MARINE LIFE OF MEXICO

treasures of the depths

GERARDO CEBALLOS
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Prologue SYLVIA EARLE

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Protection and conservation of the environment

Carlos Slim Foundation maintains its commitment to the environment, supporting protection and conservation programs, as well as education and social development plans to prevent and reverse the environmental deterioration and damage to the country's biodiversity for the benefit of present and future generations.

In partnership with the World Wildlife Fund (WWF), the world's leading environmental organization, they have allied with other local, national, and international partners to join efforts and financial and human resources for the sustainable development and biodiversity conservation in Mexico. It also works alongside federal and state government agencies to ensure investments contribute to meeting national and regional goals. At a national level, they focus on the issue of Climate Change.

This alliance has supported 63 local organizations in 104 projects in the six priority regions of the country: the Mexican Mesoamerican Reef, the Chihuahuan Desert, the Gulf of California, the Monarch Butterfly Biosphere Reserve, Oaxaca, and Chiapas.

It focuses on the conservation of 25 priority species that include big cats like the jaguar, whales that inhabit the Sea of Cortez, sea turtles that nest along the Mexican coast, tropical birds such as the quetzal and the scarlet macaw, as well as migratory species like the monarch butterfly. Many of these species are currently endangered or subject to special protection.

Equally, the Units for the Conservation, Management, and Sustainable Use of Wildlife (UMA) have been created in various regions of our country with the purpose of contributing to the reproduction, rescue, protection, safeguard, environmental education, and research.

There are also a series of books that are published to disseminate topics about the biological diversity of Mexico, its natural wealth, its importance, the threats it faces, and the possibilities of its long-term conservation. The collection is part of the programs carried out by the Carlos Slim Foundation in favor of the protection and conservation of biodiversity.

Carlos Slim Foundation and **TELMEX** reaffirm their commitment to the natural world and the environment.

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Cover: Stripped marlin hunting Pacific sardine, Magdalena Bay, Baja California Sur. © Christian Vizl
Contraportada: Gulf of California. © Luis Javier Sandoval

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treasures of the depths

If there is magic on this planet,
it is contained in water.

Loren Eiseley

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PRESENTATION

The planet's oceans are fundamental to sustain life on Earth. They host the largest amount of water on Earth, generate most of the oxygen, absorb the carbon dioxide produced by humans, and represent a food source for billions of people. The oceans maintain a wonderful biological diversity, with a greater variety of animal groups compared to terrestrial environments. As Sylvia Earle states in the prologue of this new book, "If there are no oceans, there is no life."

Mexico is home to a great number of complex and diverse ecosystems that bring together about 10 percent of the planet's diversity, including its marine fauna and flora. This thirteenth volume of our editorial program on nature and conservation, titled *Marine Life of Mexico: Treasures of the Depths*, is dedicated to the marine diversity of Mexico. Its coasts are bathed by the Atlantic Ocean, the Caribbean Sea, the Gulf of California, and the Gulf of Mexico. From mangroves and islands to corals in shallow waters and hydrothermal vents over 3 thousand meters deep can be found here; few countries have this environmental complexity. Its natural beauty and ecological wealth, as well as its historical and cultural diversity, make it astounding.

Carlos Slim Foundation maintains its commitment to the environment, supporting protection and conservation programs, as well as education and social development plans to prevent and reverse the environmental deterioration and damage to the country's biodiversity for the benefit of present and future generations.

In partnership with the World Wildlife Fund (WWF), it has worked in six priority regions of the country: the Mexican Mesoamerican Reef, the Chihuahuan Desert, the Gulf of California, the Monarch Butterfly Biosphere Reserve, Oaxaca, and Chiapas, with 104 projects for the conservation of priority species such as the jaguar, the monarch butterfly, the white shark, the leatherback turtle, and manta rays.

Carlos Slim Foundation and Teléfonos de México (TELMEX) endorse their commitment to Mexico to continue disseminating and supporting the conservation and improvement of the environment to leave a legacy to the future generations.

Héctor Slim Seade

HOPE FOR MEXICO'S BLUE HERITAGE

The great spotted whale sharks who gather in the summer along Holbox Island know. The parrotfish who flash rainbow colors among the forests of coral at Cozumel know, too.

So do the gray whales who travel thousands of miles to be in warm, shallow lagoons bordering Mexico's Pacific coast. The mantas who join the swirling currents along the jagged Revillagigedo Islands have known for thousands of years. Now, you who are holding this book can join the sea creatures who have known what humans are now beginning to discover. The more than three million square kilometers of Mexico's seas —in three dimensions— provide just the right environment to be the treasured home or an irresistible destination for an enormous diversity of life ranging from giant blue whales to miniscule jewel-like bits of plankton.

Mexico's seas are not only vital for the creatures who thrive there, but they link to the ocean beyond, the life support system for all of life on Earth. Life requires water, and that's where 97 per cent of Earth's water is held, where most of the oxygen in the atmosphere and ocean is generated, and where much of the natural and human-generated carbon dioxide is absorbed and converted to food by legions of microscopic organisms smaller than the punctuation on this page. No ocean, no life. No living ocean, no humans, either. This thoughtfully crafted, beautifully written and illustrated book conveys the reality of how all life is interlaced through dependence on one another —and on the ocean that makes this planet the only place where life as we know it can prosper in an otherwise hostile universe.

As a child living on Florida's west coast, I often looked across the Gulf of Mexico, wondering who lived beyond the horizon, and who lived in the depths beyond where I could venture with a face mask and fins. Decades later, I can look back on times when I have been privileged to join colleagues in Mexico to explore the mountains, deserts, villages and densely populated cities and have respectfully reveled in

the deep history of human cultures and the even deeper, longer history of Mexican wildlife on land and under the sea.

One memorable night, I submerged in a little one person submarine just offshore from Veracruz. The lights of the city sparkled on the horizon as I descended 33 meters down to a clear space amid mounds, columns and tangled branches of coral. For eleven hours, as a biologist, I observed, filmed and otherwise documented the kaleidoscopic interplay among the reef creatures. But for a while, I could not resist shedding the disciplined constraints of science and imagined myself as a sea creature, spending not just hours but like some kinds of plankton, living for days as a fleeting but vital part of the eat-and-be eaten nutrient cycles that shape ocean chemistry. Or to be one of the sleek reef squid that darted in and out of the glow created by the sub's lights who, if lucky, might survive the year. Or perhaps as a four-eye butterfly fish, tucked into a crevice with its mate for the night, but living for two decades or more, not moving more than half a kilometer from this place on the reef. I wondered what it might be like to be the speckled moray eel that glided by, pausing to glance at the strange object that had dropped in from the rippled surface above. Given its size, at least two meters long, the eel had likely witnessed nearly half a century of action in this part of the ocean.

In half a century, more has been learned about Mexican seas —and the ocean globally— than during all preceding history. But sadly, during the same decades, more has been lost. Since the 1970s, ninety percent of the large sharks, tunas, groupers, snappers, and many other animals have been taken from the sea for food and products by humans who now top orcas and great white sharks as the ocean's top predators. Plastic trash, toxic wastes and other pollutants now degrade the ocean everywhere. Half of the coral reefs, salt marshes, mangroves, and sea grass meadows millions of years in the making have disappeared. In 1952, the last plump, whiskered Caribbean monk seal, once abundant in the Gulf of Mexico, was seen and has been declared extinct. The same fate may await the little Vaquita dolphins, whose only home is in Mexico's Sea of Cortes.

Throughout the history of our species, we have taken from nature to foster our prosperity, but for the first time, it is now possible to see, measure and understand the consequences of the changes we are imposing on the land, the air, the water, and the fabric of life upon which we depend. Now we know what could not be known even fifty years ago. The most important thing we extract from the ocean is our existence. We need the ocean and now, as never before, the ocean needs us to protect what remains of the wild, land and sea, and restore damaged systems to better health.

Bravo, to Gerardo, Rodrigo, and all the other contributors to this magnificent tribute to the creatures who are fortunate enough to call the seas of Mexico home. Celebrated in this volume are efforts now being taken that are cause for hope. Owing to actions by the people and government of Mexico, there are more gray whales, more blue whales, more manatees and more sea turtles than when I was a child. A growing number of reefs, lagoons, waters surrounding offshore islands and critical coastal areas are being protected, with consequences that provide a brighter future for marine life —and for life on the land as well, with special reference to humans. Knowing is the key to caring, and with caring, there is hope that the children of today's children will look back at those who are now safeguarding Mexico's blue heritage, and along with new generations of turtles, sharks and maybe the little Vaquita, say "Thank you!"

Sylvia Earle

Ría Lagartos Biosphere Reserve, Yucatan.

Fernando Álvarez

MEXICAN SEAS

What is the sea?
Why does it seduce?
Why does it tempt?
It tends to invade us like a dogma
and forces us to become shore.
(...)
Perhaps, there will never be an answer
but we will continue asking
What is the sea?
Why does the sea captivate?
What does that riddle that remains beyond here
and the horizon mean?
Mario Benedetti

Mexico is a crossroads, a cauldron where elements of diverse origins have fused; it is an assembly of places and landscapes where ancient stories are narrated and life is preserved in a diversity of ways that have framed our cultural heritage and that continue to amaze us. A key component of this assembly is Mexico's marine environment. The Atlantic and Pacific Oceans carve out gulfs, bays, coves, coastal lagoons, estuaries, and sea entrances of countless dimensions as they merge with the landforms. The seas bathe the 11,122 km of Mexican coastline, and the territorial sea, a band 22 km wide, creates an area of 232,000 km^2 while the exclusive economic zone, a 322 km band extending outward from the shoreline, encompasses an area of 3,150,000 km^2. In comparison to the country's landmass, Mexico's marine heritage is 1.6 times as large. Mexico enjoys large marine-influenced transition zones and an extraordinary variety of habitats that are dramatically influenced by sea currents in part because of the range of latitude that Mexico occupies and the unique characteristics of the bodies of water that lap at Mexico's shores.

The oceans off Mexico's coasts display a complex pattern of currents, the product of multiple fluxes and underwater features. The Califor-

nia Current, characterized by slow moving cold water, reaches a depth of 500 m and flows south along the entire peninsula of Baja California until it deviates west at Cabo Corrientes, in the southern end of Bahía de Banderas, and integrates into the North Equatorial Current. Cabo Corrientes is also the northern limit of the Costa Rica Coastal Current which brings warm water north until it turns west and conjoins the North Equatorial Current. The waters of the Gulf of California exert another major influence on the marine environment of Mexico's west coast. This marginal sea of the Pacific Ocean, separated by the Baja California Peninsula from the Mexican mainland, is 1,200 km in length and 240 km at the widest point and has an incoming flow during the summer and an outgoing flow during the winter.

The northward flowing Yucatán Current passes through the 400-meter-deep Cozumel Channel off Mexico's Caribbean coast. Upon reaching the northeastern tip of the Yucatán Peninsula, part of it flows into the Gulf of Mexico where it circulates clockwise, forming the Loop Current. This circular route loops eastward, exits through the Straits of Florida, and joins the Gulf Stream that eventually crosses the Atlantic Ocean.

Water currents off Mexico's coasts vary seasonally in speed, temperature, depth, and salinity, and they are further affected by major climatic events such as hurricanes, northers and El Niños. During El Niño events, the surface water temperature of the central and eastern Pacific Ocean, from eastern Indonesia to Ecuador, increases by 1 °C to 3 °C above the normal levels, resulting in higher rates of evaporation, decreased rainfall in Indonesia and increased rainfall over the central and eastern Pacific Ocean. El Niño events also display changes in wind patterns: winds that normally blow from east to west along the Equator weaken, and in some years, reverse direction. El Niño events change the global atmospheric circulation, which, in turn, impact the currents that provide moisture (rain) to terrestrial areas. Typically, El Niño events are characterized by more hurricanes along the Mexican coast of the Pacific Ocean and fewer in the Atlantic Ocean.

This complex mosaic of geographic and temporal conditions provide a very dynamic marine environment off Mexico's coasts that support a very rich species diversity and high abundance of marine life throughout the year. While scientists and other explorers have uncovered and identified many of the marvels of Mexico's marine environments, numerous features and inhabitants of this water world remain to be discovered, further enriching our lives and future.

Biological Diversity

Mexico is home to about 10% of the world's biodiversity, and about 40% of the country's species are endemic. Despite an illustrious legacy of exploration and natural history study, scientists feel that only a small portion, perhaps as little as 30% of the species currently living in Mexico, have been discovered and/or adequately studied and described. While studies of terrestrial flora and fauna are replete with unique challenges, it is even more difficult to study life in the marine environment. Current data show that the seas around Mexico support a very large number species of the world's most important marine groups: 2,000 macroalgae; 1,490 planktonic algae; 152 stony corals; 2,787 fish; 1,500 polychaetes; 2,707 crustacea; 42 pycnogonids (sea spiders); 4,643 mollusks; 517 sponges; 289 jellyfish; 643 echinoderms; and 45 mammals. This total of 16,816 species probably is an underestimate of the actual number, and does not include groups of other very important marine organisms such as protists, cyanobacteria, bryozoans, ctenophores, other groups of crustacea, echiurans, chaetognaths, and foraminifera which have not yet been evaluated.

Pacific Ocean

Water characteristics off the western coast of the Baja California peninsula, especially temperature and nutrients, are influenced by the southward moving cold California Current that flows from the Gulf of Alaska. Waters temperatures in the Mexican North Pacific region fluctuate seasonally, from a cool 10 °C in the winter to the more temperate 20 °C during the summer period. The nutrient-rich upwellings of the colder water along the Oregon and California coasts in the United States flowing into the area support very high levels of productivity of photosynthetic phytoplankton, zooplankton, and fish larvae. The abundance of these organisms constitutes the primary link of the food chain that supports an incredible abundance and diversity of marine life. About 220 species of demersal fish (associated with the seabed) have been recorded in this area, and although most of these species have very large areas of distribution, temperate and tropical species overlap in this region. Giant squid, guitarfish, brown smooth-hound, cownose ray, blue shark and

shortfin mako shark inhabit the deeper coastal waters while and the green sea turtle, abalone, spiny lobster, shrimp, pen shells, catarina scallop and pustulose ark, mussels, and barnacles inhabit the shallower coastal waters, intertidal zones, and lagoons. This region also supports an exceptional diversity of large marine mammal species such as the northern elephant seal, California sea lion, Pacific harbor seal, sea otter, many species of dolphins, beaked whales and porpoises, and the seasonal presence of numerous whale species.

Mexico's North Pacific region is prime habitat for many economically important pelagic fish species such as sardine, anchovy, Pacific mackerel, four varieties of tuna (yellowfin, big eye, bluefin, and skipjack), and the highly coveted snapper and silver bass. If their stocks are sustainably managed, they will continue to support the fishery industry and the associated cultural and social attributes they provide. This area is also a major producer of both cultivated and wild caught oysters. Excessive exploitation of sea cucumbers and abalone for food and the purple snail for its natural dye have led to declines in their harvest and threaten the stability of their populations.

The Gulf of California, a marginal sea partially separated from the Pacific Ocean by the Baja California Peninsula, sustains a great diversity of marine life and is home to numerous endemic organisms, that is, animals found exclusively here and nowhere else on the planet. Five of the world's seven sea turtles inhabit this Gulf region, as do more than 700 species of fish and 6,000 species of macroinvertebrates (invertebrates large enough to be seen with the naked eye). The Gulf of California is home to a unique and endemic species of porpoise, the marine vaquita, which cohabits only the upper portion of the Gulf of California with the totoaba, a sciaenid species believed to have aphrodisiac properties. Despite ongoing and aggressive conservation efforts, the vaquita currently faces extinction because of their very low numbers and harvest as bycatch in the totoaba fishery.

A series of islands in the Pacific Ocean extend Mexico's heritage and claim to the seas off the west coast. The oceanic conditions around islands differ from those of the mainland coastal areas and provide unique habitats and resource base which support diverse biotic communities. Examples include the uninhabited Marietas Islands, a small group and the Marías Islands, and the Marías Islands, a largely uninhabited archipelago of four islands located, respectively, a few kilometers, about 25 km and 100 km off the coast of Nayarit.

Stretching from Jalisco to Chiapas, Mexico's South Pacific region is a composite of numerous types of geographic features, environments and high diversity of biota. The proximity of the Sierra Madre del Sur and Sierra Madre de Chiapas impact the coastal areas which consist of extensive beaches interrupted by cliffs, coastal lagoons, and estuarine areas at mouths of rivers, and the numerous coral colonies near the rocky shores add to the structural complexity of the coastal ecosystem. A recent study of coastal Oaxaca revealed a very high diversity of marine life that included numerous species of 15 biological groups: algae, sponges, cnidarians, flat worms, nemertines (ribbon worms), annelids, crustaceans, mollusks, bryozoans, echinoderms, fish, reptiles, birds, and mammals. Of the 2,157 species identified, about 594 were fish, 120 sea birds, five species of sea turtles, the American crocodile, the spectacled caiman, and large marine mammals such as the fin, gray, Minke and pygmy sperm whales.

Gulf of Mexico

This semi-enclosed sea, located between the Yucatan and Florida peninsulas and Cuba, has a wide range of depths that extends to 3,900 meters at the Sigsbee Abyssal Plain which is located at the center of the basin. The continental shelf, where the seabed reaches a depth of 200 meters, is narrow along the coasts of Tamaulipas and Veracruz and widens considerably in the states of Tabasco and Campeche and reaches its greatest extent off the coast of the state of Yucatán. This extensive continental shelf is home to very large populations of commercially exploitable species such as the white, brown, and pink shrimp; the blue, black, and dwarf crab; and fish such as the northern red snapper, horse mackerel, and red porgy.

The Mexican portion of the Gulf of Mexico, a large transition zone between temperate and tropical waters, is home to more than 5,520 animal species. Temperate fauna live in the northern portion of the Gulf, mainly off the coast of the United States and also known as the Carolinian Province, and marine species requiring warm water live in the Caribbean province, or southern. Additionally, many of the Gulf's coastal species have a wide distribution in the Atlantic Ocean, from the Carolinian region on the east coast of the United States to southern Brazil.

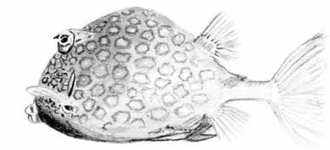
Studies of the rocky shore communities have revealed that northers may cause up to 50% turnover of species from one year to another.

These are strong winds, produced by cold fronts that run through the Gulf from October to February and reach speeds of more than 100 km per hour, generate extremely strong swells.

Most of Mexico's largest rivers, such as the Bravo, Pánuco, Papaloapan, Coatzacoalcos, and Grijalva-Usumacinta, flow into the Gulf of Mexico. When they reach the wide and extensive coastal plains, they form rich ecosystems where terrestrial and aquatic worlds meet and the speed of the water flow decreases significantly. Forming at the mouths of the great rivers, these lagoons are highly productive areas of the coastal Gulf environment. Although they are called lagoons, they are in fact estuaries where seawater mixes with fresh water under the strong influence of tides. Moving from north to south, some of the more spectacular lagoons are: Laguna Madre in Tamaulipas; the Tamiahua, Alvarado, and Sontecomapan lagoons in Veracruz; the lagoons of Carmen-Pajonal-Machoca and Mecoacán in Tabasco, and the Laguna de Términos in Campeche.

The types of vegetation inhabiting lagoons changes dramatically as the water salinity increases closer to the open sea. The more upland areas of the lagoon basin, furthest from the sea, are populated by vegetation intolerant of salt water, such as the Guiana chestnut, a tree that reaches 18 meters high and whose large root structure stabilizes the shoreline and aquatic plants such as water lilies, emergent rooted plants that stabilize the bottom of the lagoon, lilies, water lettuce, and duckweed. Mangroves are present where the salinity of the water increases towards the opening of the lagoon nearest the sea; the black or button mangroves grow along the firmest areas, followed by the white mangrove, and the red mangrove, with its roots submerged in seawater, are closest to the open sea.

Mangroves are vital for the proper functioning of the estuary and the health of the coastal zone. They protect the coastline from the constant changes of tides by capturing sediments and stabilizing them between their roots. Additionally, they are important recyclers of organic matter and return a large amount of nutrients to the aquatic environment through their fallen leaves. Seagrass beds near the shoreline and the mangrove community are critical refuge and breeding areas of countless organisms. Ecologically and economically important species such as the penaeid shrimp, oysters, crabs, a large diversity of fish are dependent on this vital ecosystem especially in their larval and juvenile stages, and seabirds and aquatic and terrestrial mammals feed on the fauna that inhabits this most productive ecosystem.



The rivers that discharge into the sea bring additional sediment to the coastal areas, helping to develop the characteristic extensive beaches. This sediment load and the cooler water temperatures during the winter season limits the development of coral reefs. However, there are some very important coral reef formations outside the area directly influenced by the river flow and where the water temperature is optimal. These structures are unique because they grow in cooler waters and the colonies thrive isolated from each other. These reef formations generally consist of multiple coral types such as elkhorn, brain, star, great star, and finger and a variety of zoanthids and anemones. The reefs in the Gulf of Mexico are rich in species of encrusting and rosette-like algae, sponges, annelid and sipunculids, clams, barnacles, chitons, shrimp, crabs, starfish, sea cucumbers, and sea urchins. The northernmost point of this reef formation is Lobos Island offshore from Tuxpan, and further south there are reefs off the port of Veracruz and between Alvarado and Coatzacoalcos. Another important reef formation is located offshore between 100 and 200 km off the coast of Campeche on the edge of the continental shelf and include Cayo Arcas, Triángulos, Cayo Arenas, Banco Ingleses, and Alacranes. Based on reef thickness and its chemical composition and dominanc coral species (elkhorn corals), it is estimated that Pérez Island, the largest of the Alacranes reef, grows at a rate of 12 meters every thousand years, equivalent to 1.2 cm per year.

Caribbean Sea

The emblematic white beach sands and turquoise waters of Mexico's coastal environment of the Caribbean Sea. The coastline, extending 418 km from Cape Catoche to Xcalak in the state of Quintana Roo on the east coast of the Yucatán Peninsula, is punctuated by three large bays, Asunción, Espíritu Santo, and Chetumal. The Mesoamerican Reef System, a principal seascape feature that distinguishes this region, stretches from the coastal areas of Quintana Roo in Mexico and along the coasts of Belize, Guatemala, and Honduras. Also known as the Mesoamerican Reef, it is not a continuous barrier but consists of dozens of reefs line up along the narrow continental shelf a short distance from the coast. This reef system consists of about 56 species of corals. Hermatypic corals, which maintain a symbiosis with zooxanthellae, are the main builders of reef structures. As

they grow, live coral deposit calcium carbonate to form their skeleton. Successive generations of coral build on the evolving base, forming large complexes with the live corals located in the highest part of the structure and the empty skeletons of the previous generations below them. These structurally complex features have a high heterogeneity that support thousands of other marine species. Because of their key role in the formation and maintenance of the reef, coral species such as elkhorn and deer horn are central to protection and recovery strategies of the reef ecosystems.

The extensive beach areas are used by many groups of animals including birds, crustaceans, mollusks, and sea turtles, among other organisms. Further out from the coast, large areas of lowlands in the intertidal and subtidal zones are covered with seagrasses. These meadows of vascular plants (not algae and having structures to transport nutrients and water) such as turtle grass, manatee grass, and shoal grass, are very important as breeding and refuge areas during some stage of life for hundreds of coastal marine animal species, and they are considered one of the most productive ecosystem on the planet. More than 225 species of algae, 985 species of mollusks and multiple species of marine mites, jellyfish, sponges, bryozoans, nematodes, annelids, sipunculids, crustaceans, echinoderms, urochordates, fish, and turtles use the seagrass beds off Mexico's Caribbean coast.

Cozumel Island and the Banco Chinchorro atoll reef and the waters adjacent to them are unique ecological treasures. Despite its location just 18 km off the Yucatán Peninsula, the island of Cozumel has a unique reef formation and a high diversity of marine life, in part because of the unique ocean conditions around the island that results from the 400-meter deep channel on the west side and the 1,000-meter deep channel on the east side. The Cozumel reefs are very diverse and consist of at least 33 species of corals, with some dominant genera. Researchers have described 334 species of algae, 73 species of shrimp and crabs, and 93 fish species in these reefs. The oval shape of the Banco Chinchorro reef formation, located about 30 km from the south coast of Quintana Roo and across the water from the town of Mahahual, may be the result of its formation as a coral atoll or the shape of the platform on which it has developed. While the queen conch, lobsters, sea cucumbers, and crocodiles have been recorded on this formation, the fauna has not been well studied and future work will likely reveal the presence of many more species. Its designation as a natural protected area, remoteness and difficult access has helped to keep this amazing ecosystem intact and well protected.

Final considerations

The poet Mario Benedetti poses the question "What is the sea?" and responds "perhaps there will never be an answer." All that remains for us is to formulate our own truth about the sea to treasure it. Our seas, the seas of Mexico, are a natural resource, and they represent wealth, responsibility, and opportunity. We must recognize that we are just beginning to comprehend the enormous value of the sea and what the seas mean to us individually and collectively and that its rational use can successfully catapult us into a hopeful future. Conservation is a matter of humans, not of nature, and we must become more knowledgeable about the seas and care for it as a member of our community.

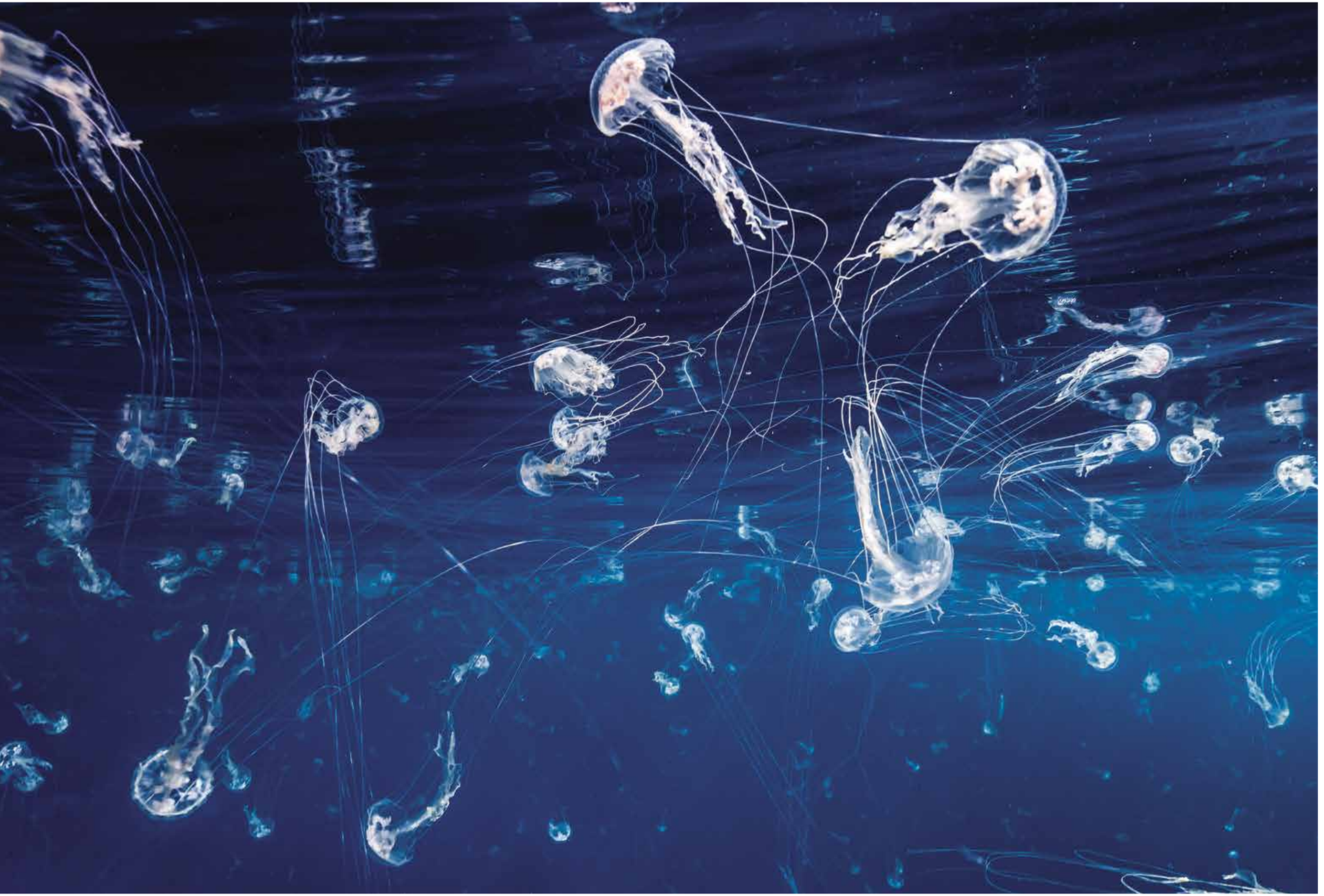
Jellyfish and sea walnuts are amongst the most beautiful creatures in the ocean. Their semi-transparent bodies lack skeletons and over 95% of their tissues are comprised by water, making them delicate and fragile organisms. If removed from the water, they'd collapse on the sand and become shapeless, since they need the support that the sea's aqueous environment provides for them.

Despite having a similar appearance due to their transparency and "gelatinous" consistency, these animals represent two completely distinct lineages separated by millions of years of evolution. Jellyfish belong to the phylum Cnidaria, which includes corals and anemones. All of them possess tentacles armed with stinging nematocysts. Sea walnuts, on the other hand, make up the phylum Ctenophora, meaning "comb-bearers" in Greek thanks to the eight rows of filaments aligned throughout their body. Their ctenophores, unlike that of Cnidarian's tentacles, lack any type of nematocysts.

Jellyfish are easily recognized by their swimming style, where their their bell-shaped body favours movement by jet propulsion, an ability they achieve by rhythmical contractions. These creatures take advantage of sea currents and even surface wind to travel great distances. They use their tentacles to capture prey such as fish larvae, invertebrates, and krill, which together form an important part of the zooplankton. As they also use their tentacles for defense purposes, the sting of some jellyfish can be extremely painful for humans and, in rare cases, fatal. However, most species are considered harmless.

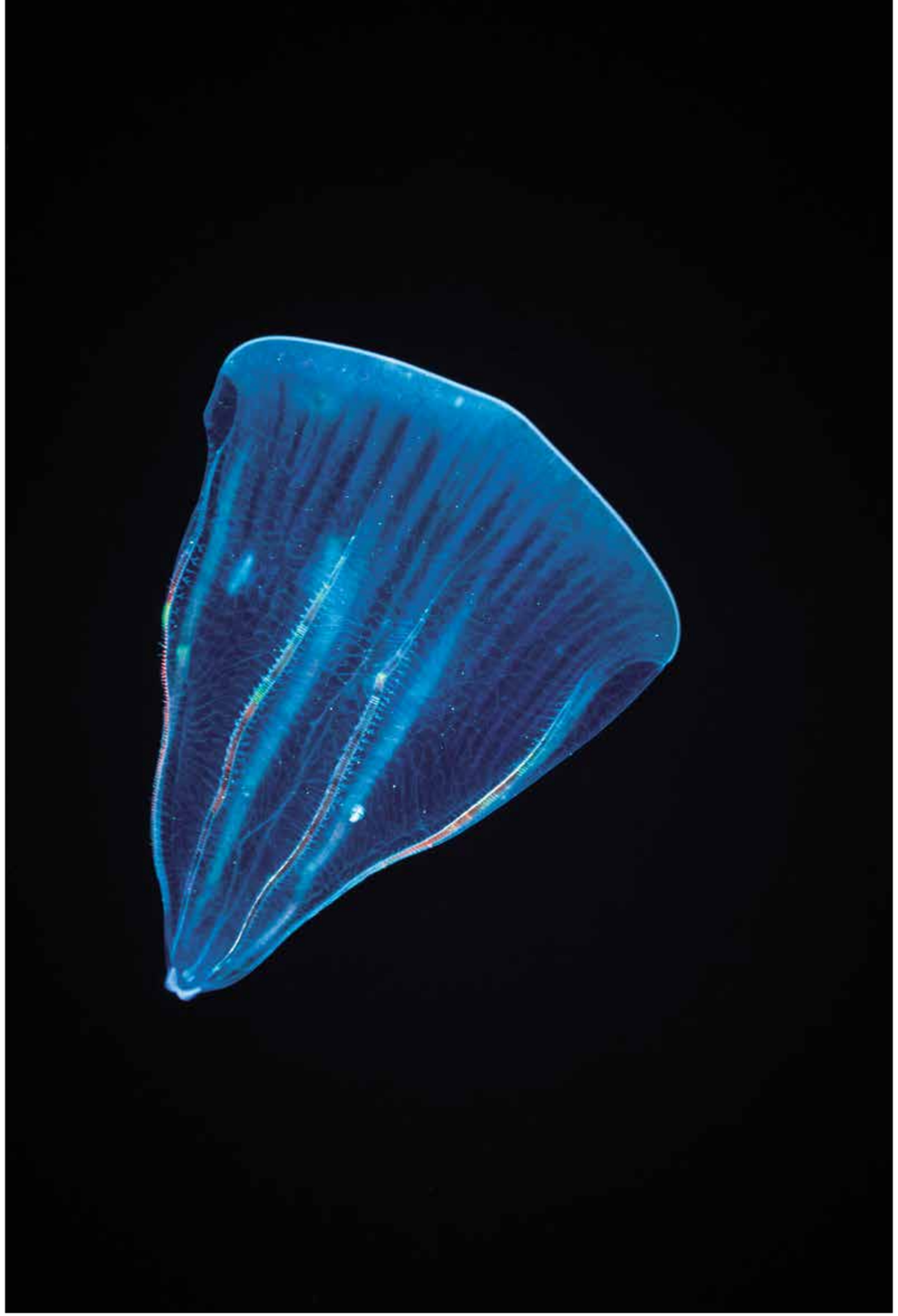
Ctenophores use their filaments for locomotion and their adhesive cells, known as colloblasts, to capture prey. Most species float near the surface of coastal waters, while others live at the bottom of the sea. Some ctenophore species possess a pair of tentacles and most of them are bioluminescent.

floating beauties



The umbrella-shaped bell of the jellyfish, which have seen the sea for over 600 million years, allows them to move in any direction, although they prefer to be dragged along the sea currents. The increasingly common formation of large groups of jellyfish, especially in places where they have never arrived before, are a symptom of changes in the temperature and salinity of the sea.

Jellyfish are carnivorous. They capture their prey and defend themselves against possible predators thanks to stinging cells called nematocysts, distributed in their tentacles.



Ctenophores differ from jellyfish by their spherical or oval shape, a more complex digestive system, their swim based on the movement of the filaments that run through their body, the absence of stinging nematocysts, and because they always live suspended in the water, without a sessile life phase.

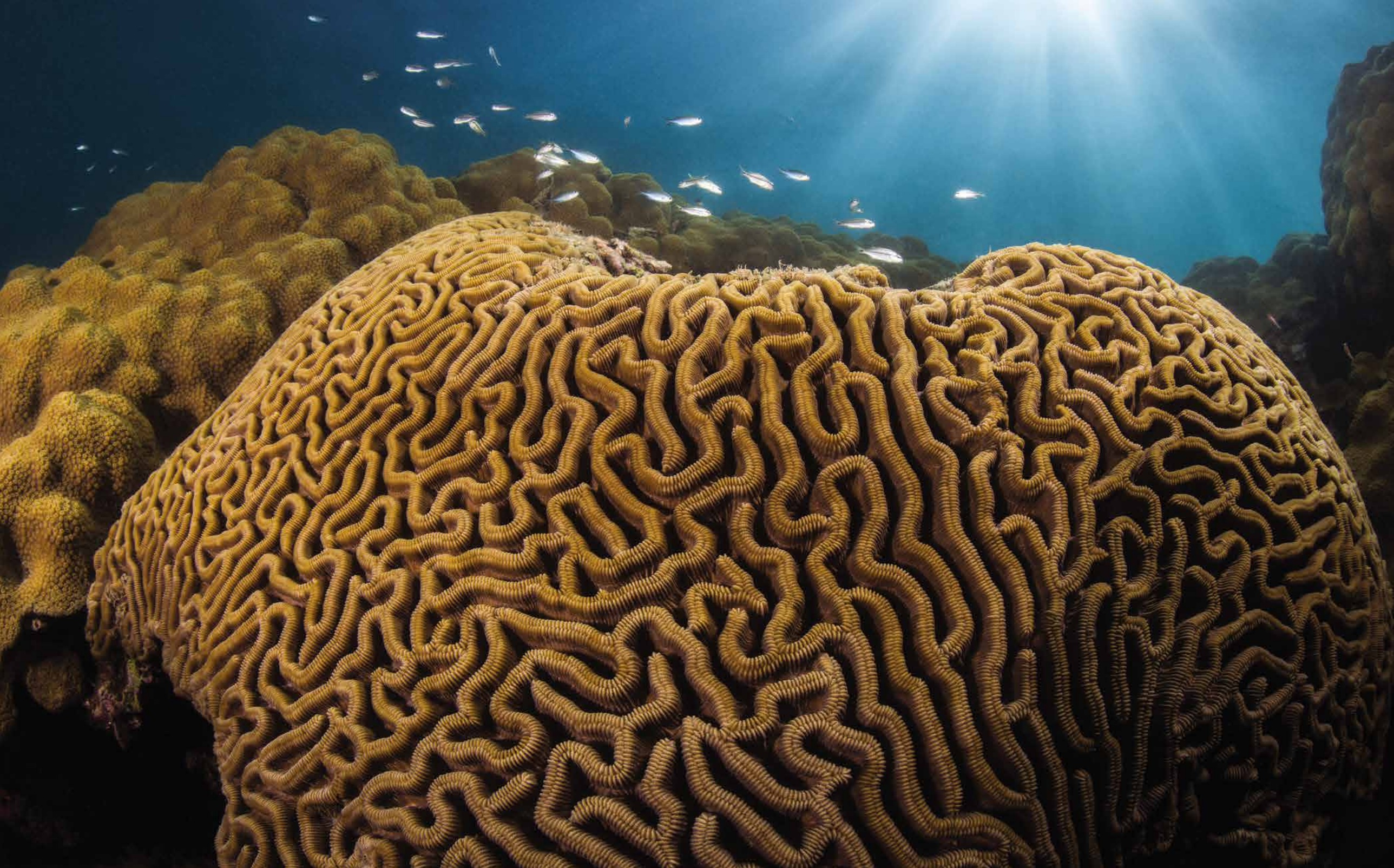
The Cnidaria group, which means “nettle” in Latin, is comprised by over 10,000 species of corals, hydroids, jellyfish, and anemones. These animals have a cup-shaped body and a single central opening surrounded by tentacles. When they look like this, they are called polyps. Polyps can live individually and attach to the substrate, in the same manner that of some species of anemones and jellyfish during their first life stages. ,Like corals, they are also able to form colonies. Their most distinctive feature is the irritating capsules called nematocysts, located in the tentacles, and which are specialized for hunting and defense.

Corals are tiny animals that form colonies of hundreds to thousands of individuals. They build their hard-exterior skeletons by absorbing the calcium carbonate that is dissolved in seawater. On the other hand, Gorgonians, are known as “soft corals” since they lack rigid and permanent skeletons; this group includes colorful sea fans and sea pens.

Inside the polyps’ tissues, groups of unicellular algae grow. These are called zooxanthellae, which provide oxygen and other compounds, and receive in return nutrients and carbon dioxide. The pigments that zooxanthellae possess are responsible for their colorful appearance. The diversity in which polyps organize themselves to form a colony, their diversity of shapes, sizes, and colors make them truly wonderful creatures.

When corals gather in large groups, they form structures known as coral reefs: one of the most fascinating and biodiverse ecosystems on the planet. To fully develop, reefs require specific environmental factors such as optimal water temperatures and clarity, sea currents, salinity and a base to adhere to. Coral growth is slow, with most species adding less than 3 centimeters per year to their length. Unfortunately, coral reefs are currently threatened by the increase in the temperature of the ocean and its acidification, which in turn lead to coral bleaching (when zooxanthellae disappear) and cause their death.

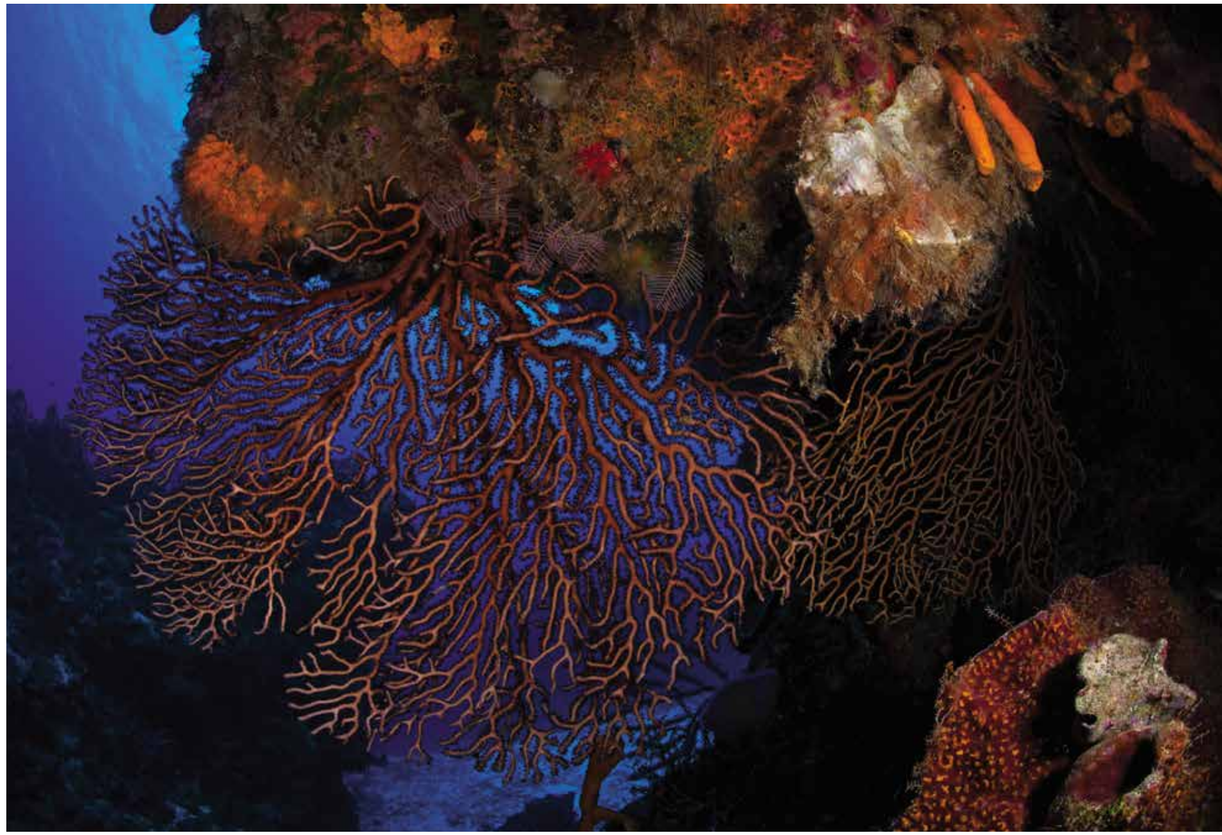
colonial builders



The rigid structure of corals occurs because each polyp, which represents an individual, secretes calcium carbonate that hardens around it. As they multiply, polyps form colonies, one generation over another, creating reefs.

Many species shelter, feed, reproduce and breed in coral reefs.

Inside corals, within the tissues of the polyps, there are algae called zooxanthellae that provide them with oxygen. In turn, corals provide protection and nutrients. Unfortunately, the rise in sea temperature is causing the disappearance of these algae and therefore coral bleaching and death.



Because of their species' diversity, coral reefs are the equivalent of rainforests in terrestrial environments. They are currently threatened by the proliferation of macroalgae associated with the discharge of agricultural and urban effluents, as well as commercial overfishing, the capture of specimens for aquariums, the accumulation of sediments from terrestrial environments, and the invasion of exotic species.

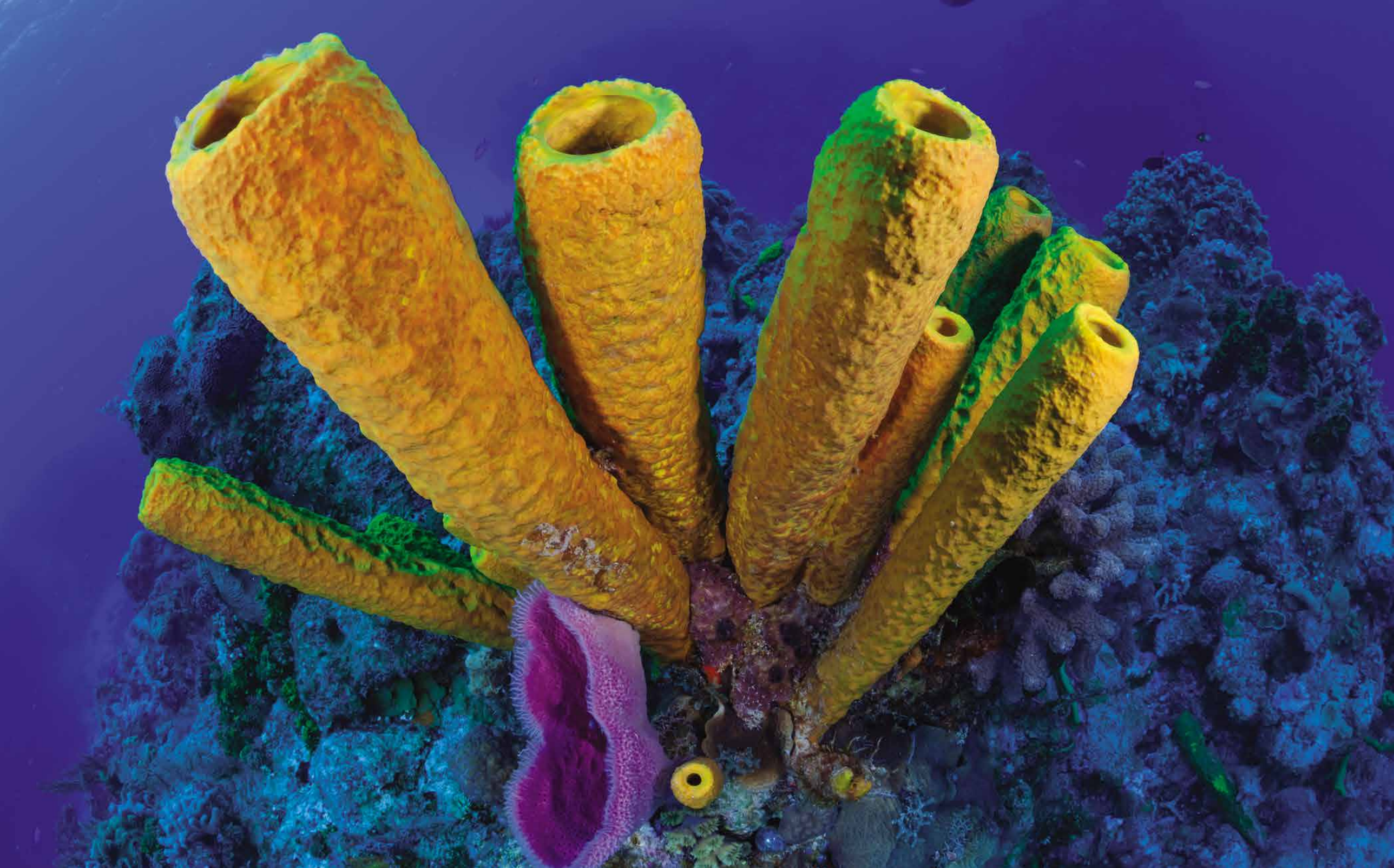
Due to their physical appearance and sedentary lifestyle, until 1825 sea sponges had not been recognized as animals. They occur mostly in shallow waters, attached either to the ocean floor or to submerged objects. However, some species can live in profound waters as deep as 5,000 meters. Others, although very few, live in freshwater habitats. However, despite their apparent simplicity, sponges are organisms that have prevailed on our planet since the appearance of the first-ever organisms, over 580 million years ago.

One of their most distinctive characteristic is the porous structure of their body, which grants them the name “Porifera”. When examined closely, numerous small pores and few larger ones become visible. It is through the small pores, known as inhaling pores or ostia, that the seawater and the suspended organic matter on which they feed on penetrate simultaneously. Through the large pores, called oscula, is were water is expelled. The body of a sponge, the complexity of which varies according to the species, is generally asymmetric, lacks defined organs, and has ducts and cavities on the interior that connect pores.

In our country, nearly 517 species have been formally recorded, but at a global scale, about 8,400 are recognized. Even so, their diversity is so vast that more species are believed to exist.

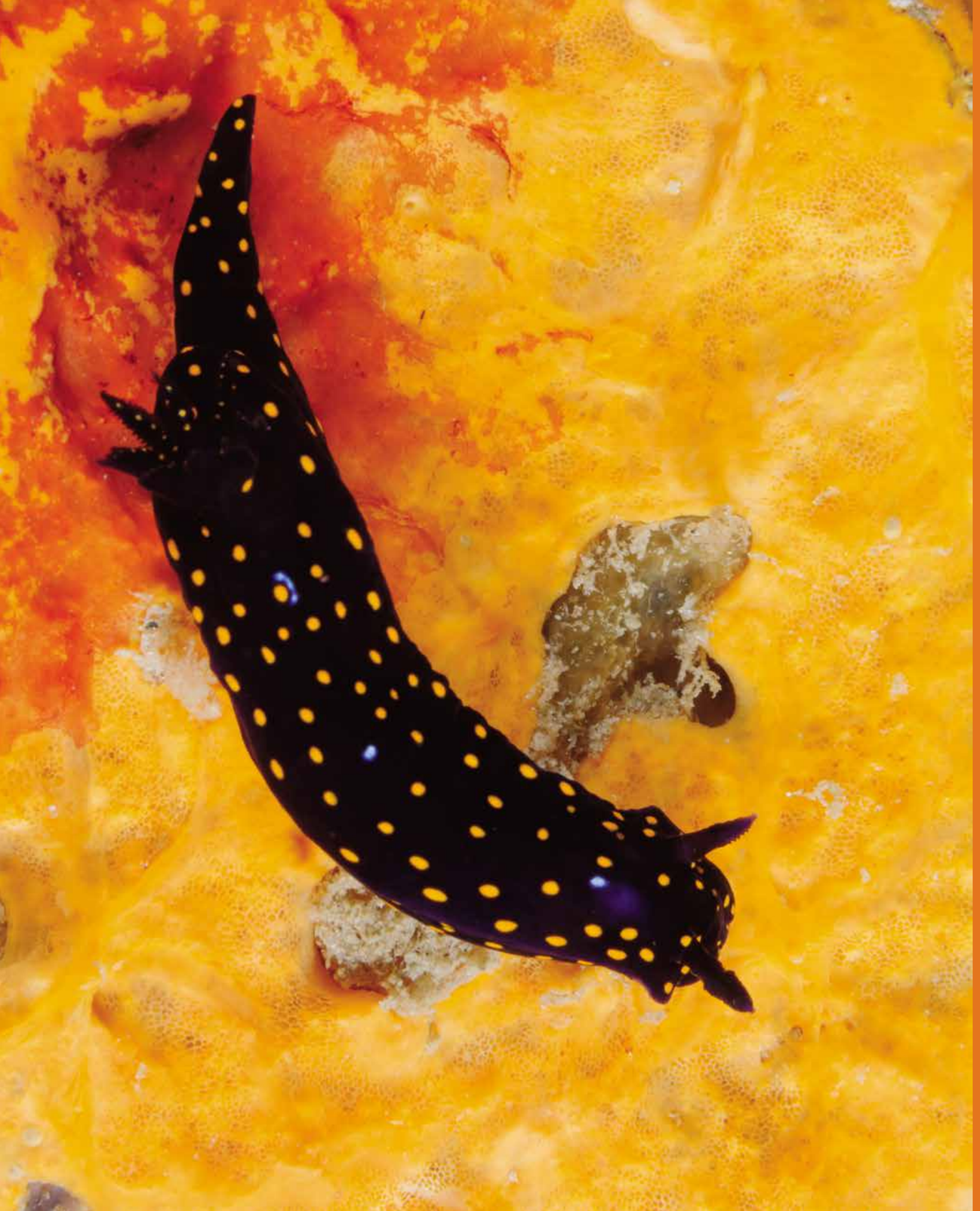
Some species have been used by humans for centuries as bathing sponges thanks to their softness and smoothness. In Mexico, humans have not been reported to use them. However, some fishermen harvest them illegally. Since studies are scarce, their abundance and conservation status are uncertain. Today, the most important threat they face is habitat destruction driven by the tourism industry, the construction of marinas, and oceanic pollution.

plant-like appearance



Sponges have no nervous, digestive, or circulatory systems. Their body is made up of pores and channels that allow the filtering of large amounts of water to trap their food; mainly bacteria and organic matter dissolved in the water. They contribute significantly to the regeneration of nutrients in the ecosystem, as a sponge of one kilogram can filter up to 1,000 liters of water per day.

Despite their apparent simplicity, sponges constitute a large proportion of the total biomass of ecosystems. In warm areas, such as the Caribbean, they can reach over two meters in height, while in cold areas, such as the Antarctic, they represent up to 75% of the total biomass at depths between 100 and 200 meters.



Nudibranchs, also known as sea slugs, are in fact snails that either lack a shell or possess extremely small shells. They are striking and photogenic creatures, easily recognized by the noticeable gills located in the back of their bodies, which gives them their name, derived from Latin and Greek, and which means “naked gills”. The antenna-like organs of their head, called rhinophores, play an olfactory role, while the appendages located in their back, called cerata, have sensory, defense, and breathing functions.

Nudibranchs display an incredible diversity of intricate color patterns that allow them to either camouflage with the substrate or, to make themselves noticeable. Their splendid coloration warns predators of their dangerous toxicity. Surprisingly, they do not produce their own defenses, and instead, they steal them from their prey. After eating a sponge or a soft coral, nudibranchs recycle their compounds and incorporate them into their tissues. For example, if they feed on a jellyfish, a coral, or an anemone, they can ingest the nematocysts (stinging capsules) and incorporate them into their own defense mechanisms. They can also obtain zooxanthellae –photosynthetic algae– from the corals they feed on, hosting them in their tissues and maintaining a symbiosis relationship with them.

Sea slugs are found throughout the world’s oceans, from the icy waters of the Arctic to the tropics, and from shallow waters in the coastline to areas around 2,500 meters deep. Although over 3,000 species live in shallow waters, more and more species are being discovered in deep-sea habitats. By late 2018, scientists had described five new species that inhabit the deep seabed off the coasts of California and Baja California.

of a thousand colors

These animals owe their name to their bare gills, which resemble beautiful plumes of bright colors. They are also characterized by the lack of a shell, which disappears at the end of its larval stage.

Nudibranchs have various strategies to protect themselves from their predators. For instance, they secrete mucus with a strong and unpleasant smell and taste, and some species can be toxic or poisonous.

With unmistakable tentacles attached to a large head, cephalopods (which in Greek means “foot in the head”) are a group of invertebrates that comprise around 800 species and share a very ancient history as the first individuals appeared over 400 million years ago. The representatives of this group are octopuses, squids, and cuttlefish, as well as the now-extinct ammonites and the nautiluses, characterized by their distinctive spiral-shaped shells. These animals have been the protagonists of classic sea monster legends and have become part of the mythology of numerous coastal cultures.

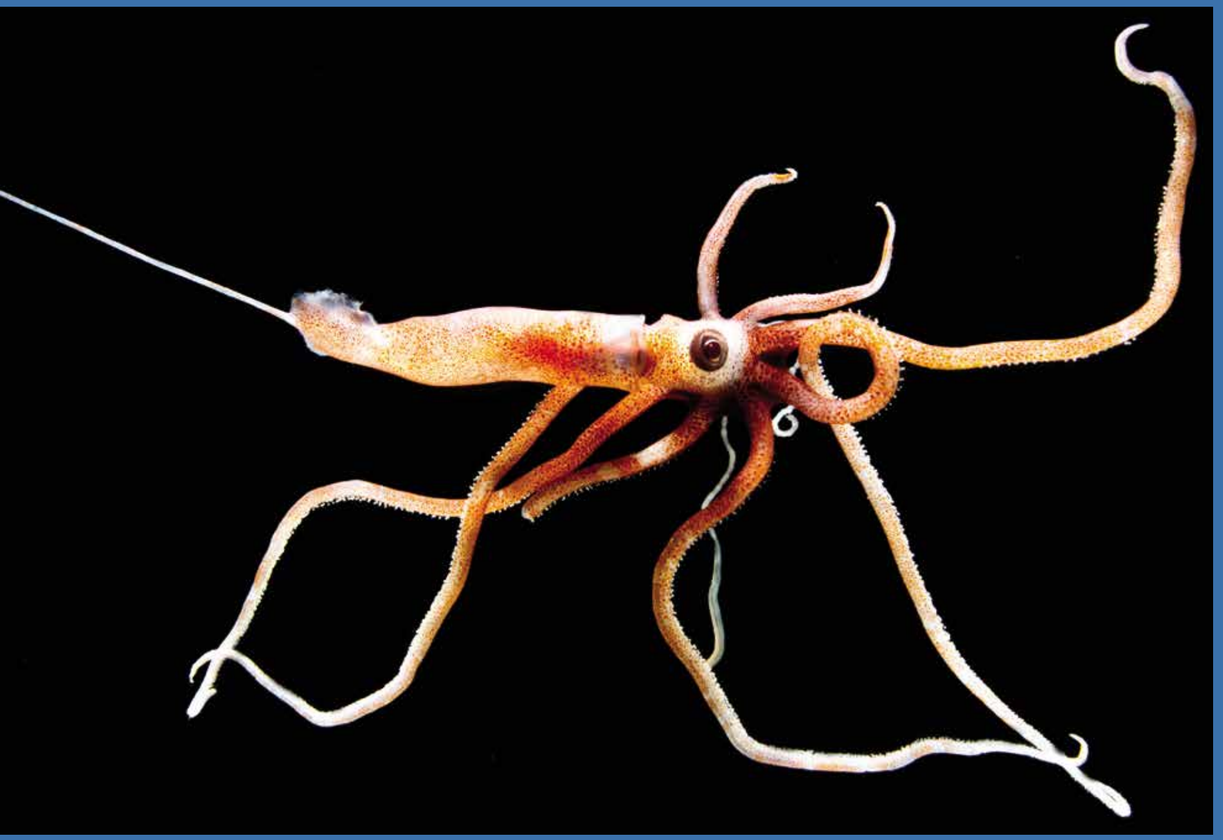
Today, we know that octopuses have the biggest brains of all invertebrates and are surprisingly intelligent. It is not easy to compare their brains with that of vertebrates, this since most of the cephalopods’ neurons are located in their eight arms, which have a highly-developed sense of touch and taste, which allows them to explore everything that surrounds them. Interestingly, octopuses have the ability to recognize a person, as well as to learn how to reach food located inside a screw-top jar at the end of a three-dimensional maze. There are even indications that they are self-aware!

Their role as predators carries great ecological importance. Cephalopods use their stalking skills to surprise their victims. To hold their prey, they make use of the strong power of the suction cups located on their tentacles, which move independently. After this, their horn-shaped beaks cut their victims into small pieces. The chromatophores of their skin –light-reflecting cells that contain pigments and are controlled by muscles– give them the ability to quickly change their conspicuous colors to camouflage or attract a partner.

Octopus and squid fisheries are highly important both in Mexico and in the rest of the world. For instance, just for the Humboldt squid species (which can measure up to 1.5 m in length), between 60 to 100 tons, are caught every year along the Mexican Pacific Coast.

lurking tentacles

Cephalopods can change their color in a few seconds thanks to specialized cells called chromatophores. They can also modify their skin texture and even emit light, an effect known as bioluminescence, thanks to cells that capture sunlight. This feature allows them to communicate their mood, initiate courtship, or defend themselves.



Among invertebrates, cephalopods have the most developed and complex central nervous system. Their tentacles have a sophisticated sense of touch and even taste, as they are also used to taste their surroundings.

Cephalopods can expel ink from their digestive system to confuse possible predators, either by avoiding detection or by creating a silhouette of themselves.

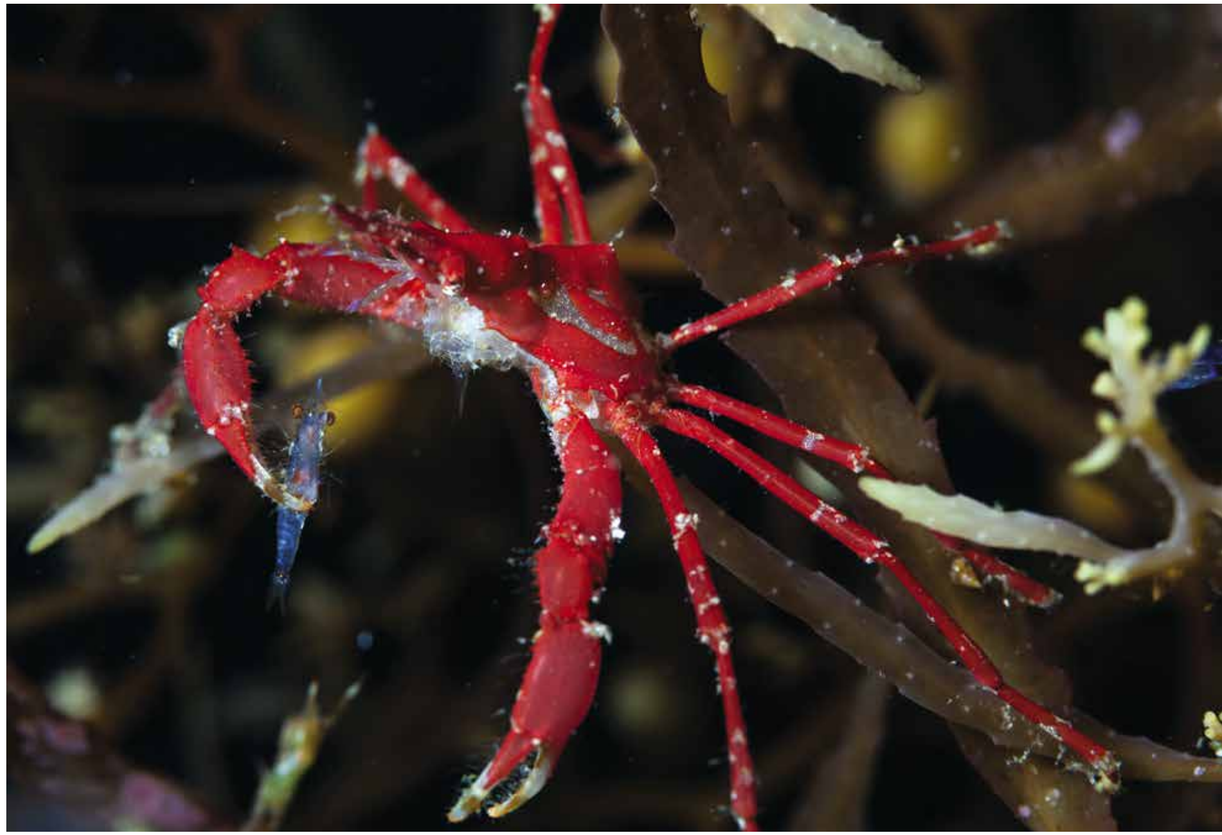
Shrimp, lobsters, and crabs, among other animals, belong to the Crustacean group. These creatures are characterized by a basic set of a head, body, a set of ten walking legs, a hard shell, and mobile joints. Today, there are over 70,000 species of crustaceans in the world that feature an incredible array of variations in shape and size.

The tiniest of all crustaceans are shrimps, whichreach a size of only 0.1 millimeters in length. They represent an important part of plankton and live suspended in the sea currents throughout their life. The largest species is a crab that reaches up to 4 meters long. There can be both translucent as well as colorful, with either short or long claws, either long and thin or short and strong legs, and with or without eyes. Their habitats range from sandy beaches to the depths of the ocean throughout our planet. Some species can be incredibly abundant, such as the euphausiid shrimp we know as *krill*, considered one of the species with the largest biomass on the planet –to only imagine they are the main food source for whales!

In contrast to flat-sided shrimps, lobsters are characterized by top-to-bottom flattened bodies that allow them to live on the ocean floor. The most popular members are the spiny lobsters, a highly sought fishing resource. Their closest relatives are red crabs, which form gigantic aggregations throughout the Gulf of California, and several species of common slipper lobsters that inhabit the ocean's rocky bottoms.

Crab's abdomens are folded under their shells. From the huge spider crabs to the tiny pea crabs that live inside clams, they all display complex behaviors and possess complex life cycles. They can communicate with each other, defend territories, and even care for their young. They represent a group of organisms that are fundamental for the proper functioning of marine ecosystems due to their wide diversity of ecological roles, complex interrelationships, and richness.

with the armor on



Crustaceans have a rigid external skeleton consisting of chitin and arthropodin. Some crustaceans live in shells abandoned by other animals, while others make their own shell.

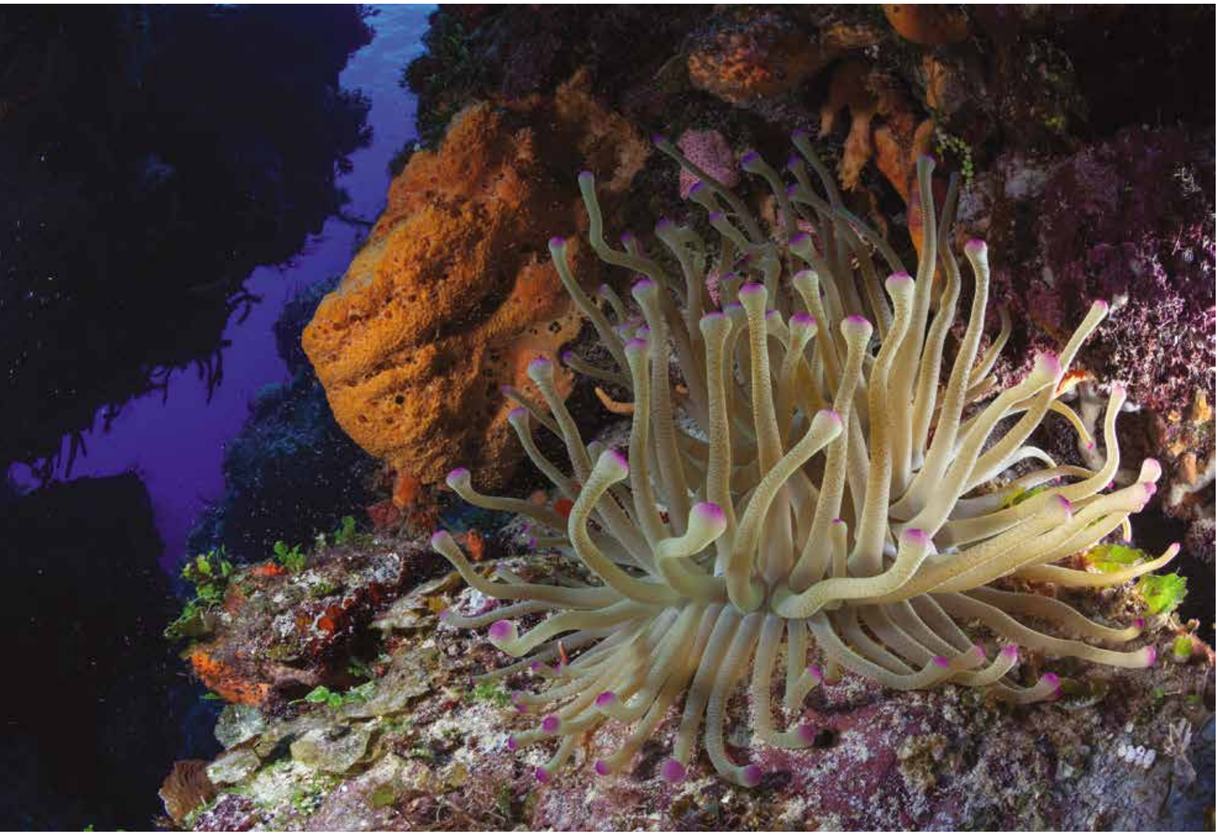
In addition to their 10 legs, lobsters (page 96) have structures called statocysts at the base of their antenna. Statocysts have a function similar to ears, providing balance by distinguish depth and terrain variation.

Crustaceans are the only class of aquatic arthropods. They are scavengers, filters, and carnivores, and are an important commercial resource for human consumption.

Every time a new sea organism is discovered, the impression that we will never uncover all the existing marine species remains with us. There are familiar forms like fish, shrimp, or whales, but among all invertebrate creatures, a hidden diversity exists. Some animals live in colonies where they feed, grow, and reproduce, such as bryozoans, whose colonies resemble plants or beautiful and delicate flower arrangements. One may be surprised to find armored animals with prehistoric appearance on quiet beaches; these are horseshoe crabs, creatures that have defended themselves for millions of years with their spike-like tails. In shallow waters, clusters of colors with either radial or spiral arrangements are observed coming out of a single rock or the corner of a reef. These are crowns of tentacles that belong to polychaete worms living inside calcium tubes in the hard substrate, which allow them to trap suspended particles in the water more efficiently thanks to their comb-shaped body.

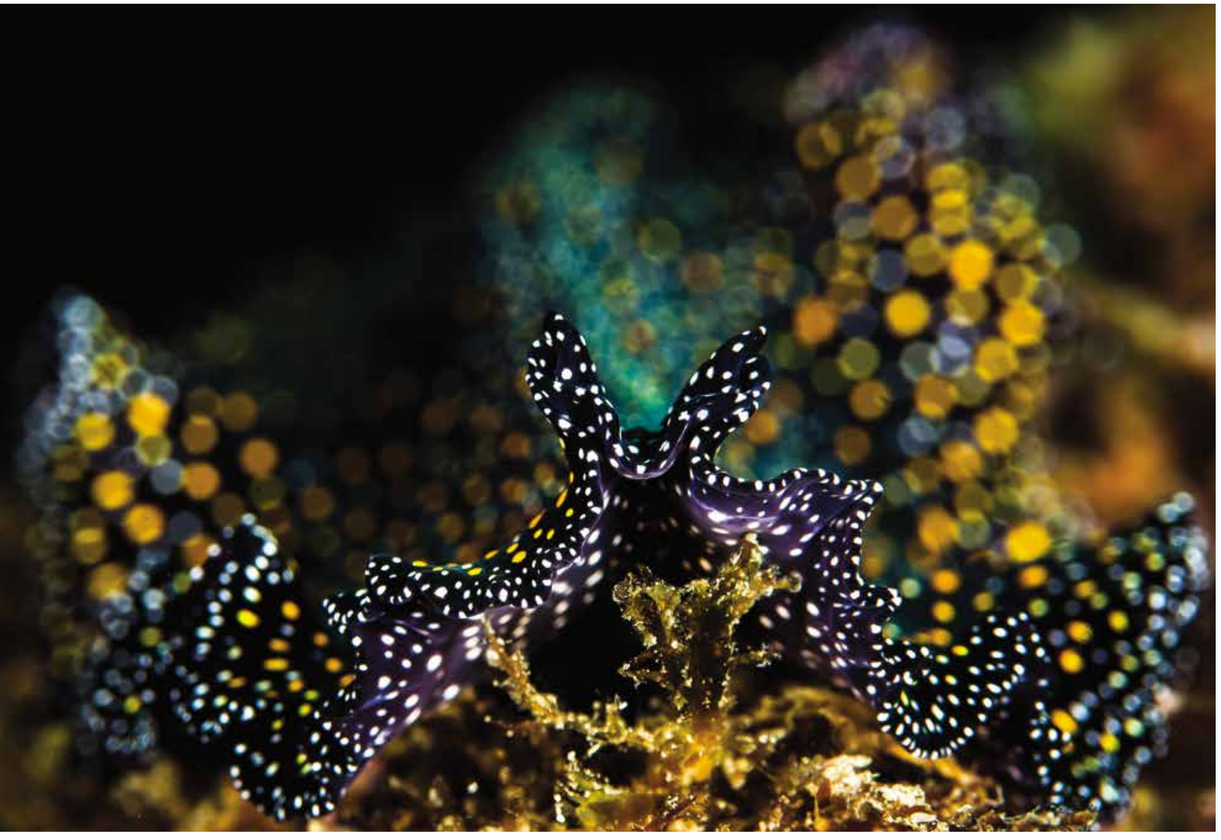
A diverse and common group that has existed for millions of years in the seas of the world are echinoderms, characterized by the spikes on their skin. Their main feature is the pentaradial symmetry, that is, a body divided into five equal parts. In this group, we find starfishes and sea cucumbers, sea urchins, crinoids or sea lilies, and ophiuroids or snake stars. The combinations of shapes and colors that exist, plus the diversity of spines, plates, and tentacles make their beauty compelling to humans, but for other sea organisms they represent food, protection, and reproduction. The threatening spines of sea urchins, the grace of the starfish, the charm of the crinoids, and the agility of ophiuroids make them surprising yet fascinating.

amazing diversity



The giant Caribbean Sea anemone is known for its symbiotic interaction with fish, in which they protect themselves by hiding in the tentacles from possible predators while the anemone benefits from the cleaning they provide.

Sea pens are relatives of jellyfish and corals. Their body has a structure similar to that of corals, so that each pen consists of numerous interconnected animals (polyps). They live in silty or sandy sediments.



Not all worms are as we imagine them. In the sea, there are colorful and undulating species of capricious forms, such as this flat worm.

The flamingo tongue snail is a relative of terrestrial snails. It lives on the seabed and is carnivorous. Its shell is also colorful, but it can only be seen when the snail is completely inside it. It feeds on gorgonians.

Oddly enough, Christmas tree worm is part of the group of annelids, same to which earthworms and leeches belong. This sea worm hides among live corals, showing its colorful spirals, which are used to feed on plankton and other particles suspended in the water.

Horseshoe crabs have not undergone morphological changes in the last two hundred million years. They live buried in the sand where they capture various invertebrates. Their behavior allows them to detect changes in the environment. They are highly valued in the pharmaceutical industry, since their blood allows the detection of various bacteria. In Mexico they are only found in the Yucatan Peninsula.

Starfish are formed by a central disk with 5 to more than 20 arms. They usually feed on clams and oysters, but they can also catch small fish.

Sand dollars are close relatives of sea stars. Due to their rigid structure they have few predators, such as starfish, crabs, octopus, and seagulls.

San Benedicto Island, Revillagigedo National Park, Colima

Octavio Aburto

GROWING THREATS

If the oceans of our Earth died
—that is, if, somehow,
life suddenly disappeared—,
it would be the most formidable,
yet definitive,
of catastrophes in the tormenting history
of man and †other animals
who share this planet with him.
Jacques Yves Cousteau

The Sea of Cortez, also known as the Gulf of California, is one of the most precious, natural features on the planet. It extends for 1,250 kilometers, from the mouth of the Colorado River, near the Mexico-United States border, to the tip of the Baja California Peninsula. Dotted with numerous islands, it is one of the most protected large marine bodies in the world. Jacques Yves Cousteau, the famous French naturalist and marine explorer, called it the "aquarium of the world."

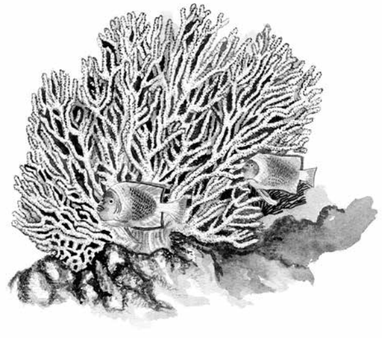
The cold waters of this sea harbor numerous natural treasures, such as Cabo Pulmo, one of the northernmost coral reefs in the Pacific Ocean. Fishermen have harvested nacre and fish form this area at least since the 18th century, but with declining yields in recent times. Recognizing the danger of continued harvesting of their marine resource base and the accompanying financial hardships it brought to the community, the local fishermen in the 1980s decided to stop fishing and worked to establish a national marine park, which was decreed by the federal government in 1995. A once moribund fishing industry has been converted into a robust tourism enterprise and the community enjoys a much-improved standard of living. This historic socio-economic shift, from resource exploitation to

a conservation-based use of their natural capital, such as diving and tours, changed the prospects of the community forever. Evaluations and monitoring of the reef health by the Autonomous University of Baja California Sur revealed that in fewer than 15 years since the establishment of the park, the numbers of species doubled, and the abundance of fish and the productivity of the ecosystem has improved markedly. A photo I took in 2012, which I call "David and Goliath", shows the magnitude of the recovery: a diver is observed near the bottom of the sea surrounded by a gigantic school of fish; it was a scene that would not have been observed there 20 years earlier because the fish populations had declined so severely.

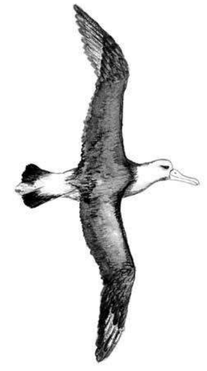
The Goliath of our times

Covering more than 70% of planet's surface, the oceans and seas are a critically important and amazingly diverse and complex feature vital for the support of life as we know it. They have been assaulted, and despite their vastness, radically changed in some instances by human activity, especially over the past century. Very few places in the marine world now remain without a footprint of human activity.

We live in a time of global-scale ecological changes such as rapid loss of biodiversity and transformation of the planet's climate. The large and growing size of the human population and the way human societies manage the natural resources are the primary factors driving the changes in this, the *Anthropocene* geologic era. In general, the cumulative effects of ignoring the environmental costs of production and consumption, such as reliance on inefficient, fossil fuel-based technologies and the absence of effective waste management mechanisms and policies, have already impacted the life and functionality of the seas and imperil life, in general, including human societies.



The complexity of environmental problems requires different strategies applied at varying spatial and temporal scales. Some activities that contribute to these challenges can be addressed at the local to national levels while others require cooperative action at the hemispheric and international level. For example, many issues of overfishing, pollution, and the modification or destruction of natural habitats, all of which can have immediate and dramatic impacts on population abundance and species diversity, can be effectively dealt with by Mexico's public (government) and private institutions through laws, management guidance and incentives. Other issues, such as changes to the composition of the atmosphere and the biogeochemical cycles (in which matter circulates between living organisms, soil, oceans, and the atmosphere) involve large parts of the planet or the entire planet itself and will require firm commitments to comprehensive international agreements, resource investment, utilization of



appropriate technologies and willingness to modify socio-economic institutions. For example, global climate change and the associated ocean acidification currently is a critical issue that demands immediate and robust international action.

Modifying cycles of millions of years

The increasing levels of carbon dioxide (CO_2) and other heat-trapping gases (e.g., methane) in the atmosphere, oceans and soil are primarily the result of emissions from the extraction and burning of fossil fuels such as coal and oil. The highest percentage of the emissions caused by human activities is trapped in the atmosphere (45%) while about 24% is absorbed by terrestrial ecosystems and the remaining 31% by the oceans. The global average concentration of atmospheric CO_2 today of 414 parts per million (ppm) represents a 48% increase compared to the 280 ppm level in 1850, during the early period of the industrial revolution. This increased level of CO_2 and other gasses is responsible for the global warming of the atmosphere and by extension, a rise in the temperature of the sea and change in its chemistry. Based on decades of data, the warming rate of both the atmosphere and sea is accelerating.

Despite the enormous amount of water represented by the world's oceans, their temperature has increased by about 0.6 °C over the last 40 years. While the upper layers absorb most of the heat, the bottom layers are not immune from the warming. The increase in sea surface temperature promotes higher levels of evaporation, which in turn, fuels larger and more intense storms including hurricanes. Some recent examples of increased storm activity that seem to validate climate change models are: three category 4 hurricanes in 2015 lined up simultaneously in the Pacific Ocean, a never-before-seen event; three category 4 hurricanes in 2017 which devastated regions in the Atlantic basin resulting in an estimated $250 billion in damage; and the first recording of the formation of a tropical storm in the Gulf of California in 2018, 2,000 kilometers north of where these storms usually form.

The combination of melting of the polar ice caps which supply a huge amount of fresh water to the sea and changes in water temperature also affect the dynamics of the currents that connect the oceans at the planetary level. For example, data show the speed of the Gulf Stream in the North Atlantic has slowed in recent decades. The Gulf Stream, which originates near Florida, flows eastward into two main branches: North Atlantic Drift, which reaches the coasts of northern Europe, and the Canary Current, which recirculates waters off the coasts of West Africa. The Gulf Stream, and by extension the North Atlantic Drift, is responsible for maintaining milder temperatures across the southeastern

United States and northern Europe. Averaging a speed of 2.5 meters per second, a width of 100 kilometers, and a depth of one kilometer, the Gulf Stream carries warm water from the tropics which eventually combines with the cold winds of the Arctic and generates ocean fronts throughout its entire flow, ultimately increasing ocean productivity. The weakening or slowing of this current may presage a significant reduction in the Earth's temperature from 4 °C to 6 °C in countries such as England and Ireland in the future, and the recent changes in the productivity in the cod and lobster fisheries and storm and rainfall patterns are likely to be linked to changes in flow patterns of ocean currents.

The ocean's water chemistry changes when carbon dioxide mixes with sea water at the ocean's surface and dissolves; a weak carbonic acid forms, changing the acidity or pH of the ocean and making it more corrosive. For more than 300 million years, the average pH of the oceans was 8.2; today, it is 8.1. Although seemingly small, this change in pH of 0.1 represents an exponential increase of 30% in the acidity of the oceans in only 200 years. An important effect of this acidification is the drastic reduction in the amount of available carbonate in the water column which is used by marine organisms such as clams and corals to build their shells and skeletons. Additionally, metabolic effects (feeding and breathing) and behavioral changes (reproduction and locomotion) occur below a pH threshold, threatening the continued existence of numerous forms of marine life.

Human activities have also dramatically modified the naturally occurring cycles of two elements critical to both terrestrial and aquatic (freshwater and marine) life: nitrogen and phosphorus. Factors that have disrupted these cycles are the burning of fossil fuels, discharges of fertilizer in watershed drainage basins, and the flushing of untreated municipal and industrial organic waste into water bodies. Rivers, aquifers and surface flow connect the upstream sources of these elements, and other pollutants, to the sea. This *eutrophication*, or resulting nutrient enrichment has negative effects on the environment and biota. The proliferation of algae on surface waters, fostered by the excessive amount of nutrients, outcompetes other organisms for space and limits sunlight penetration in the water column, ultimately causing the death of photosynthetic organisms such as seagrasses. The rapid growth of the bacteria that decomposes the dead organic matter removes oxygen from the water column, creating anoxic zones, also known as "dead zones." Additionally, the hydrogen sulfide also released by the decomposer bacteria as a byproduct of their metabolism is toxic to most animal and plant life. It is estimated that dead zones in coastal areas have increased ten times in the last five decades and four times in open seas where currents have spread the enriched waters.

Reef bleaching and the invasion of sargassum

The changes to the biogeochemical cycles, increased temperature, and eutrophication favor the proliferation of invasive species and marine diseases, and as a result, large barrier reefs, such as the Mesoamerican Reef in the Caribbean, are dying. Dying or dead reefs are characterized by bleached corals, whitish colored structures that seem abandoned. Coral bleaching occurs when the microalgae, which provide the food on which the coral depend and the color of the corals, die off from increased sea temperatures. Weakened, the coral are vulnerable to disease.

In addition to the coral bleaching and decreased diversity of marine life, another telltale indicator of large-scale changes in the marine community off Mexico's coast is the massive and uncontrollable arrival of sargassum, large masses of algae to the Caribbean coasts. This endless tide of floating vegetation is, literally speaking, drowning out the biodiversity and economy of the Mayan Riviera. The Atlantic Ocean, between Brazil and Africa where high temperatures favor its reproduction, is the source of this multi-species algae mass. The explosion of sargassum in the naturally low nutrient Caribbean Sea reflects the many human assaults on the marine environment: enormous input of nutrients from fertilizers and untreated sewage from the Mississippi River Basin in the United States and the Amazon River in Brazil; increased sea temperatures; and changes to flow currents and storm events resulting from climate change. Since 2015, the sargassum has increased annually throughout the Caribbean; it appears earlier in the year (May) and is predicted to disappear later (October). The algae mass can double its weight in only 20 days and, when it decomposes, produces dead zones: the death of marine life from suffocation and exposure to sulfuric acid (byproduct of hydrogen sulfide emitted during bacterial decomposition of the organic matter). This ecological issue has transformed the region; it has reduced tourism by up to 50% in some seasons and changed the work activities of tour operators because of the need to spend more than half of the week cleaning the beaches. In short, the sargassum invasion, a result of unhealthy ecosystems stemming from unsustainable human activities, presents a serious economic challenge to the region.

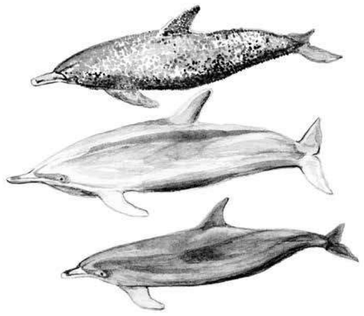
More people, fewer fish in the ocean

The immensity of the oceans tend to mask two important realities: marine natural resources are finite, and they are not distributed homogenously. The large-scale and intense fishing pressure over the past half century has severely

reduced the population of many commercially important species and has led to the collapse of economically important fisheries, such as the sardine fishery off the Pacific coast. It is estimated that today's population of large fish, such as sharks and tunas, is only 2% of 1950 number.

The potential maximum natural productivity, namely the production of phytoplankton, the basis of the marine trophic network, of the reefs, seagrasses, and seabed around Mexico has not changed in the thousands of years humans have inhabited the Americas. In contrast, since 1950, Mexico's human population, per capita consumption of fish products, and fishery capacity has changed dramatically. Mexico's 1970 population of about 52 million consumed about 3.8 kilograms of fishery products per capita per year, and yearly total production of wild caught products was about 385,000 tons per year and about 500 tons from the aquaculture industry. In 2013, the country's population was 115 million people, annual per capita consumption rose to 10.7 kilogram per year, wild caught production increased to 1,635,000 tons and aquaculture produced 169,999 tons. The human population and fishing pressures today are even greater than those 2013 values.

Current fishing productivity data show a stressed marine ecosystem and its associated industries threatened with collapse. Statistics from the National Commission of Fisheries and Aquaculture reveal that fish production has not increased over the past decade, only 10% of fisheries have a small margin of development, 70% are at peak performance and cannot increase without collapsing, and 20% have already collapsed.



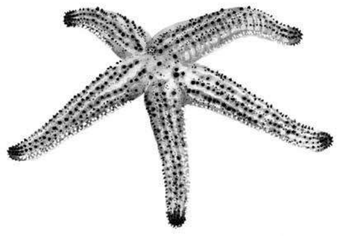
The increased fishing pressure has accelerated the rate of coastal and marine habitats disturbance and destruction, a major threat to the health and sustainability of Mexico's marine resources. The shrimp trawling industry, which employs a technique that seriously impacts the benthic (bottom) habitat, is still considered a priority fishery in Mexico even though this technique has been severely limited in other parts of the world because of environmental concerns. Trawling destroys seagrass gardens, coral reefs, and even deep habitats, some of which have not been sufficiently studied, and it also captures an enormous quantity of juvenile individuals of many species and taxa, most of which are discarded and thereby affecting other fishery reserves. Along the coastal areas, wetlands and mangroves provide the essential nutrients for the marine food webs and serve as nurseries and safe havens for numerous species of commercial and non-commercial fish and shellfish provide. However, in the last 50 years almost half of these highly productive Mexican coastal habitats have been destroyed to accommodate urban development, tourism, agriculture, and shrimp farms. The loss of these habitats does not event make sound economic sense: one hectare of mangroves is valued at $37,000 per year only in fishery products caught in open water, and up to $100,000 per year if all of its ecosystem services are included.

Another major threat to the marine environment, and one that has recently garnered increased attention, is plastic pollution. Unfortunately, plastic is ubiquitous in the sea: clumped together in large, floating masses kilometers in diameter and known as gyres, on the shores of the remotest islands, and throughout the water column, including on the seabed, thousands of meters below the surface. The amount of plastic discharged into the sea globally is estimated at eight million tons per year, of which 15% stays on the surface, 15% stays at varying depths in the water column, and 70% settles to the bottom. Plastics eventually break down, and these microplastics, particles smaller than 5 mm across, can be ingested by marine fauna, including zooplankton, crustaceans, and fish and eventually travel up the food web to the top predators. Additionally, turtles, seabirds, mammals and larger fish may ingest larger pieces of plastic, mistaking them for food. These plastic items become imbedded in their digestive system or entangle the animal, often resulting in their death. Some estimates suggest that plastic pollution will increase by 900% by the end of the next decade and that by 2050 its mass will be greater than that of all the fish.

Only a decade to achieve great transformations

Globally, the oceans are in trouble and the litany of threats is long. There is no one region in the world that is free of the stressors that has imperiled them. The expanding demands of an increasingly large human population endanger the naturally complex biodiversity of marine flora and fauna, their habit, and the functionality of the marine world which has supported life on Earth for millions of years.

What can we do? What should we do? What will happen to the oceans if we fail to take appropriate action and reverse the trend of deterioration? These are questions that must be addressed urgently and followed up with strategies that incorporate sustainability as a primary goal. While some goals have been established at the international level, strategies to reach many of them have yet to be fully implemented. *The Oceans Compact*, a United Nations initiative that emerged as part of the final report of the Rio +20 meeting "The Future We Want," has a strategic vision for marine conservation and set a clear path to follow. However, the guidelines and recommendations are challenged by entrenched policies and political differences. *The Oceans Compact* argues that by 2015, the multiple anthropogenic pressures on coral reefs and other vulnerable ecosystems should have been reduced in order to maintain their integrity and proper functioning. By 2020, at least 10% of marine and coastal areas,



especially those of special importance for biodiversity and ecosystem services, should be conserved through effective and equitable management, including ecologically representative and well-connected protected areas and other conservation measures integrated with the wider terrestrial landscapes and marine seascapes. Finally, by 2025 all countries should set targets to address problems of eutrophication, marine debris, and wastewater. In addition, the regions and countries most vulnerable to sea level rise should be identified to help in the development of mitigation and adaptation plans.

In Mexico, the 2015 goal was not met, only half of the 2020 goals have been implemented to date, and there are no clear strategies in place that will help achieve the 2025 goal. Although it is recognized that international collaboration is necessary to achieve many of these goals, Mexico can and should do more to change the degradation we currently observe occurring in our seas.

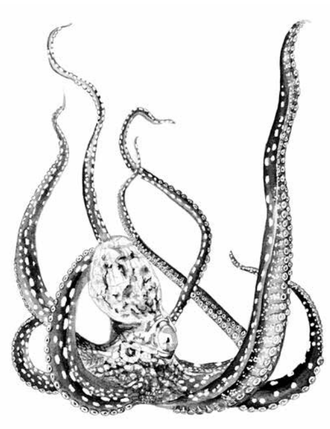
A change in how fisheries are managed in the country is urgently needed. Currently, the fisheries administration in Mexico continues to focus on factors, often politically driven, that promote fishing and not the sustainability of fisheries: size of fishing catches, number of boats, and people working in the fishing sector. In contrast, fishing sustainability is measured by the health of marine communities, areas of the sea protected from fishing pressure, environmental standards to maintain ecological balance, and surveillance actions to ensure these standards are met. The fisheries administration in Mexico has not evolved since the growth spurt of the industry in the 1970s; it has opposed changes that will help fisheries become a sustainable industry, such as increasing fully-protected marine areas and involving other government agencies and local communities in monitoring and surveillance actions.

The fisheries administration in Mexico has lagged and relies primarily on models that only take into account one species or the economic benefits without considering the importance of maintaining the integrity of ecosystems. For example, driven by a strong economic interest in exploiting all potential marine environments, fisheries policies until recently generally disregarded the important role of protecting marine reserves. These reserves, where fishing is not authorized, provide significant benefits both to the marine biota and the fishing industry. They have been shown to increase the abundance and size of fish. Closing some areas of the ocean to fishing is not a new concept; island nations in Polynesia and Micronesia have regulated and protected their resources for centuries by using marine reserves which serve as a refuge for multiple species to congregate for reproduction and feeding. These island nations and other countries have also learned that preserving and protecting mangroves and seagrass beds are effective management practices that support high and sustainable yields of marine biota.

Stones for David's sling

In the biblical narrative of David and Goliath, the smaller contestant challenges the larger and more powerful one, and with the use of a small stone wins the contest and ends the threat. This story, widely disseminated and told in many ways, has inspired people of different cultures and reminded them that, despite overwhelming odds, there is always a chance to succeed. This story, for me, is well illustrated in the conservation-oriented events of Cabo Pulmo, a small community that overcame the challenge of overfishing.

Who would have thought that fishermen would stop fishing when the national park was established in 1995? Who would have thought that, without any five-star hotels or large public works, a small town could generate profits that, on a *per capita* basis, are greater than any other tourist hub in Mexico? Who would have thought that the number of marine species in the national park would double, fish biomass (tons per hectare) would increase by over 400% and the biological productivity would be five times higher than in other reefs in the Gulf of California? Who would have thought that pulmeños (inhabitants of Cabo Pulmo) would own their businesses and properties without paying rent and their savings and investments would be in those reefs? Now tourists from other parts of Mexico and around the world come to the area to experience the wonders of a healthy and thriving marine environment replete with examples of the large fish and almost countless diversity of marine flora and fauna that once were the hallmarks of the waters off Mexico. This fully protected marine reserve is the stone with which the pulmeños defeated the great Goliath of overfishing.



The importance of Cabo Pulmo example is that it demonstrates that coastal communities can grow economically without squandering their natural resource base. Recovery of the reefs has brought a level of well-being to the entire community, and hopefully the passion to preserve and protect the natural heritage will be inherited by future generations of the inhabitants. As a country, Mexico must make significant changes with respect to coastal development models that has been promoted to date. The Cabo Pulmo experience offers a strategic model that can and should be replicated in other regions. New public-private investment schemes are needed which invest in conserving ecosystems while producing more economic benefits and greater social equality. Cabo Pulmo is an example of what sustainability means and how it can be achieved. This example and other conservation initiatives targeting the seas around Mexico, offer hope that this enormously complex and productive natural inheritance can be sustained to provide the resources for the inhabitants of Mexico and the world community at large.

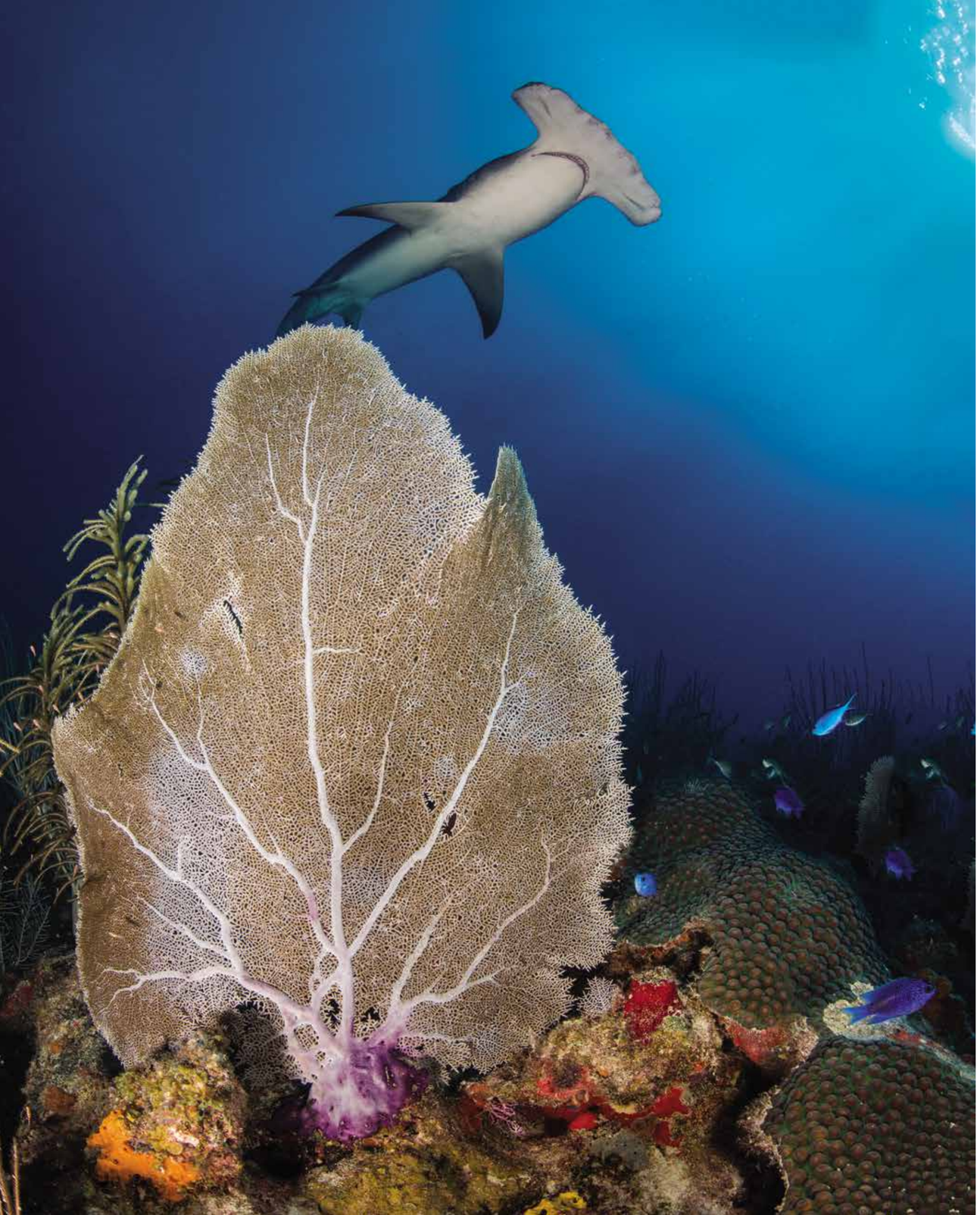
Sharks have swum in the planet´s oceans for about 400 million years. There are many fossilized shark teeth and scales that have allowed us to follow their trail throughout evolution. The origin of sharks is older than that of dinosaurs, mammals and even insects. Sharks have survived the five mass extinctions that decimated life on Earth. Today there are more than 400 species in the world, descendants of those who survived the fifth extinction in which dinosaurs disappeared 65 million years ago.

Mexico has more than 100 species of sharks. The largest fish in the ocean, the whale shark, lives on both coasts of Mexico and supports an important tourism industry based on the incredible experience of swimming with this animal about 10 meters long. Sharks have managed to overcome numerous threats throughout their existence and today there are few predators and natural diseases that affect them. However, the human being and his insatiable thirst for natural resources have put the survival of these animals in check. Currently there are about 140 species of sharks in danger of extinction or threatened around the world by overfishing, because so many animals are captured that population recovery is prevented –and bycatch– when they are caught in nets destined for other species. Instruments such as the Convention on International Trade of Endangered Species of Wild Fauna and Flora (CITES) provide measures to be taken to improve the identification of meat and fins, as well as their traceability, in the markets, as well as to regulate fisheries and promote sustainable practices that ensure the future of this fascinating group of fish.

mighty predators

Sharks are an example of the adaptive success of this lineage of marine animals. Their hydrodynamic body, extraordinary sense of smell, and powerful teeth place them as the greatest predator of the seas. The white shark (page 124) is the largest marine mammal hunter. There is an abundant population on Guadalupe Island, 250 kilometers off the coast of Baja California.

In some places –as in the waters of the Revillagigedo Islands– shark populations are still as abundant as 50 years ago. It is possible to observe large concentrations feeding on tuna and schools of sardines. It is also possible to observe groups of white tip reef sharks in very peculiar formations at the bottom of the reef. Today, sharks are severely threatened by overfishing and bycatch, which have caused over 80% of some species to disappear.



In Mexico there are more than 100 species of sharks including the bull shark (above), the tiger shark, the whale shark, the white shark, and the hammerhead shark (left). Marine protected areas such as Cabo Pulmo and the Revillagigedo Archipelago are very important sites for the conservation of this group.

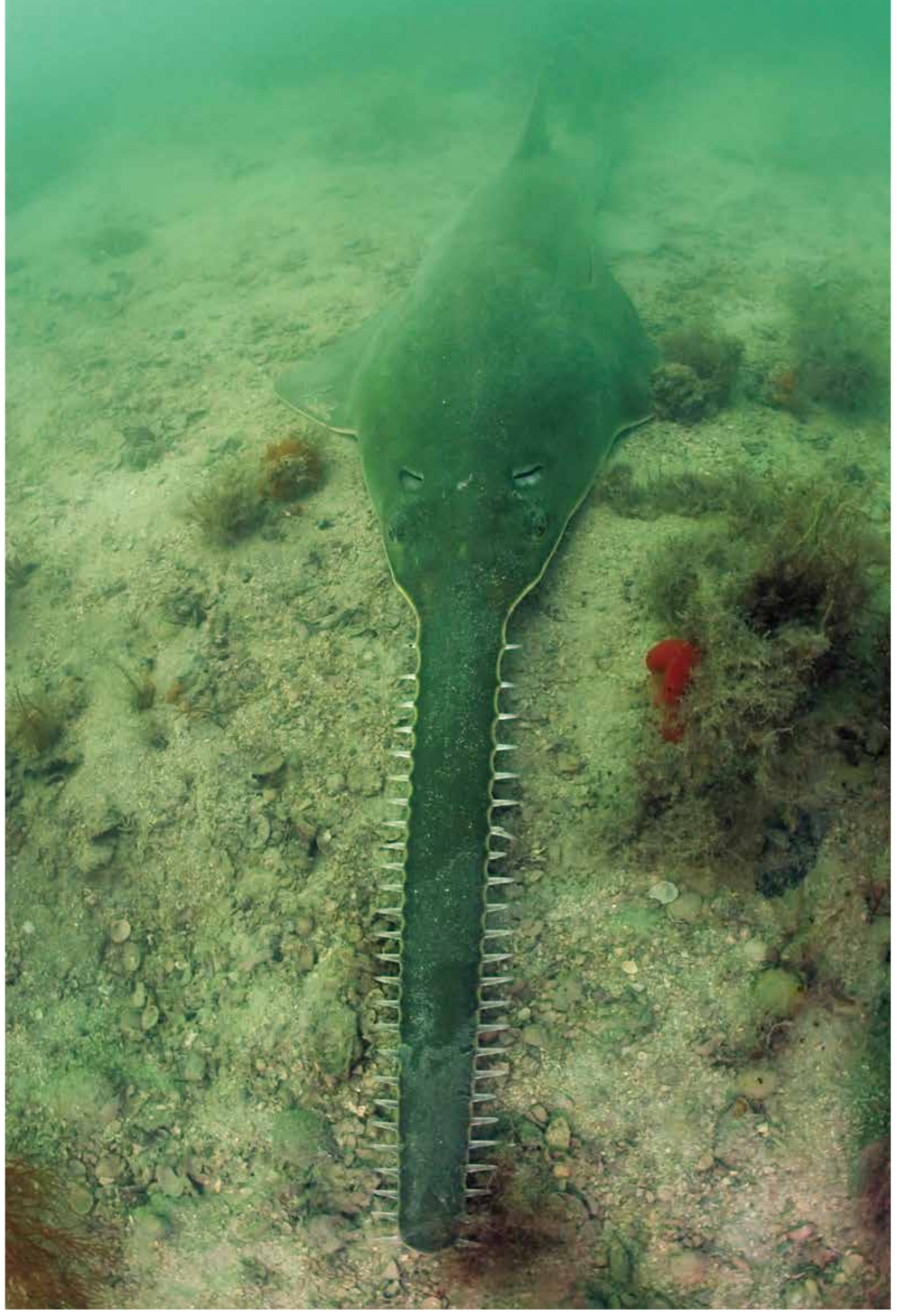
The whale shark is the largest known extant fish. On average, they reach 12 meters long and weigh up to 9 tons. Despite their gigantic size, they feed primarily on plankton captured by filtering huge amounts of water through their gills. They make long migrations following the coast line. In Mexico they can be easily observed in the Caribbean, especially in the Holbox and Mujeres islands, and in La Paz, Baja California Sur.

Cartilaginous fish, whose skeleton is made of cartilage instead of bone, includes highly specialized species with morphological and biological characteristics unique in the world. The oldest ones adapted to life on the floor of the oceans about 200 million years ago. There are at least 600 species of rays, of which most live in the sea, and about 100 inhabit Mexican waters. With their flattened shape, many of them inhabit the seabed and others swim (fly, you might say) in mid-water, where they catch the plankton they feed on.

One of the most spectacular groups of rays are the mantas and the so-called mobulas, which are the largest species in this group. The mantas can reach six meters from one fin tip to the other! In addition, they have the curious habit of jumping out of the water and doing all kinds of pirouettes in the air and in the water, although the reasons why they jump like this are not known precisely. Their value for ecotourism is incalculable. In addition, mantas have the largest brain in the fish world, with areas specialized in learning, problem solving and communication. The brain of a manta is ten times larger than that of a whale shark.

Unfortunately, as is the case with so many other marine species, the mantas are in danger of extinction. The sawfish, another very unique cartilaginous fish whose snout is covered by two series of elongated teeth, is about to disappear from Mexican waters. Fortunately, the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) includes mantas, mobulas and other rays in its appendices, providing them with a blanket of protection.

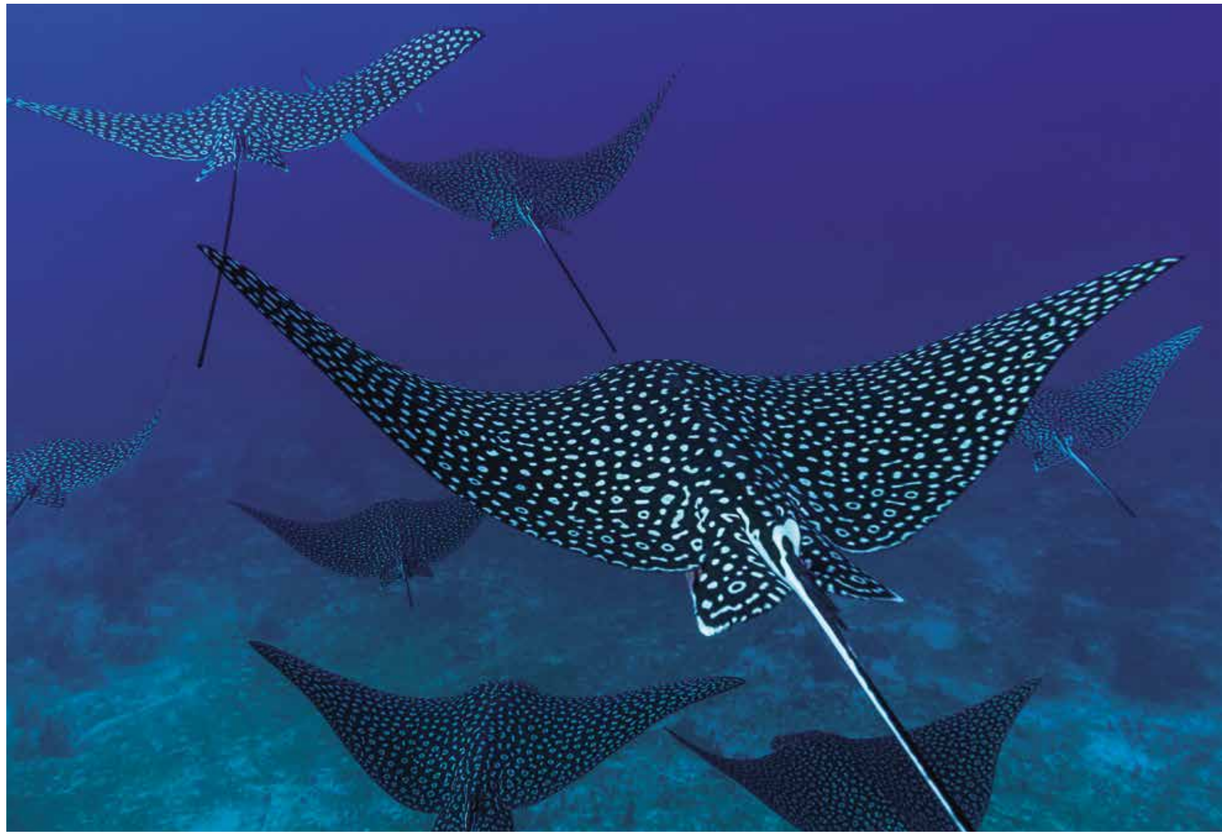
flying in the sea



ABOVE *It is common for the Mobula ray and other species to perform majestic leaps out of the water, which serve to eliminate parasites from the skin and, possibly, communicate with each other. When they fall into the water, they produce sounds that can be heard from many kilometers away.*

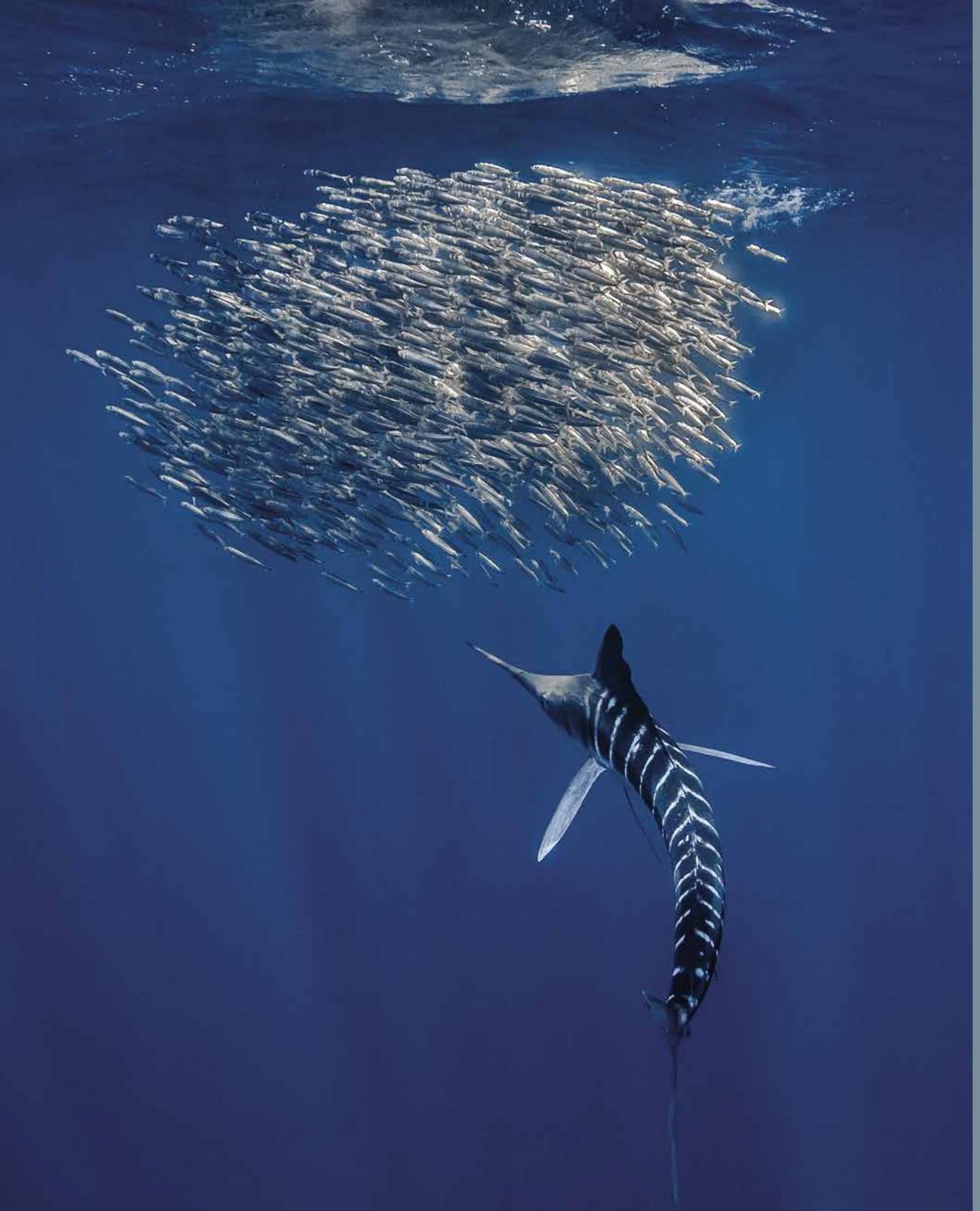
RIGHT *There are five species of sawfish that can be found in tropical seas around the world. They are characterized by an elongated snout with saw-shaped teeth and, like sharks and rays, have organs called the ampullae of Lorenzini that are sensitive to electricity and allow them to detect their hidden prey in the ground. They are seriously threatened for their indiscriminate capture.*

The difference between stingrays and manta rays is that the former have a poisonous sting in the tail which, among other things, makes them dangerous for human beings.



Rays and stingrays belong to the group of fish whose skeleton is formed by cartilage, which also includes sharks and sawfish (Chondrichthyes class). They have a flattened body and widened pectoral fins. Most species live on the seabed and feed on crustaceans, snails, clams, and even fish. Some species, such as the giant manta, live in open waters and feed on plankton.

It is common to observe remoras, which are also fish, attached to the giant mantas that serve as a means of transport. They are harmless to the species to which they adhere.



To comprehend what open waters are, one can suggest as a practical definition those waters that can be observed from the beach and extend beyond the horizon, more than 10 kilometers away from the coast. Their fish inhabitants are generally gray, either bright or opaque, enabling them to blend in with their surroundings. In these waters, fish species like the whale shark –the largest fish in the world reaching 12 meters long and weighting over 20 tons–, a great variety of other shark species that rarely approach the coast, or the great tunas that reach 3 meters in length and weight several hundred kilograms, are observed. These giants are powerful swimmers that carry out long migrations and go through prolonged life cycles, such as the swordfish, the marlin, and the dorado. Smaller individuals can form immense schools of fish at specific times of the year by following upwelling and temperature changes.

Schools of fish are a fundamental link in the marine food chain as they are the intermediaries between plankton and large predators like fish, dolphins, and sea birds. The largest fish in these waters, such as tunas and sharks, lack predators once they reach adulthood. However, in recent decades, their populations have been decimated by overfishing. It is estimated that, from all the large fish species that existed 50 years ago, only about 2% remain. For this reason, comprehending that open-ocean fish can cross borders between international waters and exclusive economic zones is crucial to create global strategies for their exploitation and conservation.

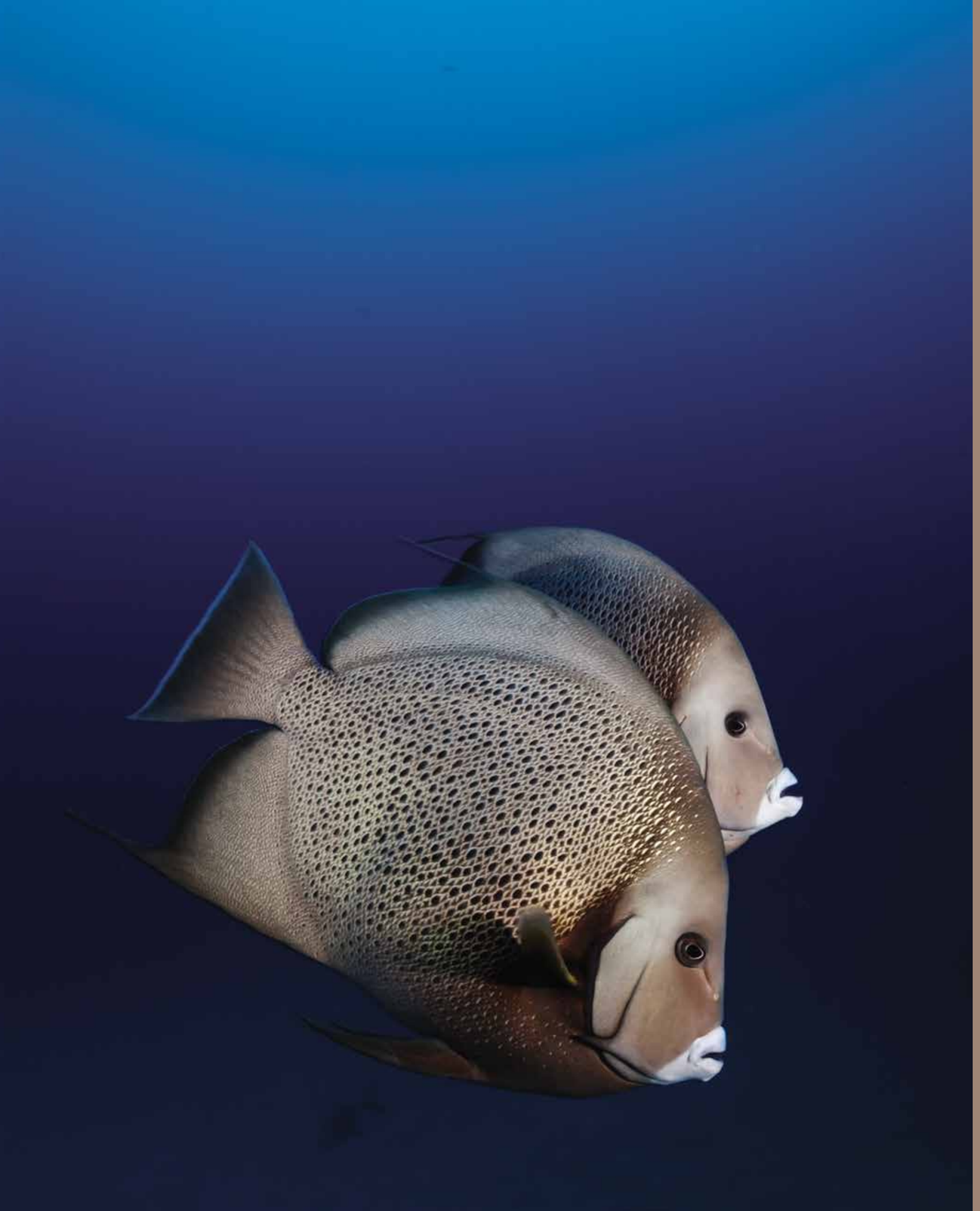
from open seas

The open waters –known as the pelagic zone of the ocean– have been classified according to the depth and presence of light. The photic zone, where light penetrates, extends from the surface to up to 200 meters deep. Pelagic fish have sober colors, such as gray and silver. Many of them form large schools that give them protection against predators.

The pelagic zone is the largest aquatic habitat, with an approximate volume of 1,347 million cubic kilometers.

Striped marlin (page 144) and sailfish (left) are part of a group of pelagic sea species that inhabit tropical and subtropical waters. They are characterized by presenting the upper part of the dorsal fin in the form of a sail and the upper jaw extremely prolonged, in the form of a beak. They use the beak in an extraordinary way to stun and kill their prey.

Tuna and related species are of great economic relevance for human consumption. Its extraction has gone up, and populations of some species are threatened. The majority of commercial tuna fishing happens in the Pacific Ocean, followed by the Indian Ocean, Atlantic Ocean, and the Mediterranean Sea.



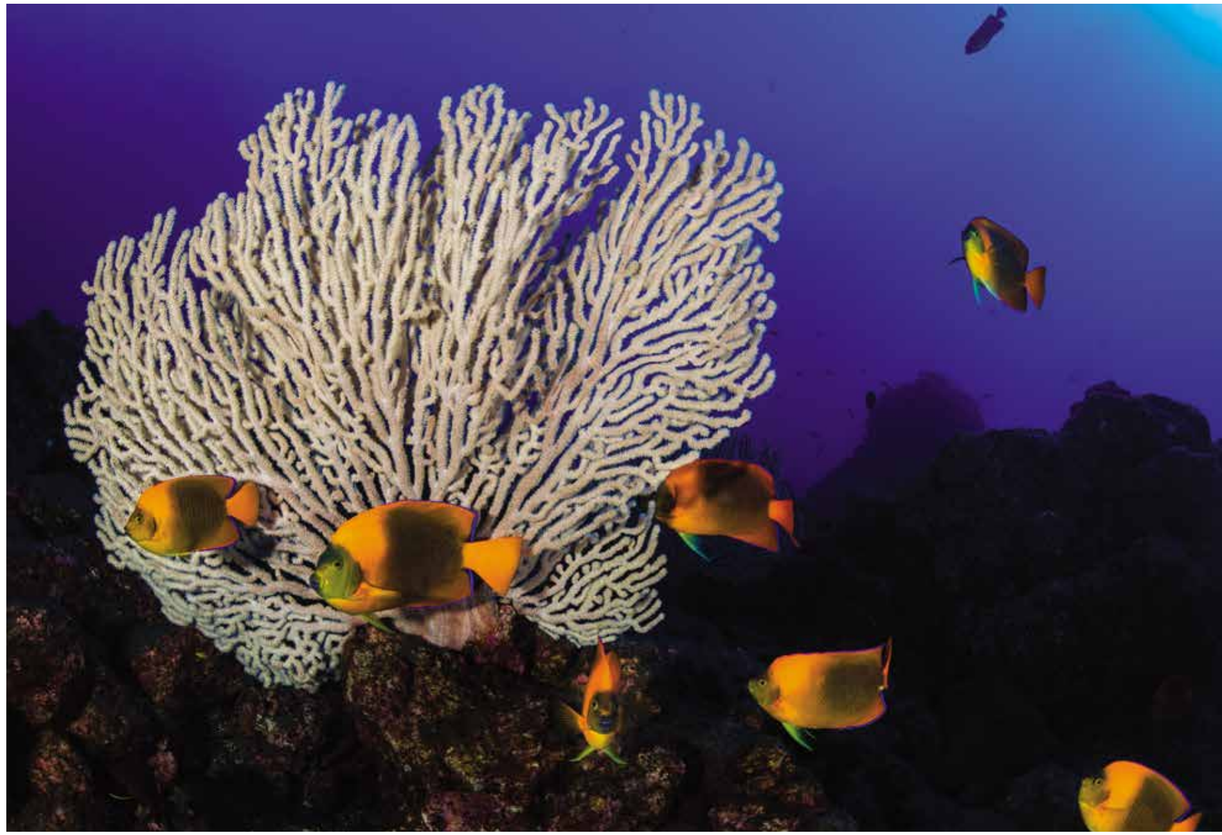
Fish have been associated to humans since ancient times. An essential symbol of the aquatic world, their features are present in Gods from different cultures and in extraordinary half woman-half animal mythological beings. Today, they are also present in our daily lives in forms of toys, as pets and, of course, as food.

The most common fish are those that inhabit coastal waters, caught by smaller vessels, and observed from a pier or boulder. There is a wide variety of species in coastal waters that are distinguished by their shapes, colors, common names, and by the season in which they appear. Names like sierra, liza, Pacific sardine, skipjack tuna, Pacific red snapper, bonito, coney, brown smooth-hound, ray, grouper, Gafftopsail catfish, cobia, blue butterfish and mojarra, among others, come to one's mind. Other species, usually excluded from our diet, inhabit rugged, rocky, or reef bottoms, habitats that make them harder to find. These fish species are rays, morays, lizardfishes, trumpetfish, scorpionfish, California sheephead, barracuda, surgeonfish, damselfish, stoplight parrotfish, butterflyfish, angelfish, grunts, boxfish, lined seahorse, squirrelfish, streaked prochilod, Atlantic pomfret, and many more.

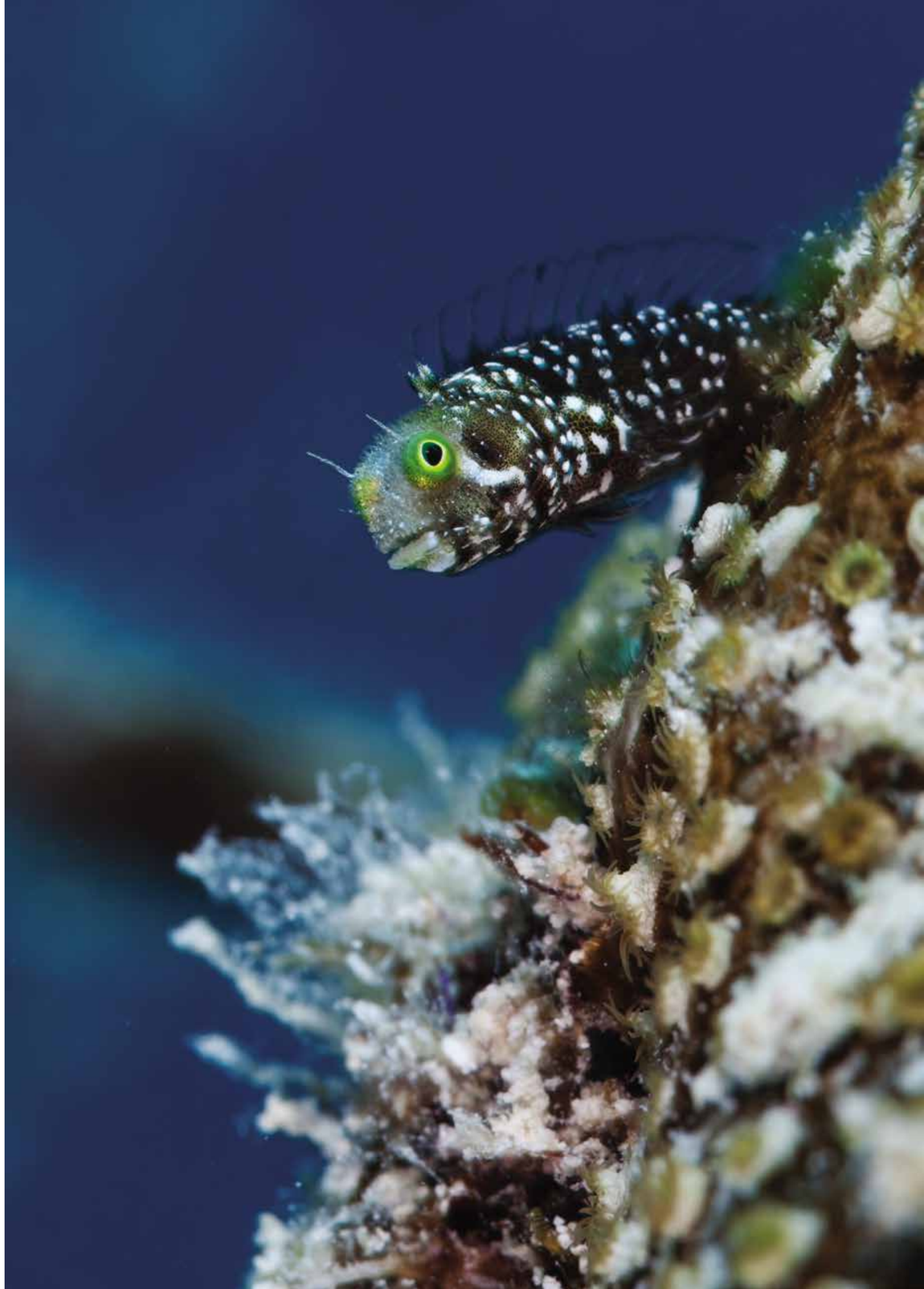
Hundreds of species inhabit our coastlines, each one of them taking advantage of the environment of their choice. Some of them form schools of thousands of individuals, while others have a solitary existence; some swim at high speed while others remain stationary in the same waters; some are buried in the sand and others become flyers that glide long distances over the surface of the sea. There are fish that release eggs in the water and fish that keep them and provide special parental care; some have thorns and large teeth, while others have smooth bodies and small mouths. They may possess the most astonishing colors or swim with a discreet yet elegant metallic gray shade. Fish, with their protective scales, fill our plates and our seas. But above all, they are a vital part of our environment.

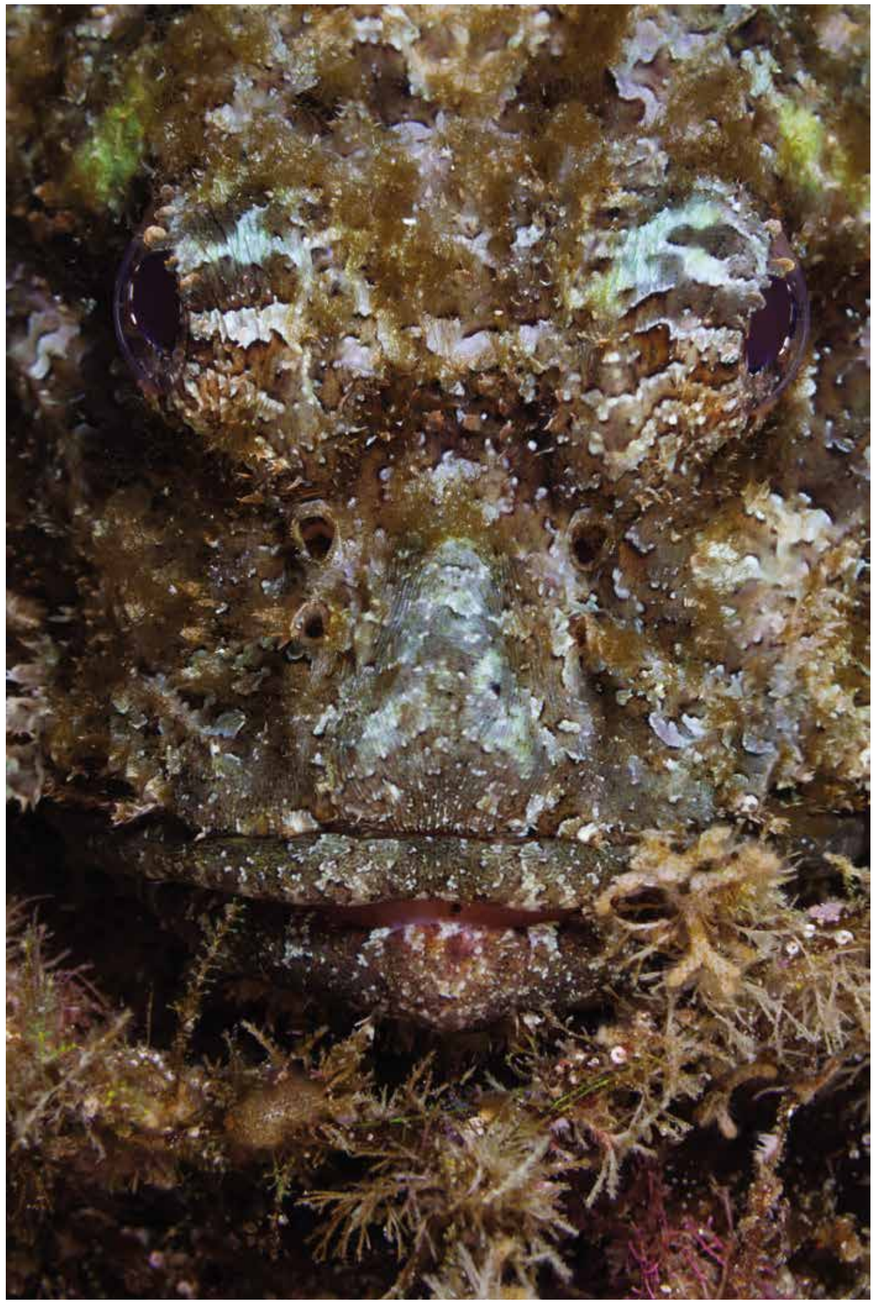
shining under the sea

Coastal fish inhabit a wide variety of environments in areas near the coast and on the continental shelf, an area that represents about 5% of the planet surface. They are the most diverse fish with thousands of species. Their color varies from very inconspicuous species that are confused with the seabed, to the most colorful ones.



Coral reefs are one of the ecosystems with the greatest diversity and abundance of species in the world. 25% of all the marine fish species fill the reefs with color and life.



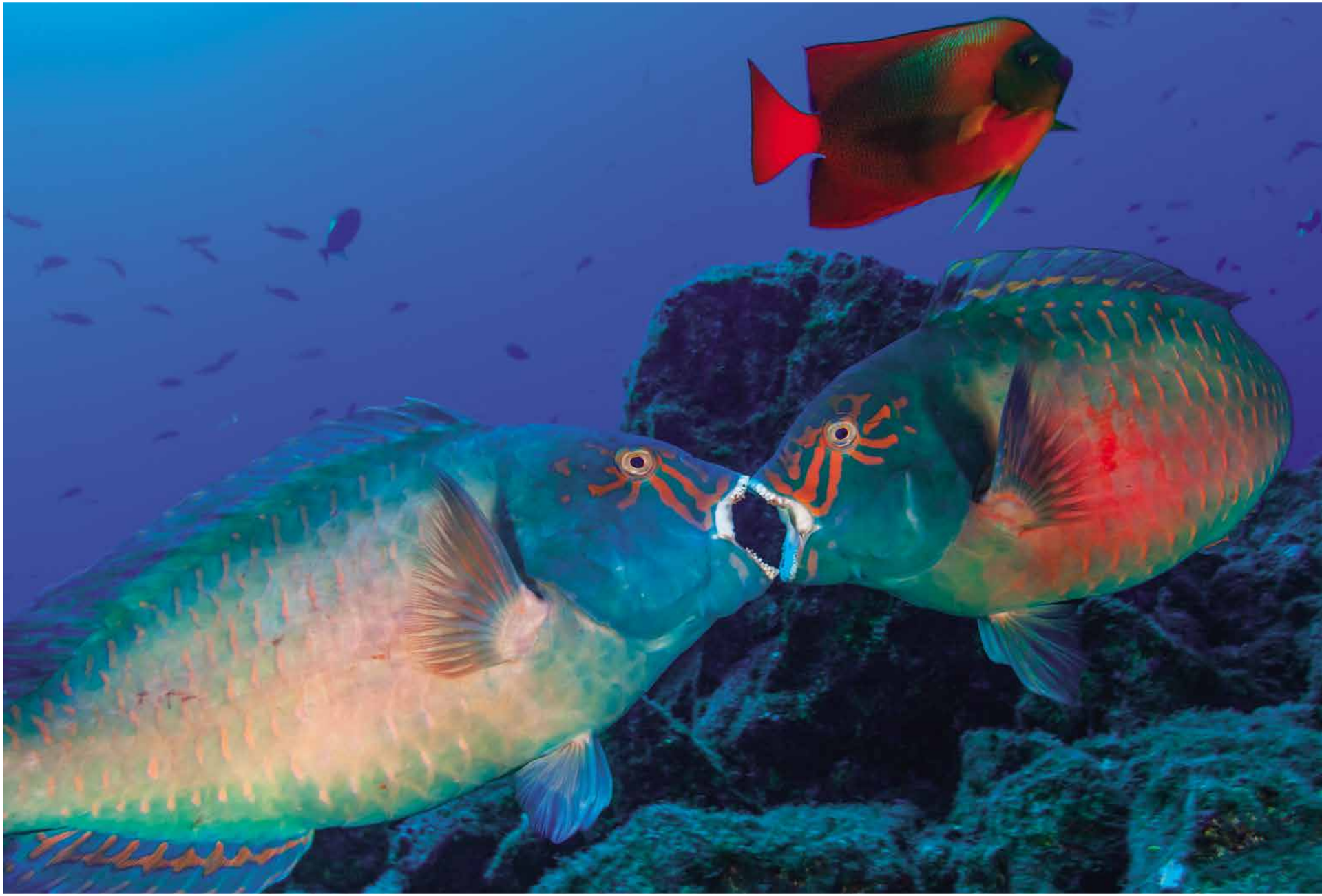


Some species of coastal fish, such as the stonefish (left) or the splendid toad fish endemic to Cozumel (above), camouflage themselves in an extraordinary way. These species of fish can be confused with rocks, corals, algae or sand.

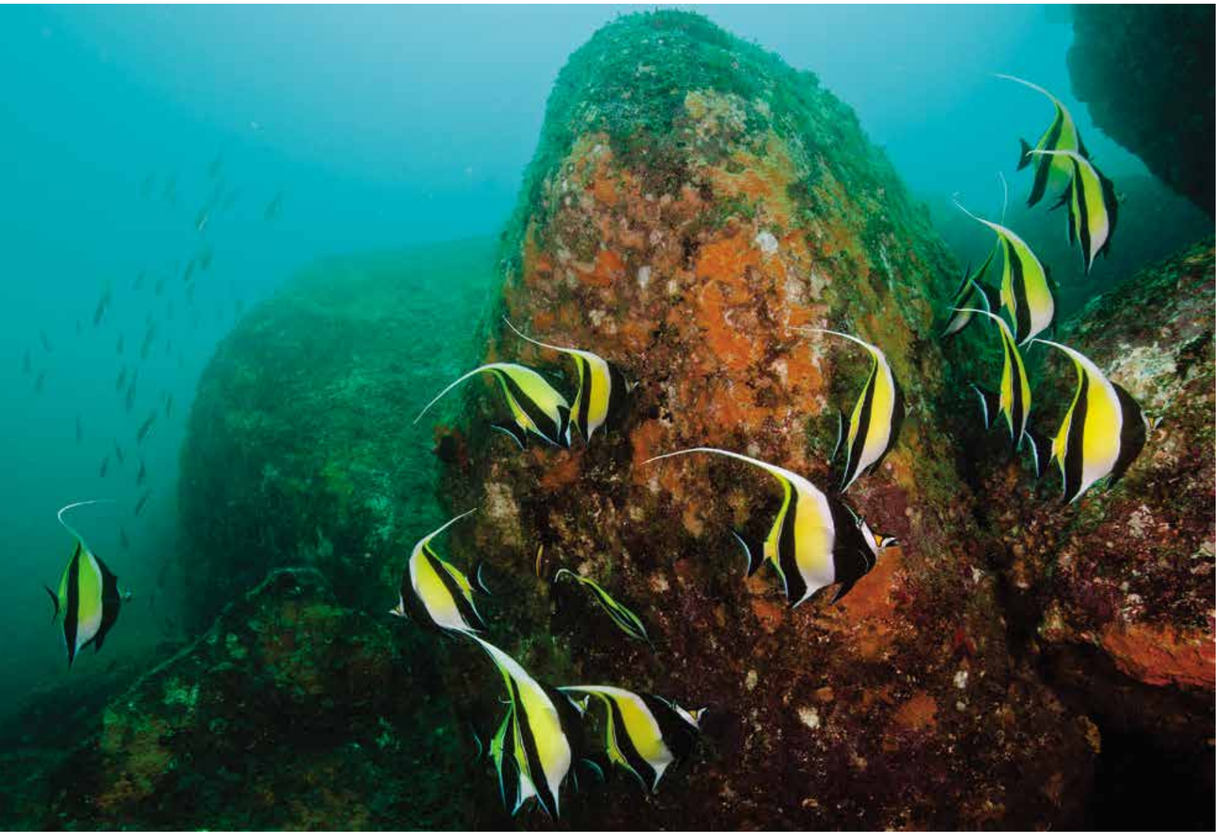
There are several species of fish known as cleaner fish that establish a mutually beneficial (mutualistic) relationship with other fish. Some, like the Graybar grunt, benefit from having their mouths, gills, and skin cleaned, while cleaner fish, such as butterflyfish, get their food.

The sea, the sea!
I feel it inside of me.
Just thinking
in him, so mine,
My thought tastes like salt.

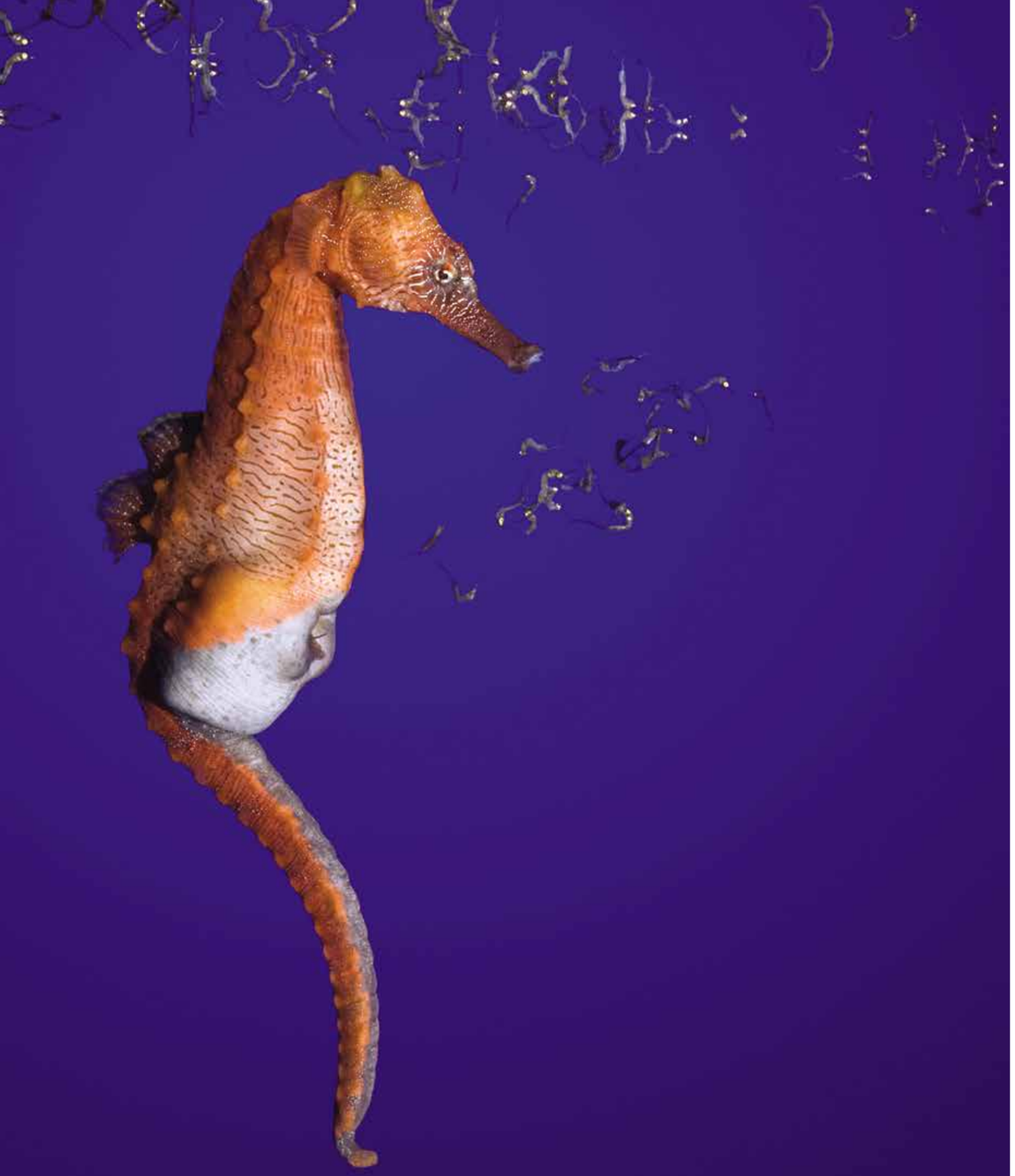
José Gorostiza



Different species of reef fish, such as parrotfish, establish territories to attract females during mating season. They defend their territories aggressively with their sharp teeth.



Between 18 and 30 million reef fish are sold annually for aquariums worldwide. Main exporting countries are the Philippines, Indonesia, Australia, Mexico, and Thailand. Characteristic species from this ecosystem are the clownfish, parrotfish, moray eels, seahorses, surgeon fish, and butterfly fish.



An interesting feature of some coral reef species and other coastal areas fish is that either males or females take care of the eggs and the young. In seahorses or hippocampus (left) the female deposits mature eggs in the male's pouch. The young develop there, protected from predators, and then disperse. In other cases, such as the goosefish (above), the male protects the eggs in his mouth for several weeks.

Groupers are large pelagic fish, with a very robust body, which can measure up to two and a half meters long and weigh up to 60 kilograms. In general, they are dark in color like the gulf grouper (right) although others like the red grouper (above) are more colorful. They are solitary organisms. Their populations have been decimated by overfishing.

Coral reef fish have an extraordinary variety of shapes, sizes, and colors. Some are very small, like the blennies and gobies that are unnoticed among the corals. Others, like soldierfish, take refuge in caves and hollows. Visiting a coral reef in good condition, such as those in Cozumel or Revillagigedo, allows the appreciation of unique life forms on the planet.

The moray eels are extraordinary inhabitants of the coral reefs. They are characterized by their elongated bodies that give them a snake-like appearance. They are excellent predators that find refuge in the hollows between corals. The largest ones, such as the Panamic green moray (left), are two meters long. Others like the zebra moray (above) are smaller and have a beautiful color.

Mangroves are ecosystems that thrive at the boundary between the land and the ocean water that shapes the coastlines. They are formed by trees that possess the unique and extraordinary ability to tolerate high levels of salinity found in seawater, a strategy accomplished through various mechanisms.

The arc-shaped aerial roots allow the Red mangrove to attach to muddy soils and breathe properly. The Black mangrove is characterized by the ability to expel the salt it absorbs from the water through the surface of its leaves. Also, similarly to the White mangrove, it has roots that develop noticeable knee-shaped roots from the ground, which allow them to breathe even if they are underwater. At the same time, the Button mangrove has salt-excreting glands located at the base of its leaves. Typically, these four mangroves, which are the most common in our country, can be found in different areas: the Red mangrove thrives deeper in the ocean than the other species; then, the Black and White mangroves grow in a more stable soil setting and expose their roots to the air during low tides; and finally, the Button mangrove creates the last transition to terrestrial habitats.

This forest stabilizes and protects the coastlines against erosion caused by tides, allows the recycling of large quantities of organic matter carried by rivers and streams, and provides nursery areas to innumerable bird species, such as pelicans, frigates, seagulls, and herons. They also provide habitat for reptiles such as crocodiles, iguanas, and snakes; and some mammals like raccoons and opossums. In the aquatic portions of mangroves, the roots create important microhabitats used by invertebrates and fish as breeding and refuge areas, representing a strategic area for numerous commercially important species that return to the open waters after spending their first life stages in the mangrove. Algae, clams, mussels, shrimps, and crabs grow on and between their roots. In Mexico, all mangrove species are protected by environmental laws and combined, they cover around 775,000 hectares on both coasts.

between land and sea

Mangroves are among the most productive habitats on the planet. They hold a large number of marine species that inhabit them to reproduce. Large schools of fish (right) attract many predators, including birds such as anhinga (above), the black skimmer (page 196), and white ibis (page 197) that use different techniques to capture them.

Fiddler crabs (page 198) inhabit coastal lagoons of brackish water. Males have a large major claw, which sometimes weighs half of their body weight. This claw is used to compete against other males in their characteristic courtship ritual.

The American flamingo (page 200) is a bird of pink coloration in adults and white in juveniles. The coloration is due to the intake of crustaceans with high carotenoid content. This species can reach a height of up to 1.4 meters and has a curved beak that allows it to filter its food from the mud. In Mexico, the American flamingo is distributed along the coast of the Yucatan Peninsula, in a set of wetlands that cover around 8,000 square kilometers, where the Celestún and Ría Lagartos Biosphere reserves are located. Ría Lagartos has the only reproductive population in the country.

Every individual matters,
Every individual has a role to play
Every individual makes a difference

Jane Goodall

In the Pacific Ocean of North America, from Alaska to the north of Baja California, a forest of brown algae, known as “kelp forest”, grows. An ecosystem that can be found in cold, shallow bodies of water distributed across the planet with temperatures below 15 °C. Algae attach to the substrate with the help of large discs from which long stems emerge, giving rise to ribbon-like sheets that range from 5 to 20 meters long. This forest is home to a unique diversity of wildlife species and provides multiple ecological services, that is, benefits that humans gain from the proper functioning of ecosystems.

Throughout their lives, these algae absorb large quantities of carbon dioxide dissolved in seawater, which originally comes from the atmosphere. All of this carbon is converted to biomass and contributes significantly to the fight against climate change. Armed with photosynthetic pigments that include chlorophyll and fucoxanthin (which gives them their brown color), they grow about 25 centimeters per day. Then, as their leaves come off, the nutrients are utilized by decomposing organisms such as crabs and shrimps. Algae are also preyed upon by sea urchins, abalone, and snails, which regulate their growth and regeneration and maintain a healthy forest. Together, these simple creatures are the base of complex trophic systems in which numerous species of mollusks, fish, and marine mammals participate.

Apart from being an important food source, kelp forests also represent the structure of this ecosystem where dozens of other species exist. Here, dominant carnivores such as sea otters, spiny lobsters, and a fish known as the California sheephead find food and shelter. The presence of archaeological remains from early stages of the American colonization, from around 13,000 years ago, suggests that human groups that once settled along the coasts of California and Baja California relied on the high productivity of kelp forests to survive.

of giant algae

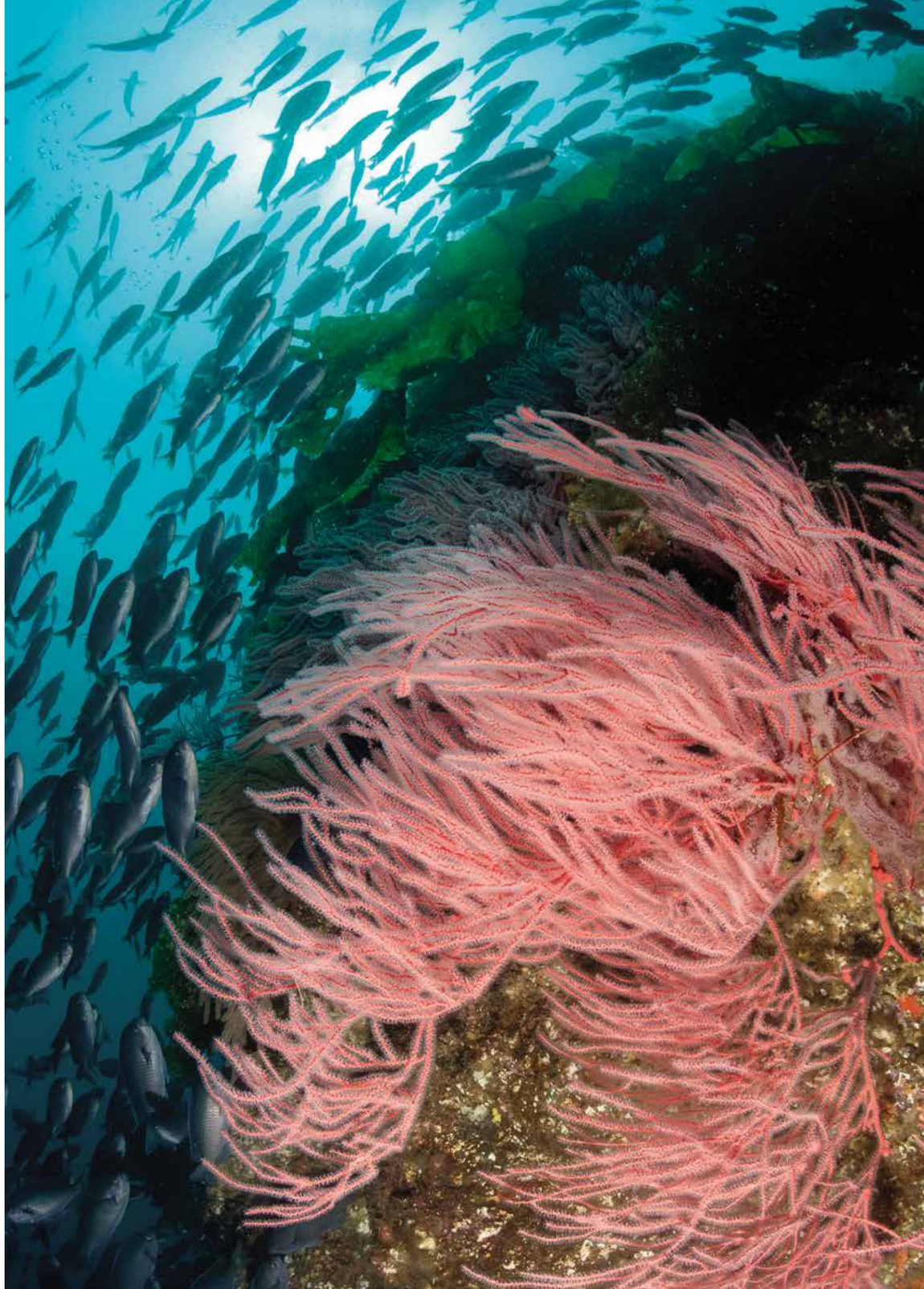
Among algae, corals, seagrasses, invertebrates, and fish, the seas acquire captivating shades. In addition to delighting the human eye, kelp forests have great economic importance. More than 4,000 tons are harvested annually to extract alginates and emulsifiers used in toothpastes and cosmetics.

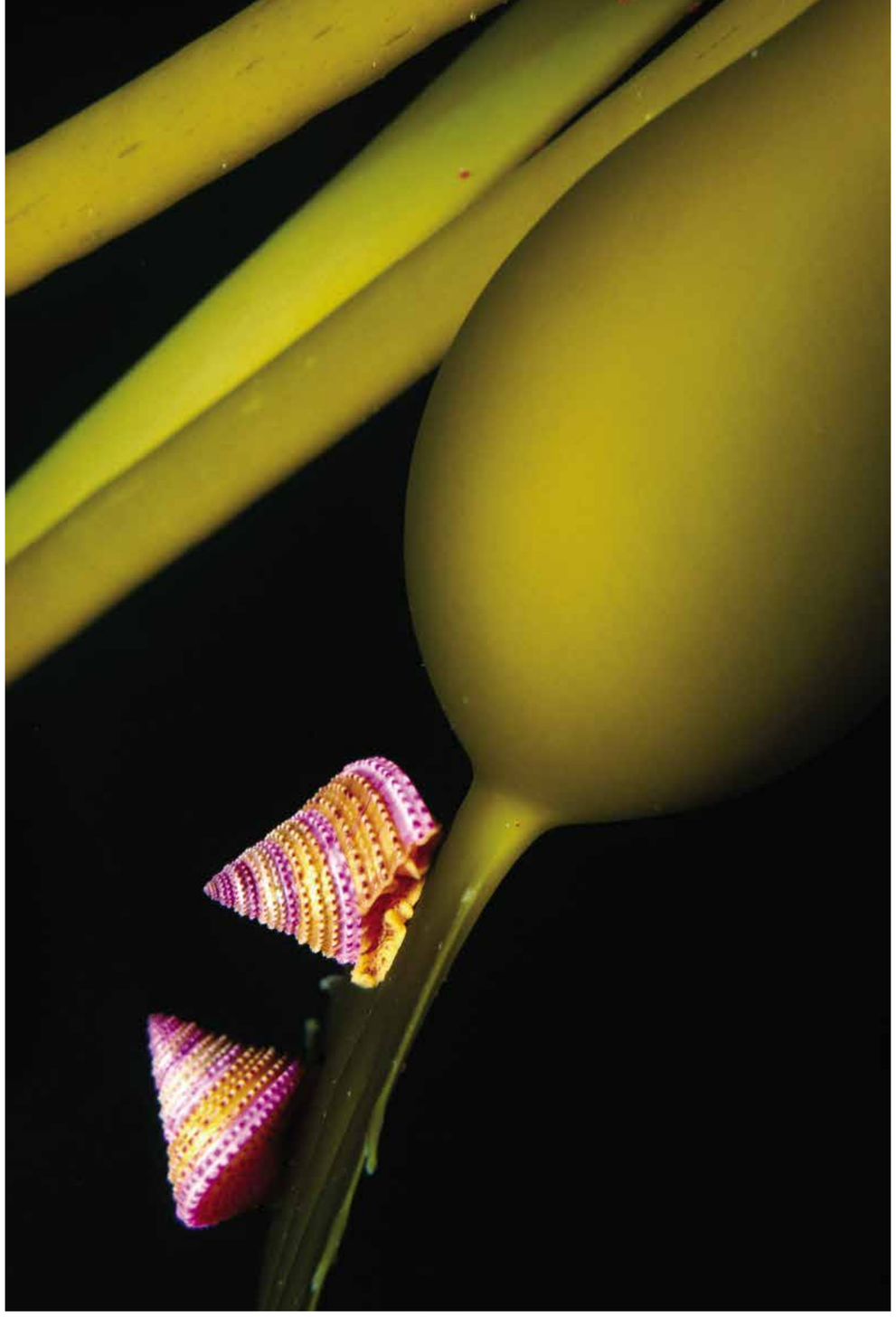
Not only invertebrates and organisms of fishing importance, such as lobsters, feed and refuge in algae forests. Marine mammals like seals are frequent visitors of these underwater paradises.

Before the dream (or terror) had begun to glean
its web of myth and cosmogony,
before time had settled into days,
the Sea –the ever Sea– existed and had been.

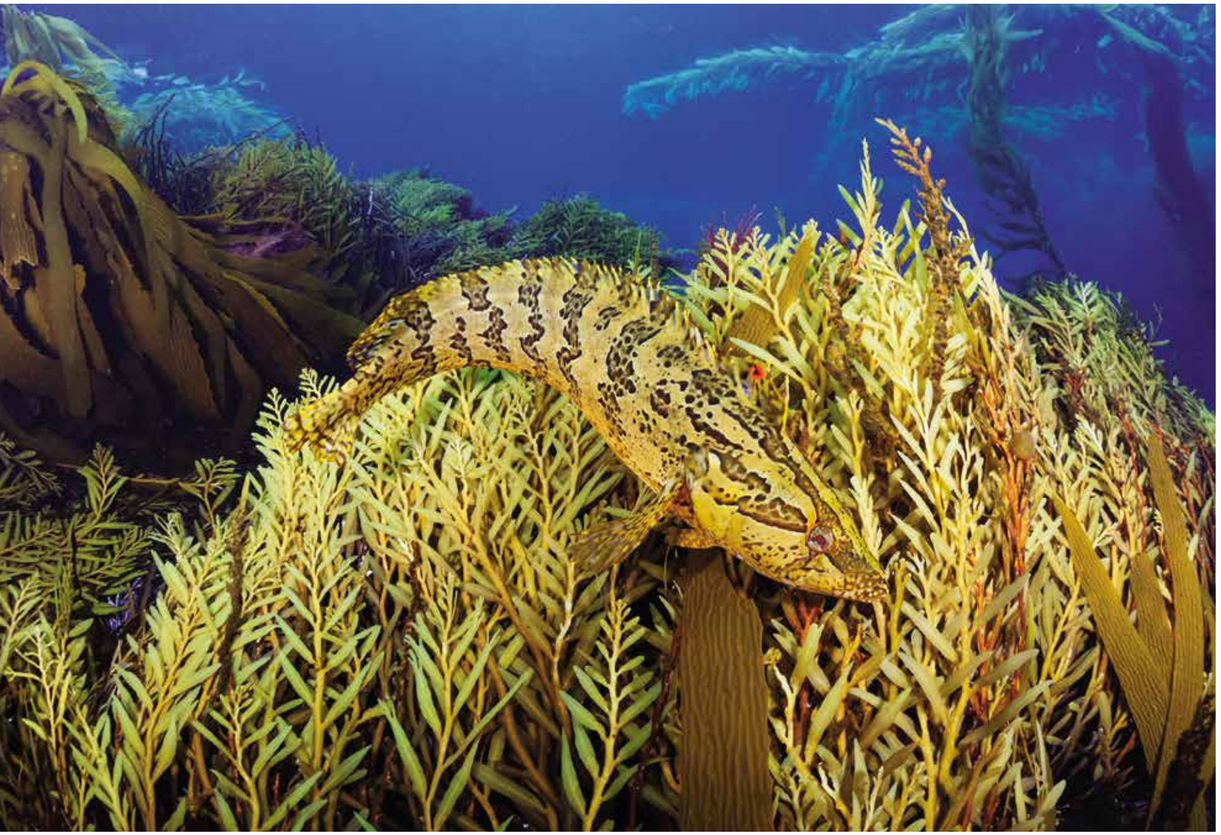
Jorge Luis Borges

Algae forests have been studied due to the complexity of their trophic networks. Algae function as producers for many organisms such as sea urchins. When consumed by carnivores –such as sea otters– sea urchins are kept in balance. Human impact on sea otter populations has caused an uncontrolled increase in sea urchins, which in turn consume unlimited algae. Currently, the recovery of sea otters is helping to control these organisms again.





Animals of all sizes feed on algae, such as the purple snail (right) that measures between 15 and 35 millimeters.



The kelpfish (above) is a species that can be found hidden between the giant kelp and seaweed, main algae of the kelp forests.

The ocean sunfish (right) is the heaviest bony fish in the world. It can measure over three meters long and exceed two tons in weight. It feeds on large quantities of jellyfish and is a frequent visitor of the kelp forests, where other fish remove their external parasites. They are highly valued in the eastern market and recognized for approaching the surface of the water to "sunbathe."

The abyssal zone is found at depths below 2,000 meters, where the temperature of the water reaches under 4 °C. To thrive in this dark environment, life forms depend on the remains that fall from the upper layers and, in the case of hydrothermal vents, on the chemosynthesis that replaces photosynthesis, in which bacteria convert inorganic compounds into organic ones, establishing the first link of the food chain.

Despite being the largest environment on the entire planet, the abyssal zone is one of the most enigmatic and unknown ecosystems. The strange-looking fauna survives without light, at high pressures –up to 600 atmospheres–, and low oxygen levels. Many of these creatures can produce their own light through oxidizing compounds known as luciferins. This bioluminescence allows them to startle predators and attract prey. Despite these apparently adverse conditions, many species of corals, hydrozoans, squids, jellyfish, snails, octopus, ctenophores, amphipods, shrimp, crabs, worms, and fish live in the abyssal depths.

Hydrothermal vents or smokestacks are cracks that lie at the bottom of the ocean where very hot water flows due to the presence of magma. They are generally located where tectonic plates meet as a result of geothermal processes. In Mexico, hydrothermal vents can be found in the Gulf of California and the Guaymas Basin located at depths of 2,000 meters and temperatures between 12 °C and 300 °C. They are highly localized environments that have a surprising diversity of organisms including tube worms, clams, and crabs. This fauna depends on bacteria that feed on the compounds released from hydrothermal chimneys such as carbonates, metal sulfides, and silica minerals.

from the deepest darkness

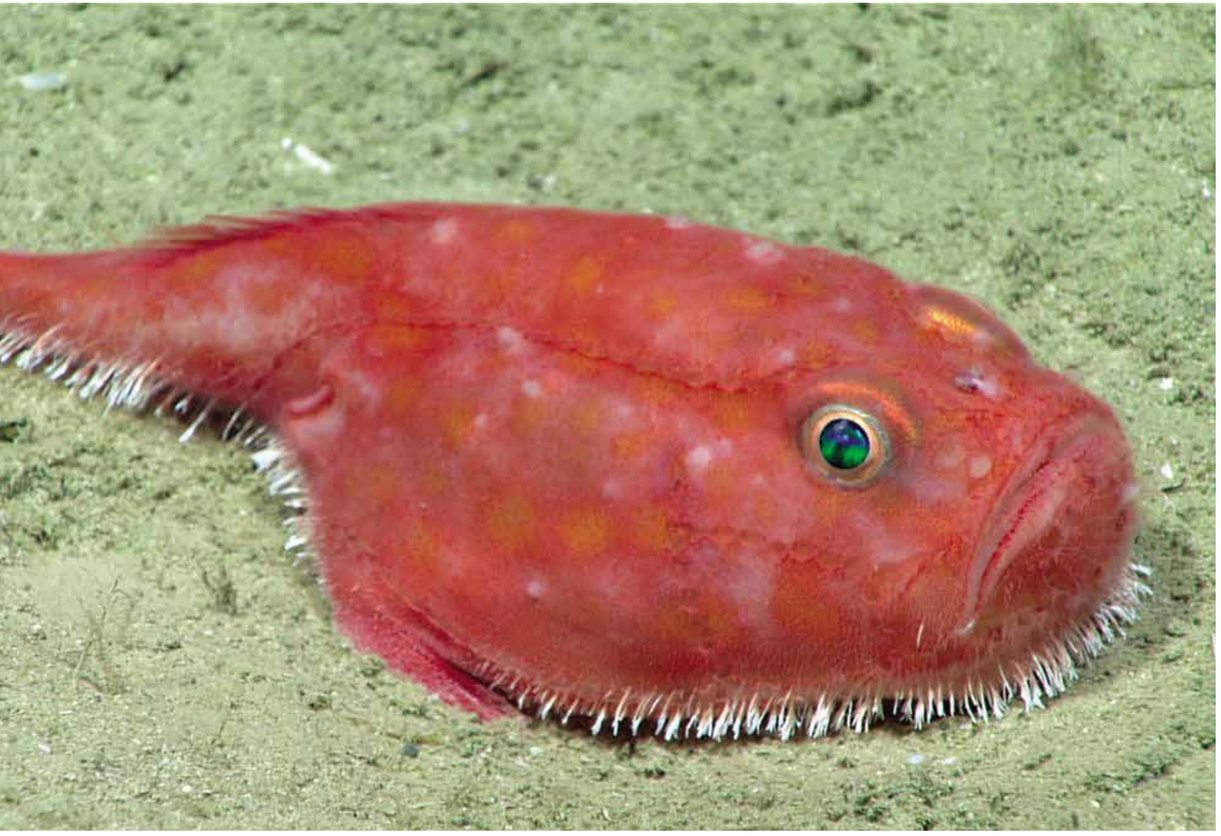
Despite the harsh conditions of the deep sea, there is no impediment to life and its diversity of forms. The deep gelatinous squid (above), when feeling threatened, introduces the head and tentacles inside its body and swells into a ball, making it difficult for its predators to eat it. The humpback anglerfish or humpback black devil (right), which lives at depths between three and four thousand meters, has a type of bioluminescent antenna to attract prey.

We know less about the ocean's bottom than about the moon's back side.

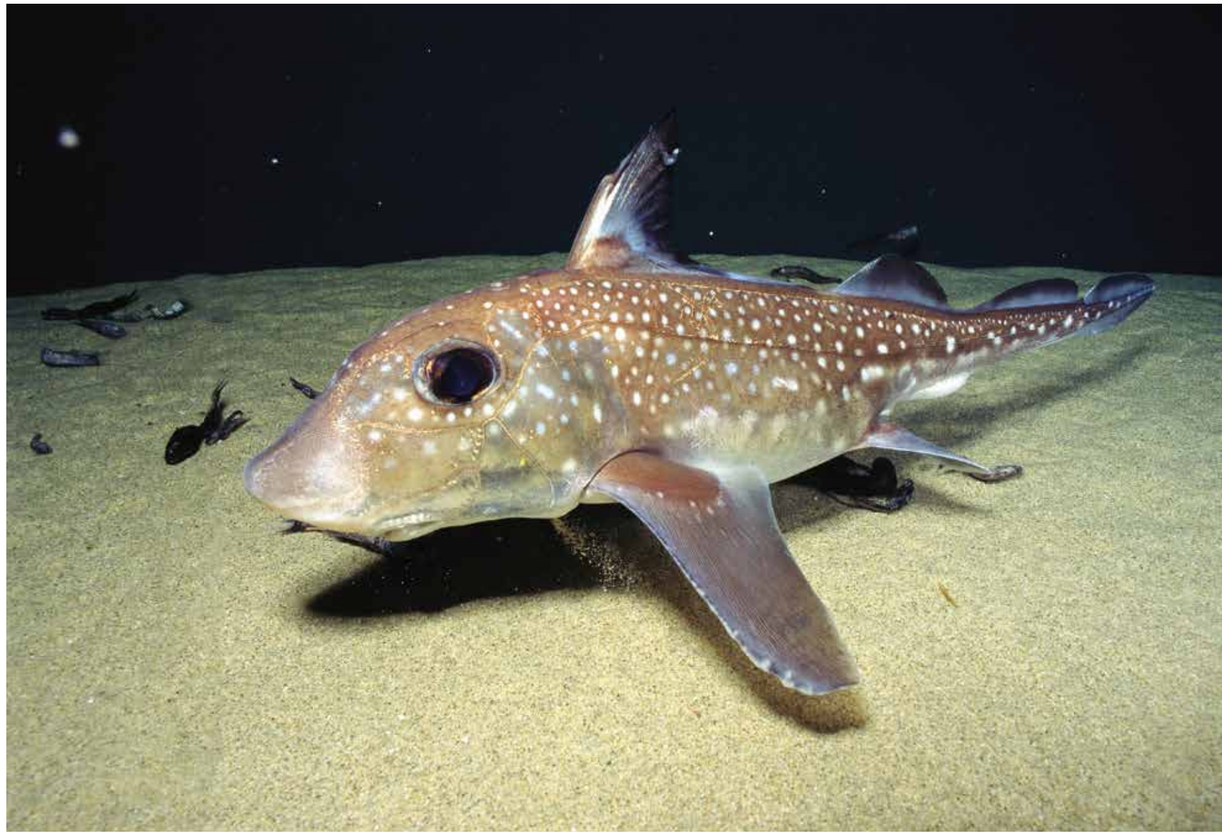
Roger Revelle

Abyssal animals seem to emerge from a horror story. They have soft bodies, big mouths, and some like giant amphipods, are translucent.

Outside the human sight, beyond 1,000 meters deep, the abyssal zone has neither light nor heat, and its inhabitants must have bodies adapted to extreme conditions. This deep-sea fish has a bioluminescent structure to attract its prey. In addition, it has structures called photophores that produce red light and help to see potential prey of that color, such as prawns.



The sea hides wonderful and strange treasures. Some species resemble toads more than fish.

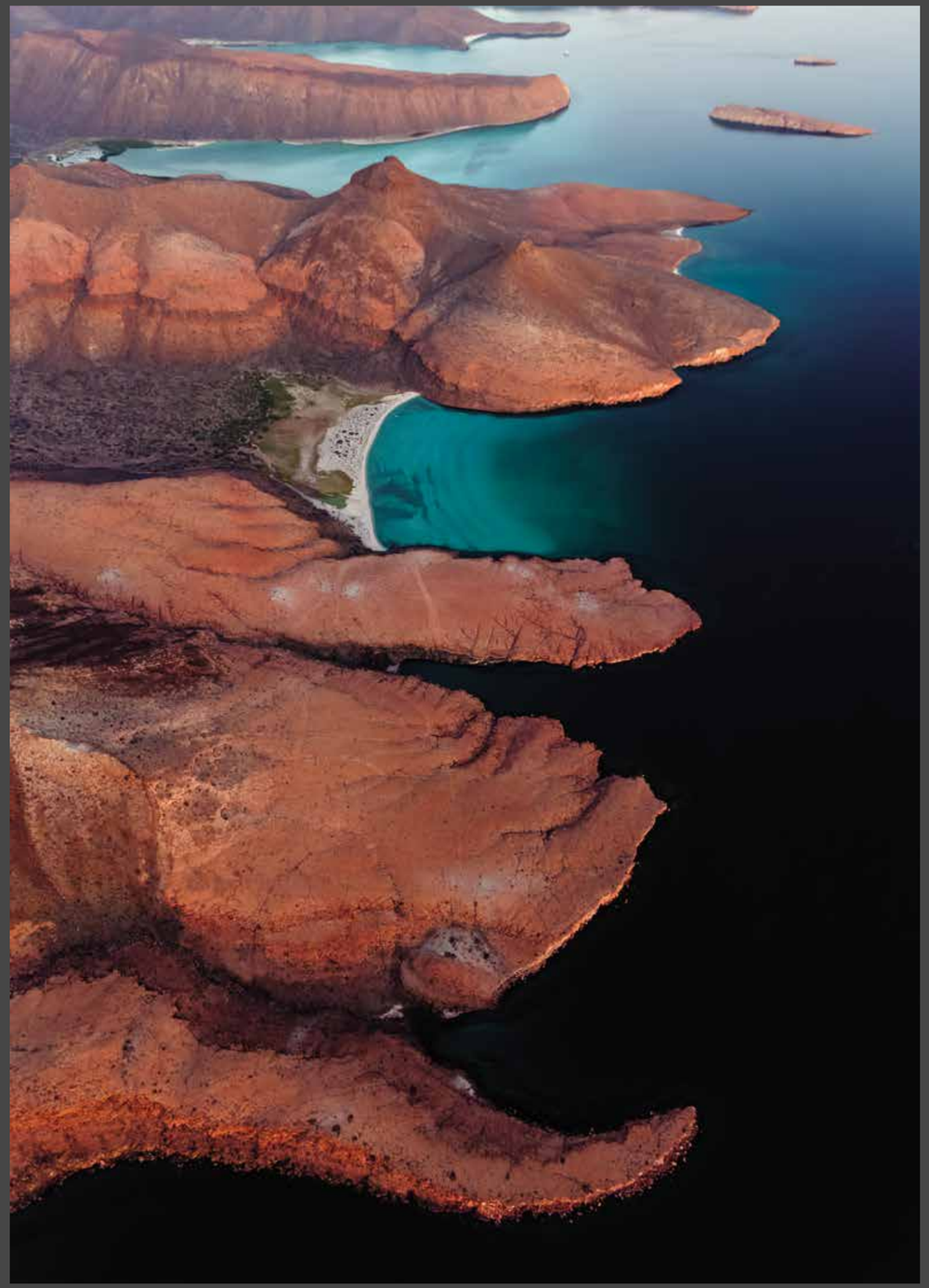


The spotted ratfish is a member of the chimaera group. It inhabits between 300 and 400 meters deep and is characterized by the presence of a toxic dorsal spine. This species is closely related to sharks.

The snipe eel, although it seems to have a beak like birds, is a fish related to eels. This beak is present in females, while males lose it when they mature. Both have sharp teeth to hunt crustaceans.

Most fish perceive light with their eyes, although many abyssal fish lack them. The telescope fish, with its impressive cloudy eyes, has an extraordinary view that allows it to track bioluminescent preys in the depth. To avoid being discovered with the remains of bright preys in the stomach, it possesses a black tissue that prevents it from becoming transparent.

Marine hydrothermal vents were discovered in 1977 aboard a submarine at a depth of 2,400 meters in the Pacific Ocean. These are fissures in the seabed surface from which geothermal water flows at temperatures up to 400 °C. They are commonly found in volcanically-active places where magma is near the surface. Water flowing from the hydrothermal sources of the ocean floor consists mainly of seawater and magmatic water released by the rise of magma. Some hydrothermal vents form almost cylindrical chimneys up to 60 meters high.



Espíritu Santo Island, Archipelago Espíritu Santo National Park, Baja California Sur.

Gerardo Ceballos

CONSERVATION AND AN UNCERTAIN FUTURE

The Pacific Ocean overflowed the map.
There was no place to put it.
It was so big, unruly and blue,
that it did not fit anywhere.
That is why they left it in front of my window.
Pablo Neruda

I still remember the first time I saw and touched the sea. I was a little boy, fascinated by walking on a beach with my feet sinking slightly in the sand and hearing the menacing roar of the waves. Many years later I explored part of the Gulf of California on a small cruise ship with the goals to look for marine fauna, including mammals, and to marvel at the extremely scenic beauty of this region. The ship departed from La Paz in the afternoon and passed by Isla Espíritu Santo with its abundance of sea lions, just before sunset. For eight days, we explore islands, bays, and the sea and observed sea lions, dolphins, and several species of whales, including a blue whale, the largest animal that has ever existed. Like many others who have an opportunity to travel on the seas, this trip nourished my appreciation and awe this vast liquid universe which hides countless mysteries. Perhaps our sense of astonishment and wonder about the sea lies in the fact that every human (and all life forms) has a very distant connection with the marine world through the origins and evolution of life and its emergence from this watery world, the oceans. The similarity of salt concentration in human blood and the marine environment is a reminder of the close unity between humans and this remarkable and mysterious world.

My experiences with the sea as a child and adult have helped me to appreciate the role of oceans as fundamental ecosystems that maintain the conditions that make life on Earth possible and to understand that they are threatened by our (human) activities. The threats to our oceans are so severe that collectively, we as the human community, have only two or three decades to avert a possible environmental collapse which will likely have serious consequences for life on Earth in general and for humans, in particular. Our collective actions or inactions in addressing these threats and the outcome they engender will be inscribed in the history of humanity.

An unknown world

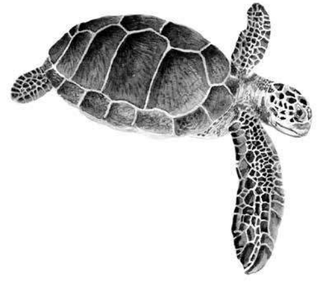
The seas and oceans cover about 70% of the Earth's surface and are hold estimated 1,347 million (or 1.347 billion) cubic kilometers of water. To put this number in perspective, a cubic kilometer of water contains billion liters. Despite the long history of human activities involving the seas and oceans, relatively little is known about them. Surprisingly, the topography of the surface of Mars is better known than that of the ocean floor, even though for decades before the first spacecraft explored the Red Planet, many efforts were undertaken to explore the ocean to describe and understand their physical and chemical properties and dynamics and to identify the multitude of life forms they harbor. For example, the American naturalist and marine explorer William Beebe used a bathysphere in the 1930s to observe deep-sea animals in their native environment. Marine biologist and explorer Sylvia Earle asked NASA officials why they were more interested in space than the ocean, to which they answered, "Because the sky and the stars are above; while the deep darkness is below." In a curious twist in the trail of human efforts to understand the world around us and on which our lives depend, the oceans are one of the last frontiers to explore.

Most of the species living on our planet, especially marine organisms, have not been described yet. The scientific description of a species involves collecting specimens, determining if it is different from other known species, placing the specimen in a reference collection, and assigning it a scientific name. By convention, the scientific name is binomial (consisting of two names), uses Latin even though its meaning may be derived from other languages, and consists of the name of the genus and the epithet of the species. For example, the scientific name of the vaquita, *Phocoena sinus*, is derived from the Latin *Phocoena*, meaning porpoise, and *sinus*, meaning cavity, a reference to the Gulf of California. Translated literally, the name refers to the porpoise of the Gulf of California.

The species classification system dates back to 1758 when it was proposed by the Swedish naturalist Carl von Linné in his seminal work, *Systema Naturae*. Over the course of two and a half centuries, taxonomists, biologists who specialize in the identification of flora and fauna specimens, have classified and assigned scientific names to an estimated 2.2 million species. Until almost a decade ago, the total number of species in the world was estimated to be about 50 million. However, estimations based on recent work peg this number, which includes microorganisms, as high as 24 billion! Considering this immensely larger number, it is very possible that humans will never identify all the species that share this blue planet with us.

The discovery, identification and description of new species is an ongoing process. In 2007 alone, more than 18,000 species, from microscopic organisms to primates and dolphins, were described. The feeling of finding a new species is difficult to describe: a mixture of enormous satisfaction, stupefaction, and euphoria. In a way, it is the coronation of the work efforts of many years, which is why I can imagine the joy of colleagues who have made remarkable discoveries recently.

In 2010, during an expedition to study sperm whales in the Gulf of Mexico, researchers from the University of Tulane in the United States accidentally found the 14-centimeter-long pocket shark in the waters off Mexico. This species, which lives at depths of 100 to 2,000 meters in permanent darkness, is black and therefore cannot be seen from above. However, it secretes a glowing fluid from small glands located on its underside near the pectoral fins; this secretion may help attract prey. A member of the team that discovered this new species stated, "I hope we have time to continue discovering the countless species and treasures that nature has for us, instead of continuing with their obsessive predation." This newly discovered shark is only the second known species of this very rare group. The other member was discovered in the waters off Chile in 1979, 31 years earlier.



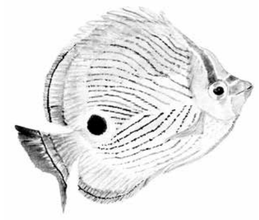
A very important discovery of Mexico's marine biodiversity heritage was made in July of 2019. Researchers from the Veracruz Autonomous University and the Technological Institute of Boca del Río, with support from the Mexican Center for Environmental Law and fishermen in the region, discovered eight new reefs; the coral reefs are named Corazones, Oro Verde, Pantepec Norte, Pantepec Sur, Blake, and Piedras Altas, and the two non-coral reefs are called Camaronera and Los Gallos. Combined, they cover an area more than seven square kilometers along a corridor that extends 500 kilometers from the Tamiahua Lagoon to the mouth of the Papaloapan River. Corazones, the northernmost reef in the Gulf of Mexico, is five kilometers long and 700 meters wide. Like other ecosystems in the Gulf of Mexico, these newly discovered reefs face multiple threats, such as oil exploitation in the region, and urgently need protection.

Threats to marine life

What other wonders may be hidden in the oceans of Mexico and the world? What will happen to these ecosystems and species under siege from our activities? Some time ago, with the collaboration of a couple of colleagues, I described this situation as follows: "Humanity has unleashed a massive and progressive attack against all living beings on this planet… The roots of this destruction have an ancient origin… However, today, our collective attack on animals, plants, and microorganisms has reached such horrendous levels that any alert we emit will be too tenuous to match the tragedy that is unfolding. The alarm must be amplified." One way to amplify the alarm for the urgent and immediate need to address the serious environmental challenges that confronts our well-being is to communicate to the community at large the need to take corrective action and the strategies to ensure the paths forward are environmentally sustainable.

The planet's oceans face serious stressors that threaten their physical and chemical properties, biodiversity, structure, and function. Climate change, overfishing, and pollution are some of the problems described in Chapter Two of this book. Alterations and changes caused by human activities are very complex and, in many cases, have unknown implications. For instance, climate change is causing the melting of the polar ice caps, which results in the rise of sea levels, changes in salinity, and alterations of ocean currents. The increase in sea temperature is causing, among several things, mass coral bleaching events which can lead to the disappearance of this ecosystem in many regions of the world in the next decade or two. Similarly, much of the carbon dioxide and other gasses from the burning of fossil fuel that are released into the atmosphere are eventually absorbed by the oceans, resulting in increased acidification of the water. This change in water chemistry decreases the availability of calcium in the sea, which, in turn, increases the mortality of organisms that need it to build their exoskeletons, such as coral, oysters and crabs.

Discharge from large rivers into the Gulf of Mexico and the Atlantic Ocean, such as the Mississippi River in the United States and the Amazon River in Brazil, contain large amounts of sediment and nutrients. Combined with increased in sea surface temperature caused by climate change, this large-scale pollution has stimulated the growth of huge swaths of sargassum, a floating seaweed that blocks sunlight from penetrating the surface and thereby affecting the photosynthetic zooxanthellae algae found in corals. This massive "sea" of sargassum, which at times has stretched for two thousand kilometers in the Atlantic Ocean between the United States and Brazil, has already affected the beaches of Quintana Roo in Mexico and those of the Caribbean islands. During the first months of 2019, an estimated 30% of coral reefs in Quintana Roo have died or showed signs of weakening as a result of sargassum and global warming.



Plastics are ubiquitous in modern society, and their proliferation has had and will continue to have, dramatic deleterious impacts on the ocean. Every year, seven million tons of plastic accumulate in the oceans. There are currently five gigantic "plastic" islands in both the Pacific and the Atlantic. One of these accumulations or gyres, called the Great Pacific Garbage Patch, lies between the coasts of Baja California and Hawaii and extends over 1.6 million square kilometers, equivalent to 70% of the territory of Mexico or three times the territory of France. Initially, most plastics float on the surface and in the uppermost five meters deep, and eventually some will descend throughout the water column and settle on the seabed. Eventually, the plastic breaks down into microparticles which ingested by zooplankton where they are passed up the food chain to the top predators, including humans. The health risks of these microplastics to the links in the food chain and to humans are not yet understood. These plastics often have other insidious effects on sea birds, marine mammals and sea turtles. Often mistaken for food, they are ingested and frequently cause the death of the animal by starvation or blockage of the digestive tract. Lately, the news media coverage showing images of dead baby albatrosses and whales with large amounts of plastic in their stomachs, has helped to publicize this serious environmental threat and galvanize efforts to address the issue of plastic pollution.

Although the complexity, number and scale of the threats to the oceans seems overwhelming and perhaps impossible to address because of the absence of effective technology and policy directives, it is imperative to not only prevent a further deterioration of them, but a determined effort must be employed to clean up and to help restore the health of the oceans on which our future depends. Actions such as mitigating climate change, preventing pollution, reducing overexploitation and illegal trafficking of species, and establishing reserves to protect ecosystems are essential for the protection and conservation of the oceans.

On the verge of extinction

In the 1940s, Nobel Laureate writer John Steinbeck published his novel *Cannery Row* which contextualized the town of Monterey, a commercial fishing hub located on the central coast of California which had a robust economy based on the sardine fishery that started established at the beginning of the twentieth century. The schools of sardines, fed by the rich cold waters that emerged from the Pacific, seemed endless. As the world's most successful fishing industry at the time, more than two million cans of sardines were processed annually at its peak production. Sometime shortly after World War II, the schools of sardines abruptly disappeared and the fishery industry collapsed, a victim of indiscriminate fishing practices.

The lessons of the collapse of the Monterey fishery has done little to change destructive patterns. Today, most of the world's fisheries are being exploited at the highest possible level and more than 30% have already collapsed. Fish, shrimp, lobsters, sea cucumbers, and many other organisms are overexploited, and in many cases, illegally. Sharks, tunas, sardines, and Pacific red snappers are just some of the affected species. It is estimated, for example, that 98% of the large fish have been exterminated in the ocean since 1950!

Population levels of some marine species have declined so drastically that they are in danger of extinction. The most emblematic species in Mexico is the vaquita, endemic to the upper reach of the Gulf of California. The population of this small porpoise, which resembles a dolphin in appearance, has declined from about 570 in 1997 to 10 or fewer today. Its extinction in the very near future is almost a certainty. Despite the enormous efforts by government agencies, academic institutions and private organizations to save it from extinction, the principal cause of its demise has not been fully removed. The vaquita is a victim of the incidental catch in gillnets used to capture the totoaba, an endemic and endangered fish which inhabits only the same area in the Gulf of California. The totoaba is fished illegally because its swim bladder is extremely valuable in the black market. A kilogram will fetch about $4,000 dollars in Mexico, $20,000 once it has crossed the United States border, and up to $100,000 in China. Well-organized mafias, corruption, and impunity in these three countries seem to determine the fate of this unique animal. Its loss to humanity, for the profits of a few, will be chronicled in the annals of conservation as emblematic of human apathy and unbridled greed.

Conservation: cases of success

Fortunately, there are successful stories where conservation actions have had positive impacts on species and ecosystems. Nature conservation in Mexico is based on the protection of natural areas to maintain the functionality of ecosystems and support biodiversity, and on strategies to protect endangered species, either individually or as a group of related species. Today, there are more than 190 protected areas decreed by the federal government which include national parks, biosphere reserves, flora and fauna protection areas, and sanctuaries. Combined, these areas constitute more than 20% of the continental and marine territory of the country. There has been a robust effort to protect and conserve marine biodiversity in Mexico since the twentieth century, and currently more than 40 million hectares of the seas around Mexico are protected. All these reserves are managed by the National Commission of Natural Protected Areas (Conanp) of the Ministry of the Environment and Natural Resources (Semarnat). The creation of this Commission in 1994 was an exceptionally visionary success in conservation history in Mexico.

Decreeing a natural protected area in Mexico requires enormous commitment and effort. In addition to technical studies to assess the biodiversity in the area, agreements with landowners and multiple political and economic actors are required. In a country with a growing population and increasing demands from economic sectors such as mining and oil, allocating areas for conservation is extremely difficult. This challenge is exemplified by the need to balance the interests of the fishing industry with the interests of communities or the country to prohibit or severely limit fishing in a marine area. As described in Chapter Two of this book, there is much scientific evidence of the ecological, economic, and social benefits of fishing bans or curtailment. However, the medium and long-term benefits are harder to grasp than the immediate payouts when resource exploitation is prioritized.

Despite the challenges to achieve environmental protection, sustainable development and greater social equity, Mexico has made notable progress, especially over the past three decades. The transformation of a moribund fishing industry in Cabo Pulmo into a vibrant national marine park is an example of what is possible if the resources, political will and community talent and involvement are pooled together to create a system that is both ecologically sustainable and economically rewarding. This marine park has demonstrated that since its creation in the mid-1990s, the marine fauna can recover very quickly if a fishing ban is enacted.

Other major protected marine areas are the: Veracruz Reef System National Park that protects coral reefs; Banco Chinchorro Biosphere Reserve, Cozumel Reef National Park, Isla Contoy National Park, and Sian Ka'an Biosphere Reserve that protect the marine biodiversity of Quintana Roo, the most diverse region in the country; Huatulco National Park in Oaxaca on the Pacific coast that protects the staghorn coral reef, a unique ecosystem in Mexico; Vizcaíno Biosphere Reserve on the coast of Baja California that protects the coastal lagoons where the gray whales calve; and Upper Gulf of California and Colorado River Delta Biosphere Reserve that was established to protect the vaquita and the totoaba, among other species. Additionally, three immense areas, which combined cover more than 22% of the country's seas, have been decreed natural protected areas in recent years: the Mexican Caribbean Biosphere Reserve; the Revillagigedo Archipelago National Park; and the Deep Mexican Pacific Biosphere Reserve. The creation of these new reserves demonstrates the desire, creativity and leadership of the Mexican society to protect its marine resources.

The Mexican Caribbean Biosphere Reserve protects more than 5.7 million hectares, including all the reefs in Quintana Roo, which represent about half of the Mesoamerican Reef System. These reefs are the habitats of more than 90 species of corals and 200 species of fish. The Revillagigedo National Park is one of the *crown jewels*. It protects the four islands of the archipelago and 15 million hectares of the surrounding sea, making it the largest natural reserve in North America. The islands have been compared to the Galapagos Islands because of its extraordinary biodiversity and uniqueness, features essential to Charles Darwin in his development of the theory of evolution. The waters of the archipelago support more than 750 species of animals such as fin whales, large groups of mantas and sharks, and schools of tunas. Lastly, the Deep Mexican Pacific Biosphere Reserve extends from the Revillagigedo Islands and the coast of Colima to the coast of Chiapas and gives protection from the mining of the hydrothermal vents and seabed.

Species conservation

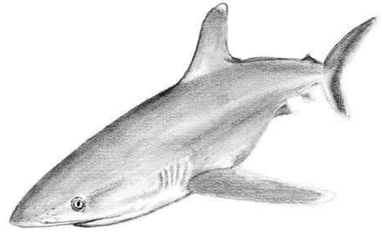
Aldo Leopold, a twentieth century American conservationist, noted that even in a world full of wounds and in the face of overwhelming odds, conservation success stories should provide hope for humanity. Individual species-focused protection efforts provide stories of success and insights into the strategies to bend the trajectory away from extinction. Some examples are the northern elephant seal, fur seal, gray whale, and Pacific ridley sea turtle. In all these cases, recovery was eventually achieved even though their populations became precarious small.

The history of the decimation of marine mammals off the Pacific coast of Mexico began in the early 19th century. Guadalupe Island, 250 kilometers off the coast of the Baja California Peninsula and "lost" in the vast Pacific Ocean, historically hosted huge populations of sea otters, fur seals, sea lions, and northern elephant seals, among other species. Isolated and out of reach from the authorities of the nascent country, the slaughter of these animals was carried out with impunity for a few decades until the huge aggregations became only a memory of the past. The fur seal population dropped to fewer than 10 individuals and for several decades it was considered extinct. Northern elephant seals, with males weighing up to three tons and a native population of about 100,000, were nearly exterminated and only about 100 individuals were left. Commenting on the near total decimation and probable extinction of this species, the American scientist Laurence M. Huey wrote in 1930: "*few, if any, living species today have been so deeply scored, so driven to the very brink of extermination [as the elephant seal].*"

In another story of a species nearing extinction, thousands of gray whales were hunted on the shores of the Baja California Peninsula until their numbers plummeted drastically. In an unusual event of enormous vision for conservation at that time, Mexican President Álvaro Obregón (1920-1924) helped to save this and other species by prohibiting the hunting of all marine mammals. In addition, he decreed Guadalupe Island a national park. Today, the populations of the fur seal and the northern elephant seal are estimated to be more than 15,000 and 180,000 individuals, respectively, and the gray whale population exceeds 15,000. Gray whales travel from the waters of the Bering Sea in Alaska to the coastal lagoons of Ojo de Liebre and San Ignacio in Baja California Sur every winter to calve; the round-trip migration covers about 15 thousand kilometers and is one of the longest among marine mammals. The story of the recovery of the Pacific ridley sea turtle is amazing. By mid-1980s, fishing had caused the alarming decline of these sea reptiles. Implementation of policies prohibiting their capture and extensive efforts to protect nesting beaches have resulted in a marked turn around on their population trajectory. The current population of the Pacific ridley sea turtle in the waters off Mexico's coasts exceeds 1,300,000 individuals, and at some beaches, such as Escobilla in Oaxaca, more than 150,000 females have been observed nesting in a single season. Watching thousands of sea turtles nesting simultaneously is an unforgettable experience.

An uncertain future

The seas and oceans of Mexico and the world are in danger. The rapid growth of the human population, excessive consumption patterns, and inefficient technologies are the cause of environmental issues such as climate change, species extinction, and pollution. The future of the seas and oceans relies on the actions that will be carried out globally in the next two or three decades. The future of this amazing, mysterious blue world with its complex array of interconnected flora and fauna communities will depend on the decisions made, and actions taken by the human community, individually and collectively.



With extremely short legs or even dragging their bellies on the ground, reptiles have scale-covered skin, lay eggs, and have a variable body temperature and, interestingly, their teeth cut but do not chew. The largest members of this group are crocodiles. In Mexico, there are three species of the 23 that exist in the world: the river crocodile, the swamp crocodile, and the spectacled cayman. As their home, they choose warm regions next to bodies of water where they can easily catch their food.

Sea turtles also belong to this group. Eight species are documented throughout the world, seven of them are found in Mexico. Thanks to their four fin-shaped appendages, they appear to be flying elegantly under the sea surface. Adult females return to the beach to nest –the only moment they leave the ocean. Due to their longevity and characteristic shell, various cultures have integrated them into their mythology. In Mesoamerica, turtle representations are part of the Mayan and Aztec codices and murals. Since historical times, they have been hunted for meat consumption and for the scales of their shell, a material known as hawksbill, used to make combs, jewelry, and other accessories. While hunting has been banned since the 1970s and today all species are protected, sea turtles are still seriously threatened due to bycatch. The leatherback turtle, the largest of all, is on the verge of extinction.

Possibly less charismatic but equally attractive are sea snakes. There are about 60 marine species living in coral reefs, estuaries, mangroves, and oceanic waters. Their paddle-like tail and a laterally-compressed body have allowed sea snakes to adapt to a fully aquatic life. This group includes species that possess the most potent venoms, but fortunately, the most dangerous ones are not found in Mexican waters.

marine reptiles

Six of the seven species of sea turtles visit the Mexican coasts to lay eggs: hawksbill (page 244), Kemp's ridley (top), olive ridley (right), leatherback (page 248), green (page 250) and loggerhead (page 252). In Mexico, they are all classified as endangered species due to their exploitation for the illegal consumption of meat and eggs and, in the case of the hawksbill sea turtle, for its valuable shell used for jewelry.

Mating of sea turtles takes place at sea, but females must go to the beach to dig nests and lay their eggs. Most species spawn at night, although the olive ridley sea turtle does it also during the day. If, when leaving the water, the turtles are disturbed by lights or noise, females will return to the water without having laid their eggs.

The leatherback turtle is the largest sea turtle in the world. It can reach over two meters in length and weigh more than 600 kilograms. Its main food is jellyfish, followed by various fish, crustaceans, squids, sea urchins, and seaweed. This species has become iconic in the fight to reduce our consumption of plastic, particularly disposable bags, since they often confuse them with their food and eventually die.

Sea turtles have traveled the seas for over 100 million years, accompanying now-extinct reptiles such as dinosaurs. It has been estimated that they can live over one hundred years. In addition to their lifespan, they are migratory and can travel hundreds and even thousands of kilometers. They can have their nesting sites in one country, while feeding and breeding in others. Preserving them must be an international effort.

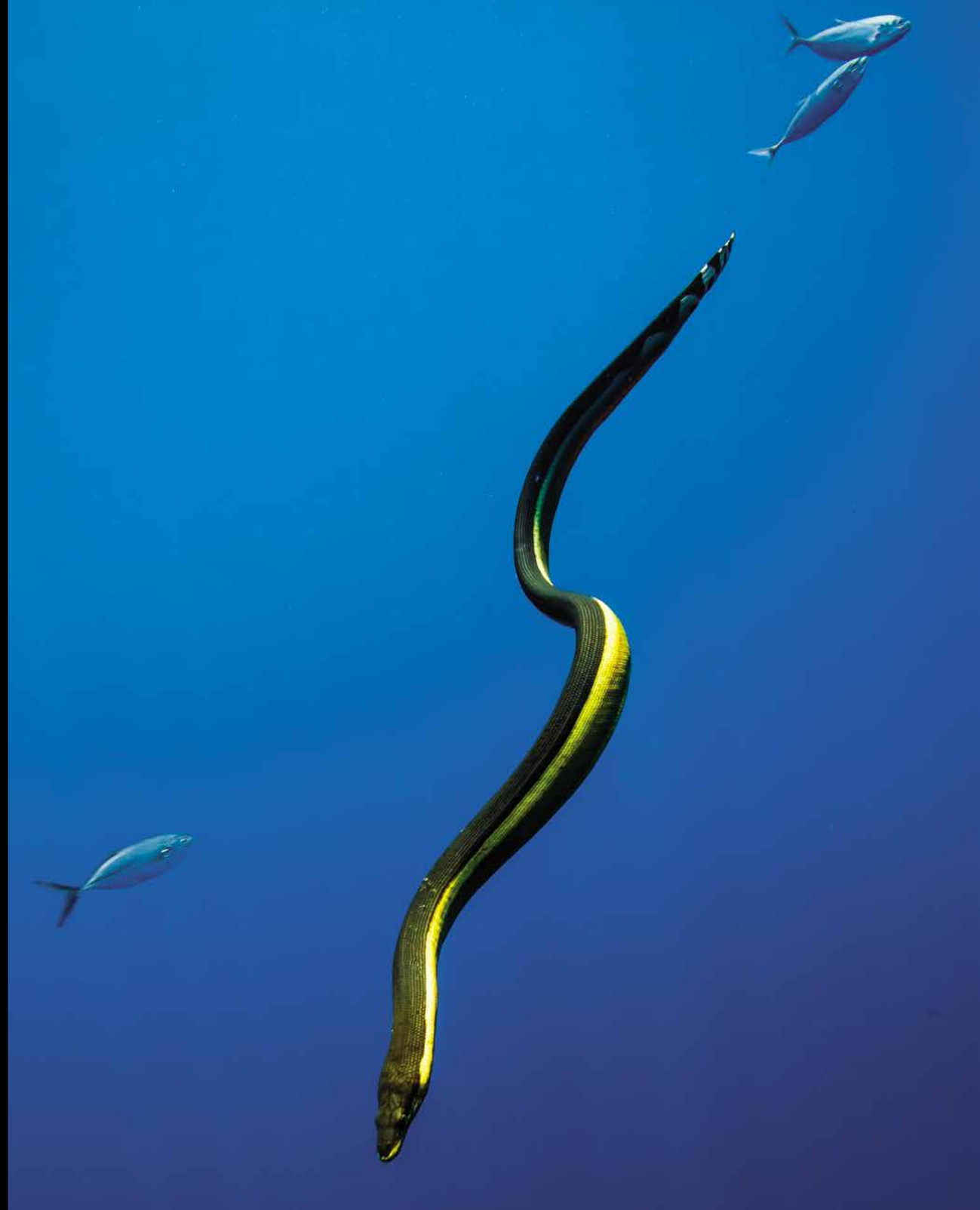
Every time I sleep into the ocean,
its like going home.

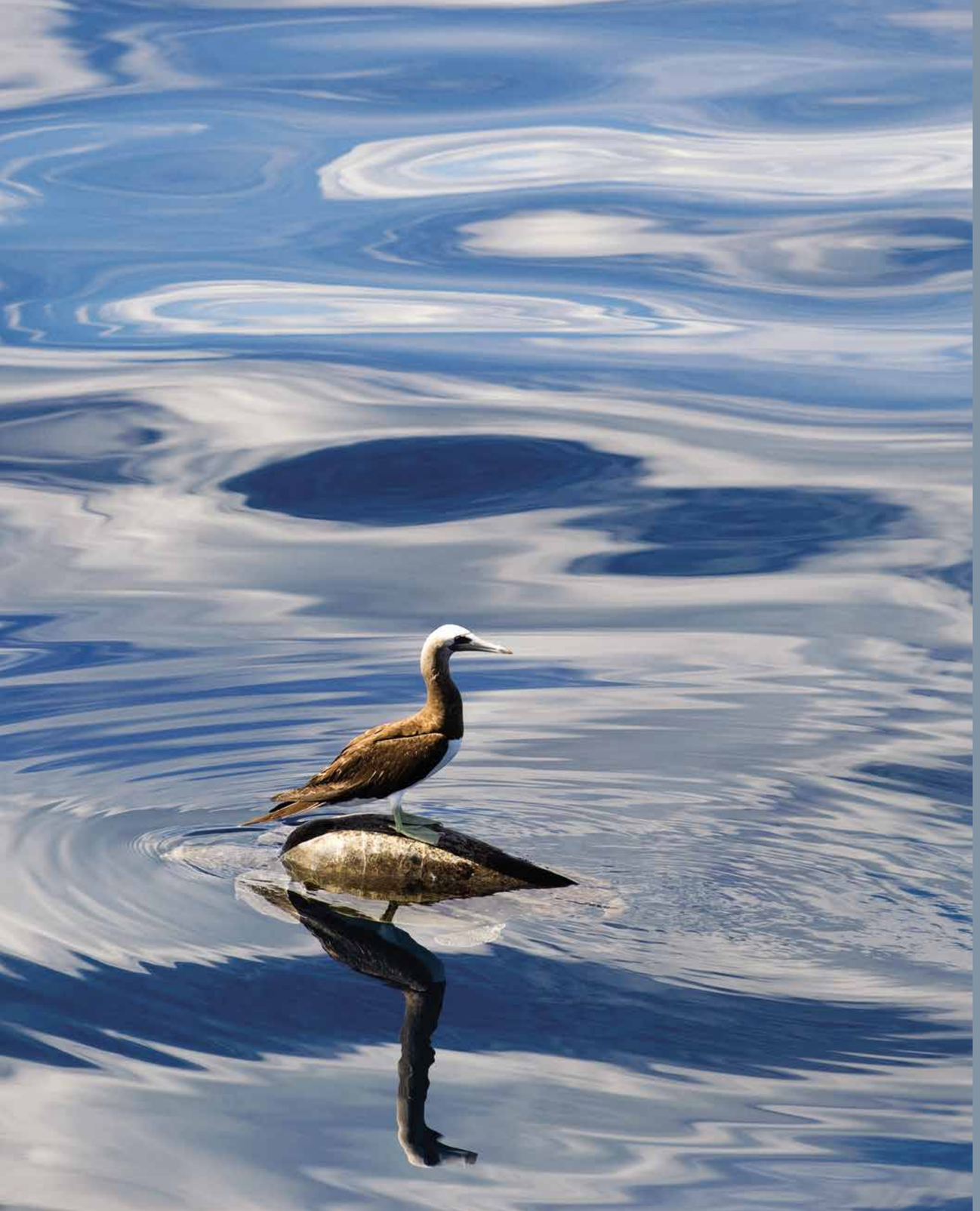
Sylvia Earle

In Mexico there are two species of crocodiles, the Mexican and the American. They can measure between 3 and 6 meters in length respectively. Both species can be found in areas of coastal wetlands and brackish waters.

The greatest threat to our planet
is the belif that someone else
will save it.

Robert Swan





Seabirds are adapted to life in a marine environment, from which they obtain their food and find shelter. This diverse group has exceptional adaptations that allow its members to fly, swim, float, and dive. For instance, they have nasal glands that expel salt, hydrophobic feathers that repel water, webbed feet, and a lightweight body that enables them to fly for long periods of time or to stay afloat. They have anatomical features that allow them to dive without getting water into their nose and prevent them from breaking their neck when they hit the sea at high speed to catch fish.

Some species spend their entire lives in the ocean, except during nesting seasons. Others inhabit coastline ecosystems, where they remain year-round. Some seabirds are famous for their long migrations, such as the Arctic tern that nests in the Arctic (northern Canada, Europe, and Asia) during the northern summer, but spends the northern winter (the summer of the southern hemisphere) in the Antarctic Circle waters.

In general, seabirds live longer than other bird species, breed at an older age, and lay fewer eggs (some of them only lay one egg per year) as they spend most of their time taking care of their offspring. Most seabirds form nesting colonies that range in size from a few dozen to millions of individuals. They are found in inaccessible regions such as islands or cliffs where land predators are scarce. Today, seabirds are among the most endangered bird groups in the world. According to the International Union for Conservation of Nature (IUCN), 28% of the 346 species of seabirds on the planet are listed as *Endangered* and another 10% are listed as *Near Threatened*. Accidental fishing, pollution, and constructions near the seas and coasts are the main causes of seabird population decline.

from the sky and sea

There are dozens of seabirds that inhabit our country. Some inhabit coastal wetlands, others the seashore and cliffs, while others spend most of their lives flying in the open sea. Among the adaptations of these birds are the secretion of an oil that makes them impermeable when submerged, webbed feet for easy swimming, and glands that excrete salt from seawater.

Seabirds with clear examples of parental care include the blue-footed boobies (left), famous for their elegant courtship rituals in which they show off their colorful feet. Both parents take care of the chicks.

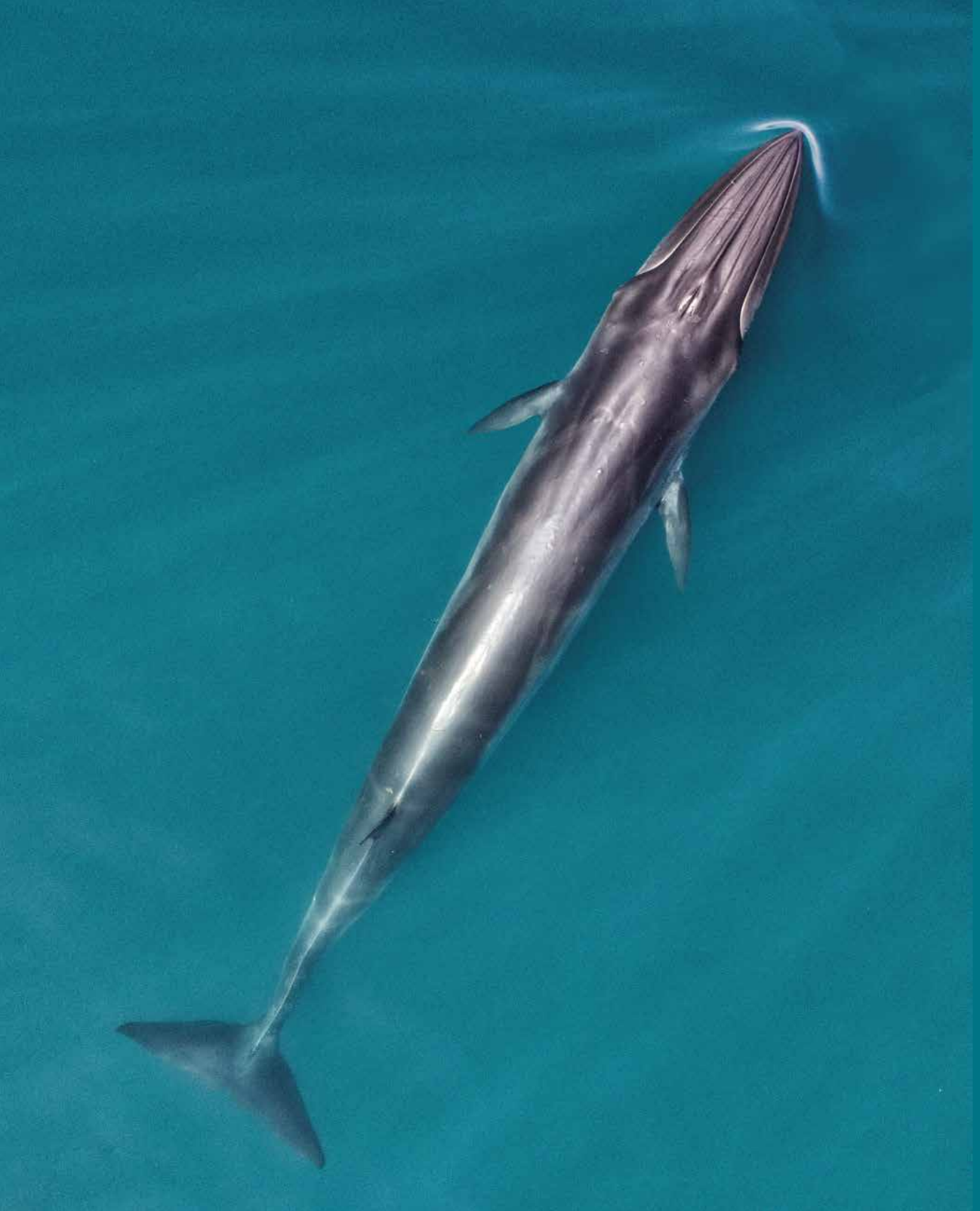
The elegant tern (above) that nests at Rasa Island, is famous for its "nursery" formation, where chicks are congregated in groups to prevent predation, food theft, and to facilitate the process of socialization among them.

The foam plays with the sun
from dawn to night,
the music of the sea never repeats.

María Guerra

There are three species of boobies in Mexico, the blue-footed boobies, the brown boobies, and the red-footed boobies (left). These charismatic birds, nest in trees and are the smallest members of this group.

Albatrosses (page 264) are a group of seabirds distributed in the Antarctic Ocean, Pacific Ocean, and South Atlantic Ocean. They have the largest wingspan of all birds, allowing them to spend most of their lives in the open sea. They feed mainly on fish, squid, and krill. They form colonies, monogamous relationships, and commonly nest on islands, this being the only time where they touch land.



Marine mammals have adapted to spending all or part of their life at sea. Those that never leave the ocean are cetaceans –whales, dolphins, and porpoises– and sirenians –dugongs and manatees–. While dolphins and porpoises have teeth and a diverse diet, whales possess beard-like plates –known as baleen– associated with a very specialized diet: krill, tiny crustaceans that form large clusters. Sirenians feed primarily on seagrass. From the 90 species of cetaceans that exist in the world, 40 of them inhabit Mexican seas, mostly in the Pacific and the Gulf of California.

Because food availability does not coincide geographically or temporarily with the breeding season, whales usually feed on krill in polar waters during the summer, and then, spend the winter in subtropical waters where they give birth to their offspring. The gray whale spends the summer in the Arctic Circle, while in the autumn, it begins a long migration toward the coastal lagoons of Baja California, such as Guerrero Negro, characterized by a shallow depth, high salinity, and isolation that offer an ideal breeding ground.

Marine mammal species that spend part of their life on land are seals, sea lions, and walruses (pinnipeds), sea otters (mustelids), and polar bears (ursids). They feed in the sea but return to the coast to rest and mate.

Unfortunately, species like the sea otter and the Caribbean monk seal disappeared from Mexico as a result of indiscriminate hunting. Currently, the biggest tragedy is the case of the marine vaquita, the smallest marine mammal species that weights no more than 50 kilos. Endemic to the Gulf of California, it is now at imminent risk of extinction due to bycatch and habitat destruction.

sea mammals

The blue whale, with a length of up to 30 meters and weighing 180 tons, is the largest mammal in the world. Only his tongue weighs the equivalent of an elephant and his heart is the size of a car. The blue whale inhabits all oceans. In Mexico, it visits the Gulf of California between the months of December and April. This majestic species was affected by the oil industry in the 17th century. It is currently estimated that there are just over 1,600 whales in the North Pacific Ocean; their populations are in recovery thanks to policies that prohibit their hunting.

Like terrestrial mammals, marine mammals feed exclusively on breast milk when they are young. Females have a pair of mammary glands located below the pectoral fins. In the case of blue whales, it is known that during the first year of life calves can increase up to 90 kilos per day! Another similarity with terrestrial mammals is the presence of vibrissae, a type of vestigial hair that can be observed near the corner of the mouth in the young, which disappears within a few weeks.

All things pass and stay forever,
yet we pass eternally,
drawing footpaths in our passing,
footpaths on the restless sea.

Antonio Machado

The vaquita is a unique species of the Gulf of California. Currently, there is no hope that there are more than 30 individuals, so only critical, urgent, and international actions between Mexico, the United States and China can help to reverse the imminent extinction of the species. The main threat is the illegal fishing of totoaba fish where the vaquitas are accidentally entangled in the nets.

(Image captured with express permission (Official Letter DR / 488/08) of the National Commission of Natural Protected Areas / Ministry of Environment and Natural Resources, in a natural protected area subject to special management. We appreciate the collaboration of the Research and Conservation Coordinator of Marine Mammals, National Institute of Ecology)

These agile dolphins are called false killer whales due to their similarity in coloration with the killer whales, their large size, feeding habits, and their aggressiveness towards other species of dolphins.

Like other dolphins and whales, white-sided dolphins find their food thanks to echolocation. They can detect prey and threats outside their visual range. Each individual has a unique sound that allows them to identify each other. In addition to this auditory communication, they communicate by contact, are extremely active, and often interact with other cetaceans.

Manatees, also called sea cows due to their herbivorous habits, inhabit both fresh and salty coastal waters of the Gulf of Mexico, the Caribbean Sea and some lagoons and rivers in the southeast. Although they do not have natural predators, they are threatened by the loss, degradation, and fragmentation of their habitat, either by pollution, oil exploitation, or by accidental capture in illegal fishing nets.

Sea lions have visible ears and a thin neck, while seals only have a hole that connects their ear with the outside.

The Guadalupe fur seal (left) inhabits only the Guadalupe island and the San Benito archipelago. In the 19th century, they were almost exterminated by fur hunters and by 1897 they were believed extinct. Today, they are threatened by pollution, the introduction of exotic species, the rise of sea temperature, and changes in prey abundance due to El Niño events.

The California sea lion (above) is one of the most charismatic and agile hunters in the Gulf of California. Its hydrodynamic body allows it to feed on a wide variety of fish, mollusks, and squid. Because they are long-lived and frequent visitors to the same sites every year, they are excellent ecosystem health indicators. Since the 1980s they are considered to have better conservation status and their populations are recovering.

Elephant seals are the largest pinnipeds in the Northern Hemisphere, distributed from the coast of Alaska to the peninsula of Baja California. Its name comes from the characteristic protrusion of their face, similar to the trunk of an elephant. An adult male can weigh two tons and measure over 4.3 meters in length, while females are significantly smaller, and can reach weights from 600 kilos to one ton and measure three meters in length. They can be seen resting on the coast, although they spend about 85% of their time diving.

Poza de Xcalak, Arrecifes de Xcalak National Park, Quintana Roo.

Gerardo Ceballos

EPILOGUE

Mexico is a special place. It has one of the most varied biological communities on the planet and its extraordinarily picturesque landscape and seascape features make it a unique, special place.

The waters of the Pacific Ocean, Gulf of California, Caribbean Sea and Gulf of Mexico massage the 11 thousand kilometers of Mexican coastline and hundreds of islands and islets. At the coastal interface, mangrove forests and estuarine lagoons transition to the marine environments, while slightly offshore, extensive beds of seagrass fan out and eventually give way to the highly productive and beautifully complex coral reefs, including the largest coral reef off the American continents. Further out yet from the coasts, hydrothermal vents, some at depths of three thousand meters, form complex deep-sea structures which support unique and strange lifeforms. The fusion of temperate and tropical waters of the oceans and seas, input of freshwater and sediments from the coasts, and a complex underwater topography create a highly heterogeneous environment beneath the undulating blue waters off the coasts of Mexico.

The sea is one and several seas at once. Seas are dynamic through time and across space, and what appears to be a continuous, border-free environment is, in fact, a highly connected and fluid world of: intermixing currents, temperatures, salinity and chemistry; geologic processes; and the evolutionary

history of species. Some marine organisms continue to live just as their ancestors did hundreds of millions of years ago, while others arose in a flash —in geologic terms— such as the species that evolved separately when the Isthmus of Panama formed three million years ago, joining the North and South American continents and separating the Pacific Ocean from the Caribbean Sea and Atlantic Ocean. The seas of Mexico are home to an exceptional diversity of marine life: more than 50% of all marine mammal species and six of the seven sea turtle species in the world; thousands of species of fish; and tens of thousands of species of other organisms, including invertebrates, microorganisms and plants, many of which have not yet been identified.

The reefs off Mexico's Caribbean coast are a sampling of the beauty and complexity of this inspiring natural treasure. A few meters below the water's surface, an immense variety of formations harbor corals of incredible shapes, sea sponges, hundreds of species of multi-colored fish, octopuses, shrimp, crabs, anemones, starfish, sea cucumbers, and numerous other invertebrates and plants. With a bit of luck, divers may observe sea turtles and, rarely, manatees. The Mesoamerican Barrier Reef, one of the longest in the world, runs along the entire coast from Cozumel in the state of Quintana Roo to Honduras.

Unfortunately, Mexico's rich biological heritage currently is at risk because the competing social, economic, and political challenges and global-scale assaults on the environment limit the scope of efforts and resources needed to safeguard it. Like many other places in the world, the seas of Mexico are seriously threatened by the warming and acidification of the water brought on by climate change, the overexploitation of fisheries and loss of species, pollution from untreated or inadequately treated discharges, excessive use of fertilizers, and the increasing presence of millions of tons of plastics and other solid waste. These environmental assaults are changing the marine environment so rapidly and in such profound ways that, if continued unchecked, it may no longer be possible to preserve the incredible diversity of marine life or recover the full functionality it has provided for millions of years. It will unconceivable sad and senseless if we do not save it for the simple reason of its existence, beauty, and essence. A healthy marine environment is imperative for the maintenance of the planet's biodiversity on which the well-being and future of humankind depend.

What it is at stake is our own future!

The truth is that the natural world is changing. We totally depend on this world. It provides our food, water, and air. It is the most precious thing we have, and we must defend it.

DAVID ATTENBOROUGH

COMMON AND SCIENTIFIC NAMES

Abalone • *Haliotis* sp.
America blue crab • *Callinectes sapidus*
American crocodile • *Crocodylus acutus*
American manatee • *Trichechus manatus*
Anhinga • *Anhinga anhinga*
Arctic tern • *Sterna paradisaea*
Atlantic horse mackerel • *Trachurus trachurus*
Bat eagle ray • *Myliobatis californica*
Black mangrove • *Avicennia germinans*
Black skimmer • *Rhynchops niger*
Blue shark • *Prionace glauca*
Blue shrimp • *Litopenaeus stylirostris*
Blue whale • *Balaenoptera musculus*
Blue-footed booby • *Sula nebouxii*
Brain coral • *Diploria clivosa*
Brown sea cucumber • *Isostichopus fuscus*
Brown shrimp • *Farfantepenaeus californiensis*
Brown smooth-hound • *Mustelus henlei*
Brown-footed booby • *Sula leucogaster*
Bryde's whale • *Balaenoptera edeni*
Bull shark • *Carcharhinus leucas*
California anchovy • *Engraulis mordax*
California sea lion • *Zalophus californianus*
California sheephead • *Semicossyphus pulcher*
Caribbean flamingo • *Phoenicopterus ruber*
Caribbean monk seal • *Neomonachus tropicalis*
Caribbean reef squid • *Sepioteuthis sepioidea*
Caribbean spiny lobster • *Panulirus argus*
Catarina scallop • *Argopecten circularis*
Christmas tree worm • *Spirobranchus giganteus*
Chub mackerel • *Scomber japonicus*
Cobia • *Rachycentron canadum*
Common dolphinfish • *Coryphaena* sp.
Common remora • *Remora remora*
Coney • *Cephalopholis fulva*
Coral • *Acropora* sp.
Duckweed • *Lemna* sp.
Dugong • *Dugong dugon*
Dusky grouper • *Epinephelus marginatus*
False killer whale • *Pseudorca crassidens*
Fiddler crab • *Uca* sp.
Fin whale • *Balaenoptera physalus*
Finespotted jawfish • *Opistognathus punctatus*
Flamingo tongue snail • *Cyphoma gibbosum*
Foureye butterflyfish • *Chaetodon capistratus*
Fur seal • *Arctophoca philippii*
Gafftopsail sea catfish • *Bagre marinus*
Giant Caribbean anemone • *Condylactis gigantea*
Giant kelp • *Macrocystis pyrifera*
Giant kelp • *Macrocystis* sp.
Giant kelpfish • *Heterostichus rostratus*
Giant manta ray • *Manta birostris*
Giant swimcrab • *Callinectes toxotes*
Goose neck barnacle • *Pollicipes elegans*
Gray whale • *Eschrichtius robustus*
Great hammerhead • *Sphyrna mokarran*
Greenturtle • *Chelonia mydas*
Greybar grunt • *Haemulon sexfasciatum*
Gulf grouper • *Mycteroperca jordani*
Gulf grouper • *Mycteroperca jordani*
Harbor seal • *Phoca vitulina*
Hawksbill sea turtle • *Eretmochelys imbricata*
Horseshoe crab • *Limulus polyphemus*
Humpback anglerfish • *Melanocetus johnsonii*
Indo-Pacific sailfish • *Istiophorus platypterus*
Jumbo squid • *Dosidicus gigas*
Kemp's ridley sea turtle • *Lepidochelys kempi*
Killer whale • *Orcinus orca*
Large pelagic amphipod • *Cystisoma* sp.
Leatherback sea turtle • *Dermochelys coriacea*
Lesser starlet coral • *Siderastrea radians*
Lined seahorse • *Hippocampus erectus*
Loggerhead sea turtle • *Caretta caretta*
Magnificent frigatebird • *Fregata magnificens*
Manateegrass • *Syringodium filiforme*
Mangrove cockle • *Anadara tuberculosa*
Mangrove oyster • *Crassostrea corteziensis*
Minke whale • *Balaenoptera acutorostrata*
Money tree plant • *Pachira aquatica*
Morelet's crocodile • *Crocodylus moreletii*
Northern elephant seal • *Mirounga angustirostris*
Northern white shrimp • *Litopenaeus setiferus*
Ocean sunfish • *Mola mola*
Pacific oyster • *Crassostrea gigas*
Pacific red snapper • *Lutjanus peru*
Pacific Ridley • *Lepidochelys olivacea*
Pacific sardine • *Sardinops sagax*
Pacific spotted scorpionfish • *Scorpaena mystes*
Pacific white-sided dolphin • *Lagenorhynchus obliquidens*
Pelagic red crab • *Pleuroncodes planipes*
Pen shell • *Atrina* sp.
Pink shrimp • *Farfantepenaeus duorarum*
Pocket shark • *Mollisquama mississippiensis*
Polar bear • *Ursus maritimus*
Polyclad flatwarm • *Pseudobiceros bajae*
Purple snail • *Plicopurpura pansa*
Purple-ring topsnail • *Calliostoma annulatum*
Pygmy sperm whale • *Kogia breviceps*
Queen conch • *Lobatus gigas*
Red mangrove • *Rhizophora mangle*
Red Snapper • *Lutjanus campechanus*
Red-footed booby • *Sula sula*
Ridged slipper lobster • *Scyllarides nodifer*
Rough cranch squid • *Cranchia scabra*
Rugose pen shell • *Pinna rugosa*
Sea cucumber • *Holothuria* sp.
Sea otter • *Enhydra lutris*
Sea snail • *Tegula* sp.
Seaweed • *Sargassum* sp.
Shoal grass • *Halodule wrightii*
Shortfin mako • *Isurus oxyrinchus*
Shovelnose guitarfish • *Rhinobatos productus*
Slender snipe eel • *Nemichthys scolopaceus*
Smalltooth sawfish • *Pristis pectinata*
Spectacled caiman • *Caiman crocodilus*
Spiny lobster • *Panulirus interruptus*
Spotted moray • *Gymnothorax moringa*
Spotted ratfish • *Hydrolagus collei*
Staghorn coral • *Acropora cervicornis*
Stargazer • *Uranoscopus scaber*
Stoplight Parrotfish • *Sparisoma viride*
Surgeonfish • *Paracanthurus hepatus*
Swordfish • *Xiphias gladius*
Telescopefish • *Gigantura* sp.
Tiger shark • *Galeocerdo cuvier*
Tomato clownfish • *Amphiprion frenatus*
Totoaba • *Totoaba macdonaldi*
Trumpetfish • *Aulostomus maculatus*
Tuna • *Thunnus* sp.
Turtlegrass • *Thalassia testudinum*
Urchin • *Stongylocentrus* sp.
Urchin • *Lytechinus* sp.
Vaquita • *Phocoena sinus*
Water hyacinth • *Eichhornia crassipes*
Water lettuce • *Pistia stratiotes*
Whale shark • *Rhincodon typus*
White ibis • *Eudocimus albus*
White mangrove • *Laguncularia racemosa*
White mangrove • *Conocarpus erectus*
White shark • *Carcharodon carcharias*
White snook • *Centropomus viridis*
Whitetip reef shark • *Triaenodon obesus*
Yellow waterlily • *Nymphaea mexicana*
Yellow-bellied sea snake • *Pelamis platura*
Yellowline arrow crab • *Stenorhynchus seticornis*

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PHOTOGRAPHS FIRST AND LAST PAGES

PÁGINA 4 *While the oceans cover 70 percent of the surface of our planet, water is a scarce element in the galaxy. Life depends largely on the oceans. Earth is a blue planet, strong and fragile at the same time.*

PÁGINA 6 *The richness of marine life can be imperceptible to the naked eye. Beyond the majestic whales, there are extremely small organisms. It is estimated that over a thousand animals and microscopic algae can be found in just one liter of seawater.*

PÁGINA 8 *The seas are home to habitats brimming with life. Various physical and chemical factors, such as ocean water temperature, maintain the great diversity of marine species and also influence the composition of neighboring terrestrial ecosystems.*

PÁGINA 10 *The brown seaweed forests paint the cold waters of the coasts of Baja California, the Gulf of Mexico, and the Caribbean Sea in red and green tones. In them, life flourishes in diversity and abundance, which makes them fundamental to the economic activity of these regions.*

PÁGINA 12 *Killer whales, because of their enormous size, carnivorous habits, and incredible capacity for vocal communication, are prominent representatives of cetaceans. They are distributed throughout the world and can be found in all Mexican coasts. Although they are migratory, there is a resident group in Baja California.*

PÁGINA 14 *Numerous species of fish aggregate in banks to reproduce and protect themselves from predators. In addition to their beauty, these large groups sustain important fisheries such as tuna, sardines, mackerels, and snappers.*

PÁGINA 16 *The sea hides giant and tiny, colorful, and transparent treasures, hunters and preys. Although they are different from each other, they all play an important role in the functioning of the oceans.*

PÁGINA 22 *Rays, along with sharks, sawfish, and chimeras, belong to the group of cartilaginous fish, since their skeleton is composed of cartilage. This group, despite being one of the oldest and most diverse, is in danger due to overfishing and bycatch.*

PÁGINA 26 *The intricate interactions between marine species maintain the biological richness of the oceans.*

PÁGINA 294 *It is estimated that, due to global warming, more than half of the coral reefs have died. There are still many ways to protect the remaining reefs and the life that emanates from them.*

PÁGINA 296 *The life of thousands of marine predators depends on the large schools of fish: birds, mammals, and fish. The protection of marine areas through the regulation of fishing and tourism activities, as well as the decree of reserves, is essential.*

PÁGINA 298 *Since ancient times, whales have captivated humans for their great beauty and size. Mexico is a country of great importance for this group due to the feeding and breeding sites it holds.*

AUGMENTED REALITY

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- Page 133
- Page 178
- Page 274

Acknowledgments

We want to express our deepest and most sincere gratitude to the Carlos Slim Foundation and Teléfonos de México for their determined support for over a decade on the elaboration of this exceptional editorial project. This extraordinary series of books incorporate the most complete collection on environmental issues and biological diversity of Mexico, the problems that threaten its persistence and the challenges of its conservation. This volume, the 13th of the series, is dedicated to the seas of Mexico, a country that is uniquely rich in biological and cultural diversity, but that also faces major environmental problems. We express our deep gratitude to Mr. Héctor Slim Seade for his trust in our work, his commitment to this long-term project, and his interest in the conservation of nature. Also, to Graciela Chacón from Teléfonos de México, for her dedication and coordination of the project. Our special thanks to our families, source of inspiration and constant support. To Guadalupe Mondragón, Pablo Ceballos, Regina Ceballos; Clementina Equihua, Rodrigo Medellín, Alejandra Medellín; María Elena Camacho, María Elena Álvarez, Fernando Álvarez; Catalina López, Ari Maetzi Aburto, Guadalupe Oropeza, Octavio Aburto González; Guillermina Silva, Patricio Silva Ortega, and Ana Elizabeth Bacmeister; Mares Mexicanos, Rocio del Mar Liveaboard and Dora Sandoval, and Fay Crevoshay from Wildcoast; to Arturo Orta. We want to highlight our deepest recognition to the team of collaborators and friends whose dedication and work have made it possible to achieve the quality of this work. Throughout these years their participation has been the basis of the success of this editorial project. To Rosalba Becerra for the design and editorial coordination, to Claudio Contreras Koob for his iconographic work, to Xitlali Aguirre Dugua for the revision and correction of style, to Greta Cerecedo Palacios, Lourdes Martínez Estévez, and Daniela Medellín for the captions, to Yanet Sepúlveda for the translation, to Ronald Bjorkland for the revision of the style in English. Finally, to Héctor Tobón y Hernández and Adriana Iwasaki Otake for the illustrations.

Coordination: Gerardo Ceballos
Design: Rosalba Becerra
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Spanish text edition: Xitlali Aguirre Dugua
Translation: Yanet Sepúlveda
English text edition: Ronald Bjorkland
Ilustrations: Héctor Tobón y Hernández and Adriana Iwasaki Otake
Editorial: Trazos, consultoría editorial
Photography:

Alain Mafart-Renodier / Biosphoto, page 287
Alex Mustard / Naturepl.com , pages 96, 208
Andy Murch / SeaPics, pages 84, 122, 255
B. Murton / Latinstock México, page 232
Blue Planet Archive / SeaPics, page 233
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Christopher Swann / SeaPics, pages 6, 12, 135, 136
Claudio Contreras Koob, pages 2, 4, 10, 14, 16, 28, 46, 50, 51, 53, 54, 56, 58, 59, 62, 64, 66, 68, 79, 86, 88, 89, 90, 91, 98, 100, 101, 108, 110, 111, 112, 126, 132, 139, 140, 141, 146, 148, 149, 150, 158, 160, 163, 164, 166, 167, 168, 171, 172, 175, 177, 178, 184, 185, 186, 188, 190, 195, 197, 198, 200, 202, 204, 205, 206, 211, 216, 234, 244, 247, 250, 260, 262, 264, 266, 274, 284, 285, 286, 290, 294, 296
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Thomas A. Jefferson, page 278
Yvette Tavernier / Biosphoto, page 106
Valeria Mas, pages 48, 75, 78, 82, 104, 130, 161, 162, 249, 279

Color separations and prepress: UniPlus Hong Kong Limited
Printing: Toppan Leefung Printing Ltd, China

Parque Vía 190, Col. Cuauhtémoc, C.P. 06599, Ciudad de México
ISBN 978-607-9057-14-5

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ISBN: 978-607-9057-14-5