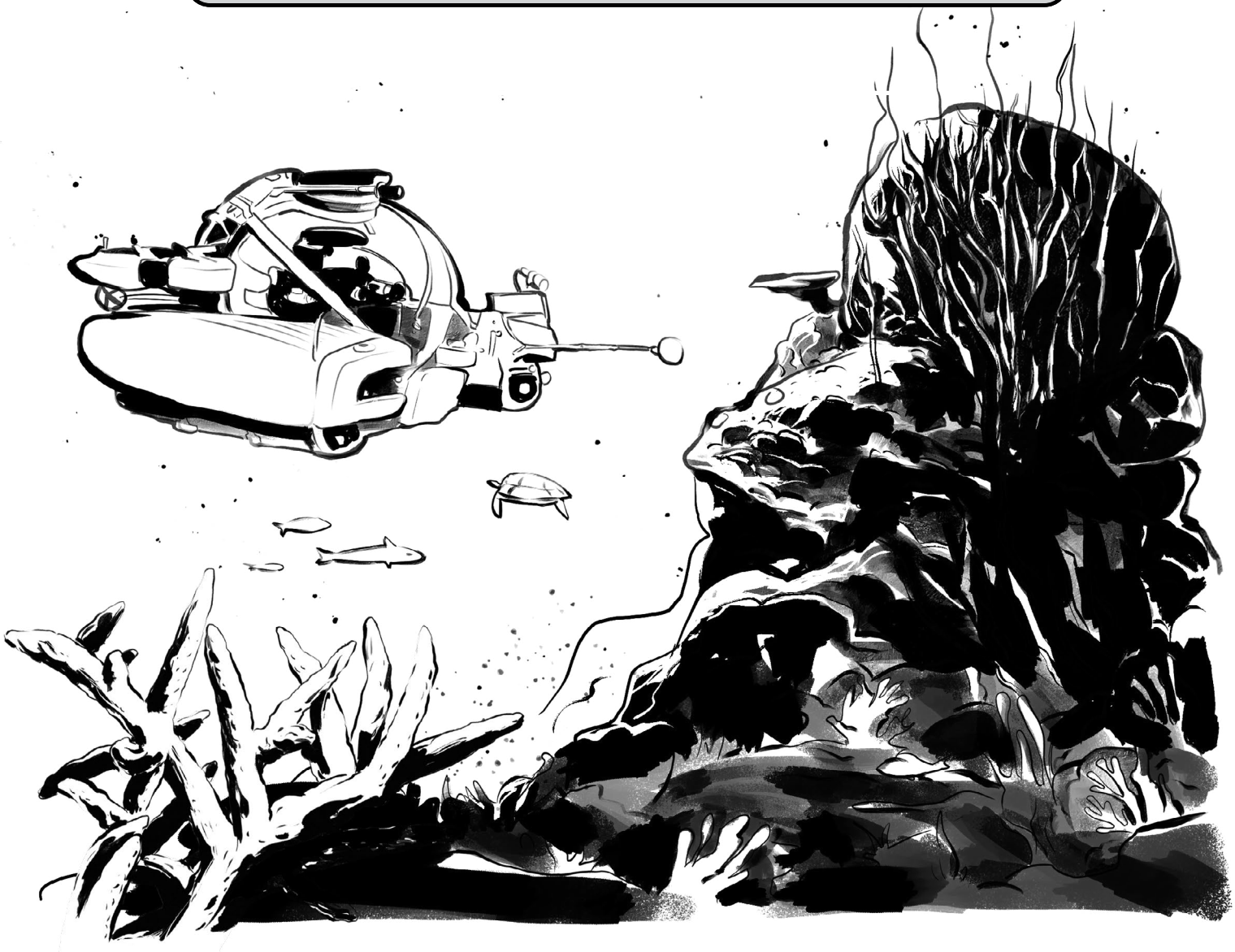
EXPLORING THE OCEAN

SINGAPORE



OCEANX
Education

Exploring the Ocean - Singapore

OceanX is on a mission to support scientists to explore the ocean and to bring it back to the world through captivating media. We hope that you'll join us in learning about this amazing environment and the ways that we can engage with it.

The ocean plays an important role in all of our lives. In this book you will learn about:

- What ocean exploration is and why it matters
- What ocean science is
- Tools used in ocean exploration
- Singapore's ocean environments
- Ways that you can help to protect the ocean

Let's dive in!

This book belongs to:

What is Ocean Exploration?

Ocean exploration is the exciting process of investigating and learning about the ocean and everything in it. Ocean explorers are like detectives, discovering new underwater worlds and solving mysteries of the deep sea. Ocean exploration combines adventure, science, and technology to discover the wonders of the ocean and ensure its protection for future generations.

It is important to explore the ocean so that we can learn more about how it works and how it is changing. Increasing our understanding of the systems and creatures within it will help us to better conserve creatures, manage marine resources, and understand how the world is connected.

You can be part of the ocean exploration adventure by learning more about the ocean, participating in conservation efforts, and supporting scientific research.

Planet Ocean

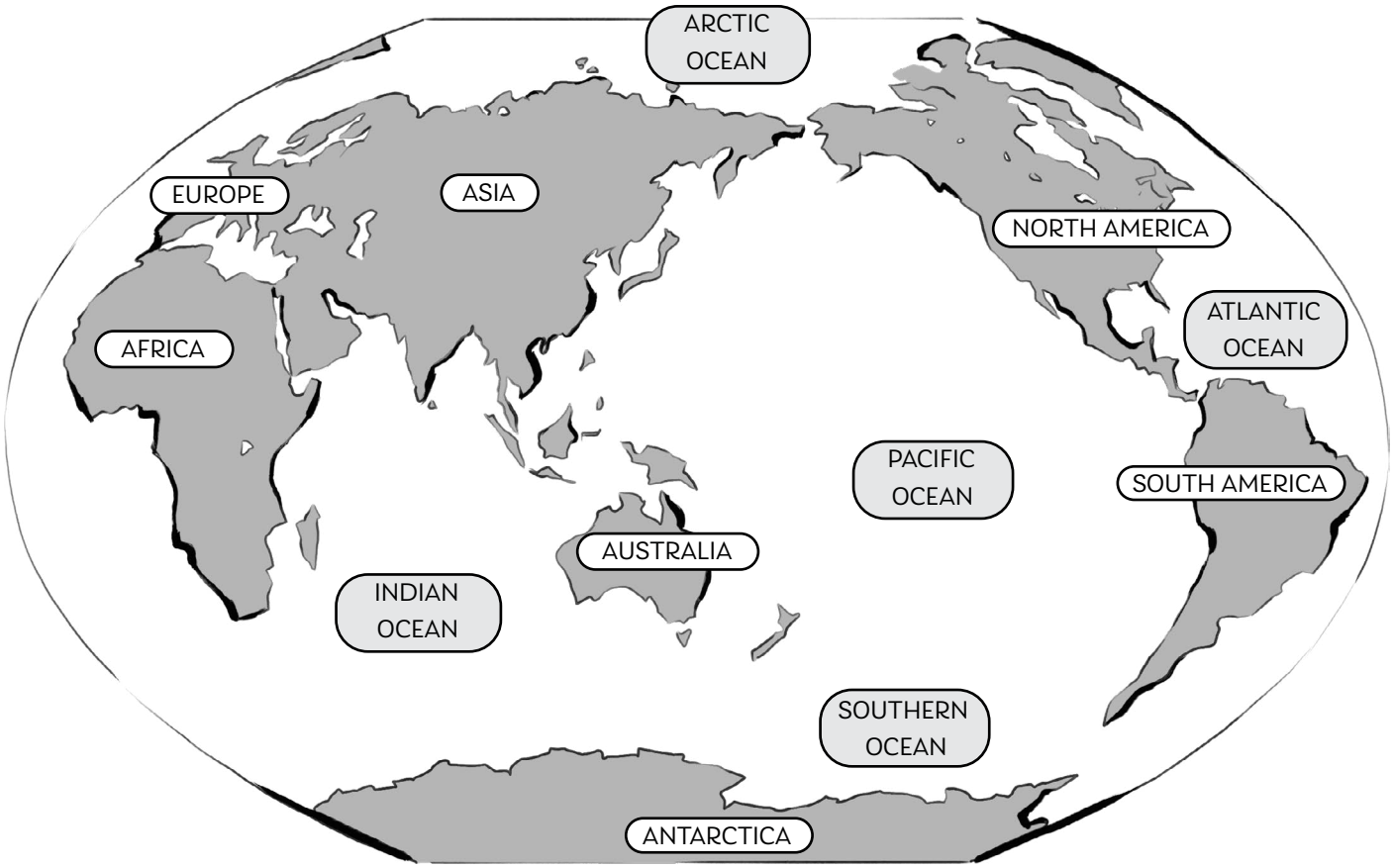
Earth is a water planet.

The ocean is a massive body of salty water that covers over 70% of the Earth's surface! The ocean is essential to all life on Earth. The ocean is connected, but we divide the ocean into five different basins:

- Pacific Ocean
- Atlantic Ocean
- Indian Ocean
- Arctic Ocean
- Southern Ocean

Interesting ocean facts:

- The Pacific Ocean is the largest of the ocean basins, covering about 30% of the Earth.
- The deepest part of the ocean is the Mariana Trench. Its deepest point is about 11 kilometers deep.
- The longest mountain range in the world is found underwater. It is called the mid-ocean ridge and is over 16,000 kilometers long.
- If all the salt was removed from the ocean and poured on the continents, it would cover them all to a depth of 152 meters.

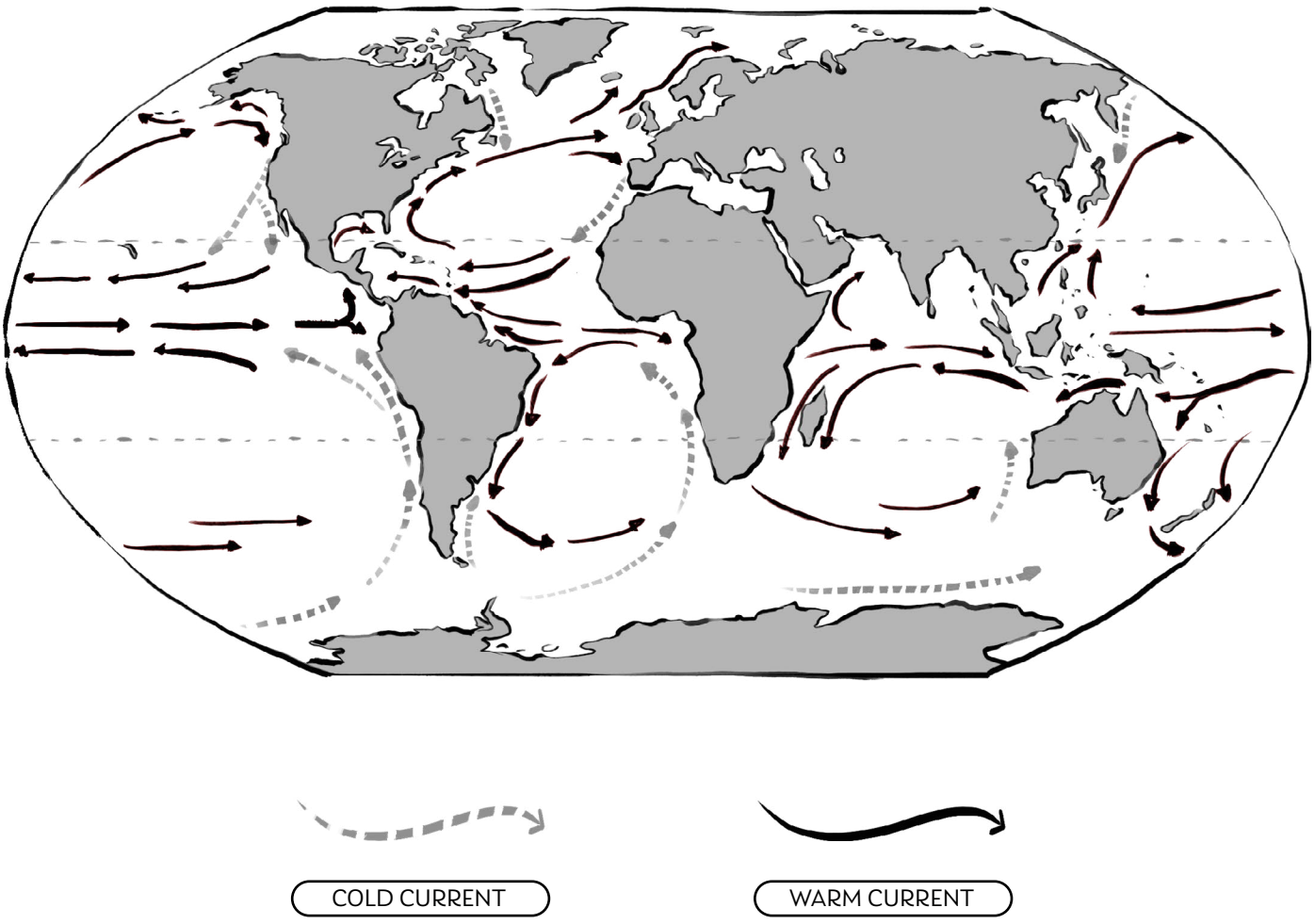


Ocean Waves, Currents, and Tides

In the ocean, water is constantly moving. On the surface, water moves in the form of waves, which are caused by wind pushing water across the surface of the ocean.

Below the surface, ocean currents are continuous flows of water that transport heat around the world. Ocean currents are caused by four main factors:

- Wind
- Earth's rotation
- Density differences caused by temperature and salt content
- Gravity from the moon and the sun



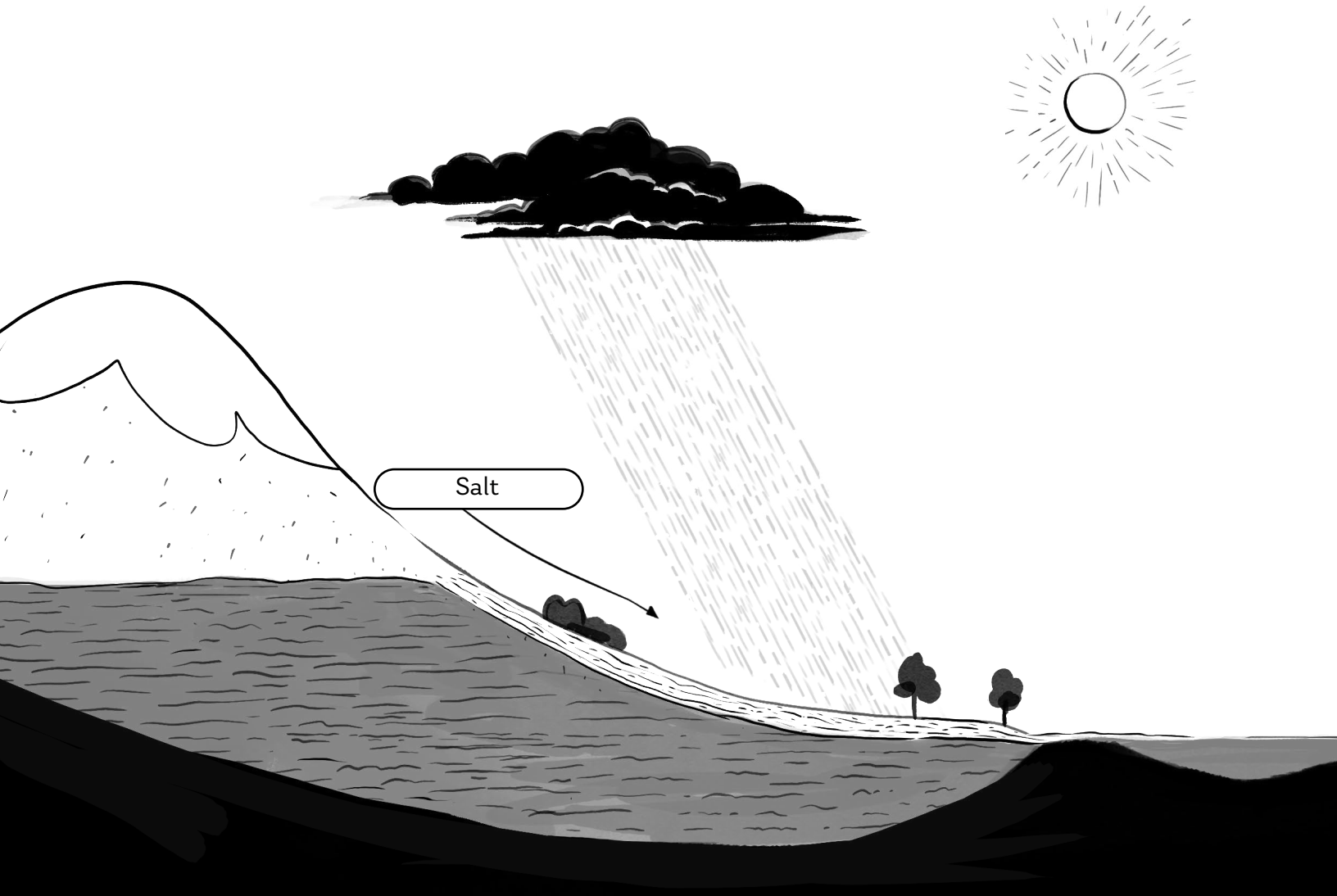
Chemical Oceanography

What is water?

Water is essential for all life. Water can exist in many forms, including solid (like ice), liquid (like the water we drink), and gas (like steam). Because water can exist in these different forms, it can then form precipitation (rain, hail, and snow), clouds, and water vapor. Water also can dissolve more substances than any other liquid and can absorb a lot of heat, making it incredibly important to the way our planet functions.

Why is the ocean salty?

The ocean is salty because rocks and minerals (such as salt) on land are eroded by water and transported by rivers to the ocean. These salts and minerals accumulate in the ocean over millions of years, making saltwater. Approximately 97% of the water on Earth is the saltwater in our ocean, which means that only about 3% of the water on Earth is freshwater, made up of ice, glaciers, lakes, rivers, groundwater, and other surface waters.



Ocean Mysteries

The ocean is vast and mysterious, and there is still so much we don't know. Below are just three unsolved mysteries of the ocean.

What causes the milky sea phenomenon?
In the Indian Ocean and in Indonesian seas, mariners have been reporting "milky seas" for centuries. These milky seas are huge patches of glowing bioluminescence that cover miles and last for long periods of time. Bioluminescence is light created by living creatures using a chemical reaction to make their bodies glow, like a firefly. The nature, function, and extent of bioluminescence is still not well understood.

How do "immortal jellyfish" regenerate?
The Immortal Jellyfish (*Turritopsis dohrnii*): The immortal jellyfish is a small jellyfish found in warm waters that has a special capability that most creatures lack. When the immortal jellyfish starts to die, it sinks to the ocean floor and dissolves itself into a blob of cells, which will become new baby jellyfish. This incredible ability is still not well understood and is an important discovery for science.

Who is the mystery whale?
Scientists have recorded calls from one whale that are recognizable because of its very unusual high pitch and high frequency (52 hertz). These calls do not match any other whale species and have been recorded in many places around the world since the 1980s. No one has ever seen this mystery whale. Its migration track is unrelated to that of other species. Scientists hope to find this mystery whale.

What other ocean mysteries can you think of?

Why Ocean Exploration Matters

There is so much more to learn about the ocean! Most of our ocean is underexplored and not well understood. More than 90% of the ocean has not been explored. There are so many discoveries waiting to be made!

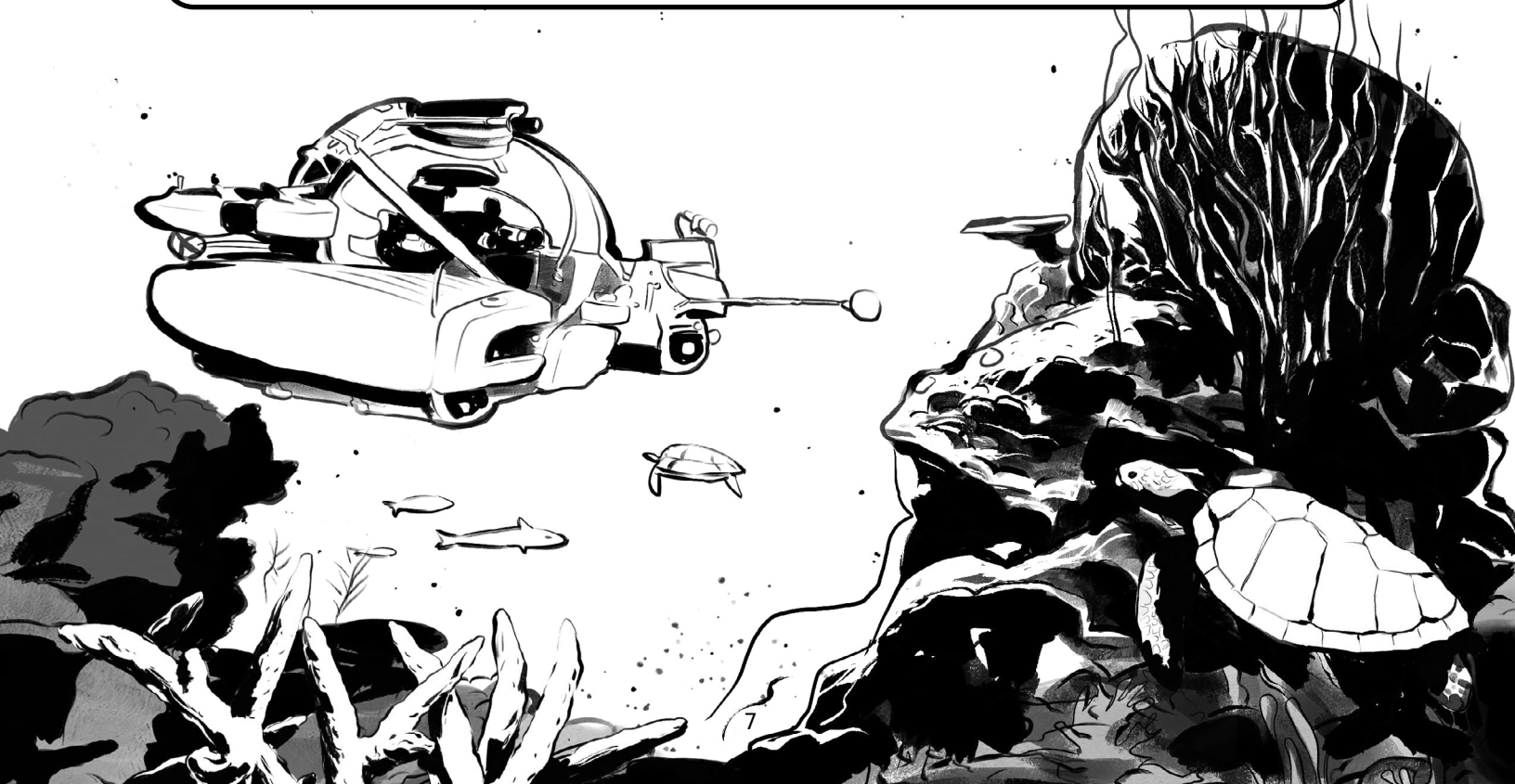
- What animals might live in the unexplored parts of the ocean?
- What sorts of underwater environments are in the deepest parts of the ocean?
- Can you imagine what undiscovered ocean plants might look like?

Studying the ocean is also important for understanding how we can best manage, protect, and conserve the planet's resources. It also can help us understand how we are changing the ocean.

Understanding the deep ocean and extreme habitats will help us to understand life and oceans on other planets.

Exploring the deep can help us develop new innovative technology that can withstand the extreme pressures and temperatures of the deep ocean.

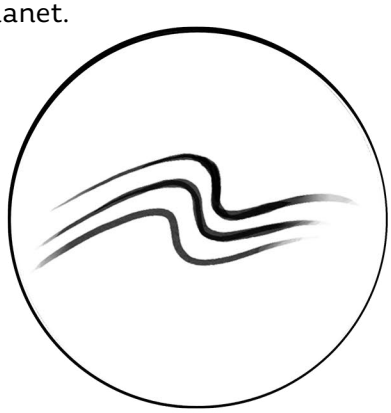
What parts of the ocean do you want to explore?



The Ocean Impacts Us All

The ocean is home to fish, mammals, birds, reptiles, bacteria, fungi, and more. Humans depend on the ocean for food, transportation, jobs, culture, and our everyday lives.

The ocean absorbs heat from the Sun and moves it around the planet through currents. Without the ocean, the Earth would be much hotter and have less oxygen in the atmosphere—we have the ocean to thank for regulating our climate. Protecting the ocean means protecting the future of our planet.

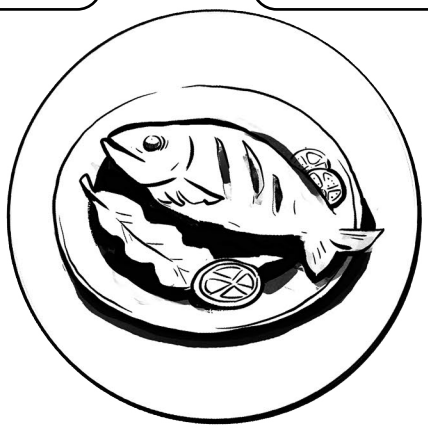


The air we breathe

Climate regulation

Transportation

Recreation



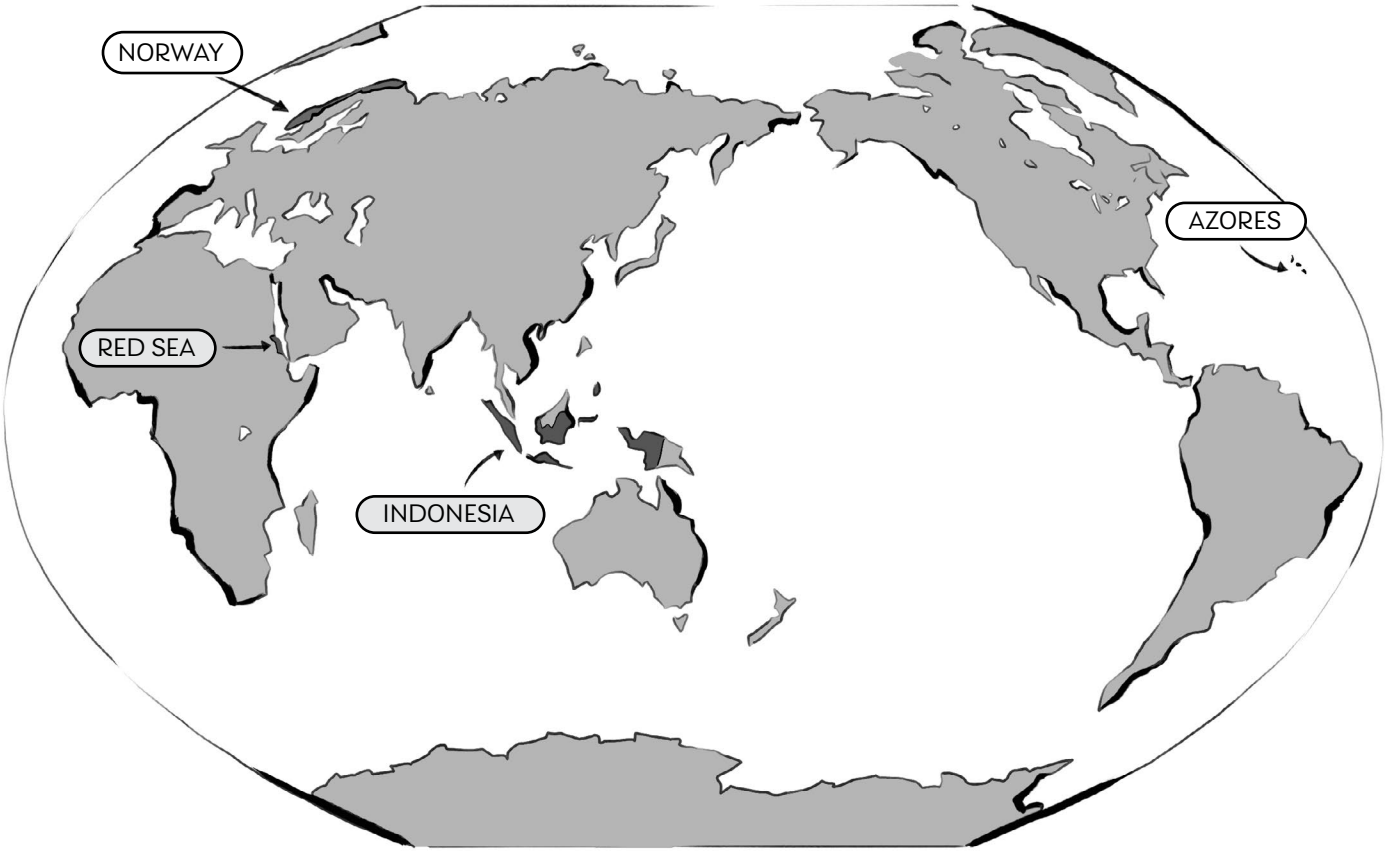
Food

What are some other ways that you interact with the ocean?

OceanX Scientific Missions

OceanX conducts missions working with crew members, technicians, scientists, and filmmakers. The studies done on each mission are guided by local scientists, resource managers, and other governmental organizations involved in the exploration and management of a country's marine resources. After a mission, discoveries are published in scientific journals and made publicly available for the scientific community.

Below are a few of OceanX's recent missions.



Mission	Year	Discoveries and Accomplishments
Red Sea	2020	Identified adaptations of heat resilient reefs, called "Super Corals"
Azores	2021	Documented never-before-seen sponges and reefs
Norway	2023	Discovered new species of sea star and jellyfish
Indonesia	2024	Discovered deep-sea corals

Meet the OceanXplorer

The OceanXplorer research vessel was built to help OceanX explore the ocean and bring it back to the world. It provides access to advanced research tools including submersibles, robots, SCUBA gear, a helicopter, and sampling tools.

There are many laboratories, including:

- The wet lab, where scientists test and analyze samples
- The dry lab, where scientists analyze environmental DNA (eDNA)
- The media lab, where the media team creates and edits film and photos

The OceanXplorer serves as home for scientists, crew, and guests, for up to months at a time. You will find bedrooms, lounges, and a dining hall on board. When the crew is not hard at work, you may even find them playing basketball on the back deck!

SCUBA

SCUBA is an acronym that stands for Self-Contained Underwater Breathing Apparatus—the equipment that divers use to breathe underwater. SCUBA divers use a large metal tank filled with compressed air, a regulator for breathing air from the tank, a mask to see through, a snorkel to breathe at the surface, fins to swim better, and a wetsuit to keep them warm underwater.

Jacques Cousteau was a French ocean explorer, oceanographer, and filmmaker who co-invented the first SCUBA diving equipment, called the Aqua-Lung, in 1942. The Aqua-Lung helped make it possible for Jacques to produce the first underwater films.

Where would you SCUBA dive?

Submersibles

Submersibles are underwater vehicles designed to take people down in the ocean's depths. Unlike SCUBA diving, people using a submersible stay in a dry compartment and can breathe without a mask.

Each of the submersibles used on the OceanXplorer can hold three people. One person is the pilot, who is responsible for controlling the vehicle. The other seats are typically taken by scientists or filmmakers. Submersibles are used around the world by oceanographic explorers and researchers.

The submersibles on the OceanXplorer are named Nadir (which is designed to carry cameras and film equipment) and Neptune (which is designed to take scientific samples). These submersibles can go down 1,000 meters.

In the picture below, the seats next to the pilot are currently empty. Who would you want to go exploring with?

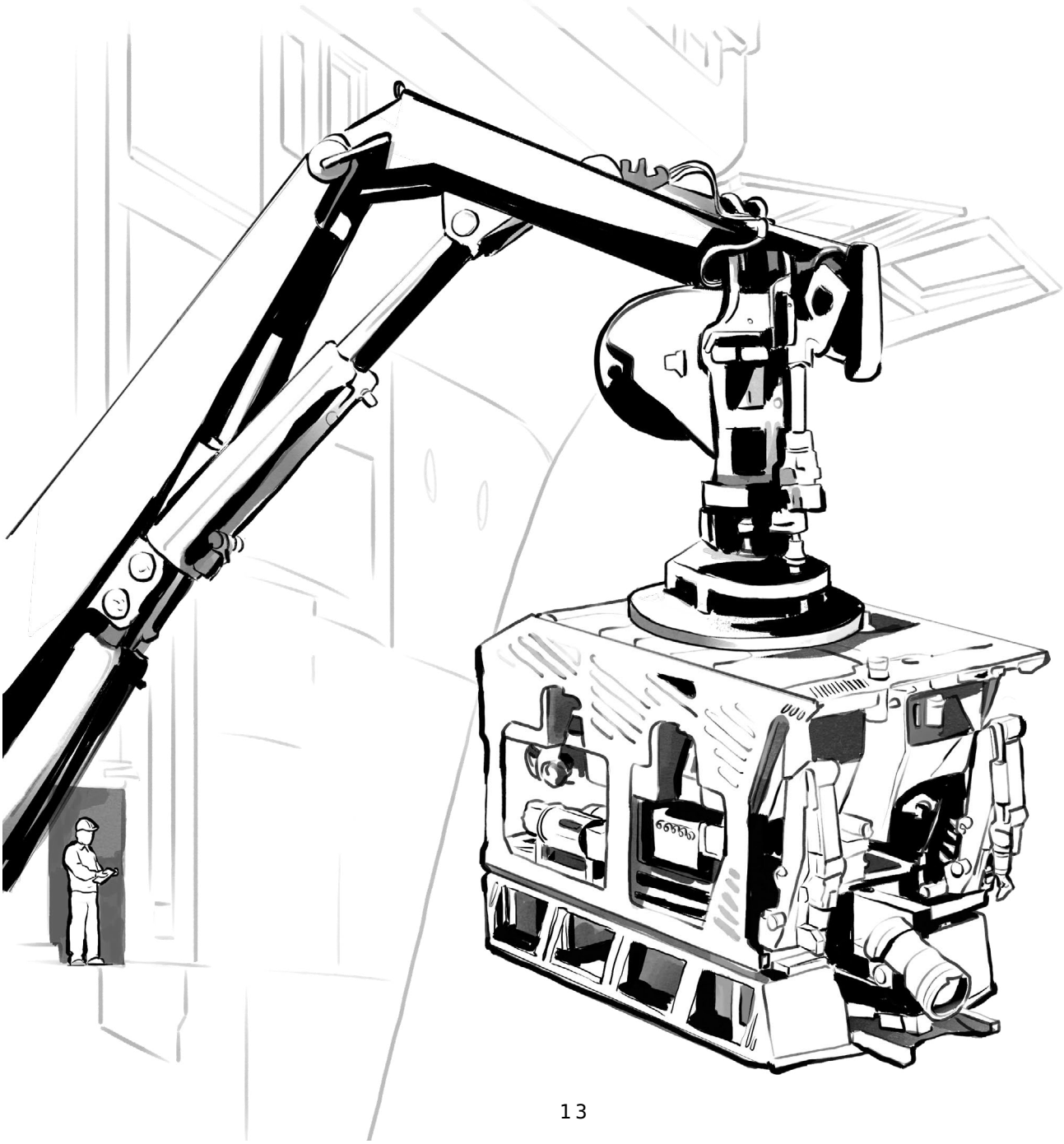
Draw yourself and your exploration buddy in the empty seats.

ROV

ROV stands for Remotely Operated Vehicle. ROVs are robots that are used to take videos and photos and sample underwater environments. Unlike a submersible, people cannot ride in an ROV, and thus the ROV does not have human life support systems on it. This means that the ROV can stay down in the ocean longer than a submersible and go places that would be dangerous for humans.

The ROV on the OceanXplorer is named Chimera and can go down 6,000 meters. (Since 96% of the planet's ocean is 6,000 meters or shallower, this ROV can explore in almost any place that the OceanXplorer could travel to.)

The ROV is connected to a cable on the ship that helps to lower down the ROV into the ocean. The ROV is driven and operated by a person onboard the ship. On the ROV are cameras, bright lights, and manipulator arms. The ROV moves with its thrusters that propel the ROV through the water.

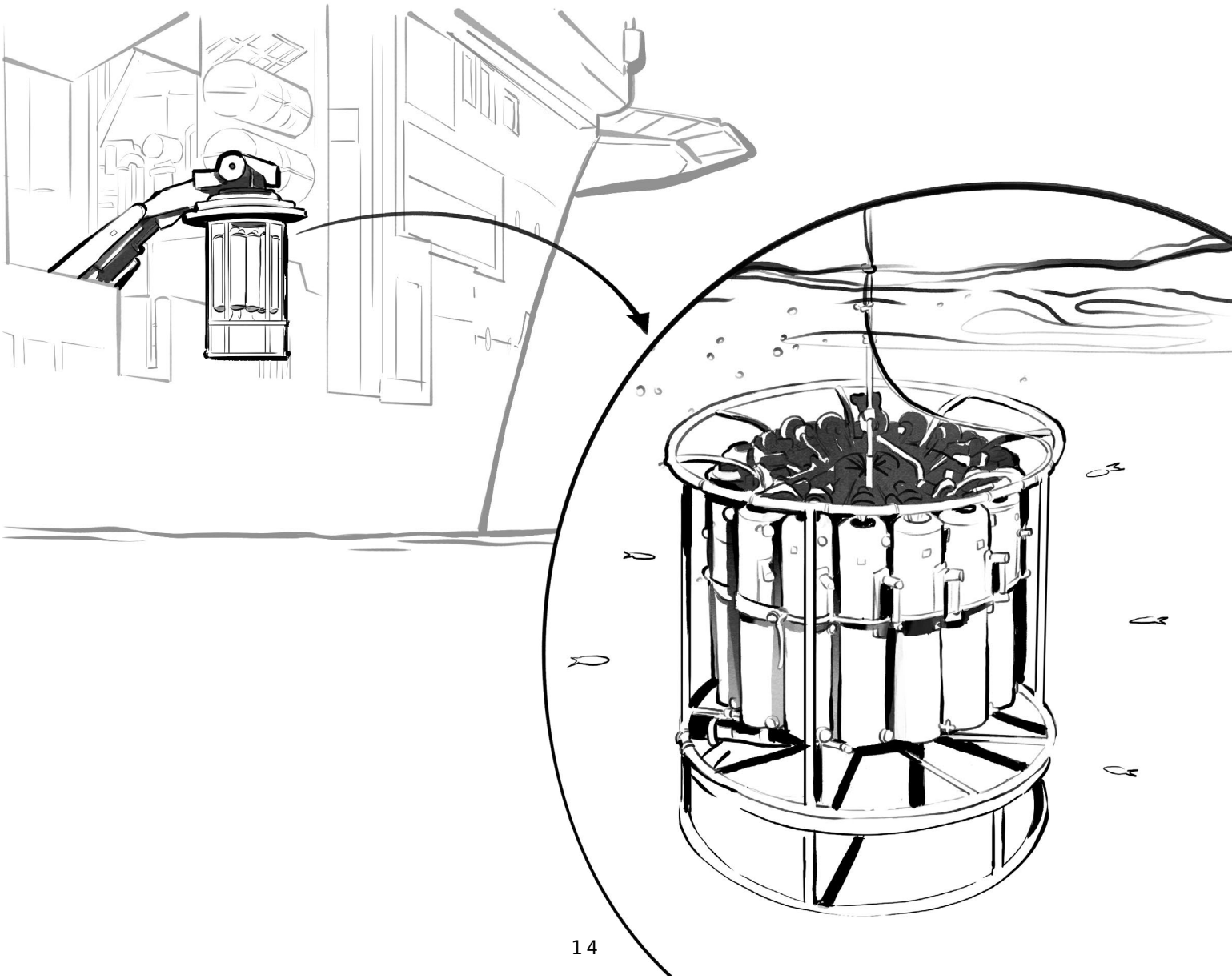


CTD

One of the tools scientists use to understand the water in our ocean is a CTD profiler. CTD stands for Conductivity, Temperature, and Depth.

- Conductivity is a measure of how much electricity can be conducted through a substance, and is directly related to the salt content, or salinity, of water.
- The temperature of the water is measured, and when combined with the salinity, we can calculate the density of the water, which tells us more about currents.
- By combining this information with the depth that the data is taken, we can build a vertical (up and down) set of data about the properties of water in a certain location.

The CTD profiler has a large metal frame that holds sampling bottles. On a mission, the CTD profiler can be sent down deep into the ocean, attached by a signal cable. As the CTD slowly returns to the surface, it can be programmed to open individual bottles at different depths along the way. This allows for water data to be collected at multiple points.



Environmental DNA (eDNA)

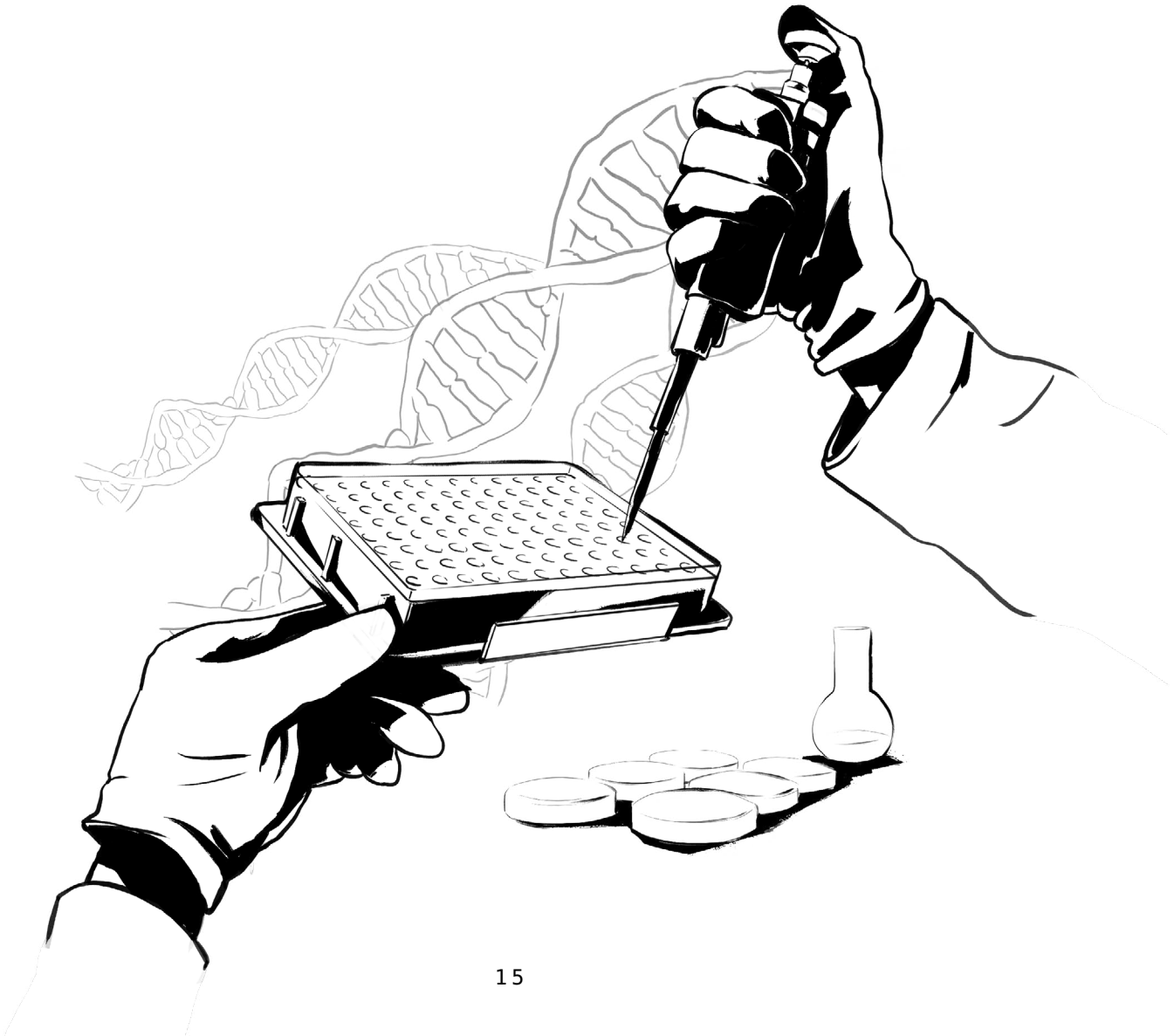
Ocean explorers can figure out what animals have been in parts of the ocean without even seeing them. How? By looking for information left behind in the water.

When people leave a room, they leave behind skin cells and hair, which have DNA (genetic material that carries all of the information about living things, including how things look and function) in them.

When sea creatures travel through an area, they leave behind skin, hair, scales, mucus, and even poop. That means that DNA is left in the water.

Environmental DNA is the DNA left behind as creatures pass through an area, and scientists can analyze this to figure out who has been visiting those waters. Scientists match the DNA that they find with existing libraries of DNA. Sometimes it turns out that the DNA found in the water does not match any known DNA patterns, and that means that those explorers may have found a new species!

The OceanXplorer has a DNA lab on board, though these labs can also be found in many universities and research centers. If a ship doesn't have its own DNA lab, the scientists can bring their water samples to labs when they return to land.

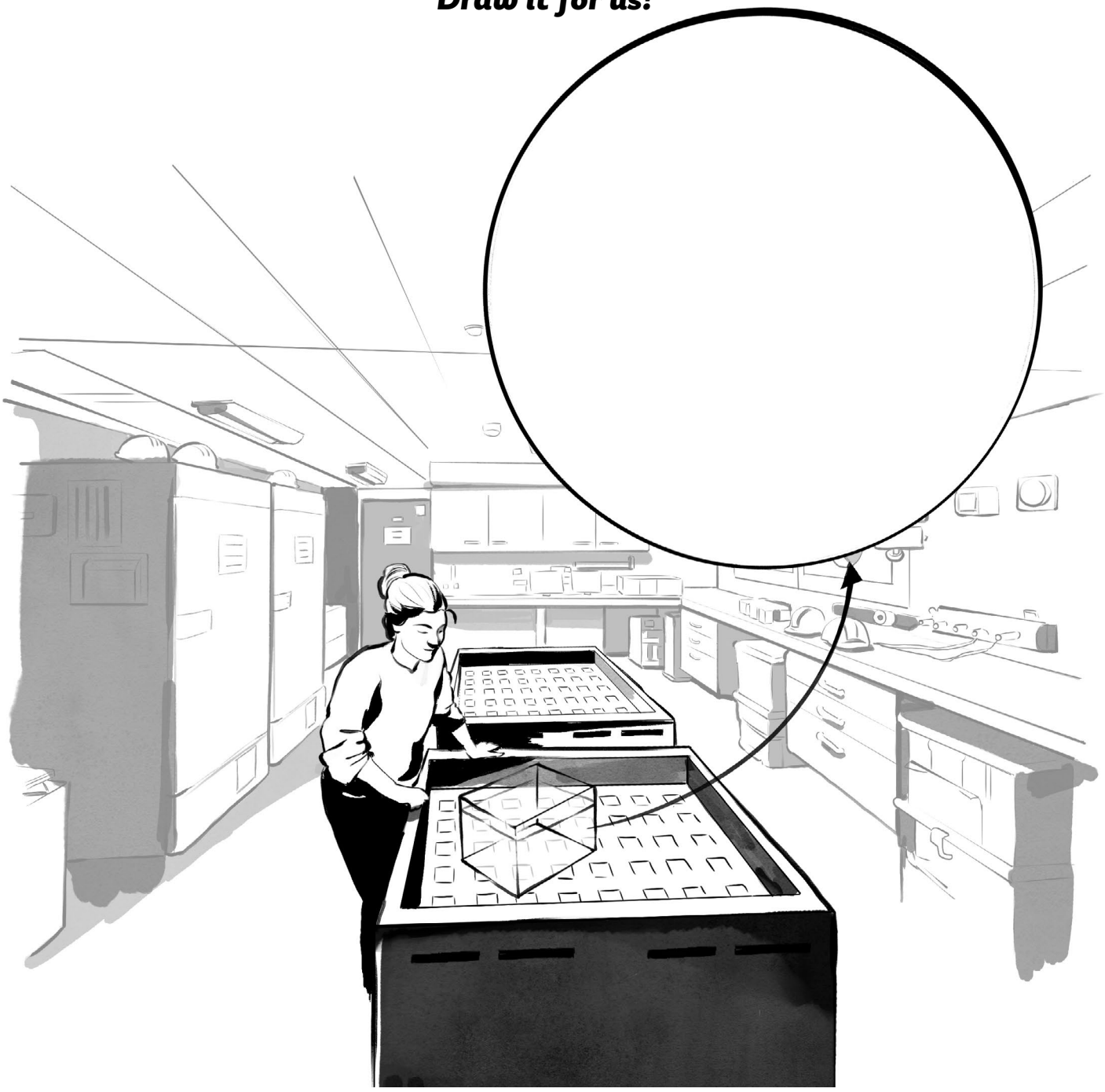


Wet Lab

Wet labs can be found on land and in research ships at sea. They are called wet labs because the room is designed to handle spills, chemicals, and lots of water. On a research vessel, the wet labs are where samples collected by the submersibles, ROV, and SCUBA divers would be brought.

OceanXplorer's wet laboratory is where sample testing, experiments, and analysis happens. In the wet lab, there are sinks, tanks, refrigerators, and freezers for samples, sampling, and analysis equipment.

What do you think is in the tank that this OceanX scientist is looking at? Draw it for us!

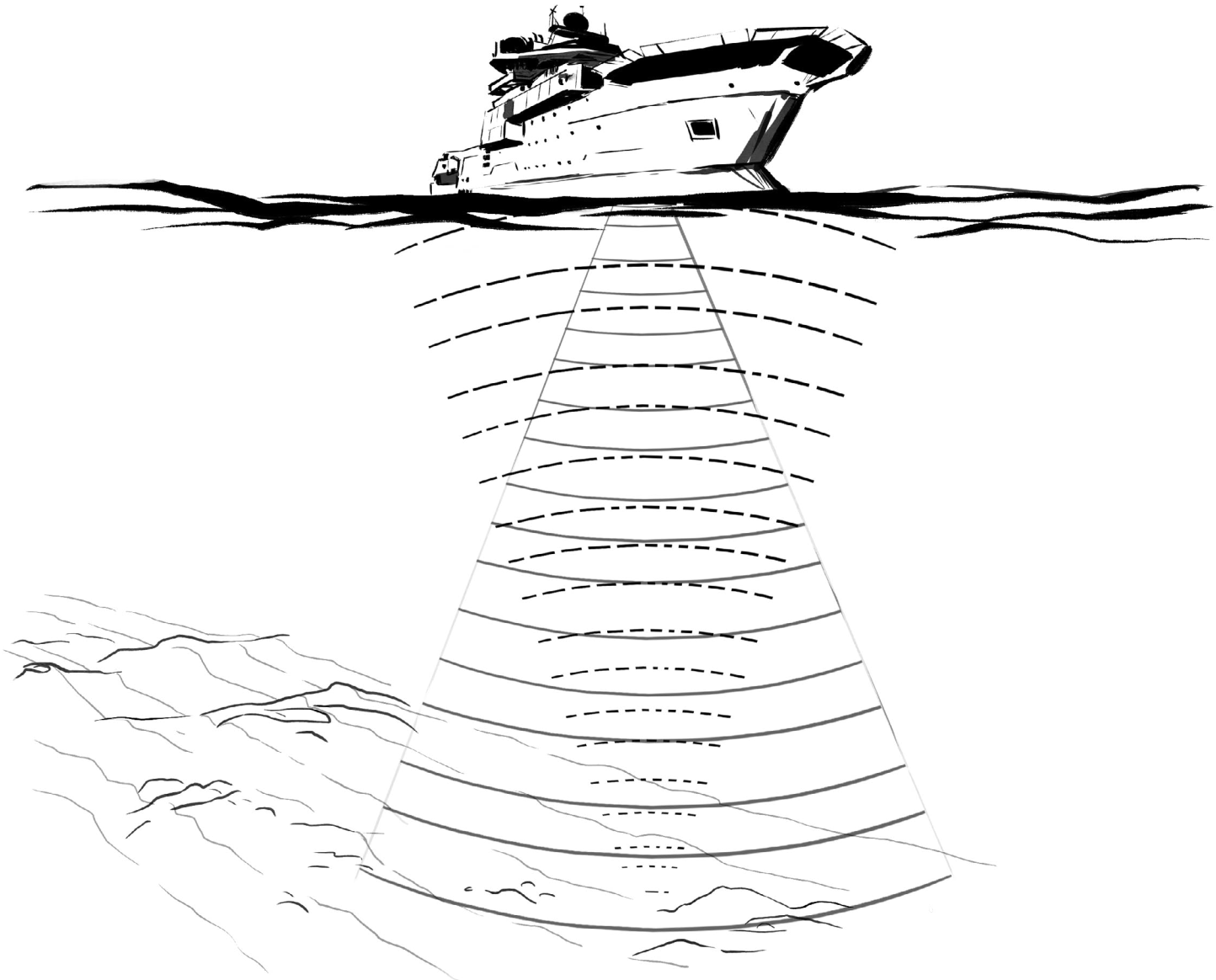


Seafloor Mapping

Seafloor maps show landforms below sea level to help us understand ocean habitats. Maps help us plan safe expeditions and teach us about the natural landforms in the ocean, since most of them are unexplored.

Most modern ocean floor maps are made using acoustic mapping. This means that sound waves are used to find out how deep the water is. Scientists send a signal from the bottom of a ship to bounce sound waves down to the bottom of the ocean and receive a return echo to determine how deep the seafloor below them is, depending on how long it takes for the sound to return. From these echoes, scientists can create maps of the seafloor.

Ocean creatures such as dolphins also use a similar method, called echolocation, where they create noises and then can navigate through the water based on the echoes of those sounds.



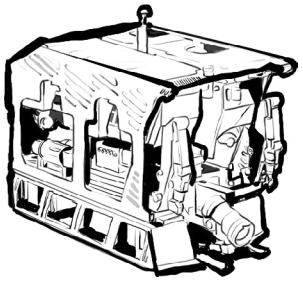
Ocean Exploration Careers

Ocean exploration is a team effort and involves many people who have a wide variety of skills and interests. Here are just a few of the careers involved in an expedition:

- **Captains** are responsible for all aspects of a research vessel and the safety of its crew. Ocean research expeditions involve many people, lots of equipment, and often dangerous weather and conditions. The captain is constantly assessing the situation and making choices to enable the success of the mission and the safety of everyone involved.

- **Ocean scientists** conduct experiments, collect data, and analyze trends to understand how our ocean works. Ocean exploration involves scientists from many specialties, such as marine biology, chemistry, and geology.

- **Submersible pilots** are responsible for the maintenance and operation of ocean submersibles. They make sure that the vehicle is ready to safely dive deep into the ocean, and then they are the ones driving the submersible and operating most of the equipment on board.



- **ROV pilots** maintain and control the remotely operated vehicles. Typically, the ROV pilot is on the ship that the ROV is attached to, and they are the one watching the video and sensor data coming from the robot in real time. They often work closely with the scientists and expedition leaders to ensure that the desired data and samples are collected.

- **Filmmakers** oversee all aspects of film production—from the idea, to writing, to the final movie or show. Ocean storytelling is an important way of getting people to care about protecting our ocean.

- **Chefs** on oceanographic research vessels are responsible for cooking and preparing the food that is served on the ship. Food is an important part of keeping an ocean expedition's crew happy, so the chef is a very important part of the team.

- **Seafloor mapping specialists** use equipment including sonar to create maps of underwater environments and provide support on the ship for navigation.

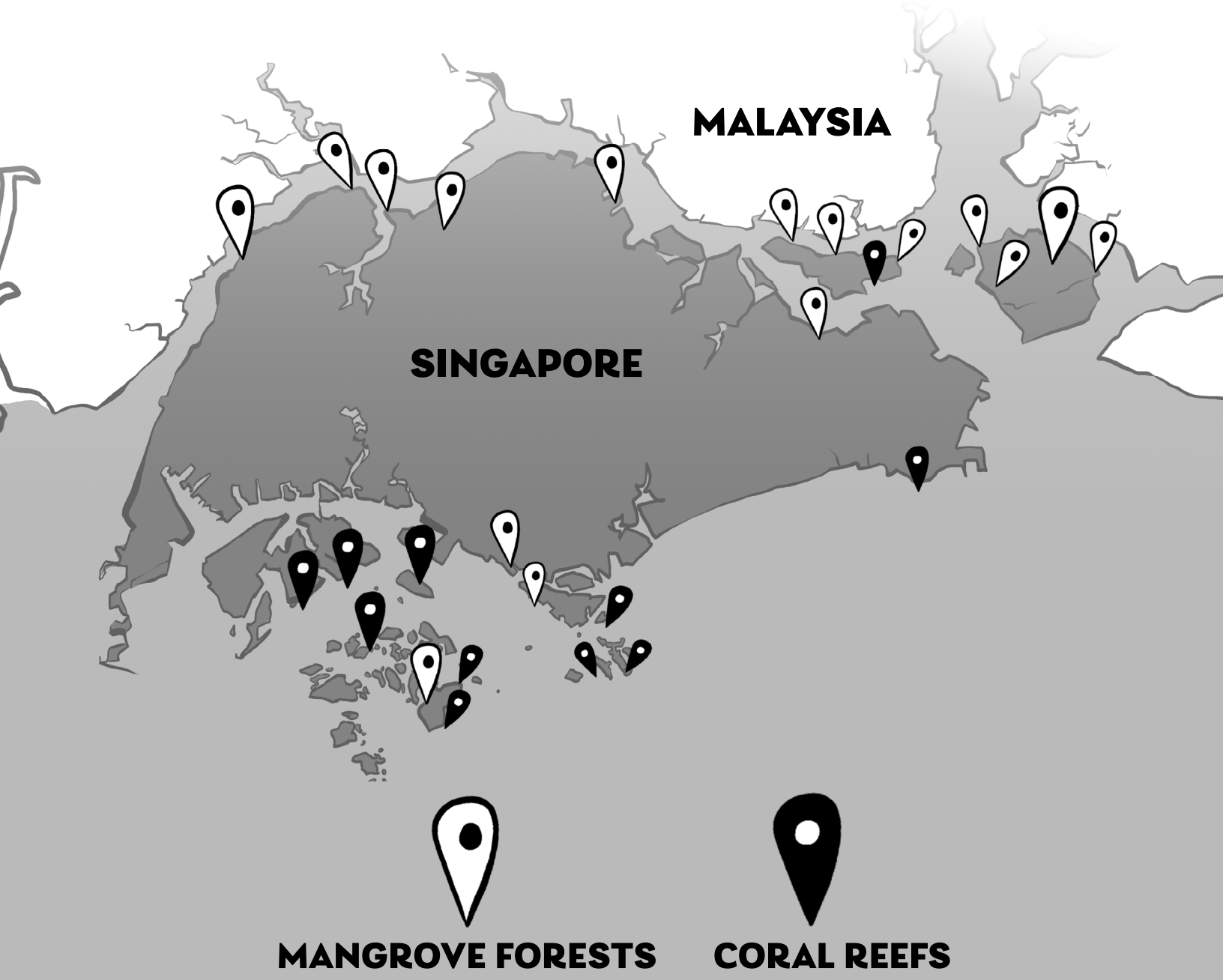
- **Deckhands** maintain the ship and its mechanical equipment. They have to understand how the ship operates, the goal of each mission, and the environment.

Which job do you find most interesting? Why?

The Ocean and Singapore

Singapore is a country with a tropical rainforest climate, located approximately one degree north of the Equator. It consists of more than 60 islands, though only two are inhabited by people. Mainland Singapore (historically known as Pulau Ujong, meaning 'island at the end') and Pulau Ubin (or 'granite island') are home to Singapore's population of nearly 6 million people. In spite of its small size of approximately 730 square kilometers, Singapore is home to one of the largest and busiest ports in the world!

With the Johor Strait to the north and the Singapore Strait to the south, the waters surrounding Singapore connect the Indian Ocean to the South China Sea. These waters feed and flush into marine ecosystems in Singapore like coral reefs, seagrass meadows, and mangroves. Even though Singapore's seascapes have seen many changes due to rapid development, land reclamation, and seaport activities, an impressive amount of marine biodiversity continues to thrive in Singapore.



Singapore's Coral Reefs

Coral reefs are the most biologically diverse marine ecosystems on the planet. Typically found in shallow water depths, these underwater cities are made up of colonies of hard and soft corals that support a wide range of fascinating marine life.

Coral reefs are important because they:

- Provide shelter, food, and breeding grounds for 25% of all marine species
- Protect shores from being washed away by strong waves
- Provide income and food for millions of people who live along the coasts and depend on fisheries for their livelihoods

Located in a region with shallow tropical waters ideal for supporting coral life, Singapore is home to amazing coral reef diversity – some of which have been growing for more than 7,000 years.

There are more than 250 species of corals, more than 200 species of sponges, and 120 species of reef fish that call Singapore's waters home – mostly in the Southern Islands. The diversity of corals here is almost half of what you would find in the Great Barrier Reef in Australia and about three times as many as in the Atlantic Ocean!

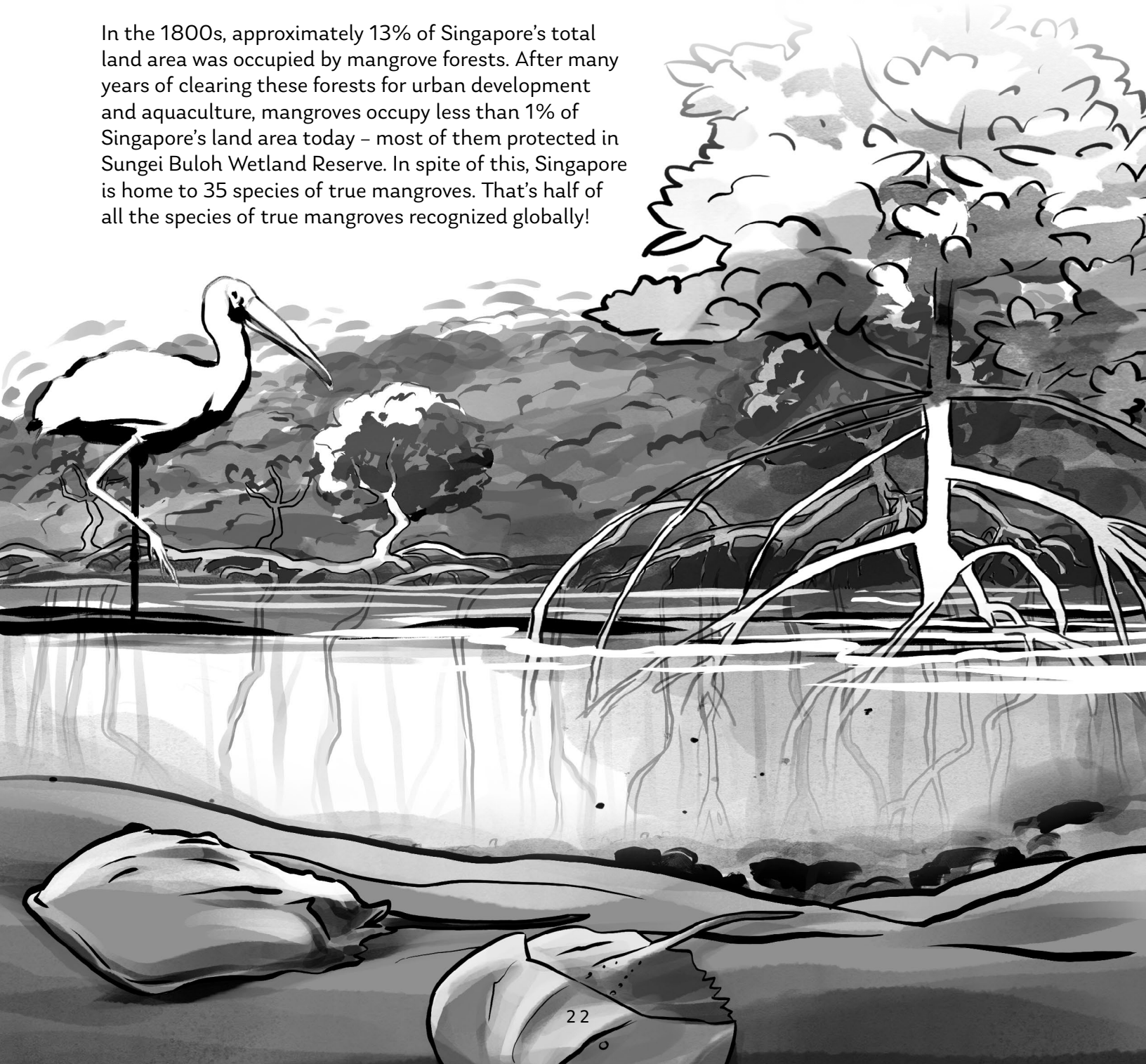
Singapore's Mangroves

Mangroves are trees that can be found along coastlines and rivers, which means they can survive in brackish and saltwater environments. There are many types of mangroves, though some of them are easily recognizable because their thick tangle of roots make the trees look like they are standing on stilts in the water.

Mangroves are extremely productive and necessary ecosystems, because they:

- Protect coasts from intense storms, floods, and erosion
- Provide shelter, nursery grounds, and food for many animals such as fish, crabs, and birds
- Provide natural resources and raw materials for many people (especially coastal communities)
- Absorb and store large amounts of carbon

In the 1800s, approximately 13% of Singapore's total land area was occupied by mangrove forests. After many years of clearing these forests for urban development and aquaculture, mangroves occupy less than 1% of Singapore's land area today – most of them protected in Sungei Buloh Wetland Reserve. In spite of this, Singapore is home to 35 species of true mangroves. That's half of all the species of true mangroves recognized globally!



Singapore's Seagrasses

Seagrasses are the only flowering plants that have the ability to live submerged in the sea. Though seagrasses are generally less well-studied and mapped globally, we know that they are unique ecosystems that are home to marine biodiversity.

Seagrass meadows are extremely important ecosystems, because they:

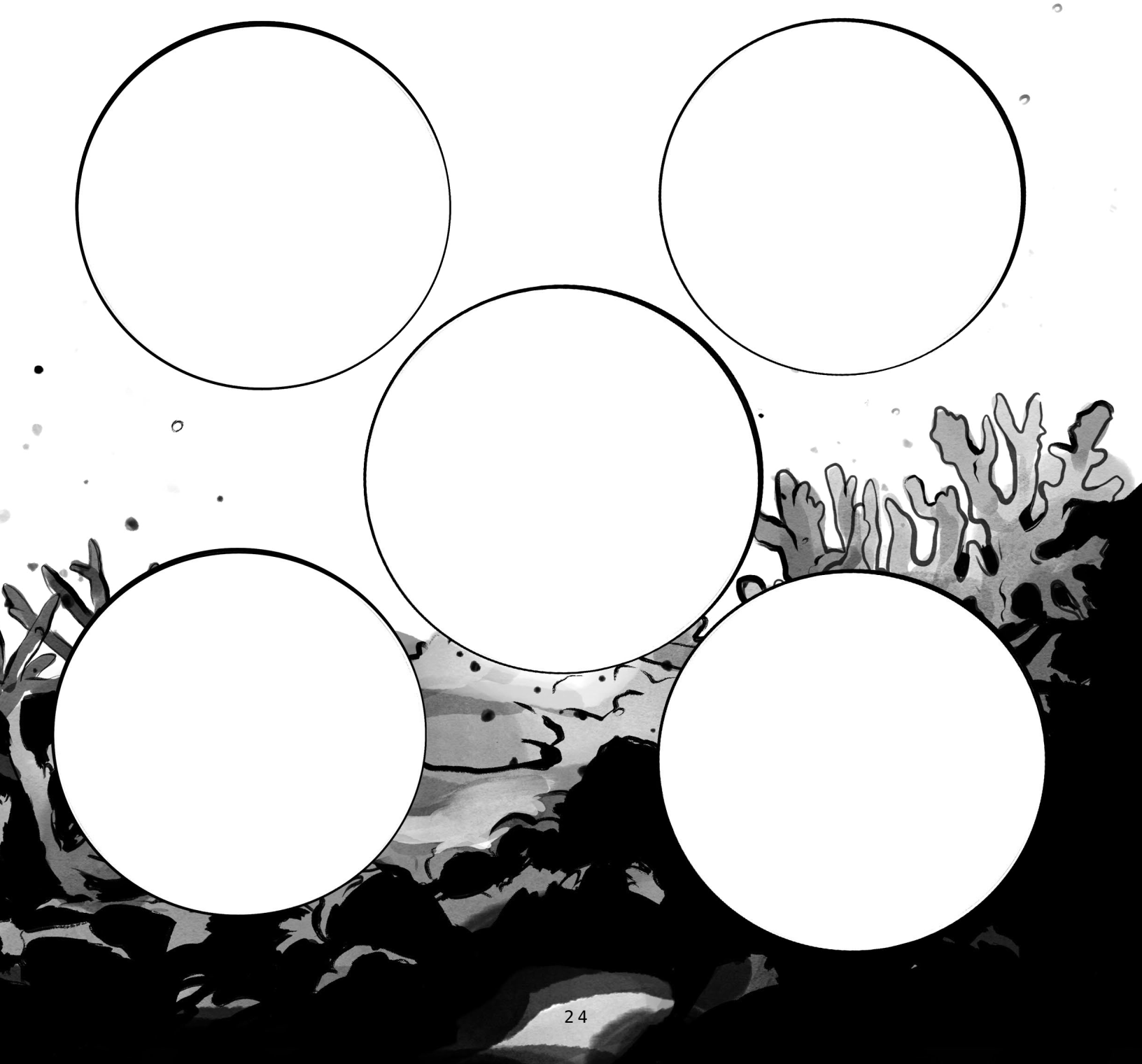
- Provide shelter, nursery grounds, and food for many marine species such as fish, sea stars, seahorses, turtles, and dugong
- Stabilize the seabed during storms and by trapping sediment and nutrients
- Filter the surrounding seawater
- Absorb and store large amounts of carbon

Singapore is home to an incredible 12 species of seagrasses, some of them tinier than your finger, while others like Tape Seagrass *(Enhalus acoroides)* could grow to 1.5 meters long! Though they form the main part of the diet of dugongs and some sea turtles, seagrasses are also hosts to algae, which make seagrass meadows great restaurants for small marine wildlife that need something to hang onto while they feed. Most of Singapore's seagrasses can be found in Chek Jawa Wetlands on Pulau Ubin in the north, and Pulau Semakau and Cyrene Reef in the Southern Islands.

How can we help the ocean and the creatures that live there?

Even someone who lives far away from the ocean is impacted by it. Every one of us can have an impact and help protect our ocean.

Write down, or draw, 5 ideas you have for actions that will make a positive impact on the ocean.



OCEANX
Education

Hello educators and students!

This book is a prototype of OceanX Education's classroom resource for primary and secondary school students. We would love to hear your feedback. Please send your ideas and suggestions to education@oceanx.org and also let us know if you would like copies for your students.

OceanX is on a mission to explore the ocean by combining science, technology, and media to study and raise awareness for the oceans and create a community engaged with protecting it. OceanX supports and facilitates ocean research for scientists, institutions, media companies, and philanthropy partners.

OceanX Education is creating a generation of passionate ocean leaders who will use their ocean knowledge to have profound and lasting impacts on our planet. This nonprofit initiative educates young people about the importance of ocean conservation, research, and science communication to bring more diverse voices from around the world into the critical conversations about the biggest issues facing our planet. OceanX Education is bringing programming and opportunities for deep-sea exploration, media, and innovation to audiences worldwide, with a behind-the-scenes chance to understand deep-sea exploration and media production.

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