THE REEF AT NIGHT

INTRODUCTION

As a scuba diver, you have a remarkable capability. Unlike most of the planet's inhabitants, your ability to breathe underwater gives you a front-row seat to explore a largely unknown world. Of Earth's population of 8.1 billion, fewer than 10 million are certified divers and thus blessed with the unique privilege of understanding why Earth has been called the "Blue Planet."

Still, there is an obstacle to gaining a full appreciation of the underwater world. The emphasis during your scuba training was almost entirely on the knowledge and skills required to dive safely. Yet, learning the theory and practice of scuba diving was probably not why you chose to become a diver. After all, learning to dive is just a means to an end – a way to get there – not the end itself. For most people, the real motivation to dive is to explore the 71 percent of the Earth that most others cannot experience and to observe creatures and phenomena most people only see in movies and social media.

The lack of emphasis on the environment during scuba training means that most divers graduate without a clear understanding of the underwater world and are therefore unable to fully appreciate what they see around them. As a result, many divers quit diving once the excitement and adventure of simply being underwater begins to wane.

The Reef Smart Guides Ocean Explorer program is designed to enhance your underwater experience. The contents of this program include waterproof handheld cards and guided activities provided by a Reef Smart-trained dive professional, as well as optional online reading materials that provide additional context. The program's goal is to provide an intimate understanding of how coral reef ecosystems function, the challenges they face, and the action that is being taken to protect them.

The Reef Smart Guides Ocean Explorer Program is ideal for any avid diver or snorkeler who wants to learn more about the marine environment, particularly coral reefs, irrespective of their age or educational background. The Ocean Explorer Program consists of several individual modules that are designed to provide insight into a particular facet of the marine environment. Each module listed below is designed to complement the others in the program and can be completed in any order:

THE BENTHOS

This experience familiarizes divers and snorkelers with critical environmental aspects of coral reefs and the key benthic species that form the basis of this incredibly productive and diverse ecosystem. The objective is to hone observational skills and gain an understanding of subtle yet vital indicators of coral reef health.

THE FISH COMMUNITY

This experience familiarizes divers and snorkelers with coral reef fishes, but it involves so much more than "fish ID." The objective is to introduce the concept of how fish morphology (form) drives their behavior and role (function) in the coral reef ecosystem.

THE REEF AT NIGHT

This experience familiarizes divers and snorkelers with various phenomena that can be observed on coral reefs at night, such as bioluminescence and bioflorescence. The objective is to raise awareness of how the

coral reef community's "night shift" differs from its "day shift" and some of the behaviors that can be observed.

While each module covers the background material required to enhance your dive experience, it does not include many in-depth aspects of coral reef ecology. For a more thorough treatment of the topic, we suggest purchasing a copy of *Beneath the Blue Planet: A Diver's Guide to the Ocean.*

THE REEF AT NIGHT

Although some divers can be understandably anxious about diving at night for the first time, it can be one of the most rewarding underwater experiences. In fact, many divers find that night diving is their favorite form of diving, which is hardly surprising considering that the reef at night seems like an entirely different place than it is during daylight hours. And that's not just a matter of perception. Many of the creatures, behaviors, and phenomena you'll experience at night do not – and many cannot – occur in daylight. So, if you think scuba diving is an awesome experience, wait until you discover the reef at night. As the old saying goes, "You ain't seen nothin' yet!"

LEARNING OBJECTIVES

1. Describe how the coral reef community changes at night compared to daytime regarding the organisms observed.
2. Recognize diurnal, nocturnal and crepuscular organisms and observe how their behavior differs as night falls.
3. Explain the *fluorescence* phenomenon and how it differs from *bioluminescence* and *phosphorescence.*
4. Describe the methods and equipment needed to observe and photograph fluorescence.

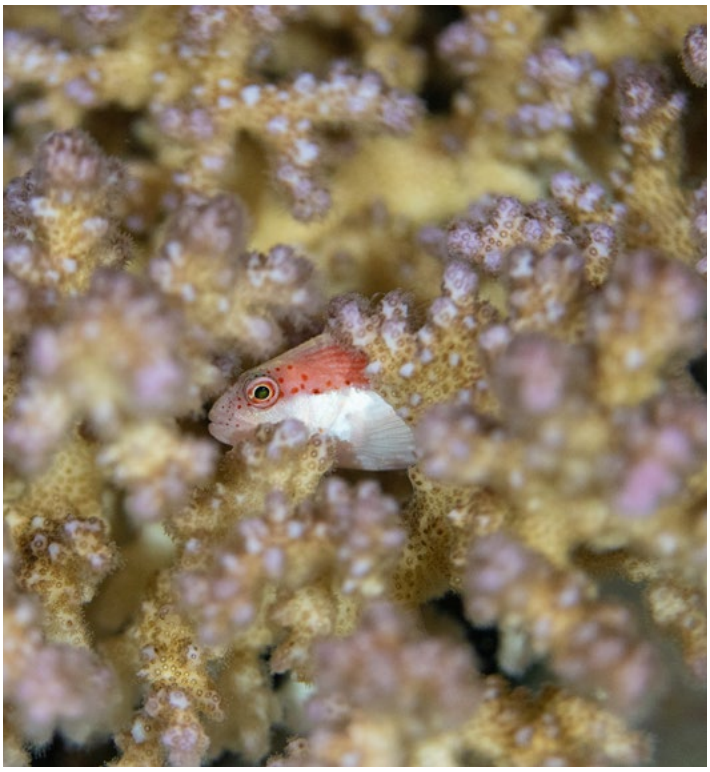
THE SHIFT CHANGE

Much like a factory, a coral reef operates 24 hours a day. There are three distinct shifts that operate at distinct times throughout the day, namely diurnal, nocturnal and crepuscular. On a coral reef, each of these shifts has its own complement of species that are adapted to the ecological role they play. By exchanging roles between shifts, a greater number of species can exist on the reef without directly competing with one another. Consider the following:

Diurnal creatures are active during the day. This group is the largest of the three shifts and consists of the creatures that divers and snorkelers are usually more familiar with, such as parrotfishes, angelfishes, surgeonfishes, and butterflyfishes, among many others.

At night, diurnal fishes are less active. They often seek shelter through numerous strategies to reduce their chances of being eaten while they sleep at night. Most diurnal species wedge themselves into coral reef cracks and crevices at night. Others, such as some wrasse species, bury themselves in the sand.

Some parrotfishes and wrasses have a particularly unique strategy: Every night, they secrete a mucus cocoon from a gland at the base of their gills that surrounds them like a bubble. These "parrotfish pajamas" mask the fish's scent from predators, particularly moray eels, which have very poor eyesight and hunt largely by smell at night. In addition, the instant the mucus net is disturbed, it alerts the owner, who awakens and can escape.



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*Some diurnal species, like this freckled hawkfish (*Paracirrhites forsteri*), found in the Indo-Pacific region and the Red Sea, wedge themselves between the branches of coral for protection.*

Tidewater Teddy/Shutterstock©

*Some parrotfish species, such as this bullethead parrotfish (*Chlorurus sordidus*), found in the Indo-Pacific region and the Red Sea, secrete a mucus cocoon at night.*

Research has also shown that this mucus contains antibacterial compounds that kill pathogens and block blood-sucking parasites from getting to the fish. Studies have shown that removing a parrotfish's cocoon leads to a nine-fold increase in the number of disease-carrying parasites. While this mucus production is energetically expensive, accounting for about 2.5 percent of the fish's daily energy budget, the evolutionary success of parrotfish tells us it must be well worth it. Still, not all species of parrotfish cocoon. But those that can't have yet another trick to deter parasites: toxic skin.

IN-WATER ACTIVITY

On your Reef Smart Guides waterproof cards, see if you can identify the two types of sleeping fishes shown 1) fishes that have wedged themselves into the reef for protection, and 2) parrotfishes that have secreted a protective mucus cocoon.

DID YOU KNOW?

Some nocturnal species, such as grunts and snapper, leave the reef at night to feed in seagrass beds, mangroves, and sandy areas near the reef. They can range up to a mile (1.6 kilometers) from the reef to find suitable nighttime feeding habitat. Studies have shown that their foraging patterns and densities at night are governed not by the availability of their food, but by the risk of predation. In fact, these fishes choose safety over a guaranteed meal because they are more likely to avoid areas where their food might be most abundant but where the risk of predation is also the highest.

Nocturnal creatures are active during the night. Members of this group are often found hiding within the reef or underneath overhangs during the day, such as moray eels, soldierfishes, squirrelfishes, lobsters and octopuses.

Almost all nocturnal species are predatory and rely more on touch, taste, smell, and motion to hunt than they do vision. They also have mouths adapted for powerful vacuum action, rather than pecking or grasping. Although they often have large eyes that allow them to gather more of the dim light available at night, it is primarily to help them see motion rather than detail. Good visual acuity is just not that important at night.

Night is also the time that certain rare mass spawning events can be witnessed, such as coral spawning and grouper spawning. Coral spawning dives have become particularly popular in the Caribbean in recent years, where multiple species can spawn in a synchronized event typically following the full moon in August.

Nassau grouper also spawn in large aggregations in the Caribbean, as do some Indo-West Pacific species such as the marbled grouper. Nassau typically spawn around the full moons in December and January, often for just a few days each year. By gathering in such large numbers, these fish overwhelm predators who like to

*Marbled grouper (*Dermatolepis inermis*) gather to spawn in aggregations that can consist of many hundreds of individuals.*

Subphoto.com/Shutterstock©

*The large eyes and red coloration of this of blackbar soldierfish (*Myripristis jacobus*) is also common in other nocturnal fish families, such as squirrelfishes and cardinalfish.*

feed on tasty fish eggs. The sheer number of eggs in the water means that enough will survive to ensure the population continues. Mass spawning events usually occur on the outer edges of offshore reefs. The strong currents found there can propel gametes away from the reef, which increases the survival of the larvae.

Crepuscular creatures ply their trade in the twilight hours between day and night. Typically made up of predators, these creatures have two peaks in activity – one at dawn and the other at dusk. Barracuda are members of this group, along with several members of the grouper family, including black grouper, tiger grouper, Nassau grouper, and smaller species such as graysby and coney. Perhaps the best-known members of the crepuscular group are sharks, whose eyes are perfectly adapted to the low-light levels typical of twilight.

IN-WATER ACTIVITY

Take a look at your Reef Smart Guides waterproof cards and, along with your dive leader, see if you can check off some of the crepuscular and nocturnal organisms during your night dive and snorkel activity.

CORALS AT NIGHT

Like many of the more mobile reef inhabitants, corals also have distinct differences in their behavior and appearance between the phases of day and night.

Corals are living animals with tentacles that actively feed on passing plankton. During the day, divers and snorkelers are used to seeing corals relatively inactive, with their polyps closed. When the sun is out, the microscopic zooxanthellae in the coral tissues use the sun's energy to photosynthesize. But at night, these tiny polyps burst into life, with their tentacles outstretched, grasping for their planktonic prey.

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During the day, coral polyps are usually closed, as seen in this image.

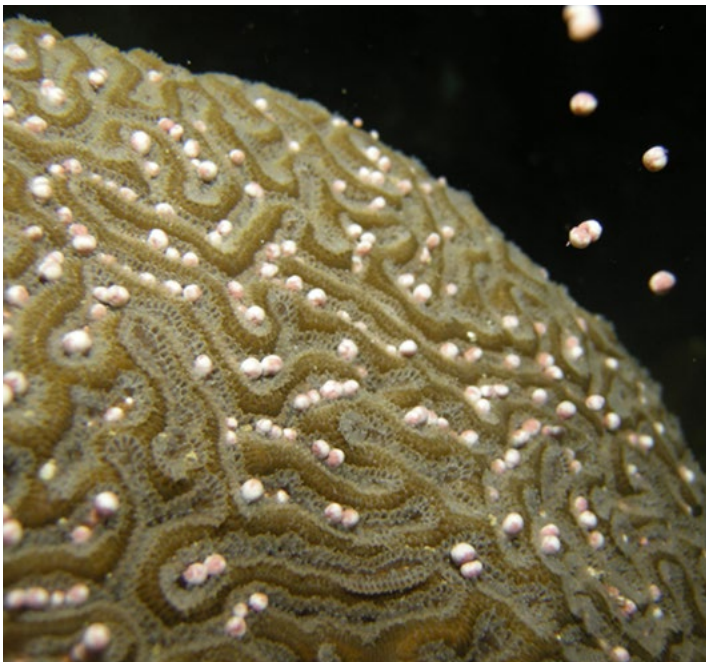
John A. Anderson/Shutterstock©

At night coral polyps open so their tentacles can grasp passing food from the water.

IN-WATER ACTIVITY

On your Reef Smart Guides waterproof cards, see if you can identify corals that are feeding on plankton at night.

Also at night, divers and snorkelers might witness coral spawning. This often happens for multiple species in a coordinated event, typically timed with the full moon and generally in the summer months. Many dive operators track coral spawning events over the years to offer dive opportunities during these rare events.



Emma Hickerson/FGBNMS©

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Corals spawn sexually as well as asexually (by fragmentation). Sexual reproduction involves the rare event of mass eggs and sperm release into the water.

DO FISH SLEEP?

Yes, fish do sleep, but their sleep patterns and behaviors are quite different from those of humans and other animals. Fish sleeping patterns are often influenced by environmental factors, such as light levels, water temperature, and water flow. And since fish do not have eyelids, they cannot close their eyes in the way that most mammals do, nor do they experience rapid eye movement (REM) sleep like humans. Instead, fish have evolved adaptations to rest and conserve energy while remaining alert to potential threats. Here are some key aspects of how fish sleep:

Reduce activity

During their resting periods, fish typically reduce their swimming activity and metabolic rate. This strategy allows them to conserve energy.

Hide or seek shelter

Many fish seek shelter or hide in crevices or vegetation. This behavior helps protect them from predators while they are less active and less alert.

Unihemispheric slow-wave sleep

Some fish exhibit a sleep pattern known as *unihemispheric slow-wave sleep*. In this type of sleep, one hemisphere of the brain remains active while the other hemisphere rests. Dolphins also sleep in this way. This allows fish to remain partially alert and responsive to their surroundings even while they allow part of their brain to get some rest.

It's important to note that the sleep patterns of fishes are diverse, and that they vary significantly between species. Additionally, the exact mechanisms and the purpose that sleep plays in fish health and physiology is still an ongoing subject of research.

DIVING WITH ULTRAVIOLET LIGHT

A unique aspect of this Ocean Explorer experience is the opportunity to see a coral reef not just in regular light but under ultraviolet light. This is often referred to as "fluoro diving." When viewed with this "black light," the reef becomes a spectacular world that displays a plethora of unimaginable colors.

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The reef can look remarkably different when viewed under UV light compared to normal sunlight. Consider these photos of some zooanthids viewed under regular light (above on the right) versus UV light (above on the left).

But why does it take this unique form of light to render this hidden psychedelic realm visible? The phenomenon is the result of what's formally termed biofluorescence. So, what is biofluorescence, and how does it differ from other instances where creatures, objects, or the environment glow or produce light? It is often easier to describe what biofluorescence is by first explaining what it isn't.

Biofluorescence is often confused with *bioluminescence*, which is the production and emission of light by a living organism through internal chemical reactions. This is found in a vast array of marine life, including bacteria, fungi, algae, jellyfish, worms, crustaceans, and fishes (including some sharks). In fact, some 1,500 fish species have the power to create light, along with tens of thousands of other invertebrates. In some creatures, the light is bacteriogenic, meaning it's produced by symbiotic bacteria – often from the genus Vibrio – while in others, it is autogenic, produced by the animals themselves. Typically, if you turn your light out and wave your arms back and forth during a night dive, you'll witness a light show compliments of the tiny planktonic creatures that surround you in the water column. This is an example of bioluminescence.

Candyfloss Film/Shutterstock©

Bioluminescence in the water is a common phenomenon that can be experienced not just by divers and snorkelers, but by anyone standing on the shoreline.

Eddie Espriella/ShutterstockCaption©

Some divers attach single-use chemical glow sticks to their gear during a night dive, a practice that is thankfully becoming less common because there are negative environmental impacts to these glow sticks, including contributing to plastics ending up in the environment.

Yet luminescence does not require the intervention of biology; it can be produced by chemicals, which in this case is called chemiluminescence. This is what happens when you activate a chemical glow stick. Here, hydrogen peroxide and sodium hydroxide are held separately in a breakable vial inside a plastic tube filled with luminol solution. Breaking the vial mixes the chemicals and leads to the release of energy from the chemical reaction in the form of visible light.

There's yet another common light-producing phenomenon called *phosphorescence*, which is also confused with biofluorescence. Phosphorescence is the emission of light from a substance exposed to radiation, where the light persists as an afterglow when the exciting radiation has been removed. The faces of many analog gauges used by divers are phosphorescent so that they can be read more easily at night.

With those other terms better understood, we can now focus on the explanation of what is biofluorescence. In its simplest terms, biofluorescence is the result of the absorption of high energy light (usually in the wavelengths of violet, blue and particularly ultraviolet (UV)) and the re-emission of lower energy light (usually the wavelength of red, yellow, or green).

This is made possible through the presence of green fluorescent proteins (GFP) found in anemones, jellies, zoonathids and corals, among other species. These proteins exhibit fluorescence when exposed to light in the blue to ultraviolet range.

As such, the most effective way to see biofluorescence in coral reef creatures is to use an underwater UV light source during a night dive or snorkel. These activities have more recently become known as "fluoro diving."

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Your dive gauges and compass are often coated in a phosphorescent material to make them glow in the dark.

IN-WATER ACTIVITY

Use your Reef Smart Guides waterproof cards to check off some of the common examples of coral reef biofluorescence on your night dive and snorkel.

DID YOU KNOW?

Green fluorescent proteins (GFP) were first discovered in 1962 by Dr. Osamu Shimomura – a Japanese organic chemist and marine biologist who worked at several U.S. institutions, including Princeton, Boston University, and the Marine Biological Station in Woods Hole Massachusetts. Shimomura and two other scientists were awarded the Nobel Prize in Chemistry for their research on the crystal jelly (*Aequorea Victoria*), a bioluminescent hydrozoan jellyfish found off the west coast of North America. Their research led to the discovery of GFPs. While the term GFP refers to the first protein discovered, yellow, cyan, and red fluorescent proteins are all mutations of GFPs.

Some divers and snorkelers prefer to use a yellow filter over their facemask or camera lens during a fluro dive or snorkel. The yellow filter removes the blue haze that is visible when using an underwater UV light source, leaving only the color emitted by the proteins absorbing the ultraviolet light.

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A yellow filter over the facemask vastly improves the visual experience underwater when using a UV light.

DID YOU KNOW?

The way our eyes perceive color is through the reflection of light from the objects we view. For example, blue objects appear blue because they reflect blue light while red objects appear red because they reflect red light. Most objects appear blue underwater because there is not enough red light that penetrates from the surface of the water to reflect into our eyes (unless viewed with an underwater source of artificial light). However, some colonies of giant star coral (*Montastraea cavernosa*) in the Caribbean have a distinct red glow, even at depths where red light does not penetrate, as shown by the image below. This red hue is the result of biofluorescence.

Ricardo Cordeiro/Shutterstock©

*This daylight image, shot at a depth of 70 feet using no artificial light, shows a colony of giant star coral (*Montastraea cavernosa*) glowing red at 70 feet of depth.*

WHY CORALS FLUORESCE

Scientists have known for a while that many species of corals fluoresce. Yet only recently have the reasons for this phenomenon come into focus. It's been shown that green fluorescent proteins (GFP) serve as a beacon to attract and capture dinoflagellates in the water column that become the zooxanthellae within the tissues of adult corals and coral larvae. Research has also demonstrated that in shallow-water species, GFPs act as a form of sunscreen by eliminating excess light energy and reducing UV damage. Conversely, in deeper water corals, the GFPs produce photosynthetically active radiation (PAR) for use in photosynthesis and to attract prey. Some sources also believe biofluorescence may perform an antioxidant function to help maintain coral tissue health.

DIVE/SNORKEL PREVIEW

An important factor to consider when planning a nighttime excursion is when to enter the water. In most cases, night dives and snorkels are scheduled to begin at or near twilight, allowing those involved to gradually adapt to the darkening conditions. This is an excellent idea, especially for beginning night divers who are often understandably anxious about being in the open ocean at night. However, the changeover from a diurnal to a nocturnal environment requires time. So, when possible, try to schedule your night dive later in the evening when the day shift is long asleep, and the night shift has been long at work.

SAFETY TIP

Diving at night requires a few extra precautions relative to diving during the day. For instance:

- It's important to carry a backup light in addition to your primary light – no mechanical device is immune to malfunction, and a night dive without a light is not going to end well.
- A battery-operated marker light attached to your tank valve is a useful way for your buddy (and your surface support) to keep track of your location (skip the glow-stick).
- Purchase a dive light with the option of switching to a red bulb to help avoid night-blindness while on the surface.

During your dive, you will carry with you an ultraviolet (UV) light. Some manufacturers now offer models with both white and UV bulbs precluding the need to carry two different lights. Some models are available with a third, red bulb, which can come in handy. In addition to helping to prevent night blindness during surface preparation, many marine creatures have limited or no ability to see red light, which means red light is far less obtrusive and makes marine life easier to approach.

Your instructor or guide will brief you on other pertinent night-diving procedures relevant to your location and any special considerations about your specific dive site. The main objective of the dive is simply to observe your surroundings, paying particular attention to the following:

Bioluminescence

Once you are comfortable and acclimated to the darkness, turn off your light and wave your arms back and forth. In most cases, this will activate a bioluminescent response from tiny planktonic organisms in the water column, often providing one of the ocean's most fantastic light shows.

Biofluorescence

Periodically, switch off your white light and scan the bottom with the UV light to see and record what organisms fluoresce. Here are some of the coral reef creatures that are known to fluoresce:

- Corals
- Anemones
- Annelids
- Zoonathids
- Fishes
- Nudibranchs
- Crustaceans
- Cephalopods
- Sea Jellies
- Comb Jellies

Feeding coral polyps

While some corals feed during the day, such as soft corals, it is more likely to observe this behavior at night. The difference between night and day is stark among hard coral species. And by shining your light near a coral colony, plankton often approach the light, getting close enough for the coral polyps to capture and eat them.

Spawning

While fish tend spawn during the day, most invertebrates tend to spawn at night, so keep an eye out for this behavior. Most corals spawn synchronously as a group at a particular time of the year. Yet some species spawn frequently throughout the year. Sponges are also good candidates to observe spawning behavior.

Nocturnal creatures and behavior

While on your dive, take note of the line-up of fishes and invertebrates at night compared to your daylight dives. Also try to note any different behaviors they display that you haven't witnessed during the day.

After your dive, your instructor or guide will debrief you and discuss these observations and data to gain a sense of the health status of the dive site.