



CORALS AND CRABS

MARINE LIFE IN THE REEFS OF GOA

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CORAL REEFS OF GRANDE ISLAND
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DR. PRAMOD SAWANT
CHIEF MINISTER, GOA

Date: 08-05-2019

MESSAGE

The shores of Goa have long been an important tourist destination, attracting nature enthusiasts, adventure seekers and holidaying families alike. Whereas, the Arabian Sea has provided Goa with both unmatched beauty and invaluable resources, we have been slow to fully understand and evaluate the marine biodiversity that it hosts. I am happy to release this first-of-its-kind book, which offers a rare but fascinating glimpse into the biodiversity of the reefs around Grande Island in Goa.

WWF-India has been a longstanding conservation partner throughout the country. I commend the efforts of WWF-India in undertaking several underwater surveys and putting together this captivating book, which will help us better understand the marine biodiversity in the state. I am hopeful that this book will help marine enthusiasts, students, tourists to understand and appreciate the wonderful vastness of nature and life forms it hosts, and inspire more scientific observations of biodiversity in Goa.

(Dr. Pramod Sawant)



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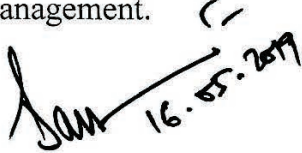
e-mail: cs-goa@nic.in
Dated: 16-05-2019

MESSAGE

The majestic forests and beautiful beaches of Goa make it one of the finest tourist destinations in the country attracting large number of visitors, both domestic as well as from other countries. However, people have little knowledge about the amazing marine biodiversity in Goa's coastal waters, particularly about the coral reefs of Grande Island and the amazing under water ecosystem. Marine based tourism thus has huge scope for creating economic opportunities for the local people.

It gives me immense pleasure to note that WWF-India along with the Forest Department, Government of Goa has come out with this publication on coral reefs of Grande Island, which will help in increasing the public awareness on coral reefs and their conservation.

I am sure that this book will help educate everyone, from students and scientist to general public, and will inspire more research in hitherto unknown areas of marine biodiversity, for its protection and sustainable management.


(Parimal Rai)
Chief Secretary &
Secretary (Forests)



FOREWORD

Subhash Chandra, IFS
Principal Chief Conservator
of Forests

Coastal waters of Goa are abundant in marine biodiversity, yet very few know about these fascinating ecosystems and species that inhabit them. In recent years, marine nature-based tourism such as scuba diving, snorkelling and dolphin watching along the continental shelf has grown steadily. There is an increasing interest in exploring these diverse ecosystems of marine wildlife and corals in the Grande Island archipelago, which has high conservation and educational value. Sustainable marine tourism can also create additional livelihood opportunities for local people.

WWF-India with the support of Goa Forest Department, conducted a survey on the ecological status of coral reefs of Grande Island during 2018. This booklet, an outcome of the extensive fieldwork by young dedicated researchers, offers a glimpse of beautiful marine species inhabiting this archipelago. We hope this will assist us in reaching out to diverse audience in Goa and beyond, including tourists, students, conservationists and those interested in marine ecosystem. I am sure more and more youth and students will join and support marine wildlife conservation programme.

I congratulate the WWF-India and the entire team of researchers for their hard work and passion in making this work possible.


(Subhash Chandra)

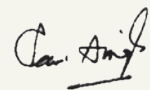
FOREWORD

Coral reefs are some of the most fascinating yet underexplored ecosystems on the planet. With climate change mounting pressure on marine health, protecting coral reefs, which host over 25% of global marine life is critical. Recent studies show that 19% of the world's coral reefs are completely degraded and a further 60% to 75% are under direct human pressure.

India's coral reefs are found along the Lakshadweep and Andaman and Nicobar Islands, the Gulf of Mannar and the Gulf of Kutch. 60% to 80% mortality has been reported from the reefs in Mannar post 1998. This makes it critical for us to understand and conserve existing reef habitats and also explore smaller and lesser known reefs along the country's coastline such as the patchy coral reefs in Goa's waters.

As we learn more about the need for marine conservation in India, we have also come to recognise the gaps in awareness about marine ecosystems and species. Coral reefs off India's coastline especially are severely understudied; this booklet is therefore a step towards better understanding reef diversity and health.

Over the past two decades, the Grande Island Archipelago off the coast of Goa has witnessed a steady stream of individuals, all looking to experience its phenomenal coral reefs. Through this booklet, we have captured some of the rare marine species found in these reefs and intend for it to serve as a valuable reference for marine enthusiasts, amateur divers and anyone with an interest in marine wildlife, while exploring the marine biodiversity of Goa. With over 30 captivating photographs of life underwater, we hope that this booklet will be useful to help navigate the murky but surreal waters of Grande Island.



Ravi Singh
Secretary General & CEO
WWF-India

INTRODUCTION

The small state of Goa, is endowed with a dazzling array of marine biodiversity along its coastline. These species span across the open waters off Goa's coast, to the reefs of Grande Island, they inhabit coastal mangroves, and can even be found all along Goa's popular seashores. This biological treasure is the backbone for fisheries - which have been a traditional occupation and a way of life in this region; it also supports the marine nature-based tourism industry, and thus significantly contributes to the state's economy and to peoples' livelihoods.

We live in an age of accelerated human impact on marine ecosystems everywhere. Goa is no exception to this case. Besides human-induced climate change, these marine ecosystems are also threatened at local levels by excess human use, including fishing pressure, unregulated tourism, and unplanned coastal development.

Just as significant as those threats, however, is the knowledge gap on marine biodiversity as a whole. Marine biodiversity in Goa has thus far not been adequately studied to inform good management practices. Most of the current knowledge on marine ecosystems is restricted to the region's fishing communities and scientists.

The best way to bridge this knowledge gap, as with conservation everywhere, is to make the knowledge of biodiversity accessible to every citizen – be it a student or enthusiast, scientist or hobbyist, local resident or visitor. And in turn, conservation is helped immensely when citizens explore closer natural spaces, document what they see, and bring local biodiversity and its conservation into the public domain

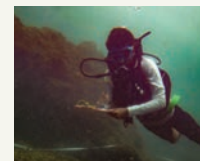
AT A GLANCE



Freddy's Nook, Grande Island
© Abhishek Jamalabad / WWF-India



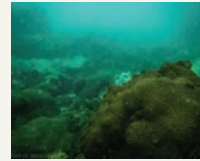
Shipwreck, Grande Island
© Abhishek Jamalabad / WWF-India



Estimating Substrate cover
© Vardhan Patankar / WWF-India



Coral Plates
© Abhishek Jamalabad / WWF-India



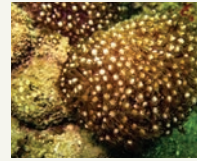
Massive Corals
© Abhishek Jamalabad / WWF-India



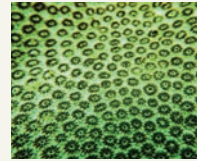
Encrusting Corals
© Abhishek Jamalabad / WWF-India



Whip Corals
© Abhishek Jamalabad / WWF-India



Flowerpot Corals
© Abhishek Jamalabad / WWF-India



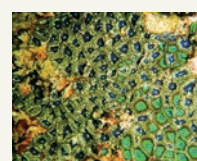
Coral polyp colonies
© Abhishek Jamalabad / WWF-India



Snowflake Corals
© Abhishek Jamalabad / WWF-India



Coral Algal Phase Shift
© Vardhan Patankar / WWF-India



Zoanthids
© Abhishek Jamalabad / WWF-India



Decorator crab
© Abhishek Jamalabad / WWF-India



Ghost Pipefish
© Tanmay Wagh / WWF-India



Dottyback
© Ajay Venkataraman / WWF-India



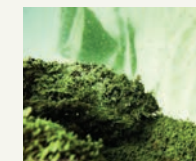
Honeycomb Moray Eel
© Vardhan Patankar / WWF-India



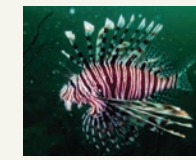
Orange Spotted Grouper
© Abhishek Jamalabad / WWF-India



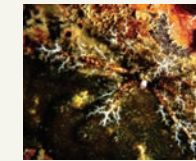
Stingray
© Abhishek Jamalabad / WWF-India



Scorpion fish
© Abhishek Jamalabad / WWF-India



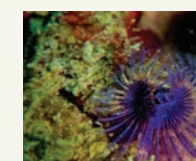
Lionfish
© Vardhan Patankar / WWF-India



Sea Cucumber
© Zoya Tyabji / WWF-India



Featherstar
© Abhishek Jamalabad / WWF-India



Fanworm
© Abhishek Jamalabad / WWF-India



Sea Squirts
© Abhishek Jamalabad / WWF-India



Coral Hermit Crab
© Abhishek Jamalabad / WWF-India



Gem Dorid
© Abhishek Jamalabad / WWF-India



Three-Margined Dorid
© Abhishek Jamalabad / WWF-India



Margined Elysia
© Abhishek Jamalabad / WWF-India



Ocellated Phyllidia
© Abhishek Jamalabad / WWF-India



Sea Urchin
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Marine Litter
© Vardhan Patankar / WWF-India

THE SIGNIFICANCE OF CORAL REEFS

For a habitat that is estimated to make up just 0.1% of the total marine environment, coral reefs have long been the centre of conservation attention and with good reason. Reefs around the world are home to over 25% of the earth's marine biodiversity, making them a small but critical habitat for us to protect.

Coral reefs play a vital role in supporting the biodiversity and resilience of a marine ecosystem. Reefs function as nursery grounds, aiding in the growth of a large number of commercially important and iconic fish species, before they head out into open waters. The high biodiversity and accumulation of nutrients in a reef enables a range of species with differing diets and nutritional requirements to co-exist in the same habitat. This contributes towards the health and output of fisheries, provides tourism opportunities, and has enormous aesthetic and cultural value.

The productivity and diversity of coral reefs around the world is on the decline. Average live coral cover has been decreasing across tropical oceans, with repeated disturbance events reducing the ability of reefs to recover. There is a gradual change in the nature of coral reefs, with the distribution and diversity being affected by small and large scale anthropogenic disturbances. Mass bleaching events have significantly degraded some of the world's coral reef hotspots such as the Indo-Pacific, and the Great Barrier Reef in Australia which has witnessed large scale mortality in the past two to three years.

India's coral reef biodiversity is clustered around the archipelagos of Andaman and Nicobar, Lakshadweep Islands, the Gulf of Kachchh and Mannar. In the light of a changing global climate, and repeated persistent impacts on corals, the role of smaller, patchy reefs such as the reef in Grande Island have become significantly more important. There is an urgent need to study and protect our reefs, to ensure that we preserve the vast marine biodiversity unique to the region.

ABOUT GRANDE ISLAND

Grande archipelago (15.352°N, 73.773°E) situated near the Marmagoa port in Goa has patchy corals and serves as an important habitat for reef fish and other reef associated flora and fauna. The archipelago is a prominent tourist attraction primarily because of the reefs and two sandy beaches.

The island offers offers impressive underwater scenery, an old shipwreck and unique reef formations characterized by large plate corals and whip coral patches that support high biodiversity. 3000 dive tourists are estimated to visit the Island annually, contributing significantly to the local economy. Regular dive trips are conducted from October to May in suitable weather conditions.





MARINE TOURISM AT GRANDE ISLAND

Following global trends, marine tourism in Goa has been growing exponentially, attracting an increasing share of tourists who frequent the state. Marine tourism comprises both recreational and nature-based tourism. Recreational tourism includes fishing and water sports such as riding water scooters, water skiing, para sailing, jet-skiing, kayaking, canoeing, rafting, wind surfing, riding banana boats, sailing, and yachting while marine nature-based tourism includes watching Indian Ocean Humpback dolphins on tour boats, snorkeling, tour boat-based visits, and scuba-diving at the Grande Island archipelago.

Initiated in the late 1980s, and early 1990s, marine nature-based tourism started out when a few local fishers at



Dona Paula jetty in Goa took tourists out on boats to watch dolphins, and visit the Grande Island archipelago. Roughly two and a half decades later, the industry has spread to cover the length of the Goan coastline. It is estimated that during the peak tourist season, up to 700 boats operate for marine nature-based tourism activities throughout the day. While the reefs are protected by the Wildlife (Protection) Act (1972), tourist activities are more than likely to impact them.

WWF-India undertook a survey of the reefs around Grande Island to assess the ecological impact of tourism on the biodiversity in the reef. During our survey we encountered and photographed amazing and rare species of corals, fish and other invertebrates, some of which have not been previously recorded at the site. This book captures a minute part of the vast and vibrant marine biodiversity present in the reefs of Grande island through its pictures and is intended to serve as a reminder of the need to protect this stunning habitat.

IDENTIFYING CORALS

For marine enthusiasts and divers corals are often very complex organisms to identify. Most are formed as colonies made up of multiple clones of polyps. It is estimated that a single coral polyp take around 10,000 years to form a coral reef. More extensive reefs can take anywhere between 1,00,000 to 3,00,00,000 years to form¹.

FAN-SHAPED

Corals are categorised based on whether they are hard or soft and further broken down by general shape, such as branching or columnar, fan shaped or massive boulders, among others. Then individual corallites (cup-like skeleton of a single polyp) are examined closely, to look at the structure of ridges and the presence of key features. This makes identification in the field a laborious process, often needing photographs which can be examined at a later time.



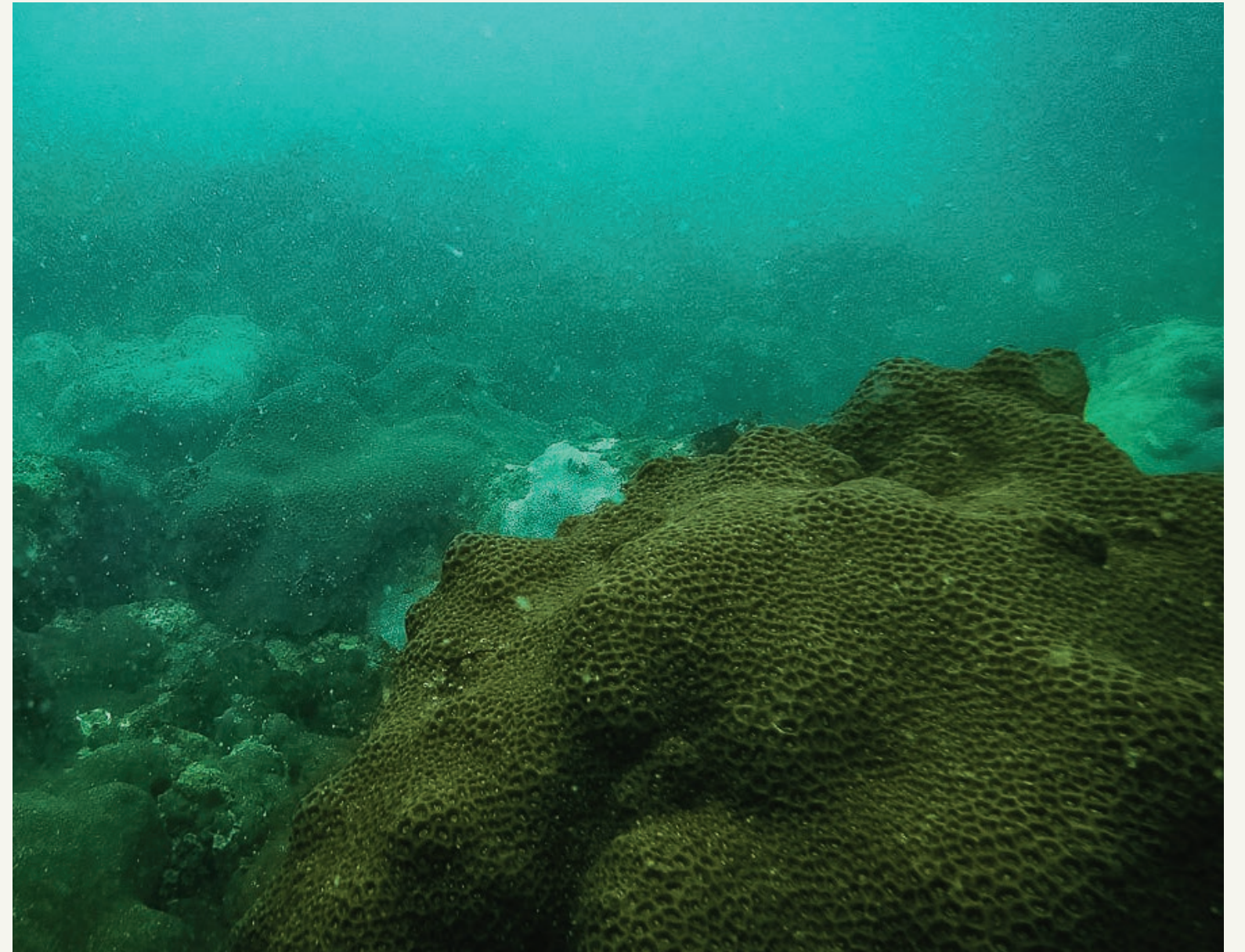
Estimating substrate cover was one of our most strenuous tasks, and the one that always caused most of us to run low on air in our tanks! A grid was placed at marked points along the transect belts, and the proportions of different substrates within it were noted.

¹https://oceanservice.noaa.gov/education/kits/corals/coral04_reefs.html



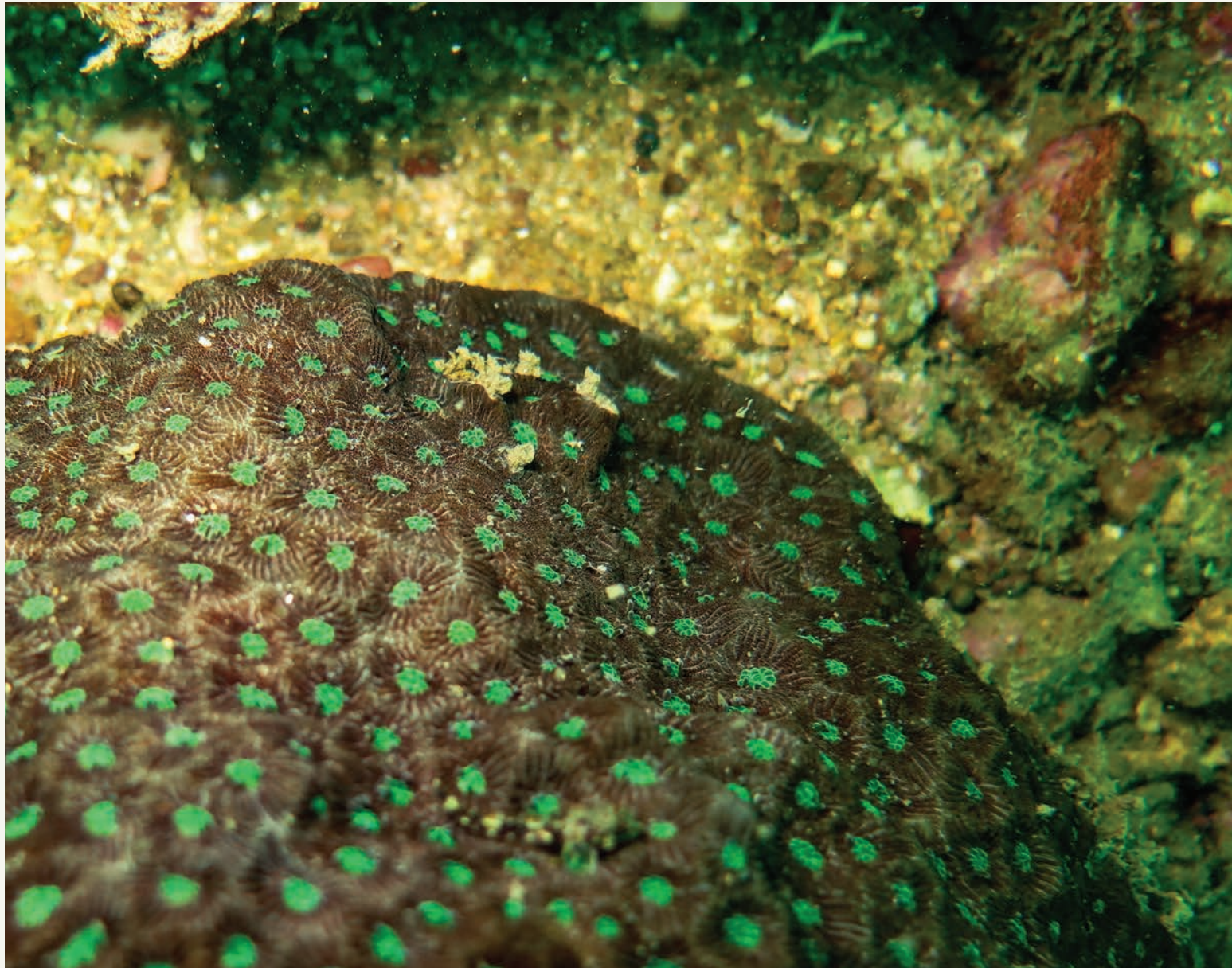
PLATE CORALS

The reefs in these coastal areas are unlike the reefs you would see on postcards. One of the most prominent corals here is *Turbinaria*, which grows as flat plate-like colonies. At some sites, they are truly extensive, with plates the size of dining tables spread out as far as the eye can see even on a clear day.



MASSIVE CORALS

Living in shallow waters that are cloudy with the sediment emptied here by large rivers, these corals are of a resistant type – a handful of species that are specialists. Massive corals are found in these reefs and usually take on a boulder-shaped appearance. These corals are relatively slow-growing but tend to have very stable lives.



ENCrustING CORALS

Encrusting corals are polyps that stick to and grow on hard rocky surfaces. these corals are better suited to survive stormy conditions due to lesser chances of breakage. The disturbed and sediment heavy nature of the water around Grande Island, has resulted in more plate, massive and encrusting coral growths than branching or columnar ones.



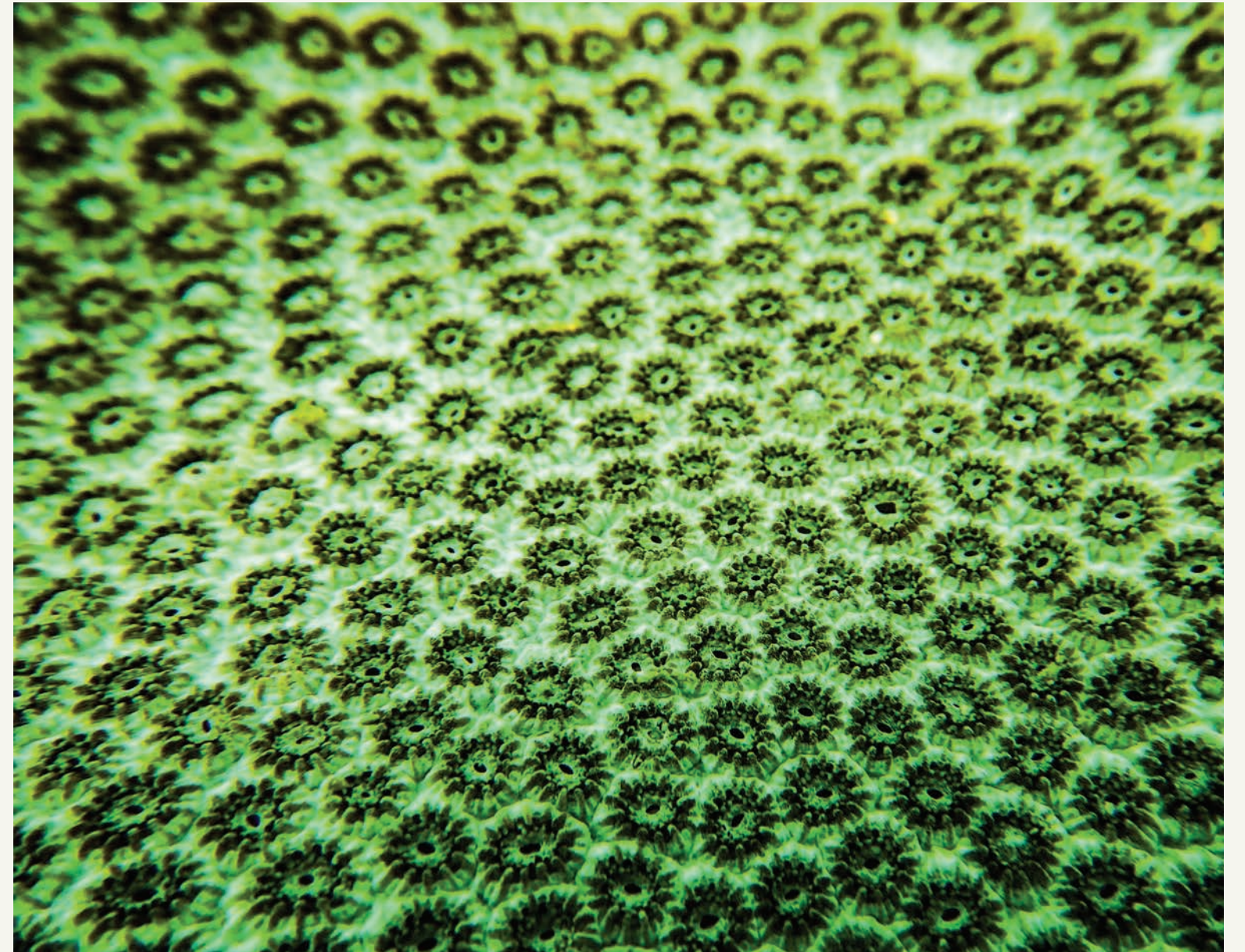
FLOWERPOT CORALS Goniopora

These corals, with their soft, fleshy polyps that sway with water currents, are often mistaken for soft corals, but are in fact hard corals with stony skeletons at the bases of the polyps.



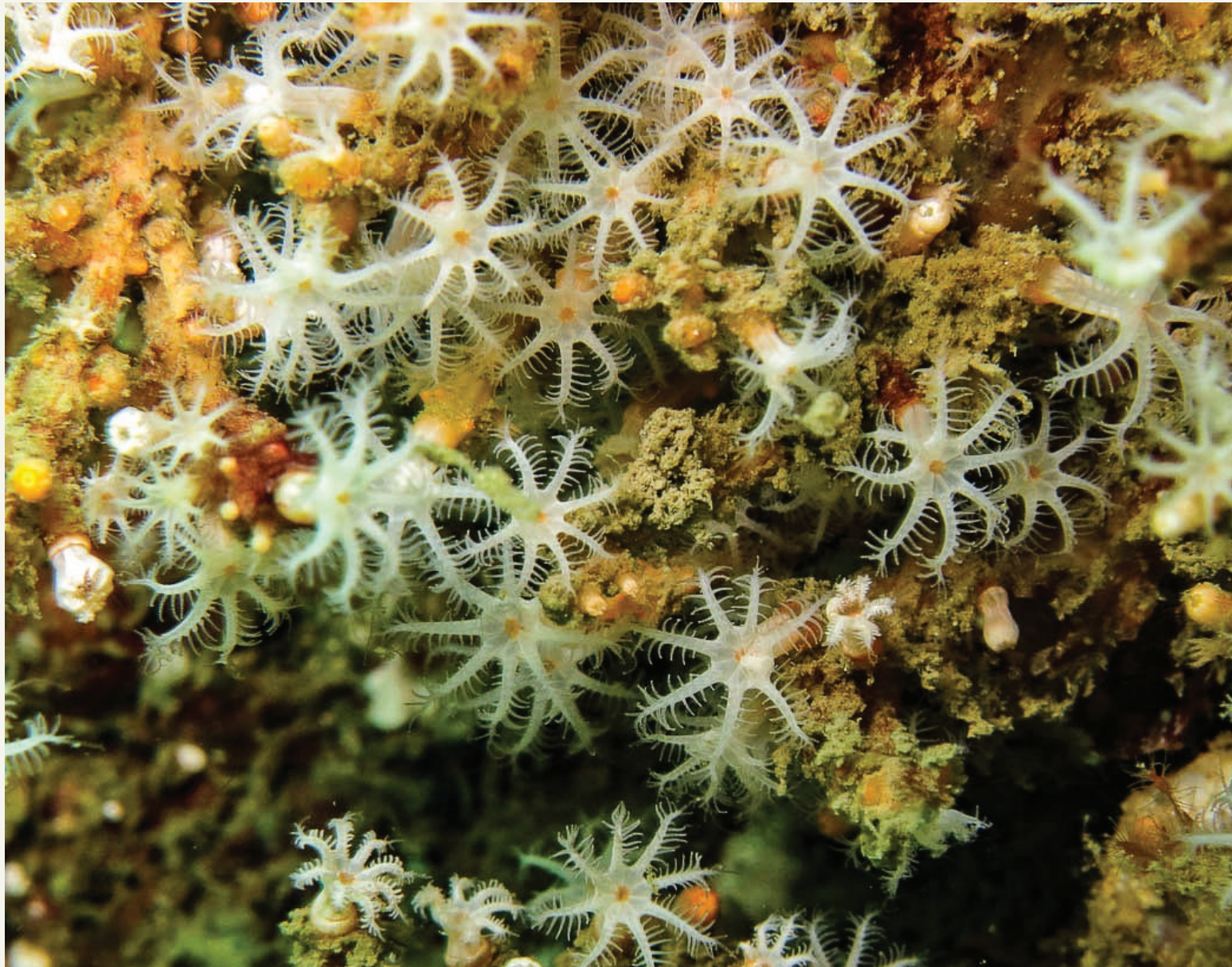
WHIP CORALS

Whip corals are soft coral, which do not construct a hard calcium carbonate skeleton. Being fragile and inhabiting the sea floor, these are among a range of species severely affected by bottom trawling, which clears vast tracts of the sea floor, taking coral, sponges, algae and bottom dwelling invertebrates, among others.



CORAL POLYP COLONIES

Coral polyps cannot photosynthesis and depend on Zooxanthellae, tiny algal cells, that provide them nutrition. These cells have been seen to transfer up to 90% of the nutrition obtained from photosynthesis to their hosts.



SNOWFLAKE CORALS

Clavulariidae

These are highly invasive species of soft coral that outcompete other species on reefs and artificial structures not exposed to direct sunlight. They are particularly successful at invasion due to fast growth rates and early sexual maturation. The species have also been reported from Andaman and Nicobar Islands, Gulf of Mannar, Lakshadweep Islands and Gulf of Kutch.

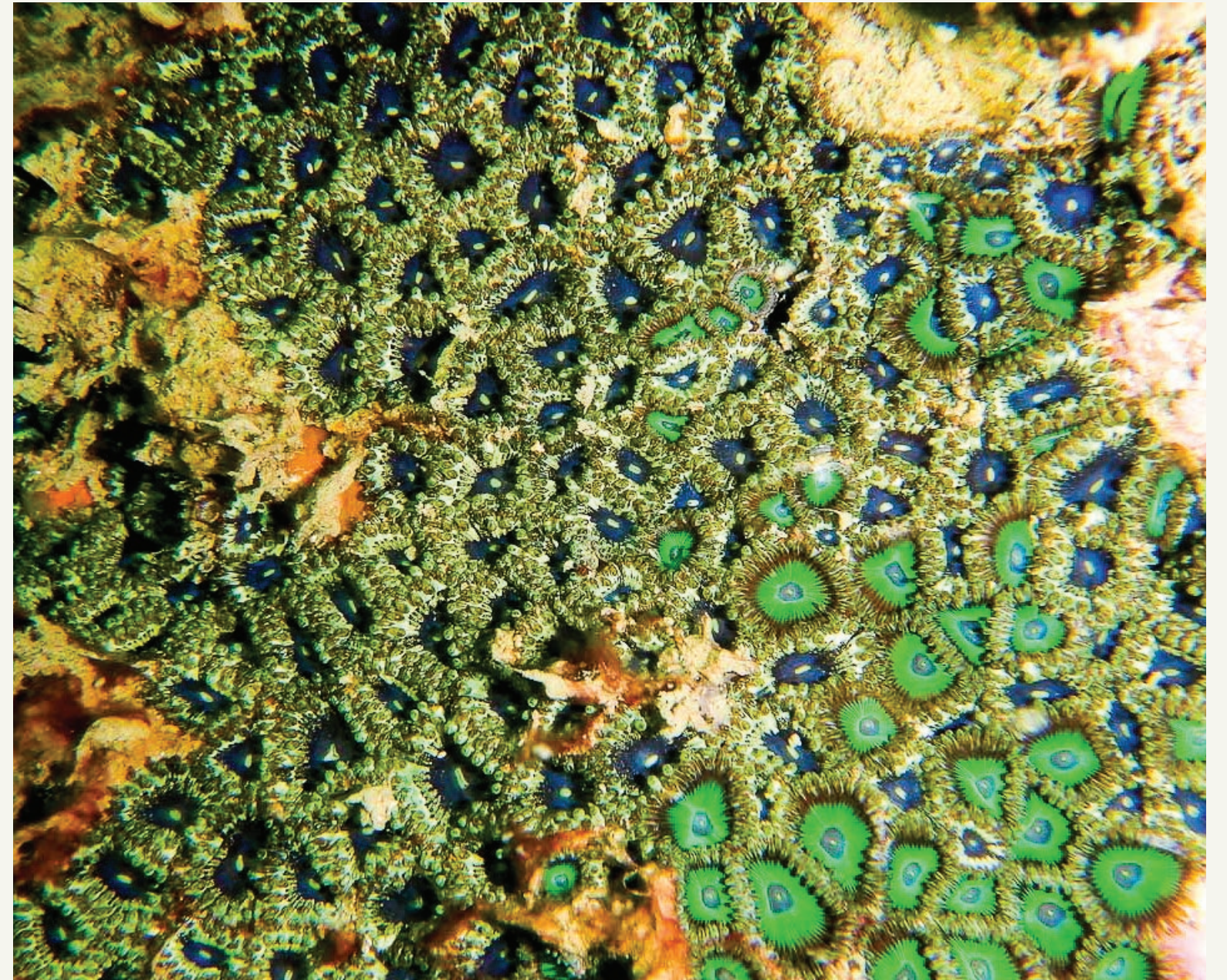


CORAL-ALGAL PHASE SHIFT

Corals are very sensitive to changes in their habitats. “Phase shifts” occur when algae takes over a coral reef, following the loss of coral cover. Corals may die from bleaching events, storm damage, loss of reef fish, or disease, and algal dominance is established.



These patchy reef systems are by no means quiet. Many of the sites we surveyed were bustling with crowds of busy reef fish, like an underwater metropolis. Hordes of red-tooth triggerfish swim around slowly, lone groupers and moray eels quietly lie in their crevices, huge armies of territorial damselfish hover above their patches of turf, and gangs of parrotfish prowl around the reef looking for corals to nibble on.



ZOANTHID
Zoanthus sansibaricus

This species of zoanthid, was recorded multiple times during the dive surveys. Green, pink, blue and orange colonies were seen for the same species!



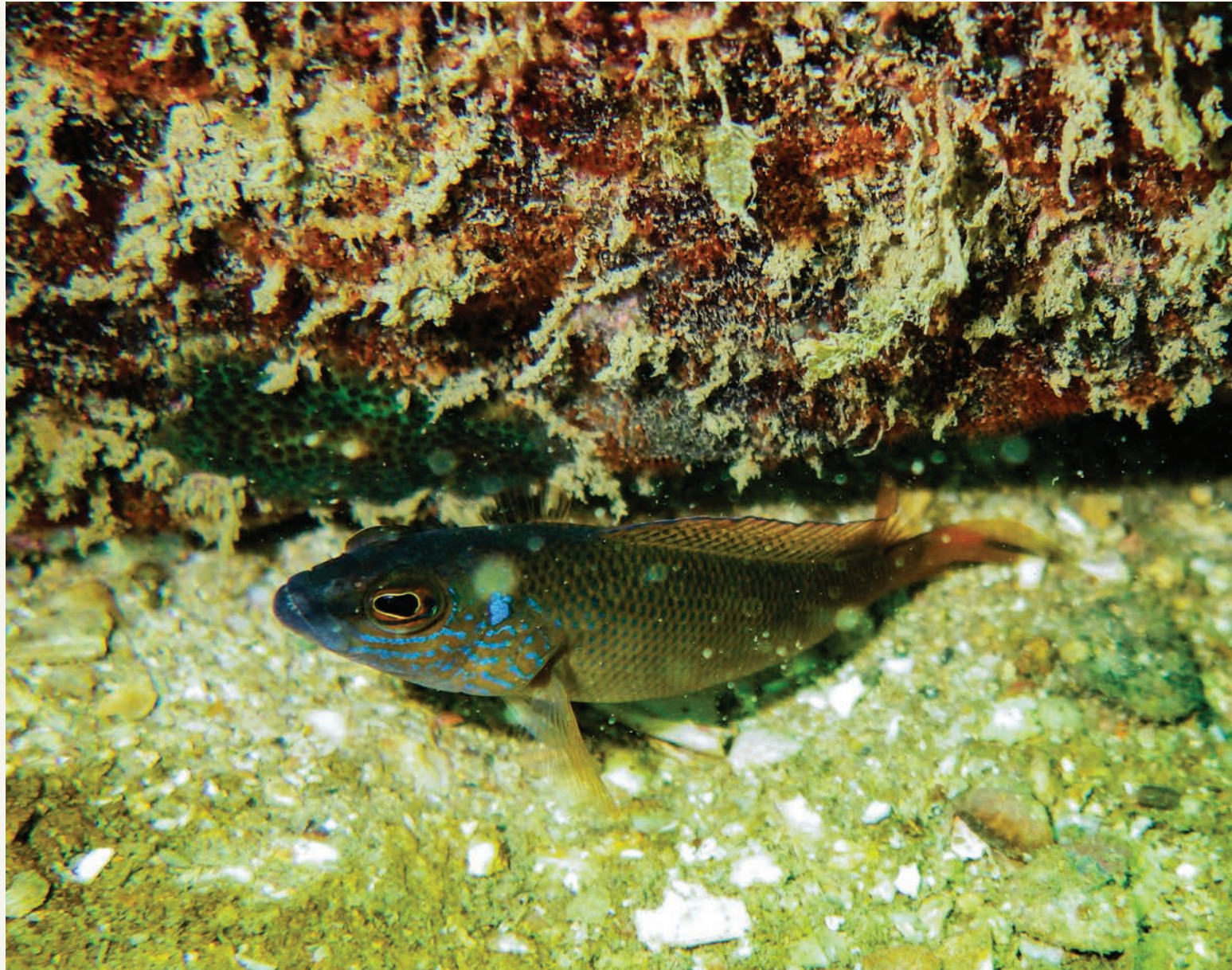
DECORATOR CRAB
Majoidea

Decorator crabs such as this one can be hard to spot on the reef. They get their name from their habit of camouflaging themselves by actively planting growth from their surroundings onto themselves, so each decorator crab resembles the biological neighbourhood it lives in.



ROBUST GHOST PIPEFISH
Solenostomus cyanopterus

Related to seahorses, pipefish float vertically, mouth down and suck up invertebrate prey from the ocean floor. Unlike seahorses ghost pipefish males do not incubate eggs; however, they are monogamous like other related fish.



DOTTYBACK

Pseudochromis tapeinosoma

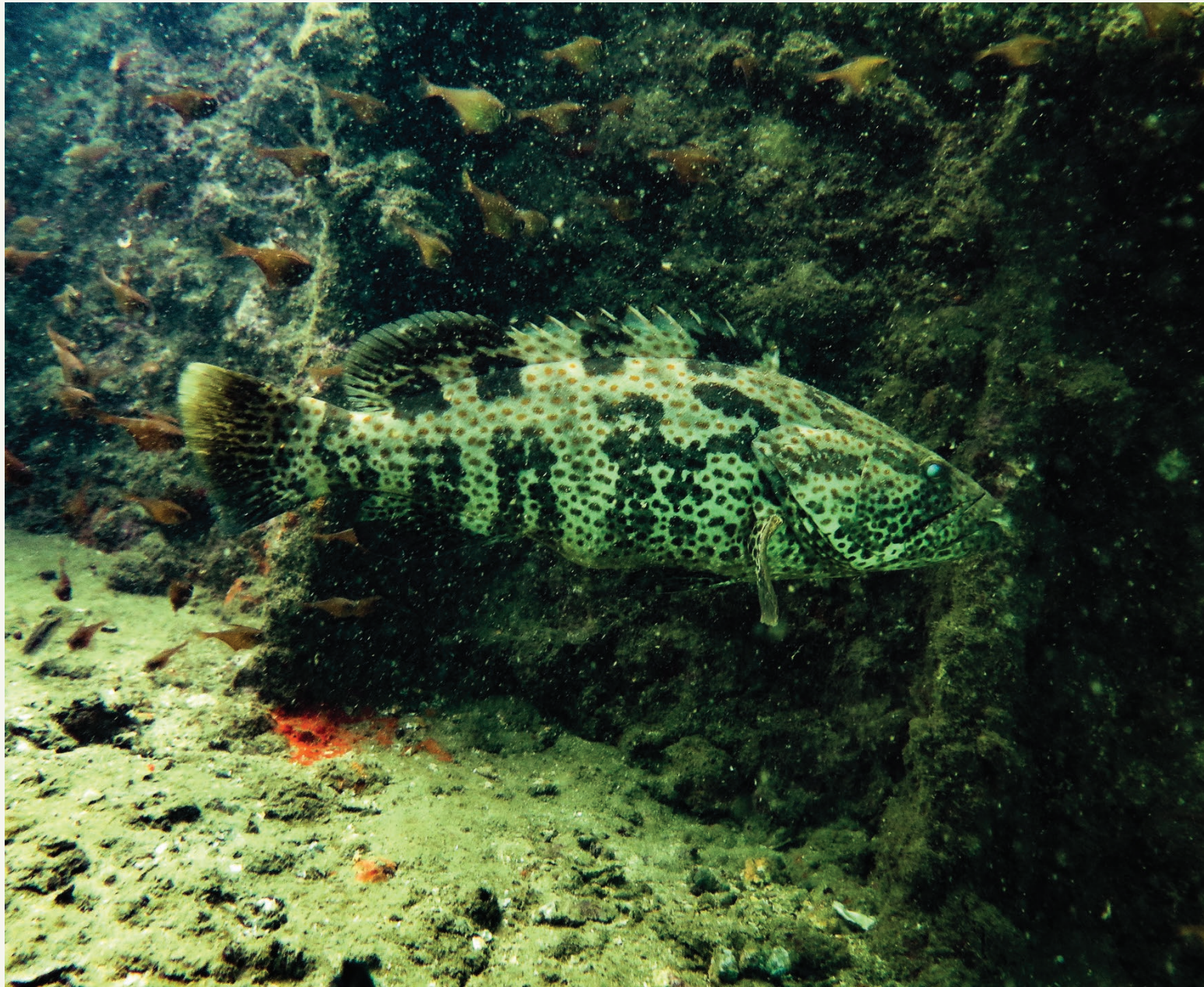
During our surveys, this species of dottyback, was observed being highly territorial and quite fearless of divers, standing its ground outside burrows, usually under small outcrops of coral. In addition, they displayed unusual behaviour, such as moving little bits of shell from place to place, seemingly for decorative purposes.



HONEYCOMB MORAY EEL

Gymnothorax favagineus

Some species of moray eels have two sets of jaws; one for grabbing prey and one that reaches up from behind its skull to grasp and transport prey back into the throat, assisting in swallowing.



ORANGE SPOTTED GROUPER

Epinephelus coioides

IUCN Status: Near Threatened

A popular food fish, global populations of this species and other groupers are declining due to water pollution, overfishing and habitat loss for residential and commercial development.



STINGRAY

Dasyatidae

Stingrays inhabit the sandy seabed surrounding and interspersing the reefs at Grande island. Though sometimes seen swimming, they are most often encountered hidden under the cover of sand, like this one.



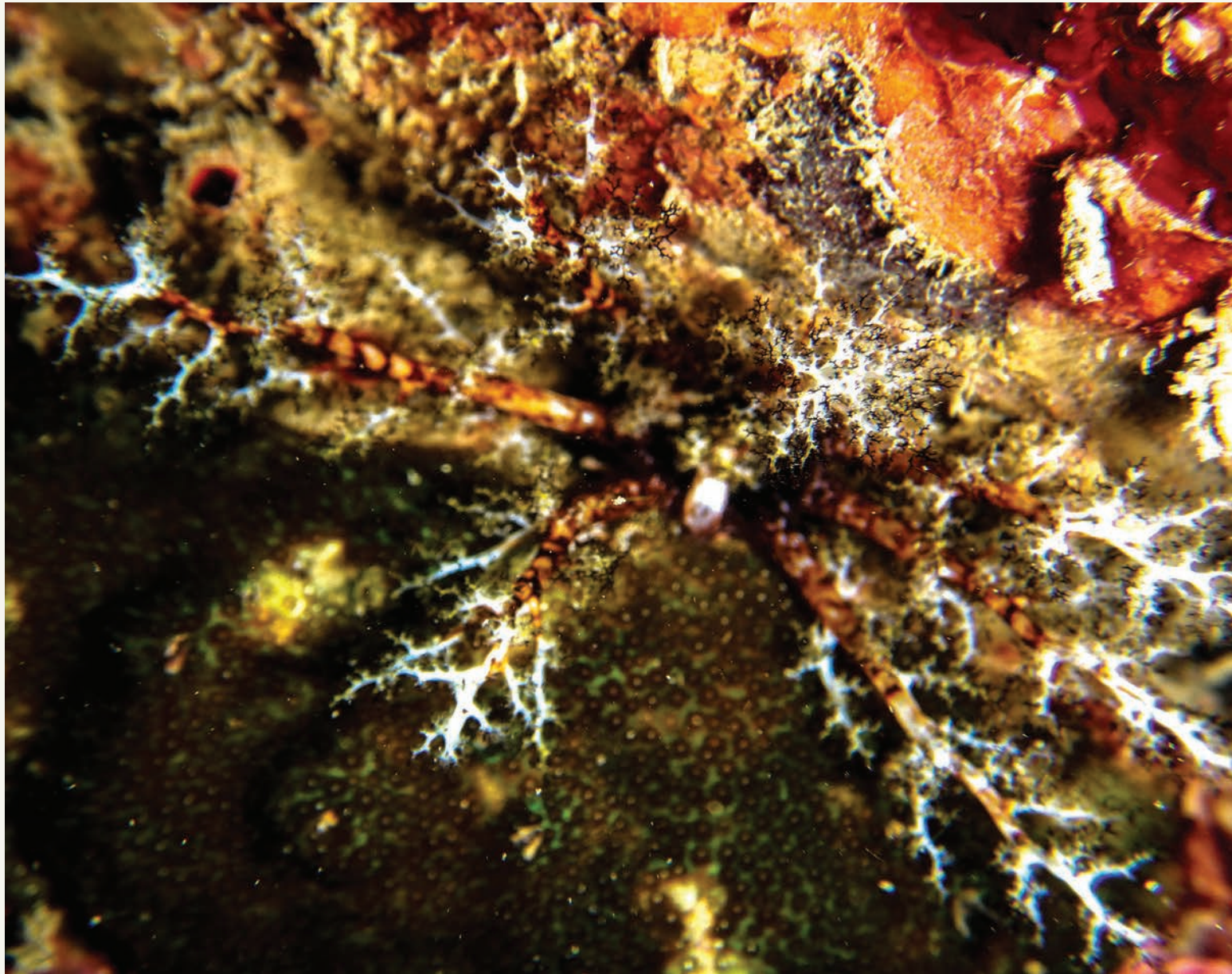
SCORPION FISH
Scorpaenopsis sp.

The family Scorpaenidae includes some of the world's most venomous fish. The venom is delivered through fin spines, inflicting serious and sometimes fatal wounds on humans. The venom of some species has been shown to have therapeutic properties, showing anti-microbial and anti-tumoral effects.



LIONFISH
Pterois miles

Found in Indo-Pacific waters this species, has proven to be highly invasive. They are not picky with their diet, and can feed on a variety of fish irrespective of area. They spawn yearly, and have venomous spines along their back for self-defence, making them extremely competitive.



SEA CUCUMBER Holothuriidae

Sea cucumbers extend a mass of branched tentacles (seen here) around their mouth to reach out for food. Some species eject sticky portions of their respiratory organs at attackers, while others cut off and release parts of their organs as decoys against attackers. Lost parts are then quickly regrown.



SEA SQUIRTS Ascidiidae

Ascidians are marine filter feeding invertebrates, related to sponges. Thousands of natural products have been isolated from ascidians. Being stationary on the sea floor, ascidians manufacture a range of chemical compounds to escape predation. Many drugs have been developed using such compounds.



FEATHERSTAR

Crinoidea

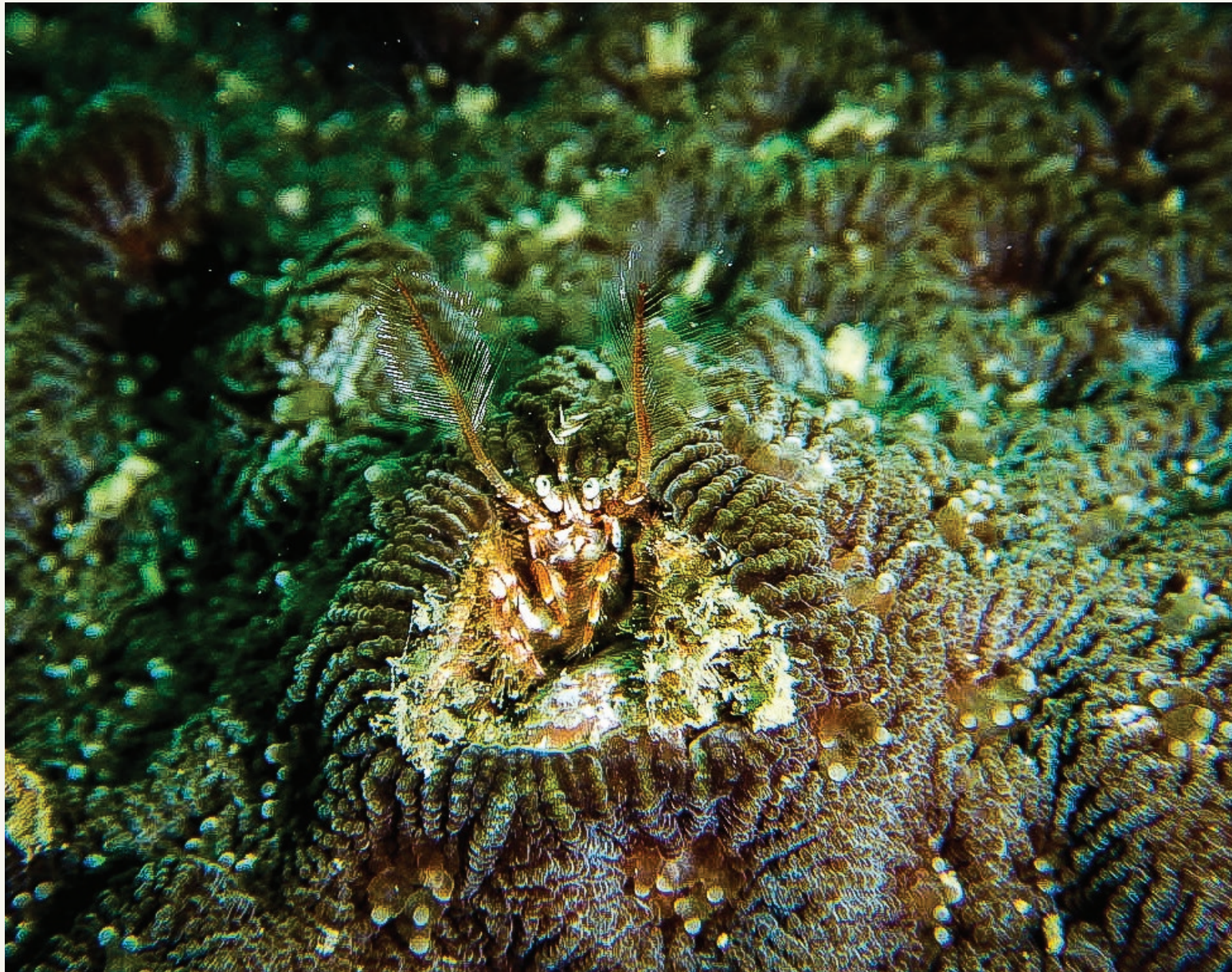
Featherstars, also known as Sea Lillies, are increasingly being harvested for trade. Global export of ornamental species has been on the rise over the past 3 decades, with 50-60% of the demand being met by Asian countries. India is considered among the top ranking countries globally, in terms of ornamental fish reserves.



FAN WORM

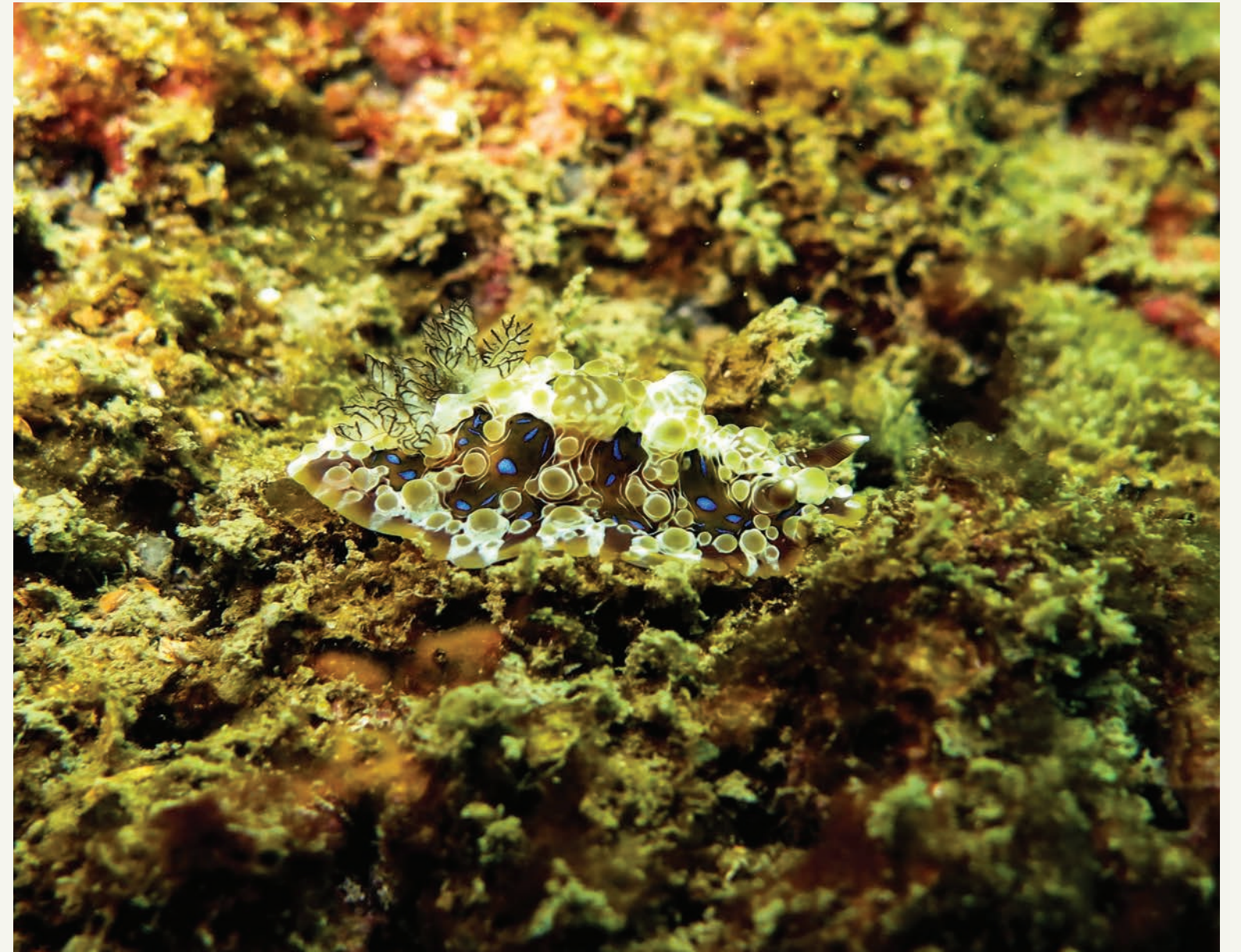
Sabellidae

Fan worms are another marine species that are exploited in Indian waters to supply the ornamental aquarium trade. While India's contribution to the global ornamental marine trade is currently insignificant, rising trends indicate that the sector is in need of close monitoring.



CORAL HERMIT CRAB
Paguridae

Paguritta are a genus of hermit crabs, whose species have found a niche for themselves, living in self-created boreholes or tubes left behind by polychaete worms in coral. They also differ from other hermit crabs in that they completely depend filters are located on modified versions of their antennae for feeding, as seen in the photo.



GEM DORID
Dendrodoris denisoni

Opisthobranchs, commonly known as sea slugs or sea hares, are marine molluscs, characterised mostly by the reduction or absence of a shell. Previous studies have found that approximately 400 species exist in Indian waters.



THREE-MARGINED DORID
Goniobranchus trimarginatus

Nudibranchs are hermaphrodites, and both receive and deliver sperm. Some species of Chromodoris have been seen to leave a portion of their penis behind after mating. This is of very little concern to them, being equipped with upto two spares.



MARGINED ELYSIA
Elysia marginata

Elysia is a genus of shell-less sea slugs that are able to retain chloroplasts ingested when feeding on green algae and use them to photosynthesize. In addition, the green colour imparted on the slug might facilitate camouflage. Nudibranchs, usually found in near shore waters, often feature intricate patterns in striking colours.



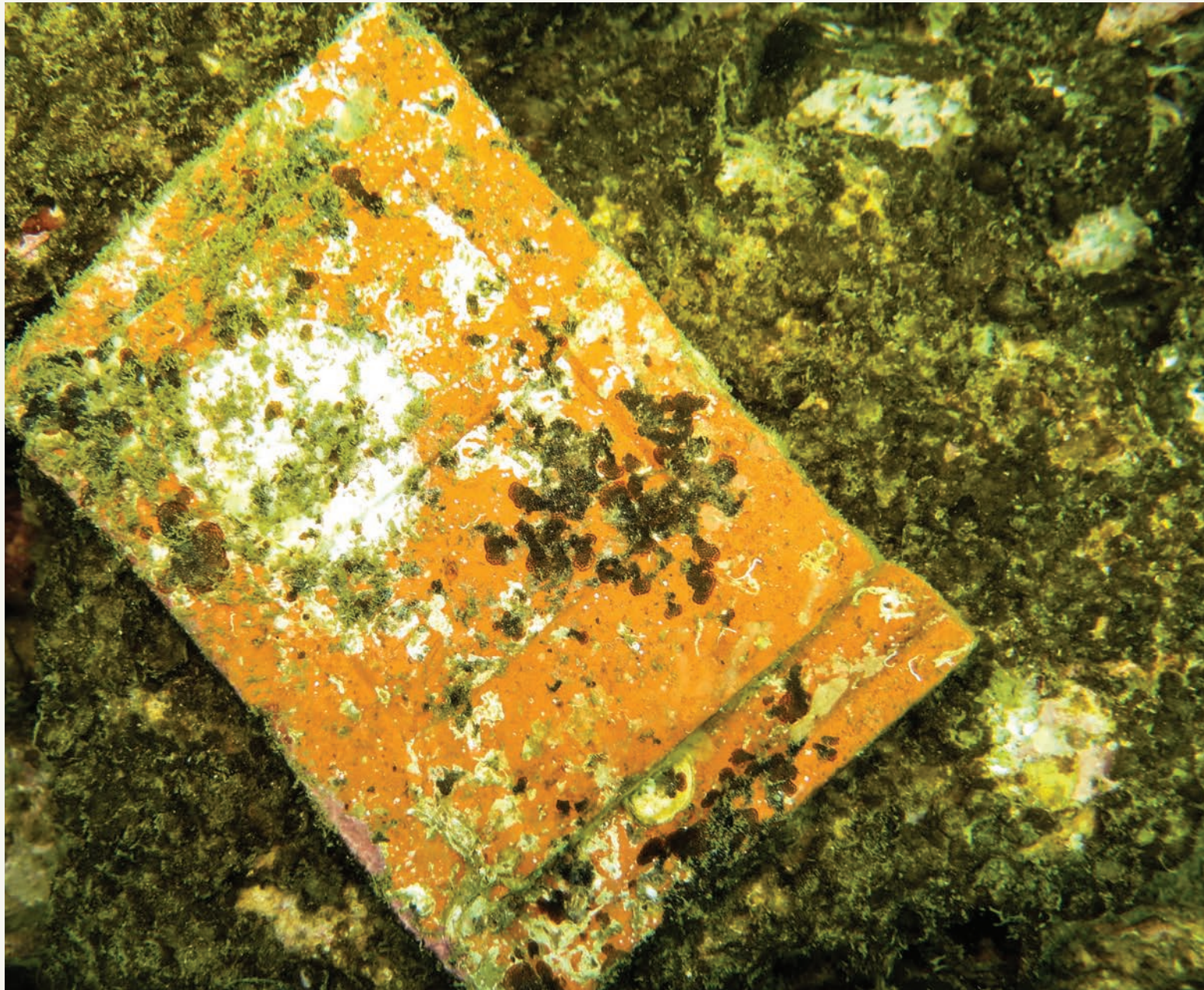
OCELLATED PHYLLIDIA
Phyllidia ocellata

This nudibranch sea slug is commonly found at dive sites around Grande Island. As advertised by the colours, these sea slugs are toxic, secreting a pungent mucus that deters predators. Despite their relative abundance, there is very little known about these slugs.



SEA URCHIN
Diadema sp.

Sea urchins act as grazers on the reef, feeding on algae and in turn, become prey for a number of carnivores. Having such a prominent role in the food web, and being easy to sight and monitor, sea urchins are therefore a good indicator of reef ecosystem health over extended periods.



It is worth noting that we did not see high levels of garbage at Grande Island. This is thought to be, at least in part, due to the recent reef clean-up activities conducted by dive schools and volunteers. The requirement of permits to visit Grande Island has also helped control the number of tourists on the island consequently controlling the waste generated here.

Our survey provided the first comprehensive overview of the Grande Island reef status and a detailed quantification of corals, reef fish, invertebrates and garbage on the reefs. Overall we found that while these reefs have largely been left out of conservation efforts, they are very much alive and abuzz with unique assemblages of biodiversity.

While tourism in the region is a source of livelihood to many, it is also as an eye-opener to marine biodiversity and its conservation. There is little doubt, therefore, that the sustainability of the activities happening here is of utmost importance, and an immediate priority. To ensure that the reef continues to stay healthy, it is important to put in a place a long-term periodic monitoring system of pre-selected ecological indicators and for local stakeholders to collectively agree on indicators and involve themselves in monitoring activities.

HOW CAN YOU HELP?

Every trip to the beach invariably sees the odd flip-flop or water bottle left behind and eventually washed to sea. A lot of corals and clams end up in little containers in living rooms where they have little purpose except to serve as as morbid reminders of a habitat we're slowly destroying.

Addressing declining marine health is a matter of global concern and one that needs all the help it can get. While cleanup solutions and sustainable alternatives to plastics are being developed, prevention is still our best solution. Beyond ingenious scientists working on global solutions, and passionate conservationists preaching against plastic, a lot of progress towards healthy seas banks on regular people being just a little bit more conscious about their choices and behaviour.

To know more about steps you can take to help protect our oceans scan the QR code below or visit us at https://www.wwfindia.org/get_involved/



ABOUT THE CONTRIBUTORS



AJAY VENKATARAMAN

Ajay is a marine biologist who enjoys diving, mucking around in estuaries and swimming in the open ocean. He takes avid interest in the connectivity between coastal and marine habitats. Ajay divides his spare time between football fields and mountain trails.



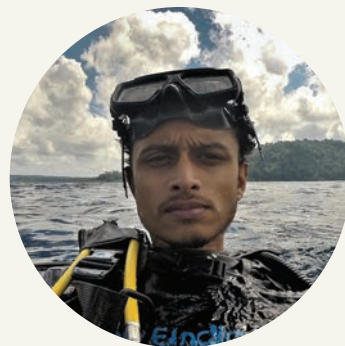
GAURAV PATIL

Gaurav is a marine biologist based in Mumbai, currently working as a freelance writer, illustrator and photographer. He is also part of a citizen driven initiative known as 'Marine Life of Mumbai', which has fuelled his interest in the intertidal zone. He also takes keen interest in fish taxonomy/ecology.



VARDHAN PATANKAR

Vardhan is a DST-INSPIRE faculty fellow working with WCS-India and NCBS. He currently focuses on documenting patterns and processes of reef ecosystem and describing ongoing shifts on reef ecosystems caused due to the impacts of humans and climate change.



ABHISHEK JAMALABAD

Abhishek is a Programme Officer with the WWF-India Marine Programme in Goa. He has completed his Masters in Marine Biology and currently works on a variety of projects involving marine mammals, coral reefs, seashore biodiversity, fisheries and outreach & education about marine habitats.



CORALIE D'LIMA

Coralie D'Lima is an interdisciplinary scientist focusing on the interface between social sciences, environmental economics, and natural sciences of Marine Conservation and Fisheries Sustainability issues. She currently manages WWF-India's Goa office as Senior Programme Coordinator



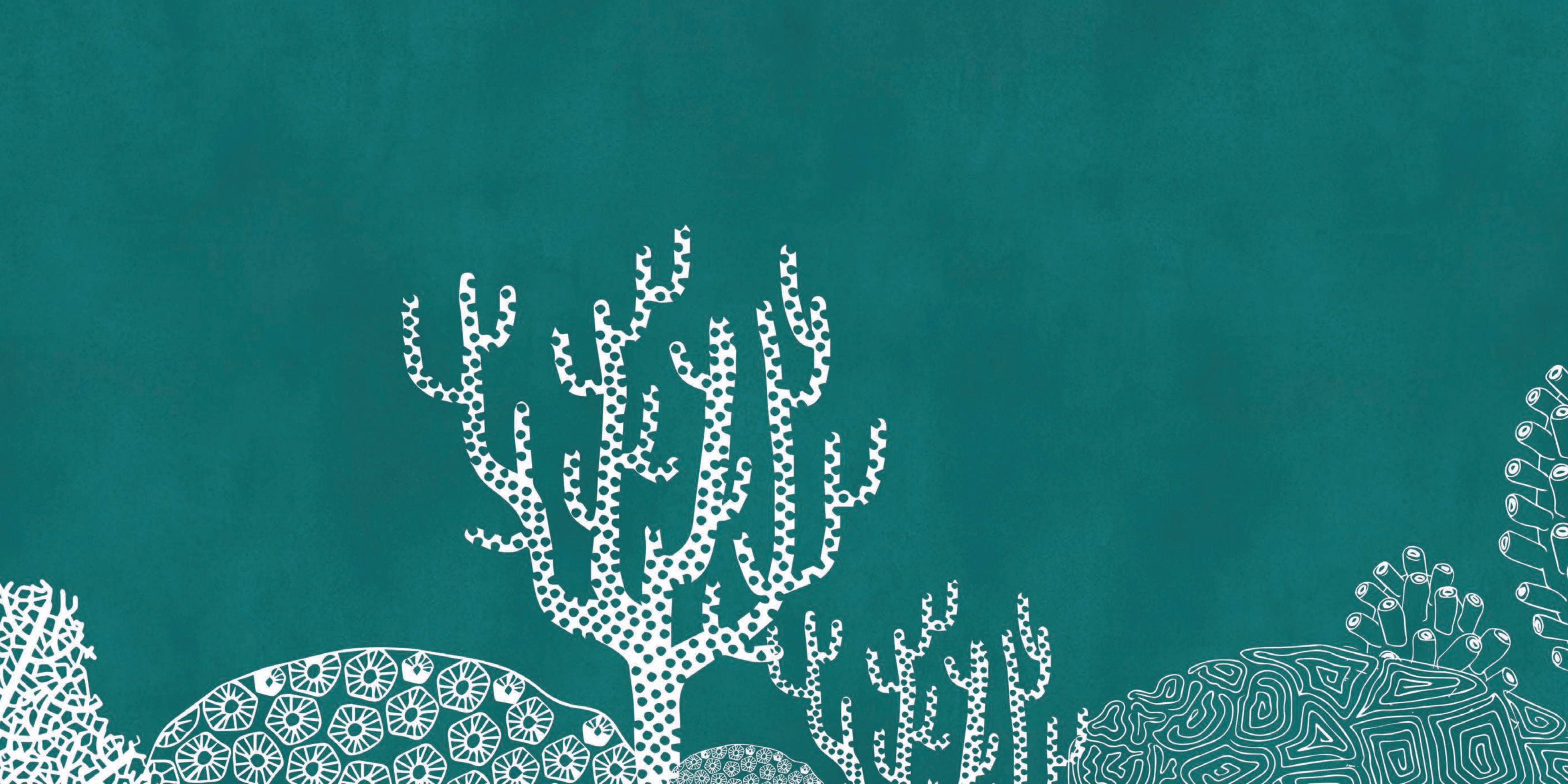
ZOYA TYABJI

Zoya is a researcher assessing the conservation status of elasmobranchs in the Andaman and Nicobar Islands, India. Her main interest lies in marine ecology, particularly in elasmobranchs and the coral reef ecosystem; and issues pertaining to biodiversity conservation.



TANMAY WAGH

Tanmay has long been intrigued by marine ecosystems and the intricate ties coastal communities share with them. His research focuses on coral reefs in the Andaman islands, their response to changing climatic regimes and anthropogenic pressures, and the role of certain species in structuring these ecosystems.





Why we are here

To stop the degradation of the planet's natural environment and to build a future in which humans live in harmony with nature.

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