ACE Diver Manual

Andaman Coral Ecologist :
A citizen science protocol for
coral reef monitoring

ReefWatch
Marine Conservation

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Introduction

Welcome to the Andaman Coral Eco-Diver Course! As scuba divers we are extremely privileged. We get to explore an incredible space – a place all life on Earth sprang from. In a romantic sense we are allowed the opportunity to go back to our collective roots. However in a more practical sense we are accessing a space that has since become alien. We need a scuba tank and regulators to breathe here. We need fins added to our feet to move effectively. We need a mask to be able to see clearly.

And the training that allows us to use all these tools efficiently gives us a glimpse of a beautiful ethereal world. Here in the Andaman Islands, scuba diving brings you face to face with coral reefs – full of colour and life, you might make eye contact with a sea turtle, brush fins with a fish, be glared at by a grouper or be kissed by a cleaner wrasse.

As a diver you probably cherish these experiences and have developed a closer relationship with the ocean than most other people. Participating in this course – becoming an ACE diver – gives you a perfect way to give back to the ocean as you enjoy its beauty. Through this course you will learn about reef ecology. You will learn about the function of certain species of fishes and invertebrates and how to identify them. You will also learn scientific techniques of collecting data while scuba diving, and the data you collect during your course dives will directly help scientists and officials working on conserving the coral reefs of the Andaman Islands.

Participating in this course makes you a citizen scientist and a conservationist and through this activity you fulfil some of the responsibility that the great privilege of being an underwater explorer gives you.

PREREQUISITES & COURSE OUTLINE:

Participants must:

- Be Open Water Diver Certified
- Have at least 10 logged dives
- Prior to diving the survey sites, the participant must demonstrate good buoyancy skills (to the satisfaction of the Instructor). These should include basic hovering, diving with fins above head level, fin pivots and ability to fin without stirring the substrate.

Course Outline :

The ideal course length is 2.5 days and 4 dives for completion. However, the course length is flexible as long as all the dive and theory components are completed. Apart from going through this book and completing the video exam at the end, you will be required to do 4 dives on data collection. Following each day of diving you will be required to input your data into the database as instructed by your dive guide.

INTRO TO CORAL REEF ECOLOGY

They look like rocks, behave like plants while actually being a colony of clonal animals – and as a result corals confounded the scientists trying to classify them for a long time. Belonging to the Kingdom Animalia in phylum Cnidaria, corals are in fact tiny soft bodied animals, called polyps and are closely related to jellyfish. Like jellyfish they have little tentacles, a single opening that acts both as the mouth and the anus and have stinging cells called nematocysts in their tissues. Unlike jellyfish however, the tentacles of a polyp is home to algae called zooxanthellae. These zooxanthellae are what gives coral their plant-like behavior and subjects them to the same restrictions. The algal cells photosynthesize – hence require sunlight, warmth and micronutrients – and pass on most of the energy they make to the coral polyp which uses some of it to combine calcium and carbonate ions in seawater to make calcium carbonate. Over thousands of years, layer by layer, coral polyps secrete calcium carbonate to eventually make the massive stone-like structures underwater that we call coral reefs. Despite being very small soft bodied animals with no Central Nervous System, no eyes and no brain, they have together managed to build the largest structure to ever be built on Earth by any living being – this includes anything built by humans!

There are currently around 1317 described species of hard corals and this results in all its different shapes – branching, boulder, brain, encrusting and so on. All this structure provides the perfect home for small fish and invertebrates who in turn provide food for larger ones and so on, making coral reefs incredible biodiversity hotspots. At the phylum level they display even more biodiversity than tropical rainforests and hence they are often referred to as 'rainforests of the ocean'. Though they cover only 0.02% of the ocean's surface, they are home to more than 30% of the ocean's life.

Corals have evolved on our planet around 500 million years ago in the Late Cambrian Era and over time have become the complex and diverse ecosystems we see today. However, as suggested by the tiny section of the ocean they occupy, they can only exist in a narrow bandwidth of abiotic and biotic conditions. Here are some of the conditions corals require:

Temparature

Corals are highly sensitive to temperature changes in the water, they thrive in a narrow temperature bandwidth of 22°C to 28°C, though are able to survive anywhere between 18°C and 30°C. When sea surface temperatures soar to over that – thanks to changing weather patterns, global warming or repetitive El Nino events – the fundamental relationship between coral polyps and their symbiotic zooxanthellae breaks down, leading to the former expelling the latter out of its tissue. Without the pigments of the zooxanthellae, the polyp tissue becomes clear, revealing the white calcium carbonate structure beneath it. This phenomena is known as 'coral bleaching' and leads to a severe weakening and eventual death of the coral unless there is a timely drop in temperatures.

Water Quality

Though polyps do feed on passing plankton, they rely on their photosynthesizing zooxanthellae for a large part of their energy requirement. For the zooxanthellae to photosynthesize, they need light. Sunlight can only sufficiently penetrate seawater in the tropics (where the angle of the rays are almost perpendicular) and where the seawater is clear. Particulate matter in the water reduces its clarity as it deflects the sun's rays as they enter.

Seawater can be unclear due to sedimentation and muddy run-off from land washing into the ocean

due to rainfall. This usually happens where there has been extensive coastal development and the clearing of forests and mangroves.
Seawater can also be unclear due to high nutrient levels that cause plankton blooms. Generally warm, tropical waters hold far fewer nutrients than cold, polar waters – making them ideal for corals – however anthropogenic influences such as untreated sewage inflow can reduce water quality. High nutrient waters are doubly threatening to coral reefs. Not only do they reduce the clarity and therefore the sunlight entering the water, but they also can lead to macro-algal blooms that grow faster than and smother corals. Macro-algae and corals are in constant competition. In low nutrient waters, the structure-giving, habitat-creating corals fare better. The trace micronutrients that zooxanthellae need to photosynthesize is provided to it by the polyps, from the plankton it captures in its tentacles and eats. Macro-algae by comparison, unaided by polyps, need a lot more nutrients to grow. Conversely, in high nutrient waters, the macro-algae – soft, wavy and very limited in its habitat creating ability – is favoured over the slow growing coral. This transition of a coral-dominated ecosystem to an algal dominated ecosystem is known as a 'Phase Shift' and is not always reversible.

Symbiosis

Coral reefs, as we have seen are similar to trees in that they are living beings, while simultaneously are habitat to other living beings. While it is true that all the animals that live on a reef are dependent upon corals, it is also true that corals depend on these animals right back. For instance, many fish on the reef are herbivores – they graze on the macro-algae that might grow on a reef during periods of high nutrient inflow, thus helping corals maintain their competitive edge and not allowing the Phase Shift we had discussed earlier from occurring. Top level predators on a reef are important to the corals. They control the numbers of mid level predators, thus ensuring that sufficient numbers of herbivores that left on a reef. Other animals are filter feeders – they take process vast amounts of seawater through their bodies each day, feeding on the nutrients that may be in it and expelling it as clear, low nutrient water. Corals also depend upon ecosystems around them – mangroves for instance – that slow down the flow of the freshwater coming in from land, thus allowing most of the mud and particulate matter to settle in the mangroves instead of washing into the ocean.
In a situation where there is uncontrolled or extensive fishing on a reef, even if the methods used are not harmful in themselves (for instance, line fishing instead of bottom trawling or dynamite fishing) a change in the composition of reef fish and invertebrates can have negative consequences for the corals. Similarly, uncontrolled coastal development that involves the clearing of other island ecosystems such as forests, mangroves or mudflats, can have troubling impacts on corals reefs further out in the sea.

Structure

Coral polyps require a hard structure to grow on. The larvae will not settle on soft structures such as algae. They also require the structure to be stable – though larvae often accidentally settle on rubble or even a glass bottle on the sea floor – they will not survive if the substrate rolls around and gets smothered in the sand.

Status of Coral Reefs Today

A cursory glance at the requirements of healthy coral reefs reveals just how much human activities are affecting them. Water temperatures are rising steadily thanks to unabated fossil fuel emissions. Water Quality is steading declining thanks to the clearing of mangroves, coastal development and untreated sewage inflow due to burgeoning coastal tourism and population growth. The removal of large fish from the ocean – particularly top predators such as sharks – is changing the composition of fish species in all parts of the ocean including coral reefs. Unsustainable fishing practices such as dynamite fishing and bottom trawling regularly decimate structure – turning a reef that has taken millennia to form into a pile of unstable rubble in the matter of a few minutes. Unless effectively managed, tourism activities such as snorkeling or diving also cause structural damage to the reef from boats throwing their anchors on it, snorkelers trampling on corals or divers damaging it through poor buoyancy control and finning techniques.

Given all these pressures, 40% of the world's coral reefs are dead or highly degraded. In the Andaman Islands, studies show that we have dropped from 70% to only 30% live coral cover since the early 2000s. Given that corals only cover 0.02% of the ocean's surface to begin with, these drastic declines are a massive cause for concern. As divers, it is our privilege and our responsibility to contribute to coral reef conservation in whatever way we can.

Data Collection Methodology

Now that you know a bit about coral reef ecology you know that reefs exist in a complex balance, where many different components – both biotic and abiotic – function together to create a highly productive ecosystem.

This is why monitoring a coral reef is such an essential part of conserving it. Firstly, information gathered from our dives helps us assess the health of the reef. Regular monitoring shows us whether the reef is thriving or ailing. By also looking at the assemblages of fish and invertebrate species we can also pinpoint the reason for changes in reef health. We are able to narrow down which of the many factors – e.g. nutrient levels, turbidity, water quality, fishing pressures – that contribute to coral health is changing and therefore affecting the reef. Having this information is invaluable to coral reef conservation as it allows managers and policy makers to specifically and effectively target threats as they emerge, before their impacts become irreversible or widespread.

Our data collection methodology is designed in a way that maximizes the information we can get with practical limits of underwater survey time and scientific training. We do this by using fixed survey sites and indicator species.

Fixed Survey Sites:

Though coral reefs may cover only a small fraction of the ocean's area, it would be impossible to monitor every square inch of them in the Andamans - or even every square inch of a dive site - with a good degree of detail. To overcome the obstacles of limited bottom time and limited numbers of surveyors we use fixed sites at different depths at different parts of the islands and use these as a proxy for the larger ecosystem. Each survey is like a zoom lens applied to a wide landscape so as to see its details. We zoom in to the same location each time in order to be able to track the changes over time. A long term monitoring program is like a series of photographs over time of the same spot to be able to note the changes that are occurring seasonally and over the years.

The sites that have been chosen for our surveys are not random. They are chosen to enable various comparisons – they include variables such as depth (so we might see how shallow reefs are faring as compared to deeper ones), locations (so we might see how reefs on the west of the islands are faring as compared to the reefs on the east or how mid-water reefs are faring as compared to island-fringing ones) and land use (so we might see how reefs off inhabited islands are faring as compared to uninhabited ones) and so on.

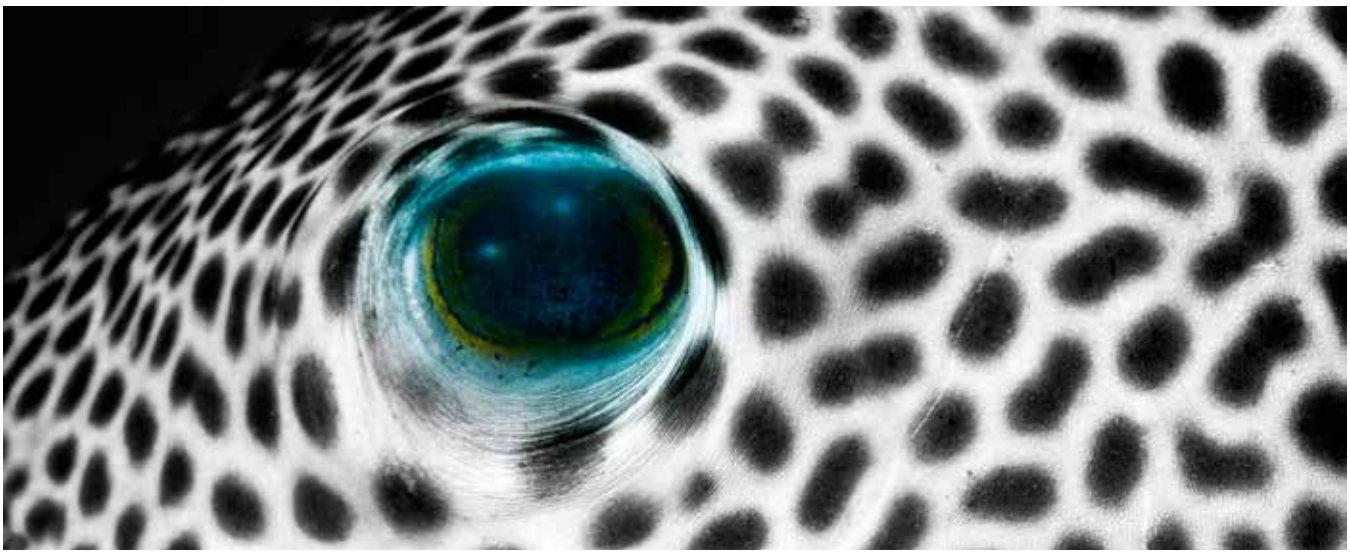
Indicator Species:

More than 4000 species of fish live on coral reefs. Reefs are also home to many thousands of species of invertebrates such as molluscs, crustaceans, arthropods and so on. Even for an ichthyologist (scientists who study fish) or a similar expert it would require years of training to be able to identify every single species that lives in the haven of biodiversity – for a nonscientist recreational diver the task would be impossible.

For this reason, we use "Indicator Species". An indicator species is an organism whose presence or absence signifies something larger about the health of the ecosystem. We use indicator species all the time in our daily lives. For instance, if you see rats running around in a restaurant you might infer something about the hygiene levels of the establishment. When you see vultures circling the sky in a distance you assume there must be something dead on the ground beneath. When sailors lost in a storm see seabirds they know land is near.

Similarly the species selected for our surveys are chosen on the basis of what their presence might tell us about the environmental conditions prevalent. For instance, flatworms require very good water quality, so an abundance of flatworms on the reef indicates the same. If we begin to see fewer and fewer flatworms over time, it might suggest a decrease in water quality in that area. By using an indicator species we are spared the high costs of sophisticated scientific instruments that are needed to measure water quality. A red-breasted wrasse requires a high abundance and diversity of small crustaceans in its diet. Measuring the number or diversity of these tiny animals is a difficult task, but seeing several of these fish on a reef immediately tells us that microscopic invertebrate life is thriving there.

As you explore the Fish and Invertebrate chapters you will learn about what each species signifies and tips and tricks to identify them easily.



Preparing the slate / Metadata

Metadata is the information about data that has been collected, which in our case is the ACE diver slate. Metadata generally has the means of creation of the data, purpose of the data, time and date of creation, creator or author of the data and standards used. The slate which is given to the diver for the ACE diver course contains information about the diver, the dive center the diver dived with and the conditions on the dive. This information is necessary and important because it helps us gauge the experience of the diver and the accuracy with which the data was logged.

The slate also contains the fish and invertebrate exam scores so that will help us understand the ability of the diver to identify the species on the reef. The dive site and the ocean conditions will help us correlate the data with the dive conditions experienced and the site at which the data was collected. Overall, this metadata will help us assess the data collected by the diver under certain conditions better.

Please take the time to fill out this slate carefully and as accurately as possible as the data collected during your dives will be meaningless without knowing key information about the dive site, the weather and visibility conditions, the date of collection and the ability of the collector (i.e. you).

Safety in Scientific Diving

As a certified diver you are aware of the risks associated with Scuba diving and the precautions you need to take to avoid them. These include:

1. Decompression Sickness (DCS)

What it is:
Decompression sickness (a.k.a the bends) occurs when dissolved gasses come out of solution in your body causing 'bubbles'. Nitrogen from the air we breathe at pressure mixing into the liquid in our body at depth, but releases out of solution as we ascend and the pressure begins to drop. Once it bubbles out of solution is can go to various places – the brain, the heart, the chest or lungs, under the skin, in our joints and so on, and depending on where it goes the symptoms present differently. DCS can be cause severe symptoms including unconsciousness, paralysis and even death.

If DCS is suspected it is important to administer 100% oxygen (usually available on all dive boats and dive centres) until one is treated at a Recompression chamber.

How to avoid it:
While DCS is serious and life threatening, the good news is that it is one of the easiest things to avoid. All you need to do is stay well within your No Decompression Limits – as specified by your dive computers or the Recreatinal Dive Planner, to never ascend faster than 18 metres per minute – again follow your dive computer or ensure you are always ascending slower than your Instructor and to follow the first rule of Scuba Diving – never ever hold your breath (especially on ascent).

2. Out of Air situations:

What it is:
Out of Air or Low on Air situations are when you breathe your tank dry. When this happens, it can cause panic and rushing to the surface (causing DCS) or drowning.
One of the reasons it might occur, especially in less experienced divers, is when they are doing something new which changes their usual air consumption. This could include diving deeper than usual, diving in stronger currents or colder water than what they are used to or starting a new activity alongside your normal dives such as photography or surveying.

How to avoid it:

Be sure to check your pressure gauge often. This is particularly important during your survey dives as it is easy to become so involved with finding, counting and recording the species that one forgets to check air and time spent underwater. Be particularly vigilant – make it a habit to check your air after each segment of the dive. For example, after you finish one quadrat, after you finish the fish swim and so on. When you check your own air, ask your buddy for their remaining supply as well.

3. Getting lost:

What it is:
Visibility underwater is significantly more compromised than that on land. Thanks to all the particulate matter in the water – from plankton to sand and silt – and the reduced ability of light to cut through this denser medium, we are often not able to see something that might be just a few metres away from us. While your dive leader will still find his way to our quadrats and through your fish swim, you will be lost if you are not able to see them or your buddy.

How to avoid it:
Be sure to always keep an eye on your dive leader and your buddy even while you are conducting the survey. This is particularly important if it is a day wiyh low visibility or strong currents. Be careful not to stir up the sand (or any substrate) while you are doing any part of the survey. Remember your usual lost diver protocol. If you are not able to see any other divers from your group, search underwater for one minute before slowly and calmly surfacing. The other members of your group will do so too and you can reunite at the surface. While searching underwater, be sure to look not only at your own depth level but look up towards the shallower part of the water column too. The light is brighter there and you might spot your group's bubbles as they expand more easily than the divers themselves.

4. Stings, Cuts, Bruises:

What it is:
The reefs in the Andaman Islands are home to many organisms that can sting when touched. These include certain species of corals, hydroids, jellyfish and sea urchins. Accidentally touching these can be painful and cause discomfort such as numbness or itching. Our reefs are also home to highly camouflaged scorpion fish and stone fish. Touching these, especially with impact, can be highly painful and potentially life threatening. Being underwater for extended periods of time makes your skin soft and tender and thus more susceptible to cuts and bruises even from gentle brushes against sharp things underwater.

How to avoid it:
Be highly mindful of your buoyancy and fin slightly above the reef. Watch where you are going even as you are busy counting and noting down your fish. Avoid touching the reef, rubble or

rock as far as possible. If the current is pulling you towards the reef, use your pencil to gently push you off, rather than your hand. If you must place your hand on the substrate for any reason, make sure you look at the are carefully first and gently wave your hand over the area to check if there is any camouflaged animal there.

As you add another dimension to your dives – that of looking for specific species and tallying them on your slate while either hovering over a 2m x 2m square of reef (in the Invertebrate Survey) or finning slowly behind your instructor while surveying a fixed belt on either site of you (in the Fish Survey) it is essential to not forget the basics.

It is important to collect your data accurately and to the best of your ability but your safety – and that of your buddy's – still remains the most essential component of your dive. Make sure that you do not so involved in conducting the survey that you forget to regularly check your pressure gauge to ascertain your have enough air. When you hit 50 bar, let your Instructor know and end your dive – no matter how much of the survey you have completed! Check your dive computer regularly or make sure that you are never deeper than your Instructor during the dive to stay well within your No Decompression Limits. The buddy system remains key in diving – whether it is a fun dive, a course dive or a survey dive. Especially on days with poor visibility stay extra vigilant of the location of your dive buddy and instructor. This is important for your safety and theirs.

Dive skills are as important and an integral part of dive safety. Your buoyancy skills become more important than ever when you are conducting your surveys. The reefs in the Andaman Islands are home to many stinging and venomous animals including scorpionfish, stonefish, lionfish, sea urchins, fire coral, etc. As many of these species are very well camouflaged it is important to stay neutrally buoyant and keep your arms and legs away from the reef. For the Invertebrate Survey where many species are small and need a close search, it is recommended that you get into a head down, feet up position – keep your back arched so your fins are well above the reef. If you need to push yourself off the reef, use the back of the pencil you are using for your survey rather than your hand.

At any point during your survey dive, if you begin to feel overwhelmed or uncomfortable with your buoyancy or water safety, signal 'Not Okay' to your Instructor and make the 'Cut' sign (like a scissor snipping with 2 fingers) to clarify that you would like to end the dive or the survey.

Coral Survey

The coral survey, also known as the benthic (sea floor) survey, is the only one in the ACE Diver program that does not involve indicator species or the tally system. Identifying coral species down to the Genus level requires a high level of training and the amount of information we would like to have in our coral surveys are beyond the realm of a citizen science protocol. To simplify the process, we use photo quadrats. An underwater camera is a great tool for citizen scientists to have and use because it allows them to record information without necessarily needing to understand or analyze it. As long as appropriate photography techniques are used, the data collected through a photograph can later be analysed by scientists to generate a wealth of information. In this section you will understand exactly what a photo quadrat is and learn the correct photography technique for it.

Photo Quadrats

A photo quadrat is basically a square image of a section of the sea floor. It can be an enormously useful way of gathering data because it can later be used for a variety of information. With the invertebrate or fish survey for instance, we will only ever know the numbers of our indicator species present. A scientist studying the information you gather 5 or 6 years from now will not be able to determine the number of other fish that were present, or the size of the spider conches you counted, or how many of the fish you counted had parasites on them. With a photo quadrat on the other hand, different scientists over time can look at different aspects. Even though we are taking the pictures to look at coral species, size and health (presence or absence of coral disease marks, bleaching, etc), another scientist can use the same photo to determine something totally different – like the number of sponges in the quadrat or types of algae present and its changes over time.

The photo quadrats you take will be saved by the dive centre with the correct metadata and analysed by ReefWatch scientists at the end of each month. We are looking for coral diversity, coral health and size, at the change in coral cover relative to other substrates (rock, sand, silt, algae etc) over time as

well as the presence of coral recruits.

You might be wondering that if the photo quadrat is such a great methodology, why are we not using it for invertebrates and fish as well? The main reason for this is that analyzing photographs and videos to extract the information from them takes a lot of time and computer hours. Further, for a photo quadrat to be useful, it requires some metadata – where the picture was taken, at what depth, what the scale is, how far away from the subject the camera is. These metadata are easy to have in a static place – like a marked quadrat – and more difficult when it comes to videoing fish as one in diving along a transect. Also in the case of the invertebrate and fish surveys, the subjects of interest are not always revealed on a two dimensional plane. Coral groupers are often hiding under a coral crevice, sea urchins might have retreated under a coral head during day time hours and to see and count all of these, the human eye far supersedes the camera.

Photography Techniques for Phot Quadrats

Taking a photographic for scientific purposes is quite different normal underwater photography. An underwater photographer aims to make his or her work powerful and beautiful. The angle, the lighting, the subject, the composition of the picture are all chosen to enhance beauty. For a scientific photographer, particularly in the context of the ACE Diver Program, the ultimate aim is consistency. For our pictures to be useful in the long term monitoring program, we need to have the images photographed from the same angle, the same distance, the same location and with the same colour settings by every single diver that undertakes the survey.

To achieve that consistency, we ask you to:

Before the Dive:

1. Set the size ratio of your camera to 1:1 (square instead of the default rectangular setting)
2. Set the Colour Balance or Mode to 'underwater'.

While taking the picture:

1. Your dive leader will place a tape or a ruler with the length of 1 metre along the edge of the invertebrate survey quadrat.
2. You need to position yourself so that the 1 metre tape/stick forms the outer edge of your photo and no part of it is cut out.
3. You also need to position your camera so that it is parallel to the sea floor on the quadrat. The picture must be taken from directly above the sea floor, not at an angle.
4. Remember to half-click to focus, before you fully click to take the picture. This is very important as a blurry picture is a useless one in terms of data retrieval later.
5. Your dive leader will ensure that you begin your first photo quadrat from the corner on to which the

buoy is tied. Once you take the first picture, the instructor will move the tape so that you go in a clockwise manner to cover the entire 2m x 2m square by taking 4 pictures of 1m x 1m each.

After the Dive:

1. When you come back to the dive centre you will be asked to download the picture.
2. You must save the picture with its original name as given by the camera itself (e.g DSCN0274) followed by your full name (e.g DSCN0274 John Doe).
3. When you are filling out the excel data sheet for your dives, you will copy and paste each photo file name into the columns for Quadrat 1, Quadrat 2, Quadrat 3 and Quadrat 4. Quadrat 1 will have the file name of the first picture you took and the following will go in the same clockwise order that you took the pictures.

Photos and Drawings

Fish Survey

About Marine Fish

Fishes evolved about 500 million years ago. Ancestors of human beings, in contrast, evolved only 2.3 million years ago. Fishes are the most abundant vertebrates on the planet – with more than 30,000 recorded species they outnumber amphibians, turtles, lizards, birds and mammals combined. They are not only diverse in their species, they are also display enormous diversity in the habitats they live in, the food they eat, their reproductive behavior, life cycle stages, communication strategies and so on.

However, they can be loosely bound together as a group of vertebrates (animals with a spinal column) that live in water (usually, but not always), breathe through gills (usually but not always), are cold blooded (usually, but not always) and have finned limbs (again, usually, but not always).

Our survey includes only reef-associated fishes, with one exception – sea turtles –an ocean-living vertebrate but not a fish. Fish vary enormously in their morphology – they can range from just a few millimeters in length to more than 15 metres in the case of the whale shark (the largest fish on Earth), they can have bodies that are rounded, flat, elongate, their colours, patterns and markings differ wildly – however below you can find some few anatomical features of fishes that can help you better define and identify them.

Why we look at fish in a coral reef survey

Corals are complex organisms – they are simultaneously an animal as well as a habitat. Thousands of years worth of polyp after polyp setting down calcium carbonate layer after layer create structural complexity on otherwise sandy sea beds. Thus creating homes for fish and invertebrates. The smaller

organisms that take shelter at a reef attract larger ones that prey on them and still larger ones that rule the food chain. This thriving ecosystem that houses a third of all marine species is dependent on corals to survive but the dependency does not go only one way. Corals too have grown to become dependent on that life that inhabits them. Some species give coral a competitive edge over algae that could otherwise smother them. Others help maintain healthy diversity amongst the different coral species themselves by pruning faster growing species making room for slower growing ones.

The species of fish selected for this survey not only tell us about the health of the reef itself, but their numbers – and the changes in these numbers over time – also warn us about arising threats with causal and locational specificity. Over time the record of numbers of these fish will help us identify natural patterns and help to separate them from anthropogenic pressures.

How to identify fish and what to do if you are unsure of one

The fish chosen for this survey are relatively easy to identify. Reading this chapter in detail and going over the pictures a few times should leave you well-equipped to spot and record during the dives. Your slates have also been printed with pictures to further aid the process. Going through the quizzes before you dive should give you a good idea of your ability. We recommend you review the particular fish you found difficult to remember once more after you complete the quiz. We have created two versions of the quizzes so you can fine tune your identification skills.

However, if you see a fish that you are unsure about including in your tallies during the dive, make a note of its characteristics in the blank space provided on the slate and you can check with your Instructor after the dive. We have also included the dive signs for each fish on this survey, so if you happen to catch your Instructor's eye in time, you can check double check with them during the dive itself by pointing to the fish and indicating the one you think it is to them for confirmation.

Methodology

How to do the fish survey

After you complete your photo quadrat for our benthic study and the invertebrate search in the quadrat, you will be led out for a 10 minute timed swim by your instructor in a pre-determined direction. As you swim out, your study zone is the 2 metre wide area to either side of you. You will only note down fish that are in our survey that you see within that 4m belt. If you see a particularly rare species (Shark, turtle or ray) that fell outside that 10m belt you may jot it down in the 'Notes' section of your slate.While doing the fish survey remember to fin slowly – never ahead of your dive leader and search carefully.

Be sure to look at all parts of the study area – the water column, the coral heads, the crevices of the side of the corals and on both sides of you in order to not miss any of the survey species. Equally important, try your best not to recount any individual. For instance, if you see a fish you have already tallied, scooting a few metres ahead on your path be sure not to count it again as you pass by it further ahead.

How to estimate distance

Some of us find it hard enough to estimate 2 metres on land and without familiar references in the water

it can be almost impossible. So here are some tips:

- Before going for your dive measure your own arm span – from your fingertips on your right hand across to the fingertips on your left. For most adults this length should be between a metre and a half to about 2 metres. Based on your measurement you can estimate where the 2 metre mark that ends your study zone on either side might be.
- Underwater, after you complete your invertebrate study and before you set off on the fish swim, take a good look at the length of the quadrat. Our quadrats are squares with sides of 2 metres each, so thats exactly the width of the study area on either side of you.
- You can also ask your Instructor to bring a tape measure or piece of rope that is about 2 metres long and unroll it just before beginning the fish swim to give you a reminder of its distance visually.

How to estimate length

Certain fish in our survey have been split into size categories – individuals smaller than 30 cm are counted separately from those larger than 30 cms. Your slate shows you which species are differentiated for size. At the bottom of your slate you will find a ruler showing you 30 cm so you can use this reference to judge which category the fish falls under.

Butteryfly Fish

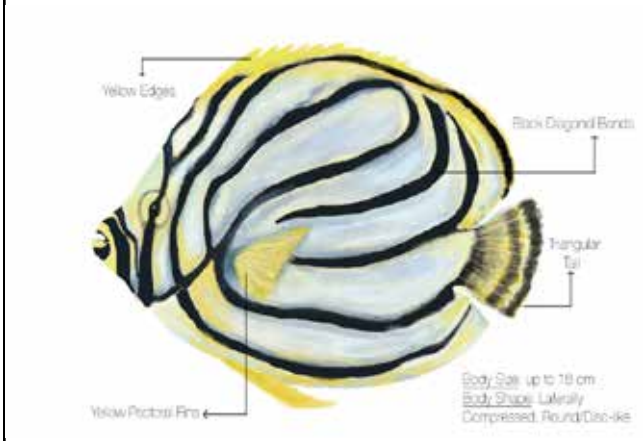
Butterfly fishes are quintessential coral reef fish. This family of fishes is often very colourful and brightly patterned, they are about the size of an adult palm when seen from the side, but paper-thin when seen head on. This sheet like body has evolved to avoid predation – of which there is a lot on a reef! If seen head on by a predator they are hard to spot, their slim bodies can easily squeeze into coral crevices, their bodies are the exact opposite shape from the shape of a shark's mouth (amazing, how predation informs evolution). Look closely at their bodies and you'll see that many (but not all) species of butterfly fishes have tails with very similar patterns to those on their heads. This is so that if a predator sees them from their side it will be confused about which direction the butterflyfish might swim off in.

insert captions

Because this family of fishes have evolved on coral reefs and are almost exclusive to this ecosystem, many individual species have habits and requirements that are closely dependent on corals thus making them a great indicator species for reef health. Our monitoring protocol involves 3 species of butterfly fish, each of which tells us a specific thing about reef health.

Meyer's Butterflyfish

Chaetodon meyeri



Spot them by :

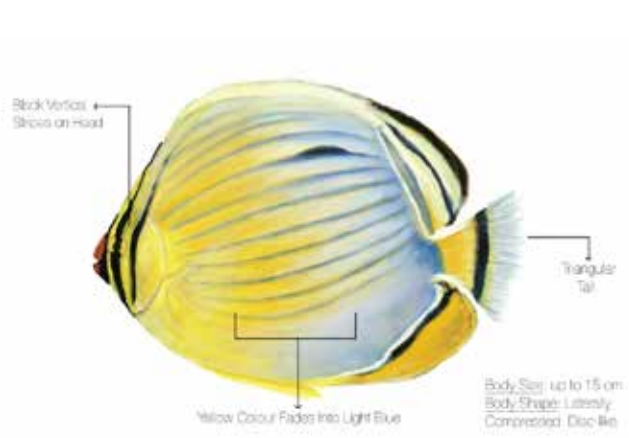
Paper-thin (laterally compressed) and about the size of your palm, these butterflyfish are distinguished by the cream coloured bodies tinged with yellow on the edges and lined with prominent black stripes that curve diagonally across their bodies.

Count them because :

You tend to see this particular species of butterflyfish only hovering over patches of reef that contain live coral so their abundance is an indication of a healthy reef.

Rip Butterflyfish

Chaetodon trifasciatus



Spot them by :

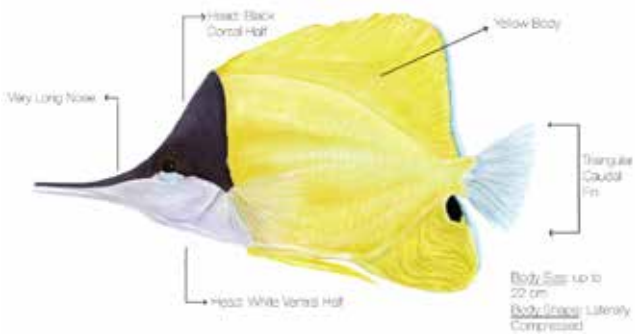
Shaped in the traditional form of a butterflyfish laterally compressed, palm-sized, disc-like body shape this species is distinguished by its paler pastel colours. It has a pale blue body with stripes in a still paler blue and a black flattened blotch towards the back. It has a distinctive orange caudal peduncle, yellow-ish orange pectoral fins and is infused with a light yellow tinge on its ventral (underside) side. Adults from this species are also most often found in pairs.

Count them because :

They really seem to know what they want and make the fussiest of us feel better for being ridiculously picky eaters.

Long nosed Butterflyfish

Forcipiger longirostris



Spot them by :

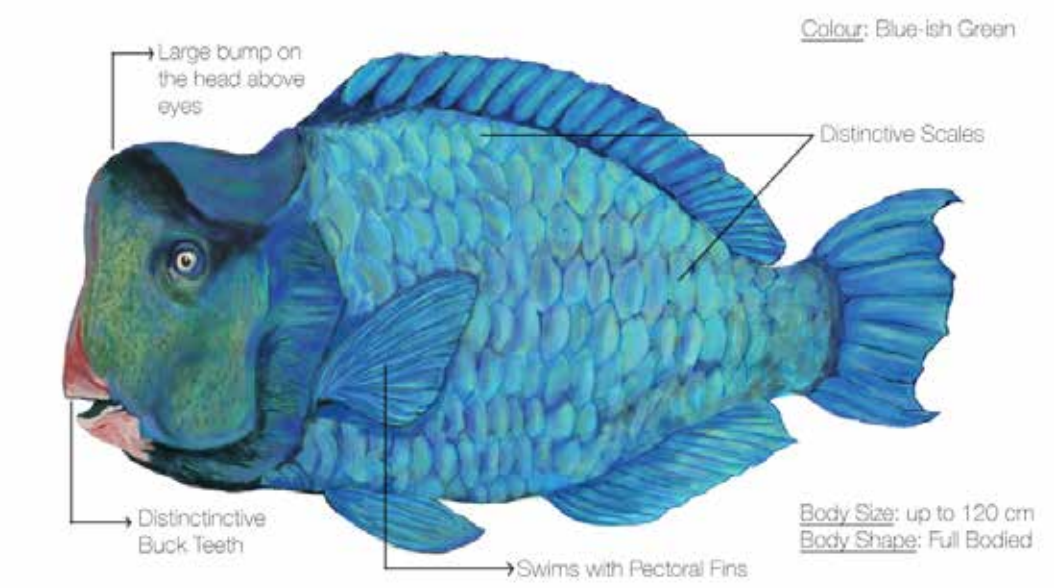
Long-nosed butterflyfish are the easiest of all butterflyfish to identify and spot. Their flat disc-like bodies are coloured bright yellow and their head extends into a long pointed Pinocchio-like nose. The head and nose are black on top and white on the bottom half.

Count them because :

Long-nosed butterflyfish are also indicators of a healthy coral reef.

Bumphead Parrotfish

Bolbometopon muricatum



Spot them by :

Their big, bulky, blue-green bodies that grow up to about 120 cm (over a metre long). They are named after their distinctive rounded bump on their heads that make them look like a cartoon with a head injury. Like other parrotfish, they have big beak-like white teeth and swim by flapping their small pectoral fins out to the side.

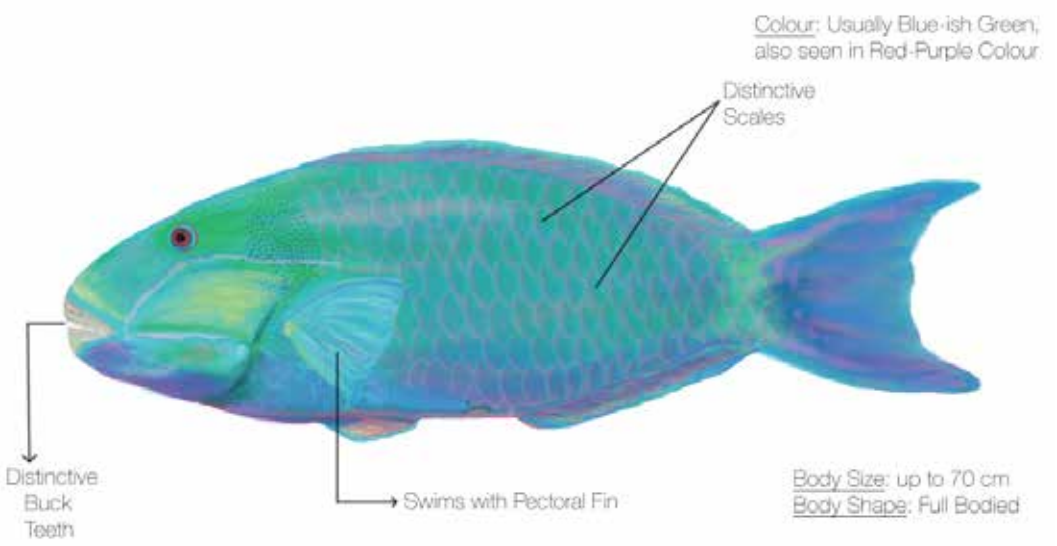
Count them because :

They often arrive in the Andamans in large schools of about 30 to 50 individuals. We are keen on tracking these movements every year and understand what it is related to. We also count Bumphead parrotfish because they are herbivores in the category of excavators and bio-eroders and tracking their numbers is important for reef monitoring.

Love them because :

There is nothing like seeing a massive school of these big fish circling and surrounding you on a dive.

Parrotfish



Spot them by :

Parrotfish are easily identifiable by their smooth rounded bodies, incredibly bright colours and their four front teeth that are large and bucktoothed. They have prominent brightly coloured scales and swim around by flapping their pectoral fins that stick out of their sides like bird wings.

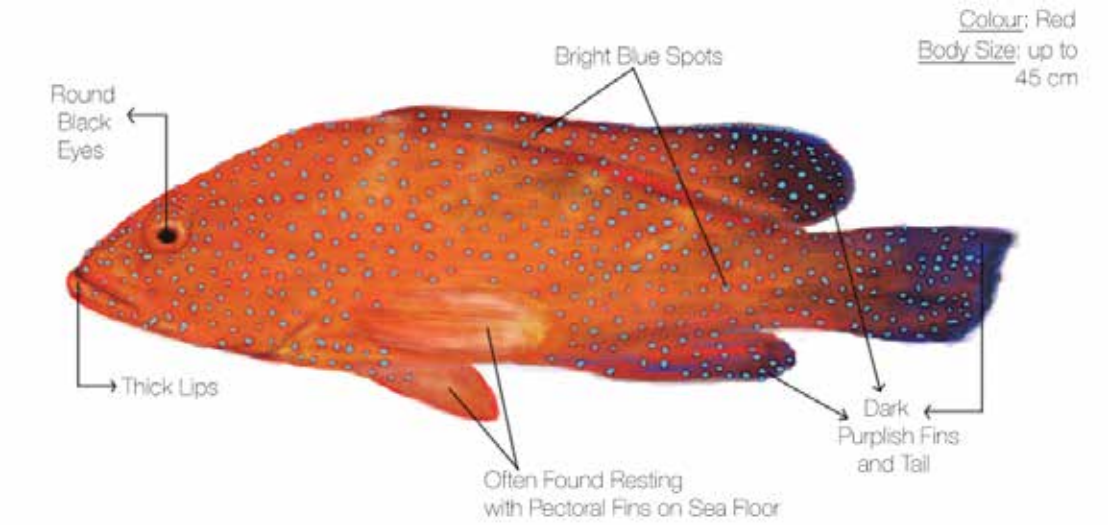
Count them because :

Parrotfish are key herbivores on a reef and are instrumental in tilting the balance towards corals in their competition with macroalgae. When temperatures rise or nutrients (such as sewage and organic waste for instance) enter the water, patches of corals suffer, bleach and die and macroalgae starts to grow in its place. For this patches to become coral dominant again, they rely on herbivores such as parrotfish to scrape off the algae and create clean hard space for new coral recruits to settle on. Tracking the number of herbivores on a reef is important to indicate the reef's potential resilience and current state. Parrotfish are also split into size categories on our surveys – we count the individuals smaller than 30cm long separately from the ones that are bigger than 30cm. This is because smaller individuals graze differently from larger ones. While the former are scrapers, the latter can contribute in bio-erosion.

Love them because :

Their poop (almost pure calcium carbonate) makes much of the white sand that fills our beaches!

Coral Grouper



Spot them by :

Their bright red bodies with blue oval-ish spots are hard to miss. They are usually found around coral and rocks, low down towards the sea floor, almost propping themselves up on the pectoral fins (like we do on our elbows while lying on our stomachs). You almost never see them swimming higher up in the water column. They have a long body and are relatively slender. They can range from about 15 cm to a little more than a foot long.

Count them because :

Groupers are an important mid-level predator on the reef. Their presence is an important control for species below them on the food chain as well as essential for the higher level predators that feed on them. Groupers are also one of the most heavily targeted fish on the reef by fishermen. Their presence or absence is not only an indicator of the robustness of the reef food web but also of the fishing pressures on that area.

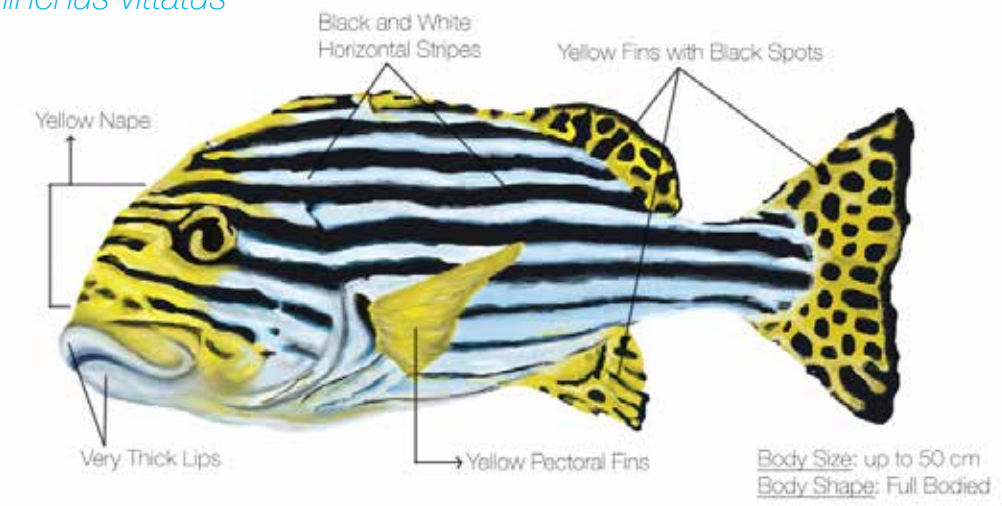
There are several species of groupers in the Andaman Islands and it would be impossible to identify and count all of them without extensive training. To reduce the chances of error and miscounts we have included the most distinctive looking and easy to spot grouper in our survey to serve as a proxy. This is one of the species that we divide into size classes. We ask you to tally the individuals smaller than 30 cms long (easily referenced by the ruler provided at the bottom of your slate) separately from the individuals longer than 30 cm.

Love them because :

They wear their identity lightly, and easily transform from female to male. All groupers are born female and then the largest in their territory transforms into a male. If something happens to the resident male – if he is fished out or eaten – the next biggest female changes into a male. This is part of the reason we split our counts into smaller than and bigger than 30 cm for it is at about this threshold size that the sex change becomes possible. Fishing targets larger individuals in a species and a reef that constantly has only small groupers is one that suffers from too much fishing and likely has only the female individuals as part of the population.

Oriental Sweetlips

Plectorhinchus vittatus



Spot them by :

Oriental Sweetlips are one of the most distinctive fishes of the sweetlips family. Their body is shaped similar to groupers and snappers – long and full bodied. They have fleshy lips – which is what gives this group of fishes their common name. Oriental Sweetlips have black, yellow and white horizontal stripes running alongside their body (the yellow stripes are only on the dorsal – top side – of the fish) and large, slightly protruding round eyes. Their fins are also bright yellow and their tails are yellow with black spots. They grow to about 50 cms – which is a little smaller than twice the width of your counting slate. Oriental sweetlips can be found singly or in small schools are tend to stay close to corals, rocks and the seafloor rather than higher up in the water column.

Count them because :

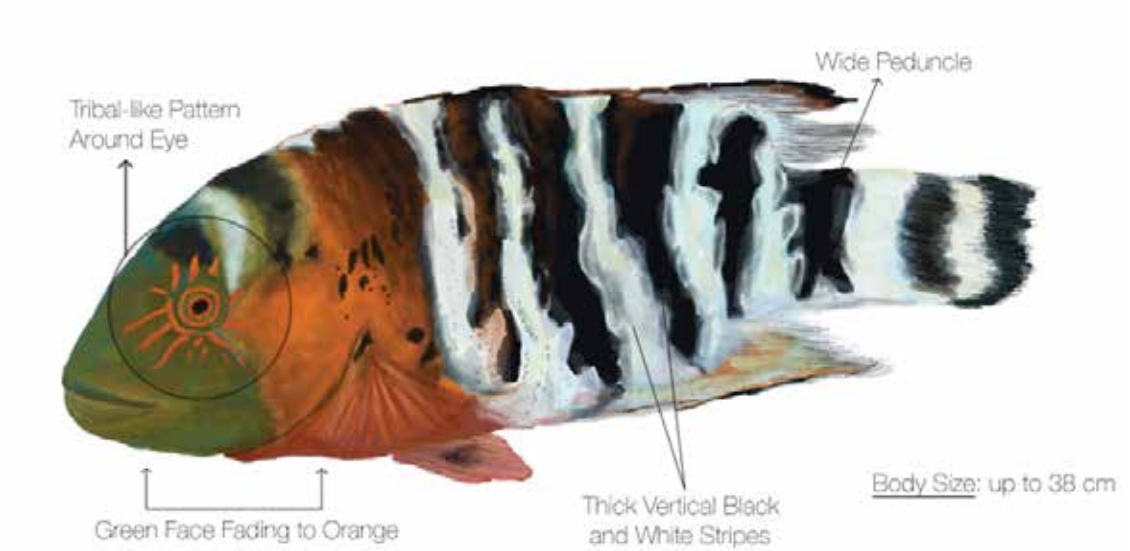
The sweetlips family is a mid-level predator of small crustaceans, their diet mainly consists of crabs and prawns. A large population of sweetlips indicates a healthy population of small crustaceans that are otherwise impossible to count. Being a fleshy, tasty fish sweetlips are also one of the fishes targeted by fishermen and hence their presence or absence on a reef is also a good indicator of fishing pressure. We use the oriental sweetlips as a proxy for the whole sweetlips family.

Love them because :

As juveniles they are one of the cutest fish on the reef. Their juvenile version starts at about 10mm small with an attractive brown, white and yellow mottled pattern. But what truly sets them apart is their vigorous wriggling, even when aren't trying to move or swim anywhere they wriggle on the spot – simultaneously moving all their fins, their tail and undulating their body. The younger they are the more vigorously they wriggle, slowing down as they become larger juveniles and eventually stopping when they reach adulthood. For all their dancing, juvenile sweetlips are extraordinarily shy and stay tucked into coral crevices and rock cuts so you need to look closely to spot them.

Red-Breasted Splendour Wrasse

Cheilinus fasciatus



Spot them by :

Up to about 40 cm in length and relatively full-bodied, the tail of a splendour wrasse tapers gradually from its body. Essentially, they have a wide caudal peduncle so that the tail is not separated sharply from their body. The top of their heads are a dull green colour which gradually changed to a dull orange-ish rust colour going down. Their protruding round eyes have slightly brighter orange coloured tribal-like lines around them. The rest of their body has wide black and white vertical stripes going all the way to their tail.

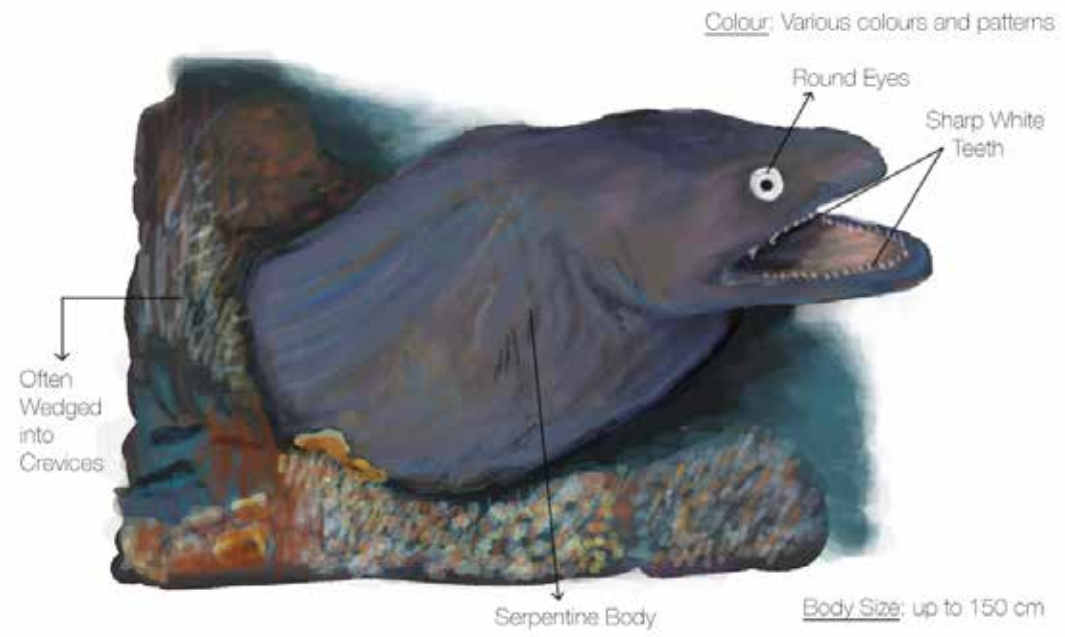
Count them because :

Red-Breasted Splendour Wrasses are a good indicator of a diverse assemblage of small invertebrates on a reef as their diet requires a high abundance of them to survive. They are also relatively uncommon and thus sightings of these wrasses suggests high biodiversity of fishes on the reef too.

Love them because :

They are shy, rare and quick to dart into hiding.

Moray Eels



Spot them by :

Their long snake-like body remains mainly concealed during the day as they curl into coral crevices and rocks, but you will always see their head sticking out as they open and close their toothed mouths. Their heads are about the size of our hands, and their mouth tapers into long triangle. Their colours range from black, to a dull brown-black blotched pattern, black based with a yellow 'spray paint', to a brighter leopard or honeycombed pattern.

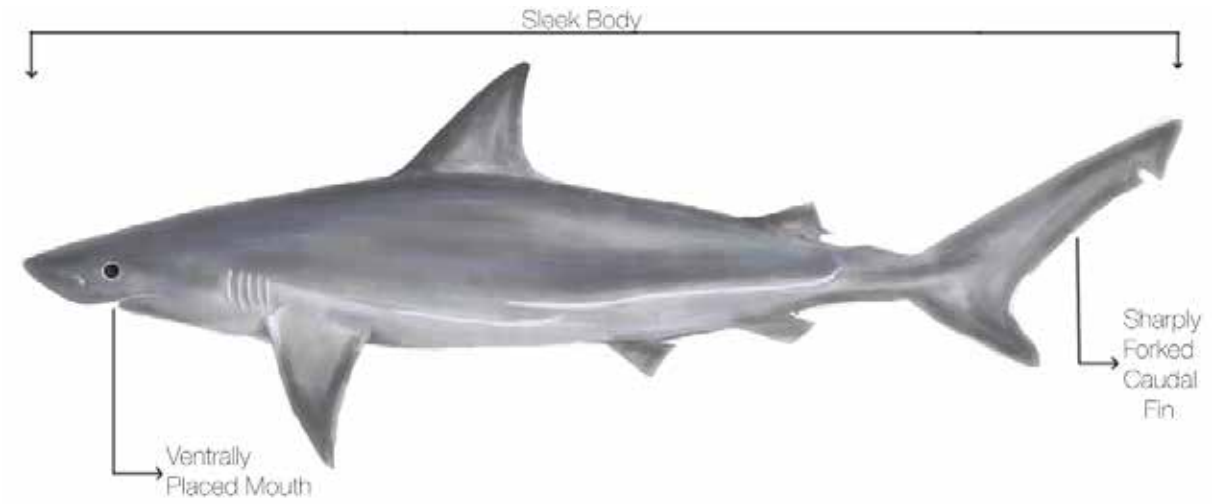
Count them because :

As mid-level predators on the reef, their numbers give us a good indication of the trophic structure on the reef. Moray eels are also sensitive to habitat destruction and changing water quality and hence a healthy presence of morays of a reef gives us a good idea of the integrity of the ecosystem.

Love them because :

Though the look menacing as they open and close their mouth, revealing their sharp white teeth, they are not actually threatening to take a bite out of you. When they aren't swimming forward but are sitting stationary as they do most of the day to conserve energy, the only way they can pump oxygen-rich water through their gills is to open and close their mouths. What looks like a threatening action is simply the moray breathing.

Sharks



Spot them by :

Their sleek grey bodies, their distinctive triangular dorsal fin and their mouth set low on the underside of their jaw.

Count them because :

We include sharks in our survey for two reasons. The first is because they are the apex predators of the reef ecosystem. A healthy population of sharks in an ecosystem increases the resilience of the system as a whole. Acting as agents of natural selection, their presence ensures that their prey population going all the way down to food chain right to the plankton, have to be stronger, more competitive and resilient to survive.

The second, less happy reason, is because sharks are also hugely threatened and targeted by fishermen. India is the 2nd largest shark exporting country in the world. Sadly, it is quite rare to see sharks while diving on Andaman reefs.

There is now a more concerted approach to shark conservation in India, with the new 'Fins Attached' policy that bans shark finning and a complete no-take policy for a few selected species. We hope to see these policies taking effect and slowly reviving shark numbers on the islands. Either way, we can track the changes in their numbers through our survey.

Love them because :

Sharks evolved around 420 million years ago. They've been ruling our oceans ever since. Like us, they have highly developed senses of sight, smell,sound, taste and touch. Unlike us however, they have an incredible additional sense of being able to detect electric fields in the water.

Their electroreceptor organs are called the Ampullae of Lorenzini, and are one of the key ways in which sharks find their prey. All living creatures generate an electric field by their muscle contractions (even when still, our heart muscle contracts and relaxes creating this field) and sensing this, sharks are able to find their prey even if it is hidden under the sand or coral head.

Sting Rays

Spot them by :

Their flattened blanket-like body on the sand. Their body makes a roundish shape with protruding eyes on top of the front of their bodies. A long thin tail usually extends out from the back of their body. These could either end in a sharp point (in the case of a string ray) or a softer, feathered tip (feather-tailed rays). Rays often shuffle into the sand a little bit so that most of their bodies are covered by sand, so look closely as you are passing sand beds for a pair of protruding eyes. Similarly, they are often tucked under an overhang or a head of table coral so be sure to scan the sea floor well to not miss these guys.

Count them because :

Like the sharks they are closely related to, rays are also considered to be top predators and thus play a similar role as sharks. Like sharks also, rays are highly overfished in the Andaman Islands, making it important for us to monitor their presence on our reefs.

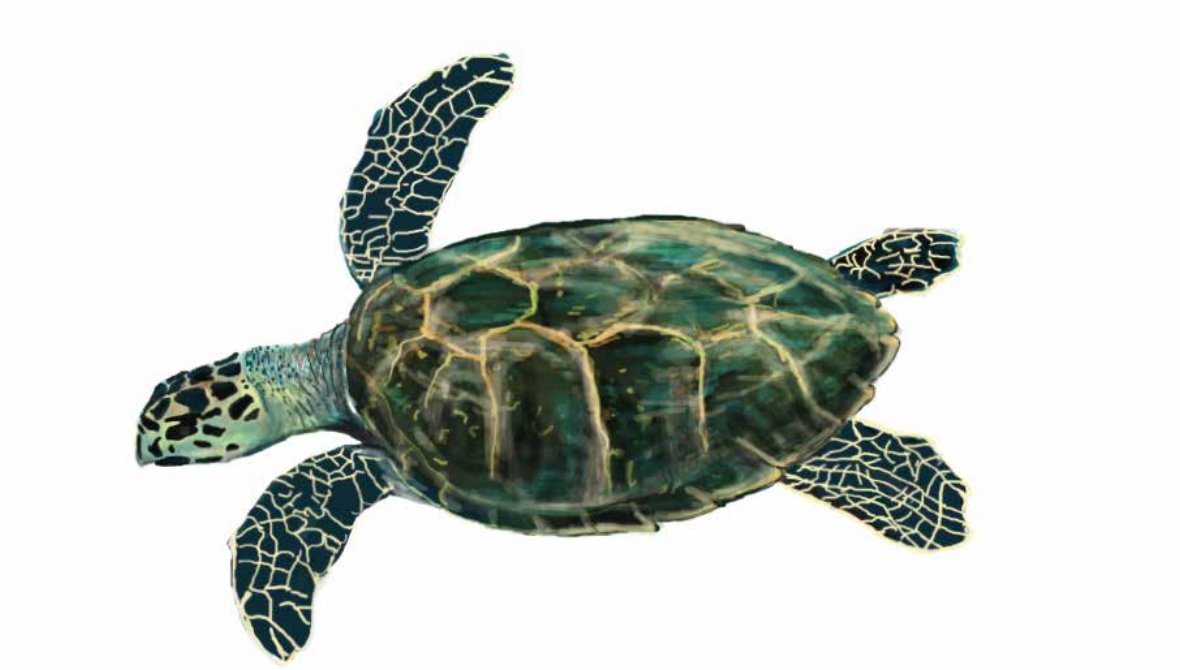
Love them because :

They are often misunderstood!

Despite their undeserved reputation due to the freak accident which killed TV presenter Steve Irwin, sting rays are actually gentle, non-aggressive animals. Their poisonous 'sting' situated at the base of their tails is a defense mechanism against predators attacking them from the water column above as they rest and forage for food in the sand on the seafloor. The sting or barn is not used to actively attack. In fact, their barb is situated most inconveniently as an attacking tool requiring them to almost twerk to jab it into anything or anyone by choice.

The only way in which people get injured by stingrays are when they accidentally step on its barb while walking in shallow water, and these injuries are almost never fatal. In the case of the famous Australian TV presenter – he happened to descend upon a swimming sting ray, bringing his chest directly over the barb, resulting in the tragic fatality.

Sea Turtles



Spot them by :

Looking closely. Sea turtles blend easily into the rock and reef while they are resting. You might also find them feeding on algae and sponges on the reef.
Sea turtles are so distinctive and well known they hardly need a description. Here on our reefs you see mainly hawksbill turtles and green turtles.
Hawksbill turtles have a distinctive sharp beak-like mouth with the top lips protruding significantly over the bottom lip – sort of like an overbite. The edge of their shells are sharply serrated. Their necks are narrower than their heads.
Green turtles (not green to look at from the outside at all) have a scalloped pattern on their backs (like roofing) and have a smooth edge (unlike Hawksbills).
Their necks and heads are almost the same width making it look like they have no neck at all. Green turtles can grow much larger than Hawksbills and are the second largest species of sea turtles in the world (after the leatherbacks).

Count them because :

Sea turtles are a good indicator of biodiversity and anthropogenic pressures as they are extremely threatened by a range of human activities including fishing, coastal development, marine debris (especially plastic) and entanglement. Try to differentiate and note down the species of sea turtle you spot on your dive – your dive guide can help you with this after the dive also.

Love them because :

Sea turtles have swum in our oceans well before even dinosaurs walked on land. Yet today all 7 species ofextant sea turtles are highly threatened and on the IUCN Red List of Endangered Animals. Their presence in our oceans shows us it is not yet too late to act to conserve it. Love them because they have the wisest eyes. Love them because they have an incredible sense of direction and female seaturtles return to nest at the exact same spot as where they hatched out of their eggs – often decades after they are born after having circumnavigated across the world's oceans.

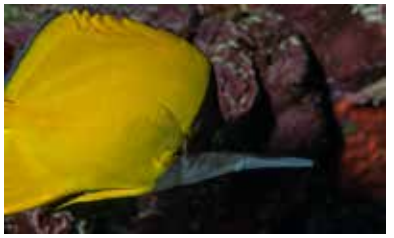
Quiz

1. Long nosed butterfly fish

A)

B)

C)



C)

2. Red breasted wrasse

A)

B)

C)

D)

3. Bumphead parrot fish

A)

B)

C)

D)

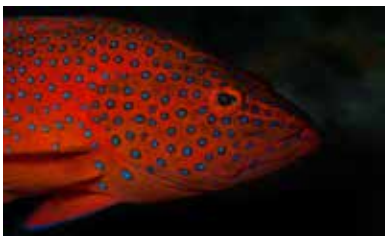
4. Coral Grouper

A)

B)

C)

D)



5. Sweet lips

A)

B)

C)

D)

6.

A) Parrot Fish

B) Snapper

C) Grouper

D) Bumphead Parrot Fish

7.

A) Shark

B) Turtle

C) Ray

D) Sweetlip

8.

A) Rip Butterfly Fish

B) Oriental Sweetlips

C) Red Breasted Wrasse

D) Meyers butterfly fish

9.

A) Sting Ray

B) Shark

C) Moray Eel

D) Coral Grouper

10.

A) Sting Ray

B) Parrot Fish

C) Red Breasted Splendour Wrasse

D) Moray Eel

11. How many meters to either side of me is the study area?

a) 4 meters to my left and right

b) 2 meters to my left and right

c) 10 meters wide in total

d) 4 meters between me and my instructor

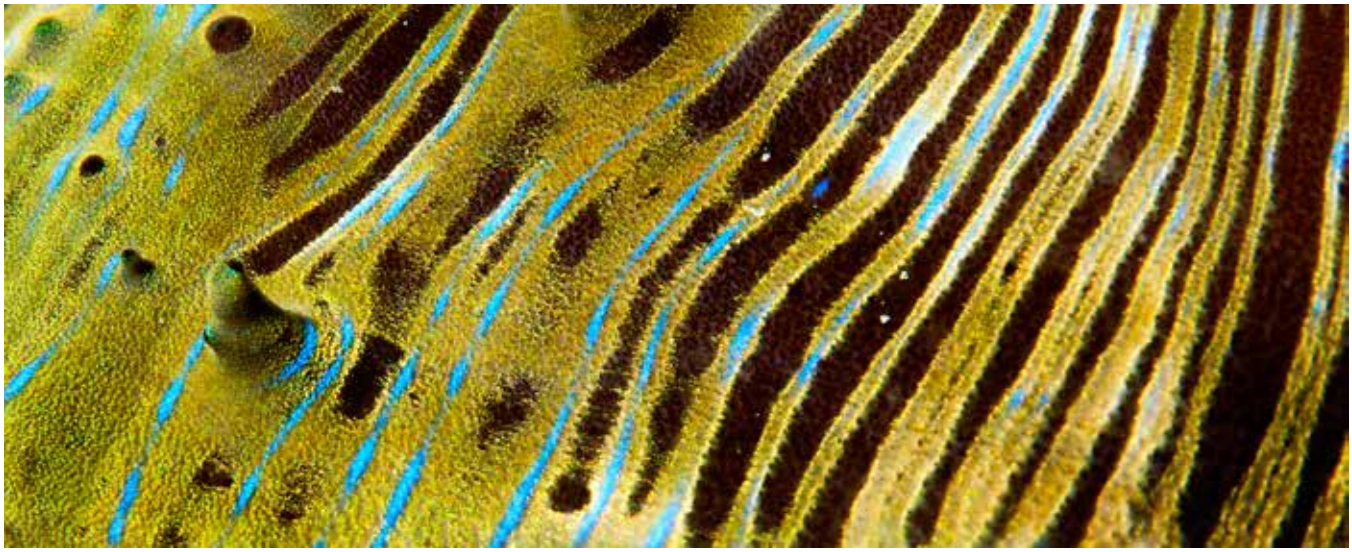
12. For the fish survey I need to swim

a) directly behind my instructor

b) diagonally behind the instructor on one side and my buddy on the other

c) In front of my instructor

d) with my buddy above my instructor



Invertebrate Survey

about marine invertebrates

Animals that lack a back bone are known as invertebrates. If we view this set of animals from an evolutionary standpoint, then they are more ancient than vertebrates, which came later. Over 98% of species on earth are invertebrates. Invertebrates use exoskeletons and shells for support like snails and crabs. Inside their exoskeleton and shell, they are soft bodied animals. Many marine invertebrates are filter feeders meaning they siphon small food particles from the water column into their digestive systems. Marine invertebrates represent the vast majority of marine biodiversity.

While invertebrates might be more 'simple' evolutionarily and many of them have no Central Nervous System, no digestive system, no eyesight, hearing or many of the functions we associate with the 'animal kingdom', it is still a marine invertebrate that is responsible for building the largest structure ever to have been built by any living being. The Great Barrier Reef – larger than the Great Wall of China or any other human made artifice – was built by coral polyps who are also invertebrates.

Some of the most common marine invertebrates are sponges, cnidarians, marine worms, mollusks, arthropods and echinoderms. Some of these invertebrates are also commercially important like oysters, prawns, scallops and pearl oysters.

Why we look at invertebrates in a coral reef survey

Though relatively small and inconspicuous, some marine invertebrates have a dramatic effect on the composition of their environment. They play a crucial role in maintaining a stable and healthy marine ecosystem. They act as the base of many marine ecosystems. Animals of higher trophic levels depend on these invertebrates as a food source to survive. Some invertebrates like the Crown of Thorns star fish which feeds on coral and increase in their numbers can be a threat to the reef. Most of the marine invertebrates thrive in waters free from terrestrial run offs but some also thrive in turbid waters. Overfishing, ocean acidification, invasive species and climate change are the major threats to marine invertebrates. Since invertebrates form a major component of coral reefs, we include a few key indicator species in our surveys to gauge the health of the reef.

How to identify inverts and what to do if you are unsure of one

Most of the invertebrates in our survey are extremely slow moving to the extent that they are almost completely static. This gives you enough time to look carefully and correctly identify each species. Certain species can be confusing – for instance a boring clam and a giant clam can be confused with each other if the latter is in a juvenile phase or is ensconced in a crevice. When this happens, do check with your Instructor to confirm that you have the right answer.

The more important factor in accuracy in the invertebrate survey is making sure all the survey species are spotted and counted, so take your time to search all the nooks and corners of the quadrat.

Methodology

Your instructor will take you to a pre-marked 2 metres x 2 metres square quadrat. This is your study area for the invertebrate survey. This is not a timed survey so take your time to slowly and methodically search the area for the selected indicator species. Some species such as giant clams, sea cucumbers and Indian cushion seastars will be easy to spot because they are large and static. Others will be harder to spot due to their camouflage or their tendency to hide under rock and coral.
Other species such as sea urchins and boring clams are difficult to accurately count because they can be present in great abundance. To overcome these issues and gain maximum accuracy we recommend dividing the large square into 4 smaller squares in your head and covering each square one by one.

How to position yourself

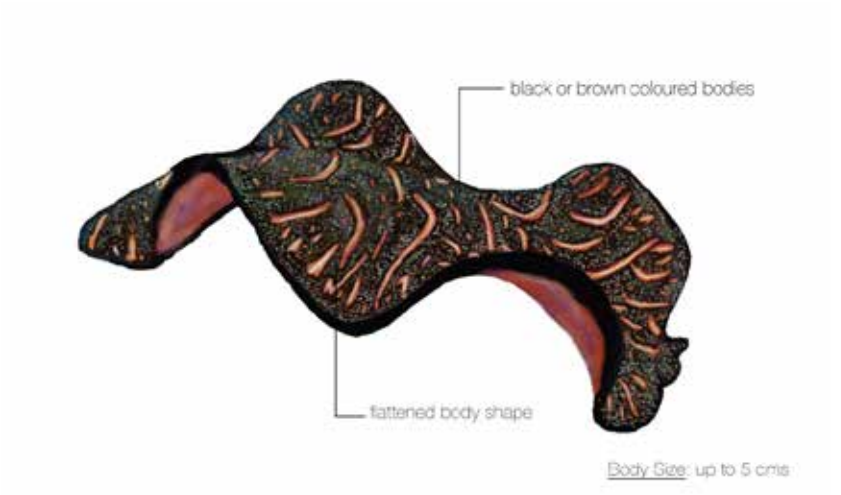
Depending on the dive site you are at, the invertebrate study quadrat might be adjacent to a sand patch or in a coral dominant area. If you do have a sand patch next to the quadrat use it to kneel on and survey the square statically. This will make the survey easier and help you avoid crashing into other divers, disorientation etc.
For quadrats that are in coral dominant areas surrounded by reef you will need to get into a head down-feet up body position. To achieve this position, it helps to arch your back – thus lifting your legs up high – and keep your head facing straight ahead rather than down – for orientation. This position helps you get your eyes close to the study area to spot the small and hidden species without simultaneously kicking the reef with your fins.
If there are 2 divers conducting the study at the same time, you should start at diagonally opposite ends of the square and continue clockwise along each edge. If either of you is not a very strong diver, do the survey one after the other instead of crowding out the space.

How to be safe

This survey requires you to be close to the reef – unlike the fish survey which includes fairly large and colourful species – many of the invertebrates in the survey either use camouflage or rock to hide themselves and require careful searching. However it remains essentially important that you do not get too close and accidentally touch the reef with your hands or kick it with your fins. The reefs in the Andaman Islands contain many venomous and stinging organisms from scorpion fish, lionfish to sea urchins and hydroids, that can result in reactions that are either deeply painful and sometimes near-fatal if touched. Additionally, the integrity of the survey itself is compromised if the surveyors keep kicking the reef with their fins – damaging it as they study it – and over time creating a survey area that is not at all representative of the area in general

For these reasons it is important that you keep your eyes close to the reef but your hands and feet away from it.

Flatworms



Spot them by :

Flatworms are not easy to spot because of their tiny size. They are usually no bigger than about two inches long and about two centimeters wide. As their name suggests, they lie flat on coral and rubble, no thicker than a sheet of paper. They are usually beautifully coloured and patterned – the species illustrated on your slate as the most common ones found in the Andaman Islands however they come in a range of colours and you are required to count all of them. Flatworms move in a beautiful way, sending undulating ripples down the edges of their bodies to propel themselves forward.

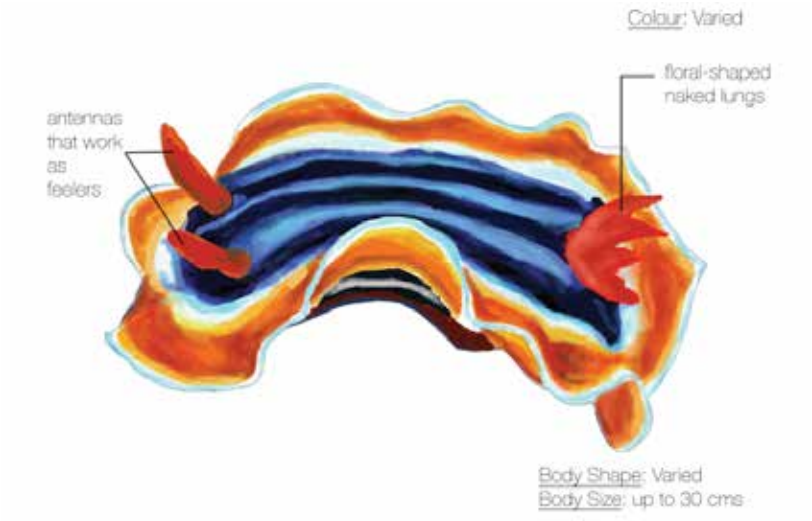
Count them because :

Flatworms are a good indicator of invertebrate biodiversity as they are relative uncommon but also their presence indicates good water quality as they need this to survive.
An increase or decrease in numbers is a good proxy for changing parameters in water quality that would otherwise require expensive precision instruments to measure.

Love them because :

They look like miniature magic carpets on which Aladdin and Jasmine discovered ‘a whole new world’.

Nudibranches & Sea Slug



Spot them by :

The colourful bright patterns on their small bodies, similar in size and shape to their land-slug cousins. Both sea slugs and nudibranches have two tiny antennae on their heads but nudibranchs are further differentiated by a small feathery appendage towards the back of their bodies. Though this appendage may look like a little bunny-rabbit tail they are in fact the gills of the animal which give them their name – Nudi (naked) branch (from bronchioles associated with lungs).

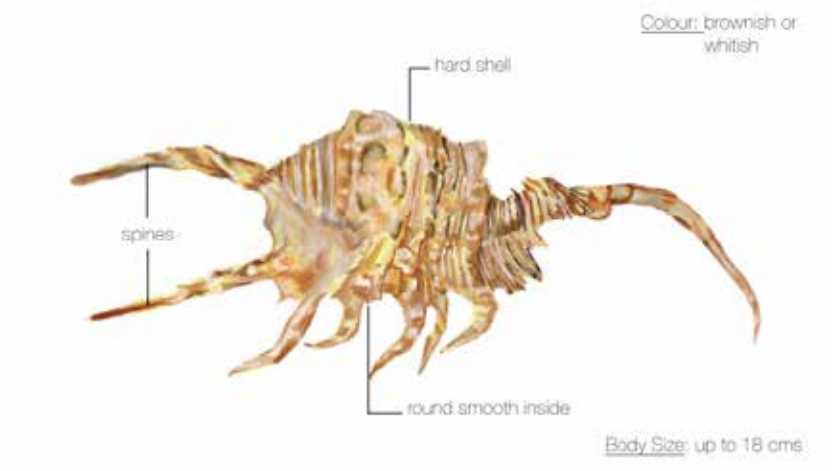
Count them because :

Nudibranchs and sea slugs are also very sensitive to water quality – and changes in these or habitat destruction can negatively impact their populations.

Love them because :

Nudibranchs and sea slugs are gastropods, likely evolved from snails but have lost their shells over time. Shells offer these small soft bodied animals essential protection from predatos but they are difficult to make and require a big energy budget both to build and to carry around. These incredible animals have sidestepped this problem by using a different tool for protection – they feed on toxic sponges and stinging hydroids and incorporate the toxins into their bodies to make themselves poisonous.

Spider conch



Spot them by :

Spider conches can be found on the seabed – on sand as well as reef or rock. They are hard shelled organisms and look a bit like a closed fist with curved sharp appendanges protruding from the 'knuckles'. The outer shell is often well camouflaged thanks to the dull layer of algae growing on it, however when flipped over they look shiny and very much alive.
They can be as small as an actual adult fist with sharp appendanges but can also grow to about twice the size with narrow but more blunt protrusions.

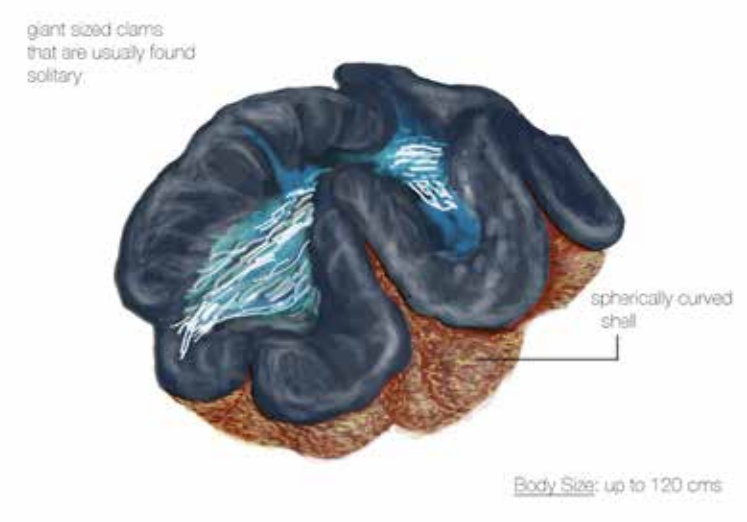
Count them because :

They are a good indicator of invertebrate biodiversity.

Love them because :

They have a cool retracting claw on their undersise, which they draw into their bodies when you flip them over. They don't have any feet to move, but this claw lets them pull themselves forward on the sand or reef as they feed. If a wave, or a large fish (or diver), flips them over accidentally, they can use that claw to roll them back over so they are the right side up again.

Giant Clam



Spot them by :

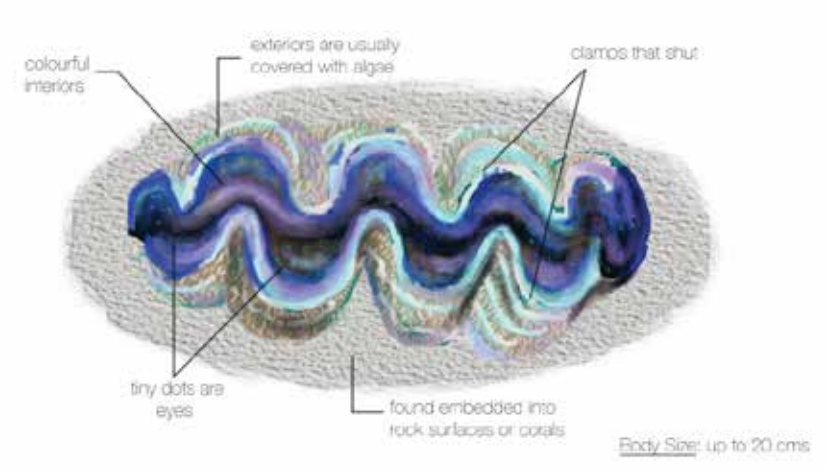
Giant clams are rooted to a spot on the reef bed and have two large shells, joined together at the base that houses a soft-bodied fleshy animal that spreads over the opening of the bivalved shell. They usually have two circular openings in their flesh through which the pump seawater in and out. Waving your hand over them causes the shells to snap shut (usually the bigger the shell is, the more reluctantly it snaps shut) and retract the fleshy part of its body tighter into its shell. Giant Clams have the same zooxanthellae symbionts as corals do, and through these photosynthesizing algal cells they get their stunning colours and patterns (and the energy that they need to build the big basin-like shells that house them!).

Count them because :

Love them because :

They have a cool retracting claw on their undersise, which they draw into their bodies when you flip them over. They don't have any feet to move, but this claw lets them pull themselves forward on the sand or reef as they feed. If a wave, or a large fish (or diver), flips them over accidentally, they can use that claw to roll them back over so they are the right side up again.

Boring Clams



Spot them by :

Boring clams are from the same family as giant clams, but tend to be much smaller – less than 5 cm long – and bore into rocks and corals so you usually cannot see much of their shells. They look a bit like purple painted lips on the tops of coral heads. Waving your hand above them also causes the purple 'lips' to retract slightly, revealing the white outline of the shell underneath.

Count them because :

Like giant clams and corals they have zooxanthellae symbionts. However since they are boring animals, a sudden increase in their numbers might suggest a weakening of the coral (hence allowing them to bore in) or an increase in the coverage of boulder-type corals which are the kind that house these animals.

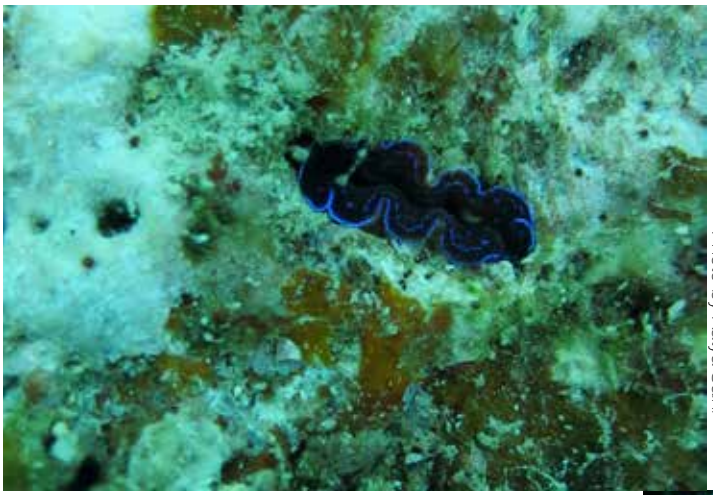
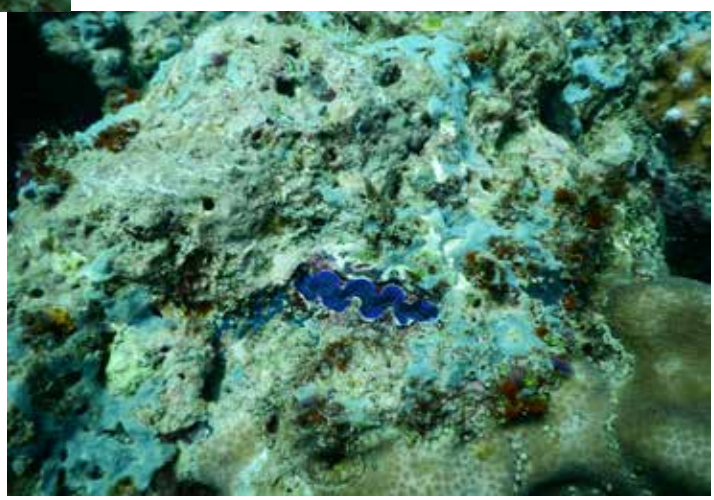


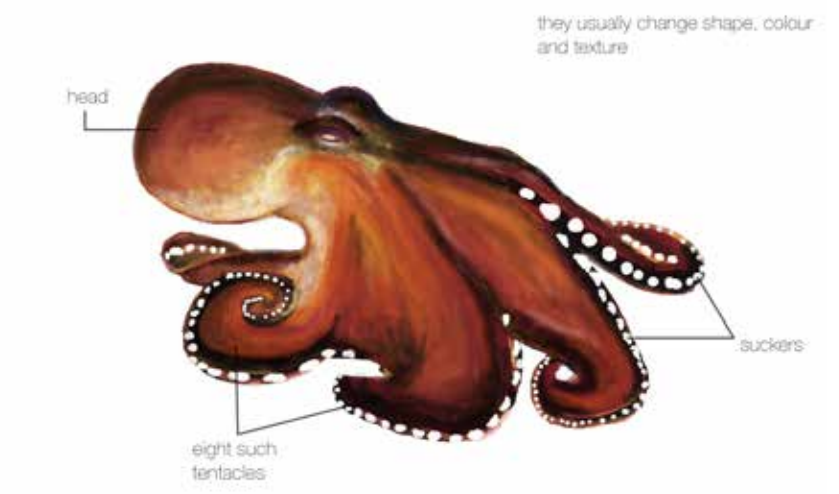
Photo by Katya Saini



Love them because :

Their bright lips smile at you from the top of the coral and add bright splotches of colour to the reef.

Octopus/Squid/Cuttlefish



Spot them by :

All three of these animals are incredibly hard to spot. Masters of camouflage, these cephalopods can not only rapidly change colours as they are moving over different parts of the reef they also change their texture to blend in better! You have to look quite closely to spot them.

Count them because :

Their presence is a good sign of reef biodiversity. They are also voracious predators and their presence is sign of abundant crustacean life. Your Invertebrate slate only has an image of an octopus – as this will be the most likely seen in the quadrat – however do count any of the three you see with a mention of whether it was an octopus, a squid or a cuttlefish. If you see any of these even during your fish swim add it to the notes section of your slate.

Love them because :

Cephalopods translates to 'Head-foot' and are named so for their bizarre body shape of having their 'feet' (tentacles) protrude directly out of their heads. They have extremely developed brains and have been seen using tools and have the ability of recognizing human faces.

Indian Cushion Seastar

Spot them by :

Named for its plumped up appearance, the Indian Cushion Sea Star looks a bit like a pentagonal pillow on the reef. It is usually about a foot in width and comes in a variety of muted colours from dull green with small black and orange dot-like spines to tones of pinkish-brown and purple. As part of the 'echinoderm' phylum – a term that means 'spiky skin' – all seastars have some form of spines on their body however in some species these are highly reduced to make their surface look almost smooth. In cushion sea stars, they are an intermediate stage – not fully smooth but the spikes are very short.

Unlike most starfish that have 5 or more distinct limbs and look a lot like the star shape we all learn to draw as kids, cushion sea stars have a more rounded body without the protruding 'arms'. The cushion seastar's mouth and small tube-like feet are all located at the underside of its body and can only be seen if flipped over (not recommended).

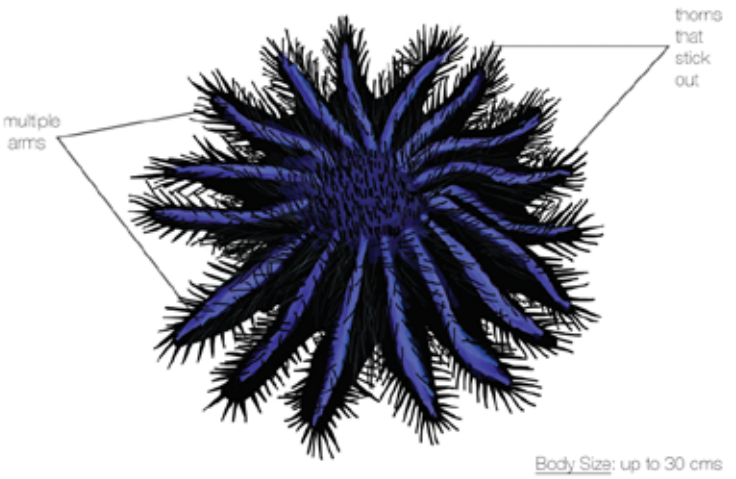
Count them because :

They are the proxy for (most) star fish in our survey. Being some of the largest, they are relatively easy to spot and also feed the most. They eat detritus, small invertebrates and small amounts of hard coral.

Love them because :

They genuinely do look like lovely little cushions decorating the reef.

Crown of Thorns Sea Star



Spot them by :

Crown of thorns sea stars in the Andaman Islands are very strikingly coloured in jet black and an electric blue-ish purple. Also echinoderms, these have prominent toxic spines all over their bodies and can have anywhere up to about 18 ‘arms’ radiating out of a circular centre. The only predators that are able to feed on this toxic sea star are Titan Triggerfish and a large shelled invertebrate called the Triton Trumpet.

Count them because :

These sea stars are voracious coralivores. When their populations explode they can destroy large areas of coral in a matter of weeks. In many areas of the world, divers can sign up for Crown of Thorns removal dives – where the entire dive is spent collecting these sea stars from the reef into a bag and taking them up to the surface. In low numbers they actually benefit the reef by clearing areas for juvenile corals to settle and strengthen the reef's resilience by providing a small level of disturbance thus acting as an apex predator does for its prey population – as an agent of natural selection. Crown of Thorns sea stars are able to sense chemicals released by stressed or weakened corals and thus arrive to prey upon them, making space for more fit corals to grow and thrive.

A sudden increase in numbers of Crown of Thorns are an important indication of weakening coral and a problem that required urgent attention. If you see a Crown of Thorns sea star during the fish swim part of your dive, please add it to the Notes section of your slate.

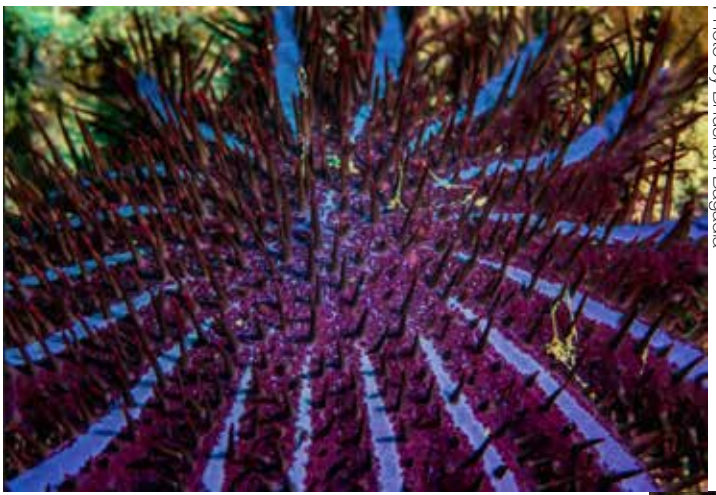


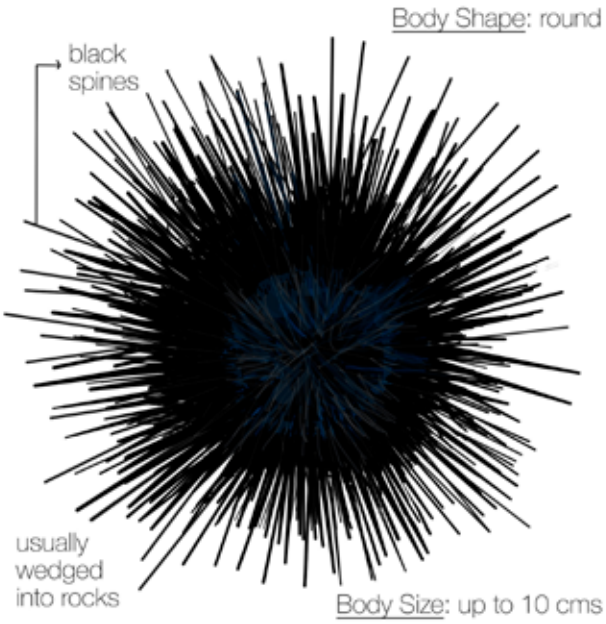
Photo by Bhushan Bagadia

Photo by Bhushan Bagadia

Love them because :

They genuinely do look like lovely little cushions decorating the reef.

Sea Urchin



Spot them by :

Looking for a cluster of sharp pines protruding from corals and crevices. Sea urchins have a small round body with sharp spines extending out of the entire surface. When seen feeding – usually at night – one is able to see their entire bodies. In the day however, they are tucked into the coral and you see only some of the spines protruding.

Count them because :

They are extremely effective herbivores on a reef and control the spread of macro-algae – the biggest competitor to coral. They are also a prey species for several fish as well as a few large invertebrates. In very high numbers though, they indicate an imbalance in the reef – either too many nutrients (too much macro algae, their food) or too few predators (overfishing).

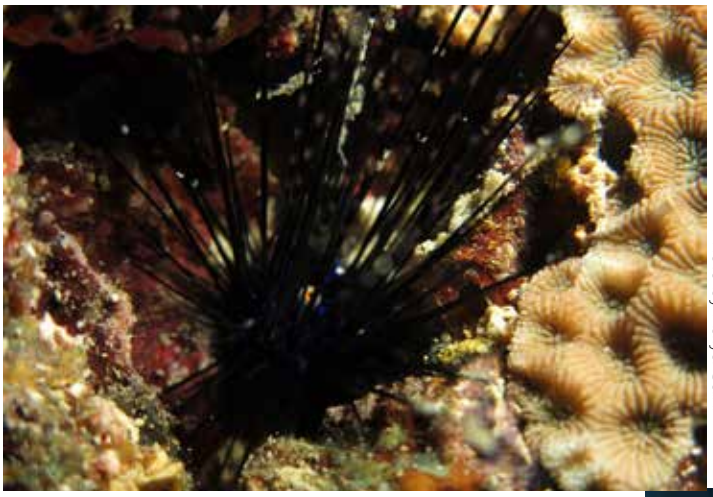
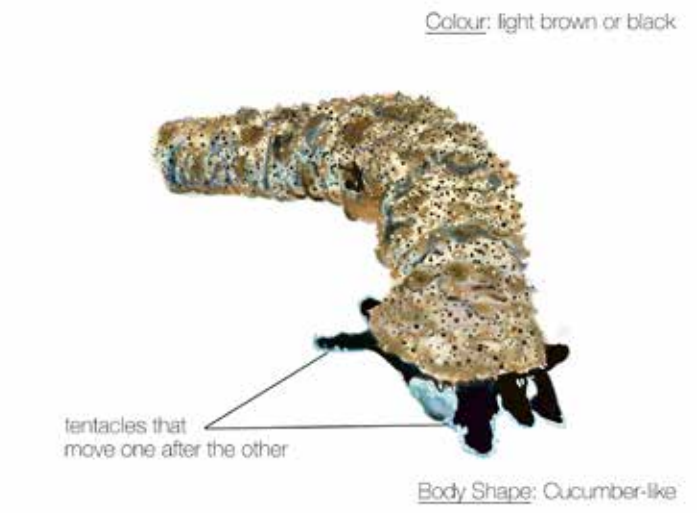


Photo by Katya Saini

Love them because :

They teach you the importance of good buoyancy and spatial awareness while diving. Their sharp spines not only poke you but also detach from their bodies and lodge themselves in your skin. A sea urchin injury can be extremely painful and leave a scar for weeks.

Sea Cucumbers

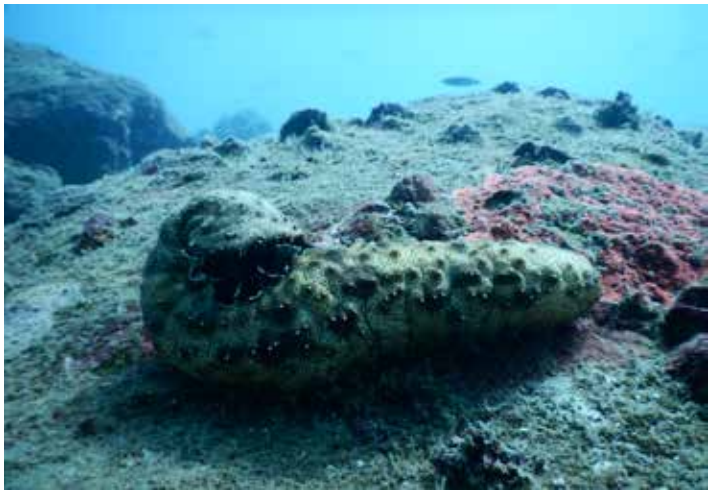


Spot them by :

Their elongated bodies that look very much like large, fat cucumbers lying on the sea floor. They come in a variety of colours – black, green, brown, dusty pink amongst others. One distinctive sea cucumber – the pineapple sea cucumber – looks like it has stars stuck all over its body and the one pictured in your slate – the marbled sea cucumber – has small tube-like feet with flattened ends protruding out of the front of its body. It has a brown, black and white marbled body colour, hence the name. The marbled sea cucumber is pictured on your slate because it is the one most likely to be found in your quadrat – as it usually feeds on algae growing on the reef itself rather than on sand.

Count them because :

They are important in controlling nutrient levels on the reef. They clean rocks and corals off microalgae and create clear substrate for coral larvae to settle.



Love them because :

They look a little like friendly aliens, waving around their feathery feet searching the area around them.

Quiz

1. Nudibranch

A)

B)

C)

D)

2. Cushion Star

A)

B)

C)

D)

3. Crown of thorns

A)

B)

C)

D)

4. Giant Clam

A)

B)

C)

D)

5. Sea Urchin

A)

B)

c)

d)

6.

A) Octopus

B) Cuttlefish

C) Squid

D) Sea Cucumber

7.

A) Slug

B) Nudibranch

C) Flatworm

D) Sea Cucumber

8.

a) Sea Urchin

b) Crown of Thorns

c) Spider Conch

d) Indian Cushion Sea Star

9.

a) Boring Clam

b) Squid

c) Octopus

d) Nudibranch

10.

a) Nudibranch

b) Slug

c) Sea Urchin

d) Sea Cucumber

11. Whats the correct body position during the invertebrate survey

a) Verticle with feet down and head up

b) Kneeling on the reef at one corner of the quadrat

c) Hovering horizontally above the quadrat

d) My back arching, fins well away form the reef with head and eyes close to the quadrat

12. I should make sure that I search the entire 2 mts x 2mts quadrat thoroughly by

a) Looking for largest indicator species

b) Divide the quadrat in 4 small sqaures in my head, take my time and search in each sqaure while being close to the quadrat

c) Swim in a U pattern over

d) with my buddy above my instructor