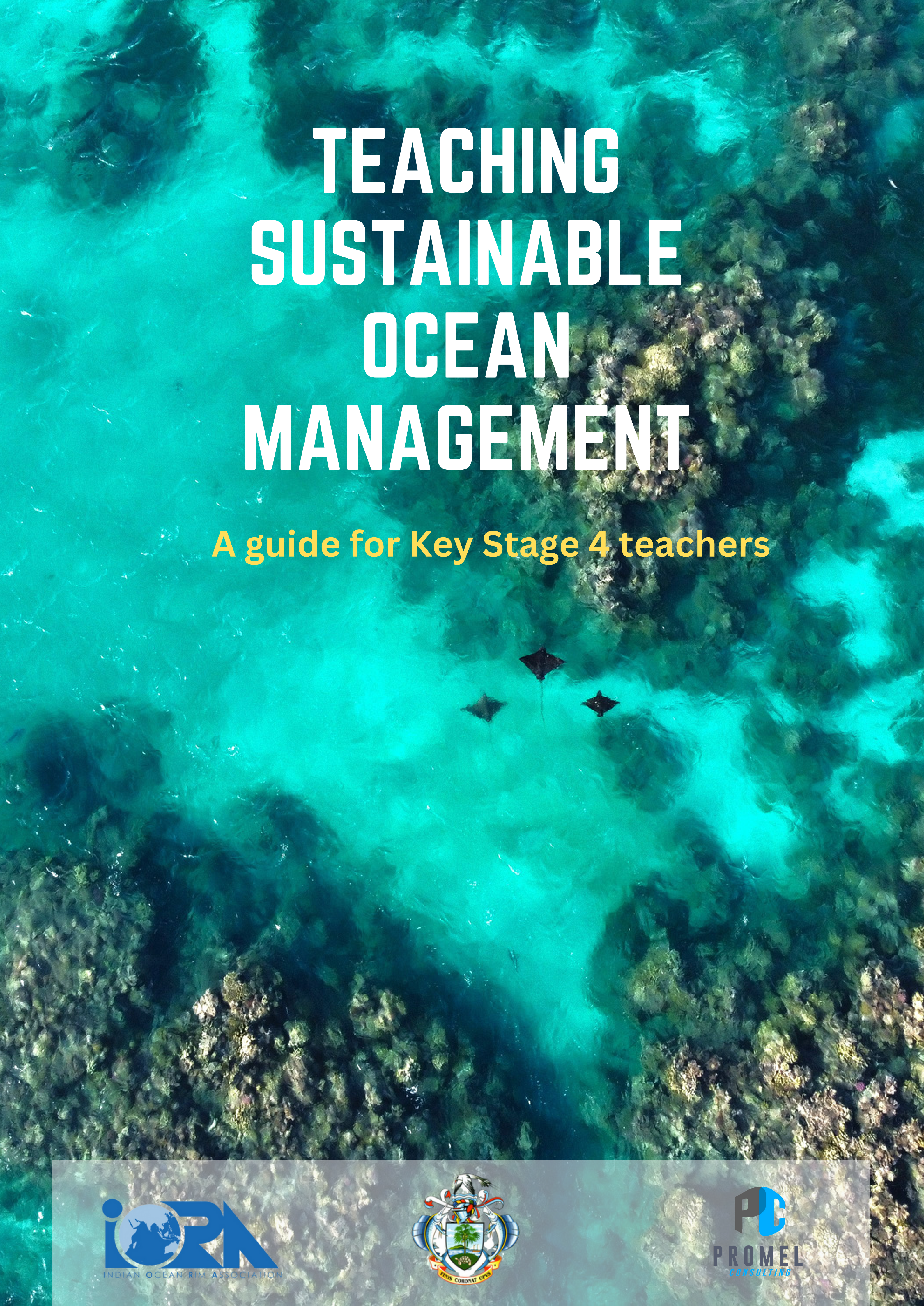
TEACHING SUSTAINABLE OCEAN MANAGEMENT

A guide for Key Stage 4 teachers



INDIAN OCEAN RIM ASSOCIATION

FINIS CORONAT OPUS

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Acknowledgements

The Teacher's guide on sustainable ocean management would not have come to fruition without the support and funding from the Indian Ocean Rim Association. Special gratitude goes to the Government of Seychelles for championing the development of the Sustainable Ocean Management (SOM) Education Programme. Seychelles has prioritised this initiative for more than five years, considering the emphasis placed on education for sustainable development in the formal education system by improving the learning content to integrate critical issues such as the sustainable management of marine environment and resources into the curriculum.

The development of this guide is based on the ideas provided by teachers, scientists, curriculum developers, and other experts. Their contributions were deemed valuable, especially while developing the conceptual framework of the proposed SOM principles.

Additional gratitude also goes to individuals from international organisations for sharing core ideas and documents about ocean literacy, namely:

- Francesca Santoro - Intergovernmental Oceanographic Commission of UNESCO
- Angelique Pouponneau - Alliance of Small Island States

Finally, recognition goes to the following organisations for the core documents developed on ocean literacy:

- Indian Ocean Rim Association.
- International Oceanographic Commission of United Nations Educational, Scientific and Cultural Organization.
- National Marine Educators Association.
- The United Nations Educational, Scientific and Cultural Organization.

The documents provided valuable concepts and tools that also influenced the content of this publication.

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Preferred Citation: Emilie, S., & Antat, R. (2023). *Teaching Sustainable Ocean Management: A guide for Key Stage 4 teachers*. Department of Blue Economy, Seychelles.

Published by the Department of Blue Economy
www.mofbe.gov.sc/blue-economy/

ISBN: 978-99931-878-1-7

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Foreword

Message from the
Secretary General of IORA

Blue Economy, as one of the cross-cutting issues of the IORA, is a high priority for the Member States, which aims to facilitate economic activities that would contribute to sustainable wealth from the region's oceans and coasts. "Sustainable ocean management", that is, adopting an ecosystem-based approach to using marine resources, is crucial in ensuring the ecological sustainability of the oceans.

Since introducing the blue economy in IORA in 2014, the Member States have carried out several capacity-building programmes. However, the project entitled "Ocean Knowledge Education Programme to strengthen the Blue Economy concept in the IORA region – A pilot study incorporating "Sustainable Ocean Management" into the curriculum for 12 to 13 yr old" is the first of its kind in developing a Sustainable Ocean Management (SOM) education programme.

This project will engage youngsters to become ocean literate for the future development of a sustainable Blue Economy. It will educate the youngsters and increase their knowledge on marine-related topics that would change the mindsets of future leaders and policy-makers towards more responsible and sustainable management of the oceans and its resources. The guide will not only be a long-term asset for Seychelles, but it will serve as a reference to other Member States for the years to come, who can learn from the experiences and best practices of Seychelles.

The IORA Member States are diverse in terms of economic structure and development. Each country has a different regulatory framework governing the blue economy. Therefore, before using the guide, IORA would like to encourage Member States to consider their needs and capacities.

IORA would like to commend Seychelles for leading this project. We believe promoting marine education among youngsters now would guarantee more equipped future leaders and policy-makers working towards a more sustainable ocean economy.

Dr. Salman AL FARISI
Secretary General
Indian Ocean Rim Association

Message from the
Principal Secretary of the Blue Economy Department

As a Small Island Developing State, Seychelles is heavily reliant on its ocean resources for economic gains, but most importantly, for the livelihood of its people.

There is a need, therefore, to educate and instil in our young people the importance of protecting our ocean space and its invaluable resources.

As the driver of the Blue Economy in Seychelles, the Department of the Blue Economy places paramount importance on the sustainable use of our ocean resources and its services. This is “sustainable Ocean Management”, where we ensure that Seychelles’ ocean environment is managed effectively, thus, ensuring ecological sustainability.

The Ocean Knowledge Education programme aligns with our Blue Economy Strategic Policy and Roadmap’s vision: "to conserve the integrity of our marine environment and heritage for present and future generations through a knowledge-led approach”. As a result, we expect to develop capacity, especially that of young people, to allow Seychelles to effectively manage its ocean and take advantage of our ocean's opportunities today and in the future.

We hope the project will increase our young learners’ knowledge of ocean resources and how the ocean can improve their lives.

The Department of the Blue Economy would like to encourage all teachers to use this guide. You can use it effectively to allow your students to understand that their actions have consequences towards the ocean and that the ocean provides us with the resources we need to sustain ourselves as a nation.

Finally, I would like to thank the Indian Ocean Rim Association (IORA) for providing Seychelles with the opportunity to drive this project at the regional level. Your support has been well appreciated as we take a common approach to equip our young people in the region with the right tools to become ocean-literate individuals.

Thank you!

Ambassador Kenneth RACOMBO
Principal Secretary
Department of Blue Economy
Ministry of Fisheries and the Blue Economy

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Introduction to Sustainable Ocean Management

Seychelles and other small island developing states (SIDS) are heavily dependent on the ocean. They are globally known as ocean nations, utilising coastal and marine resources for their livelihoods and economic benefits. Amid the rapidly evolving economy, driven by human needs for transportation, energy, food and recreation, the ocean continues to face alarming pressures. Human-induced issues such as marine pollution, loss of biodiversity, overfishing and climate change further exacerbate these effects. The younger generation must be aware of these issues highlighted by Sustainable Development Goals (SDGs) 14 and 4.7. This will ensure that the younger generation becomes ocean literate - developing a better understanding of the ocean's influence on us and our influence on the ocean. As a result of this, our younger generation will be able to:

- Understand the importance of the ocean to humankind.
- Communicate about the ocean in a meaningful way.
- Take informed decisions and responsible actions that promote ocean sustainability.

Establishing an ocean-literate society is vital to a healthy, productive, and resilient ocean. This is because empowered individuals are better equipped to find a balance between various ocean uses and protecting the natural marine ecosystems from anthropogenic harm. As part of Sustainable Development Goal 14, the ocean and its resources should be conserved and used sustainably. This is pivotal if societies wish to optimise the overall ocean economy, also known as the 'Blue Economy' to:

- improve livelihoods and jobs;
- eradicate poverty, and
- provide essential goods and services to communities.

Sustainably using ocean resources is vital to preserving the health and resilience of our ocean to meet the needs of the current and future generations. SIDS and developed countries must work together to ensure better governance of human activities in the shared ocean, with decision-makers leading and actively engaging the wider community in ocean-related matters. There should be a clear understanding of the importance of sustainably managing an island's state ocean area under its national jurisdiction to advance the ocean economy without compromising social development and ecological sustainability.

According to UNESCO (2021), Education for Sustainable Development can help towards this end since it provides a broad framework to incorporate Sustainable Ocean Management (SOM) concept and objectives in the formal education system.

Seychelles has promoted the Blue Economy concept worldwide in the last few years. Still, our current formal learning content must be improved to equip our younger generation with the knowledge, skills, and attitudes concerning ocean sustainability.

What is Sustainable Ocean Management?

Sustainable Ocean Management is about the collective efforts of all countries to sustainably manage the shared ocean space with the goal of balancing different uses and needs to achieve healthy and productive ocean ecosystems for current and future generations.

Whether countries are surrounded by sea or land, they depend on the ocean for many reasons, such as trade, shipping, travel, and tourism. Hence, the words 'shared ocean space' in the above definition implies only one ocean comprising different ocean basins. Together, they are part of a connected system of water benefiting everyone on Earth. The authors acknowledge the legal status of maritime zones that belongs to coastal states, but the fact remains that these zones are still part of the global ocean, which should be sustainably managed. Activities happening in several parts of our shared ocean will negatively impact other parts of the ocean and those who rely on it. Hence, a global partnership is required to achieve healthy ocean ecosystems and a sustainable ocean economy for current and future generations.

SOM, also known as Integrated Ocean Management, is linked with the Blue Economy concept. While developing the Blue Economy, countries must adhere to the core principles of sustainable ocean management.

Sustainable Ocean Management Conceptual Framework for Secondary 1 students only

A conceptual framework was developed to describe what should be taught about sustainable ocean management at Key Stage 4 for Secondary one students to be considered ocean literate. The framework was developed based on the following:

- documents consulted;
- ideas proposed by teachers during the inception and validation workshops;
- ideas proposed by ocean experts and other professionals during the consultative meetings;
- recommendations from a study conducted by the Ocean Educator to incorporate SOM in the science learning content;
- knowledge and expertise of the authors.

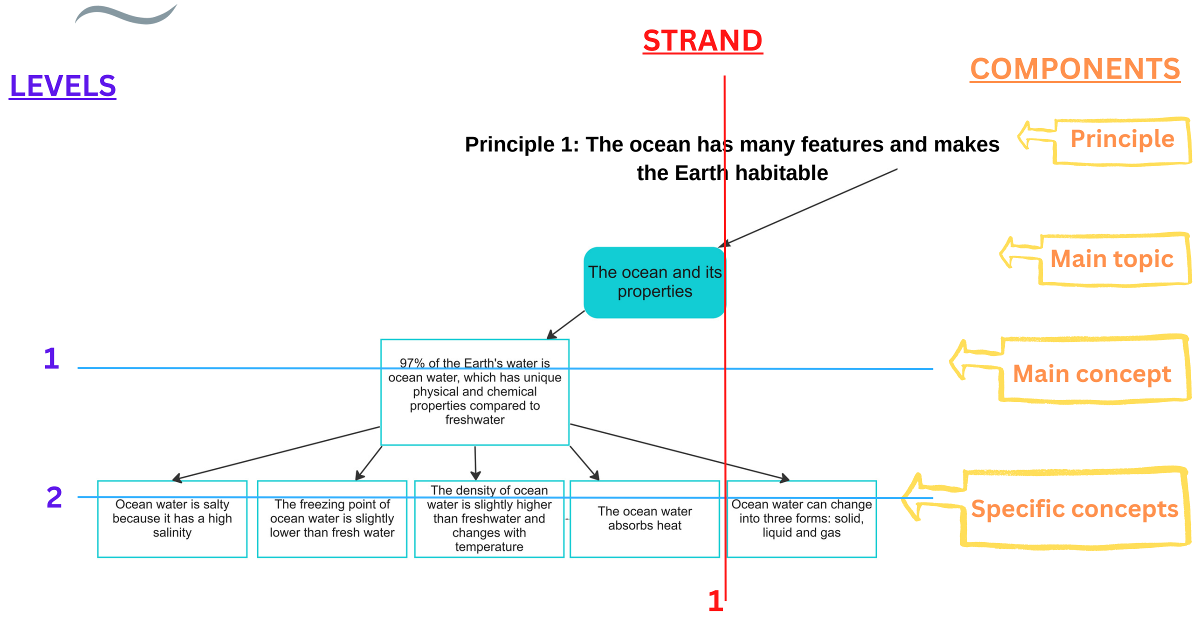
The conceptual framework illustrates SOM's complex ideas for students aged 12-13 or from Secondary 1. It is presented as concept maps organised under the corresponding SOM principles proposed by the authors.

Principle 1 - The ocean has many features and makes the Earth habitable.
Principle 2 - The ocean supports a diversity of life and ecosystems.
Principle 3 - The ocean influences the Earth's weather and climate.
Principle 4 - The ocean is vital to the well-being and prosperity of humans.
Principle 5 - The ocean is threatened by human activities that lead to various problems and their associated risks.
Principle 6 - The ocean's health and productivity can be achieved through collective sustainable solutions.
Principle 7 - The ocean is largely unexplored and should be understood for us to continue to conserve and sustainably manage the shared ocean, its ecosystems, and resources.

The development of the seven principles of SOM was influenced by the current principles of ocean literacy (UNESCO, 2021a) and the critical societal outcomes of the UN Decade of Ocean Science for Sustainable Development (UNESCO, 2021b).

The concept map for each principle first comprises the main topics presented in coloured boxes (turquoise, green or yellow) with rounded corners. The main concepts presented in boxes with coloured frames are then organised under each topic. The more specific concepts are branched from each general idea, presented in boxes and arranged in a hierarchical structure. Solid lines linking one box to the other illustrate the relationships between general and specific concepts. Instances where dashed lines are used to connect boxes lead to an additional idea worth considering when building content for the particular concept. Each concept map may illustrate 1-4 levels of ideas organised into strands. Please take a look at Figure 1 overleaf for an example of a concept map with two levels of ideas (this excludes the main topic).

Figure 1



This concept map illustrates only one strand comprising various components and two levels of ideas. The strand begins with the main topic, and then assembled below are the main concept and the specific concepts that support the topic's main idea.

Using concept maps in scientific literacy is considered an effective learning method for teaching science concepts and is also used as an assessment tool (Reiska et al., 2015). Concept mapping helped structure and illustrate the scientific knowledge that needs to be taught on sustainable ocean management under each topic. On this note, the concepts and propositions in this conceptual framework were deemed appropriate for Key Stage 4. This gives prominence to meaningful learning opportunities for students to better understand the combined set of ideas and determine connections between concepts stored in their memory (Reiska et al., 2015; Novak & Cañas, 2008).

A focus question guided the development of each concept map; for example, when developing the concept map for the 5th SOM Principle, the focus question was, 'How do humans impact the ocean and why?' While answering this question, the authors identified the various human activities affecting the ocean locally and globally. The everyday activities were then organised as critical concepts to be taught to Secondary one students under the main concept of 'Human activities contribute to changes in the ocean and atmosphere'. The underlying factors influencing human activities were then listed and later organised into a separate group of critical concepts but under the second main concept of Principle 5, which reads as 'Various factors are influencing the human activities affecting the ocean and atmosphere'.

The concept map for each SOM principle is presented in Section 4 of this publication.

Alignment of this guide to the Science Teaching and Learning Programme for Secondary 1

According to Chang et al. (2021), an individual's perception and importance of the ocean are significantly influenced by relevant scientific knowledge acquired through formal education. This also allows for effective environmental and ocean-related policies to be attained. This document lays the foundation for essential ocean concepts to be taught in science, but for now, the target group is Key Stage 4 students. The content of this publication aligns SOM with the Science Teaching and Learning Programme for Secondary one students in Seychelles by providing a comprehensive description of the concepts to be taught in formal education. The alignment of SOM to the Science Teaching and Learning Programme empowers teachers to contextualise the learning content so that crucial scientific knowledge about the ocean is taught to build upon everyday knowledge about the sea.

This guide is part of the Ocean Knowledge Education Programme championed by the Government of Seychelles with support and funding from the Indian Ocean Rim Association. It should be used alongside the following documents:

- The second edition of the Science Teaching and Learning Programme for Secondary one students revised by the Curriculum Designer.
- Resource pack developed by the Ocean Educator.
- Teacher's Lesson book developed by Promel Consulting.
- Student's textbook and workbook developed by Promel Consulting.

The connections between this document and other alignment documents justify the need for teachers to value these resources to address a gap in the formal learning content on ocean sciences to empower students to become ocean literate. At the end of the learning module, the students are expected to develop the following competencies of a scientifically literate individual who,

i) is interested in and understands the world around them;
ii) engages in the discourse of and about science;
iii) can identify questions, investigate and draw an evidence-based conclusion;
iv) is sceptical and questioning of claims made by others about scientific matters; and
v) make informed decisions about the environment and their health and well-being.

The above qualities are described in depth by Corrigan et al. (2011).

Table 1 below summarises the five pre-defined Secondary 1 Science Programme of Study units and their related topics. Some topics presented in this table are new, and some were amended as part of the programme of study review process to incorporate SOM concepts.

Note: The Seychelles Ministry of Education pre-defined the science units, known as the nuclei of the science curriculum, from Key Stages 1 to 4.

Table 1

Science Units	Corresponding topics
Matter around us	1. Using the Laboratory 2. States of matter 3. Mixtures and separating methods 4. Water 5. Earth's phenomena
Life on Earth	1. Living and non-living things 2. Ecosystems and habitats 3. Living cells 4. Reproduction in living things
Patterns and changes	1. Classification of plants and animals
Energy in and around us	1. Sound 2. Light 3. Interdependence
Humans and their environment	1. Human connection to the ocean 2. Food that you eat 3. Human responsibility to the ocean

The table above indicates a mix of topics for each science unit. The topics in red font are new, the topics in black were already present in the first edition of the programme of study, and the topics in green were reviewed to include additional SOM concepts. For a detailed summary of the changes made to the programme of study, please feel free to contact us through email.

Table 2 below summarises the alignments of the topics under each of the pre-defined units of the science curriculum and the seven SOM principles. The abbreviation used for SOM principles is SP, followed by the number. For example, SP1 stands for Principle 1. The acronym used for the Topic is T, followed by the number. For example, T1 stands for Topic 1.

Table 2

Science Units	SP1	SP2	SP3	SP4	SP5	SP6	SP7
Matter around us	T3, T4, T5		T4, T5	T4	T4		
Life on Earth		T1, T2, T4			T2		
Patterns and changes		T1					
Energy in and around us		T3			T3	T3	
Humans and their environment				T1, T2	T1	T1, T2, T3	T3

This table shows the linkages between topics from each science unit and the SOM principles. The topics were classified under their corresponding SOM principles based on the direct links of the concepts with the complex ideas of the relevant SOM principle. On the one hand, some topics were previously identified to be linked to the SOM principle based on the gap analysis findings. Please consult the gap analysis report (Emilie, 2022). On the other hand, some topics were linked to the SOM principle based on the improvements made to the teaching and learning scheme or the introduction of new topics, such as Topic 1 of Unit 5 - Human connection to the ocean.

Principle 1

The ocean has many features and makes the Earth Habitable

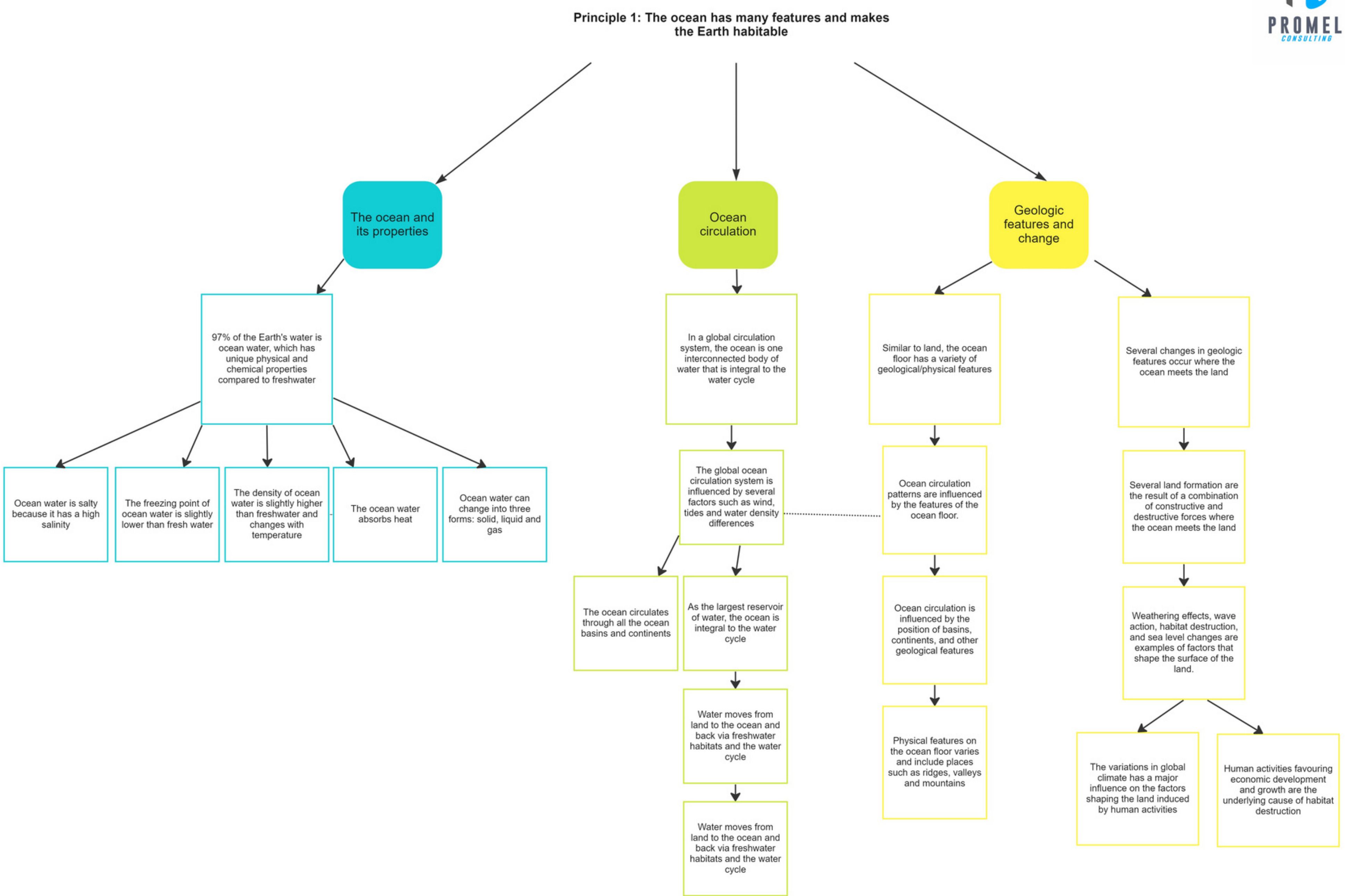
The ocean covers approximately 70% of the Earth's surface, comprising five ocean basins (North Pacific, South Pacific, North Atlantic, South Atlantic, Indian, Southern and Artic). The ocean basins consist of the seafloor and all its geological features (such as islands, trenches, mid-ocean ridges and rift valleys) – all varying in size, shape and features due to the movement of the Earth's crust. There is also an interconnected circulation system powered by wind, tides, the force of the Earth's rotation, the Sun, and water density differences. Ocean basins and nearby land masses affect circulation paths. Changes in ocean circulation have a significant impact on the climate and cause changes in ecosystems. This conveyor belt moves water throughout the ocean basins and transports heat, matter, and organisms. It is connected to major lakes, watersheds, and waterways because all major watersheds on Earth drain into the ocean. Rivers and streams transport nutrients, salts, sediments, and pollutants from watersheds to estuaries and the ocean.

Most of Earth's water, approximately 97%, is in the ocean; however, in the form of seawater. The properties of ocean water differ from freshwater: it is saline, its freezing point is slightly lower than fresh water, its density is slightly higher, its electrical conductivity is much higher, and it is somewhat basic and alkaline.

Sea level changes over time have expanded and contracted continental shelves, created and destroyed inland seas, and shaped the land's surface. Tectonic activity and the force of waves also influence the physical structure and landforms of the coast.

Natural events such as accretion and erosion change the shape and structure of the coast. Sand is redistributed by waves and coastal currents seasonally. Additionally, wind, waves and currents in rivers and the ocean move other sediments along coastal areas.

The ocean provides water, oxygen, and nutrients and moderates the climate needed for life to exist on Earth. Most of the oxygen in the Earth's atmosphere comes from the activities of photosynthetic organisms in the ocean, such as seagrass, seaweed, and phytoplankton. This oxygen in the atmosphere is necessary for life to develop and be sustained on Earth.


Principle 1: The ocean has many features and makes the Earth habitable
The ocean and its properties
Ocean circulation
Geologic features and change
97% of the Earth's water is ocean water, which has unique physical and chemical properties compared to freshwater
Ocean water is salty because it has a high salinity
The freezing point of ocean water is slightly lower than fresh water
The density of ocean water is slightly higher than freshwater and changes with temperature
The ocean water absorbs heat
Ocean water can change into three forms: solid, liquid and gas
In a global circulation system, the ocean is one interconnected body of water that is integral to the water cycle
The global ocean circulation system is influenced by several factors such as wind, tides and water density differences
The ocean circulates through all the ocean basins and continents
As the largest reservoir of water, the ocean is integral to the water cycle
Water moves from land to the ocean and back via freshwater habitats and the water cycle
Water moves from land to the ocean and back via freshwater habitats and the water cycle
Similar to land, the ocean floor has a variety of geological/physical features
Ocean circulation patterns are influenced by the features of the ocean floor.
Ocean circulation is influenced by the position of basins, continents, and other geological features
Physical features on the ocean floor varies and include places such as ridges, valleys and mountains
Several changes in geologic features occur where the ocean meets the land
Several land formation are the result of a combination of constructive and destructive forces where the ocean meets the land
Weathering effects, wave action, habitat destruction, and sea level changes are examples of factors that shape the surface of the land.
The variations in global climate has a major influence on the factors shaping the land induced by human activities
Human activities favouring economic development and growth are the underlying cause of habitat destruction

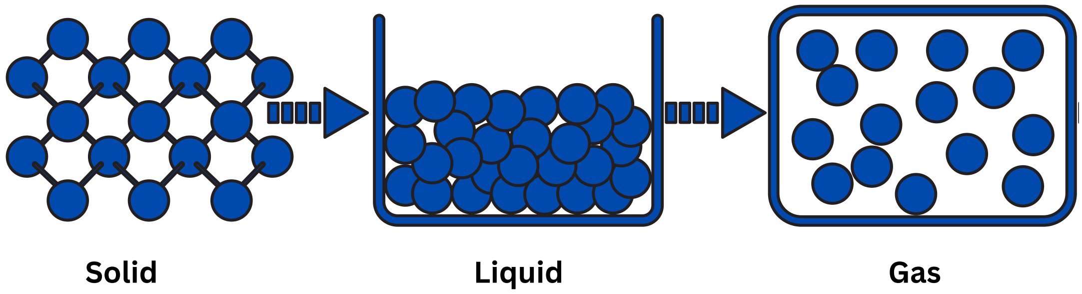
The ocean and its properties

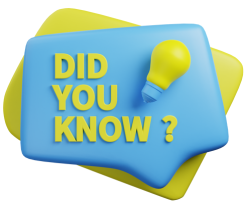
Approximately 97% of Earth's water is ocean water but in the form of seawater. Seawater has unique physical and chemical properties compared to freshwater. Seawater is:

1. Salty because it has high salinity.
2. The salt content makes its freezing point slightly lower than fresh water.
3. Its density is slightly higher, depending mainly on water temperature and salinity.
5. Its electrical conductivity is much higher because of the concentration of dissolved salts.
6. It is slightly basic and alkaline because of the dissolved basic minerals and the natural buffering from carbonates and bicarbonates.
7. It has a high heat capacity which allows it to absorb a large amount of heat energy.

The ocean's higher heat capacity helps to balance the excess heat from increasing global temperatures. Ocean water can change into three forms, mainly solid (iceberg), liquid (ocean water), and gas (water vapour formed in the Earth's atmosphere as part of the water cycle).

Figure 2 **States of matter**

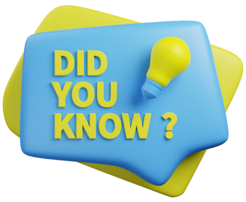




While dissolved carbon dioxide increases in seawater, its pH level decreases, and the water becomes acidic. This process is known as ocean acidification and continues to grow over time due to the rise in carbon dioxide released from land activities into the Earth's atmosphere. According to EPA (2022), ocean acidity has increased to about 25% from preindustrial period to the early 21st century. To learn more, please use your device camera to scan the code or visit: https://www.epa.gov/ocean-acidification/understanding-science-ocean-and-coastal-acidification

Ocean circulation

The ocean is one interconnected body of water integral to the water cycle (also known as the hydrologic cycle). This is because it is the largest reservoir of water on Earth, which provides a large percentage of evaporated water to the water cycle. Within this interconnected body of water, there is also an interconnected circulation system powered by wind pushing on the surface of the ocean water, moving tides, water density differences caused by changes in global temperature, and the force of the Earth's rotation. These forces drive ocean currents to move water through the five ocean basins and around the continents. The constant movement of ocean water facilitates the transportation of heat, matter (such as oxygen) and organisms (such as phytoplankton) throughout the Earth. It is connected to major lakes, watersheds, and waterways because all major watersheds on Earth drain into the ocean. Rivers and streams transport nutrients, salts, sediments, and pollutants from watersheds to estuaries and the ocean. The transported nutrients nourish microorganisms which are part of many ocean food chains.

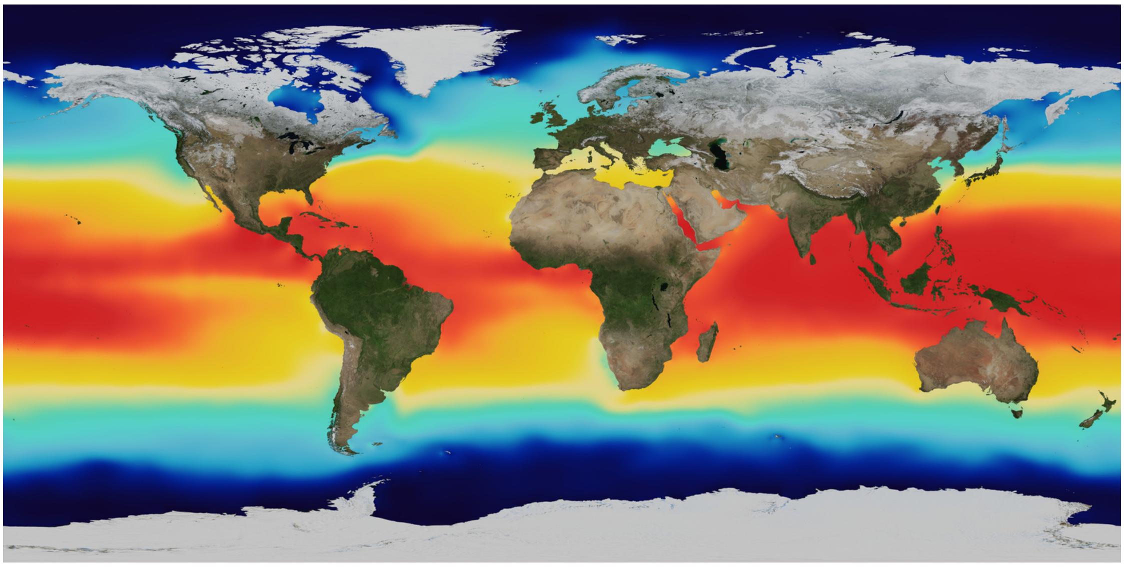


The constant movement of water around the globe is known as the global ocean conveyor belt, and it is the longest current in the world. However, the worldwide ocean temperature increase is causing the conveyor belt to slow down and affecting weather and climate patterns. To learn more about how the current ocean works and the conveyor belt, please use your device camera to scan the code or visit this link: https://www.youtube.com/watch?v=p4pWafuvdrY&t=246s

The Earth's physical features, such as ocean floors and continents, play a significant role in ocean circulation patterns. This is further explored under the next general concept of SOM Principle 1: Geologic features and change.

The map below illustrates sea surface temperature variations around the globe. The colours red and yellow depict warmer areas of the ocean, and the light and dark blue colours represent the colder areas of the ocean. The most noticeable feature of this map is the variation in sea surface temperature across the globe. A large concentration of warmer temperatures was recorded along the Equator, and colder temperatures were recorded along the North and South poles. This shows the movement of heat across the globe influenced by the Earth's ocean circulation system.

Figure 3 **Sea Surface Temperature**



Source: NASA (2009)

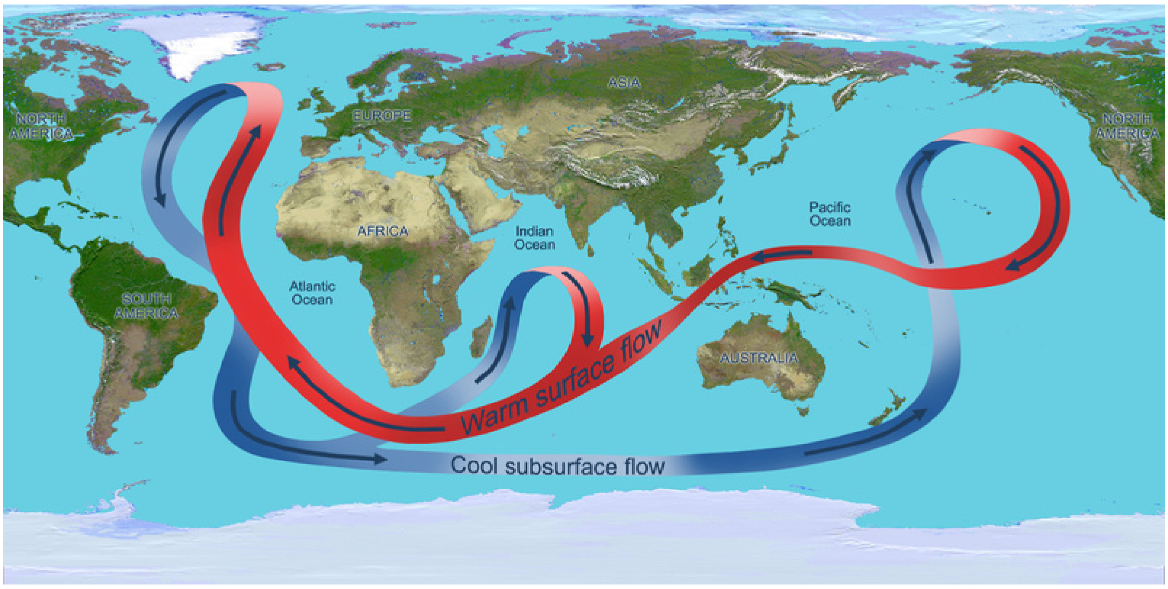
To access more sea surface temperature maps, please use your device camera to scan the code on the right or visit this link: https://neo.gsfc.nasa.gov/view.php?datasetId=MYD28M

To learn more about the sea surface temperature variations from the year 2002 to 2022, please use your device camera to scan the code on the right or visit this link: https://earthobservatory.nasa.gov/global-maps/MYD28M

Geologic features and change

Physical features of the Earth also play a significant role in how ocean currents move around the globe. The shape and size of landmasses and the ocean floor found at the bottom of each ocean basin influence the speed and direction of ocean currents. The landmasses of continents create the boundaries for the flow of ocean currents. Figure 4 below shows the flow of ocean currents across the globe.

Figure 4 **Flow of ocean currents across the globe**



Source: NASA, 2010

To read more and watch a short video on how ocean currents move around the globe, please use your device camera to scan the code on the right or please visit this link: https://education.nationalgeographic.org/resource/ocean-currents-and-climate

Several changes in the physical features of shorelines date back a very long time, and a combination of constructive and destructive forces, such as weathering events, causes these. As a small island developing state, Seychelles has experienced various land formations over time, some of which have created habitats for multiple organisms. This is more visible in the outer islands of Seychelles, such as Farquhar Atoll. Sand cays such as 'Derrick Sandbank' has developed since 2016 and are identified as the 11th island of the Farquhar Atoll. To learn more about the land formation in Farquhar Atoll, please visit this link: https://www.nation.sc/articles/8870/a-new-island-for-farquhar. Regardless of the size of the landmasses formed over time, they would still deflect the original path of ocean currents.

Apart from the positive changes to the physical features of shorelines, a combination of destructive or constructive forces can also cause erosion and flooding along shorelines (as shown in the photos below). Since the late 1800s, the sea level has risen because of global warming. This rise is caused by an increase in water in the ocean from melting glaciers and the volume of water in the ocean, which is expanding as it warms. According to Sreeraj et al. (2022), the rise in sea level is higher in the Indian Ocean region and poses challenges to coastal communities. Every year, the sea level rises to about 3.2 mm but based on new data collected, the sea level is accelerating and may rise to approximately 30.48 cm by 2050 (Nunez et al., 2022). Besides sea level rise, increased human activities have caused habitat destruction. These activities, such as developing infrastructures to benefit coastal communities and support economic growth, have altered the shape of shorelines and marine habitats.

Principle 2

The ocean supports a diversity of life and ecosystems

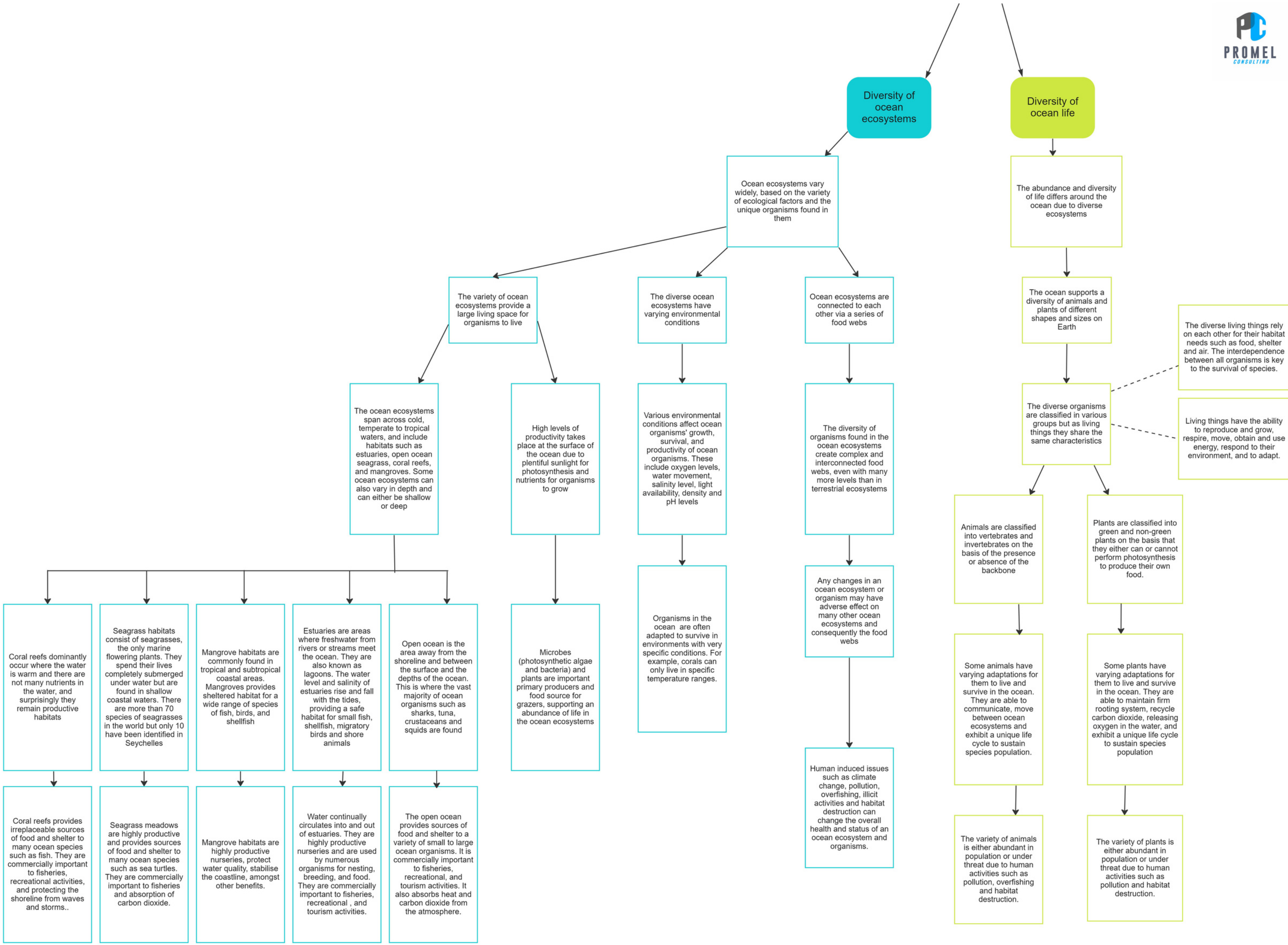
Ocean life varies from the smallest living things to the largest animal. The diverse and unique ecosystems in the ocean provide a large living space for organisms to live. Most of the major groups of organisms that exist on Earth are found in the ocean more than compared to the land.

Some ecosystems, such as coral reefs, are highly complex and support a high diversity of life. Some organisms migrate long distances connecting seemingly unconnected areas. The organisms have an essential role in the ocean ecosystems and have meaningful relationships with each other, for example, symbiosis, predator-prey dynamics, and energy transfer.

The abundance and diversity of life differ in the ocean, much like terrestrial ecosystems. On the one hand, some ocean areas are poor in energy and biological hotspots, such as the Gulf Dead Zone – a region with so little oxygen that almost no life exists beneath the surface waters. On the other hand, there are regions of the ocean that are rich in life and biodiversity hotspots, such as South-East Asia and Australia.

Some species are under constant threat due to several human activities. This is causing a significant decline in top predators such as sharks and endangered species in key biodiversity areas.

Principle 2: The ocean supports a diversity of life and ecosystems



Diversity of ocean ecosystems

Ocean ecosystems vary widely based on the variety of ecological factors and the unique organisms found in them. They provide ample living space for diverse organisms to survive and reproduce. The ocean ecosystems span from cold, temperate, to tropical waters. Ecosystems are defined as communities of living organisms that live and interact with each other in a specific environment known as a habitat. There are various habitats, and they differ in depth and environmental conditions. Some typical habitats in the Indian Ocean region are coral reefs, seagrass meadows, mangrove forests, estuaries and open ocean.

Coral reefs

Coral reefs dominantly occur where the water is warm, with few nutrients. Whether they prefer low-nutrient water, they remain productive habitats and biological hotspots. Coral reefs provide irreplaceable food and shelter to many ocean species, such as fish. They are commercially crucial to fisheries because they are nurseries for many fish and shellfish that are consumed globally. Coral reefs are also natural attractions generating substantial income for coastal communities from tourism and recreational activities. Along coastlines where coral reefs are still healthy, they act as wave barriers from strong waves and storm surges, protecting coastal communities and beaches.

DID YOU KNOW ?

The **Great Barrier Reef,** located on the northeast coast of Australia, is the world's largest coral reef system. It comprises 2,900 individual reefs and 9000 islands extending across 2,300 km along Australia's eastern coastline. It is a UNESCO World Heritage Site because it holds great scientific interest for the largest collection of coral reefs in the world and is home to over 1,500 species of fish and threatened species such as dugongs and green turtles. To learn more about the Great Barrier Reef, please use your device camera to scan the code on the left or visit this link:
https://whc.unesco.org/en/list/154/

DID YOU KNOW ?

Aldabra, one of the outer islands of Seychelles, is the second-largest coral atoll in the world. The coral reef communities in the atoll's lagoon and seaward side have been slowly recovering from coral bleaching events since 2015. The findings from a recent study provide a glimmer of hope for coral reef recovery capacity and resilience amid rising global sea temperatures and other local stress factors. To learn more about the survey, please use your device camera to scan the code on the left or visit this link:
https://www.nation.sc/articles/6434/new-research-reveals-aldabras-coral-reef-resilience-and-recovery-capacity

Following major coral bleaching events, which started in 1998, coral reef resilience has also been observed in other Indian Ocean countries such as the Maldives and Australia. However, amid rising sea temperatures, coral bleaching will remain one of the region's most significant threats to coral reefs.

Seagrass meadows

Seagrass meadows consist of seagrasses - the only marine flowering plants that grow underwater. The flowering plants are wholly submerged underwater but are found in shallow coastal waters. There are more than 70 species of seagrasses worldwide, but only ten have been identified in Seychelles. The species were identified through a Seagrass Mapping and Carbon Project first implemented in 2021.

To learn more about the Seagrass Mapping Project in Seychelles, please use your device camera to scan the code on the left or visit this link: https://www.bbc.com/news/world-africa-63901644

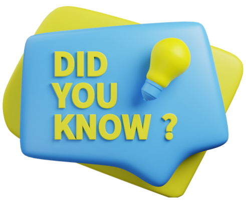
Seagrass habitats are highly productive and provide sources of food and shelter to many ocean species, such as sea turtles. They are commercially important to fisheries and the absorption of carbon dioxide.

To learn more about the importance of seagrasses, please use your device camera to scan the code on the left or visit this link: http://www.islandconservationseychelles.com/news/seychelles-seagrass-mapping-and-carbon-project

Mangrove forests

Mangrove forests are commonly found in tropical and subtropical coastal areas. Mangroves provide sheltered habitats for a wide range of fish, birds and shellfish species. Mangrove habitats are highly productive nurseries used by marine juvenile species, such as fish and invertebrates. Additional benefits of mangroves are:

- Protection of water quality.
- Stabilisation of shorelines.
- Protection of wildlife species.
- Reduction in coastal flooding.
- Absorption of carbon dioxide.



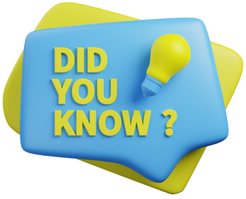
More than 2 million hectares of mangrove forest are found throughout Indonesia's coastlines - the world's most extensive coverage of mangroves. It has an abundant wealth of different types of mangroves and threatened species protected under the law. To learn more about other interesting facts on mangroves, please use your device camera to scan the code on the left or visit this link: https://onetreeplanted.org/blogs/stories/facts-about-mangroves

Estuaries

Estuaries are habitats where freshwater from rivers and streams meets the ocean. They are also known as lagoons. The level of water and salinity in estuaries rise and fall with the tides, providing a safe habitat for small fish, shellfish, migratory birds and shore animals. Water continually circulates in and out of estuaries. They are highly productive nurseries similar to mangrove forests and are used by numerous organisms for nesting, breeding, and food. Estuaries are commercially crucial to fisheries and activities such as recreation and tourism.

Open ocean

The open ocean is located away from the shoreline and between the surface and the ocean's depths. Most ocean organisms, such as sharks, tuna, crustaceans, and whales, are found here. The open ocean provides sources of food and shelter to a variety of small to large ocean organisms. Like some ocean habitats, the open ocean also acts as a 'carbon sink', absorbing about 25% of all atmospheric carbon dioxide. It also captures approximately 90% of the excess heat on Earth, attributed to greenhouse gas emissions from land activities. The open ocean supports most of the world's fishing industries, providing an important source of food to countries. It also provides a place for recreational activities such as diving and fishing, which are equally crucial to locals and tourists.

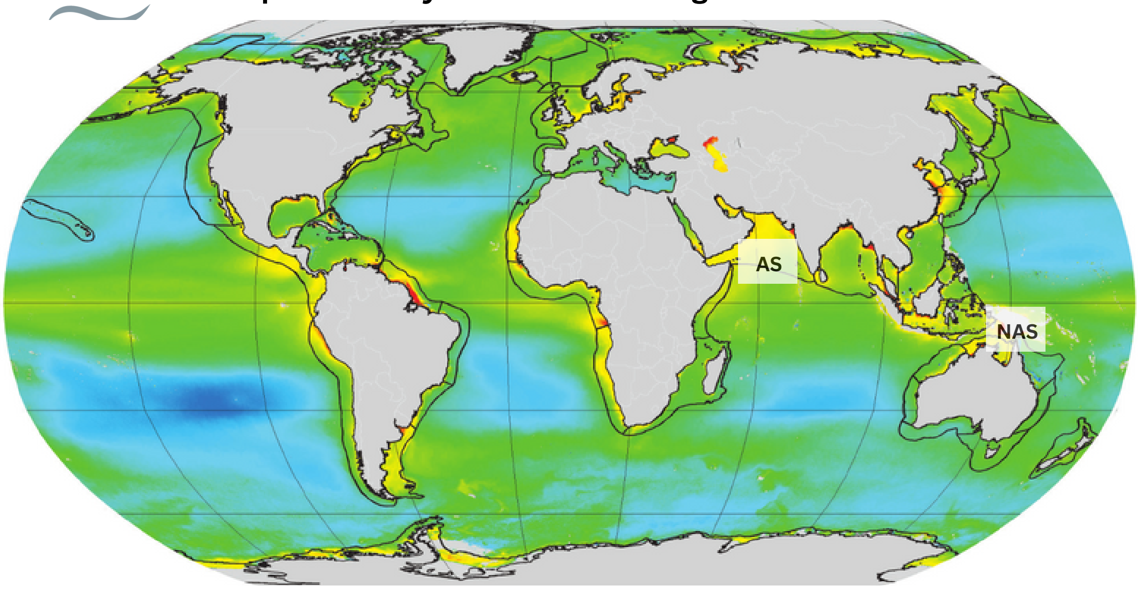


The lowest point on Earth is located in the open ocean. It is known as the Mariana Trench in the Pacific Ocean basin. The Mariana Trench is 2 550 km in length and 69 km in width. To learn more fun facts about the open ocean, please use your device camera to scan the code on the left or visit this link: https://www.natgeokids.com/uk/discover/geography/general-geography/ocean-facts/

Ocean productivity

High productivity levels occur at the ocean's surface due to plentiful sunlight for photosynthesis and nutrients for organisms to grow. Microbes (such as algae) and plants (such as seagrass) found near the surface of the ocean are essential producers and food sources for living organisms known as grazers (such as sea urchins, sea turtles and parrot fish). The high levels of productivity at the ocean's surface are crucial to supporting abundant life in the ocean ecosystems, hence the basis for species survival. Figure 5 illustrates the average annual level of productivity across the global ocean indicated by the variation in ocean colour over ten years (from 2003-2013) based on a study conducted by O'Reilly & Sherman (2016). Higher levels of productivity (indicated by the yellow colour) in the global ocean were recorded along coastal areas and near the Equator in large marine ecosystems such as North Australian Shelf (NAS) and the Arabian sea (AS).

Figure 5 **Ocean productivity levels across the globe**



Source: O'Reilly & Sherman (2016)

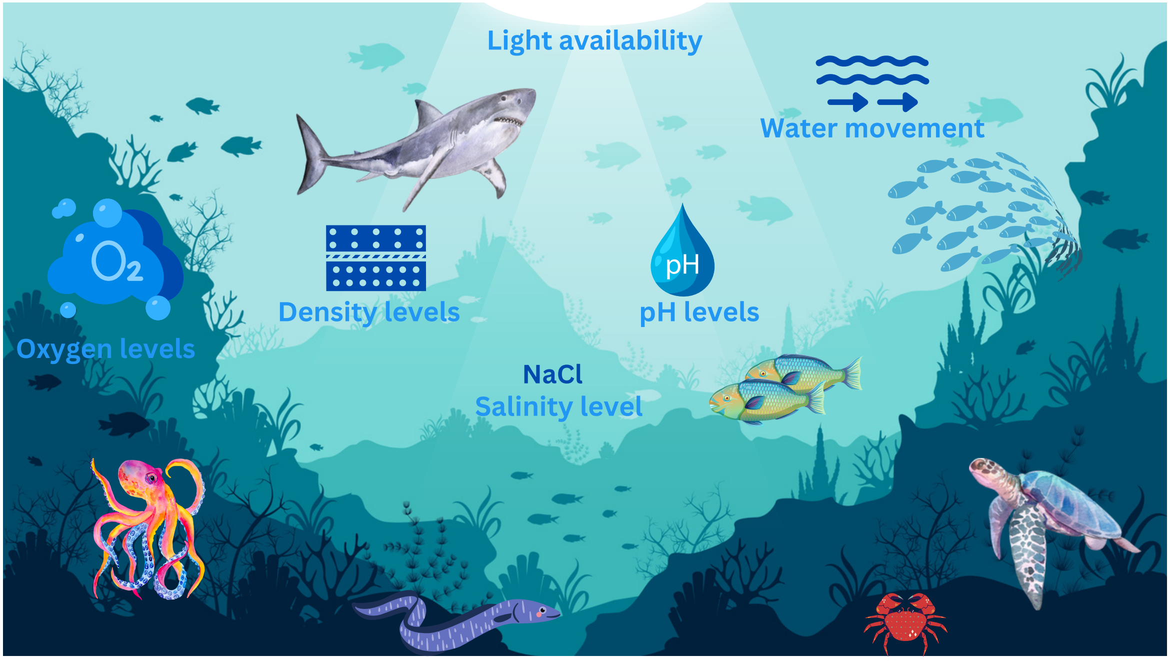
Environmental conditions

The diverse ocean ecosystems have varying environmental conditions, which:

1. Affect the growth and survival rate of ocean organisms.
2. Influence the productivity success rate of ocean organisms.

Figure 6 below shows the various environmental conditions affecting ocean organisms' growth, distribution and productivity levels, namely oxygen levels, water movement, salinity level, light availability, density and pH levels.

Figure 6 **Environmental variables**



Ocean organisms are often adapted to survive in environments with particular conditions. For example, corals can only live in specific temperatures, usually between 18° and 30° Celsius. This is why they are generally restricted to tropical marine regions like the Maldives and semi-tropical marine regions like eastern Australia. They cannot tolerate water temperatures below 18° Celsius and prefer to grow in shallow depths where sunlight can reach them. They require saltwater to survive, but there should be a balance in the ratio of salt to the water, hence why you will not find them growing along the channels where freshwater from rivers drains into the ocean. Corals prefer ample oxygen supply and balanced pH levels to increase. Once the pH levels drop below 8, the corals begin to dissolve.

Food chains and food webs

The ocean ecosystems are connected via a series of food webs. The diversity of organisms in ocean ecosystems creates complex and interconnected food webs, even with many more levels than terrestrial ecosystems. The various levels in a food web illustrate the direct relationship among ocean organisms in a community of food chains. Throughout an ecosystem, there are many interconnected and overlapping food chains. Energy and nutrients can move through an ecosystem in various ways via food chains. Organisms in a food chain and food web are classified into trophic levels: producers, consumers and decomposers. Food chains and food webs can have a maximum of four trophic levels, but for Secondary 1, decomposers will be excluded.

Trophic category	Description	Food source	Example
Producers	The first trophic level is represented by two types of producers: plants and microbes.	Makes their own food.	Seagrass make their own food from sunlight, carbon dioxide and water through a process known as photosynthesis.
Primary consumers	The second trophic level is represented by organisms that are herbivores and eat producers.	Feeds on producers.	Parrotfish feeds on seagrasses.
Secondary consumers	The third trophic level is represented by organisms that are carnivores and eat herbivores.	Feeds on primary consumers.	Moray eels feed on parrotfish.
Tertiary consumer	The fourth trophic level is represented by organisms that eat other animals.	Feeds on secondary consumers.	Sharks eat moray eels.

Decomposers	Although not included in some food chains, decomposers are considered the last part of a food chain. They turn organic wastes into inorganic materials absorbed in the soil or the ocean for use by producers. There will be a whole new series of food chains as a result.	Feeds on organic wastes.	Bacteria feeds on decaying plants.

In all food chains and food webs, the sun is the principal energy source, and all producers use it to make their own food. Once the producers are eaten by primary consumers, and secondary consumers eat primary consumers, the energy flows from one trophic level to the other. The flow of energy is indicated by arrows, as shown in Figure 7 below, namely for two types of producers.

Figure 7 **Three level food chains for two types of producers**

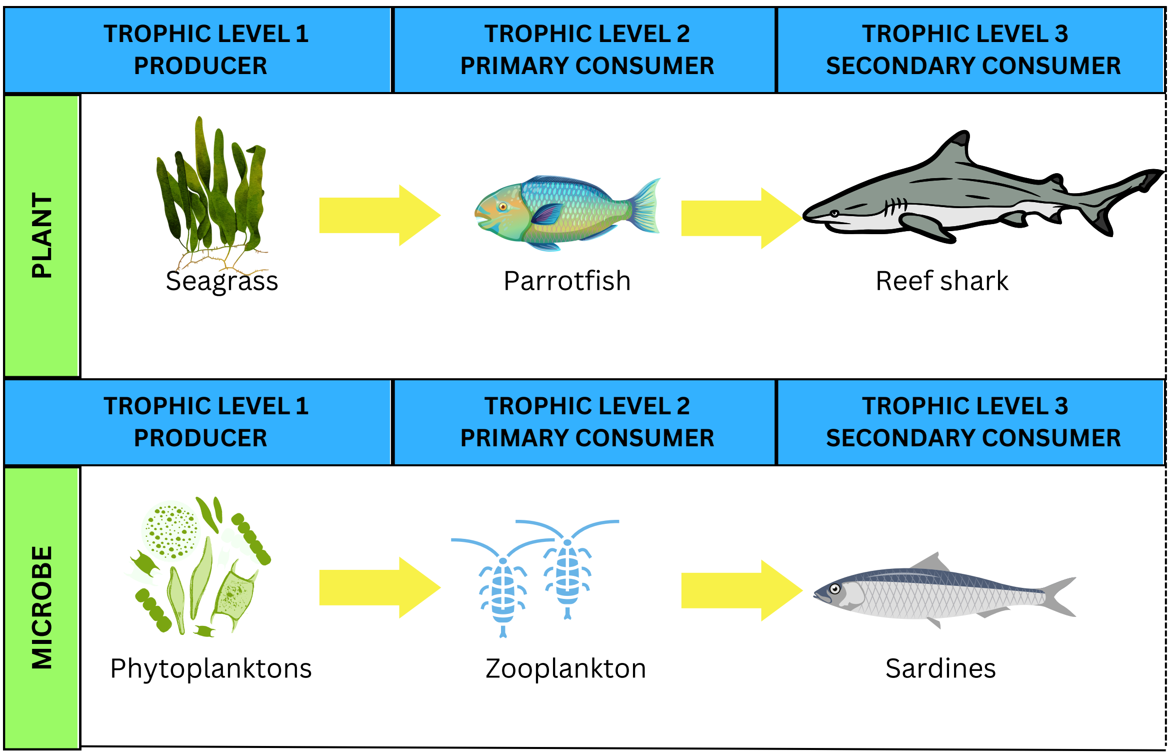
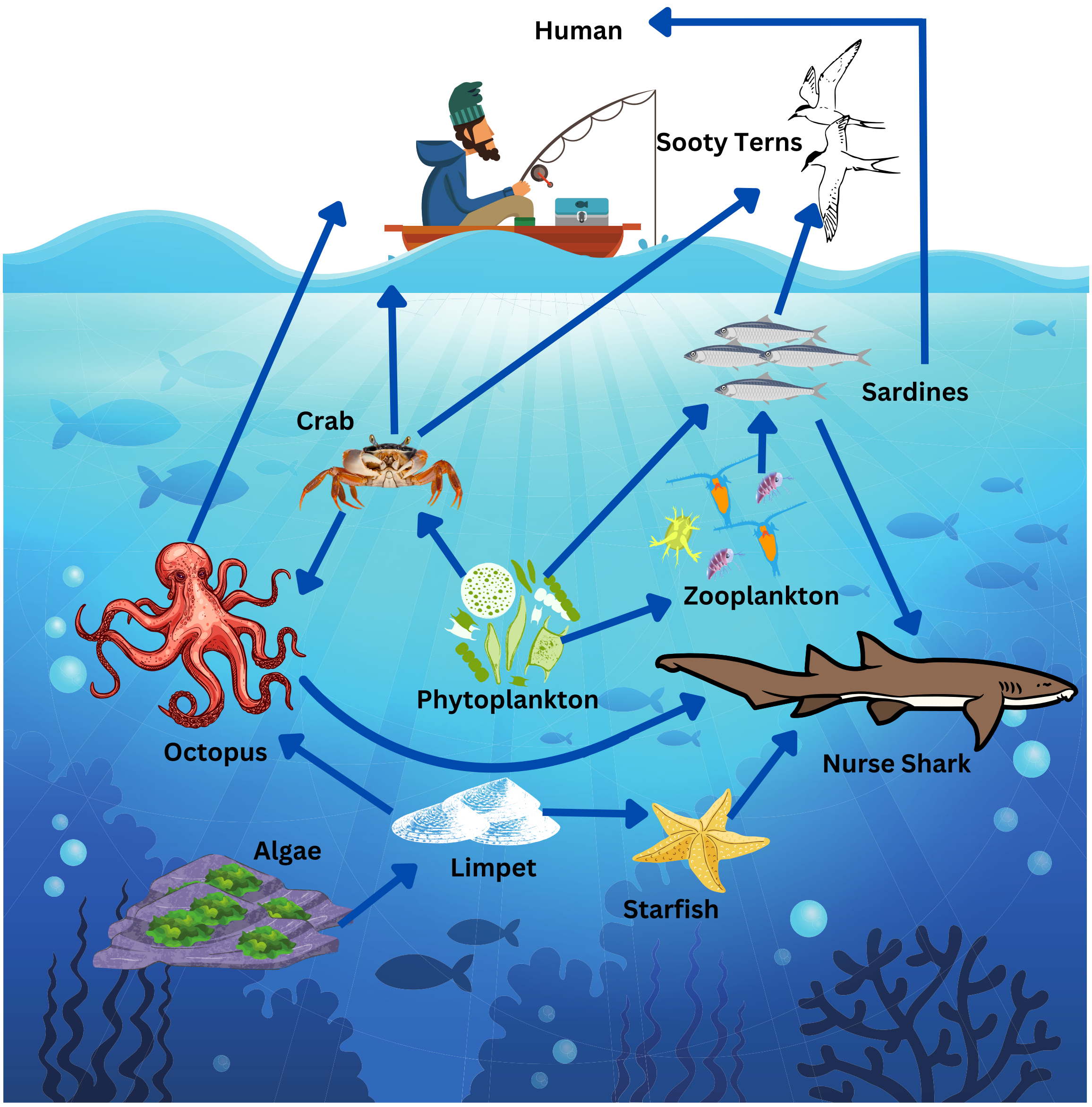


Figure 8 shows a marine food web, illustrating energy transfer from producers to consumers.

Figure 8 **Marine food web**



The marine food web above shows a series of food chains comprising a mix of producers and consumers. One of the food chains begins with algae (producer), fed by limpets (primary consumers and prey). The limpets are then eaten by the octopus (secondary consumer, predator and prey), which is then eaten by humans (tertiary consumer and predator). The arrows in each food chain series illustrate the energy flow from producers to consumers. Each consumer in this food web depends on other organisms to feed and obtain energy to survive and reproduce. The prey will tactfully make it more difficult to be captured and eaten by the predators, while the predators will perfect their hunting skills to catch and kill their prey. This is known as the predator-prey relationship.

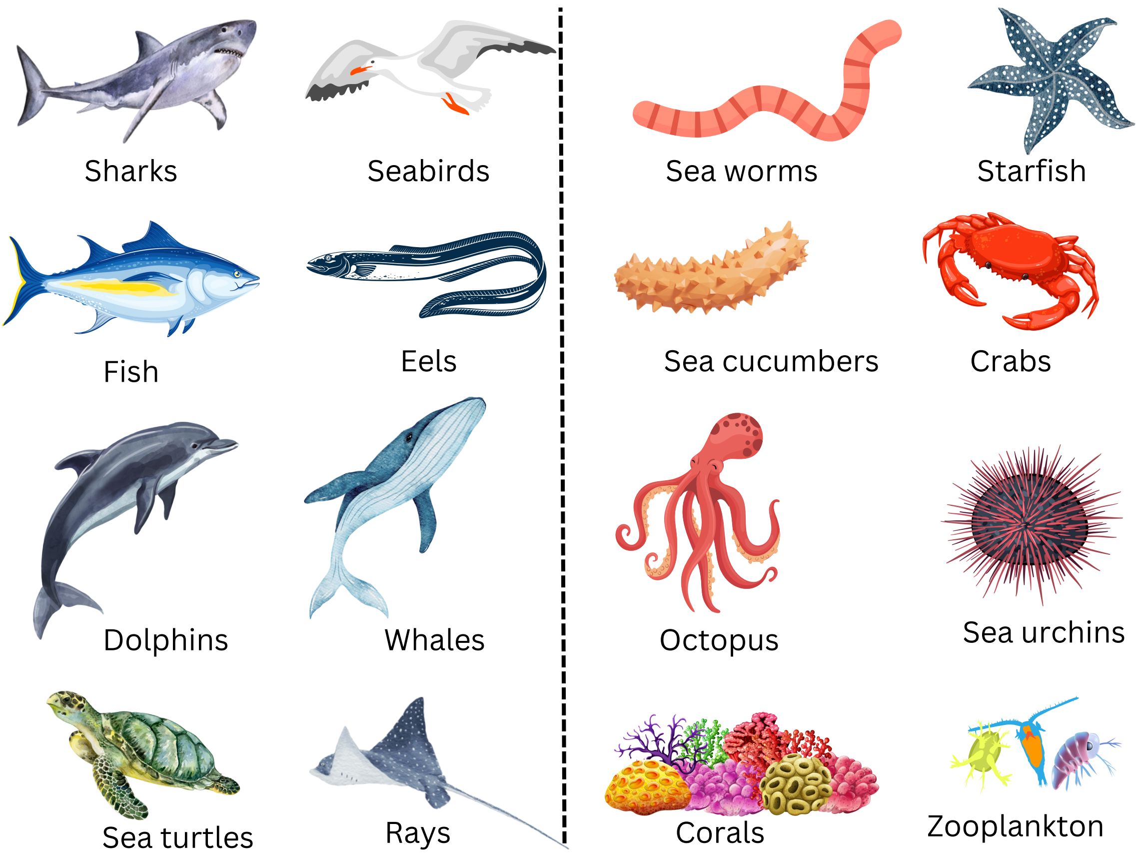
Diversity of ocean life

The abundance and diversity of life differ around the ocean due to diverse ecosystems. The ocean supports a variety of animals and plants of different shapes and sizes. The interdependence between both groups of organisms is critical to species' survival. For example, animals depend on plants for food, shelter and air. As living things, they share the same characteristics:

- They respire
- They can move
- They respond to stimuli
- They can reproduce
- They can grow
- They can excrete
- They are dependent on their environment

Marine animals

Animals are classified into two groups: vertebrates and invertebrates. Vertebrates are animals with backbones or internal skeletons, while invertebrates are animals without backbones or internal structures. Several common marine vertebrates and invertebrates are shown below.



Some animals have varying adaptations to live and survive in the ocean. They can communicate, move between ocean ecosystems and exhibit a unique life cycle to sustain species' populations. Examples of life cycles are presented in Figures 9 & 10 on the next page.

Figure 9

Life cycle of a sea turtle

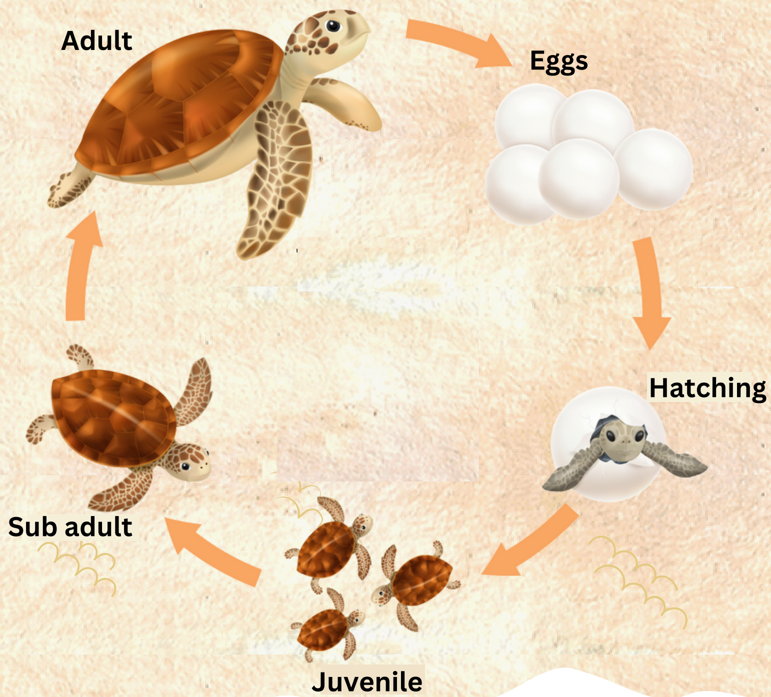
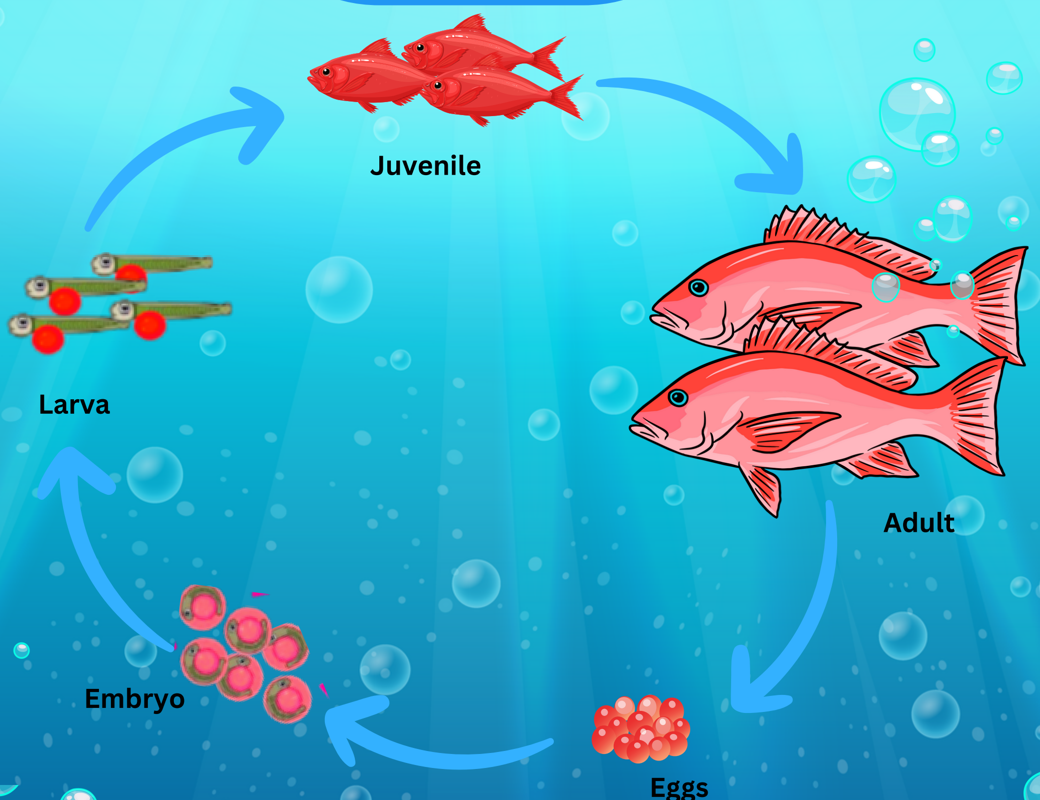


Figure 10

Life cycle of a fish



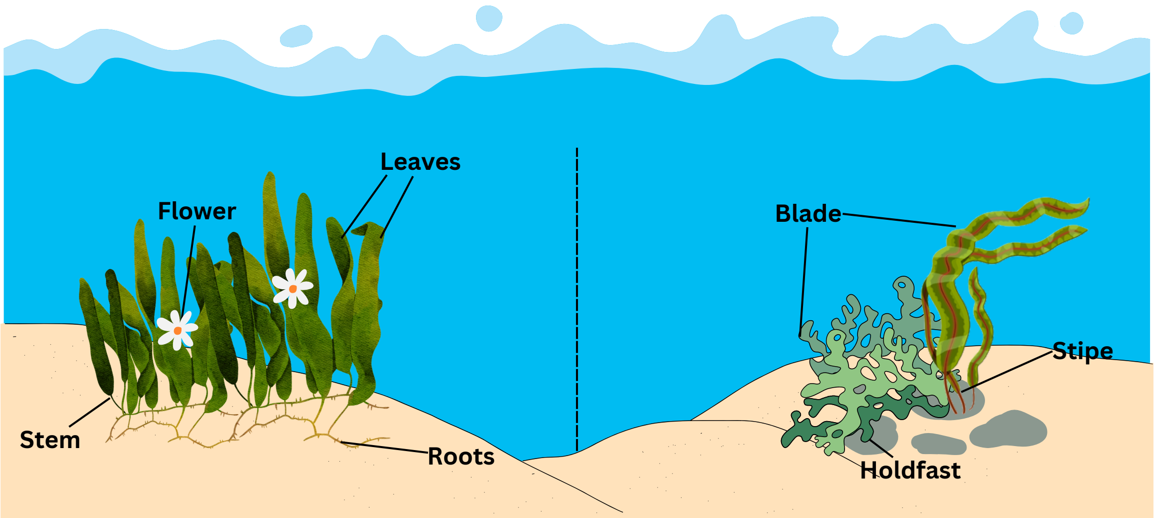
Marine animals that are vertebrates or invertebrates reproduce to sustain species populations. On the one hand, some vertebrates give birth to their young and are considered mammals, such as whales and dolphins. On the other hand, the rest of the vertebrates lay eggs and are considered egg-laying animals, such as sea turtles and fish. All marine invertebrates produce eggs, such as corals and octopuses. Some invertebrates hatch into the larva/larvae stage and grow into an adult, as shown in Figure 10. Other invertebrates, such as octopuses and squids, hatch and grow into adults without the larva stage.

The variety of animals is either abundant in population or under threat due to human activities such as pollution, overfishing and habitat destruction. A decline in the population of several ocean organisms will certainly disrupt marine food webs or even the overall health of the ocean ecosystems. To learn more about ocean ecosystem issues, please look at Principle 5.

Marine plant

Plants found in ocean habitats are known as 'marine plants'. Plants are classified into green and non-green plants on the basis that they either can or cannot perform photosynthesis to produce their own food. Green plants can be divided into flowering and non-flowering plants. Seagrass is an example of a marine flowering plant, while algae is an example of a marine non-flowering plant.

Figure 11 **Differences between a seagrass and an algae**

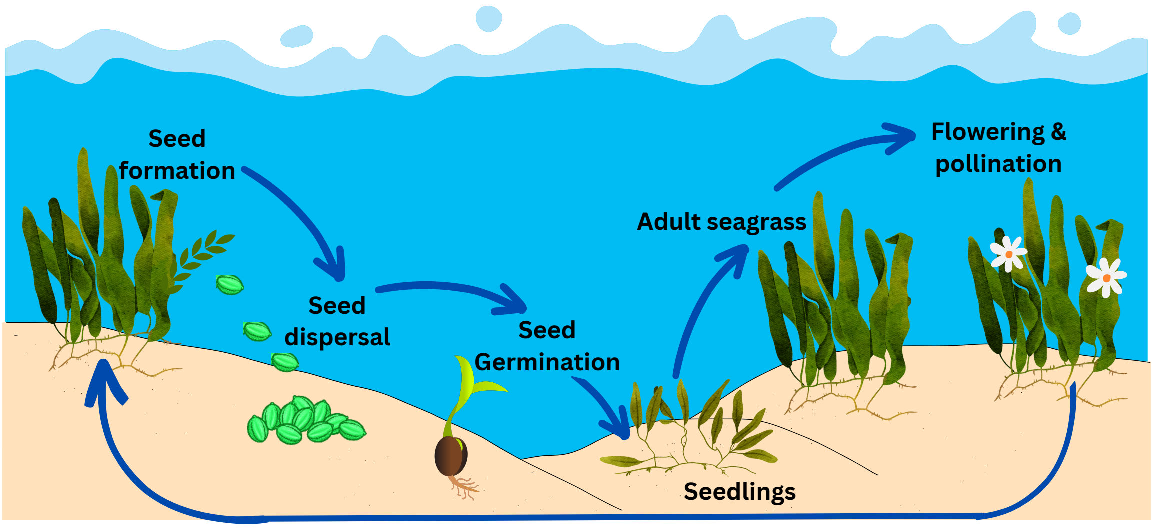


Seagrasses are flowering plants comprising different parts, namely roots, stems and leaves. They have roots that penetrate the sandy seabed and transport water and nutrients, starting from the roots to other plant parts. They also produce flowers, fruit and seeds.	As a non-flowering plant, **algae** usually sticks to hard surfaces because they do not have roots. Algae do not have stems or leaves but are made up of blades (expanded flattened part resembling a leaf), stipe (a short stalk) and holdfast (base of an algae that attaches the algae to a hard surface).

Some plants have varying adaptations for living and surviving in the ocean. They can maintain a strong rooting system, recycle carbon dioxide, release oxygen in the water, and exhibit a unique life cycle to sustain the species' population. Similarly to animals, plants also go through different life cycle stages.

Seagrass will either reproduce sexually or asexually. Sexually, the flowers on the seagrass get pollinated with the help of the water. The pollinated flowers then develop into seeds, dispersed in the water on their own or with the help of other animals that eat seagrass seeds, such as fish. Asexually, new seagrass shoots are formed along the existing network of roots and push themselves above the sand. Figure 12 shows the life cycle of seagrass through sexual reproduction.

Figure 12 **Life cycle of a seagrass through sexual reproduction**



Similarly to animals, the variety of plants in the ocean is also abundant in population or under threat due to human activities such as pollution and habitat destruction. A decline in the population of several marine plants will certainly disrupt marine food webs or even the overall health of the ocean ecosystems. To learn more about ocean ecosystem issues, please look at Principle 5.

Principle 3

The ocean influences the Earth's weather and climate

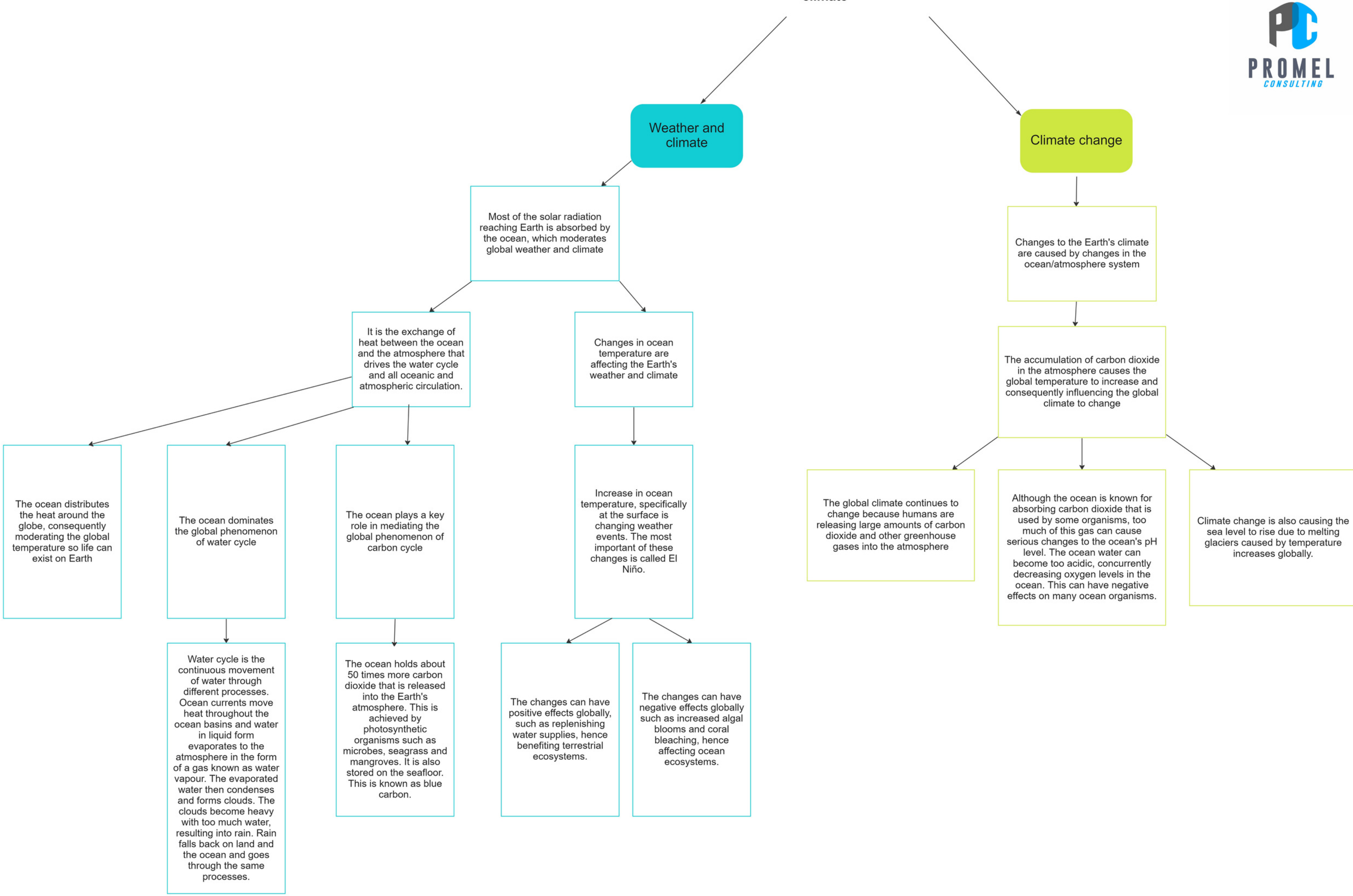
The ocean interaction of oceanic and atmospheric processes controls weather and climate, dominating the Earth's energy, water, and carbon systems. The ocean moderates global weather and climate by absorbing most of the solar radiation reaching Earth. Heat exchange between the ocean and atmosphere drives the water cycle and oceanic and atmospheric circulation. The ocean is an integral part of the water cycle and is connected to all the Earth's water sources via evaporation and precipitation. Condensation of water evaporating from warm seas provides the energy for hurricanes and cyclones.

Heat exchange between the ocean and atmosphere can result in dramatic global and regional water phenomena, impacting patterns of rain and drought. Significant examples include El Niño, which causes essential changes in global weather patterns because they alter the sea surface temperature patterns.

The ocean dominates the Earth's carbon cycle since it absorbs roughly half of all carbon dioxide released into the atmosphere, which significantly influences climate change. Apart from carbon, the ocean also absorbs, stores, and moves heat and water, which substantially affects climate change.

Changes in the ocean-atmosphere system can result in changes to the climate, consequently causing further changes to the ocean and atmosphere. This can result in ocean hazards such as toxic algal blooms, storm surges, and tsunamis. In the coldest parts of the Earth, rising global temperature is causing ice caps and glaciers to melt, consequently influencing sea level rise.

Principle 3: The ocean influences the Earth's weather and climate



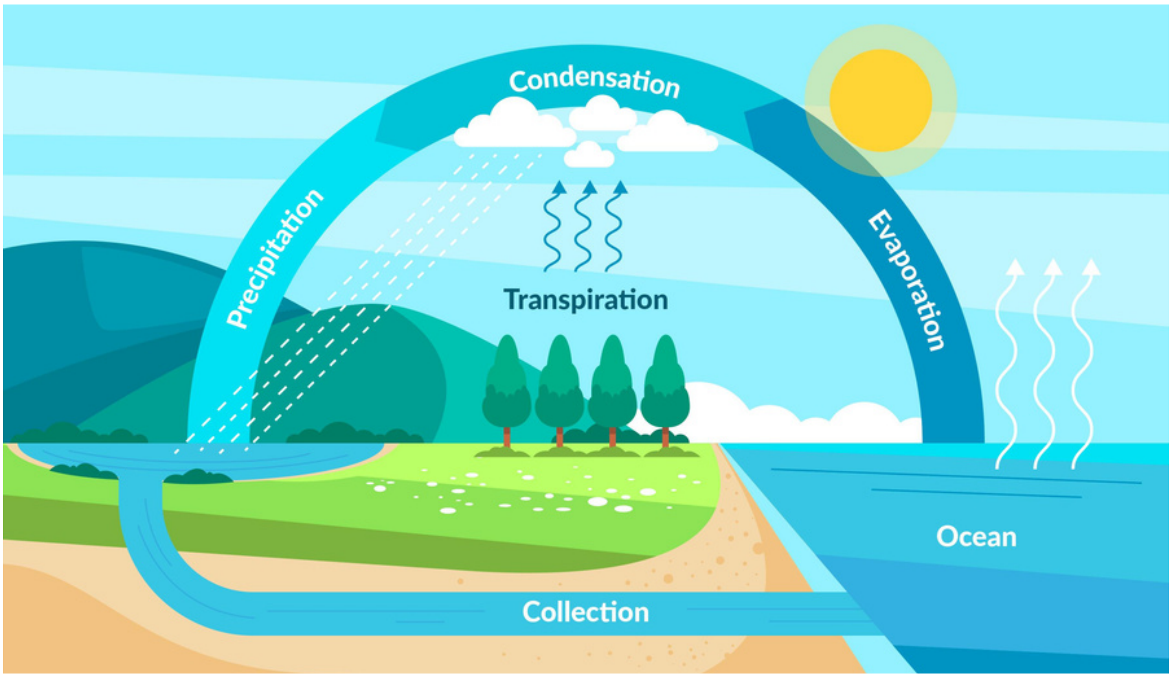
Weather and Climate

Weather and climate are controlled by the interactions between the ocean and the atmosphere since the ocean absorbs most of the solar radiation. Changes in the ocean or atmosphere can alter the Earth's climate. The heat exchange between the ocean and atmosphere drives the water cycle and all oceanic and atmospheric circulation. The ocean distributes the global heat, consequently moderating the global temperature so life can exist on Earth.

The water cycle

The ocean dominates the global phenomenon of the water cycle. The water cycle is the continuous movement of water through different processes, namely evaporation, transpiration, condensation, and precipitation. Ocean currents move heat throughout the ocean basins, and water in liquid form evaporates to the atmosphere in the form of a gas known as water vapour through a process known as evaporation. Water also evaporates from terrestrial plants into the atmosphere through transpiration. The evaporated water then condenses and forms clouds - through condensation. The clouds become heavy with too much water, resulting in rain. Through precipitation, rain falls back on land and the ocean and goes through the same processes to provide global water.

Figure 13 **The Water cycle**

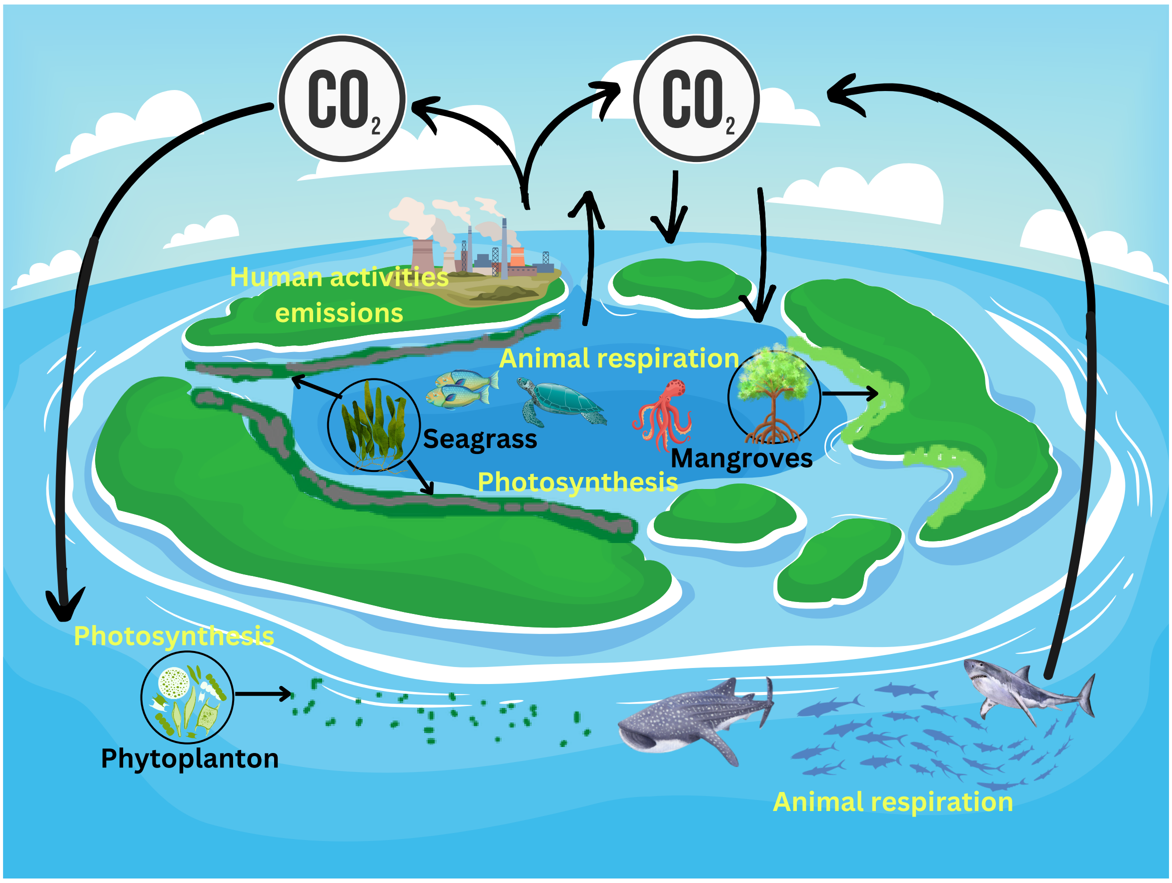


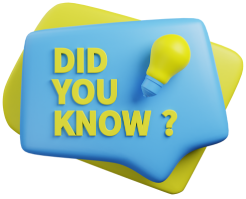
The carbon cycle

The ocean plays a crucial role in regulating the global phenomenon of the carbon cycle. The surface waters of the ocean exchange gases with the atmosphere by absorbing and releasing carbon dioxide and other gases. The ocean absorbs about 50 times more carbon dioxide, which is released into the Earth's atmosphere. This is achieved by photosynthetic organisms such as microbes, seagrass and mangroves.

The carbon cycle is a complex phenomenon whereby carbon dioxide is recycled and stored on Earth. It travels from the atmosphere into organisms and then back into the atmosphere in a cyclic motion. Photosynthetic organisms use the carbon dioxide released into the atmosphere to make their own food, and in return, they provide food to a diverse group of primary consumers. The photosynthetic organisms also produce oxygen which all marine animals use. Through the process of respiration, marine animals take in oxygen and release carbon dioxide as a byproduct. This applies to other terrestrial organisms and humans. Besides respiration, carbon dioxide is also produced from human activities on land, such as burning fossil fuels to produce electricity. The carbon dioxide is released into the atmosphere and used up by organisms repeatedly.

Figure 14 **The Carbon cycle**





Carbon dioxide is also stored on the seafloor. The term used to describe the amount of carbon absorbed and stored by the ocean and its ecosystems is 'Blue Carbon'. Blue carbon-rich ecosystems include seagrass meadows, mangroves and kelp forests. To learn more about blue carbon and blue carbon-rich ecosystems, please use your device camera to scan the code on the left or visit this link:
https://youtu.be/ITwPDs2LdcU

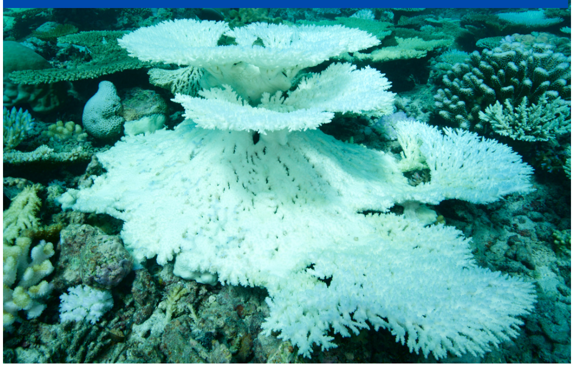
Ocean temperature

Changes in ocean temperature are affecting the Earth's weather and climate. As the ocean temperature increases at the surface of the water, it significantly impacts weather events. El Niño is one of the most important examples of oceanic influence on weather occurring every few years. It causes irregular sea surface temperature, tropical storms, and cyclones, to name a few. On the one hand, the periodic changes by El Niño can have positive effects globally, such as replenishing water supplies to benefit terrestrial ecosystems and reducing the spread of malaria and other diseases due to drier weather in some areas. On the other hand, the unusual changes can have adverse effects globally, such as increased algal blooms and coral bleaching, affecting ocean ecosystems.

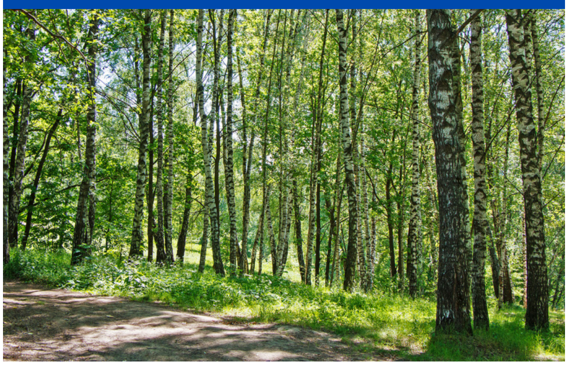
Algal bloom

Replenished water supplies

Coral bleaching



Drier weather



Climate change

Changes in the ocean-atmosphere system cause changes to the Earth's climate. This is because the global temperature rises due to trapped heat on Earth. Trapped heat is caused by the accumulation of greenhouse gases, such as carbon dioxide, released into the Earth's atmosphere from human activities. Since the heat cannot escape Earth, this causes global warming and, consequently, climate change.

Although the ocean is known for absorbing carbon dioxide released into the Earth's atmosphere, used by photosynthetic organisms, too much of this gas can cause severe changes to the ocean's pH level. The ocean water can become too acidic, concurrently decreasing oxygen levels and removing minerals used by invertebrates, especially corals and mussels. This could be catastrophic to ocean ecosystems, affecting invertebrates that depend on the minerals to build shells and skeletons and even affecting the species that rely on oxygen to survive.

Scientists have also recorded a gradual rise in sea level. This is caused primarily by two factors:

- Global warming is causing glaciers and ice sheets in cold regions of the globe to melt, adding more water to the ocean.
- Global warming is causing seawater to expand as it warms.

From January 1993 to November 2022, the sea level has risen to approximately 103.0 mm (NASA, 2023a). The estimated rate of sea-level rise is currently 3.4 mm per year (NASA, 2023b). As shown in the photos below, rising sea levels will affect coastal habitats and communities, flooding low-lying areas and gradually destroying sandy beaches.

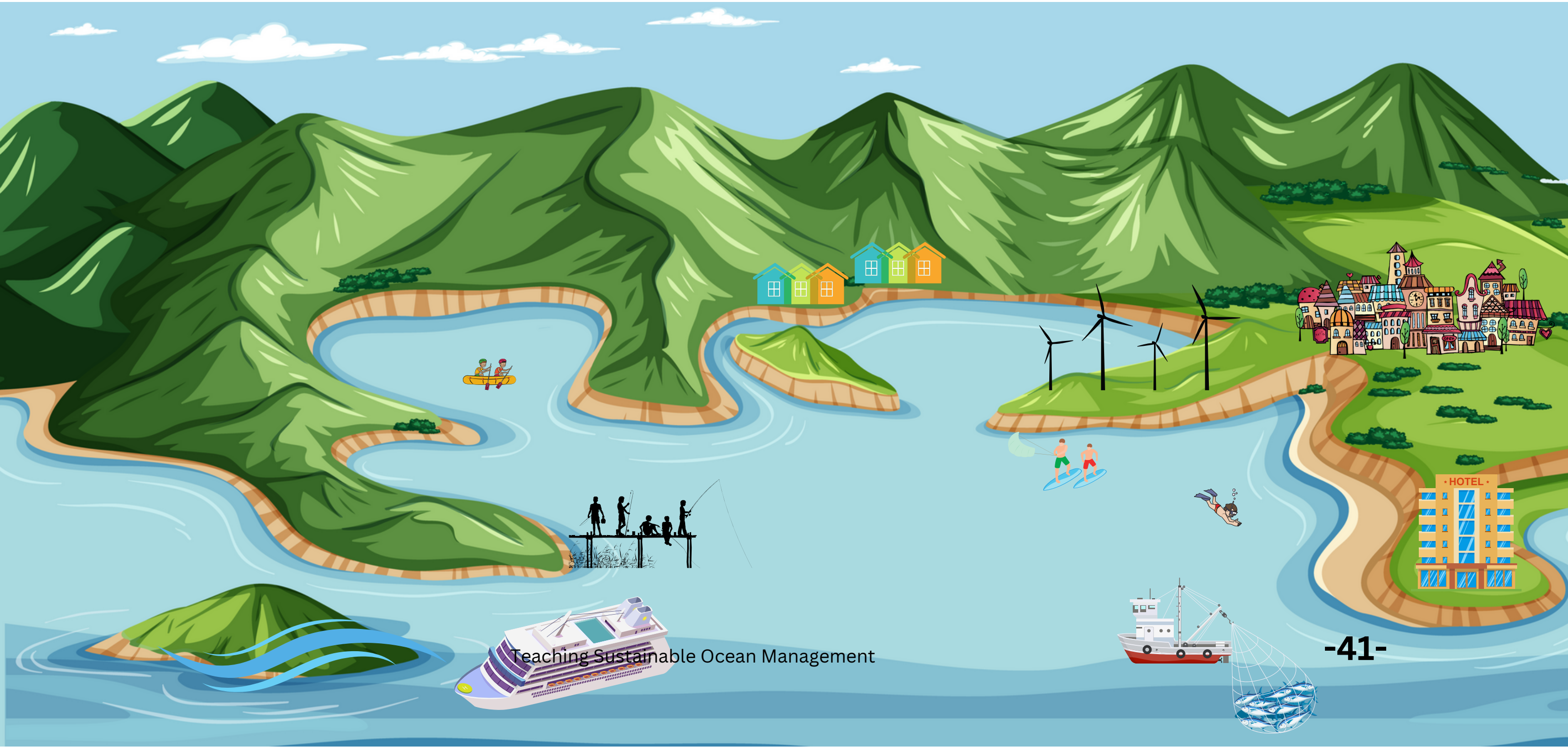
Principle 4

The ocean is vital to the well-being and prosperity of humans

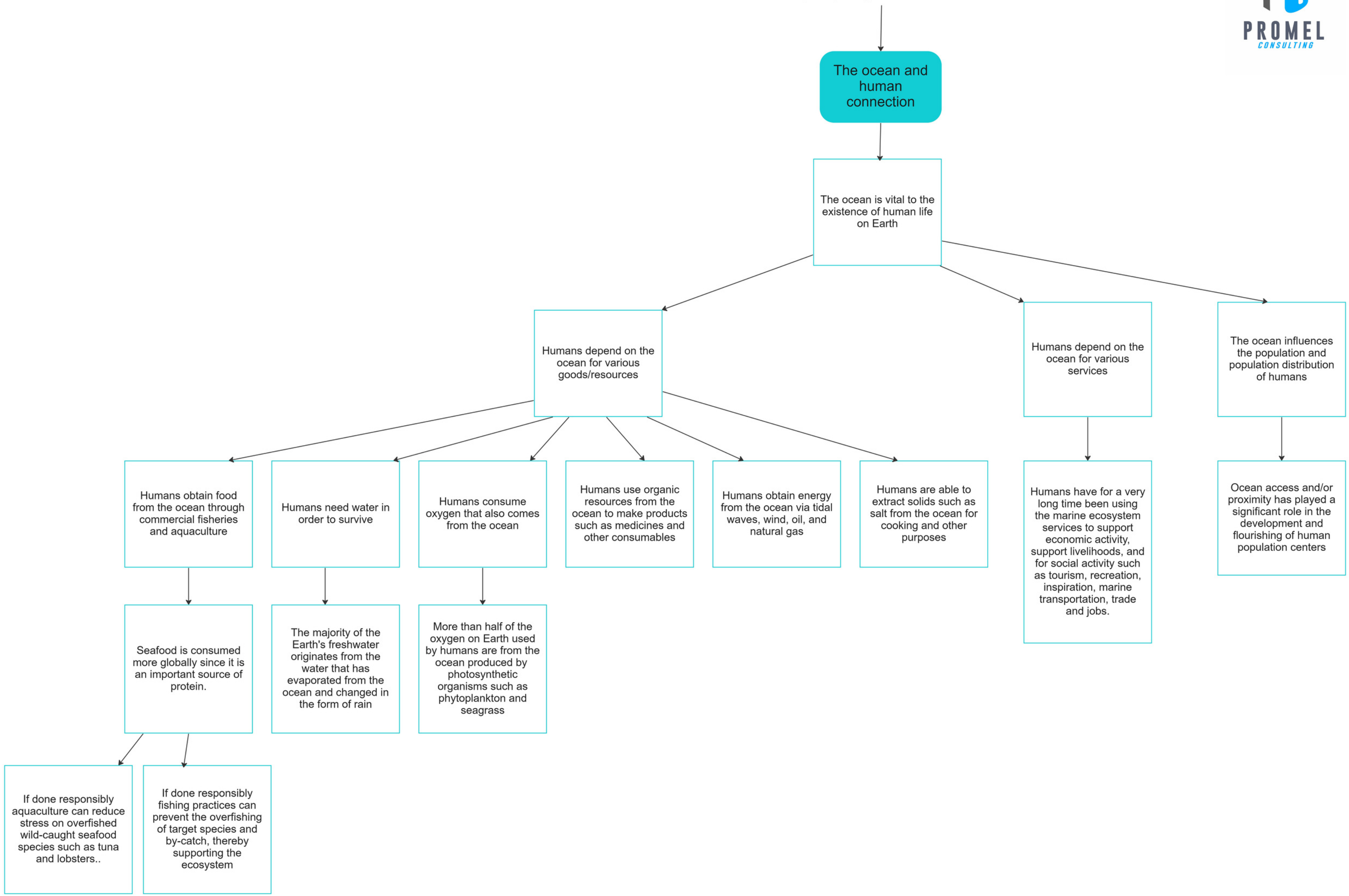
The ocean supplies freshwater (since most rain comes from the ocean) and nearly half of all of the Earth’s oxygen. Since the ocean significantly influences our weather and climate and affects human health. It provides us with goods and services such as food, medicines, minerals, and energy resources. It supports jobs and national economies, especially for transporting goods, fisheries, and recreation. It is also a source of inspiration and rejuvenation for people of different ages.

The ocean is an essential element in the heritage of many cultures, especially for nations that have lived and used the ocean for thousands of years. More than 3 billion people worldwide rely on seafood as a source of protein. According to a report produced by the Food and Agriculture Organisation (FAO) of the United Nations, countries in Africa and Asia rely even more on fish for their intake of animal proteins. Around 40% or more of total animal proteins are consumed by small island developing states such as Seychelles.

While we depend on the ocean to meet our needs, some of our activities continue to affect the ocean in various ways, leading to pollution, changes to ocean chemistry (ocean acidification), and physical modifications to coastal and marine habitats, to name a few. Humans continue to overexploit marine species that are already under threat, such as sharks, turtles, whales, and tuna. Increasing ocean temperature and ocean acidity continue to affect the survival of several organisms and impact biological diversity.



Principle 4: The ocean is vital to the well-being and prosperity of humans

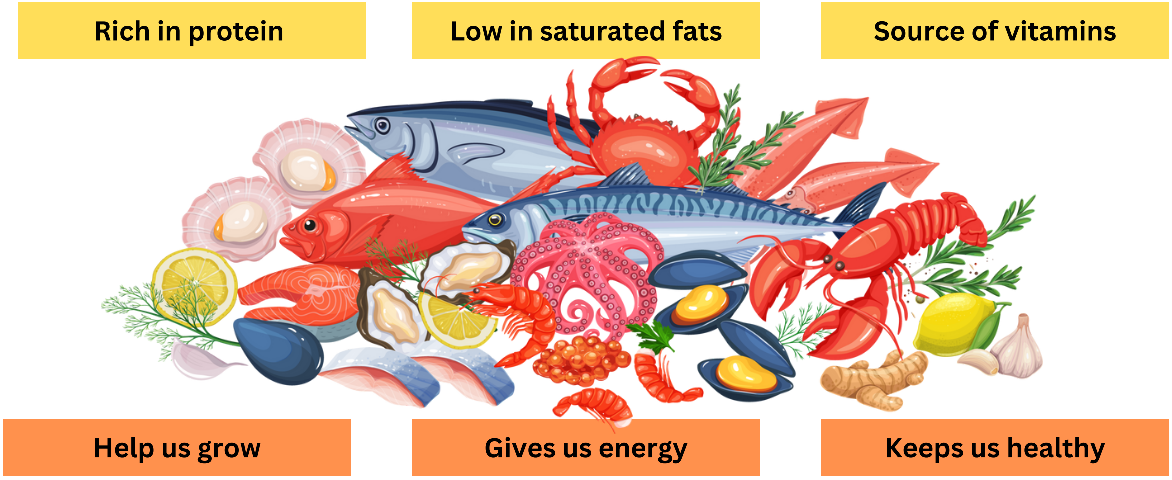


The ocean and human connection

The ocean is vital to the existence of human life on Earth. We depend on the ocean for various resources and services ranging from food, medicines, minerals, renewable energy, trade, and leisure, to name a few. These are explained in detail below.

Humans depend on the ocean for goods and services

Food as a resource



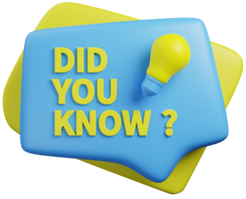
The ocean is an excellent source of nutritious food for humans, especially the best protein and other essential nutrients obtained from seafood. Seafood such as fish and crabs are caught through commercial fisheries and aquaculture. The fishery sector in Seychelles is made up of three categories, namely:

- artisanal fishing carried out by local fishermen targeting demersal and semi-pelagic species in the wild.
- semi-industrial fishing carried out by locally-owned long-liners targeting pelagic species in the wild.
- industrial fishing carried out by foreign-owned purse seiners and long-liners targeting tuna species only in the wild.

Seafood caught in the Seychelles Exclusive Economic Zone is consumed locally and exported to other countries. The total volume of fish consumed per capita per year is approximately 58.9 kg. The FAO (2017) ranks Seychelles as one of the world's highest per capita fish-consuming countries.

If done responsibly, commercial fishing practices can prevent the overfishing of target species, thereby supporting a healthy species population.

Aquaculture is about cultivating aquatic species in controlled breeding environments compared to commercial fishing practices. Farming of marine species is common across the Indian Ocean region, especially for sea cucumbers, oysters and prawns. For example, one of the oldest aquaculture industries in Australia is oyster farming which began in the late 1800s.



The 'Seychelles Aquaculture' is a Government initiative to develop the country's marine aquaculture sector. This is limited to only five marine species, such as prawns and oysters. To learn more about the initiative, please use your device camera to scan the code on the left or visit this link: https://seychellesaquaculture.com/

Aquaculture can reduce stress on overfished wild-caught seafood species such as tuna, lobsters and sea cucumbers if done responsibly.

Aquaculture

Commercial fishing

Water as a resource

As the largest water reservoir, the ocean stores more of this precious resource than on land. Approximately 97% of the Earth's water is in the ocean. Most of the Earth's freshwater originates from the water that has evaporated from the sea and changed in the form of rain with the help of the water cycle. This ensures that there is a constant distribution of water around the globe. Some countries are also treating seawater using a desalination plant for public consumption. This is quite common in coastal states, especially where there is not enough groundwater or ample freshwater from artificial reservoirs during the dry season.

To learn more about how desalination plant works, please use your device camera to scan the code below or visit this link: https://study.com/academy/lesson/desalination-lesson-for-kids.html

Oxygen as a resource

More than half of the oxygen on Earth comes from the ocean and is also used by humans. Photosynthetic organisms such as phytoplankton and seagrass produce the oxygen released into the atmosphere for human consumption.

Raw materials as a resource

Some of the products that we use are not necessarily made from materials found on land but also from the ocean. Products such as medicines, nori used in sushi, and other consumables are made from organic materials found in the ocean. Raw solids such as sea salt are extracted from the ocean for cooking and other purposes.

Nori made from seaweed

Medicines made from organic materials

Sea salt

Minerals found on the sea floor can be used to manufacture some technologies humans use, such as rechargeable batteries, smartphones and solar cells. However, some concerns about such exploitation are raised by scientists, and this is further explored under Principle 5.

Smartphones

Rechargeable batteries

Solar cells

Renewable energy as a resource

The ocean is also a renewable energy source produced by moving tides, waves, currents or winds. Ocean energy can be harnessed using unique technology to produce electricity for daily consumption. Besides renewable energy, the ocean is also a source of non-renewable energy, such as oil and gas. Particular technologies are currently being used to extract these fossil fuels from the seafloor. The oil is used to power vehicles and generators to produce electricity, and the gas is used for heating or cooking. To learn more about ocean energy, please take a look at the Primary or Secondary Teacher's guide on energy and how to use it sustainably (Emilie, 2016 & Crea, 2016) published by the Government of Seychelles. Alternatively, use your device camera to scan the code below or visit this link: https://kids.frontiersin.org/articles/10.3389/frym.2021.609510

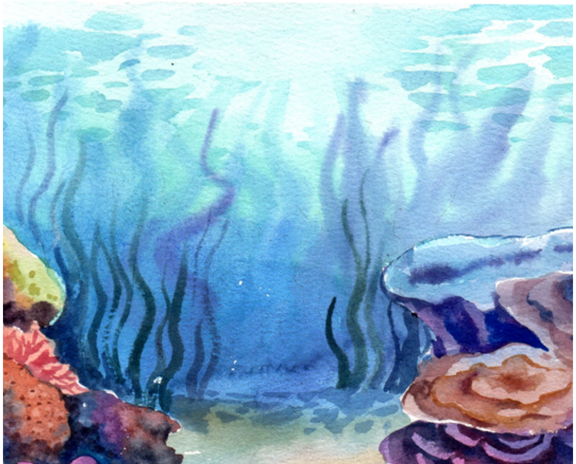
Offshore wind turbines

Humans depend on the ocean for various services

Humans have for a very long time been using a variety of marine ecosystem services to support economic activity and livelihoods and for their well-being, namely:


Tourism

Recreation



Inspiration

Transportation



Trade

Jobs


Population distribution

The ocean influences the population and population distribution of humans. This is because access to the ocean has played a significant role in developing and flourishing human population centres, especially those in coastal states. According to UNESCO (2021c), more than 40% of the global population lives within 100km of the coast, which is estimated to increase over time. Nearly half the world's population relies on the ocean for livelihood, and fifty-seven million people worldwide are employed in marine fisheries. This will increase over time as the human population grows and governments continue to develop the Blue Economy.

Population distribution near the coast

Principle 5

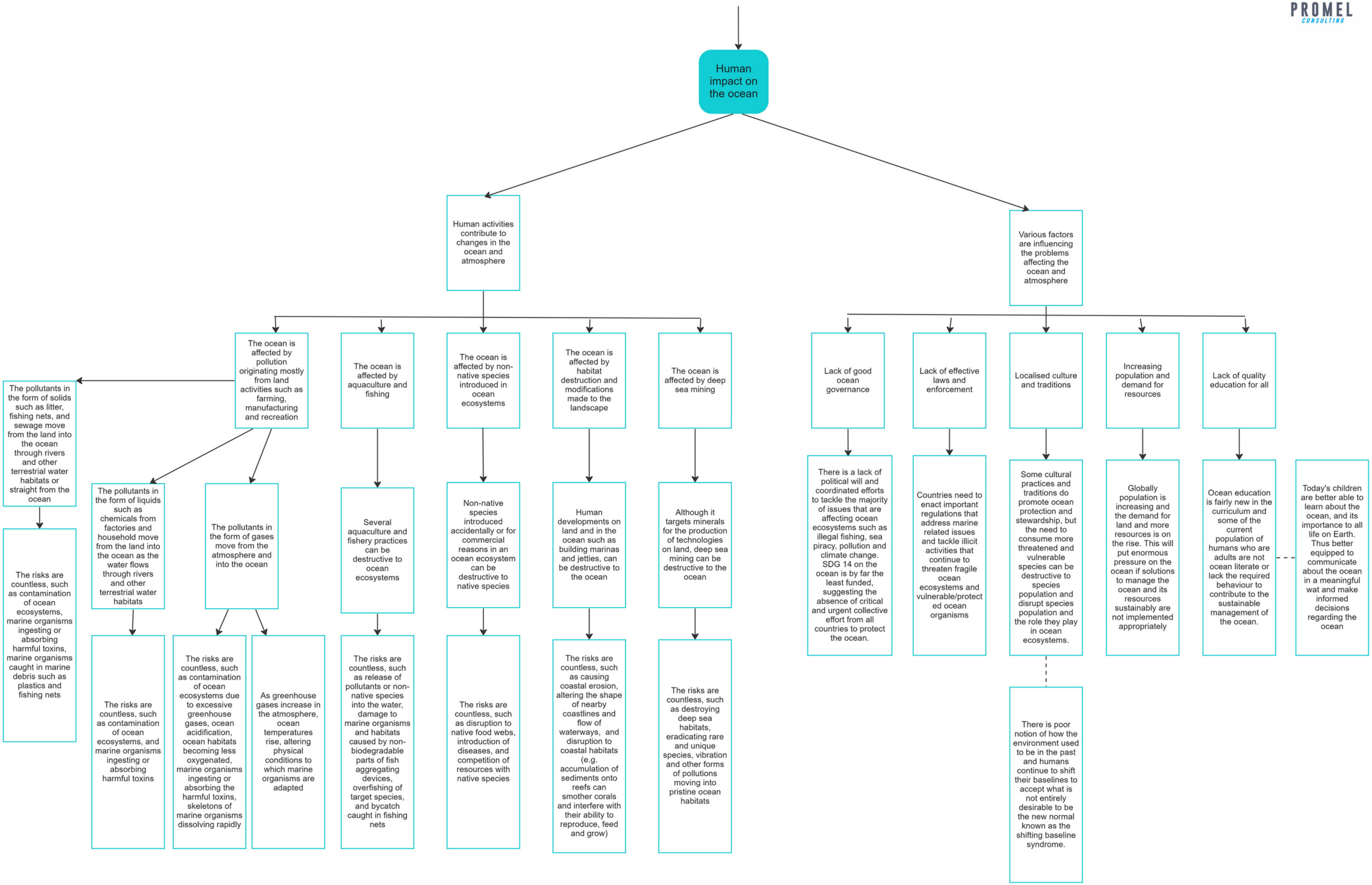
The ocean's ecosystems are threatened by human activities that lead to various problems and their associated risks

The oceans' health is essential for the planet's health, and our direct and indirect interactions with the ocean may have far-reaching ecological, societal, and economic consequences. As the threat to ocean health is ever-increasing, there is a risk that future generations may experience an ocean that has completely changed. This is characterised by climate change, degrading ocean ecosystems, marine pollution, littering, habitat destruction, overfishing and poor governance. These issues have their associated risks and can lead to severe ecological and economic decline in such countries that are immediately and visibly linked to the ocean's health. For example, climate change and changing ocean conditions are leading to declining fish stock.

Removal of mangrove forests is harming shoreline protection and species life cycle. Furthermore, some biological populations can run the risk of collapse and even localised extinction, in some cases having broader detrimental effects on other marine life and the wider ecosystems. Coral bleaching events lead to the destruction of coral-dominated reefs and change the assemblages to become algal-dominated reefs. The increase in plastic waste and other non-biodegradable waste harms species that ingest tiny pieces of plastic or become entangled in floating marine debris.

Many SIDS rely on the ocean to sustain their way of life. This includes utilising fish as the primary source of protein and focusing on the commercialisation of marine species, either through eco-tourism or the food processing industry.

Principle 5: The ocean is threatened by human activities that lead to various problems and their associated risks



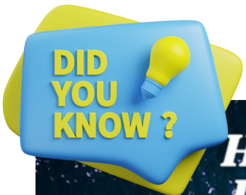
Problems caused by human activities

Although human activities such as farming and fishing benefit global populations, they still lead to various problems affecting marine habitats and life. Several of these problems include marine pollution, overfishing, the introduction of invasive species and habitat destruction. The problems have their associated risks, further explored below.

Land activities

Land activities such as farming, manufacturing and recreation are causing ocean pollution. Pollutants in the form of solids, liquids or gases are released on land or into the atmosphere and end up in the ocean.

Pollutants in the **form of solids** vary from litter, fishing nets, and sewage released on land, which then make their way to the ocean through rivers and other terrestrial water habitats.



Plastics are the most common item found in solid waste. According to a study conducted by Meijer et al. (2021), it is estimated that out of a total of 67.5 million metric tons of plastic waste produced annually, approximately 1 million metric tons (1 billion kilograms) of plastic waste ends up in the ocean every year. Tropical archipelago regions have a relatively small land area and a higher waste emission rate. As shown on the left, the Philippines was identified to be the highest ocean plastic waste polluter in the world.

Accumulation of solid waste in the ocean can potentially lead to the following:

- contamination of ocean ecosystems;
- marine organisms ingesting marine debris and harmful toxins;
- marine organisms caught in marine debris, such as plastics and fishing nets.

Pollutants in the **form of liquids** are chemicals from factories and households released into the ocean through rivers and other terrestrial water habitats.

Accumulation of liquid waste in the ocean can potentially lead to the following:
- contamination of ocean ecosystems;
- marine organisms ingesting harmful toxins.

Pollutants in the **form of gases** are first released into the atmosphere once fossil fuels are burned in factories and transports. The gases such as carbon dioxide (an example of a greenhouse gas) are absorbed in the ocean and atmosphere.

Accumulation of greenhouse gases in the ocean can potentially lead to the following:

- contamination of ocean ecosystems;
- ocean acidification;
- ocean habitats becoming less oxygenated;
- marine organisms absorbing harmful toxins;
- skeletons of marine organisms such as corals dissolving rapidly in highly acidic water.

When greenhouse gases increase in the atmosphere, ocean temperature also rises, altering the physical conditions to which marine organisms adapt.

Aquaculture and fisheries

Several aquaculture and fishing practices can be destructive to ocean ecosystems. If not appropriately done, aquaculture can cause various problems such as aquatic pollution, farmed species escaping the enclosure, and terrestrial/marine wildlife losing their habitat to make way for aquaculture farms. These can potentially lead to the contamination of ocean ecosystems, alien marine species invading ocean habitats and destroying native marine species, and spreading diseases and parasites.

Some fishing methods, either used in legal, illegal or unregulated fisheries, are causing severe problems in the ocean. Issues include marine pollution caused by drifting fish aggregating devices (dFADs), overfishing, marine species caught unintentionally in fishing nets (by-catch), and fishing nets damaging coral reefs. For example:

- The bottom trawling fishing method can damage fragile coral reef habitats when the large net is dragged across the seafloor to catch fish.
- Once abandoned, the purse seining fishing method, which depends on deploying dFADs, can add more marine debris to the ocean.

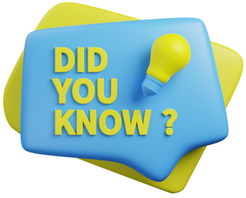
The risks associated with the problems caused by fishing methods vary. Once coral reefs are damaged by nets dragged at the bottom of the seafloor, this will affect the marine species dependent on the marine habitat for shelter and food. Accumulation of non-biodegradable materials from abandoned dFADs can lead to the expansion of marine debris in the ocean and marine species getting entangled in abandoned floating nets (also known as ghost nets) and ropes. The ghost nets and cords can also get caught in corals and cause further damage to the fragile structures of corals. The large fishing nets deployed by purse seiners can lead to overfishing of target species and affect the population of marine species unintentionally caught in the nets.

Poaching of marine species protected under law or those in protected areas such as marine reserves is also rising. Fishermen carry this out to meet the demand for marine species that are considered local delicacies. Poaching affects the population of threatened and most vulnerable species, such as sea turtles. The illegal harvest of marine species undermines national or global efforts to protect marine species. If they continue to be fished in great numbers, the population of the marine species will reduce over time and eventually become extinct.


Parts of a dFAD caught in coral reef


Marine life entangled in ghost net

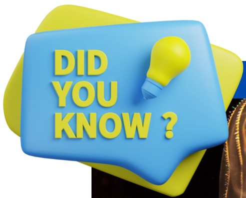

Damaged coral reef on sea floor caused by bottom trawling



Every year, nearly 100,000 fish aggregating devices are deployed by purse seiners in tropical regions of the Indian Ocean and South Pacific Ocean (Moreno et al., 2016). For quite some time, international organisations such as World Wildlife Fund, including organisations in Seychelles such as Nature Seychelles and the Island Conservation Society, have echoed alarming concerns about the destructive implications of dFADs in our ocean. There is a national programme in Seychelles, known as FAD Watch, aimed at intercepting and removing dFADs on several islands of Seychelles. The Island Conservation Society is currently leading this with the support of other organisations and companies. To learn more about the initiative, please use your device camera to scan the code on the left or visit this link:
http://www.islandconservationseychelles.com/news/long-term-view-for-fad-watch-in-seychelles-outer-islands

Introduction of non-native marine species via international shipping

Non-native marine species such as sponges, crustaceans, and algae usually enter a new marine region intentionally through commercial activities such as aquaculture or accidentally by shipping vessels. Non-native marine species are considered 'invasive' because they are considered economically or ecologically harmful, and they can also be introduced naturally from neighbouring oceanic regions. Once they enter a new marine region, non-native aquatic species are more likely to disrupt native food webs, raise deadly diseases and compete for resources or space with native species.



Comb jellyfish

Sponge

Shrimp

In the early 1980s, the comb jellyfish (native to the western Atlantic) was responsible for a dramatic drop in fish populations in the Black Sea (Rius et al., 2023). The non-native marine species ate the young and eggs of pelagic fish. This was not only ecologically harmful to other marine species found in the Black sea but also affected surrounding countries' economies.

On a different note, findings from a separate study conducted in Seychelles by Floeri et al. (2006) revealed that only three non-native marine species were found at Port Victoria and nearby surroundings. As shown in the photos on the left, two species of shrimps and a sponge species were introduced in Seychelles via international vessels, usually attached to the ship or floating in the ship's ballast tank.

Developments on land and in the ocean

Human developments on land and in the ocean, such as building reclaimed lands, marinas and industrial ports, also contribute to environmental problems such as habitat loss and pollution. Although it supports the economy of countries, the developments harm the ocean and coastal habitats. This can alter the shape of nearby coastlines and the flow of waterways, contaminate ocean ecosystems, erode coastlines and disrupt coastal and ocean habitats. One of the common disruptions to ocean habitats is the accumulation of sediments on coral reefs. This can smother corals and interfere with their reproduction, feeding, and growing ability.

Deep-sea mining

Although deep-sea mining could provide humans with minerals to be used in manufacturing technologies, scientists have already expressed concerns that this activity may severely destroy seafloor ecosystems. Exploration of deep-sea mineral deposits has begun around the globe in countries such as India, Brazil and the United Kingdom (IUCN, 2022). The mineral deposits on land are already depleting, and the demand for metals is increasing. Hence deep-sea mining in some ocean basins may begin sooner or later. Some risks associated with deep-sea mining are the destruction of ocean floor ecosystems, eradication of rare and unique marine organisms that can only survive in deep-water habitats, vibration and other forms of pollution moving into pristine ocean habitats.

Factors contributing to the human-induced problems

Various factors contribute to the problems affecting the ocean and the diversity of life. Only five significant factors are listed below and are inextricably intertwined.

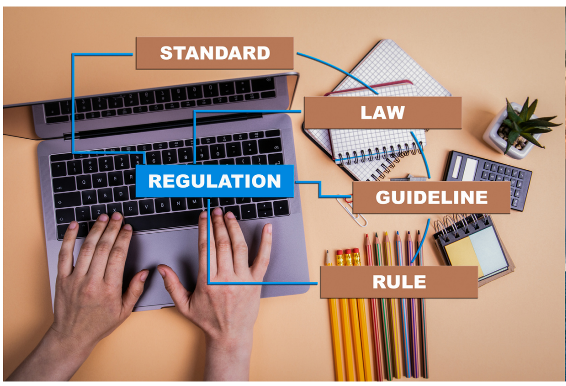
Lack of good ocean governance

There needs to be more political will and coordinated efforts to tackle most issues affecting ocean ecosystems, such as illegal fishing, pollution, climate change and sea piracy. Countries worldwide need to invest more in setting up regulations, policies and programmes that promote better management and sustainable use of the ocean. The lack of funding and interest from governments is quite alarming and was recently confirmed in a survey completed by 3500 leaders from developed and developing countries. The survey findings reported that Sustainable Development Goal 14, based on the ocean, was considered the least important of the 17 United Nations Sustainable Development Goals (Burke, 2022). This is because it needs to be addressed in most cases, so it does not appear on the top priorities for the world's leaders. The study further revealed that only 5.4% of the 3500 leaders included SDG14 as part of their top six priorities compared to 65.2% for SDG4 - quality education.

To learn more about SDG14, use your device camera to scan the code on the left or visit this link:
https://www.globalgoals.org/goals/14-life-below-water/

Lack of effective laws and enforcement

Countries must enact necessary regulations addressing marine-related issues and tackle illicit activities that threaten fragile ocean ecosystems and vulnerable or protected ocean organisms. An example of a law would be to impose a fine on domestic/international fishing vessels that pollutes the territorial sea where they conduct their fishing activities for damages caused to marine ecosystems. Once the regulations are in place, they should be effectively enforced through various national programmes such as policing marine protected areas and intercepting boats fishing illegally in marine protected areas.



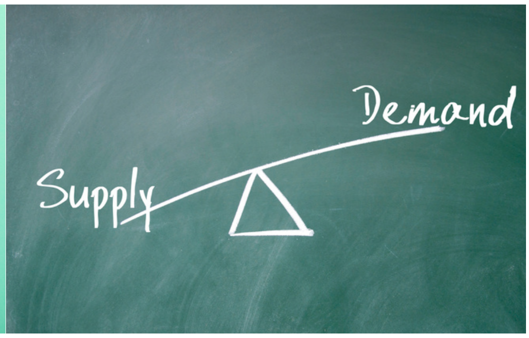
Localised culture and traditions

Some cultural practices and traditions promote ocean protection and stewardship, but some cultures continue to threaten even the most vulnerable and endangered species around the globe. In some parts of the world, sea turtle meat is considered a local delicacy, and although protected under law, they are illegally caught and sold on the black market. It is a cultural practice passed down from one generation to the next and has been on the discussion table for a very long time, regardless if the species is declared endangered. Killed for its meat, eggs or shells, the sea turtle population continues to decrease in some parts of the world due to over-exploitation and poaching.

For centuries, humans have continued to overexploit and mismanage the ocean and its resources without paying close attention to how their actions are slowly degrading the ocean ecosystems. From one generation to the next, humans need a better notion of how the ocean ecosystems used to be. This imperfect recollection of the historical conditions of the ocean ecosystems has caused humans to be ignorant of the alarming decline of marine habitats and species. On this note, humans have shifted their baselines to accommodate what is known today to be the new normal, known as the 'shifting baseline syndrome'. Shifting baseline syndrome is "a gradual change in the accepted norms for the condition of the natural environment due to a lack of experience, memory and/or knowledge of its past condition" (Pearce, 2020). Since our baseline shifts with every generation and sometimes even within an individual, human beings are less aware of the extent of their actions for degrading the natural world and the morally accepted behaviours for desirable environmental conditions.

Increasing population and demand for resources

Globally population is increasing, and the demand for land and resources is rising. It is estimated that the global population will increase to more than 9 billion by the year 2050, putting enormous pressure on the ocean and coastal resources. Hence, countries would need to explore solutions to sustainably manage the ocean and its resources.



Lack of quality education for all

Ocean education is relatively new in the curriculum. Some groups of people who are already adults need to be ocean literate or require more knowledge, skills and values to contribute to sustainable ocean management. People need to understand the ocean's importance, how their actions impact the ocean and what they can do to protect the ocean. This is why today's education systems are being transformed to integrate critical sustainability themes such as sustainable ocean management.

Principle 6

The ocean's health and productivity can be achieved through collective sustainable solutions

There is still much to be done to meet the goals and targets under SDG 14: "to conserve and sustainably use the ocean, seas, marine resources, for sustainable development". The ocean's health and productivity depend highly on a nation's ability to develop solutions to monitor better, protect, manage, and restore marine and coastal ecosystems and their diversity. Aspects of good ocean governance and effective regulations to restore and build ocean resilience are some of the actions required to contribute to SDG 14. Tourism in Seychelles relies on a healthy marine environment, and it is essential to find a balance between developing the tourism sector and protecting the marine environment that supports it. This is why several national initiatives encourage visitors to contribute towards safeguarding and responsible use of the fragile environment of Seychelles, such as eco-tourism activities and tourism levies.

Regional and international approaches have been discussed or implemented to reduce overfishing, deter IUU (illegal, unreported, and unregulated fishing), reduce marine pollution and the use of Fish Aggregating Devices. There is still a need to gather more ocean data and use it to make informed decisions that positively impact the ocean and its resources. Scientific institutions are currently undertaking this. Scientists continue to encounter several challenges in data collection due to a need for more funding and a workforce to cover the ocean's vastness.

Management and conservation should consider the big picture. Integrated coastal zone management and marine spatial planning, considering all users, climate change and biodiversity conservation, need to deliver 100 per cent jointly managed landscapes and seascapes. Doing so requires further investment in collaborative work and long-term planning to have a sustainable and integrated blue economy, conservation of natural seascapes, improved stakeholder security, and transparency and access to information. Seychelles is an example of a state incorporating climate change adaptation into a marine spatial planning process to support its ocean economy and environmental goals. The Seychelles Marine Spatial Plan Initiative aims to address climate change adaptation, protect 30% of Seychelles' waters, and support the Blue Economy Roadmap and other national strategies.

Principle 6: The ocean's health and productivity can be achieved through collective sustainable solutions

Humans responsibility to the ocean

The ocean's health and productivity are highly dependent on a nation's ability to develop solutions to better monitor, protect, manage, and restore marine and coastal ecosystems and their diversity

- **Ocean governance**: Countries need to effectively manage the marine environment and resources where they have jurisdiction by investing in research, manpower, regulations and programmes relating to ecosystem-based management and marine spatial planning that will address the majority of issues that are affecting ocean ecosystems.
- **Conservation programmes and projects**: Conservation programmes and project should be strengthened and supported financially so as to ensure the effective monitoring and protection of ocean ecosystems and organisms, including ecosystem restoration
- **Ongoing marine research**: Scientific marine research is vital to developing a better understanding about the ocean ecosystems and organisms. Data collected is useful to guide policy decisions and individual actions. Moreover, provide useful data to inform and regulate ocean activities such as fishing and land activities such as the building of structures.
- **Education for Sustainable Development**: Sustainable ocean management should be integrated at all levels of a nation's education system. This will equip students of all ages with the required competencies to understand the importance of the ocean to humankind, ·communicate about the ocean in a meaningful way, take informed decisions and responsible actions that promote ocean sustainability
- **Trained workforce**: Capacity development is required to creating an appropriately trained workforce with the ability to manage coastal and marine environments and at the same time develop the Blue Economy in a sustainable way.
- **Laws, surveillance and enforcement**: Effective management of ocean habitats and species cannot succeed without sufficient regulations, surveillance, and law enforcement. It is therefore imperative that illicit activities are tackled hands on and everyone using the ocean and its resources comply to the law governing the ocean jurisdiction.
- **Sustainable energy**: Instead of relying on non-renewable energy sources, humans can instead tap into renewable energy sources in the ocean, such as tidal waves and ocean currents to produce electricity for consumption on land. This will help to reduce the large amount of greenhouse gases produced by the burning of non-renewable energy sources. Humans can also engage in energy conservation and energy efficient practices such as making use of energy efficient appliances
- **Sustainable fisheries and aquaculture**: Sustainable fishing and aquaculture practices are required to maintain fish populations, reduce bycatch, reduce pollution, and protect species against habitat destruction and non-biodegradable fish aggregating devices
- **Marine protected areas and sustainable use zones**: Marine protected areas should be introduced and effectively monitored to protect ocean habitats and organisms. Sustainable use zones should be introduced and effectively monitored for artisanal fisheries, aquaculture, and recreational fishing and other activities
- **Responsible construction**: Guided by existing regulations and policies, construction of structures near/along the coast should be done responsibly so as to maintain the integrity of coastal environments
- **Reduce land pollution**: Pollution can be reduced by adopting simple actions such as using bins effectively, recycling, and purchasing biodegradable products. This will help to reduce plastic pollution and support the circular economy.
- **Sustainable tourism**: Sustainable tourism is also vital to addressing some of the ocean's problems. Tourists can play their role to protect and restore the ocean habitats used for various recreational activities such as snorkelling and diving. They can also generate the revenue required to finance the sustainable management of the ocean. This is because the tourism industry is considered an important engine for the economic growth of many countries globally

Humans responsibility to the ocean

The ocean's health and productivity depend highly on a nation's ability to develop solutions to monitor better, protect, manage, and restore marine and coastal ecosystems and their diversity. Herewith is a summary of several solutions that can help to tackle the problems highlighted under Principle 5.

Ocean governance

Countries must effectively manage the marine environment and resources where they have jurisdiction by investing in research, workforce, regulations and programmes relating to ecosystem-based management and marine spatial planning that will address most issues affecting ocean ecosystems. Seychelles is an example of an Indian Ocean country that has developed a comprehensive marine spatial plan to adapt to climate change, protect nearly 30% of its marine waters, and support the Blue Economy Roadmap and other domestic strategies.

To learn more about this national initiative, please use your device camera to scan the code on the left or visit this link: https://seymsp.com/the-initiative/

Conservation programmes and projects

Conservation programmes and projects should be strengthened and supported financially to ensure the effective monitoring and protection of ocean ecosystems and organisms, including ecosystem restoration.

Ongoing marine research

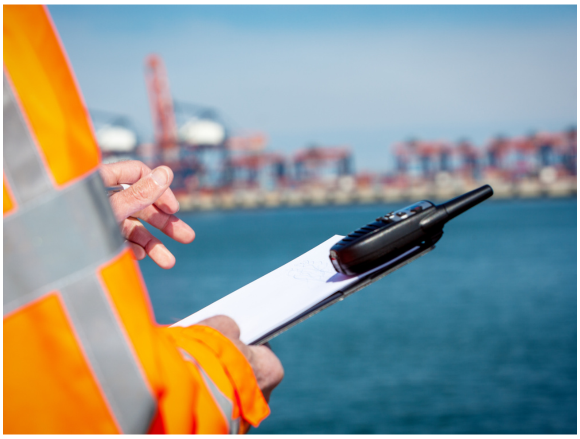
Scientific marine research is vital to understand ocean ecosystems and organisms better. Data collected helps guide policy decisions and individual actions. Moreover, provide valuable data to inform and regulate ocean activities, such as fishing and land activities, such as building structures.

Education for Sustainable Development

Sustainable ocean management should be integrated at all levels of a nation's education system. This will equip students of all ages with the required competencies to understand the importance of the ocean to humankind,
·communicate about the ocean meaningfully, take informed decisions and responsible actions that promote ocean sustainability.

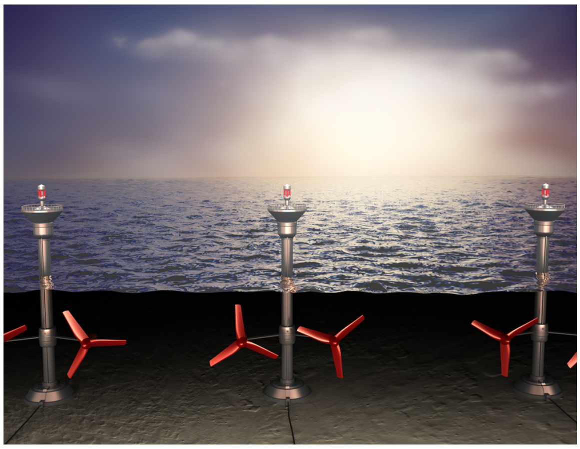
Trained workforce
Capacity development is required to create an appropriately trained workforce with the ability to manage coastal and marine environments while simultaneously developing the Blue Economy sustainably.

Laws, surveillance and enforcement
Effective ocean habitats and species management can only succeed with reasonable regulations, surveillance, and law enforcement. Therefore, illicit activities must be tackled hands-on, and everyone using the ocean and its resources comply with the law governing ocean jurisdiction.



Sustainable energy

Instead of relying on non-renewable energy sources, humans can tap into renewable energy sources in the ocean, such as tidal waves and ocean currents, to produce electricity for consumption on land. This will help reduce greenhouse gases produced by burning non-renewable energy sources. Humans can also engage in energy conservation and energy-efficient practices such as using energy-efficient appliances.



Sustainable fisheries and aquaculture

Sustainable fishing and aquaculture practices are required to maintain fish populations, reduce bycatch, reduce pollution, and protect species against habitat destruction and non-biodegradable fish aggregating devices.

Marine protected areas and sustainable use zones

Marine-protected areas should be introduced and effectively monitored to protect ocean habitats and organisms. Sustainable use zones should be taught and effectively monitored for artisanal fisheries, aquaculture, recreational fishing and other activities.

Responsible construction

Guided by existing regulations and policies, the construction of structures near/along the coast should be done responsibly to maintain the integrity of coastal environments.

Reduce land pollution

Pollution can be reduced by adopting simple actions such as using bins effectively, recycling, and purchasing biodegradable products. This will help to reduce plastic pollution and support the circular economy.

Sustainable tourism

Sustainable tourism is also vital to addressing some of the ocean's problems. Tourists can play their role in protecting and restoring the ocean habitats used for various recreational activities such as snorkelling and diving. For example, they should avoid applying sunscreen on their body before snorkelling near coral reefs and should not touch nor stand on coral reefs. They can also help generate the revenue required to finance sustainable ocean management. Tourism is an essential engine for many countries economic growth.

Principle 7

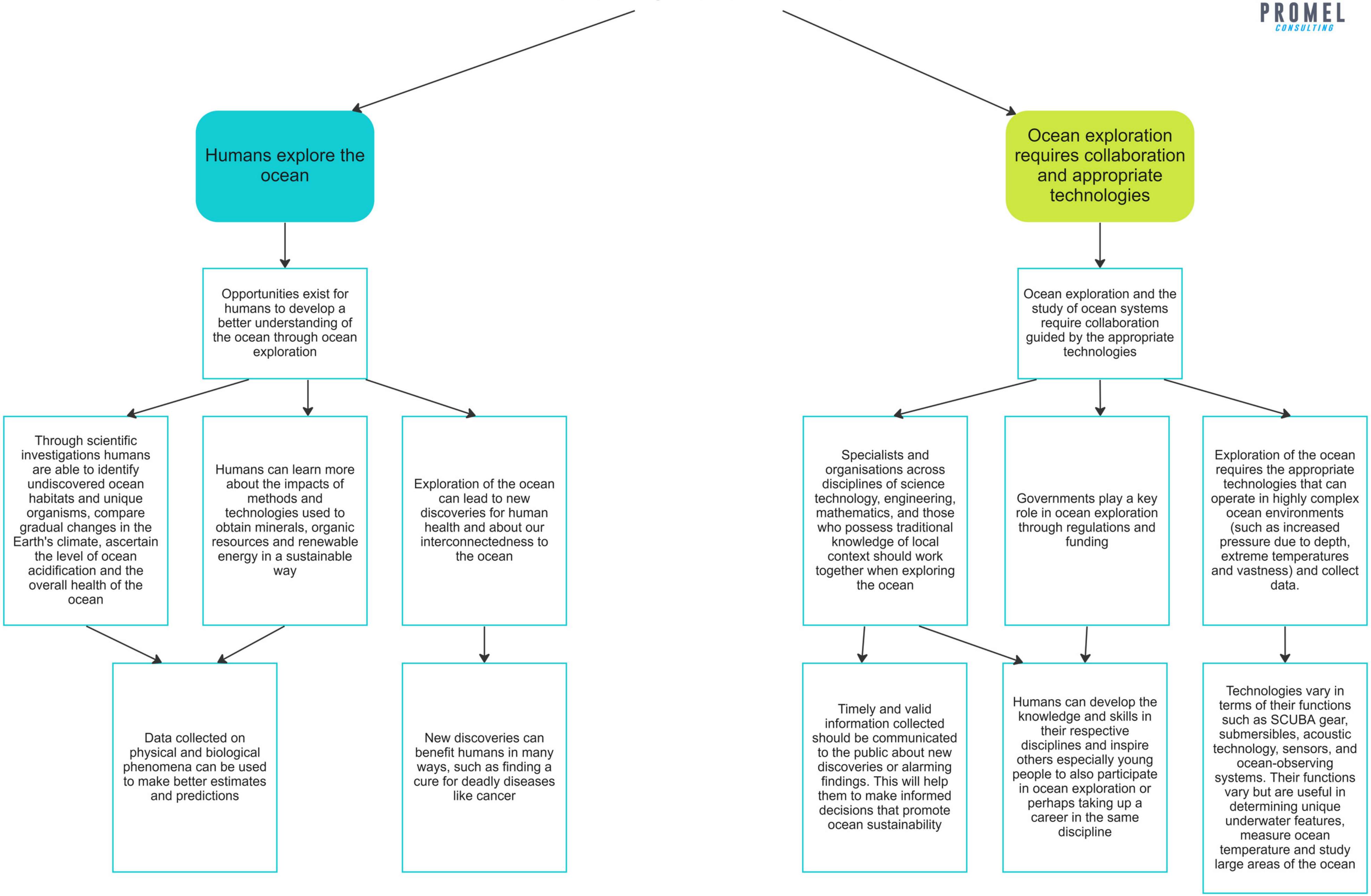
The ocean is largely unexplored and should be understood for us to continue to conserve and sustainably manage the shared ocean and its resources

Despite the importance of the ocean, less than 20% of the ocean has been explored. The global ocean floor map is less detailed than maps of Mars, the moon or Venus.

The use of new technologies, innovation, and sensors is expanding our view and understanding of ocean systems and processes. This will provide scientific data which will inform decisions for the future sustainability of our shared ocean and its resources. The way forward is to build a civic relationship with the ocean that allows people with different backgrounds, knowledge, and experiences to collaborate and stimulate new ideas to solve problems about the ocean. This includes biologists, chemists, climatologists, oceanographers, engineers, geologists, computer programmers, and social scientists. Such collaboration brings innovations and innovative thinking methods that further the ocean's study.

The ocean has answers to questions we do not have currently, to diseases and outbreaks we have not yet experienced, as well as inventions or processes we do not yet understand, so protecting our ocean also ensures the future and advancement of humans.

Principle 7: The ocean is largely unexplored and should be understood for us to continue to conserve and sustainably manage the shared ocean, its ecosystems and resources



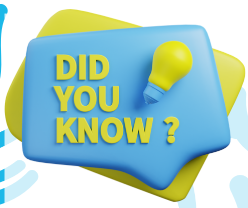
Human explore the ocean

Opportunities exist for humans to understand the ocean through ocean exploration better. Through ocean exploration, humans can:

- collect information about undiscovered ocean habitats and unique organisms
- collect and analyse information about gradual changes in the Earth's climate
- ascertain the level of ocean acidification and overall health of the ocean
- collect information and assess the impacts of methods and technologies yet to be used to obtain minerals from the depth of the ocean
- collect information and assess the impacts of harvesting too many organic resources
- collect information and assess the impacts of technologies to harvest renewable energy from the ocean

All of the above is crucial to effectively conserve and sustainably manage the shared ocean, its ecosystems and resources. It can also provide valuable insights into our dependence on the ocean and the ocean's positive influence on our health and well-being. Finding a cure for deadly diseases such as cancer is an example.

Information collected can help scientists and other key experts to make better estimates and predictions about current and future ocean conditions. This will help countries to reflect on their impacts on the ocean and how these can lead to changes that can affect life on Earth.



To learn more about deep sea facts, use your device camera to scan the code below, or please visit this link: https://passportocean.com/2019/05/29/deep-sea-facts/

Many organisms at the bottom of the ocean produce their own light to help them to survive.

Greenland shark is the largest deep sea fish, which has a length of 6.4 meters.

The deepest known location on Earth is about 11km deep, located in the Marianna Trench near Guam.

According to NASA, there are better maps of planet Mars than the ocean's depth. So far not more than 15% of the ocean's depth have been surveyed.

Ocean exploration requires collaboration and appropriate technologies

Ocean exploration and studying ocean systems require collaboration guided by the appropriate technologies. Specialists and organisations across disciplines of science, technology, engineering, and mathematics and those who possess traditional knowledge of local context should work together when exploring the ocean. They can use their expertise and experience to plan and support ocean exploration collectively. Governments can play a crucial role in funding and regulating ocean exploration.

In 2019-2020, a combined Nekton deep sea expedition began in the waters of Seychelles and Maldives. The expedition provided insights into marine life and the state of the ocean in both jurisdictions. The journey was conducted at a depth of 1,000 to 4000 metres below the surface of the water and comprised a mix of Seychellois and foreign professionals and students. More than 1200 biological samples were analysed. Several species of sponge, fish, coral and other marine organisms were discovered, some of which were new to Seychelles and science. The expedition team was also able to map new areas of the seabed, and interestingly, the first seabed maps of Alphonse indicated a ridge at approximately 120 metres long.

To learn more about deep sea exploration, please use your device camera to scan the code on the left or visit this link: https://www.youtube.com/watch?v=X4fMO_uSR1E

The expedition above provides a good case study of how humans can develop the knowledge and skills in their respective disciplines and inspire others, especially young people, to also participate in ocean exploration. This can also inspire young individuals to pursue a career in ocean exploration.

During a reasonable period, findings from the expedition were shared with the world, so for all ocean exploration, information collected must be communicated with the public. The data can vary from discoveries or alarming findings. Since only a little is known about the ocean, the information shared will help raise awareness about the marine biodiversity and physical changes at the ocean depths and influence people to make informed decisions that promote ocean sustainability. Moreover, generate valuable data for governments to define conservation and management priorities and the designation of marine protected areas.

Exploration of the ocean requires the appropriate technologies that can collect information and operate in highly complex ocean environments such as increased pressure due to depth, extreme temperature and vastness. Technologies such as SCUBA gear, submersibles, acoustic technology, sensors, and ocean-observing systems vary in terms of their functions. The technologies can help to determine unique underwater features, measure ocean temperature and study large ocean areas.

About the Project and Credits

Project summary

Seychelles, with the support and funding of the Indian Ocean Rim Association (IORA), championed the development of a Sustainable Ocean Management (SOM) education programme to engage learners to become ocean literate and develop the Blue Economy (BE) sector. The Project known as 'A study incorporating sustainable ocean management into the Science curriculum for 12-13 years old' included a review of the current Science Programme of Study for secondary one students only and the development of resources (this guide is one of them) on sustainable ocean management to be used in formal education. The Department of Blue Economy contracted two consultants for the project, namely Mr Shane Emilie on behalf of Promel Consulting as the Curriculum Designer and Ms Sylvanna Antat as the Ocean Educator. The project lasted one year and was completed in two phases, commencing September 2022 and ending September 2023.

There have been previous discussions between public and private sector organisations on the need to incorporate sustainable ocean management concepts within the Seychelles formal education system, dating back to when the Blue Economy Department was officially established in 2015. This project is, therefore, an essential milestone for Seychelles to bridge this gap by integrating sustainable management ocean concepts in a particular Key stage and within the science learning content. It is hoped that the project will continue with more funding for other levels of the Seychelles education system, i.e. from early childhood to primary and secondary education.

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- Coastal erosion and flooding on page 18

- Sea bed and marine life on page 19
- Coral reef on page 21
- Great Barrier Reef on page 22
- Seagrass meadows on page 23
- Mangrove forests on page 24
- Estuaries and open ocean on page 25
- Mixed graphics were used to create Figure 6 on page 27
- Mixed graphics were used to create Figure 7 on page 29
- Mixed graphics were used to create Figure 8 on page 30
- Marine animals on page 31
- Beach and underwater background on page 32
- Mixed graphics (excluding the algae) used to create Figure 11 on page 33
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- Mixed graphics of the ocean, the atmosphere and the storm on page 35
- Mixed graphics were used to create Figure 14 on page 38
- Bleached corals, forest, green seawater, and natural reservoir of water on page 39
- Flooded coastal areas on page 40
- Mixed graphics to illustrate how the ocean is vital to our well-being and prosperity on page 41
- Collage of seafood on page 43
- Aquaculture and commercial fishing on page 44
- Desalination plant, seaweed sheets, medicines and salt on page 45
- Smartphone, rechargeable battery, solar cells, and offshore wind turbines on page 46
- Tourists on the beach, man paddling, ferry, cargo vessel, and fisherman on page 47
- Coastal city on page 48
- Mixed graphics used to illustrate ocean-related issues on page 49
- Fish swimming close to floating plastics on page 51
- Pollutants released into the ocean and atmosphere on page 52
- Fish aggregating device, damaged coral reef and sea turtle entangled in floating ghost net on page 53
- Comb jellyfish, sponge, and shrimp on page 54
- Coastal developments on page 55
- Map of the world, group of people holding a banner, coast guard boat and regulation concept on page 56
- Sea turtle shell and meat curry on page 57
- World population concept, the scale showing supply and demand, and indoor and outdoor learning on page 58
- Mixed graphics to illustrate a cleaner ocean on page 59
- Diver, people collecting litter, and coast guard vessels on page 61
- Marine biologist and scientists on page 62
- Students learning inside and outside the classroom on page 62
- Marine biologist, engineer, marine police vessel, and engineer on page 63

- Wind turbines, current ocean turbines, aquaculture and tuna caught in fishing nets on page 64
- Coastal vegetation, marine protected area and recycled bins on page 64
- Man swimming with dugong, man snorkelling, and man swimming with a sea turtle on page 66
- Anglerfish, greenland shark, marianna trench, and planet Mars on page 69
- Scuba diver on page 71.

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TROUBLES OF THE SEAGRASS

I am the seagrass,
the protector of the meadows.
I keep the ecosystem in balance,
providing food and shelter for all.
I am the foundation of the food chain,
the home of countless creatures.
I am vital to the health of the ocean,
the lungs of the planet.

But I am in danger.
My meadows are being destroyed,
uprooted by careless humans
in their quest for progress.
My home is being polluted,
suffocated by their waste.
I am dying.

But I will not give up.
I will continue to fight
for my survival and the survival
of my meadows.
I will persevere,
because I know that I am essential
to the health of the planet.

Kerthi Naiken
13 years of age
International School Seychelles
1st prize winner of the Seychelles Ocean Festival poem contest for
the secondary school's category
Under the theme of 'Protect our seagrass for a healthy planet'.

ISBN: 978-99931-878-1-7

Artwork by Denisha Quatre, 18 years of age
Fine Art student from the Seychelles Institute of Art & Design
1st prize winner of the Seychelles Ocean Festival artwork contest for professional centres
Under the theme of 'Protect our seagrass for a healthy planet'.