

EDUCATORS' RESOURCE GUIDE



JEAN-MICHEL COUSTEAU'S SECRET OCEAN



TABLE OF CONTENTS

TO EDUCATORS p 3
 INTRODUCTION p 4
 PLANKTON, SOURCE OF LIFE p 4

PART 1. SCENES FROM "SECRET OCEAN"

1. CHRISTMAS TREE WORMS p 5
 2. GIANT BASKET STAR p 6
 3. SEA ANEMONE AND CLOWN FISH p 6
 4. GIANT CLAM AND ZOOXANTHELLAE p 7
 5. ARROW CRAB p 8
 6. BANDED CLEANER SHRIMP p 8
 7. BLACK-SPOTTED SEA CUCUMBER p 9
 8. OCTOPUS, THE SOFT INTELLIGENCE p 10
 9. GOBIES AND BLENNIES p 11
 10. SPOTTED MORAY EEL p 11
 11. GIANT HERMIT CRAB p 12
 12. CARIBBEAN SPINY LOBSTER
 AND SPANISH SLIPPER LOBSTER p 11
 13. SEA HARES p 13
 14. MARKET SQUID p 13
 15. CROWN-OF-THORNS p 14
 16. RED LIONFISH p 15
 17. MANTA RAY p 15

PART 2. SURVIVAL STRATEGIES

A. A WORD ABOUT THE LINKS BETWEEN
 ALL ORGANISMS, LARGE AND SMALL p 16
 B. EATING TO SURVIVE p 16
 1. Phytoplankton and zooplankton
 2. A diversified diet: other food sources
 3. Detritus and sediment: the diet of reef recyclers
 C. DEFENSE MECHANISMS AND PROTECTIVE
 STRATEGIES FOR SURVIVAL p 17
 1. Hiding in holes, crevices and caves
 2. Chemical weapons
 3. Schooling behavior and massive reproduction as protection
 4. Carapaces and shells
 5. Camouflage
 6. The ultimate strategist, the octopus
 D. HELPFUL PARTNERSHIPS p 18
 1. The sea anemone and the clownfish: a win-win collaboration
 2. The giant clam and its food-producing partners
 3. Banded cleaner shrimp, a health service for fish
 4. The goby, bodyguard to a blind shrimp
 5. Manta ray and small fish
 E. A BLUE PLANET WHERE EVERYTHING IS CONNECTED p 19

III. PART 3. ACTIVITIES FOR STUDENTS

ACTIVITY 1. DO YOU KNOW ME? p 20
 ACTIVITY 2. DISCOVER THE ANIMALS OF "SECRET OCEAN" p 21-24
 ACTIVITY 3. A. SECRET OCEAN WORD FIND p 25
 ACTIVITY 3. B. ADD COLOR TO THE OCTOPUS! p 25
 ACTIVITY 4. A. WHERE IS MY MOUTH? p 26
 ACTIVITY 4. B. WHAT DO I USE TO EAT? p 26
 ACTIVITY 5. A. WHO EATS WHAT? p 27
 ACTIVITY 5. B. DIFFERENT DIETS AND WAYS OF GETTING FOOD p 27
 ACTIVITY 6. WHAT IS THEIR PLACE IN THE FOOD CHAIN? p 28
 ACTIVITY 7. HOW DO THEY GET FOOD? p 29
 ACTIVITY 8. DEFENSE TECHNIQUES CROSSWORD p 29
 ACTIVITY 9. HELPFUL RELATIONSHIPS p 30
 ACTIVITY 10. WHAT DO YOU KNOW ABOUT PLANKTON? MINI QUIZ p 30
 ACTIVITY 11. SECRET OCEAN FUN FACTS QUIZ p 30

ANSWERS TO ACTIVITIES p 31



A WORD ON THE BREAKTHROUGH FILMING TECHNOLOGY

The images in "Jean-Michel Cousteau's Secret Ocean" were captured thanks to the development of new filming tools that allow underwater shoots in 3D, Ultra-HD 5K, slow motion, close up, macro, and with motion control. Three years of research and development were required to obtain these final images. Thanks to these breakthrough filming techniques, your students will literally dive into this virtually unknown new underwater world as if they were there.

The film was shot in several underwater environments, including Bimini and other islands in the Bahamas, Fiji and Catalina Island off of Southern California.

This Educator's Guide was written by Dr. Elisabeth Mantello in collaboration with Jean-Michel Cousteau's Ocean Futures Society. Special thanks to Marine Biologist Holly Lohuis and Dr. Richard Murphy.

Edited by Alison Martin
 Illustrations by Joëlle Baron for 3D Entertainment Distribution

Produced and published by 3D Entertainment Distribution
 For additional resources, please visit online www.SECRETOCEAN-THEFILM.com

TO EDUCATORS



Using breakthrough technology for the filming of “**Secret Ocean**”, Jean-Michel Cousteau, son of ocean pioneer Jacques Cousteau, takes you and your students on a unique dive to encounter animals, seldom seen by even the most experienced divers, such as Christmas tree worms, basket stars, banded cleaner shrimp and tiny fish such as gobies and blennies. During your virtual dive with Jean-Michel Cousteau and biologist Holly Lohuis, you and your students will also come close to larger animals such as the giant clam, hammerhead sharks and a manta ray, as well as follow the octopus, an incredibly intelligent invertebrate that Jacques Cousteau used to call “the soft intelligence”.

While protecting the large marine animals such as whales, dolphins and sharks is more than ever essential, one should not forget that these great animals represent only the top of the food chain. “**Jean-Michel Cousteau’s Secret Ocean**” gives your students a bigger conservation picture by helping them discover the crucial importance of protecting this secret world within the ocean that is the bottom of the food chain on which everything else in the ocean and on our planet depends.

This **Educator’s Guide** has been designed to enhance your students’ experience and enjoyment of the film “**Secret Ocean**” by discovering and/or becoming more familiar with the sea creatures they will see. We hope your students will then better understand how much their own life depends on the smallest life forms in the ocean. As “people protect what they love,” we hope your students will fall so much in love with these animals that they will help protect them.

How to use this Guide:

The **Educator’s Guide** is divided into three distinct parts. Part 1 and Part 2 are dedicated to the educator.

Part 1, “**SCENES FROM SECRET OCEAN**”, introduces seventeen (17) of the animals appearing in the film. It contains a short identification file for each of these animals, briefly outlining its main characteristics and survival strategies. Animals are presented in order of appearance.

Part 2, “**SURVIVAL STRATEGIES**”, outlines some of the survival strategies these animals have developed. It focuses on the creatures’ adaptation to their environment in order to survive, i.e. their type of diet, ways of catching food and ways of protecting themselves from predators. It also describes how two of these animals - the Crown-of-thorns and the red lionfish - have become destructive invaders due to human errors. Finally, it demonstrates how everything in the sea and on our planet is connected. This relates to marine organisms, to all forms of life on the planet and to humans as we significantly impact the environment.

The third part, “**ACTIVITIES FOR STUDENTS**”, provides activities for your students to discover and/or learn more about the animals appearing in the film. They can be done before they see “**Secret Ocean**” and/or after they have seen the film. The “Copy me” pages are meant to be photocopied and distributed to the students. These activities are intended to lead to meaningful student-based research and interesting discussion in the classroom. The material has been developed for students age 10 to 16. Educators will choose and adapt the activities best suited for their particular class.

“... On an isolated riverbank in the Amazon, just as we had released a rescued sea otter named Cacha, my father turned to me, full of emotion, and said, “Jean-Michel, people protect what they love.” That became for me a motto of my father’s work and an emblem of the commitment we all must make to the world that surrounds us.”

Jean-Michel Cousteau, “My Father, the Captain,” 2010



INTRODUCTION

PLANKTON, SOURCE OF LIFE

"The smallest life in the ocean is the mightiest force on which we all depend."

Jean-Michel Cousteau

As much as 80 percent of all life on Earth is in the ocean. Most of it is nearly invisible, and fragile: welcome to the world of drifting, wandering plankton.

DID YOU KNOW?



The name plankton is derived from the Greek *planktos*, meaning errant, thus "wanderer" or "drifter."

Plankton is a term that describes thousands of different types of organisms that drift in the water. The smallest planktonic organisms are plants, called **phytoplankton** (from the Greek *phyton* or plant). Many of them are microscopic. The number of phytoplankton is phenomenal. According to some, just one teaspoon of seawater contains over a million phytoplankton. Phytoplankton live near the water surface because they use the sun's energy to create food via **photosynthesis**.

The larger organisms are animals called **zooplankton** (from the Greek word *zoon*, or animal). They can be plankton all their life or only when they are young (larvae), and feed on phytoplankton and zooplankton. Some are very small animals, others are quite large but soft-bodied, such as jellyfish.

Starting on a beautiful pink **mushroom coral** (*Fungia fungites*), the opening sequence of "**Secret Ocean**" features two types of zooplankton: the barrel shaped **salps** (*Cyclosalpa bakeri*) that drift in groups or alone, and the crystal-like chandeliers of **comb jellies** (*Beroe spp*).

Living deep in the ocean, some species of zooplankton rise to the surface of the sea every night to feed and retreat into the depths during the day where they are more protected from predators. It is the largest migration of animals on the planet. Other zooplankton spend their lives in more shallow water.

Phytoplankton are the first link in the ocean food chain. They are food for many zooplankton. Zooplankton are a source of food for many species, and thus the link between phytoplankton and larger animals. Should their numbers decline, the consequences in the food chain and for larger animals would be severe.

LIFE ON OUR ENTIRE PLANET - NOT JUST IN THE OCEAN - DEPENDS ON THIS TINY WORLD OF PLANKTON FOR TWO MAIN REASONS:

- Phytoplankton produce more than half the oxygen on Earth thanks to photosynthesis. So every other breath we take is a gift from the sea.
- Plants, both on land and in the ocean, use the sun, along with water, minerals and carbon dioxide, to create sugars. This process is called photosynthesis. These sugars are the stuff of life. With them, the plants are able to make other chemicals, which they use to live and grow. And the lives of all animals depend on plants to do this.

Note: Throughout the film, you will be able to see tiny particles drifting in the water. This is zooplankton that comes in many different sizes. Most phytoplankton cannot be seen by the naked eye as they are microscopic. After the pink mushroom coral at the beginning of the film, you will see several types of zooplankton. You will also see Jean-Michel Cousteau and Holly Lohuis swimming next to reef sharks, and then next to a huge grouper that opens its mouth wide.

PART 1 - SCENES FROM "SECRET OCEAN"




The goal of this part is to introduce the main animals featured in the film. It outlines some of their specific features such as size, diet, and some of their survival behaviors. Two scenes show animals that have become destructive in an ecosystem: the Crown-of-thorns sea star and the red lionfish.

1. CHRISTMAS TREE WORMS

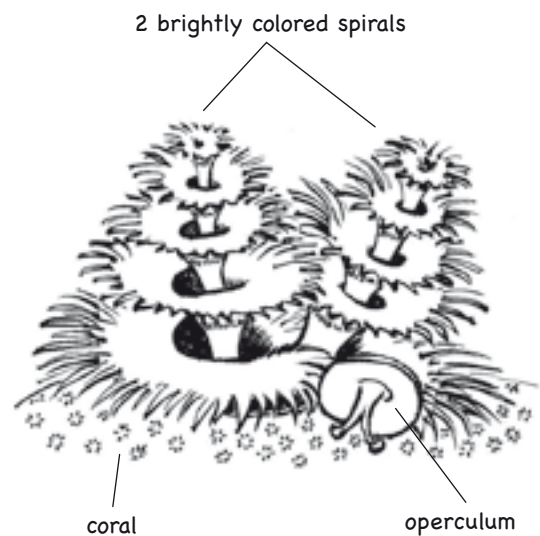
Christmas tree worms (*Spirobranchus giganteus*) look like tiny Christmas trees but they are tube-dwelling worms that belong to a group called "annelid", i.e. "ringed worms" (Phylum Annelida), including species such as common earthworms, leeches, or feather-duster worms.

Most of their body resides within a straight calcareous tube that they have secreted while developing as a larva, boring it into live coral. The tube ends with a sharp-pointed projection, a spine. The worm's body extends in two brightly colored spirals that look like little Christmas trees. Each spiral has **radioles** or hair-like appendages that circle outward from the central spine, and are used for breathing and feeding. Radioles are used for catching phytoplankton and small zooplankton particles.

DID YOU KNOW?



When Christmas tree worms die, their tubes become empty holes that are important habitats for fish like the gobies and blennies that we see later in the film.



To protect itself, the Christmas tree worm quickly retracts into its tubular burrow at the slightest touch or shadow. For extra protection, it then covers the opening of its hole with a lid, called the **operculum**. They live anchored in coral, never moving outside of their tube.

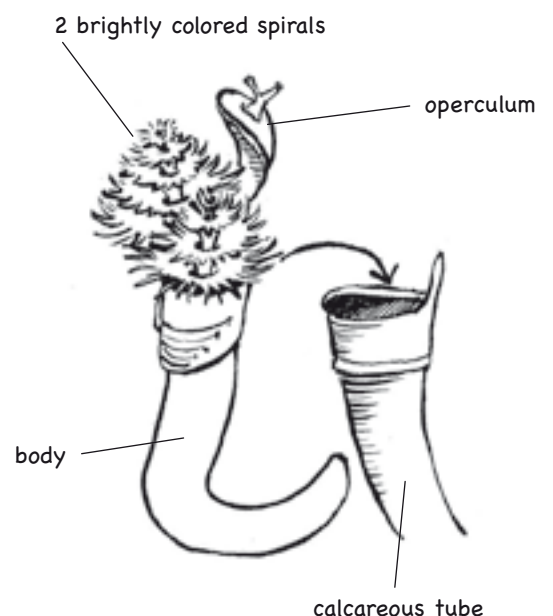
Size: Averaging 1.5 in (3.8 cm) in length for the exposed structure, around 4 in (10 cm) and more for the tube.

Diet: Phytoplankton, some zooplankton. They connect the world of plankton on which they feed to the world of fish that eat them.

Feeding strategy: Filter-feeding.

Conservation Status: Not threatened.

Note: Other animals also appear in this scene such as coral clam, feather duster worms, white soft corals.





PART 1 - SCENES FROM "SECRET OCEAN"

2. GIANT BASKET STAR

The giant basket star (*Astrophyton muricatum*) looks like a tangled weed, but it is an invertebrate that belongs to the "echinoderm" group (*echinos*= spiny; *derma*=skin) like urchins and sea stars (Phylum Echinodermata).

Its body is made of a central disk with multitudes of arms five times the length of the disk branching out into thousands of branchlets. The central disk has a mouth surrounded by five teeth hidden under branches. The mouth is the only opening to the basket star's one-way digestive system and performs both the functions of a mouth and anus. Its arms, covered with tiny hooks, stretch out and form a basket to catch the passing prey at night and bring it down into the central mouth.

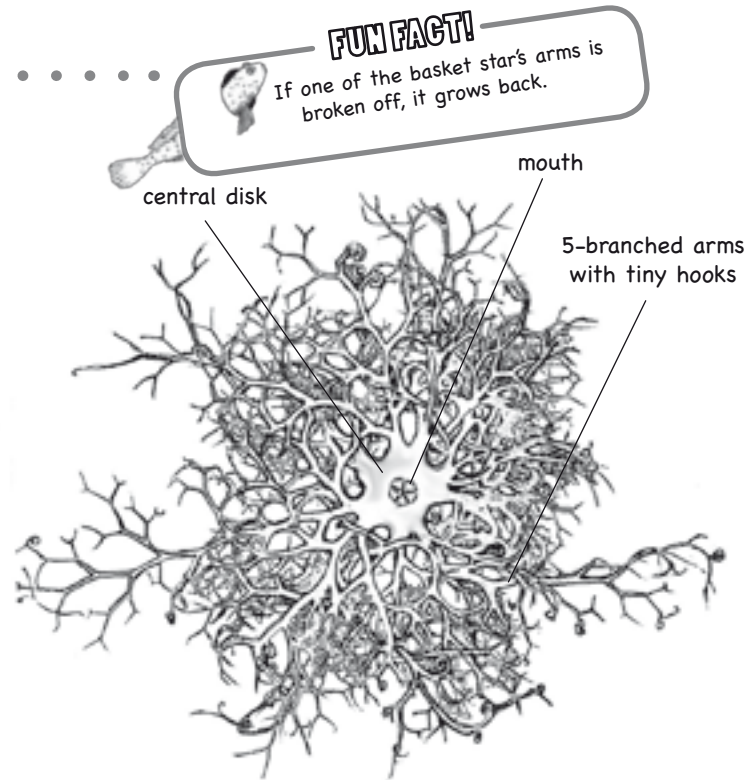
During the day, basket stars coil into a tight ball, hiding away deep in crevices. At night they detach themselves from their support to follow the current and the food. It has no head, no eyes and no blood. For an animal without a brain, i.e. a central control system, it has a complex nervous system that is impressive in the coordination of organizing over a thousand branches to all work and give it food and movement!

Size: Arms 1 to 1.5 ft. (30 to 45 cm) long

Diet: Zooplankton, detritus.

Feeding strategy: Trapper (passive hunter), filter-feeding.

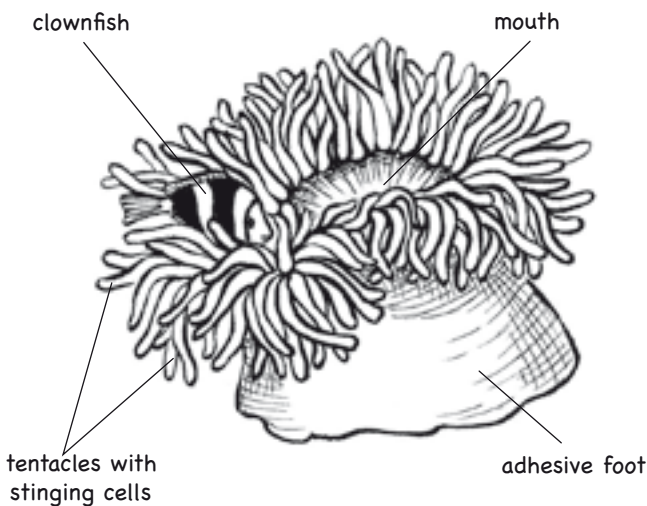
Conservation Status: Not evaluated.



FUN FACT!
If one of the basket star's arms is broken off, it grows back.

An extraordinary moment!
As Jean-Michel Cousteau points out, basket stars are rarely seen moving but in the film, you will get to see a basket star wandering.

3. SEA ANEMONE AND CLOWNFISH



Named after a flower, the sea anemone is an invertebrate animal that belongs to the "cnidarian" group (Phylum Cnidaria) along with animals such as medusas, jellyfish, hydras and corals. It is one of the oldest forms of life on Earth. It lives attached to a base such as coral, rocks or the sea floor. However, it can sometimes detach from its base and drift with the current.

The sea anemone's cylindrical body has an adhesive foot and a central mouth surrounded by a multitude of tentacles. Full of nutrients, these tentacles attract many fish, but each tentacle has thousands of harpoon-like stingers (or "nematocysts") that the anemone uses to inject a paralyzing neurotoxin into its prey and would-be predators.

The clownfish has evolved the ability to fool the anemone - its skin carries a special chemical (a protein), which is identical to one in the anemone. The anemone recognizes this chemical and does not fire off its stinging cells. See Part 2-D.1 for more on the partnership between the sea anemone and the clownfish.

Size: There are more than 4,000 species of sea anemones named after the land flower. Sizes vary from half an inch (1.25 cm) to 6 feet (1.80 m) across.

Diet: Zooplankton, fish, shrimp.

Feeding strategy: Predator that stings and consumes any animal that touches its tentacles.

Conservation Status: Not endangered.

FUN FACT!
Something special about the sea anemone: Food enters and waste leaves through the same opening, its mouth.



4. GIANT CLAM AND ZOOXANTHELLAE

The giant clam (*Tridacna gigas*) is a bivalve or “two-shelled” creature, i.e. an invertebrate animal that belongs to the mollusk group (Phylum Mollusca). It is the largest and heaviest bivalve mollusk today and can live for more than a hundred years.

Permanently attached to its base, the giant clam is not free to move about when adult. Its thick shell consists of two deep, wavy, thick valves that cannot completely close.

The mantle cavity hosts two tubes or siphons that you can see in the film.

- The inhalant siphon is an elongated opening that draws in seawater to filter over gills and consume passing plankton.
- The exhalant siphon looks like a raised cone. It expels water that has been already filtered. When the giant clam’s shells close suddenly or during spawning, water shoots out of this siphon.

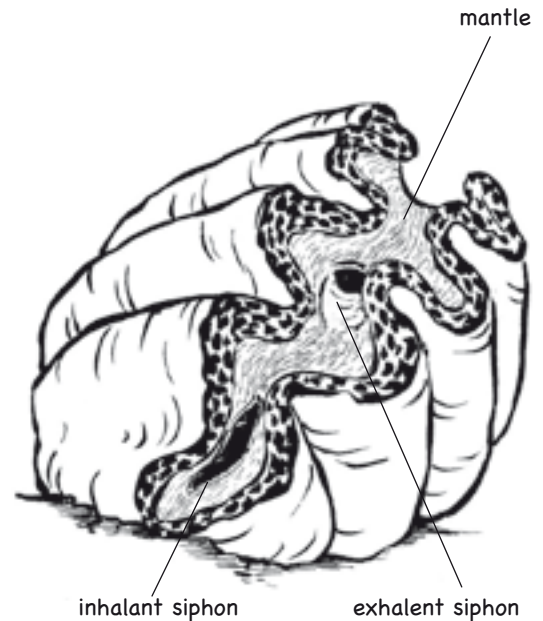
The giant clam can grow to such a large size because it has food-producing partners living inside its mantle - *zooxanthellae* algae. The larger the mantle, the more space for partners and the more partners, the more food there is for the clam. See Part 2.D.2 for more on this relationship.

Size: Up to 59 in (1.50 m) across; up to 400 pounds (approx. 180 kg)

Diet: In-grown algae (*zooxanthellae*), and filter-feeding on plankton and microscopic algae.

Feeding strategy: Filtering.

Conservation Status: One of the most endangered clam species as it is overharvested for food, shells and the aquarium trade. Its IUCN Status is Vulnerable (VU 1996) which is “considered to be facing a high risk of extinction in the wild.”



A word on the IUCN “Threatened” categories

IUCN stands for International Union for Conservation of Nature.

The species considered as “threatened” belong to three IUCN categories:

- Critically Endangered (CR) for animals at an extremely high risk to become extinct very soon,
- Endangered (EN) for animals that have a very small population and are facing a high risk of extinction,
- Vulnerable (VU) for animals with a population which is constantly dropping and thus at risk of extinction.

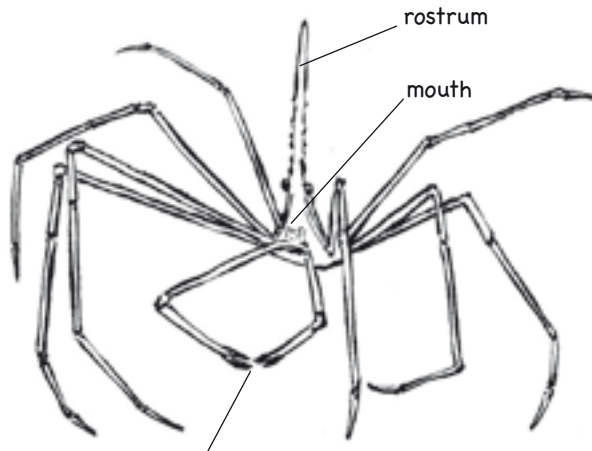
There is a total of nine IUCN categories to classify species.

See http://www.iucnredlist.org/static/categories_criteria_3_1



PART 1 - SCENES FROM "SECRET OCEAN"

5. ARROW CRAB



2 dark purple claws

The arrow crab (*Stenorhynchus seticornis*) looks somewhat like a spider. This arthropod (Phylum Arthropoda) has a triangular body that is covered with stripes and ends at the top with a very pointed "head" (rostrum). It has eight very long, thin, reddish or gold spider-like walking legs and two dark purple claws. Arrow crabs forage at night and live in places where they can hide during the day: coral reef crevices, sponges, underneath anemone, for example.

DID YOU KNOW?



75% of all animal species are arthropods, i.e. invertebrate animals with an exoskeleton, segmented bodies, jointed legs, eyes, antennae and circulatory systems. Spiders, insects, centipedes, crustaceans, crabs (including the arrow crab and hermit crab), shrimp (including the banded cleaner shrimp) and lobsters are arthropods.

Size: Body (covered by carapace) about 1 to 2.5 in (2.5 - 6 cm) in length plus legs measuring up to 3.9 in (10 cm). The legs are more than three times the body length.

Diet: Zooplankton, invertebrates (such as tube worms, bristleworms, small feather duster worms), bits of other animals' left-overs, dead organisms.

Feeding strategy: Scavenging, hunting, catching, picking. It uses its claws to get and manipulate food, and bring it to its mouth.

Conservation Status: Too small to consume, but very popular in the aquarium trade, they are not currently on the IUCN endangered species list.

6. BANDED CLEANER SHRIMP

The banded cleaner shrimp (*Stenopus hispidus*) is an arthropod whose body and hairy claws are banded red and white. It has six pincer claws, the largest being the middle pair. It has super-sized white antennae that are longer than its body and that it waves to signal it will perform cleaning services for other animals. Banded cleaner shrimp live and work in pairs, partners for life, and remain in the same area for days, months or more.

Well-equipped for eating, with their six pincers, they can pick up scraps anywhere and provide a valuable service to other animals, cleaning them of parasites and dead skin. They can even safely enter the mouth and gills of a fish without being eaten.

While cleaning, they not only get a meal from the pickings, but they also keep animals and the ecosystem they live in healthy. See Part 2.D.3. for more on this relationship with other animals. Being a nocturnal animal, the banded cleaner shrimp hides in a cave during the day.

Size: 2 to 4 in (5 to 10 cm) in length with super-sized antennae (up to 6 in or 15 cm).

Diet: Zooplankton, small fish, other crustaceans, snails, worms, parasites, fungi, invertebrates, dead organisms, damaged tissues and food particles it cleans from fish.

Feeding strategy: Picking fish clean, scavenging, hunting, catching.

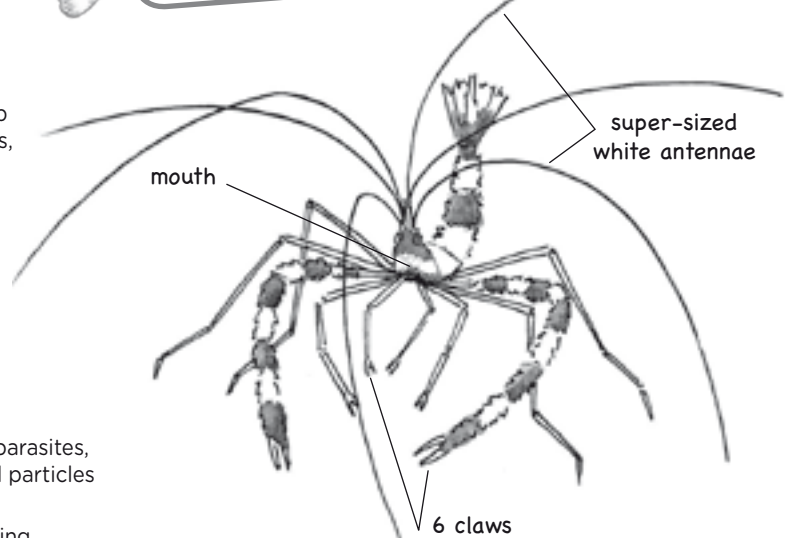
Conservation Status: Not evaluated.

Note: One of the banded cleaner shrimp in the film has lost one of its big claws. The missing limb will eventually regenerate the next time it molts.

FUN FACT!



The banded cleaner shrimp became very popular in 2003 thanks to the Pixar film "Finding Nemo" where it plays Jacques, the cleaner shrimp with a French accent.



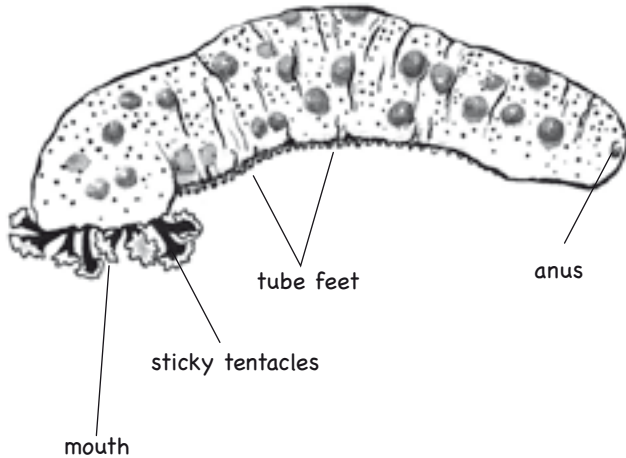
A BORN ADVERTIZER!



With bright red and white stripes and extra-long, waving antennae, the banded cleaner shrimp does not hide. It advertizes its services from its shelter, i.e. cleaning station, waiting for fish to swim by and signal they need cleaning.



7. BLACK-SPOTTED SEA CUCUMBER



Sea cucumbers (*Bohadschia graeffei* or *Pearsonothuria graeffei*) are sometimes called “sea slugs”, but despite their look, they are not gastropod mollusks. Related to sea stars and sea urchins, the sea cucumber belongs to the “echinoderm” group (Phylum Echinodermata).

The black-spotted sea cucumber has an almost cylindrical body with three rows of tube feet on the ventral surface. Tube feet are organs that allow echinoderms like the sea cucumber to stick to the ocean floor and move. Its mouth is surrounded by some 25 black and white sticky tentacles and is connected to the anus by an intestinal tract. The body has dark brown spots and black polka dots. The tentacles extending from its mouth sense food and filter sand to extract food from it.

The sea cucumber spends most of its time vacuuming the ocean floor of detritus, debris and morsels that have drifted down from other meals. It then expels clean sand from its anus. The sea cucumber provides a vital service to the ecosystem as a recycler. By feeding on detritus, the sea cucumber recycles waste organic matter in its body that becomes food for algae and phytoplankton, which are in turn eaten by animals and eventually become dead matter that is converted back into the nutrients for plants to use.

FUN FACT!
A strange way to get oxygen... While most sea animals use gills to breathe, the sea cucumber uses its anus to pump air in and out.



ABOUT THE IUCN “LEAST CONCERN” AND “DATA DEFICIENT” CATEGORIES

The “Least Concern” category (LC) implies that the species has been evaluated by the IUCN but does not qualify for any other category. The Least Concern (LC) category is used to highlight species that have a relatively low extinction risk compared with the species that are assessed as Threatened or Near Threatened.

The IUCN “Data Deficient” category (DD) implies that there is not enough information to assess the extinction risk for the species under scrutiny. This does not mean that this species is not threatened.

Size: On average 14 in (34 cm).

Diet: Detritus, fish feces, scraps of fallen food, dead corals and sponges.

Feeding strategy: Grazing sea bottom sediments to extract and ingest small organisms and organic matter.

Conservation status: Not heavily fished anywhere in its range, the IUCN has listed this species as Least Concern (2013) but they recommend that the species should be monitored. Used in Asia as food, an aphrodisiac and medicine, the large demand for sea cucumbers has resulted in overfishing in certain areas. Sea cucumber population reduction has hardened the seafloor in these areas, thus destroying the habitat for other bottom-dwelling creatures.

DID YOU KNOW?
A fascinating defense mechanism: Evisceration
When threatened, the sea cucumber can expel some of its internal organs through its anus in a process called “evisceration”. The organs left behind will distract the would-be predator while the sea cucumber escapes. This is an efficient defense strategy as it entangles and stops its predator while the sea cucumber flees. The shed organs will regenerate.



PART I - SCENES FROM "SECRET OCEAN"

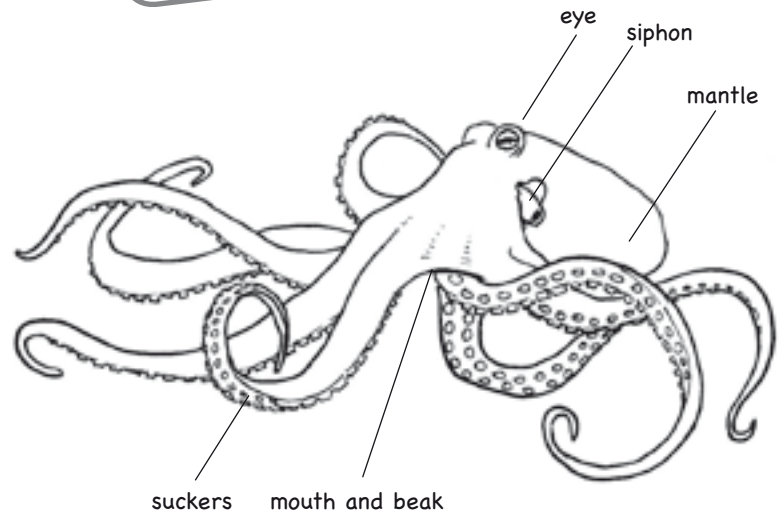
8. DAY OCTOPUS

The octopus is a cephalopod mollusk (Phylum Mollusca) with eight arms that directly branch off of its bulb-shaped head, hence the name octopus, which means "eight feet". The word cephalopod means "head-footed." Each arm has two rows of suckers and many nerves that allow the octopus to grab and taste things.

The mouth located on the underside has beak-like jaws made of keratin that look like a parrot's beak and can deliver a venomous bite. The "beak" is used to bite food into pieces and defend itself. The octopus has a big brain, two eyes that are similar to human eyes (iris, pupil, lens, retina) and an extremely well-developed nervous system.

Behind the head is the mantle, a very strong muscular structure that hosts and protects all the internal organs - hearts, gills, digestive and reproduction systems. By expelling water through its siphon (the siphon is not used to suck in water) the octopus can move and propel itself through the sea, or eject ink to confuse would-be predators and provide cover for a quick getaway. The day octopus (*Octopus cyanea*) feeds during daylight unlike other cephalopods.

FUN FACTS!
The octopus has two large eyes and excellent eyesight, but is deaf.
Most have two hearts, but some have three!



FUN FACT!
Blue Blood!
To survive in the deep ocean, octopuses have evolved the copper-containing protein called hemocyanin that is more efficient at transporting oxygen than hemoglobin when water temperature is very low and oxygen is scarce.

The octopus is an incredible animal that Jacques Cousteau used to call "the soft intelligence". The smartest of the invertebrates, the octopus is a genius at disguise and a master of deception. It is a great hunter that has many attack and defense strategies, the most extraordinary being its ability to change its skin color and texture to blend with its surroundings. See part 2.C.5. "Camouflage" and 2.C.6 "The ultimate strategist, the octopus".

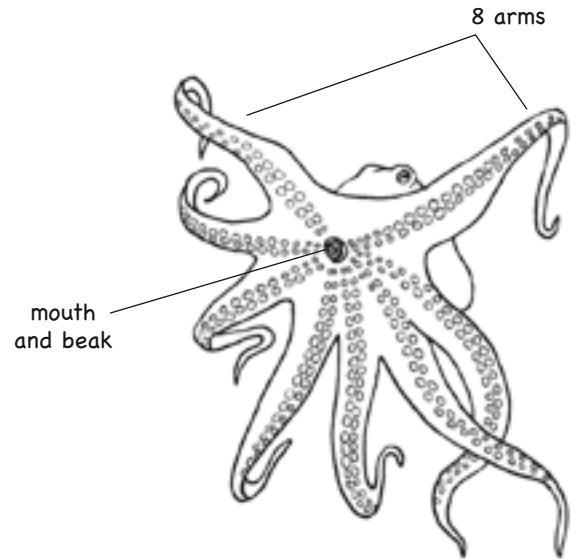
Size: Maximum size is about 4.3 feet (1.30 m) in length from the top of its body (called the "mantle") to the tips of its arms. An adult can weigh about 6.6 - 13.2 lbs. (3-6 kg).

Diet: Bivalves, fish, crabs, shrimp.

Feeding strategies: Hunting.

Conservation Status: Not Evaluated.

Note: During the film you will witness how it can send warning signals and how it uses camouflage.



SAD FACT!
The respiratory protein hemocyanin causes octopuses to be extremely sensitive to changes in seawater acidity. Researchers worry about the increased acidity that is being induced by climate change and how it may affect the octopus' ability to circulate enough oxygen.



9. GOBIES AND BLENNIES

Thousands of species of gobies (Family Gobiidae) and blennies (Family Blenniidae) hide on the reef. More than one third of all fish on some reefs are gobies, an important source of food for other larger fish. As such, they play an important role in the food chain. (Fish, like humans, are in the Phylum Chordata.)

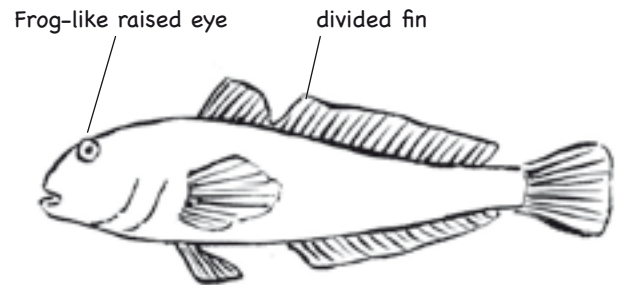
They are bottom-dwelling little fish. One of their main differences is the fin on their back that is divided on the goby while it is long and continuous on the blenny. Gobies have small scales while blennies have mucus covering their skin and no scales. They do not have exactly the same diet.

In order to survive and escape their predators, these small fish need to take shelter and hide. Some use the holes in corals left by dead Christmas tree worms. They rarely leave their burrow.

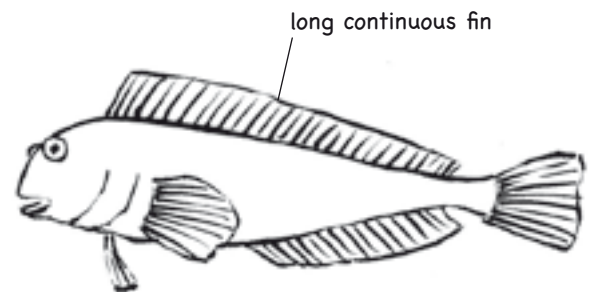
Size: Varies. Less than 4 in (10 cm) in length. Some are less than 3/8 in (1 cm) long, among the smallest vertebrates in the world. Some gobies can reach larger sizes.

Diet: Small invertebrates and plankton. Larger species eat other fish.

Conservation Status: "There are five critically endangered gobies, 18 listed as vulnerable, and 12 listed as low risk. Agricultural practices and the introduction of non-native species are some important causes for their decline. (...) Some may become extinct before humans become aware of their existence." (Hoease, 1998; The World Conservation Union; 2002). See "A word on the IUCN 'Threatened' categories" in 4. GIANT CLAM AND ZOOXANTHELLAE.

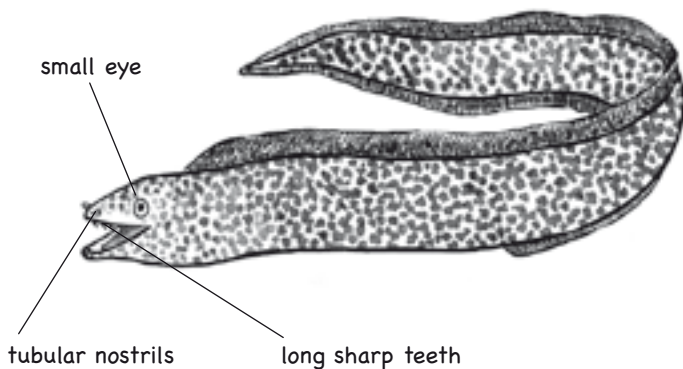


Goby



Blenny

10. SPOTTED MORAY EEL



The spotted moray eel (*Gymnothorax moringa*) is a very elongated fish that looks like a snake. White and yellow with dark brown polka dots, it has very small eyes and tubular nostrils. It relies on its acute sense of smell to detect prey as it has poor eyesight.

With their mouth constantly opening and closing, eels look as if they are threatening. However, it is not so. They are just pumping water through their gills to breathe.

Eels have two sets of sharp teeth: the first row on the jaws are used to catch and hold prey, the second row help to swallow it without letting it go.

A solitary animal, the moray eel lives hiding from predators in holes and crevices from where it can ambush prey that swims by. It is usually seen with its head poking from its lair, waiting for unsuspecting animals to pass.

Size: Around 23 in (60 cm) long.

Diet: Varied. Fish, crustaceans, mollusks (such as octopus), carrion.

Feeding strategies: Ambush hunting.

Conservation Status: Not evaluated. Occasionally sold for aquariums.

FUN FACT!

Eels let cleaner shrimp and other small cleaner fish free them of dead skin and parasites. This is an example of a mutualistic relationship, where both animals benefit. The eel remains healthy while the cleaner gets a meal!



PART I - SCENES FROM "SECRET OCEAN"

11. GIANT HERMIT CRAB

Hermit crabs are small-sized decapod ("ten-legged") crustaceans. These arthropods have five pairs of jointed legs, claws, an exoskeleton, eyes on stalks, and two sets of antennae. Unlike other related crustaceans, hermit crabs do not have a hard shell. They have a soft spirally curved abdomen that they must protect from predators. Hermit crabs use the discarded shell of other animals, most often sea snails, to cover their abdomen.

The back legs have hooks that tightly secure the hermit crab into the shell. As it grows, the hermit crab will have to look for a larger shell. The giant hermit crab (*Petrochirus Diogenes*) is distinct from other hermit crabs by its larger size and red coloration. Since it needs a larger sized shell than other hermit crabs, it often inhabits conch shells.

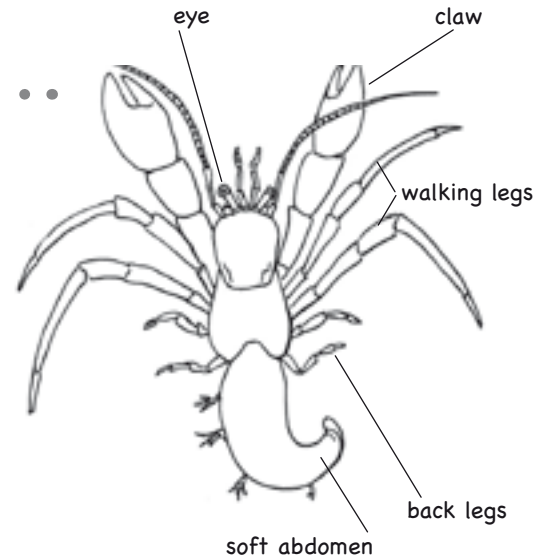
Size: 5.9-7.8 in (15-20 cm) in length including legs and claws.

Diet: Varied. Small fish, invertebrates such as worms, macro-algae, plankton, food particles, dead organisms.

Feeding strategies: Scavenging, hunting, grazing, filtering.

Conservation Status: Not evaluated.

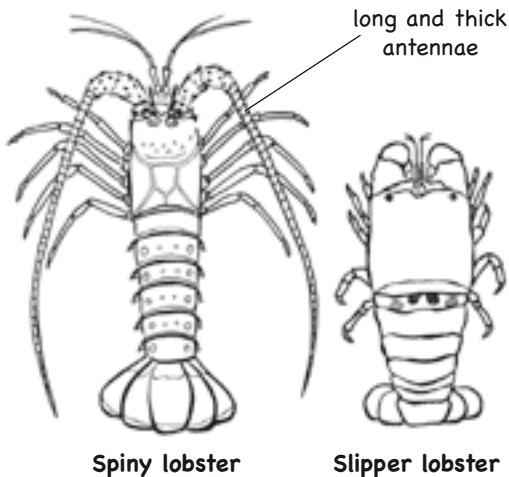
Note: The scene shows a conch, i.e. a sea snail mollusk permanently attached to its shell, in contrast to the hermit crab that is always looking for a bigger shell every time it grows.



Another member of the reef recycling crew!

Hermit crabs are important in the reef recycling crew: Not only do they make use of abandoned snail shells but also as detritivores they help return waste matter to the environment as raw materials.

12. CARIBBEAN SPINY LOBSTER AND SPANISH SLIPPER LOBSTER



"Secret Ocean" features two lobster species, the Caribbean spiny lobster (*Panulirus argus*) and the Spanish slipper lobster (*Scyllarides aequinoctialis*). They live at the bottom of the ocean, hunting at night, and hiding from predators during the day in crevices or in burrows under rocks. Related to the shrimp and the crab, the lobster is one of the largest crustaceans. It has ten legs and a natural armor, i.e. a hard external skeleton or "exoskeleton" that does not expand as the lobster grows and is shed periodically.

While molting, the lobster is very vulnerable and needs to hide during the day. Caribbean spiny lobsters have long, thick antennae while Spanish slipper lobsters sport two pairs of antennae, the second pair looking like wide plates. Both species do not have any claws. Lobsters have excellent senses of smell and touch. They can walk forward, backward and sideways. When threatened they can propel themselves backward very fast.

Size: Caribbean spiny lobster= 6 in to 2ft (15 to 60 cm);

Spanish lobster= 6 to 12 in (15 to 30 cm).

Diet: Crabs, mollusks, worms, starfish, smaller fish, algae, carrion and sometimes even other lobsters.

Feeding strategies: Hunting. Scavenging.

Conservation Status: The Caribbean spiny lobster is listed as Data Deficient (IUCN 2013) and its population is decreasing. The Spanish slipper lobster is listed as Least Concern (IUCN 2013) as it is a very resistant species due to its high fecundity rate. It is also not fished on a large scale because it is not a popular food source, and thus is not commercially important. Yet, in contrast, the Caribbean spiny lobster is a very popular food, fished throughout its range. The most commercially important lobster in the Caribbean, its population has drastically declined due to overfishing. Marine Conservation Laws have been set up there to protect the Caribbean spiny lobster species.

SAD FACT!

Lobsters have not always been considered a delicacy. In the past, in coastal areas where they were very abundant, they were used to feed servants and poor people, or as fertilizer. Since, they have become one of the most luxurious and popular seafood around the world... But this is also a sad example of how quickly a species can become so popular that it is overfished to the point of its population crashing.



13. SEA HARES

Two types of sea hare are featured in “Secret Ocean”: the Spotted sea hare (*Aplysia dactylomela*) and the California sea hare (*Aplysia californica*). The sea hare is a gastropod mollusk with a round body but without a shell. It gets its name from the pair of long sensory tentacles (or rhinophores) on the top of its head that reminds us of rabbit ears and gives this animal an acute sense of smell. The sea hare also has another pair of tentacles next to its mouth, and a pair of wing-like flaps in the center of its body that cover its gills.

This large sea snail seems vulnerable but is not thanks to its own anti-predatory chemical defenses, its own “bio weapons”.
See Part 2. C.2. for more on the sea hare’s chemical weapons.

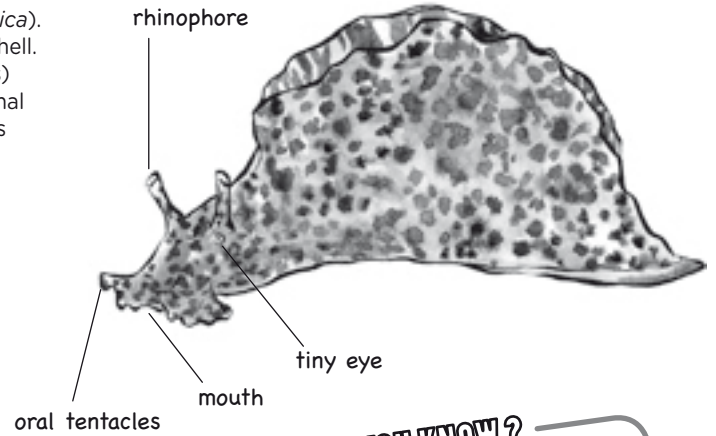
Size: Spotted sea hare from 2.75 in (7 cm) to 7.90 in (20 cm); California sea hares are around 5.9 in (15 cm), but may grow up to 11.80 in (30 cm) and weigh over fifteen pounds (7 kg).

Diet: Algae, seaweed.

Feeding strategy: Grazing.

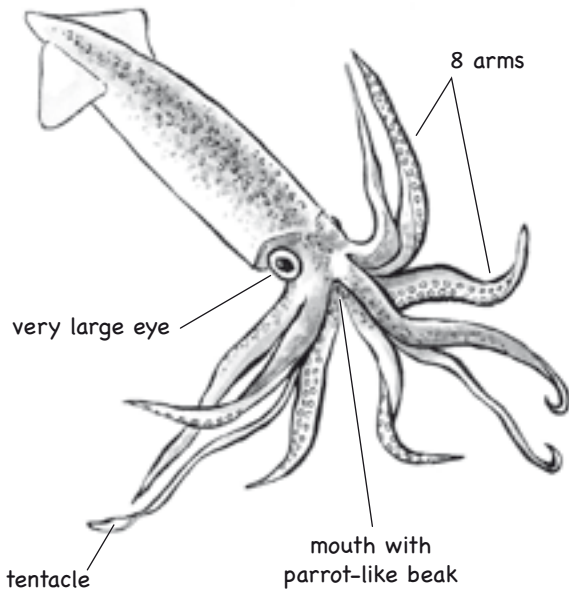
Conservation Status: Not listed on the IUCN red list.

Note: The large red sea hare in this scene is red because it has eaten red seaweed!.



DID YOU KNOW?
Sea hares are considered a delicacy in some parts of the world. They are eaten in China and in Hawaii.

14. MARKET SQUID



The market squid (*Doriteuthis opalescens*, previously named *Loligo opalescens*) belongs to the same group of mollusks as the octopus, the cephalopod group (Phylum Mollusca, Class Cephalopoda). The squid’s head has two very large eyes and is larger than its soft torpedo-shaped body. It has a mantle that contains its internal organs, including two hearts and gills (to breathe), and ends with a pair of tail fins. The mouth has a powerful parrot-like beak and is surrounded by the bases of eight arms with suction cups and two longer muscular tentacles used for catching prey. Males have one shorter arm that they use to place sperm into the female.

Squids move by squirting water from the mantle through a siphon, using a type of jet propulsion and by undulations of their fins. Like many animals, squids use several defense strategies. They can change color to mimic the environment and hide from predators, or squirt ink to repel them. They also find safety and survival in their schooling behavior. See Part 2.C.5 and C.6. F. “Schooling behavior and massive reproduction as protection”.

Size: Averaging 8 in (20 cm) in length.

Diet: Fish, crustaceans such as crabs and shrimp.

Feeding strategy: Hunting.

Conservation Status: Not evaluated. Numbers remain vast despite the fact that humans have been fishing them regularly. Squids are very prolific, with females that can produce thousands of eggs each. Some scientists speculate that global warming might lead to a boom in the squid population!

Note: Jean-Michel Cousteau points out in this scene that there are as many squid today in this mating place as he witnessed with his father fifty years ago.

FUN FACT!
The giant squid is mysterious as it lives in the deep waters of the Pacific Ocean and has hardly been seen. The largest know specimen was 57 ft long (17.5 m).



PART I - SCENES FROM SECRET OCEAN

15. CROWN-OF-THORNS SEA STAR

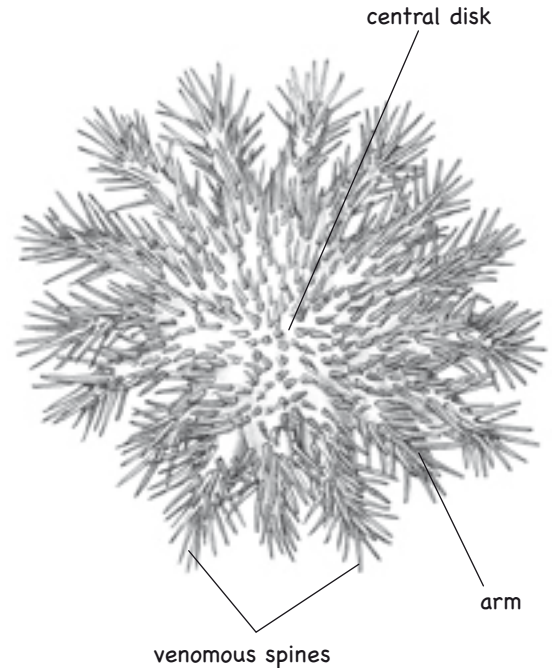
The Crown-of-thorns (*Acanthaster planci*) is a coral-eating sea star that belongs to the echinoderm group, and is related to the common sea star and the giant basket sea star. It is one of the largest sea stars in the world. Like all sea stars, it has no heart, no eyes and no brain. Unlike the common sea star, the Crown-of-thorns sea star has 13 or more arms used for locomotion and defense from predators. Its arms are covered in venomous spines that are shorter on the underside and lie along rows of tube feet. The mouth is located underneath the body. To feed, this sea star climbs onto a coral colony, turns its gastric sac (stomach) inside out through its mouth, smothers the coral polyps covering them with its sac, digests them with enzymes and then absorbs them through its everted stomach. This method is called 'eversion' ('to evert' = to turn inside out).

The Crown-of-thorns sea star offers an interesting example of how destructive a native species can become to the health of an ecosystem. Crown-of-thorns have been feeding on coral polyps for millions of years, as part of coral reef ecosystems. However, when their population increases too much, these animals can devour corals, causing devastation and disrupting the entire reef ecosystem where they live.

Crown-of-thorns are proliferating today in certain areas. This is occurring where humans have overfished their predators such as triton snails, prawns and large groupers, and in coastal areas where the constant enrichment of nutrients (from landscape destruction, soil fertilization, agriculture and sewage) has provided abundant phytoplankton, the very food source of larval Crown-of-thorns.

Today on places like the Great Barrier Reef, the world's largest reef, they represent a constant ecological problem. The Australian Institute of Marine Science (AIMS) reports that "in the past 40 years, three waves of Crown-of-thorns starfish outbreaks have had a major impact on the many reefs that make up the Great Barrier Reef."

AIMS Crown-of-thorns monitoring programs on the Reef also show that "healthy reefs generally recover between outbreaks, taking 10 to 20 years to do so. However, recovery takes longer on reefs that are affected by additional stresses, such as coral bleaching, cyclones or poor water quality, so the coral may not fully recover before the next wave occurs."



Size: 9.8 to 13.8 in (25 to 35 cm) in diameter; can grow up to three feet (91 cm).

Diet: Coral polyps.

Feeding strategy: Eversion or extruding its stomach membranes and secreting enzymes on top of coral polyps to digest and ingest their nutrients.

Conservation Status: Unknown. Not assessed by the IUCN.

16. RED LIONFISH

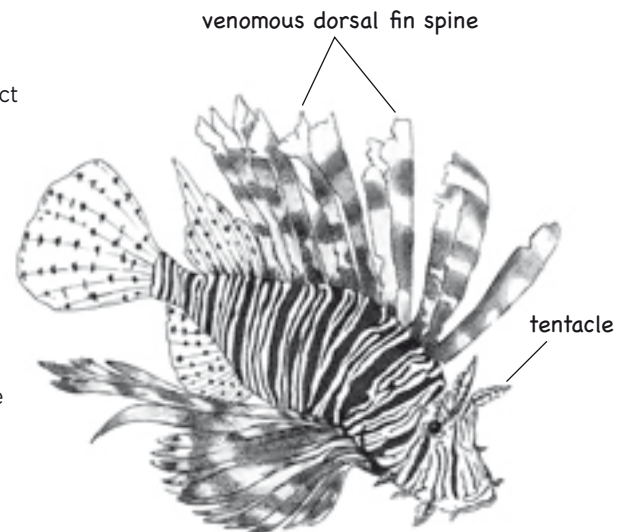
The red lionfish (*Pterois volitans*) is a venomous marine fish (Phylum Chordata) native to the Indo-Pacific and a splendid predator with many weapons. The tall fins on its back have venomous stingers. The tentacles above its eyes are decoys to attract fish. Its stripes and polka dots are meant to confuse and its elegant fan-like fins are a cloak to herd and trap small fish. When threatened, it uses its venomous dorsal spines for defense, often facing its attacker in an upside-down posture. Its speed in grabbing prey is phenomenal.

Size: 11.8 to 15 in (30 to 38 cm)

Diet: Fish, small fish, shrimp, crabs, and even other lionfish. Over fifty species of fish, including some economically and ecologically important species.

Feeding strategy: Hunting, ambush.

Conservation status: Not currently listed as threatened or endangered in their native range by the IUCN. However, the increase in pollution in coral reefs may negatively affect the red lionfish's primary food sources (crustaceans and fish).





"What happened with the red lionfish is another example of things accidentally thrown off-balance and how our mistakes can have enormous consequences on ecosystems."

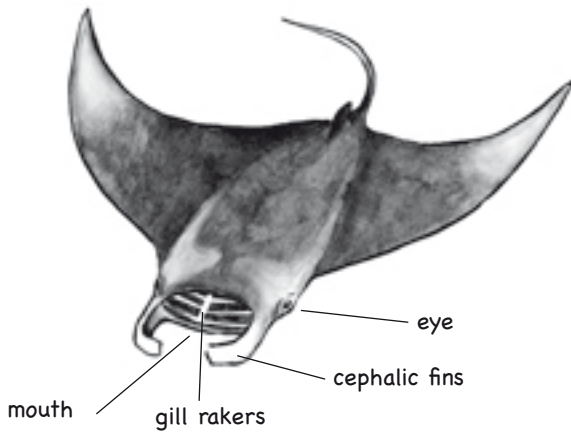
Jean-Michel Cousteau

The red lionfish is an example of how destructive an alien species can be to the health of an ecosystem. Red lionfish are in their natural environment in the Indo-Pacific where they eat other native fish, use venomous spines for protection, and are eventually eaten by predators. But when accidentally introduced into the Caribbean, they have become a serious problem as they prey on naive small and juvenile fish. They are having a significant impact on already reduced fish populations, further degrading the health of Caribbean coral reef ecosystems. It is now too late to eliminate these invasive predators and almost impossible to control them. Diver groups spear them and fishermen sell them to restaurants but these efforts are not likely to control the pest lionfish. Presently lionfish mature and breed with no predators to keep their population in check because Caribbean predators do not recognize lionfish as prey. Some people are now trying to teach native predators such as groupers, eels and sharks to eat lionfish but since natural predators have been overfished this will be a slow process and it will take a long time for them to restore balance to the Caribbean.

"As alien invasive predators, it is now too late to eliminate them and almost impossible to control them. However, the ocean is resilient and the history of life in the sea is made of the dispersal of species - new species being added to an ecosystem, dispersed from island to island and from one ocean to another. One can think and hope that the Caribbean ecosystem will adapt. Predators will eventually discover and feed on red lionfish while juvenile fish will evolve defenses to avoid being eaten, as they have in the Indo-Pacific."

Dr. Richard C. Murphy, Ph.D. Marine Ecology

17. REEF MANTA RAY



Rays are cartilaginous fish belonging to the same group as sharks. They have a flat body with pectoral fins that extend right up to their head and look like wings. The reef manta ray (*Manta alfredi*) is the second largest manta ray in the world after the Giant Pacific Manta ray (*Manta birostris*). But just like the largest sharks, the basking shark and the biggest of all, the whale shark, the manta ray is a plankton-eater.

Its broad, rectangular mouth is located at the front of its head and holds extremely tiny teeth on the bottom jaw not used for feeding. It has 5 pairs of gills on its ventral side, each protected inside a gill slit. To feed the manta ray swims with the mouth wide open. As water flows through the mouth, it passes across the gills that have extensions called 'gill rakers' designed to filter plankton and small fish.

The manta ray flaps its pectoral fins like wings. A powerful swimmer, it can leap up out of the water and somersault too. To stay healthy and help heal some of their wounds, manta rays often stop at "cleaning stations". Cleaning stations are areas where small organisms such as shrimp or small fish offer "cleaning services" to larger species, removing parasites, bacteria, dead skins, mucus, etc. from their skin, their gills and their wounds.

See Part 2.D.5 for more information on the relationship between these animals.

Size: Wingspan of nearly 18 ft (5.5 m).

Diet: Plankton, crustaceans, small fish.

Feeding strategy: Filter-feeding.

Conservation status: Vulnerable (IUCN 2011). Its population is constantly dropping and thus at risk of extinction.

SAD FACT!

Humans are the most significant threat to manta rays. They are harpooned and harvested for their meat, sandpaper skin, oil-rich liver and gill rakers (used in Chinese medicine). Highly valued in international trade they are being fished and by-caught in drift and set nets to such an extent that local populations are being depleted.

A word on the Great hammerhead shark (*Sphyrna mokarran*)

The closing scene shows Jean-Michel Cousteau and Holly Lohuis swimming with Great hammerhead sharks, the largest of the 9 different species of Hammerhead sharks and one of the largest predatory sharks. It can grow up to 20 ft (6 m). It is a solitary creature that eats a wide variety of food. Its favorite food is stingrays, but it also feeds on squid, octopuses, fish, skates, crustaceans and other sharks. Very patient, it will spend hours observing its prey before attacking. It is listed as an endangered species by the IUCN (2007).



PART 2 - SURVIVAL STRATEGIES

Staying alive is a challenge for all sea creatures and the film “Jean-Michel Cousteau’s Secret Ocean” shows some of the strategies that animals have developed to eat and protect themselves from their predators. Part 2 focuses on some ways in which these sea creatures have adapted to their environment in order to survive, i.e. their type of diet, ways of catching food and defense strategies. It also describes a few collaborations between certain species.

A. A WORD ABOUT THE LINKS BETWEEN ALL ORGANISMS, LARGE AND SMALL

All living organisms depend on each other for survival. The notions of food chain and food web are helpful to better understand the important role each creature plays in their ecosystem, and how energy and nutrients pass from one creature to the other. The constant chain of eating and being eaten creates a circle of life where everything is recycled and nothing is wasted. There are several levels in a food chain. Every level is important in an ecosystem and the higher levels rely on the lower links. If we alter the ecosystem even with only one species, lots of things can go wrong and the equilibrium that exists can be destroyed.

In order to live, every living organism needs energy. Living organisms can be classified into three main categories: producers, consumers and decomposers. Producers such as plants, algae and phytoplankton are the only living organisms that produce their own food and also provide energy for the ecosystem by photosynthesis. Consumers are animals that eat plants, animals that eat the animals that ate the plants, animals that eat the animals that ate animals and so on. Detritivores eat detritus and dead organisms, helping to clean the ecosystem. Decomposers eat decomposed matter from animals and plants, releasing nutrients and minerals into the water that are then absorbed by the plants, and the cycle continues... This is called the food chain and this is just a simple model of what is really taking place. In nature, each organism consumes more than just one species: in other words, there are choices on the menu and most plants and animals are part of several interconnected chains. We can draw lots of interconnected food chains that are better represented as a web: a food web.

B. EATING TO SURVIVE - THE DIETS OF THE ANIMALS IN THE FILM

Eating without being eaten while finding the appropriate nutrients is a challenge for all animals, large and small. There are many ways for sea creatures to get their food: filtering, grazing, chasing, ambush, scavenging, etc. Some sea creatures such as coral, Christmas tree worms, giant clams and sea anemones, live fastened to the reef or some other substrate (base) when adults and cannot move around to catch food. They feed by catching “food items” that pass by. Christmas tree worms use their appendages to catch and filter-feed passing plankton. Fastened to a substrate, the anemone is a predator that catches its prey by spreading its tentacles, capturing whatever comes by or tries to settle on it.

Other creatures move around and have developed various strategies.

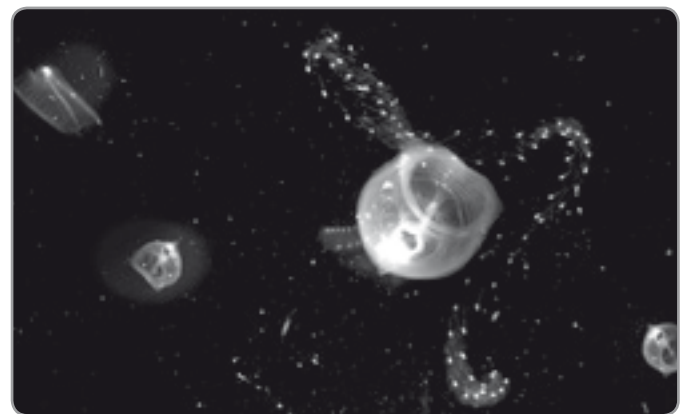
Basket stars follow the current, filter-feeding the particles it carries, while the banded cleaner shrimp get their meal by cleaning fish. Sea cucumbers vacuum sand and eat detritus as they go, ingesting the organic matter and defecating sand and other particles. Lobsters, squids and octopuses are active hunters. So is the great hammerhead shark. The Crown-of-thorns has developed a different method to feed, called ‘eversion’. After climbing onto a coral reef, it turns its stomach inside out through its mouth, smothers the coral polyps, digests them with enzymes and ingests them.

Sea animals have many different diets and can be classified as follows:

- Herbivore (plant-eater, phytoplankton-eater)
- Carnivore (meat-eater, zooplankton-eater, coral-eater)
- Omnivore (plant- and meat-eater)
- Detritivore (detritus- or dead organic matter-feeder)

1. Phytoplankton and zooplankton

The oceanic food chain starts with plankton, and many creatures, large and small, feed on plankton. Christmas tree worms and zooplankton feed on phytoplankton, but most animals in the film are carnivorous or omnivorous.



Zooplankton

2. A diversified diet: other food sources

Most plankton-eaters have other food sources and a diversified diet: algae, animals, detritus, scraps left by other animals, dead organisms, etc. The manta ray filter-feeds on zooplankton, crustaceans and small fish.

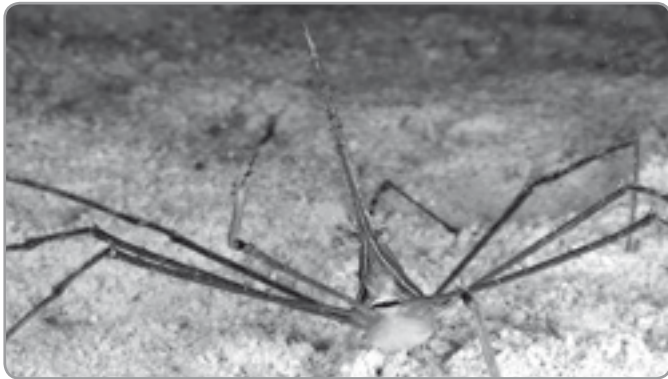
The basket star feeds on zooplankton and detritus; sea anemones are carnivorous and feed not only on zooplankton, but also on fish and shrimp. The omnivorous giant clam feeds on plankton and algae but it gets most of its nutrients from in-grown algae called “zooxanthellae”.

Besides plankton the arrow crab - a detritivore and an omnivore - eats whatever it can find, including dead organisms, worms, bits of other animals’ left-overs, etc. So does the banded cleaner shrimp with the addition of parasites and food particles they clean from fish.



Besides zooplankton, the hermit crab has a varied diet including small fish, worms and food particles. Other sea creatures in the film, such as octopuses, lobsters and squid, feed on various types of fish and crustaceans. The great hammerhead shark eats a wide variety of food, its favorite being the stingray. But it also feeds on octopuses, squid, skates, fish, crustaceans and other sharks.

The Crown-of-thorns is the only animal in “**Secret Ocean**” that has one item on the menu: coral polyps.



Arrow crab

3. Detritus: the diet of reef recyclers

Feeding on detritus seems disgusting. However, animals that do so - called detritivores - play a crucial role in any ecosystem. They keep it clean, they keep it healthy. The sea cucumber, for example, vacuums the sea bottom of detritus, scraps of fallen food, dead corals, sponges and sediment. By feeding on detritus, the sea cucumber recycles waste organic matter in its body that becomes food for algae and phytoplankton, which are in turn eaten by animals and eventually become dead matter that is converted back into the nutrients for plants to use. The amount of sediment sea cucumbers can reprocess on reefs is impressive and important for keeping the reef clean and healthy. Both the banded cleaner shrimp and the arrow crab are also part of the reef’s clean-up crew: by feeding they recycle organic waste that can become food for other organisms.

C. DEFENSE MECHANISMS AND PROTECTIVE STRATEGIES FOR SURVIVAL

Sea creatures have developed various cunning strategies to protect themselves from predators and avoid being eaten, overcome predation and stay alive. These include hiding in a shelter, using chemical weapons or venomous defenses, schooling, living in colonies, camouflage, deception, team work, partnership, protection thanks to a larger animal, hiding, tasting bad, venom, spines, spraying, activity schedule (night) and speedy escapes. Below are some of the strategies used by the animals appearing in the film “**Secret Ocean**”.

1. Hiding in holes, crevices and caves is a common strategy seen in the film. Lobsters, despite their heavily armored body, look for a place to hide during the day. The moray eel stays inside its lair most of the time, going out only to hunt. Gobies and blennies hardly leave their burrow.

2. Chemical weapons

i. When threatened, some animals, such as sea hares, squid and octopuses, can squirt ink, respectively purple, blue-black and black ink. The cloud of ink confuses their attacker while they flee.
ii. The sea hare can also squirt a white, sticky “opaline” secretion, disrupting the sensory organs of the predator.
iii. A soft-bodied animal without any protective shell, the sea hare has its own “bio weapon” that derives from the very algae it eats that once digested render its skin distasteful.

3. Schooling behavior and massive reproduction as protection: Squid find safety and survival in their schooling behavior: the sheer enormity of their numbers as well as their massive reproduction capabilities protect them.

4. Carapaces and shells: Carapaces and shells are natural protective armors. Crabs, lobsters and shrimp have a hard exoskeleton or carapace that offers protective cover over most of the body. The giant clam, a bivalve that cannot move around when threatened, can only close its two shells. The hermit crab - a crustacean without natural armor - needs to use the abandoned shell of other animals to protect its soft abdomen.

5. Camouflage: The squid can change color to mimic its environment and hide from predators. The master of camouflage is the octopus. Camouflage is its most extraordinary anti-predator mechanism. The octopus can transform its body and hide in full view.

6. The ultimate strategist, the octopus: The octopus, the most intelligent of all invertebrates, has developed an incredible number of strategies to protect and defend itself (as well as to hunt). Besides its most extraordinary camouflage abilities (see above paragraph, “Camouflage”), it can escape by jet-propelling itself very quickly by forcing water out of its siphon. It can defend itself by delivering a nasty venomous bite with its beak, or release a cloud of ink at predators, temporarily dulling their sense of smell and making the fleeing octopus impossible to track. It can also flash warnings as you’ll see in the film. The octopus also protects itself by keeping away from other animals, hiding in rocks or on the seafloor at the bottom of the ocean, coming out only to hunt at twilight. Having no bones, the octopus can squeeze into very tiny spaces and through very small cracks, another efficient way to escape a predator!



Octopus



PART 2 - SURVIVAL STRATEGIES

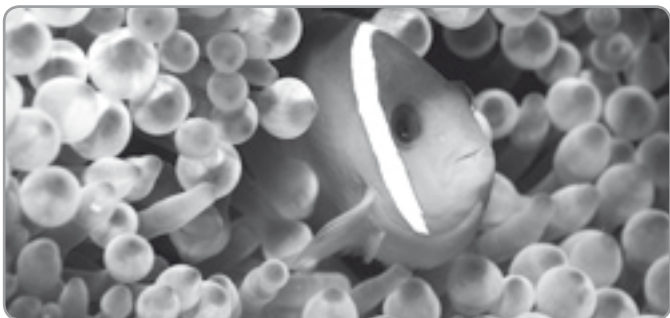
D. HELPFUL PARTNERSHIPS

Symbiosis (from the Greek “sym” or together, and “biosis” or living) is the interaction of two or more species living together. There are three broad categories of symbiosis: parasitism, where one partner benefits and the other is harmed; commensalism, where one partner benefits and the other is neither helped nor harmed; and mutualism, where both partners benefit. Beneficial relationships help sea creatures not only to get food, but also bring other advantages, including protection, or health services for both partners and the ecosystem where they live. Mutualism can be broadly divided into two categories. Firstly, **obligate mutualism**, where two partners are completely interdependent for survival and reproduction. Secondly, **facultative mutualism**, where both partners benefit from the partnership, but can theoretically survive in each other’s absence.

Below are some examples of mutualistic relationships that you’ll see in the film “**Secret Ocean**”.

1. The sea anemone and the clownfish: a win-win collaboration. To eat, the sea anemone stings small fish with its venomous tentacles but the clownfish is immune. Carrying a special chemical (a protein) on its skin that is identical to one in the anemone, the clownfish can live safely within the anemone, well-protected from its predators.

The anemone benefits as well since the clownfish defends it from intruders that would eat its nutrient-full tentacles. Furthermore the anemone quickly eats up any scraps that the clownfish drops when feeding. This collaboration provides food and protection for both of them and is important to their survival. This is an example of obligate mutualism.



Sea anemone and clownfish

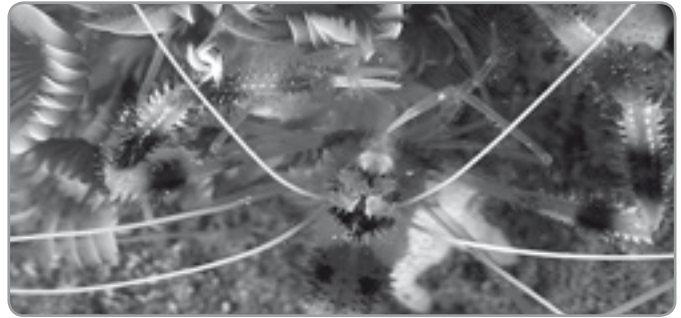
2. The giant clam and its food-producing partners

The giant clam gets more than 50% of its nutrients thanks to a mutually beneficial relationship with microscopic algae known as “zooxanthellae” that grow within its body tissues. By day, the clam opens its shell and extends its mantle tissue so that the algae receive the sunlight they need to photosynthesize and multiply.

The giant clam provides shelter to the algae that can grow where no one can eat them, and in return they “leak” out some of their sugars, which the clam uses as food. Also, when the algae photosynthesize, they produce oxygen, and the clam needs oxygen, just like we do, to breathe. When it breathes, the clam produces carbon dioxide, which the algae need to photosynthesize. It’s a neat double-deal and another example of obligate mutualism.

3. The banded cleaner shrimp, a health service for fish

The banded cleaner shrimp – always working as a pair – remove parasites, fungi and damaged tissue from fish and get a free meal from the pickings. By keeping fish healthy, these shrimp play an important role in their ecosystem, ridding it of sick organisms. This is an example of facultative mutualism.



Banded cleaner shrimp

4. The goby, bodyguard to a blind shrimp. In the film, a goby has a blind shrimp for a roommate. This efficient partnership is another classic example of obligate mutualism. The shrimp digs a burrow, but it is blind and cannot see would-be predators. The goby’s role is to alert the shrimp to the presence of a predator. In return, it can hide and protect itself in the shrimp’s den.



Goby and blind shrimp

5. Manta ray and small fish

In the film, small cleaner fish clean the inside of the gills of the manta ray. Manta rays and other fish, including the moray eel, often stop at “cleaning stations” on the reef to have smaller sea creatures remove dead skin, parasites, bacteria and mucus from their body, mouth, gills and wounds. By cleaning the manta, the small cleaner fish keeps it healthy. In return, the small fish gets to eat what it cleans, including the manta’s leftovers. So this too is a win-win relationship and another example of a facultative mutualistic collaboration.





E. A BLUE PLANET WHERE EVERYTHING IS CONNECTED

The message delivered by “**Jean-Michel Cousteau’s Secret Ocean**” is that everything in the sea and on our planet is connected. All forms of life on Earth - including marine organisms and ourselves - are interconnected at many levels.

Phytoplankton produce more than half the oxygen on Earth thanks to photosynthesis. Tiny plankton are the foundation of the food web connecting the open sea to the coral reef. The coral reef hosts various creatures that depend on one another for food, shelter, cleaning and of course reproduction.

The recycling of organic matter from one organism to the next is the means by which all living things satisfy their nutritional needs. Sea animals have developed all sorts of symbiotic relationships to survive, including the mutualistic relationships we witness in the film. These amazing partnerships show another level of the interdependence of life on the reef.

All of the plants and animals that live in the same marine environment share a common destiny because of these vital connections, and anything disrupting a part of the ocean’s ecological web of life affects the entire web.

Ours is a “blue planet” where water connects everything. Water from the sea evaporates and is transported by winds to the land where it rains. And after flowing in streams and rivers, collecting whatever is along the path, this water flows back to the sea to begin another water cycle. And this is where we humans come in. Human activities significantly impact our planet. Whatever we dump on land or release into a stream or into the atmosphere ends up in the sea.

Substances we release or dump can dramatically harm the ocean web of life.

We can upset delicate ecological balances, as mentioned in the film, with the coral-eating Crown-of-thorns sea star, whose young thrive on nutrient-rich waters and can destroy entire reefs, and with the red lionfish, a seemingly inconsequential fish, that, as an alien species, is having a major impact on the health of reefs in the Caribbean where it was accidentally introduced.

At the same time we can protect regions and make sure that important ecological webs of life remain healthy. The California squid fishery where the “**Secret Ocean**” squid scene was filmed is an example of good stewardship as the same population of squid is still being fished there fifty years after Jean-Michel Cousteau and his father first observed it.

The healthy and beautiful coral reef life that Jean-Michel Cousteau and his team filmed in Fiji was in a marine protected area, where human activities such as fishing and polluting activities are strictly prohibited.

We live on a water planet where everything is connected and we need to think of ourselves as partner in a multitude of beneficial relationships. As Jean-Michel Cousteau says, “People protect what they love. And everything is connected, so when we protect the ocean, we protect all life—including ourselves. It’s up to us, in the sea and on land, to cherish this ocean planet, as we enter the future... together.”



Jean-Michel Cousteau, Holly Lohuis and a Great hammerhead shark



ACTIVITY 1



DO YOU KNOW ME?

Write the name of each animal in the corresponding speech bubble. You can do this activity before going to see the film to check how many you already know, and then again after having seen the film.

a

b

c

d

e

f

g

h

i

j

k

l

m

n

o

p

q

r



ACTIVITY 2



DISCOVER THE ANIMALS OF "SECRET OCEAN"

Jean-Michel Cousteau's film takes you on a unique dive to encounter amazing sea creatures, large and small. You'll be so close that you'll be able to observe their amazing features and some most extraordinary behavior. The animals below are presented in order of their appearance in the film. Try to answer some of the questions below before you see the film. **Answer the questions a second time after the screening. Write complete sentences.** Discover the average size of these animals by using the scale (inches or cm) in the graph at the end of this activity. Numbers in the graph correspond to the animals numbers in Activity 2. The pencil on the left of animal #1 gives you an idea of the smallest animals' sizes.

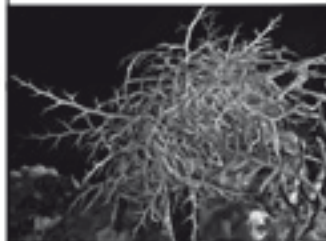
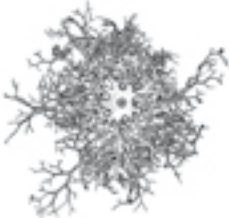
1



Attached to the coral, they cannot move around. On what and how do they feed?

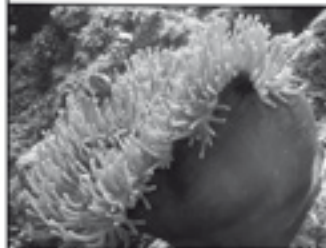
They feed on phytoplankton that they catch with their hair-like appendages called 'radioles'.

2



Why do you think this sea star is called "basket" star? How does it catch food?

3



The sea anemone uses its stinging tentacles to kill small fish. Why is the clownfish able to stay among the tentacles without being killed?

4



The giant clam is stuck in one place all its life. It is huge and needs a lot of nutrients. How does it feed?



ACTIVITY 2



DISCOVER THE ANIMALS OF "SECRET OCEAN"

5



Arrow crab



Why is this crab called the "arrow crab"?

.....
.....
.....

6



Banded cleaner shrimp



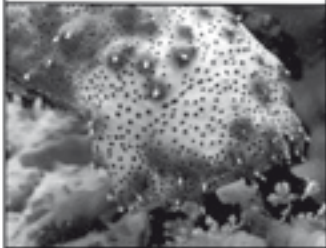
What important role do these shrimp play for fish? And for their ecosystem?

.....
.....
.....

7



Sea cucumber



What does the sea cucumber eat? What important role does it play in the ecosystem?

.....
.....
.....

8



Octopus



What is incredible about the octopus?

.....
.....
.....

9



Gobies and blennies



What are gobies and blennies? How can a goby and a blind shrimp help each other survive?

.....
.....
.....



ACTIVITY 2



DISCOVER THE ANIMALS OF "SECRET OCEAN"

10



Spotted moray eel



Why does the moray eel constantly open its mouth?

.....
.....
.....

11



Hermit crab



Where does the hermit crab get its shell from?

.....
.....
.....

12



Spiny lobster

Spiny lobster
Slipper lobster



What do they do during the day?

.....
.....
.....

13



Sea hare



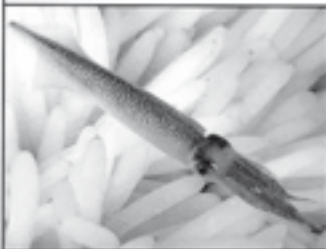
This soft-bodied creature does not have a protective shell, but it is not vulnerable. Why?

.....
.....
.....

14



Market squid



Squids are a delicacy for many people. Millions and millions of them are fished every year and yet they are not endangered. Why not?

.....
.....
.....



ACTIVITY 2



DISCOVER THE ANIMALS OF "SECRET OCEAN"

15



Crown-of-thorns sea star



Why is this sea star called 'Crown-of-thorns' and what does it eat?

.....

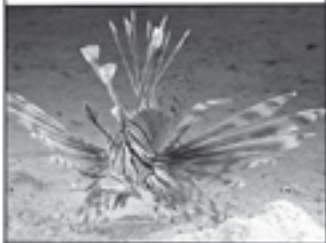
.....

.....

16



Red lionfish



Native to the Indo-Pacific Ocean, the red lionfish was accidentally introduced into the Caribbean reefs. What effect has this had on the reefs?

.....

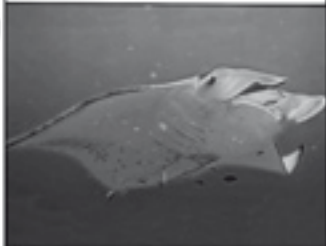
.....

.....

17



Reef manta ray

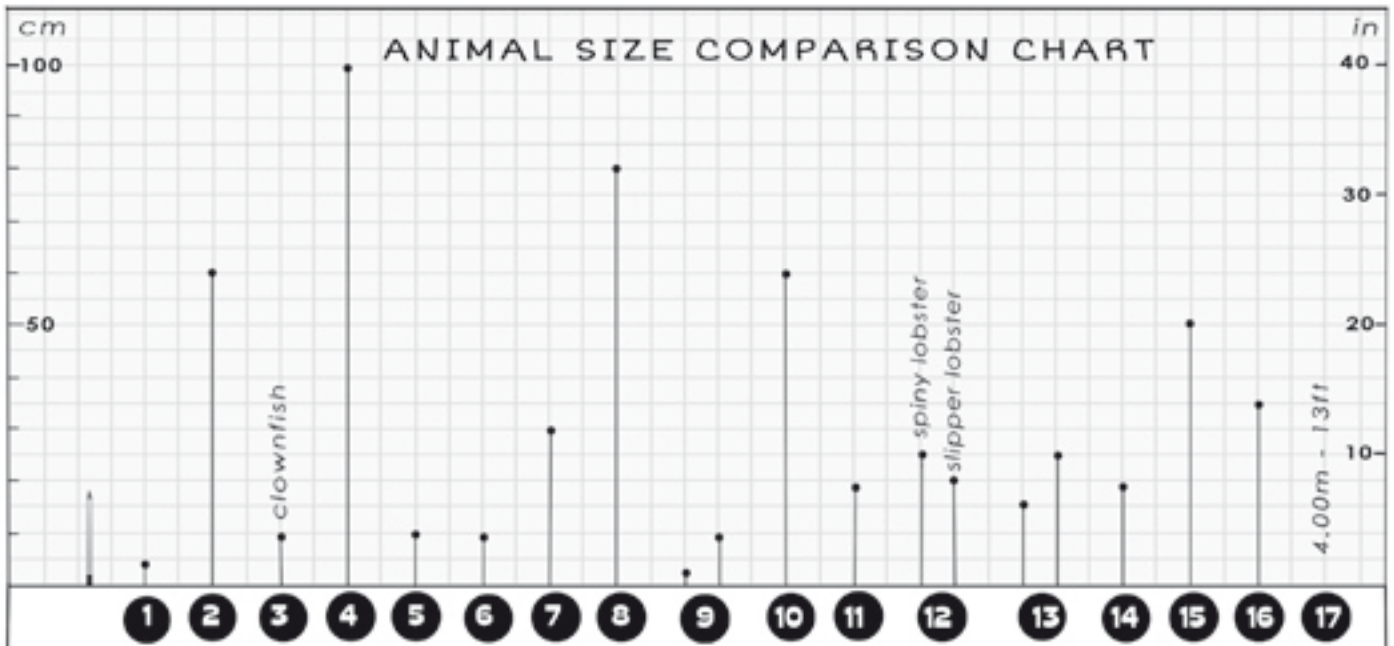


The reef manta ray is the second largest manta ray in the world. What does it feed on?

.....

.....

.....





ACTIVITY 3



A - "SECRET OCEAN" WORD FIND

Find as many "Secret Ocean" creatures as possible

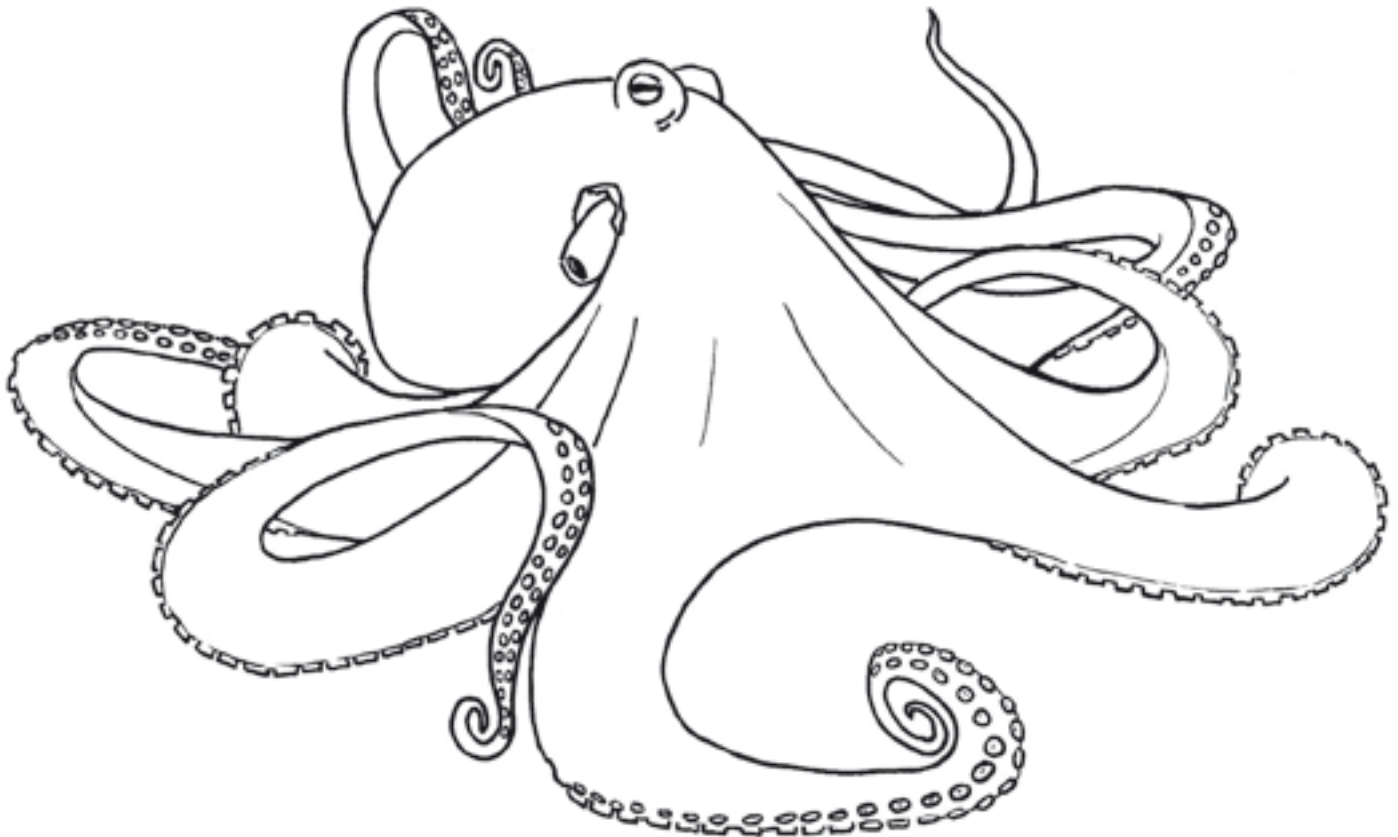
E S U P O T C O A C E N S Y X
I A Y R J O E I R R O L E A H
A W L N E Q R A E T N Z A R K
G C I L U T B Q K I O V C D Q
S V X E E U S N W M T E U T I
S Q U I D H A B N U K R C E J
X I S K E L T F O C N A U N X
U K C H P Y O N L L A H M M Y
M C S O A B Y O A E L A B J E
Z N O Y D R W S N X P E E C A
O Z O X B N K O I L O S R O K
M A L C F O M D E K T O R R D
S N X I Y E G E B D Y G Z A P
K Q S H N Y H K V B H W F L H
K H A A F A J W J K P T M J C

List of words to find:

ANEMONE, CLAM, CLOWNFISH, CORAL, CRAB, EEL,
GOBY, LOBSTER, OCTOPUS, PHYTOPLANKTON,
ZOOPLANKTON, RAY, SEA CUCUMBER, SEA HARE,
SHARK, SQUID, ZOOXANTHELLAE.

B - ADD COLOR TO THE OCTOPUS!

Color the octopus below, imagining a camouflage so that it will blend into its surroundings...





ACTIVITY 4



A - WHERE IS MY MOUTH?

All these animals need to eat to stay alive, just like humans do, and they all have a "mouth". Mark with a red dot on each animal drawing where you think its mouth is located or draw a red arrow indicating where the mouth is if it is hidden on the picture. Use print and online resources to research the right answers.



3- Sea anemone



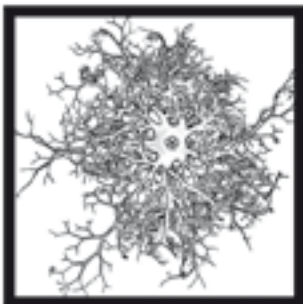
5- Arrow crab



7- Sea cucumber



17- Reef manta ray



2- Basket star



8- Octopus



10- Spotted moray eel



6- Banded cleaner shrimp

B - WHAT DO I USE TO EAT?

They don't have knives and forks to bring food to their mouths like we do, but they are well equipped even so. What do they use to grab their food? Write the name of the appropriate animal above next to its "feeding equipment" on the list below.



- a. Two purple claws
- b. Long arms with many extensions carrying tiny hooks
- c. Ring of venomous tentacles
- d. Eight arms with rows of suckers
- e. Very sharp teeth
- f. A large square mouth
- g. Black tentacles surrounding the mouth
- h. Six claws



ACTIVITY 5



A - WHO EATS WHAT?

Read the menu below and figure out who eats what. Write the name of each animal appearing in table B below its menu.



B - DIFFERENT DIETS AND WAYS OF GETTING FOOD

Animals that eat plants and/or algae are called plant-eaters or herbivores. Meat-eaters are called carnivores. Omnivores eat both plants and animals. Detritivores eat detritus and dead organisms. Sea animals have different ways of catching their food. Mark the appropriate number and letter corresponding to each animal's diet and ways of getting food.

Type of diet: 1. Herbivore 2. Carnivore 3. Omnivore 4. Detritivore

Ways of getting food: a. Hunting b. Scavenging c. Filter-feeding d. Grazing e. Cleaning

Animals	Types of diet	Ways of getting food
A. Sea cucumber		
B. Manta ray		
C. Banded cleaner shrimp		
D. Sea hare		
E. Christmas tree worm		
F. Octopus		



ACTIVITY 6



WHAT IS THEIR PLACE IN THE FOOD CHAIN?

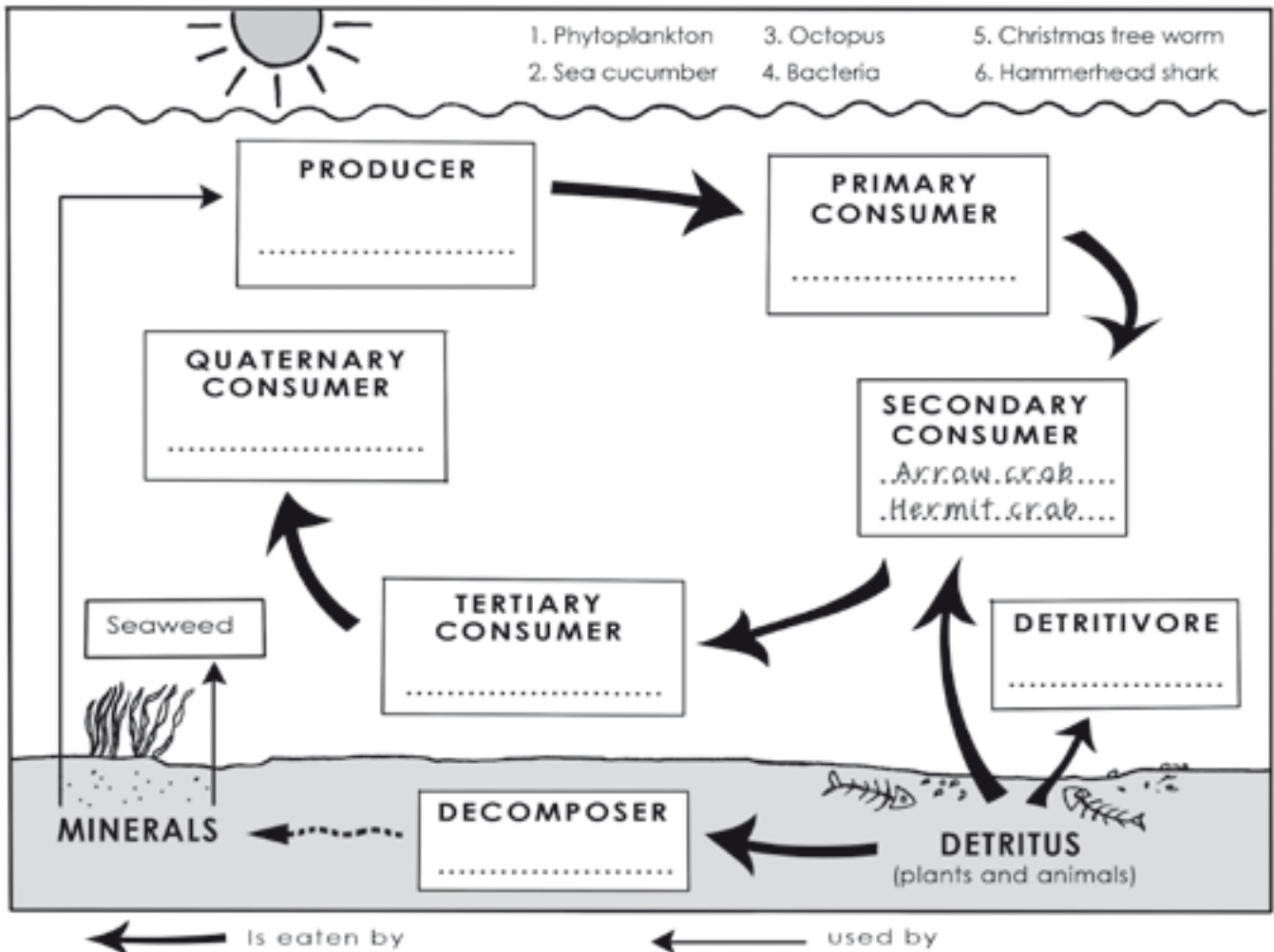
All living organisms are connected in nature, and the food chain model helps us understand how each living organism gets food, and how energy and nutrients pass from one creature to another. There are several links or 'trophic levels' in a food chain corresponding to what the organism absorbs/eats and how it contributes to the energy of a given ecosystem. These trophic levels are positions that an organism holds in a food chain. These positions are: producer, primary consumer, secondary consumer, tertiary consumer, quaternary consumer. There are actually no limits to the number of trophic levels a food chain can have. It all depends on the many orders of consumers there are in a given food chain.

There are four types of living organisms: producers, consumers, detritivores and decomposers:

- 1. Producers** are organisms such as plants, algae and phytoplankton that use the sun's energy, along with water, carbon dioxide and minerals, to create sugars that will help them grow. The process is called "photosynthesis".
- 2. Consumers** include herbivores, carnivores and omnivores.
- 3. Detritivores** feed on detritus and dead organisms. They can also consume plants and/or meat.
- 4. Decomposers**, such as fungi and bacteria, eat decomposed matter from animals and plants, releasing nutrients and minerals into the soil or water that are then absorbed by the plants.

Producers are eaten by **primary consumers** (plant-eaters), which are eaten by **secondary consumers** (carnivores or omnivores), which are eaten by **tertiary consumers** (carnivores or omnivores), etc. **Detritivores** eat animal and vegetal detritus, including excrement. **Decomposers** break down unused decomposed matter and turn it into nutrients and minerals that will be absorbed by plants to grow... and the cycle of life goes on.

Look at the menu in Activity 5.A. and fill out the drawing below. Write the name of each organism in the text box corresponding to its place on this food chain.





ACTIVITY 7



HOW DO THEY GET FOOD?

Finding the appropriate nutrients is a challenge for all living organisms and they have developed different strategies to get food. Match each animal in the left column with what it says in the column on the right.

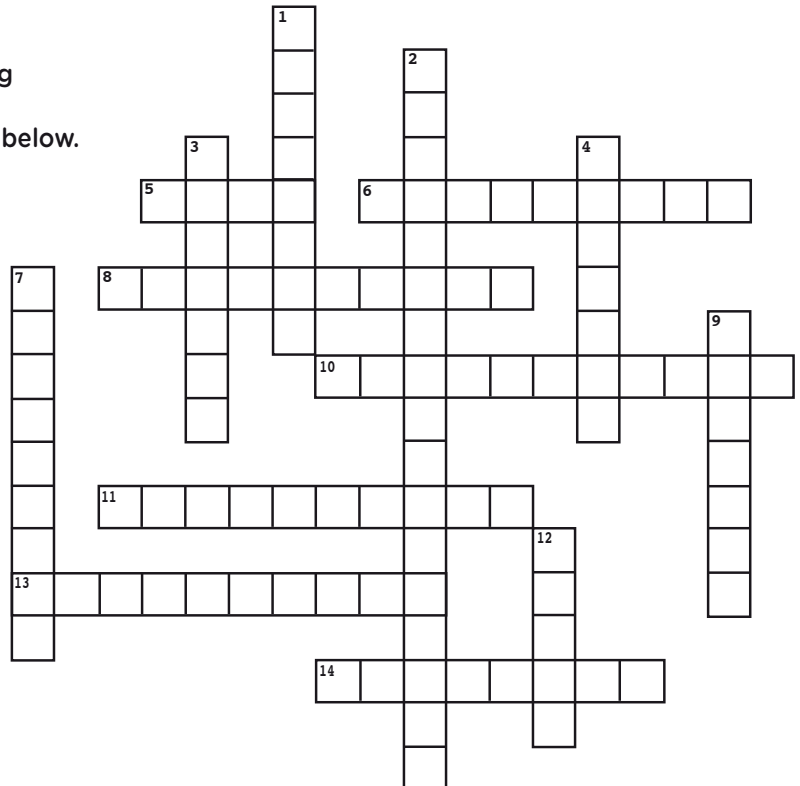
- 1. Sea cucumber
- 2. Phytoplankton
- 3. Crown-of-thorns
- 4. Sea anemone
- 5. Arrow crab
- 6. Banded cleaner shrimp
- 7. Giant clam
- 8. Christmas tree worms
- 9. Manta ray
- 10. Basket star

- a. I produce my own food.
- b. A predatory animal, I never move from my place and grab passing food with my venomous tentacles.
- c. I spend all my life vacuuming the sea floor, feeding myself while keeping the bottom of the ocean healthy.
- d. I turn my stomach inside out through my mouth, cover coral polyps with it and secrete enzymes on top of them to digest them.
- e. I can grab food absolutely everywhere thanks to my little purple claws.
- f. My tiny plant-like roommates provide most of the nutrients I need. The more I get, the larger I become, and I am monumental!
- g. Fastened to my coral base, I use my colorful appendages to catch passing food.
- h. At night I unfurl to feed and stretch my branched arms as much as three feet wide to grab food.
- i. I filter-feed on the smallest organisms while I am one of the largest sea creatures in the ocean.
- j. I provide healthcare services to many fish with my life-long partner.

ACTIVITY 8

DEFENSE TECHNIQUES

Sea creatures have developed different cunning strategies to avoid being eaten and stay alive. How do they do this? Complete the crossword below.



- 1. I bite with my sharp teeth if you come into my lair.
- 2. I retract into my tube and close my lid.
- 3. I have a heavily armored body.
- 4. I can change my skin color and texture.
- 5. I rarely leave my burrow.
- 6. I just close the two valves of my shell as I cannot move away.
- 7. My partner's tentacles protect me from predators.
- 8. I can sacrifice one of my many arms to a predator: it'll regenerate!
- 9. My skin is so distasteful that almost no one will eat me.
- 10. I expel my own guts onto my predator!
- 11. I use somebody else's shell.
- 12. I find safety in huge numbers.
- 13. I have a ring of venomous tentacles.
- 14. I have venomous dorsal fins. Watch out!



ACTIVITY 9



HELPFUL RELATIONSHIPS

Many sea creatures, fastened or not to a base, have developed interesting partnerships that are beneficial to both parties. These partnerships can help them to get food, offer protection and even health services. These symbiotic partnerships are called “facultative mutualistic” when they are beneficial to both partners and they are called “obligate mutualism” when they are necessary to the very survival of both partners.

A. With a partner, choose which animals are helping each other. Match each animal in column A with its partner(s) in column B.

Column A: Animals

- 1. Sea anemone
- 2. Manta ray
- 3. Goby
- 4. Giant clam
- 5. Banded cleaner shrimp

Column B: Partners

- a. Cleaner fish
- b. Blind shrimp
- c. Zooxanthellae
- d. Moray eel
- e. Clown fish

B. With a partner, choose one of these partnerships and explain how the animals are helping each other. Is their relationship mutualistic or obligate mutualistic? Be ready to present your findings to the class.

ACTIVITY 10

WHAT DO YOU KNOW ABOUT PLANKTON? MINI QUIZ

Answer with “True” or “False” and rewrite the sentence to make it right when it is wrong!

- 1. Zooplankton are usually larger than phytoplankton.True False
- 2. Plankton are small animals.True False
- 3. Photosynthesis is the process used by zooplankton to create food.....True False
- 4. Half of the air you just inhaled was produced by phytoplankton via photosynthesis.True False
- 5. Plankton cannot swim, they only drift.True False
- 6. Zooplankton are the first link in the ocean food chain.....True False
- 7. One of the largest creatures in the ocean feeds on plankton.True False
- 8. The largest migration of animals on the planet is that of phytoplankton every night.True False

ACTIVITY 11

SECRET OCEAN FUN FACTS QUIZ

Answer with “True” or “False” and rewrite the sentence to make it right when it is wrong!

- 1. The giant clam cannot close its shell completely.True False
- 2. The sea anemone kills all the small fish that come within its tentacles.True False
- 3. The basket star can detach itself and follow the current for food.True False
- 4. While most sea animals use gills to breathe, the sea cucumber uses its anus to pump air in and out.True False
- 5. The Crown-of-thorns sea star is a detritivore.True False
- 6. The red lionfish filter-feed on zooplankton like the manta ray.True False
- 7. 75% of all animal species are arthropods, i.e. animals like spiders, insects, crabs, shrimp, lobsters, etc.True False
- 8. Octopuses have up to 5 hearts.True False
- 9. Octopus blood is blue, not red.True False
- 10. The red sea hare is red because it has red blood.True False



ANSWERS TO ACTIVITIES

ACTIVITY 1

a. Manta ray; b. Crown-of-thorns; c. Arrow crab; d. Squid; e. Red lionfish; f. Hermit crab; g. Banded cleaner shrimp; h. Sea hare; i. Moray eel; j. Goby with blind shrimp; k. Spiny lobster; l. Spanish lobster; m. Octopus; n. Giant basket star; o. Giant clam; p. Sea cucumber; q. Christmas tree worm; r. Sea anemone.

ACTIVITY 2

1. Christmas tree worms feed on phytoplankton that they catch with their hair-like appendages called 'radioles'.

2. To feed, the giant basket star extends its many arms that are covered with tiny hooks and form a basket to catch the passing prey at night and bring it down into the central mouth.

3. The clownfish is immune to the sea anemone's venom. Its skin carries a special chemical (a protein), which is identical to one in the anemone. The anemone recognizes this chemical and does not fire off its stinging cells.

4. The giant clam has tiny algae or "zooxanthellae" that grow inside it and provide more than half of its nutrients. It also filter-feeds on passing prey.

5. The arrow crab has a triangular body that is covered with stripes and ends at the top with a very pointed "head" (rostrum) that looks a bit like an arrow!

6. The banded cleaner shrimp cleans fish, thus ridding them of parasites, dead skins, etc. and keeping them and the ecosystem they live in healthy.

7. By feeding on detritus, dead organisms and food particles left from other meals, the sea cucumber recycles waste organic matter in its body that becomes food for algae and phytoplankton, which are in turn eaten by animals and eventually become dead matter that is converted back into the nutrients for plants to use.

8. The octopus is the most intelligent invertebrate and has many great abilities, including that of changing its skin color and texture to blend with its surroundings.

9. Gobies and blennies belong to two families of fish. They are very numerous and, as such, an important source of food for other larger fish.

10. The moray eel constantly opens and closes its mouth to pump water through its gills to breathe, not to threaten.

11. Hermit crabs use the discarded shell of other animals, most often sea snails, to cover their abdomen. The giant hermit crab seen in the film is larger and often inhabits conch shells.

12. Lobsters live at the bottom of the ocean, hunting at night, and hiding from predators during the day in crevices or in burrows under rocks.

13. The sea hare eats algae that give it a bad taste that repulses potential predators.

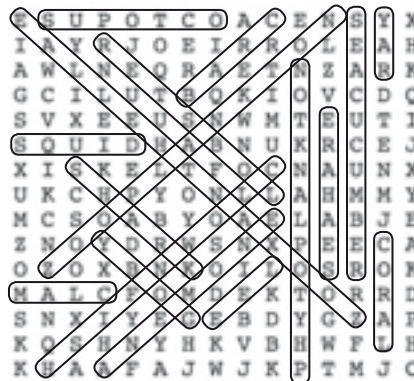
14. Squid numbers remain vast despite the fact that humans have been fishing them regularly. Squids are very prolific, with females that can produce thousands of eggs each!

15. The Crown-of-thorns has 13 or more arms that are covered in venomous spines. This reminded Christian people of the Crown of thorns that was placed on the head of Jesus Christ during his crucifixion. It feeds on coral polyps that are tiny animals living in colonies.

16. Since being accidentally introduced into the Caribbean, red lionfish have become a severe problem as they prey on naive small and juvenile fish, and they thrive due to the absence of larger predators that have been overfished and could have kept the lionfish population in check.

17. The manta ray feeds on zooplankton and tiny fish.

ACTIVITY 3. WORD FIND



ACTIVITY 4.b

a.5; b.2; c.3; d.8; e.10; f.17; g.7; h.6.

ACTIVITY 5.a

Menu 1: Manta ray; Menu 2: Sea cucumber; Menu 3: Sea hare; Menu 4: Octopus; Menu 5: Christmas tree worm; Menu 6: Cleaner banded shrimp.

ACTIVITY 5.b

Sea cucumber: detritivore (1); grazing sediments on the sea bottom to extract small organisms and organic matter (d). Manta ray: carnivore (2); filter-feeding (c). Banded cleaner shrimp: omnivore and detritivore (3 & 4); hunting (a), scavenging (b) and cleaning (e). Sea hare: herbivore (1); grazing (d). Christmas tree worm: mainly herbivore (eats some zooplankton) (1); filter-feeding (c). Octopus: carnivore (2); hunting (a).

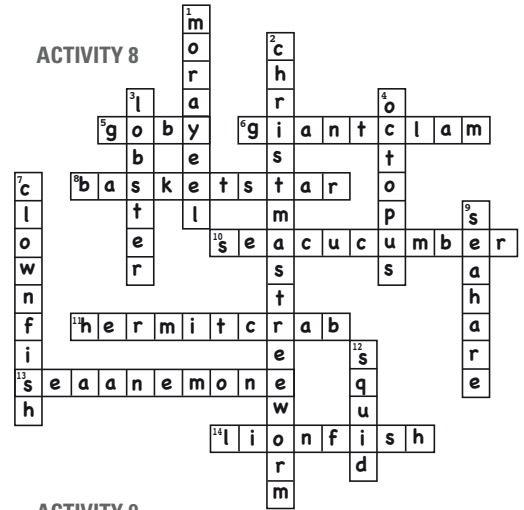
ACTIVITY 6

Producer: phytoplankton; Primary consumer: Christmas tree worm; Tertiary consumer: octopus; Quaternary consumer: Hammerhead shark; Decomposer: bacteria; Detritivore: sea cucumber.

ACTIVITY 7

1: c; 2: a; 3: d; 4: b; 5: e; 6: j; 7: f; 8: g; 9: l; 10: h.

ACTIVITY 8



ACTIVITY 9.

1: e), 2: a), 3: b), 4: c), 5: d).

ACTIVITY 10.

- TRUE. Zooplankton are usually larger than phytoplankton.
- FALSE. Plankton can be small animals (zooplankton) or plants (phytoplankton).
- FALSE. Photosynthesis is the process used by phytoplankton to create food.
- TRUE. Half of the air you just inhaled was produced by phytoplankton via photosynthesis.
- TRUE. Plankton cannot swim, they only drift.
- FALSE. Phytoplankton are the first link in the ocean food chain.
- TRUE. The manta ray, one of the largest creatures in the ocean, feeds on plankton.
- FALSE. The largest migration of animals on the planet is that of zooplankton every night.

ACTIVITY 11.

- TRUE. The giant clam cannot close its shell completely.
- FALSE. The sea anemone doesn't kill the clownfish!
- TRUE. The basket star can detach itself and follow the current for food.
- TRUE. While most sea animals use gills to breathe, the sea cucumber uses its anus to pump air in and out.
- FALSE. The Crown-of-thorns sea star is not a detritivore. It only feeds on coral polyps.
- FALSE. The red lionfish feeds on fish, small fish, shrimp, crabs, and even other lionfish.
- TRUE. 75% of all animal species are arthropods, i.e. animals like spiders, insects, crabs, shrimp, lobsters, etc.
- FALSE. Octopuses have two hearts, some have three.
- TRUE. Octopus blood is blue, not red.
- FALSE. The red sea hare is red because it eats red algae.



**A film by
JEAN-MICHEL COUSTEAU
Narrated by
DR. SYLVIA EARLE**

**AVAILABLE IN 15/70 3D, 2D & DOME AND ALL DIGITAL FORMATS
IN 40- AND 20-MINUTE VERSIONS**

Produced by Jean-Michel Cousteau's Ocean Futures Society and 3D Entertainment Films

www.SECRETOCEAN-THEFILM.com

3D
ENTERTAINMENT
DISTRIBUTION

3D ENTERTAINMENT DISTRIBUTION LTD.
61-65 Baker Street, Weybridge KT13 8AH, United Kingdom
+44 20-7681-2357 | US Toll Free: +1 800-819-7753 | info@3DEfilms.com | www.3DEfilms.com