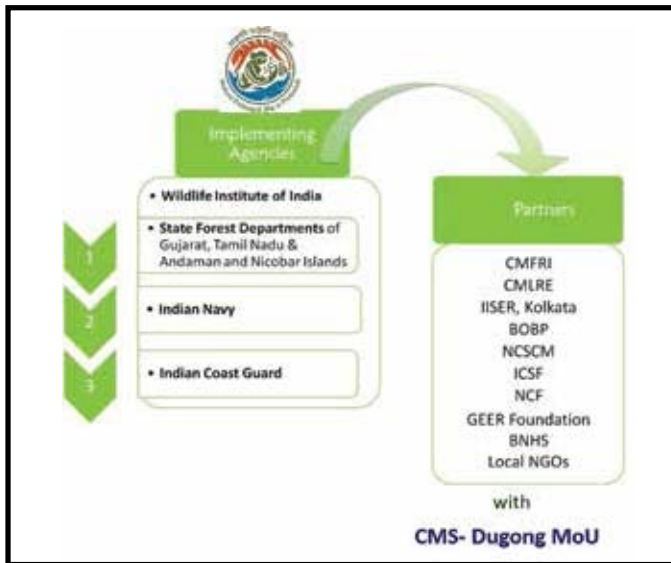
RECOVERY PLAN FOR DUGONGS AND THEIR HABITAT IN INDIA

Recovering endangered species populations entails targeted, multidisciplinary research that flows into management actions and advocacy for policy changes. With this vision, Wildlife Institute of India (WII) has commenced a Dugong Recovery Programme with funding from MoEFCC. Activities are being implemented by WII in collaboration with the species' range state Forest Departments and partner NGOs. The programme aims at: (a) assessing and monitoring dugong population and habitat status; (b) implementing site-specific management actions to recover populations and restore critical habitats;

(c) incentivizing participatory conservation efforts involving local stakeholders; and (d) improving the capacity of enforcement and management agencies to promote integrated protection and management of dugong and associated species.

As part of this programme, WII has organized a national level consultation workshop to prioritize conservation actions and organize a state level stakeholders consultation workshop in dugong range states, and finalized the modalities related to implementation of Dugong Recovery Programme with actionable conservation measures on priority in the field.

The Indian Navy and Coast Guard have been supporting WII in monitoring dugongs and creating awareness. More than 20,000 school children and fisherfolk have participated in various awareness programmes till now. A few fishermen from Tamil Nadu, who rescued and released three dugongs entangled in their fishing nets (as a result of our awareness programme), were given incentives. Sixty frontline forest staff of the Tamil Nadu Forest Department were oriented towards conservation of this species.



Partners of Dugong Recovery Programme

Incidental entanglement in fishing nets is a major reason behind dugong mortality, and therefore, appropriate conservation measures were initiated to regulate harmful practices like gillnetting in dugong habitats with help of 'Dugong Volunteer' comprising network of fishermen youths. A compensatory scheme was also initiated on a small scale in Palk Bay and the Andamans, where direct threat like fishing net entanglement was reported as high. Further, land based pollution is also one of the threats to seagrass habitats in India, especially in the Gulf of Kachchh region. Therefore, a study was initiated to understand the impact of pollution on nutrient contents of seagrass, so that an appropriate mitigation plan can be developed, including restoration of seagrass meadows.

A Marine Mammal Rescue and Rehabilitation Facility (MRF) will be developed on a trial basis in the Andamans and Gulf of Mannar areas, where numerous incidents of dugong stranding have been reported. The facilities will be developed by providing additional capacity to veterinarians and managers of these areas, to handle rescued dugongs and other marine mammals. They will also look into certain aspects of marine mammal diseases in the region. The capacity of Indian veterinarians would thus be enhanced to enable rescue and rehabilitation of stranded marine mammals with the help of international experts.

For the first time in India, after obtaining the required permissions of PCCF & CWLW of Tamil Nadu and Gujarat, genetic samples of more than 10 dugongs were collected and analysed to understand their genetic connectivity with those of Sri Lanka and the Arabian Gulf. The study found that the Indian population might have diverged from the main Australian population and thus formed a sub-population with its own unique genetic composition. Further, the study found that the genes of Indian dugongs are matching with ancient

genes of Australian dugongs, therefore, dugongs in India seem to belong to an ancient line.

As part of 'Incentive for Conservation Programme', examinations were conducted for school children of fishing communities and 150 'Dugong Ambassadors' from the three dugong range states/UT were selected. Education of these Ambassadors was supported with Dugong Scholarships of Rs. 500 per month for two years.

Recently, the Management Plan of Gulf of Mannar National Park was prepared in a participatory mode involving various stakeholders. The focus of the Management Plan is to conserve dugongs and their habitats, and associated fauna and flora. Capacity building programmes were organized to strengthen the capacity towards monitoring and management of marine animals for State Forest Departments and Indian Coast Guard personnel in Tamil Nadu, Gujarat, and Andaman & Nicobar. It is also planned to involve communities in monitoring dugongs and their habitats. In this regard, special training including SCUBA diving was provided to fishermen youths at Palk Bay, Tamil Nadu. These trained youths will also be involved in marine ecotourism activities as guides.

Efforts are underway to identify and manage critical dugong habitats outside PAs and conserve these areas with the help of local communities. Studies to understand the ecosystem services of seagrass habitats, ecology of dugongs, ecology of seagrasses and their associated fauna and flora, population genetics of dugong, behaviour, mapping of critical dugong habitats, and other aspects are being carried out in all dugong ranges in India, with active participation of more than 10 researchers.

Government of India has initiated several steps to recover dugong populations and their habitats. Efforts are currently underway to secure and strengthen community participation in the conservation of dugongs, which is an essential step in the best way forward to save these unique marine mammals.



K. SIVAKUMAR

Scientist 'F' with the Wildlife Institute of India, Dehradun, Sivakumar heads the Department of Endangered Species Management at the Institute.



Underwater photography

by Digant Desai

I have been capturing marine life on camera for the past 12 years. Through this article, I would like to give readers a glimpse of this parallel world of colours and shapes, and a life that can rival what is on land. I also give a brief introduction to the techniques of underwater photography and other prerequisites.

LEARN TO DIVE FIRST

Strange as this may sound, this is truly sound advice because if you can't get underwater and dive, this kind of photography is seemingly impossible. Therefore, getting a dive certification and then logging a few hundred dives is, in my opinion, a necessity. Each dive, depending on the depth and your

breathing rate, has a limited time frame (average 45–50 minutes) within which you must learn to operate. When diving, you have to keep track of time, depth, buoyancy, the amount of air left in your tank, life underwater, and your buddy. Keeping track of all these factors should become second nature to you. More and more logged dives, in different conditions and environments, help you to get comfortable underwater, eventually allowing you to concentrate on photography. You can then take pictures copiously, of course with the caveat that safety is of primary importance.

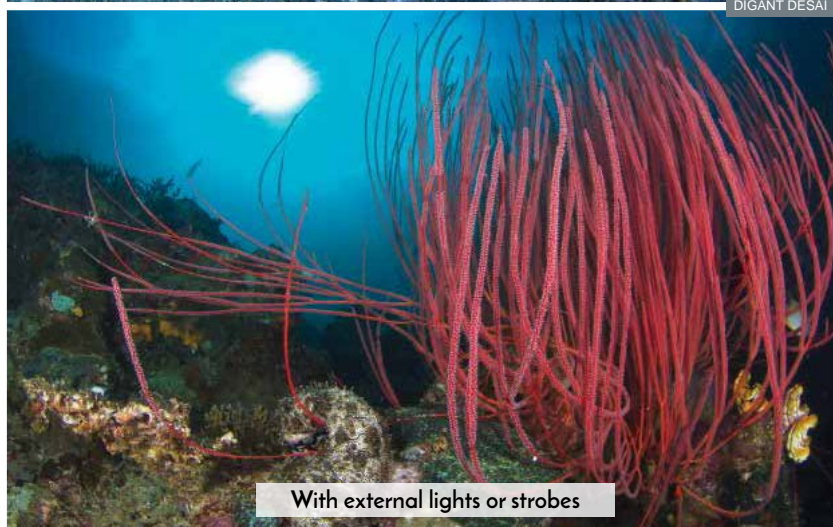
KNOW THE LIGHT!

Before jumping in, quite literally, it is essential to understand how light behaves under water. Photography is playing with light, and experimental, innovative, or proper lighting makes or breaks a photograph. Even if you just want to take some snaps on a holiday for your album or social media, light plays one of the primary roles in getting decent if not great images. Given below is a simple chart to show how light functions under water. We can deduce from the chart that we lose colours in the reverse order of VIBGYOR as we venture deeper, starting with red, orange, yellow, and so forth, till only blue remains below 45 metres, and after 60+ metres even that part of the spectrum is lost. Also, water is about 800 times denser than air and absorbs light very quickly. Not only does this result in dull, monotone colours, it also decreases contrast and image sharpness. New underwater photographers often

Below 600 metres, the sea is perpetually dark, as all the sunlight is filtered out. As no light penetrates into the deep sea, photosynthesis cannot take place, so no plants live there. Animals living here are either scavengers or detritus feeders



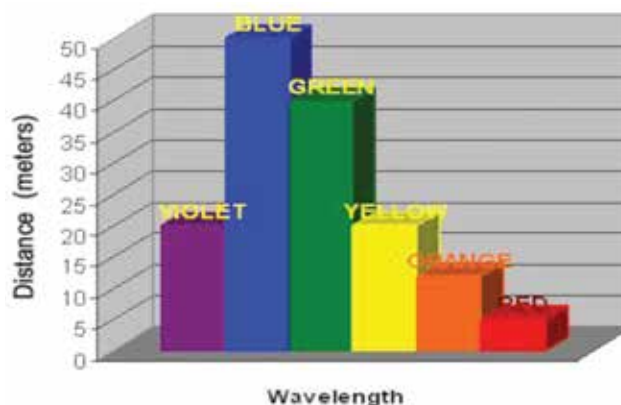
DIGANT DESAI



get frustrated with the blue / grey hue of their images – a direct result of the properties of water and the effect of light absorption.

EXAMINE THE ROLE OF LIGHT

On a bright, sunny day with clear waters and shallow depths (up to 10 m), ambient light photos are possible, but in deeper waters one needs to use external light sources to bring out the colours. The two images above will explain what I mean.



EXAMPLES OF CREATIVE LIGHTING



Side lighting highlights the hairs of this frogfish



This effect was created by using back light



This super macro image of an Orangutan crab required very low power single strobe light

KNOWING YOUR PURPOSE AND CHOOSING THE RIGHT CAMERA

For a long time, I used a simple Canon G7 camera which is one step higher than a point and shoot camera, before moving on to a DSLR and peripherals. In the absence of unlimited budgets, the best way of knowing the kind of camera needed is asking yourself why shoot underwater images and where will you use them. The answer clarifies the equipment choice and costs become clear. I would suggest that you first understand the purpose of your photography before making a choice on buying a specific camera.

- A professional photographer may aim at a full frame DSLR.
- A semi-professional may choose an APSC sensor DSLR.
- For scientific purposes, a simple point and shoot with a single flash/strobe will work.
- If you want to submit images and articles for magazines, then a Pro-Sumer camera or a mirrorless micro four-thirds may be a good choice.
- A person diving just once or twice a year may wish to use very simple, inexpensive cameras as the images are for friends and family.

Let me clarify here for readers that the same cameras that are used on land are used underwater, albeit with a waterproof case called housing. This housing/case can be used down to 40–100 m underwater and all controls to the camera are accessible from outside. For terrestrial wildlife photographers, this hobby may not prove very expensive in terms of equipment. At the market price of one long lens of about 300 mm f4 or a 100–600 mm zoom (cost about Rs. 2–4 lakhs), one can buy a complete underwater set!

SO WHAT DOES IT COST TO GET GREAT IMAGES UNDERWATER?

Starting from Rs. 35,000 to Rs. 60,000 for a point and shoot camera with housing costs can go up to Rs. 10 lakh; more for a full frame DSLR with housing, lights, strobes, and other accessories. But now-a-days some amazing images can be made with systems that cost as little as Rs. 50,000 for camera and housing. I regularly use a simple Olympus TG4 camera with some amazing results. So one does not have to burn a hole in the pocket and can still get some great images. Almost all cameras, starting from point and shoot to mirrorless and DSLRs can be used underwater, with different manufacturers offering housings and peripherals for many.



Housing for the Olympus pen camera



IMAGE OF A NUDIBRANCH TAKEN WITH AN OLYMPUS TG4 CAMERA WITH ITS OWN INTERNAL FLASH.

GENRES OF PHOTOGRAPHY

This list can be very long and there are many more genres such as cold water photography, under ice photography, etc. Genres can be broadly divided as below:



WIDE ANGLE UNDERWATER



MACRO PHOTOGRAPHY



SUPER MACRO PHOTOGRAPHY



AMBIENT LIGHT PHOTOGRAPHY



CLOSE FOCUS WIDE ANGLE



SPLIT PHOTOGRAPHY



SUN BURSTS



BLACK AND WHITE



WRECK PHOTOGRAPHY



PORTRAITS UNDERWATER

Some divers love bringing their cameras down with them just to document what they see on their dive. Others create photographs that are true pieces of art, whether of the smallest critters of the sea or the largest animals that they can capture. Even fashion photography has found its place underwater. But one genre of photography that is important in this day and age is underwater conservation photography.

CLICKING WITH CAUTION



1 First and foremost, adhere to all the rules of safe diving before venturing out with a camera. So get certified. There are many options to choose from, PADI and SSI being two prime schools for certification. I personally suggest that you don't just get an open water certification but get at least an advanced open water certification before trying your hand at underwater photography.

3 Do not destroy or damage coral.

2 Learn about marine life, know your subjects and where to find them. Some subjects such as soft coral at depths may just look drab brown, but the image taken with strobes will show a bright pink or purple. Also, knowing marine creatures and how they behave can play a crucial role. Certain underwater animals are typically found in specific places. For example, orangutan crabs are usually found in bubble coral, clingfish in crinoids, and so on.

4 Each dive has a limited time-frame in which you have to take the images, so pre-planning what you want to shoot helps. Also, on mirrorless and DSLRs, one can't change lenses underwater to switch from macro to wide, so deciding beforehand what you want to shoot is very important. Also, 'losing oneself' in capturing an image is one thing, but make sure of your depth and time.

5 Please respect the ocean and its octaves, don't take unnecessary risks, it's okay to miss some dives or creatures. Life comes first, as also your safety.

6 Staying calm and relaxed is important, as animals underwater can sense this and are more easily approachable, especially sharks and other larger creatures.

7 Understand what light is like underwater, understand the unique and inherent challenges of the sea. Respect and adhere to them.

8 A basic course in underwater photography is highly recommended, however good or skilled a photographer you may be.

9 Understand the limitations and capabilities of both the camera and yourself.

10 Being a really good diver with perfect buoyancy is a must.

11 Understand that you are a privileged guest in this environment and respect it.

WHY UNDERWATER CONSERVATION PHOTOGRAPHY?

- As accomplished an underwater photographer as one may be, taking visuals that can communicate and express for themselves and narrate a story without words is one genre that may help bring transformation, and which is also challenging.
- Conservation photography, whether it intends to stop illegal fishing, or to save mangroves that are being destroyed, or to educate children who are the future, is a very powerful and persuasive medium.
- Conservation photography is perfected when the purpose is to spread awareness through education, research, and conservation. One of the best ways to do this is to team up with an NGO that appreciates the power of this medium.
- Being part of conservation awareness programmes gives you access to places and opportunities that others may not get. It is not always a pretty sight photographing dead sharks or captured turtles, but the contentment of trying to make a change is more fulfilling than winning any photography competition.
- Moreover, since this is documentary photography, researching your subject and capturing images that tell a story is a must.



Just hatched leatherback turtle young were kept in a pen on an island resort in Maldives. The hatchlings kept banging their heads on the iron grill and some were eaten by herons till a cover was put in place. After a furore and documentation by conservationists to show that turtle hatchlings are programmed to find their way into the ocean immediately on hatching, they were finally released after three days. In my opinion, it was too late a release and I doubt that any survived!



DHRITIMAN MUKHERJEE

This shark becomes the victim of a fishing hook attached to a line. Even small sharks such as these are hunted for their fins in the night by fishermen who are desperate to make a living



DHRITIMAN MUKHERJEE



DIGANT DESAI

Apex predators are important to the health of an ecosystem. They maintain the balance in an ecosystem, and without them everything loses balance, leading to cycles of population explosions and crashes.
(above): Fins of a Hammerhead Shark being sawed.
(below): A discarded shark's head, minus its fins, stares with dead eyes



DIGANT DESAI

Even an island in Papua in Indonesia which is just 150 x 250 m in total size, with no permanent residents, does not escape plastic waste. Plastic comes in with the tide or is left behind by locals from other nearby islands

FEATHER STAR

A Crinoid or Feather Star happily makes its home on a beautiful yellow Gorgonian Fan, below a pink soft coral, under a jetty. This jetty is the landing point for Arborek – a lovely island in the middle of Raja Ampat Oceans, New Guinea.



DIGANT DESAI

DIGANT DESAI



SPOTTED BOXFISH

The male of this species is very brightly coloured with shades of blue and brown speckled with yellow dots. The female (in this image) and juveniles, though attractive, flaunt simple shades of brown and beige.

SEA GOLDIE

This is a small and colourful species.

A male retains a harem of five to ten females, but when the male dies, one of the females undergoes sex reversal and takes the place of the missing male. The Sea Goldie, like other anthias, is a protogynous hermaphrodite.



DIGANT DESAI



SOFT CORAL

Wreck in Sri Lanka.

Wrecks are a haven for life underwater and a plethora of creatures make it their abode. In this case, the wreck is adorned with soft coral in multiple hues forming a beautiful garland underwater.

DIGANT DESAI

COLEMAN SHRIMPS

A commensal, Coleman Shrimp is typically found in pairs, only living on certain species of sea urchins such as Variable Fire Urchin *Asthenosoma varium*. It has not been found to harm or help the host in any way. This shrimp grows to about 2 cm in size and can be easily identified by its large brown-red spot pattern on a yellow background.

It likely feeds on any food that happens to pass by.



DIGANT DESAI



DIGANT DESAI

Digant is one of the most accomplished marine photographers from India and has been internationally acclaimed. Marine life and the underwater world are a childhood fascination for him, and he has seized every opportunity to study this wonderful world. It has been his heartfelt desire to pursue scuba diving to capture awe-inspiring sights of the underwater world on camera. Backed by this passion, Digant finally took the plunge, quite literally, past 40 years of age in 2006, and has since been photographing this wonderful world and its even more beautiful creatures. Digant has won international and national awards and has contributed articles for various wildlife and other local and international magazines. He was the primary photographer on the team exploring the Angria Banks on a project by NIO and has co-authored the book field guide to the sea slugs of India. We need to know more about this stunningly beautiful parallel world, and it is Digant's mission to showcase it through his photographs.

THE *omnipresent photographer*

Dhritiman Mukherjee



DHRITIMAN MUKHERJEE

DHRITIMAN MUKHERJEE

REMORA AND A GREEN TURTLE

Sea turtles spend almost their entire lives in the water. It is therefore not surprising that epibionts (organisms that make their homes on the backs of marine animals) hitchhike on the backs of sea turtles. These range in size from microscopic diatoms to fish such as remoras. Scientists have started to unlock the secrets of these hitchhikers; they believe that the creatures found on each sea turtle can tell where that turtle has been and what it was doing there.

COMMON CUTLEFISH

Cuttlefish are armed to hunt. When a shrimp or fish is in range, the cuttlefish aims and shoots out two tentacles to seize its prey. Like their octopus kin, cuttlefish hide from enemies using camouflage and clouds of ink. Cuttlefish can change their skin colour and pattern almost instantly. They use their skin to communicate, flashing stripes and patches of colour to convey threats or courtship messages.





DHRIITMAN MUKHERJEE

YELLOWMASK SURGEONFISH

Surgeonfish have a blade-like spine on both sides of the tail that points outwards when bent. It is used for defence and is as sharp as a surgeon's scalpel, hence the name 'surgeonfish'.

BLUESPOTTED STINGRAY

This stingray migrates in groups into shallow sandy areas during the rising tide to feed on molluscs, worms, shrimps, and crabs; they disperse at low tide to seek shelter in caves and under ledges.



DHRIITMAN MUKHERJEE

GIANT GROUPE

Giant Grouper is a very slow swimmer. It has a wide range, living in reefs throughout the Indian and Pacific oceans. This Giant Grouper is seen here with juvenile Golden Trevallies, displaying prominent dark bands.



DHRIITMAN MUKHERJEE



DHRITIMAN MUKHERJEE

MUDSKIPPER

Mudskippers are, perhaps, the most conspicuous fish in our mangroves, mainly because they spend most of their time out of water. Uniquely adapted among fishes for terrestrial activity, they breathe by holding water in their mouth and gill chamber, replacing it with a fresh gulp when it becomes deoxygenated.

STARFISH SHRIMP ON A CUSHION SEA STAR

The Starfish Shrimp has a symbiotic relationship with various sea star species, the Cushion Sea Star being one of them. This is a cleaner shrimp, it browses on the mouth and gills of its 'customers' to free them from ectoparasites.



DHRITIMAN MUKHERJEE



DHRITIMAN MUKHERJEE

CRINOID SHRIMP

Also known as Feather Star Shrimp, the Crinoid Shrimp is so called as it has only been seen in association with crinoids or Feather Stars. It is well camouflaged among the feathery arms and striking colours of the crinoids.



DHRITIMAN MUKHERJEE

HERMIT CRAB

Hermit crabs have a soft, vulnerable abdomen and lack a hard exoskeleton to protect it. They therefore use empty shells of other animals for protection, especially old whelk shells. As they grow in size, find a larger shell to occupy.

A SEMI-TRANSPARENT GOBY

A pelagic species, this goby is known to inhabit inshore waters and estuaries. Gobies are small, carnivorous fish related to mudskippers.



DHRITIMAN MUKHERJEE



DHRITIMAN MUKHERJEE

One of the most respected and loved nature photographers in India today, Dhrityman is admired for his dedication, perseverance, and hard work. He has been awarded the RBS Earth Hero Award 2014 for inspiring people with his images towards conservation and Carl Zeiss Conservation award for contribution in conservation in 2013, with many other national and international photographic awards. As a professional photographer, his work has been published in BBC, National Geographic, New York Times, Lonely Planet, WWF, London Geographic, Telegraph, and The Guardian, besides several other print and digital media. He is a field person working from the mountains to underwater, desert to rain forest, and volcano to ice in the Polar regions. He is one of the founders of Saevus magazine. Recently, he was one of the three juries for the National Award for Photography, Government of India.

Upcoming marine photographer

Dheeraj M. Nanda



DHEERAJ NANDA

CLOWN SWEETLIP

Member of the grunt family that is native to the Indian Ocean and the western Pacific Ocean. A denizen of coral reefs, found at depths ranging from 1 to 30 m.

Can reach a maximum size of 72 cm. Juveniles brown with large white blotches, mimicking the movement of a poisonous flatworm for defence against predators. As they age, they gain more spots which reverse from white to black. Photographed at Ambon, Indonesia.



DHEERAJ NANDA

GORGONIAN SEA FAN

Found throughout the oceans of the world. Thin, erect, flattened, or branched structure, similar to corals. May be brightly coloured, often purple, red, or yellow. Usually found in shallow waters with strong currents. Photographed at Raja Ampat, Indonesia.



DHEERAJ NANDA

BLUESPOTTED STINGRAY

Common throughout the tropical Indian and western Pacific Oceans. Found from shallow areas up to a depth of 30 m. Can grow to a maximum of 35 cm in width. Easily identified by its striking colour pattern of many electric blue spots on a yellowish background, with a pair of blue stripes on the tail. Photographed at Havelock Island, Andamans.

BIGEYE SNAPPERS

Native to the Indian Ocean and the western Pacific Ocean. Inhabit offshore coral reefs at depths ranging from 1 to 96 m. Mostly silver in colour with a yellow stripe along the side and fainter yellow lines on lower half of body. Fins yellowish to whitish. Can reach a length of 35 cm. Photographed at Raja Ampat, Indonesia.



DHEERAJ NANDA



ONE-SPOT SNAPPER

Widespread in the Indo-Pacific region. Found in depths ranging from 1 to 60 m. Nocturnal, usually found schooling in small groups. Feed mainly on fishes and crustaceans. Photographed at Raja Ampat, Indonesia.

PORCELAIN CRAB
Found in all oceans except the Arctic and the Antarctic. Flattened body as an adaptation to living in rock crevices and in between corals. Delicate and can lose their limbs when attacked. Photographed at Ambon, Indonesia.



TRUMPETFISH

Trumpetfish *Aulostomus chinensis* can grow up to 80 cm in length. Found at depths ranging from 3 to 125 m. Inhabits tropical and subtropical waters in the Indian and Pacific Oceans. Usually feeds on crustaceans and small fishes. Photographed at Raja Ampat, Indonesia.



DHEERAJ NANDA

WARTY FROGFISH

Grows up to 15 cm. Occurs in sheltered rocky and coral reefs. Can change the colour and pattern on its body with the surrounding environment. Found in hues of yellow, brown, red, pink, and cream. Photographed at Ambon, Indonesia.



DHEERAJ NANDA

False Clownfish (young)

The star of the movie 'Finding Nemo' needs no introduction. They are usually found in shallower depths in the Indian and Pacific ocean. Clownfish have a symbiotic relationship with sea anemone, which is a fish-eating plant-like animal that has poisonous tentacles. Image shot at Kapalai Island, Malaysia.



DHEERAJ M. NANDA

A budding 18 year old underwater photographer, Dheeraj loves to explore the depths of the ocean. He is an accomplished rescue-level scuba diver, an enthusiastic cyclist, and wildlife photographer. Dheeraj completed more than 100 dives before turning 18; he travels the world equipped with a camera and fuelled by his passion. He hopes that through his adventures into the deep and the images that he brings back from across the world, he can inspire people to be better aware of the marine ecosystem and help conserve it. Combining his interests in marine ecosystem and photography, he started underwater photography only after his first 40 dives. His interest in learning about animals and their behaviour in their natural habitats began to increase as he started to travel more often. "The oceans have compelled me to be adventurous," he says. He was trained in Goa by a veteran in the field of diving, Venkatesh Charloo, and completed his advanced open water course at the age of 12 in 2012.



Adaptations

FOR SURVIVAL

One of the fundamental challenges for many species is to eat but not be eaten. For any species to thrive over long periods, sufficient numbers of them must live long enough to reach adulthood and reproduce. Offence as well as defence, therefore, become essential tools for survival in the wild. Species have evolved to meet the challenges of their environments by adapting to them.

FLYING FISH

As the name suggests, these fish can leap out of water into air with the help of their long, wing-like fins that enable them to glide for considerable distances above the water surface. Their streamlined torpedo-shaped body can generate enough speed to break the water's surface. The Flying Fish is one of the national symbols of Tobago, which is known as “the land of the flying fish”.



DEEPAKAPTE



PYGMY SEAHORSE

These are among the smallest seahorse species in the world, typically measuring less than 20 mm. They are associated with sea fans (or gorgonids) and soft corals, or are free-ranging among sea grass and algae. The illustration shows *Hippocampus bargibanti* that is associated with sea fans. It spends its entire life among sea fan colonies, where its cryptic coloration and appearance save it from predators.



DIGANT DESAI

DEEPAK APTE

RAZORFISH

Razorfish are adapted to swim in a head-down and tail-up position to be able to hide among sea urchin spines, or among seagrass blades or staghorn corals, and wait for prey. They form small groups and simply drift with the seagrass.



DIGANT DESAI



DHRITIMAN MUKHERJEE

GHOST PIPEFISH

These are species of “false” pipefishes. Their colours vary greatly, from grey, brown, pink, and yellow, to bright green, and resemble floating blades of seagrass. These fish drift motionlessly in the water, with their mouths facing downwards. Females carry the eggs in their pelvic fins that are modified to form a brood pouch. Two species, Robust Ghost Pipefish *Solenostomus cyanopterus* (left) and Harlequin Ghost Pipefish *Solenostomus paradoxus* (above) are shown above.



DIGANT DESAI

STONEFISH

The Stonefish is one of the most venomous fish in the world. Perfectly camouflaged to look like a rock, it lies motionless on the sea floor or among coral heads. Accidental stepping on the dorsal fin can puncture a victim’s skin and inject venom, which is fatal.

FROGFISH

These belong to the anglerfish family.

Some frogfish are found in shallow waters, while a few inhabit deep water.

In many species, the body is covered with hydroids, algae, etc. and can be mistaken for sedentary sponges, tunicates, corals, or sea urchins. Frogfish move slowly, lying in wait for prey most of the time, but they strike extremely rapidly once the prey is within striking distance. The pelvic fins are modified for walking on the sea floor.



DEEPAK APTE



DEEPAK APTE

CLINGFISH live on seagrass beds and reefs, clinging to algae, seagrass, sea urchins, and feather stars, among others. In most species, the pelvic fins are modified into a sucking disc that allows them to cling to the substrate. Most have cryptic coloration and can change their colours according to the background. Seen above is the Crinoid Clingfish *Discotrema* cf. *crinophila*.

Hidden IN THE depths

CAN YOU SPOT THE HIDDEN ANIMALS IN THESE PICTURES?

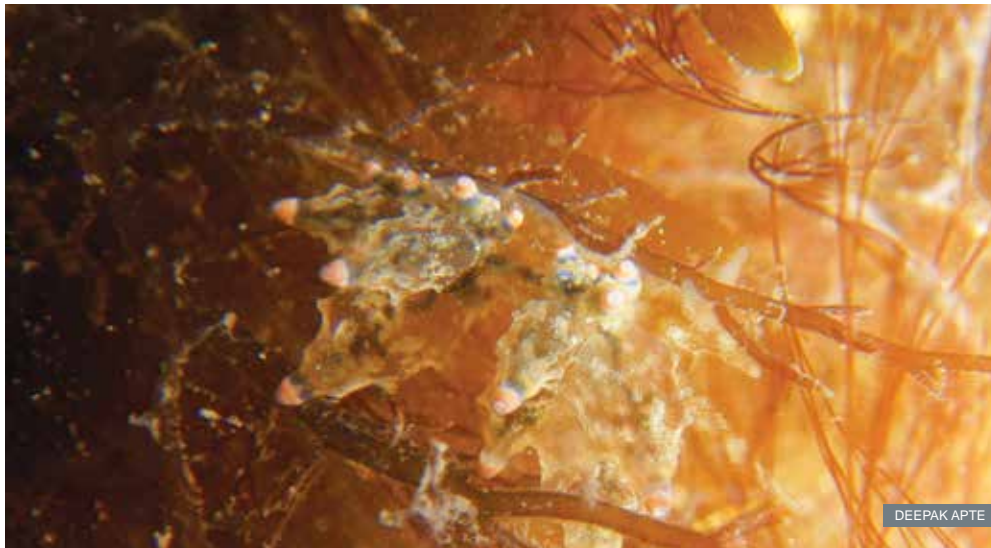
(Answers on page 117)

One of the best known survival tactics of the animal world is camouflage, rendered through adaptations of body colour and shape which have evolved over geological time, not only making animals invisible to their own predators but also helping them to approach their prey without warning. In the marine environment, we come across many such animals which are so effectively camouflaged that even an expert may find it hard to spot them in their habitat. Brightly coloured anemones and fish inhabit coral reefs, where a background of similarly colourful corals helps them to escape notice. The delicate, gel-like, transparent body of a shrimp or a jellyfish or other coelenterate is barely visible in the faint blue-green of seawater, to name just a few examples. Take a look at the pictures below.



1. CLUE:

This is also one of the smallest fish species in the world, typically measuring less than 2 cm in height.



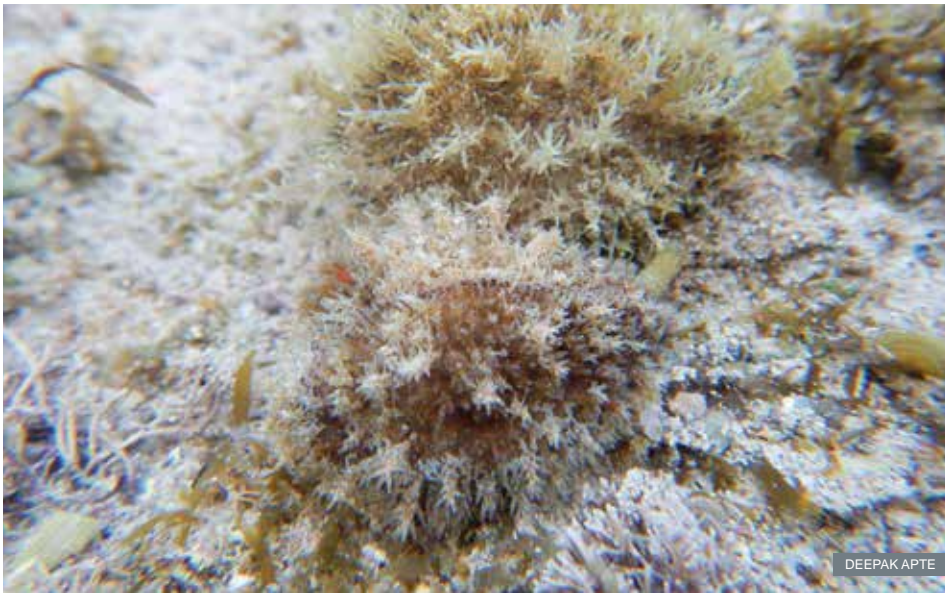
2. CLUE:
Try not to be sluggish
while looking for this
hidden one!

3. CLUE:
It waits for you to find it,
sitting patiently on this
throne of spikes!



4. CLUE:
Don't get fooled by
the bright colour you
see. What you seek is
the name of what you
cannot see!





5. CLUE:
You might get shell-shocked when you spot this one!

DEEPAK APTE



6. CLUE:
What shows off this soft cover, might just be hiding a tough exoskeleton!

DEEPAK APTE



7. CLUE:
You might not be proud of your eyesight trying to spot this one ... but so is not this animal ... it is colour-blind!

DEEPAK APTE



DEEPAK APTE

8. CLUE:
This animal is so good at being invisible, it is also commonly known as a "ghost"



DEEPAK APTE

9. CLUE:
You might be slow in spotting this one, just like its pace!



DIGANT DESAI

10. CLUE:
These masters of disguise do not like areas of strong current and prefer sheltered spots such as bays



DIGANT DESAI

11. CLUE:
Their camouflaged venomous spines are one of the reasons the snorkeler guide tell us not to touch the reefs!



DIGANT DESAI

12. CLUE:
This animal is known to also have protrusible eyes, i.e it can stick its eyes up a bit to see around



DIGANT DESAI

13. CLUE:
The fact that these are heavily spotted makes it difficult for them to get spotted!



DEEPAK APTE

14. CLUE:
These animals are respected by other creatures, often sharing burrows and crevices and working as housekeepers!



DIGANT DESAI

15. CLUE:
You may look closely at the entire picture but Mr. Crawly is right in the centre!

1. Pygmy Sea Horse
2. *Eubranchius mandapamensis*, a sea slug.
3. A species of crab. (Write to us if you know the species name!)
4. A species of starfish. (Write to us if you know the species name!)
5. Cowrie *Cyprea turdus* (Now known as *Naria turdus* (Lamarck, 1810))
6. A species of crab. (Write to us if you know the species name!)
7. *Plakobranchus ocellatus*, a sea slug.
8. Glass Shrimp
9. Lamellariid (a snail) on Bryozoa.
10. Harlequin Ghost Pipefish
11. Scorpionfish
12. Flatfish
13. Lizardfish (Write to us if you think this might be some other animal!)
14. *Saron marmoratus*, the Marbled Shrimp or Cleaner Shrimp
15. A species of shrimp. (Write to us if you know the species name!)

ANSWERS:

A Voyage TO THE Last Wilderness

by Anant Pande

It was half past midnight of January 17, 2009. A bright shining sun and its reflectance from frozen sea-ice were blinding, making it difficult to look beyond a distance. I put on my snow goggles and climbed up to the bridge, the highest place in the ship from where the Captain oversees the operations. The on duty Russian navigation officer Oleg, with a smirk on his face, asked in broken English, “Where my food?”. I had no answer to that. Half of our expedition team was eyeing the catch of 400-odd individuals of Antarctic Krill that I was rearing in a makeshift laboratory on board the vessel MV Emerald Sea, the chartered vessel for the 28th Indian Antarctic Expedition (IAE). At the age of 24, I was a student member of the 40-member strong team travelling via the sea route to the white continent. As part of my research, I was sampling Antarctic Krill at every half degree latitude and maintaining them in controlled conditions to better understand their metabolism.

Antarctic Krill (crustaceans of the family Euphausiidae), the most abundant zooplankton on the planet and food for multiple predators (including the largest animal on earth, the Blue Whale), is the keystone species of the Southern Ocean (earlier known as Antarctic Ocean). Catching krill and keeping them alive onboard was an arduous task in the gale-like wind conditions exacerbated by sub-zero water temperature of the high latitudes. Relishing every moment of the roll and pitch through the roughest waters of the planet, little did I imagine back then that Antarctica would be my *karmabhoomi* for the time to come.

Antarctica, the last wilderness or the *Terra incognita*, regulates Earth’s energy budget, oceanic temperature

gradients and atmospheric wind circulation. Scientists across the globe highlight rapidly aggravating threats to Antarctica from global environmental change. Surface waters of the Southern Ocean, the waters south of 60-degree latitude surrounding Antarctica, are becoming warmer day by day with ever-increasing input of freshwater from melting glaciers causing reduced sea-ice and elevated oceanic CO₂ concentration. The Southern Ocean teems with species which are directly or indirectly dependent on its huge planktonic food resource, and climate change may drastically impact their survival, which includes penguins, seals, whales, and several lesser known and yet to be discovered taxa.

Four years later, I once again set sail to Antarctica, as Scientific Member of the 33rd IAE. I was representing the Wildlife Institute of India, Dehradun in the project “*Long-term monitoring of Wildlife in Antarctica*”. This project aims to understand the distribution patterns of key wildlife species in Antarctica and Southern Ocean. Unflustered by my previous experience of the tortuous Southern Ocean, I had the task cut-out for the expedition to document seabirds and marine mammals on a triangular voyage path from South Africa to Antarctica and back, twice over.

The Antarctic voyage is typically divided into three phases (See Map); from South Africa to Bharati research station at Larsemann hills





ANANT PANDE

Author collecting water for Antarctic Krill rearing, icebergs in the background



ANANT PANDE

Bucket of Antarctic Krill

(takes about 8–10 days), from Bharati to Maitri research station at Schirmacher Oasis, Princess Astrid Coast (6–7 days), and from Maitri back to South Africa (8–9 days). The first and last phase are essentially journeys along the longitudinal axes (>10,000 km), while the second phase is along the coast of Antarctica (>3,000 km). The 33rd IAE was exceptional as the ship had to move twice on this voyage route, continuously for four months, covering a travel path of more than 25,000 km.

We sailed from the picturesque port of Cape Town, South Africa on December 12, 2013. As the only wildlife biologist on board, work commenced from day one. I began observations from the bridge, counting flying seabirds in 10-minute snapshots, breaking off periodically to note down the weather parameters. The warm sea surrounding the African cape provides nourishment to sub-tropical species such as Cape Gannets and Wedge-tailed Shearwaters. As the vessel descended south

on the latitudinal gradient, the warm air was rapidly replaced by the chilly winds of the roaring forties and furious fifties, as the 40-50-degree South latitudes are infamously known in the sailors' lexicon. These latitudes consist of circumpolar oceanic fronts, demarcated by varying levels of temperature and salinity, and high primary productivity. A major physical force in the region is the Antarctic Circumpolar Current (ACC), the largest current system with a discharge equivalent to all the rivers of the world taken together. ACC flows from west to east creating a formidable barrier between the warmer waters of the sub-tropics and the cold temperate waters of the Southern Ocean.

Seabird species richness peaks at the interface of these oceanic fronts, dominated by tube-nosed Procellariiformes (commonly called petrels), the largest order within seabirds. Represented by the largest of seabirds, the great albatrosses, to the tiniest of all – the storm-petrels, Procellariiformes rule

the open ocean. Highly mobile and pelagic, these long-lived birds display extreme life history strategies. Most of them lay a single egg in an irreplaceable clutch, breed alternate years, and attain sexual maturity after 8–10 years. When several seabirds follow the ship for days together, the sheer magnitude of biomass flying across is enormous, ranging from the humongous Wandering Albatross (>8 kg body weight; >3 m wingspan) to the innumerable tiny storm-petrels (<35 gm body weight; <0.4 m wingspan). With the ship cruising south of the ACC, the seabird species composition changes to cold-tolerating species of petrels such as White-chinned Petrel, large flocks of Antarctic Prion, and magnificent giant petrels. The sea is often choppy and sighting a whale is usually a challenging task, more so if one wishes to count them. Humpback whales dominate the Southern Ocean like no other oceanic giants of its class. Sightings of Sei, Blue, and Sperm whales happen frequently as we come closer to the polar circle, the imaginary boundary of the Southern Ocean.

We hit the east Antarctic coast on a bright sunny night on the 9th day of the voyage. The thunderous waves of the sub-polar latitudes are now replaced with pack-ice (large, sheet-like fragments of the frozen ocean). No other ocean throws a challenge to sailors as the Southern Ocean; navigation amid sea-ice to reach the shore. Once our vessel touched the icy waters, the speed slowed down to less than 6–8 knots, often changing course to avoid gargantuan icebergs or impending cyclones. Open waters within this sea-ice zone known as *Polynyas*, typically hold large krill concentrations, and thus are feeding grounds for a wide variety of species including the Antarctic Killer Whale. These highly productive ice-water mosaics sustain extraordinary biomass for a very short period during the summer season (December to January), witnessing large planktonic blooms. Charismatic fauna, including penguins, seals, whales, and pelagic seabirds, thrive here on the enormous supplies of the Antarctic Krill and salps. Almost every animal that inhabits or migrates to Antarctica is dependent



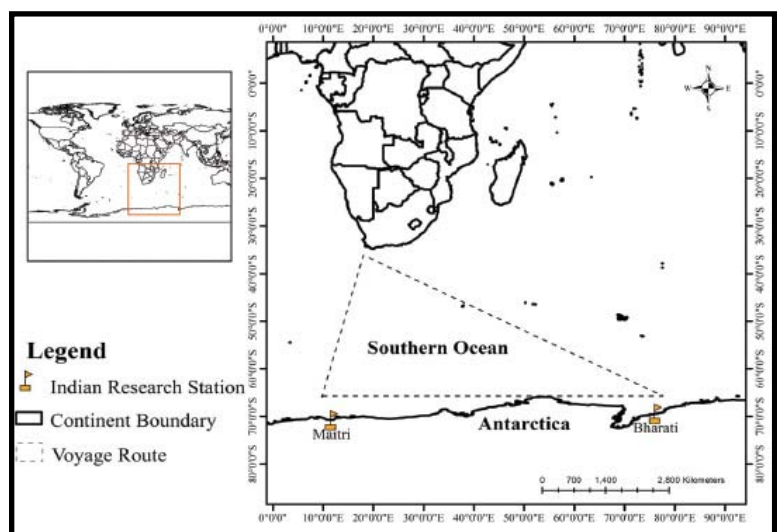
PRIYANKAR DAITTA

Adelie Penguins coming back from a foraging trip to the open ocean, Larsemann hills, east Antarctica



ANANT PANDE

MV Emerald Sea, Indian Antarctic Expedition vessel sailing through the pack-ice at Prydz Bay, Antarctica



Voyage route of Indian Antarctic Expedition

on the Southern Ocean, and thus are principally marine species. On the other hand, terrestrial life forms that exist on the



Antarctic Petrel, Prydz Bay

Antarctic landmass comprise tiny midge flies and microscopic tardigrades. The floral diversity, however, is extensive, with several species of lichens, moss, and algae inhabiting the ice-free regions. Over 99% of Antarctic landmass does not sustain any life, being covered with a dense sheet of compressed ice, averaging >2.5 km in thickness. On land, the phrase “white desert” holds true for the most hostile continent on the planet.



A colour-tagged South Polar Skua near Maitri Station

Life on the Antarctic coast can be defined in two words, charismatic and abundant. Progressing summer melts away most of the frozen ocean along the coast, leaving behind only frozen sheltered bays surrounded by small rocky islands. The fastened sea-ice (known as fast-ice or the frozen part of sea

connected with Antarctic mainland) of these sheltered bays supports some of the most well-known inhabitants of Antarctica, the Emperor Penguin and Weddell Seal. Crab-eater Seal, the most abundant seal species in the world, dominates the pack-ice region of the Southern Ocean while the Weddell Seal occupies the fast-ice zone. Other vertebrates inhabit the ice-free areas during summer, which include islands and rocky outcrops within continental ice-sheet (or Nunataks). Life is diverse and plentiful on these ice-free areas which constitute less than 0.003% of the entire continental landmass. Vertebrates including Southern Elephant Seal, Adelie Penguin, Snow Petrel, Antarctic Petrel, and



Southern Elephant Seal males having a bullfight, Vestfold hills

South Polar Skua inhabit these areas during austral summer.

Systematic surveys over one such ice-free area, Larsemann hills in east Antarctica, revealed the presence of four species of seabirds breeding around the Indian Research Station, Bharati. Snow Petrel, the most southerly breeding bird on earth, up to 400 km inland, nests here in loosely formed colonies having anywhere between 2 to 40 nests/100 sq. m. This semi-colonial bird occupies ice-free rock cavities on steep coastal cliffs in early December, and lays a single egg that is incubated by both parents (in turns) for about 40 days before hatching. The chick is fed for a period of 8–10 days with regurgitated food from the nearby open ocean and it rapidly gains body fat and develops an insulating layer of

grey down feather. After this brief period of chick rearing, the parents leave the chick to survive periods of heavy snowfall and icy winds. Utilizing body fat and stomach oil (another characteristic of the Procellariiformes), the chicks spend over a month to fledge completely and fly away to forage in the open ocean. Snow Petrel chicks not only survive the harsh climate but also the South Polar Skua, a predatory species akin to seagulls, which breeds very close to penguin and Snow Petrel colonies, preying on their chicks during early summer.

As summer in the southern hemisphere inches towards the finish line in April and as winter progresses, the waters around Antarctica start freezing. Extremely harsh weather and the sea-ice barrier



PRIYANKAR DATTA

Russian Expedition Vessel Academic Fedorov, between fast-ice at Princess Astrid Coast, Antarctica

oil spills, plastic pollution, krill fisheries, disease outbreaks, and global climate change. Changes in ecosystem structure and function would negatively impact sea-ice dependent species aggravated with erratic precipitation and fluctuations in sea-ice extent. The Convention on Conservation of Antarctic Marine Living Resources (CCAMLR) emphasizes the importance of long-term monitoring of key Antarctic species to understand the physical and biological drivers of ecosystem change. In the light of robust monitoring and accurate observations, the impact of environmental fluctuations on ecological parameters over time can be better understood.

A natural reserve dedicated for peace and science, Antarctica remains the last great wilderness on Earth, home to irreplaceable biodiversity and unspoiled environment. Over the last few years, distribution patterns and breeding periods of key Antarctic vertebrate species have seen shifts due to rapidly changing climate in the continent. Reliable estimates of species distribution patterns with sophisticated climatic models would yield better predictions of future change. Continued long-term monitoring and repeated surveys will help sustain global efforts to nurture the pristine ecosystem of Antarctica.



ANANT PANDE

Weddell Seal near Rauer Islands

notwithstanding, Emperor Penguin and Weddell Seal make the continent their home for the entire year. Species like Adelie Penguin and Snow Petrel migrate north towards the open ocean and sea-ice interface during the winter period (April to October). Many other species migrate further north to warmer areas in the Atlantic, Indian, and Pacific oceans. South Polar Skuas, for example, are known to migrate as far north as Alaska and Greenland.

Antarctic species are susceptible to a host of local and global threats to their survival. Recent studies have identified several direct and indirect threats to this pristine environment due to impacts of increasing tourism in wildlife-rich areas,



ANANT PANDE

A Project Scientist at Wildlife Institute of India, Anant is currently pursuing Ph.D. on the nesting ecology and population genetics of Antarctic seabirds.

Frozen waters

OF THE ARCTIC

by Dhritiman Mukherjee



View of the White Sea from 'sea level', Arctic Ocean, Russia

DHRITIMAN MUKHERJEE

Ice formation in the White Sea, Russia, during winter



DHRITIMAN MUKHERJEE



Anemone *Metridium* sp., White Sea, Karelia, Russia



Stalked Jellyfish *Lucernaria quadricornis* on kelp, White Sea, Karelia, Russia



Coldwater Soft Coral *Gersemia fruticosa*, White Sea, Karelia, Russia



Dendronotus frondosus – a nudibranch,
White Sea, Karelia, northern Russia



Sea Angel, swimming sea slug of the clade Gymnosomata



Bioluminescent Comb Jellyfish *Dryodora glandiformis*,
White Sea, Karelia, Russia



Starfish in kelp
under the frozen
White Sea, Russia,
during winter



Humpback Whale

DHRITIMAN MUKHERJEE



DHRITIMAN MUKHERJEE

Orca in Arctic Norway



DHRITIMAN MUKHERJEE

A nature wildlife and conservation photographer, Dhritiman loves to work on rare and endangered species in India as well as all over the world. He is an RBS EARTH HERO winner for inspiring people towards conservation.

OBITUARY



VIJAYKUMAR C. AMBEDKAR

July 3, 1932–June 3, 2018

Shri Vijaykumar Ambedkar was a well-known personality among ornithologists for his notable contributions to Indian ornithology, from the late 1960s to 1990s. He was known for two good reasons: his monumental work on weaver birds and as Dr. Sálím Ali's first research student. Vijaykumar Ambedkar, Sálím Ali and weaver birds are three inseparable entities.

Originally from Pune, he completed his graduation and joined BNHS in 1958, and enrolled for M.Sc. by research under Dr. Sálím Ali, whose zeal he shared, to study birds in general and weaver birds in particular. Ambedkar's work was so in-depth and encompassing that Dr. Sálím Ali got his manuscripts reviewed by the eminent ornithologist David Lack. Like his mentor, Shri Ambedkar was an avid and meticulous writer; he exchanged more than 100 letters with Dr. Sálím Ali while posted in Kumaon terai to study the Finn's Weaver. During this posting, it was natural that his mother worried about him. Dr. Sálím Ali made a personal visit to his home and assured his mother that her son was fine and safe. Ambedkar often used to reminisce about his communications with Dr. Sálím Ali.

Ambedkar took part in several ornithological expeditions covering Kashmir (1960), Uttar Pradesh (including present-day Uttarakhand) (1961–64), Lakshadweep (1964), Madhya Pradesh (1966), Assam, and West Bengal (1962), as part of several bird banding and bird migration studies across the country. His best contribution to ornithology was his detailed study on the breeding biology of Finn's Weaver *Ploceus megarhynchus* in the terai landscape during 1961–1976. He brought out a book *SOME INDIAN WEAVER BIRDS: A CONTRIBUTION TO THEIR BREEDING BIOLOGY* based on his thesis published by Bombay University (presently University of Mumbai), in 1964. Other than this, he had more than 30 publications to his credit, mostly on weaver birds.

Ambedkar retired from the BNHS in 1992 and settled in Pune. Even after his retirement he was very active in bird conservation, as well as education and awareness programmes. He participated in the Pakshi Mitra Sammelan (annual birdwatchers' meets) every year and encouraged the youth to take up scientific bird studies. He was a reservoir of knowledge and had in-depth insights on bird behaviour. Recently, BNHS presented him with a report on the status of Finn's Weaver by Rajat Bhargava. He was delighted to receive the report and expressed his desire to provide comments on it. He pointed out that the terai landscape is a complex ecosystem that harbours all the Indian weaver species. He was curious to learn about the possible evolutionary and geographical reasons behind the concentration of so many weaver species in one area. He wanted young researchers to work on this issue and find the answer to this ecological secret.

Ambedkar was a bachelor, and when queried about it he would, on a lighter note, say that he was married to weaver birds. He had a simple and unassuming personality, and was always helpful to others. We, the new generation of BNHS ornithologists and others who knew him, will definitely miss him.

GIRISH JATHAR & SANJEEV NALAVADE

Published on July 16, 2018, by Mr. Debi Goenka for Bombay Natural History Society, Hornbill House, Dr. Sálím Ali Chowk, Shaheed Bhagat Singh Road, Mumbai 400 001, Maharashtra, India.



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Divyabhanusinh, Asok Kumar Das, Shibani Bose

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