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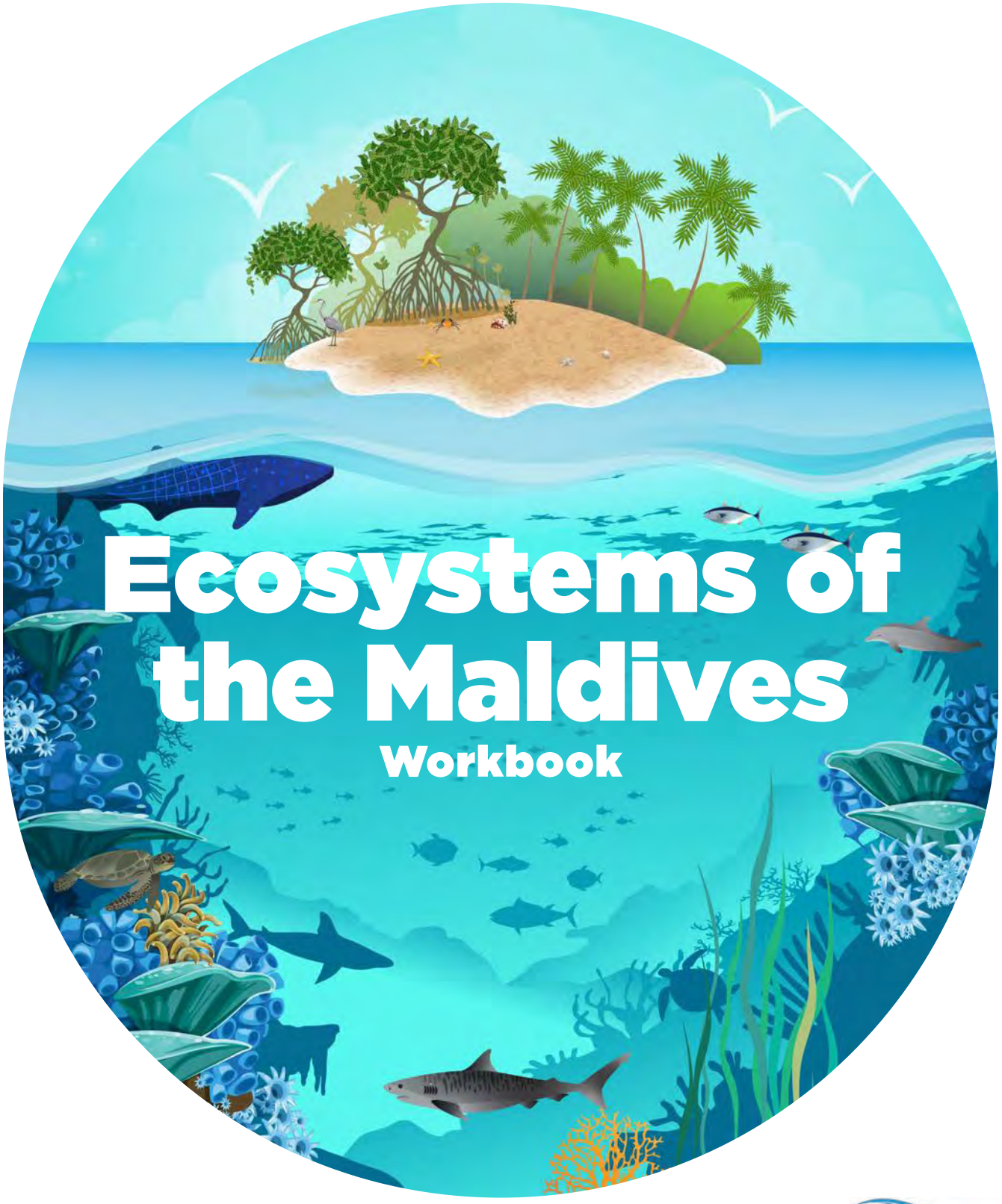

Ecosystems of the Maldives

Workbook

REGENERATE

IUCN

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CLIMATE CHANGE AND TECHNOLOGY

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Ecosystems of the Maldives

Workbook

REGENERATE
Enhancing Resilience of social-ecological coral reef systems in the Maldives

This publication has been made possible in part by generous funding from USAID.

This research has been made possible with the collaboration of Project REGENERATE partners.

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Pictures: Commonly found coral genera of Maldives. Mariyam Shidha Afzal (Pages 26-27).
Commonly caught reef fishes. Maldives Marine Research Institute / Ministry of Fisheries, Marine Resources and Agriculture. (Pages 48-49).
Mangrove species found in maldives pictures by Ahmed Shan. (Pages 94-95).

Cover Page: Reema Mohamed, IUCN, Malé, Maldives

Message by Minister of Environment, Climate Change and Technology, H.E. Aminath Shauna

We live in the Anthropocene era where human actions have already transgressed many of the planetary boundaries. The global nature and climate crises disproportionately affect us, making the Maldives among the most exposed and vulnerable countries to the adverse impacts of climate change and biodiversity loss.

While we are among the most vulnerable, we also have globally significant and outstandingly rich biological diversity, which is also fundamental to our wellbeing, economy as well as the existence of our fragile reef systems, in addition to also being an integral part of our cultural and social lifestyle.

Protection and preservation of our natural environment have been prioritized by the government in accordance with Article 22 of our Constitution. To date, a total of 79 protected areas, comprising 13% of our coral reef area, have been protected under the Environment Act, with more areas to be protected in accordance with the government's pledge to protect ecologically significant areas from each atoll of the Maldives. Our goal is the establishment of a network of effectively and equitably managed, ecologically representative, and well-connected systems of protected areas and other effective area-based conservation measures in the Maldives. We have established two nature parks with sustainable financing mechanisms and three biosphere reserves operating at atoll levels that has paved the way for local ownership of our natural resources and enhanced economic, aesthetic, and social values of local biodiversity.

In line with area-based conservation, species conservation has also been prioritized, with our charismatic megafauna and endangered species already protected. A national Red Listing process has commenced to understand the status of the different marine and coastal species, terrestrial life and avifauna. While protection of areas and species has achieved important milestones, there are also continuous efforts to address the drivers of biodiversity loss.

For the success of all the aforementioned efforts, knowledge and information about our biodiversity and conservation efforts need to be understood, documented and disseminated. As such, it is with pleasure that I encourage each and every person in the Maldives to utilize this booklet to gain more knowledge about our remarkable biological diversity as well as the functions and services of our ecosystems that enable the diversity of life on this beautiful coral island nation.

In this booklet you will find vital information on coral reefs, seagrass, mangroves, and megafauna with a focus on some of our conservation efforts, such as the establishment of Marine Protected Areas. This booklet also provides vital information on our biodiversity-dependent economic sectors and highlights some of the major threats to biodiversity in the Maldives, such as the impacts of climate change, and marine and chemical pollution.

Finally, this booklet will serve the purpose of stimulating young minds to garner an interest in conservation and safeguarding the biodiversity of the Maldives to achieve intergenerational equity.

MINISTRY OF
ENVIRONMENT, CLIMATE CHANGE
AND TECHNOLOGY

Message from IUCN Regional Director for Asia and Hub Director for Oceania, Dr Dindo Campilan

It is my pleasure to present the "Ecosystems of the Maldives – A workbook", an innovative compilation of the knowledge products developed as part of REGENERATE, a Government of Maldives project implemented by IUCN with generous funding from USAID.

Through this publication, we are pleased to reach out to the country's next-generation nature conservation advocates and professionals. With the Maldives as IUCN's newest State Member, this knowledge product is both timely and significant for our Union to share with the Maldivian youth and children our collective knowledge and tools towards enabling human progress, economic development and nature conservation to take place together.

As early as 2009, IUCN has worked closely with the Government to enhance sustainable management of coastal resources, ecosystems protection and restoration, and biodiversity conservation in general.

Maldives is at the forefront of our fight against environmental degradation. While the country is home to some 1,900 fish, 187 corals as well as 350 crustacean species, reports indicate that the major portion of the country could become uninhabitable by 2050 due to climate change. Such prospects speak to the urgency of us working together to ensure that they do not become a reality.

This publication comes at a great time, considering that 188 governments have just agreed on a ground-breaking agreement in December 2022 to address the dangerous loss of biodiversity and restore natural resources. The "Kunming-Montreal Global Biodiversity Framework", or GBF, consists of 4 goals and 23 targets for achievement by 2030, including a target to ensure that at least 30 per cent of the world's lands, inland waters, coastal areas and oceans are effectively conserved and managed.

We have a ton of work ahead, but we also have good news; there are many young people around the world, including you, who are up to taking on this difficult challenge. For instance, more than 100 youths from 12 different countries have registered as a member to the Asian Youth Network for Protected Areas, a platform established in 2022 for sharing their experiences in conservation.

I sincerely hope that this book will be an inspirational tool to think about how you can contribute to this cause. I look forward to working with you in the near future!

IUCN

Message from United States Agency for International Development (USAID), Acting Mission Director Debra Mosel

It gives me great pleasure to write the foreword for Ecosystems of the Maldives. This endeavor, supported by the United States Agency for International Development (USAID), will introduce Maldives' amazing natural environment and the importance of conserving that environment, to young readers in Maldives and around the world.

Maldives is home to a rich diversity of marine life, from whale sharks to sea turtles to a myriad of fish and coral species. This book will educate young readers on, and hopefully create passion for, the different ecosystems of the country and how to protect and preserve this precious natural heritage.

USAID has partnered with the Government of Maldives and the IUCN for over a decade to conserve and better manage marine resources. Our collaboration with the IUCN has increased the use of science and technology in the government decision making process and raised awareness among citizens of Maldives on threats to these ecosystems. The United States has provided approximately $30 million in assistance to the Maldives since 2001. USAID initiatives have protected coral reef ecosystems, built water supply systems, and strengthened the capacity of the Maldivian government, private sector, and local communities to manage and adapt to the impact of climate change.

USAID
FROM THE AMERICAN PEOPLE

Hello,

This book aims to provide an overview of the natural environment of Maldives, the different ecosystems, and their associated biodiversity. You will learn about the different species of fantastic fauna and sometimes even flora found in Maldives and where to find them.

The chapters explore how different ecosystems and wildlife relate to human existence, and the challenges faced, as well as the actions being taken to protect and preserve our natural heritage and way of living.

There are chapters dedicated to ecologically and socioeconomically significant megafauna, reef fish, and tuna, and they explore how human activities are affecting the health of the natural environment all around us.

Each chapter consists of a 'pop up quiz', field activities to train you like a field biologist, and a knowledge review to self-assess your learning. Be ready for a range of tasks, ranging from beach excursions one day, to using Google Earth another day.

A detailed map of Maldives along with Protected Areas and biodiversity hotspots are shown, with references to the information found in each of the chapters.

We hope to provide you with a deeper understanding of the coral reefs found in Maldives along with the seagrass meadows and mangroves that make our islands special for humans and other living things.

Best of luck learning through what is presented within the pages of this book, as well as through real world activities - but most of all, remember to have fun!

Our Protected Area Network

How to read the map

The map of all atolls within the Maldives is presented in 10 parts to provide a detailed image of all the Marine Protected Areas and Terrestrial Protected Areas such as islands, mangroves, wetlands and other important habitats of Protected Species.

Additionally, the map provides a rough sketch of the geographical distribution of megafauna and other biodiversity hotspots. Scroll through the map to see the different biodiversity 'hot' zones in your region.

Our network of protected areas are continuously growing. The information presented here is taken from Environmental Protection Agency (EPA) Maldives, as of February 2021. For up to date information, visit the EPA Maldives website.

NORTH

The sign "**North**" means that map is facing true north in all atolls for easier navigation and exploration.

Highlights in red represents the location of the atoll in the map of Maldives

LEGEND

- Protected Island / Sandbank
- Marine Protected Area
- Marine Protected Area / Protected Island / Sandbank
- Protected Mangrove / Wetlands

Important Species

Explore these maps and learn about the important and protected species that live amoung us.

Pay close attention to the areas highlighted on the map.

Are you familiar with any of these Protected Areas, and why these places are special?

Let's explore the distribution of megafauna, birds, and marine life across the Maldives.

What kind of biodiversity hotspots are found near where you live?

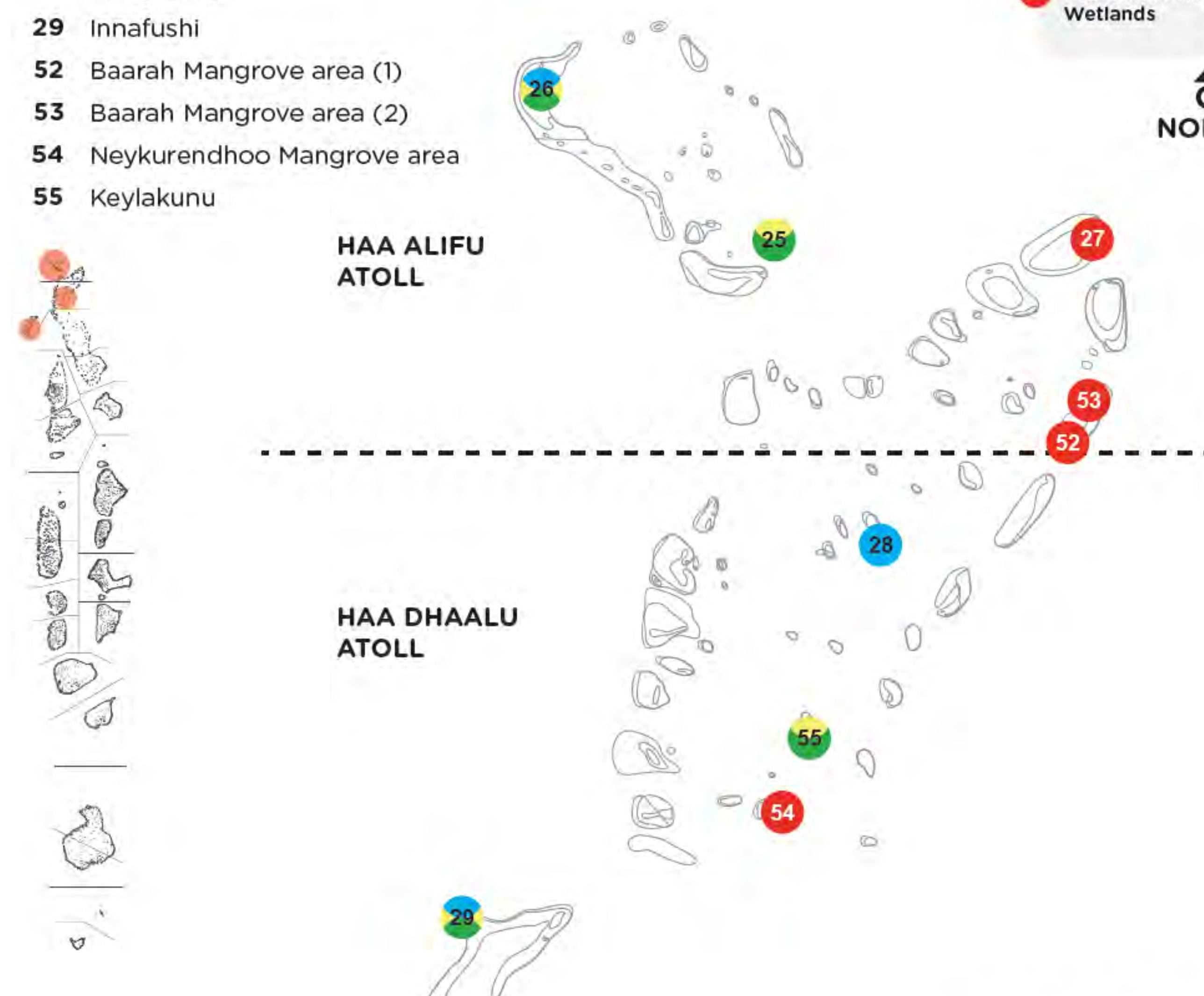
HAA ALIF & HAA DHAALU ATOLL

25 Gallandhoo
26 Bileydhoo Thila (Including Innafinolhu)
27 Kelaa Kandoofaa
28 Finey Thila
29 Innafushi
52 Baarah Mangrove area (1)
53 Baarah Mangrove area (2)
54 Neykurendhoo Mangrove area
55 Keylakunu

LEGEND

- Protected Island / Sandbank
- Marine Protected Area
- Marine Protected Area / Protected Island / Sandbank
- Protected Mangrove / Wetlands

NORTH



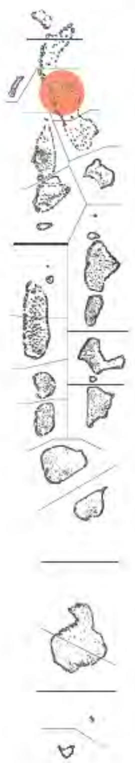
Lesser Noddy - *Anous tenuirostris* - (ކުރަނގި) are seen throughout the Maldives, especially white lesser noddies, with higher numbers being seen in the Northern region. **HA.Gallandhoo (protected island)** is a famous roosting habitat for lesser noddies, where dense flocks have been observed by the hundreds, maybe even thousands!

SHAVIYANI ATOLL

30 Bolissafaru
31 Naalaa Huraa (sand bank)
71 Farukolhu

LEGEND

- Protected Island / Sandbank
- Marine Protected Area
- Marine Protected Area / Protected Island / Sandbank
- Protected Mangrove / Wetlands



Sh.Farukolhu is the 10th largest uninhabited island in Maldives, and is among the most ecologically noteworthy protected islands in the country, with 7 different wetlands supporting both sea birds and migratory birds alike.

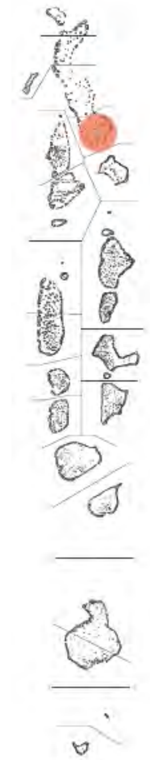
Open mangrove bays such as **Farukolhu** are connected to the sea via channels, serving as nurseries for important protected species like juvenile sharks and rays such as **sicklefin lemon sharks** - *Negaprion acutidens* - (ފަތުރުދުމުސް) and **cowtail stingrays** - *Pastinachus sephen* - (ނަރުދޮފަތި).

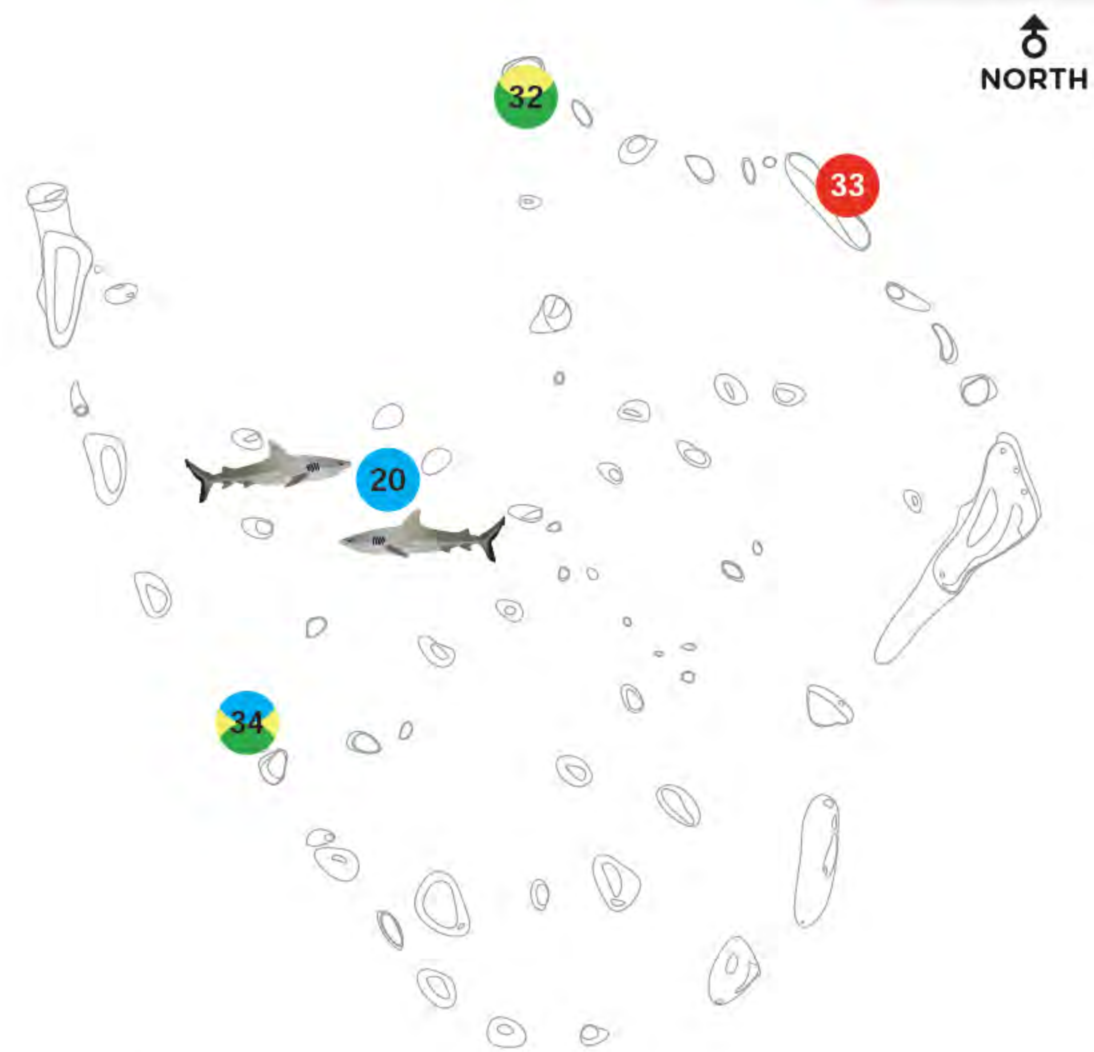
NOONU ATOLL

20 Orimas Thila
32 Bodulhaimendhoo
33 Kendhikulhudhoo Mangrove area
34 Fohdhipparu

LEGEND

- Protected Island / Sandbank
- Marine Protected Area
- Marine Protected Area / Protected Island / Sandbank
- Protected Mangrove / Wetlands

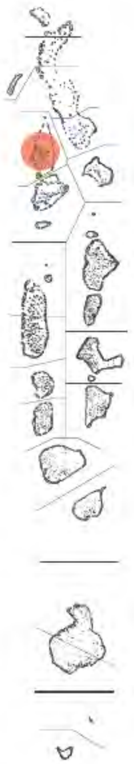


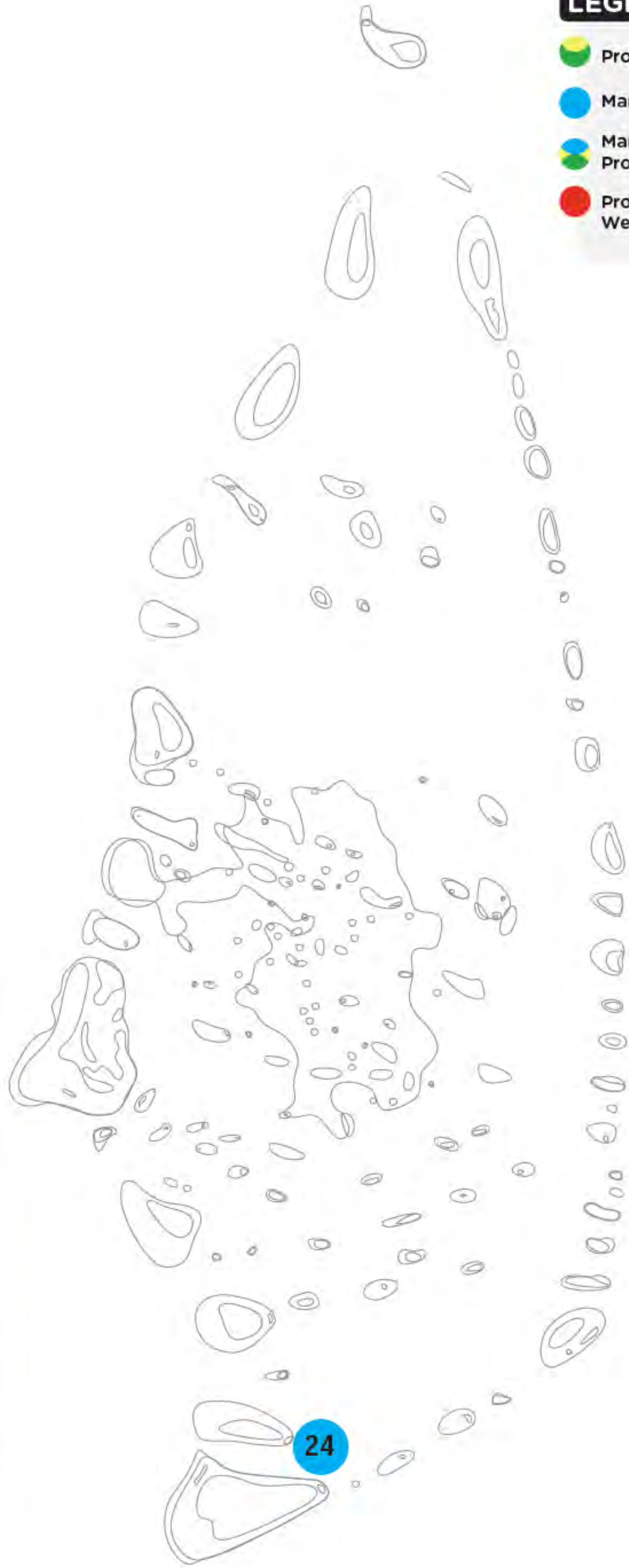


South Miladhunmadulu Atoll contains the second highest number of protected trees in the country, which are selected based on the largeness and age of the trees. The marine protected area, **Orimas Thila** is famous for **grey reef sharks**, *Carcharhinus amblyrhynchos* (ވަލޯ މިޔަރު)·These sharks are seen in large numbers at the nursery and cleaning station there.

RAA ATOLL

24 Villingilee Thila





LEGEND

- Protected Island / Sandbank
- Marine Protected Area
- Marine Protected Area / Protected Island / Sandbank
- Protected Mangrove / Wetlands

NORTH

Vandhoo island found in Raa Atoll is among the 14 sea turtle nesting hotspots identified, where egg harvesting was banned between 2006 - 2016 before sea turtles were protected.

Recently, few hatchlings of **olive ridley turtles -** *Lepidochelys olivacea* - (ވާދޮގިރިވާ) were also found in this atoll - a rare occurrence in Maldives!

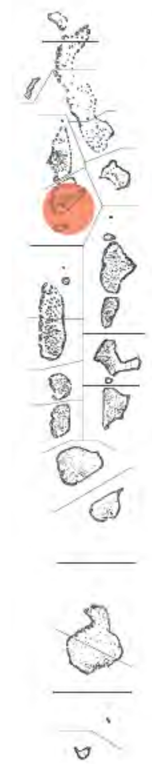
BAA ATOLL

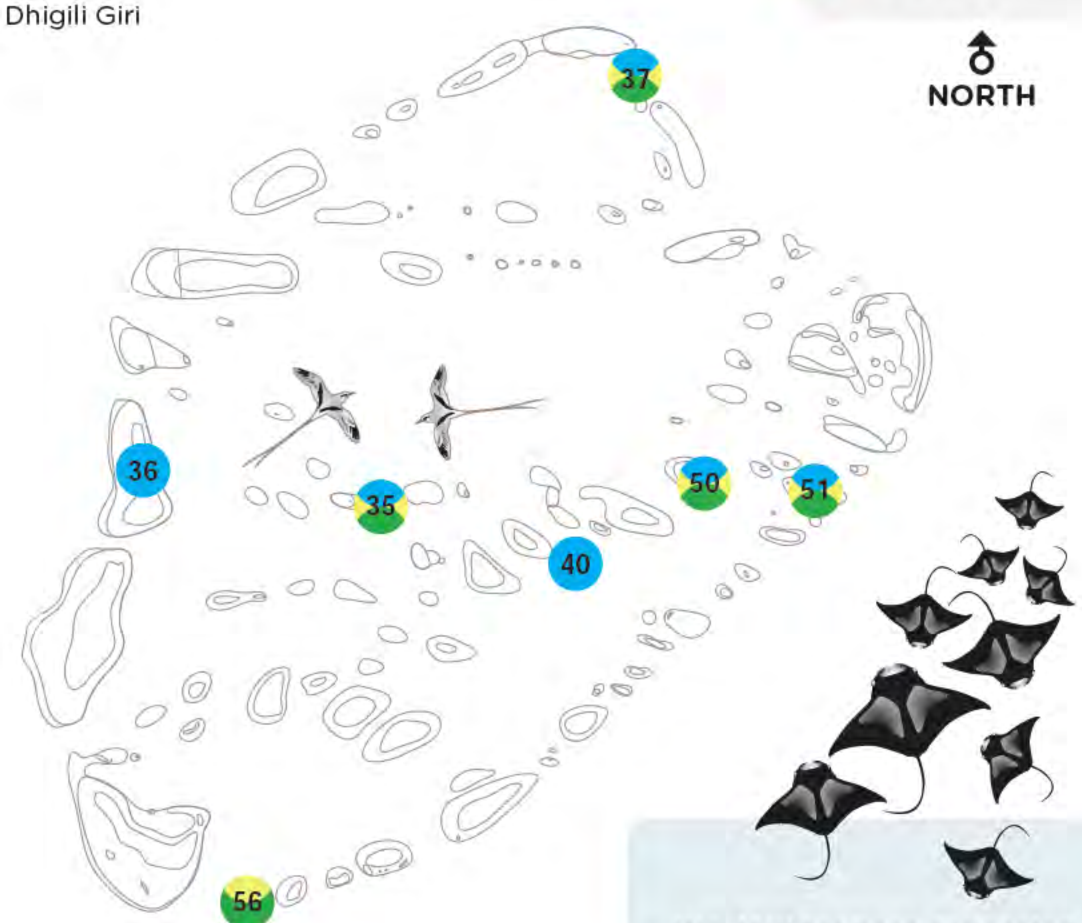
35 Mendhoo region
36 Maahuruvalhi reef region
37 Bathalaa region
38 Goidhoo koaru
39 Mathifaru hura
40 Dhigali Haa and Dhigili Giri
50 Anga Faru
51 Hanifaru Area
56 Olhugiri

LEGEND

- Protected Island / Sandbank
- Marine Protected Area
- Marine Protected Area / Protected Island / Sandbank
- Protected Mangrove / Wetlands

NORTH





The protected islands **Mendhoo** and **Olhugiri** are sea turtle nesting hotspots, as well as home for **whitetailed tropicbirds** *Phaethon lepturus* (ދަނޑިފުޅު ދޫނި) where nesting is observed.

Baa Atoll has been designated a **UNESCO Biosphere Reserve** since 2011, and consists of one of the most spectacular manta aggregation sites in the world, found in **Hanifaru bay** (MPA).

The structure of the bay creates plankton rich conditions in Hulhangu monsoon, where **reef mantas** (މަންތަރި) are seen mass feeding.

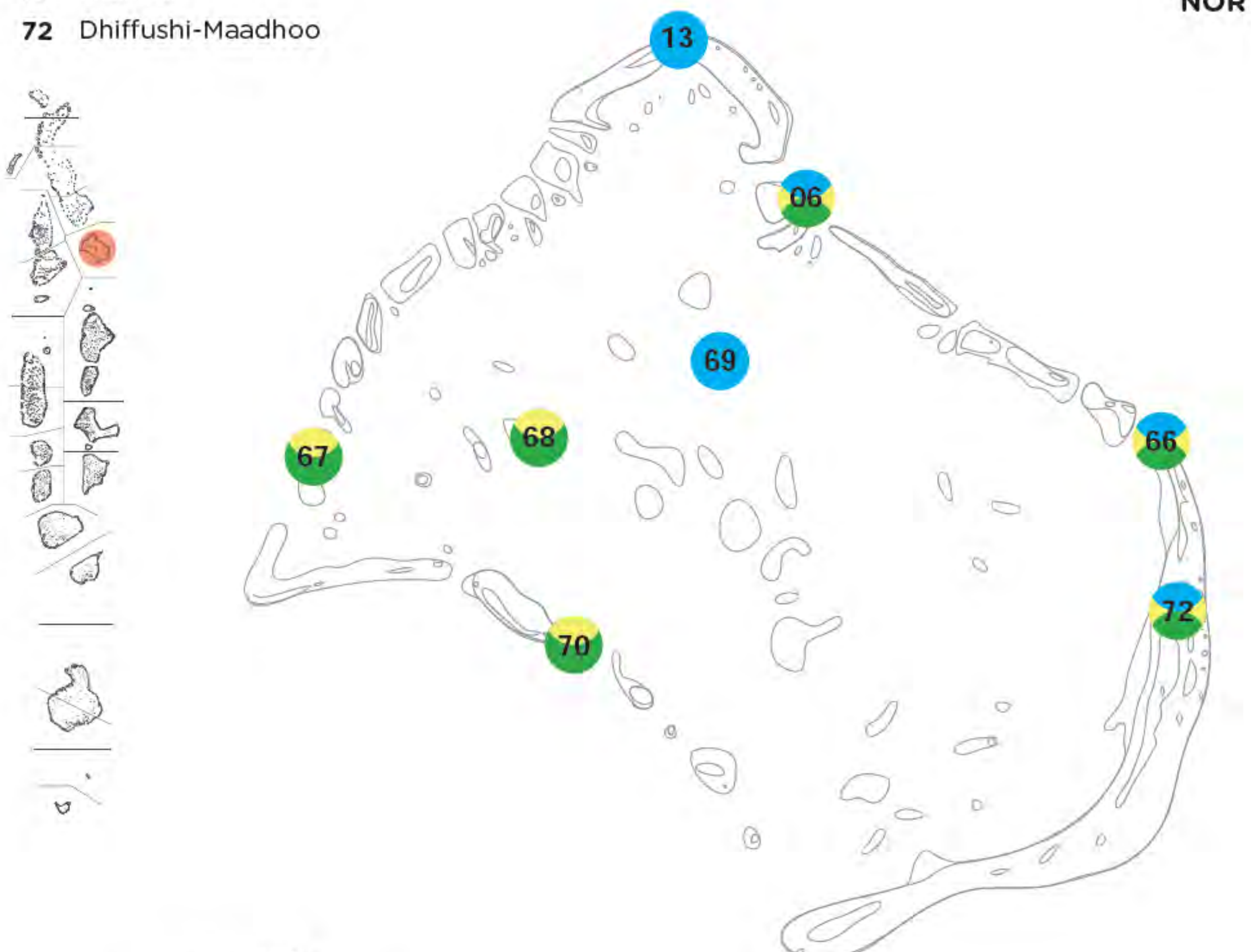
LHAVIYANI ATOLL

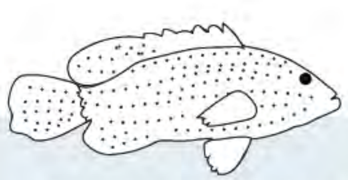
- **06** Fushifaru Region
- **13** Kuredhi Kandhuolhi (kuredhu Express)
- **66** Senhlhifushi & Huraidhoo region
- **67** Vavvaru
- **68** Dhashugirifinolhu
- **69** Anemone Thila
- **70** Maakoa
- **72** Dhiffushi-Maadhoo

LEGEND

- Protected Island / Sandbank
- Marine Protected Area
- Marine Protected Area / Protected Island / Sandbank
- Protected Mangrove / Wetlands

NORTH





Lhaviyani Atoll contains one of the five grouper spawning sites protected under the Ministry of Fisheries, Marine Resources and Agriculture. Seasonally, groupers come together by the thousands to release eggs for fertilization in certain areas.

The protected area Dhiffushi-Maadhoo contains the rare occurring trees of **looking-glass mangrove** - *Heritiera littoralis* - ([illegible]) found in the country.

Learn more about **Mangroves of Maldives in Page 88**

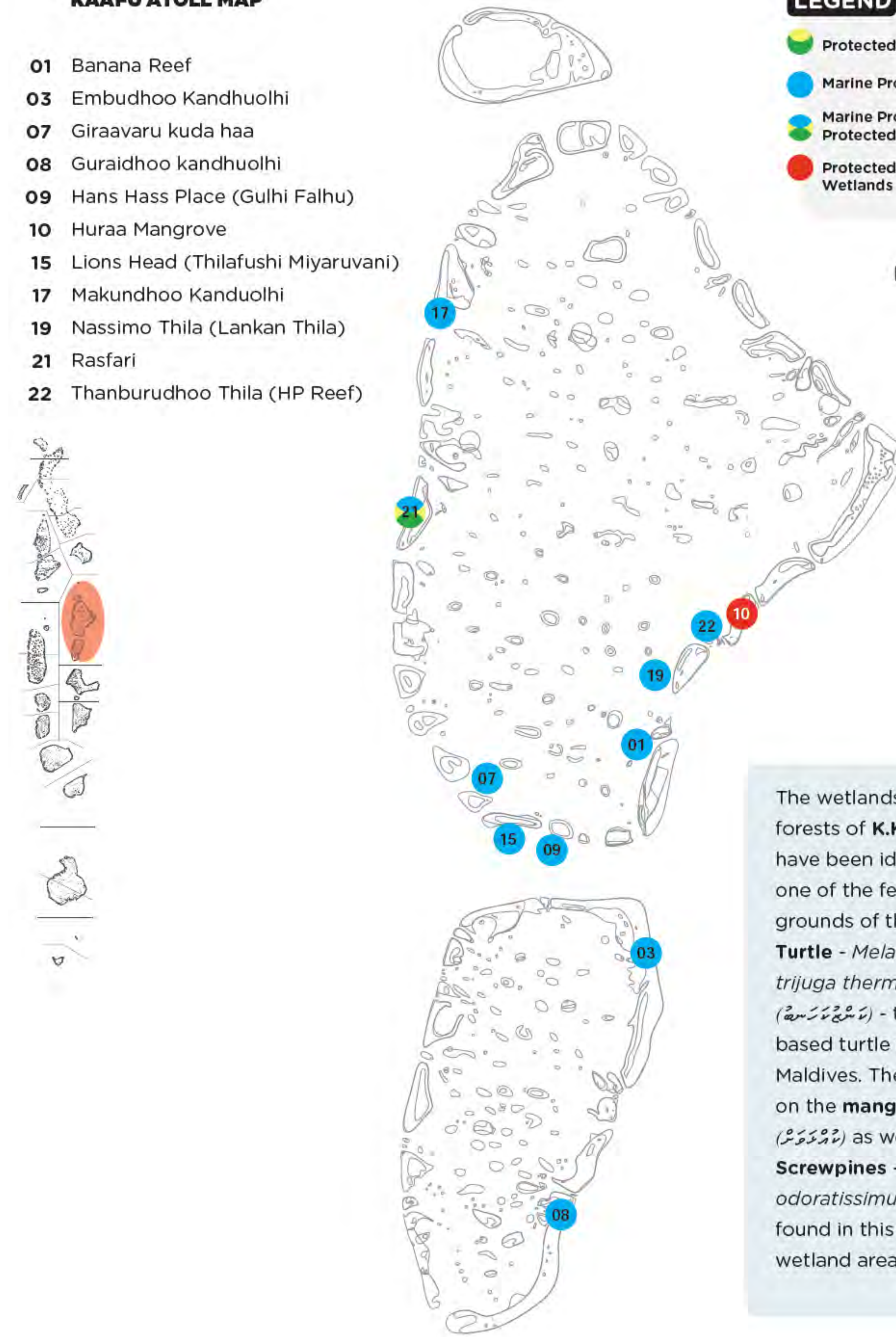
KAAFU ATOLL MAP

- **01** Banana Reef
- **03** Embudhoo Kandhuolhi
- **07** Giraavaru kuda haa
- **08** Guraidhoo kandhuolhi
- **09** Hans Hass Place (Gulhi Falhu)
- **10** Huraa Mangrove
- **15** Lions Head (Thilafushi Miyaruvani)
- **17** Makundhoo Kanduolhi
- **19** Nassimo Thila (Lankan Thila)
- **21** Rasfari
- **22** Thanburudhoo Thila (HP Reef)

LEGEND

- Protected Island / Sandbank
- Marine Protected Area
- Marine Protected Area / Protected Island / Sandbank
- Protected Mangrove / Wetlands

NORTH



The wetlands and dwarf forests of **K.Kaashidhoo** have been identified as one of the few breeding grounds of the **Black Turtle** - *Melanochelys trijuga thermalis* - ([illegible]) - the only land based turtle found in Maldives. The turtles feed on the **mangrove apples** ([illegible]) as well as the **Screwpines** - *Pandanus odoratissimus* - ([illegible]) found in this protected wetland area.

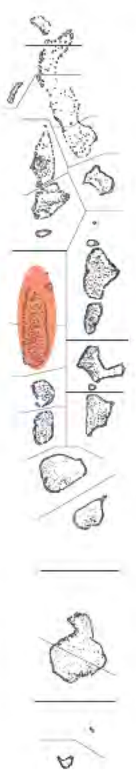
ALIFU ATOLL MAP (ALIFU ALIFU & ALIFU DHAALHU)

11 Kairibeyru Region
12 Kudarah Thila
16 Maayaa Thila
41 South Ari Atoll Marine protected area
42 Rasdhoo Maivaru Area
58 Hurasdhoo
59 Fish head (Mushimasgili Thila)
60 Rangali Kandu (madivaru)

LEGEND

- Protected Island / Sandbank
- Marine Protected Area
- Marine Protected Area / Protected Island / Sandbank
- Protected Mangrove / Wetlands

NORTH



South Ari Marine Protected Area (SAMPA) is one of the largest MPAs in the country, where **whale sharks** (ފެހުރިހި) are seen throughout the year. SAMPA is likely a 'secondary nursery' for post-juvenile **whale sharks** where they are protected from predators and are able to regulate their body temperatures at the shallow reefs.

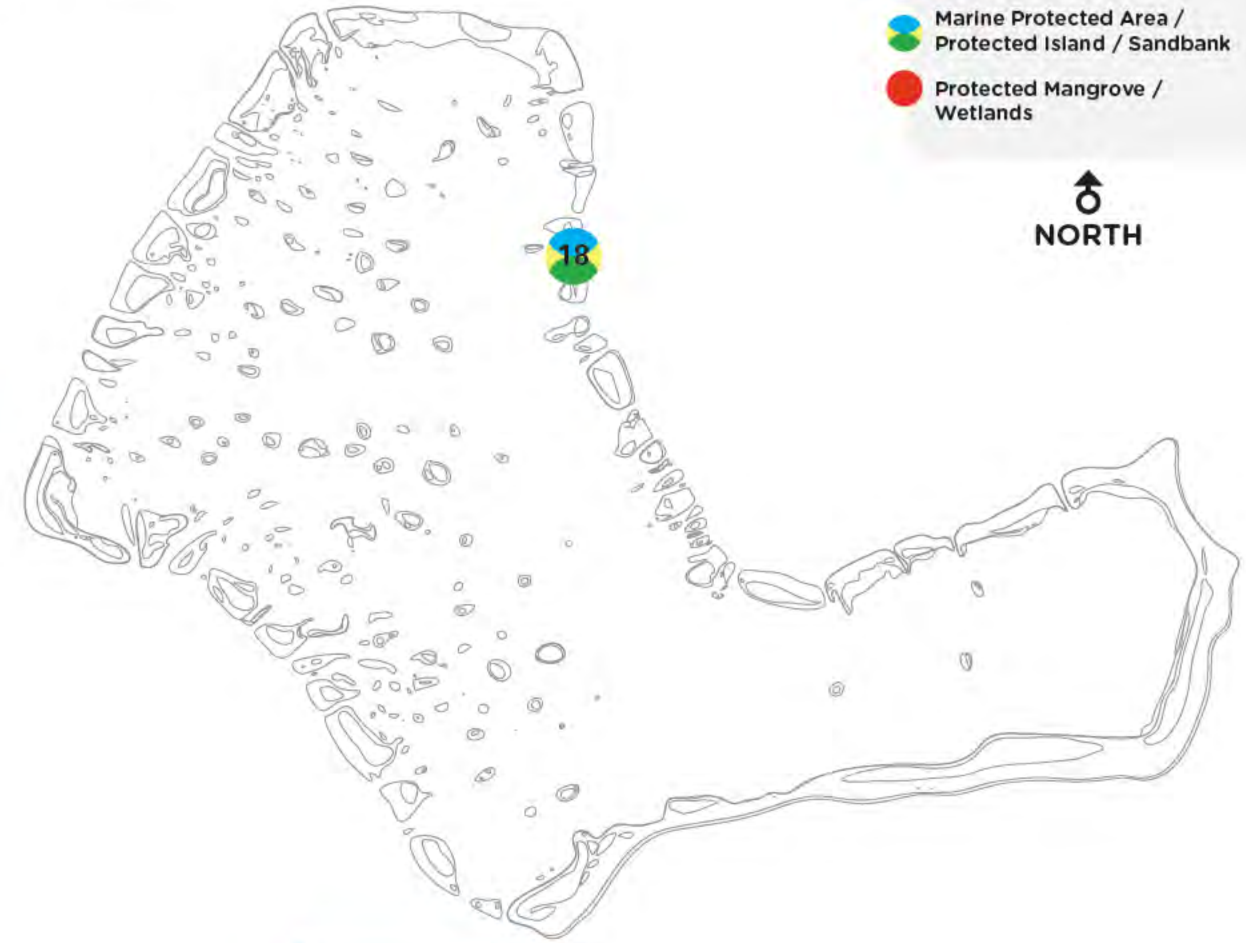
VAAVU ATOLL MAP

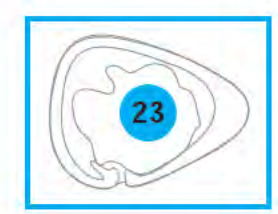
18 Miyaru Kandu Region
23 Vattaru

LEGEND

- Protected Island / Sandbank
- Marine Protected Area
- Marine Protected Area / Protected Island / Sandbank
- Protected Mangrove / Wetlands

NORTH

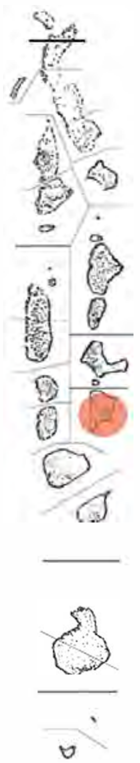


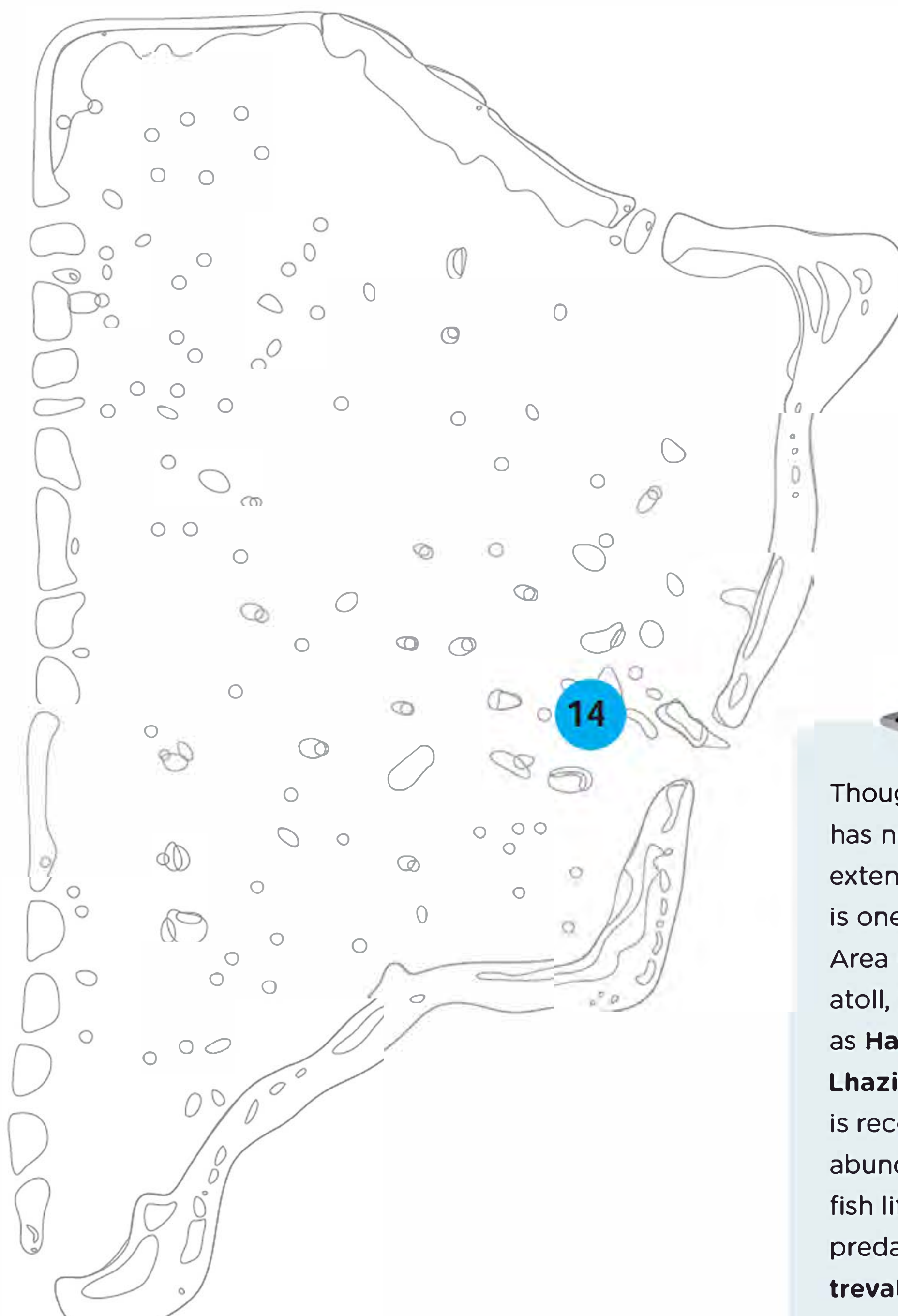


Vattaru is a small egg shaped little atoll found in **Vaavu atoll.** This Marine Protected Area also includes a channel where a large number of **megafauna** are seen throughout the year. Some of the species found in this region include, **hammerhead sharks** (ކާޅިގަސް މިޔަރު), schools of **eagle rays** (ވައިފިޔަ މަދި) and sea turtles.

MEEMU ATOLL MAP

14 Lazikuraadi





LEGEND

- Protected Island / Sandbank
- Marine Protected Area
- Marine Protected Area / Protected Island / Sandbank
- Protected Mangrove / Wetlands

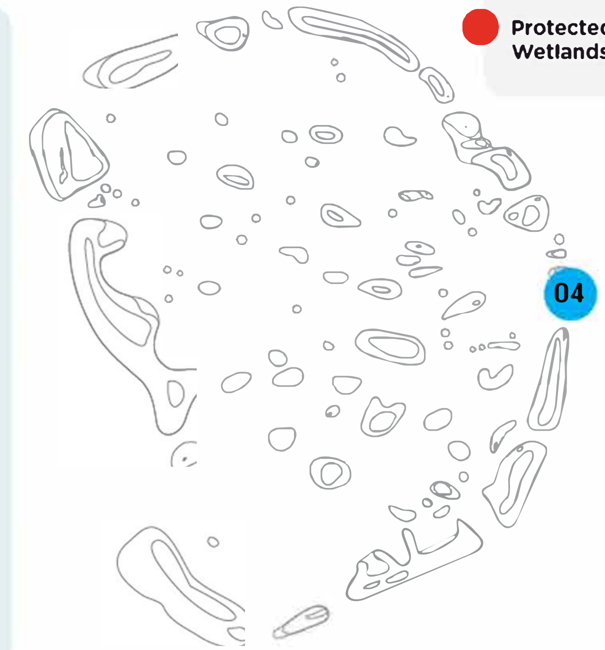
NORTH

Though **Meemu atoll** has not been surveyed extensively as of yet, there is one Marine Protected Area designated in this atoll, locally known as **Hakura thila** or **Lhazikuraadi**. This site is recorded to have an abundant and diverse fish life, with important predatory species such as **trevallies** and **grey reef sharks** - *Carcharhinus amblyrhynchos* - (ހަތިބޮޑު މިޔަރު) seen in large numbers.

(A) FAAFU ATOLL MAP

04 Filitheyo kandu

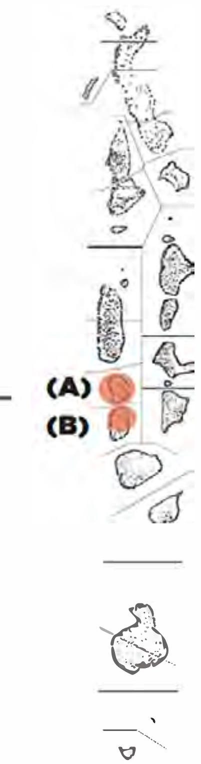
Similar to **Meemu atoll,** ecological surveys for the designation of protected areas in **Faafu atoll** are yet to be carried out. Even though this atoll contains only 1 MPA, local knowledge suggests that several sandbanks found within the atoll are important roosting and nesting sites for sea birds such as **black naped terns** - *Sterna sumatrana* - ([illegible]) **greater crested terns** - *Thalasseus bergii* - (ވިރުދޫނި).



LEGEND

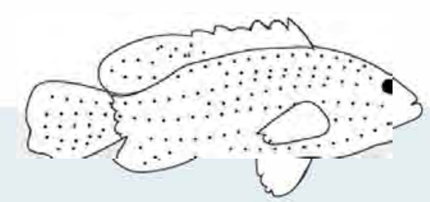
- Protected Island / Sandbank
- Marine Protected Area
- Marine Protected Area / Protected Island / Sandbank
- Protected Mangrove / Wetlands

NORTH

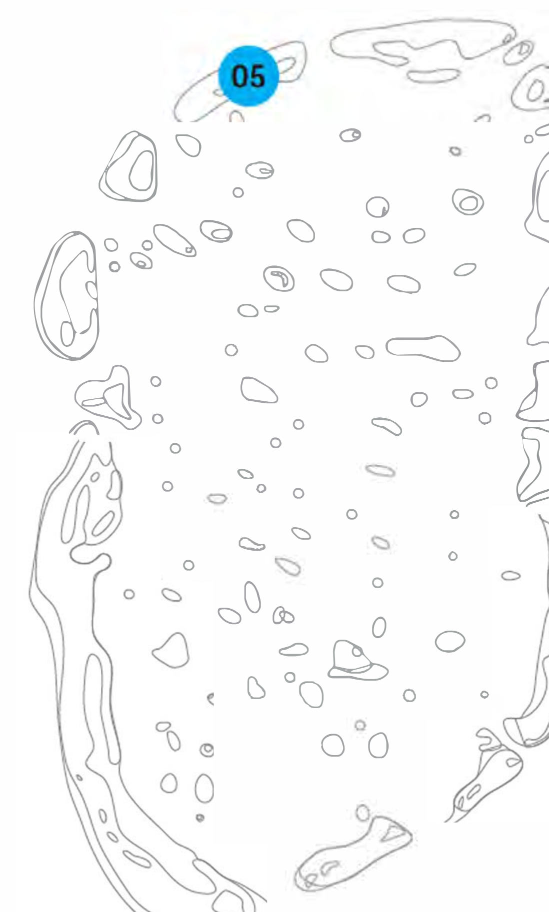


(B) DHAALU ATOLL MAP

05 Fushi kandu

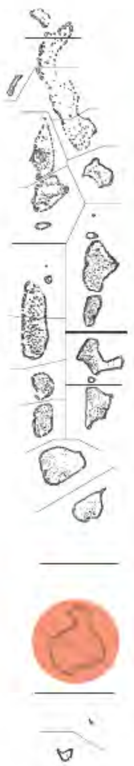


The MPA found in **Dhaalu Atoll** is notable for sharks and rays. One of the most significant aspects of this atoll however, is perhaps one of the most significant aspects of this atoll is perhaps the grouper spawning aggregation site, which is protected under the **Fisheries Law.**



GAAFU ALIFU & GAAFU DHAALU

43 Dhigulaabadhoo
57 Hithaadhoo island

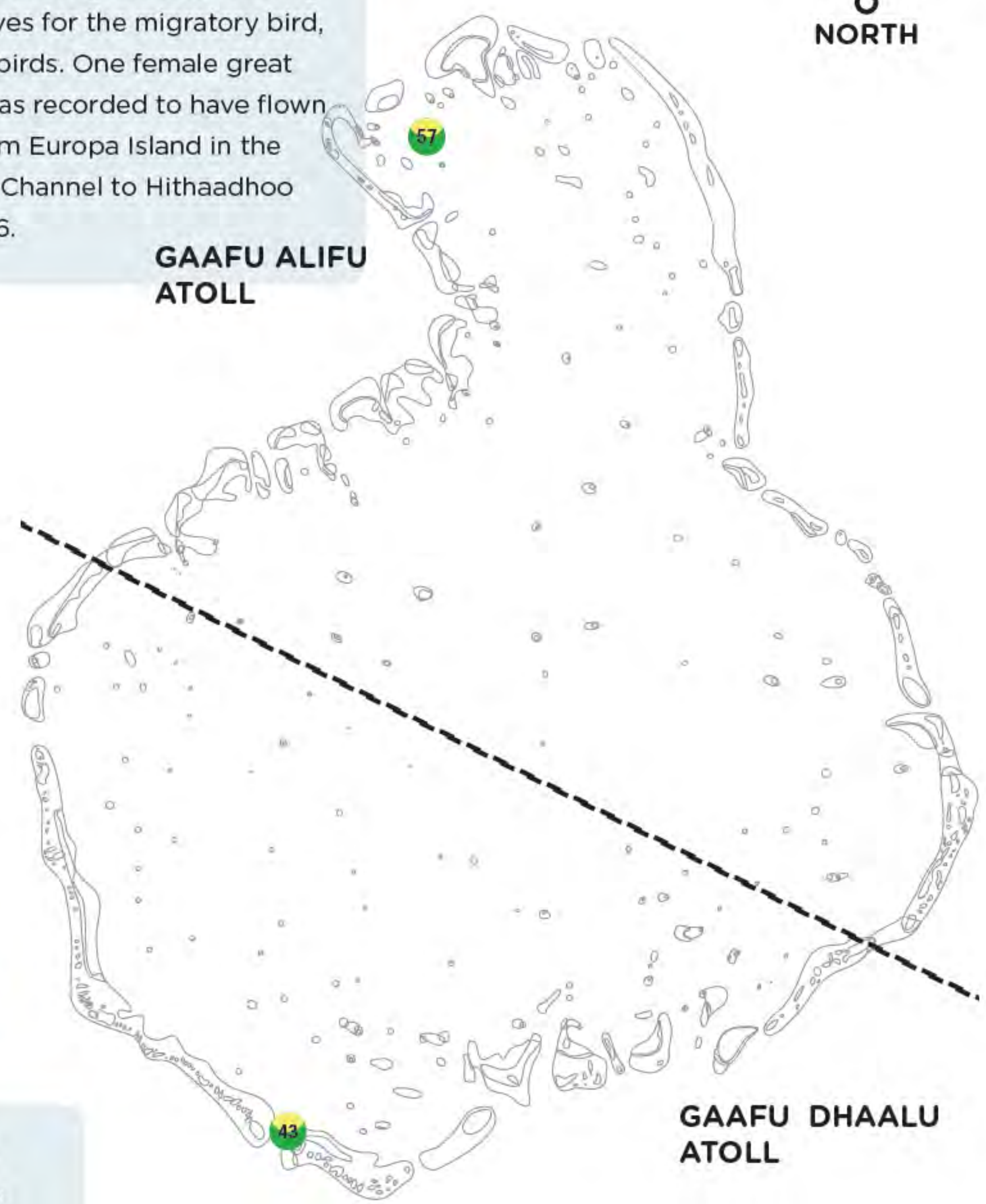


The protected island of **GA. Hithaadhoo** is among the few roosting sites in Maldives for the migratory bird, great frigate birds. One female great **frigatebird** was recorded to have flown 4,400 km from Europa Island in the Mozambique Channel to Hithaadhoo Island in 2006.

LEGEND

- Protected Island / Sandbank
- Marine Protected Area
- Marine Protected Area / Protected Island / Sandbank
- Protected Mangrove / Wetlands

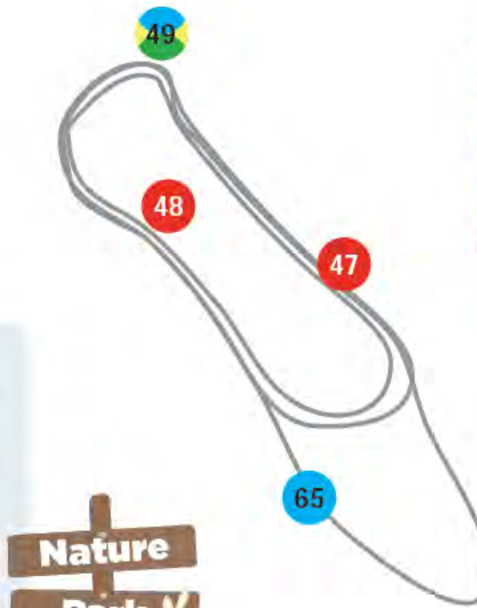
NORTH



The protected island of **GDh.Dhigulaabadhoo** is among the most beautiful, and ecologically rich islands in Maldives, where every single habitat type known to Maldives can be found in one place. The western edge of the island is highly abundant in **orange mangrove** - *Bruguiera gymnorrhiza* - ([illegible]) which surrounds a serene mangrove lake that serves as a nursery for numerous fish, including juvenile sharks and rays.

(A) GNAVIYANI ATOLL

47 Bandaara Kilhi
48 Dhandimagu Kilhi
49 Thoodhi Area
65 Farikede



LEGEND

- Protected Island / Sandbank
- Marine Protected Area
- Marine Protected Area / Protected Island / Sandbank
- Protected Mangrove / Wetlands

NORTH

Fuvahmulah was declared a **UNESCO Biosphere Reserve** in 2020, and it is indeed a special place made up of just a single island, encompassed by plunging reef walls. The atoll contains one of the two managed nature parks, and has recently opened the country's first medicinal plant nursery. Some of these plants such as **Ginger Lily** - *Hedychium gardnerianum* - ([illegible]), **Noni** - *Morinda citrifolia* - ([illegible]) and **Java plum** - *Syzgium cumini* - ([illegible]) have been used in traditional medicine or as food for hundreds of years.

The reefs around the atoll are also a hotspot for megafauna such as whale sharks, thresher sharks, hammerhead sharks, tiger sharks, mola mola, as well as oceanic manta rays.

(B) SEENU ATOLL MAP

44 Edhigali Kilhi Koattey Area
46 Kandihera-Maakandu Channel (manta point addu)
61 Kuda Kandu
62 Maa kilhi And Feheli kilhi
63 Maafishi Kilhi
64 Mathi Kilhi

Addu Atoll has also been declared a **UNESCO Biosphere Reserve** in 2020, and contains the southernmost islands of the country, where the highly territorial **white terns** - *Gygis alba* - (ދޮންދިރި) are known to breed. Addu also has a well managed Nature Park consisting of mangroves which are home to many migratory birds as well as resident birds such as **grey herons**.

Coral Reefs

The bright and vivid world of coral reefs

Questions

1. How do corals get their vibrant colors ?

- ☐ Due to the color of its skeleton
- ☐ Because of zooxanthellae
- ☐ Light reflection

2. What are the threats faced by coral reefs?

- ☐ Coral bleaching
- ☐ Habitat destruction
- ☐ All the above

Coral reefs are well known for their bright and vivid colors. As one of the Earth's most diverse ecosystems, coral reefs can be equated to rainforests. Coral reefs support 25% of all marine life. This is remarkable considering that reefs cover less than 1% of Earth's surface.

More than a million species inhabit coral reefs. Coral reefs are generally laid down by a group of species collectively known as stony corals. Within hundreds and thousands of years, as a coral colony grows, they join with other colonies and form reefs that are vast in structure and extend up to several kilometers.

The vastness of these reefs are an incredible reminder of how much biodiversity these ecosystems can support.

What are corals?

Corals are animals which are closely related to jellyfish and anemones. Even though they may look like colourful plants, a coral is made up of many tiny animals called a polyp. Coral polyps can be as small as 1-2 cm or can be as big as 15 cm.

POP UP FACT

Coral polyps themselves are actually translucent! The vibrant colors we observe on corals are also the result of zooxanthellae.

A coral polyp is made up of a sac like body with a gut cavity, and one open end with a mouth surrounded by tentacles.

These tentacles are equipped with stinging cells called **nematocysts** which helps the coral polyp to catch small organisms for food and also defend itself from predators.

Inside the sac like body of the polyp are the stomach and reproductive tissues. To protect their soft bodies and add support, the coral polyp secretes limestone skeleton (polyp calices). Each coral polyp sits in a cup-shaped calcium carbonate depression known as **corallites**. These limestone skeletons connect with one another, creating a coral colony.

As the colony grows, the polyps secrete calcium carbonate beneath itself and grows upwards.

Zooxanthellae: : most shallow water corals that are found in warm tropical regions have a single celled algae living inside their tissues called zooxanthellae.

These zooxanthellae supply the coral polyp with energy in the form of glucose, glycerol, amino acids and oxygen by the process of photosynthesis. In return, the coral provides these algae with nutrients and a protected environment.

The relationship between corals and zooxanthellae is an example of symbiosis where different species live together and help each other.

Most tropical reefs comprise mostly of stony corals, and they are the true architects of the reef. In other words, they are known as the reef builders.

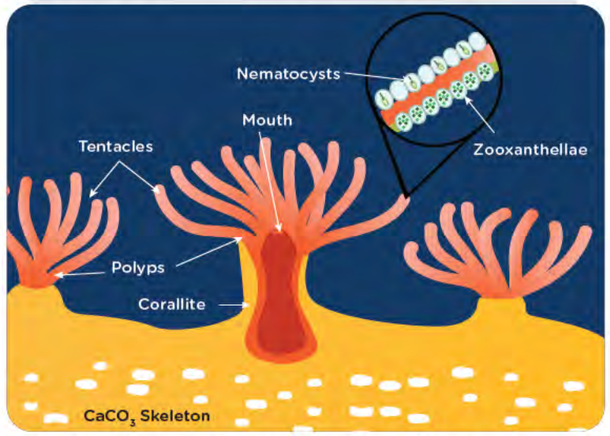


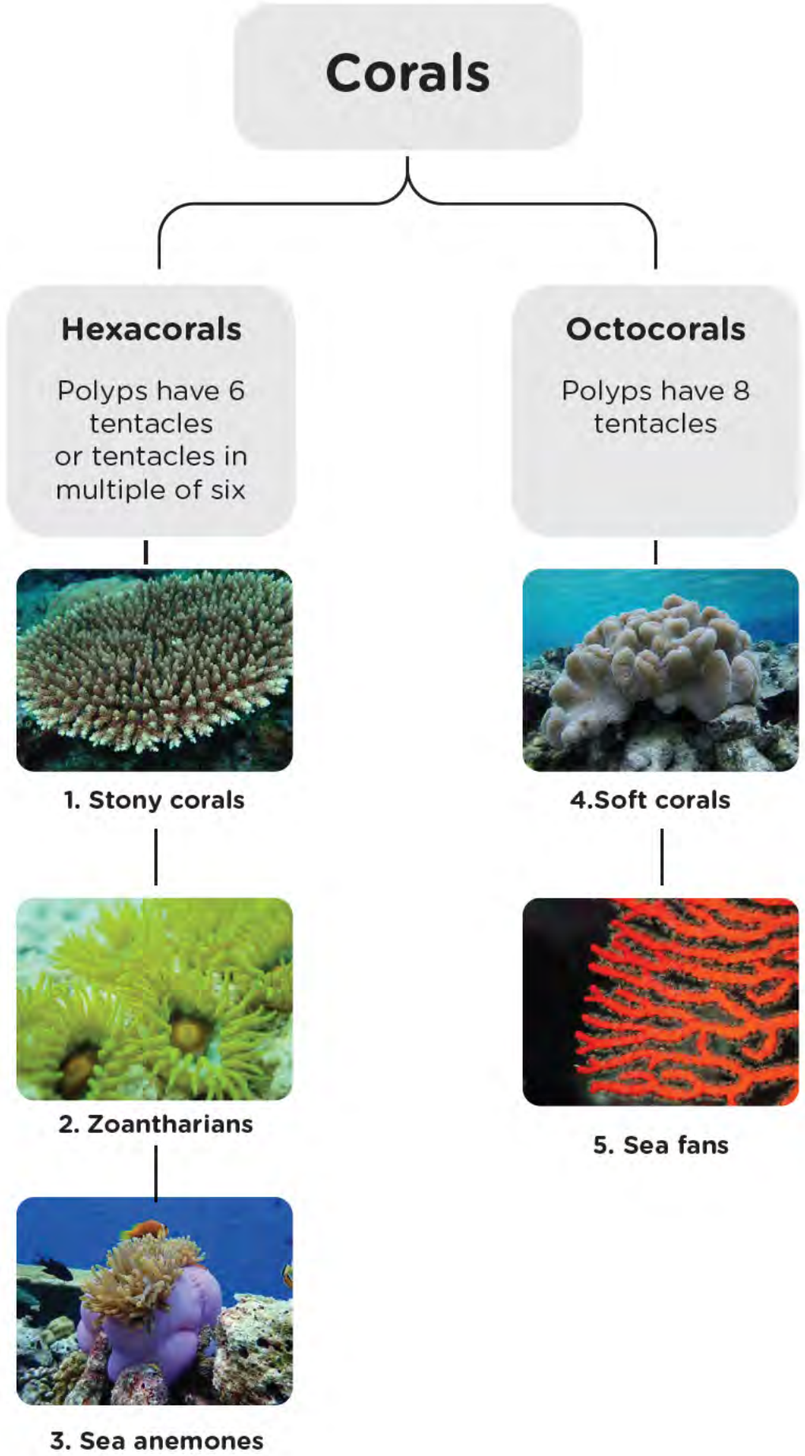
Figure:01 - Close up of coral polyp & zooxanthellae

Corals are divided into two main groups: hexacorals and octocorals.

Hexacoral polyps have 6 tentacles or tentacles in multiples of six. Stony corals, zoantharians and sea anemones are hexacorals. Octocoral polyps have 8 tentacles. Some examples include soft corals and sea fans.

There are over 800 species of reef building corals. As stony corals grow and expand, their structures can develop into several growth forms or morphologies.

These morphologies can also describe the functionality of a reef. As such, branching corals increase habitat complexity, while encrusting corals stitch the reef together.



These growth forms are generally categorised as **massive, branching, foliose, tabular, encrusting, digitate, columnar and free-living. They are used to identify and describe different genus or species of corals.**

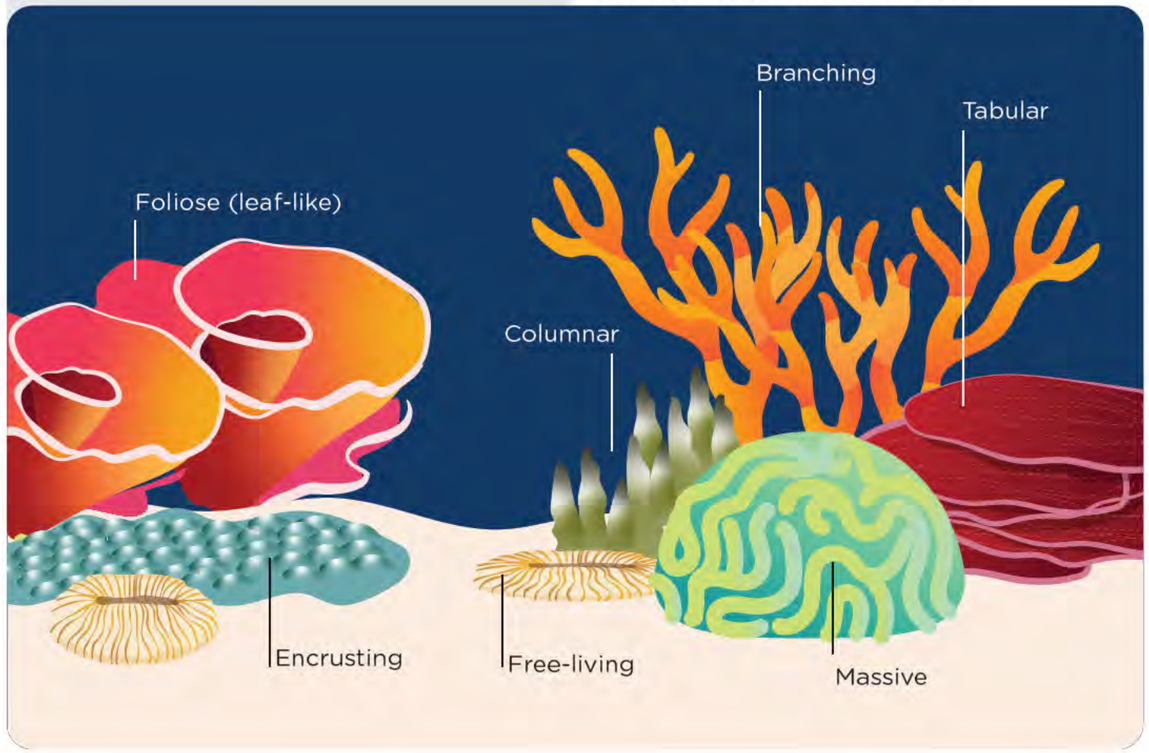
Branching corals are generally fast growing and they can grow up to 10-20 cm per year. Whereas massive corals generally display slow growth, and they usually grow up to 1 cm per year.

POP UP FACT

The largest coral reef in the world is Great Barrier Reef in Australia which is 2300 km long.

This reef is so large that it is visible to outer space. It is the same size as 70 million football fields!

Figure:02 - Typical growth forms of corals



How do corals reproduce?

Corals have several reproductive methods. Some coral species are hermaphrodites, meaning they have both female and male reproductive tissues, and are therefore able to produce sperm and eggs at the same time. Other coral species are gonochoric, meaning they are single-sex colonies and they can either produce sperm or eggs.

1. Asexual reproduction

Asexual reproduction in corals occur when a new organism arises from a single organism. The two most common types of asexual reproduction in corals are budding and fragmentation.

Budding occurs when the parent polyp grows a certain size and divides. The buds are identical to the parent polyp, and grow into their own colonies.

Fragmentation is when a piece of coral colony is broken off from the parent colony intentionally or unintentionally (storms, human disturbance such as anchor damage, etc.) and settles onto substrate and grow into a new colony.

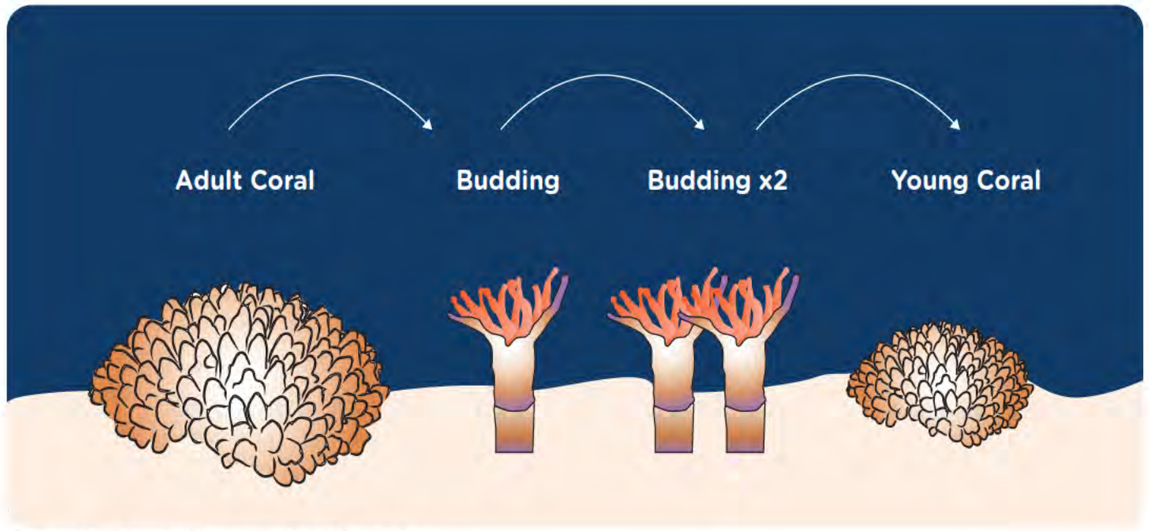


Figure:03 - Asexual Reproduction (Budding)

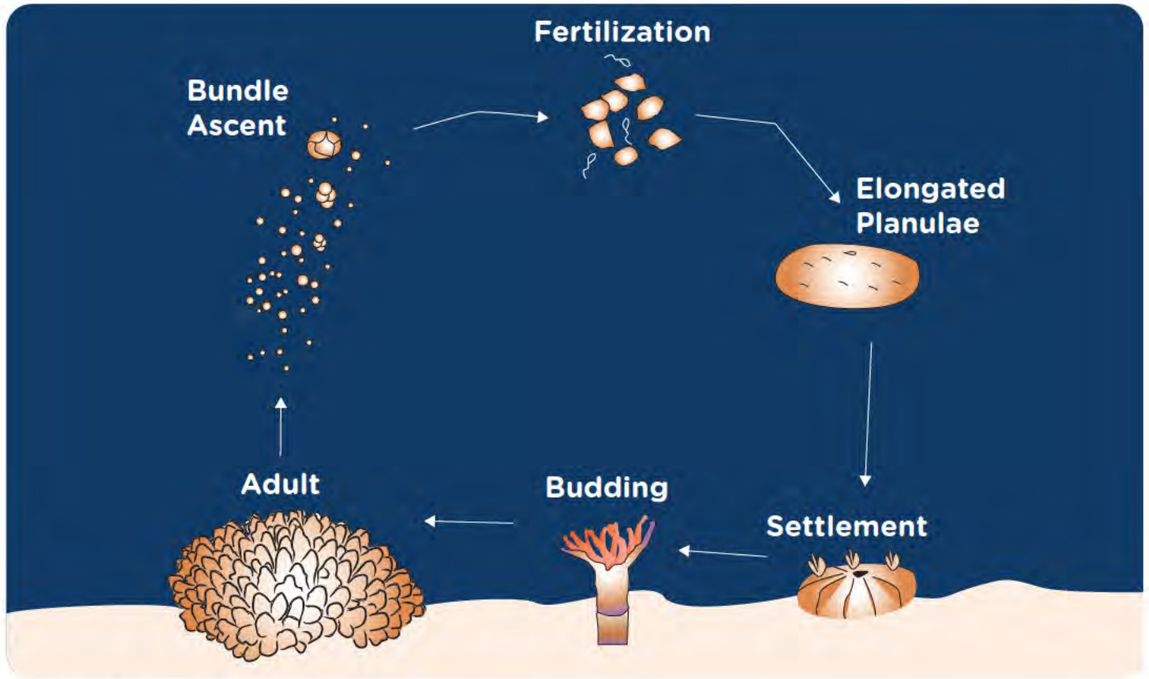


Figure:04 - Asexual Reproduction (Budding)

2. Sexual reproduction

There are two types of sexual reproduction in corals: internal fertilization and external fertilization.

In ***internal fertilization***, the sperm and egg are fertilized within the gastrovascular cavity of the polyp and expelled into the water column from the polyp's mouth opening in the form of planulae larvae. These type of corals are called brooders.

In ***external fertilization***, several coral colonies release eggs and sperm (gametes) in a bundle. These types of corals are called broadcast spawners, and are commonly observed in Maldives. These bundles float to the surface and the gamete bundle breaks and mixes with each other, and fertilization takes place.

This process can result in a mass coral spawning event, where trillions of eggs and sperm are released into the water column synchronously. Generally, reef building corals spawn once a year. A few days after fertilization, the coral embryos develop into coral larvae.

The larvae eventually find a good place to settle on the seabed and become tiny coral polyps which would eventually grow to become a mature colony, and the life cycle continues.

Commonly found coral genera of Maldives

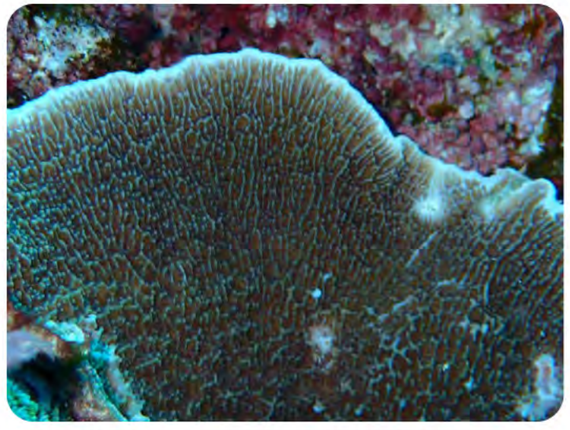
The coral reefs of Maldives contribute to 3.14% of the world's reef areas. Maldives is also home to the seventh largest and the fifth most diverse reef system in the world with 2041 distinct coral reefs found in 26 natural atolls. There are at least 258 stony coral species belonging to 57 genera recorded in Maldives.

The most commonly found coral genera are as follows:

1. Porites

2. Acropora

3. Goniastrea



4. Montipora

5. Pocillopora

6. Dipsastraea

7. Lobophyllia

8. Fungia

9. Platygyra

10. Turbinaria

11. Pachyseris

Field Activity

Learn how to do a coral reef survey

Follow the guidelines to carry out a survey about coral abundance in a nearby area.

- Mask
- Snorkel
- Underwater slate/sheet
- 20 meter measuring tape
- 1m x 1m quadrat (make a quadrat by connecting 1m by 1m pvc pipe and form a square shape)

Instructions

1. Place the measuring tape on the reef for 20m, and then gently place the quadrat at 0m on one side of the tape.
2. Note down the corals found within the quadrat using the sheet given below.
3. Move the quadrat to 5m, 10m, 15m, and continue to record corals found within each quadrat.

How to calculate your quadrat data

To calculate the how many types of corals are found in your quadrat, use the following formula below for each category of corals recorded.

*Relative abundance (branching corals) = (Total branching corals counted in 4 quadrats) / (Total number of all types of corals counted in 4 quadrats) * 100*

Eg: You counted a total of 20 corals from 4 quadrats in different growth forms. From this 20 corals, 12 of them are branching corals. So to calculate relative abundance you have to do

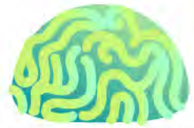
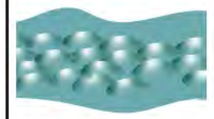
Relative abundance of branching coral
*= 12/20*100 = 60%*

So 60% of the corals in the area are branching corals

By using relative abundance calculation, you can identify which type of corals are most and least common from your survey.

Data Sheet Name: ---------- Date: ----------

Location: ----------

Coral Type	Picture	Quadrat 1	Quadrat 2	Quadrat 3	Quadrat 4	Total
Branching coral						
Massive coral						
Encrusting coral						
Foliose coral						
Columnar coral						
Plate-like coral						
Free-living coral						

Total number from all quadrats

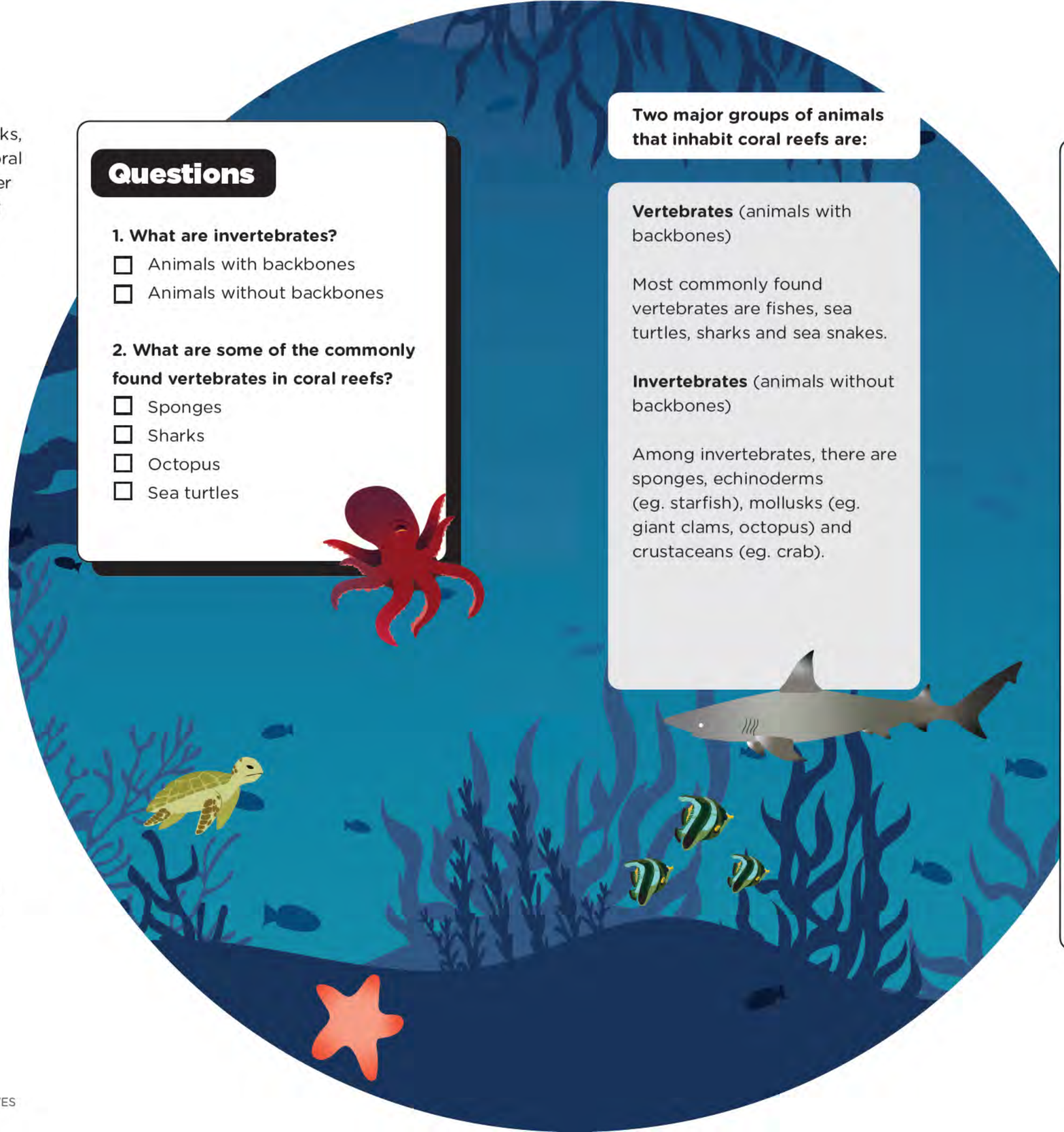
CORAL REEFS

Coral reef associated organisms

From tiny shrimps to huge sharks, thousands of species rely on coral reef ecosystems for food, shelter and protection. There are many complex food webs between various reef habitats and reef organisms.

Coral reefs support over 4000 fish species from small herbivore fish to large predatory fish. In addition to reef fish, there are also a diverse array of marine life such as invertebrates, crustaceans, reptiles and mammals that seek protection, food and shelter in the reef.

Each animal plays a vital role in the reef environment. These species are responsible for different ecosystem functions such as filtering water and preventing overpopulation of certain species and algae. By supporting such organisms, reefs are able to maintain a balanced relationship between prey and predators competing for resources



Questions

1. What are invertebrates?

- ☐ Animals with backbones
- ☐ Animals without backbones

2. What are some of the commonly found vertebrates in coral reefs?

- ☐ Sponges
- ☐ Sharks
- ☐ Octopus
- ☐ Sea turtles

Two major groups of animals that inhabit coral reefs are:

Vertebrates (animals with backbones)

Most commonly found vertebrates are fishes, sea turtles, sharks and sea snakes.

Invertebrates (animals without backbones)

Among invertebrates, there are sponges, echinoderms (eg. starfish), mollusks (eg. giant clams, octopus) and crustaceans (eg. crab).

POP UP FACT

In the Maldives there are:

258 species of reef building coral species,

36 species of sponge,

285 species of algae,

400 species of molluscs,

350 species of crustaceans,

80 species of echinoderms,

and 1000+ species of fish

Categories of coral reef fishes

Piscivorous coral reef fishes are fishes that feed mainly or entirely on other fishes. Depending on the species, piscivorous fish hunt their food using four strategies: they either run down prey, ambush their prey, get the prey used to an illusion that they are not aggressive, or stalk their prey.

Benthivorous coral reef fishes, also known as bottom feeders, are fishes that feed on a variety of animals that live on or near the substrate.

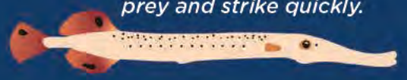
Planktivorous coral reef fishes feed on small planktons such as zooplankton and phytoplankton. There are three categories of planktivorous fish. Some are known as open water plankton feeders, and they feed on planktons during daytime.

Herbivorous reef fish are fishes that feed on plant material such as algae.

Below are some examples of the categories of coral reef fish.

Name: Jack Fish
Category: Piscivorous
They hunt by pursuing their prey using their fast speed in open water.

Name: Trumpet Fish
Category: Piscivorous
They secretly sneak up on their prey and strike quickly.



Name: Cardinal Fish
Category: Planktivorous
They are adapted to the dark and feed on plankton during the night.

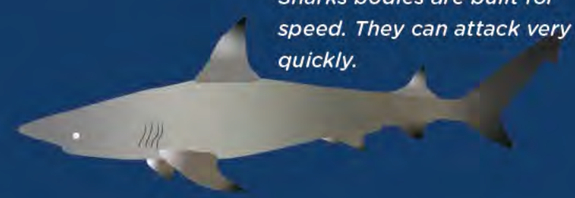
Name: Surgeon fish
Category: Herbivorous
Feeds on plant material

Name: Grouper
Category: Piscivorous
They hunt by ambushing. They camouflage themselves until an unsuspecting fish comes into range.

POP UP FACT

Parrotfish feed on algae that could overgrow or kill coral colonies, and poop out sand. They can approximately produce a tonne of sand by feeding on algae found on coral colonies.

Name: Sharks
Category: Piscivorous
Sharks bodies are built for speed. They can attack very quickly.



Name: Trigger Fish
Category: Benthivorous
Feed on a variety of organisms that lives on or near the reef bed (substrate).

Name: Barracuda
Category: Piscivorous
Yet another hunter that sneaks up on prey and strikes quickly.

Name: Damsel Fish
Category: Planktivorous
They feed on open water plankton and feed during the day.

Importance of coral reefs and threats they face

The annual value of ecosystem services provided by coral reefs globally is estimated to be more than US$375 billion. Half a billion people in the world depend on coral reefs for food and their livelihoods. Coral reefs act as line of defense against natural disasters such as storms, tsunamis and erosions. In addition, coral reefs are an important asset for countries like Maldives that rely on tourism and fisheries.

Coral reefs are also among the most threatened ecosystems in the world. Threats to coral reefs on a global scale include ocean acidification, more frequent and intense storms, and warming of oceans due to climate change, which in turn causes coral bleaching. In addition, they are also at risk due to overfishing, water pollution, habitat destruction and human negligence.

Threats to Coral Reefs

Overfishing

When reef fish are overfished, the food web of the entire reef ecosystem is affected. For example, on a healthy reef, by grazing on algae, herbivorous fish ensure that algae levels are kept in control.

Water pollution

Land based activities such as untreated sewage, industrial waste and dumping of trash can cause water pollution. An excess of nutrients in the water column can disrupt the balance of coral reef ecosystems.

Excess nutrients can increase the growth of harmful algae on corals which can kill corals by blocking their access to sunlight. In addition, trash such as plastic bags and bottles can get stuck on corals and block the sunlight needed for photosynthesis, and entangle and kill reef animals.

Habitat destruction

Activities such as coastal development, dredging and reclamation, ship grounding and boat anchors can damage or kill coral reefs. Sediment generated from dredging and coastal development activities can smother corals and kill them, while ship grounding and boat anchors can break corals and damage the reef habitat.

Human negligence

Careless diving and snorkeling activities can cause damage to coral reefs as people can grab onto corals, accidentally kick or step on them, leading to breakage.

Ocean acidification

The ocean can act as a CO_2 sink by absorbing CO_2 in the atmosphere. When there is an increased concentration of CO_2 in the atmosphere, the ocean absorbs more than normal and becomes more acidic. This makes it hard for corals to secrete calcium carbonate for their skeletons, making them more vulnerable to diseases and storm damage.

Frequent and intense storms

Due to climate change, there is an increase in the frequency and intensity of tropical storms. For example, cyclones get speed and power from warm ocean temperatures. This results in bigger, more powerful waves, which can break coral branches and damage whole coral colonies.

Coral bleaching

Coral bleaching is one of the most significant global threats to coral reefs, causing great decline in coral cover worldwide.

Coral bleaching occurs due to the warming of ocean temperatures by 1-2 degree Celsius above normal levels.

Remember that the algae zooxanthellae is what gives corals their vibrant colouration.

When corals are stressed due to heat or pollution, they expel the zooxanthellae and their white skeletons are exposed.

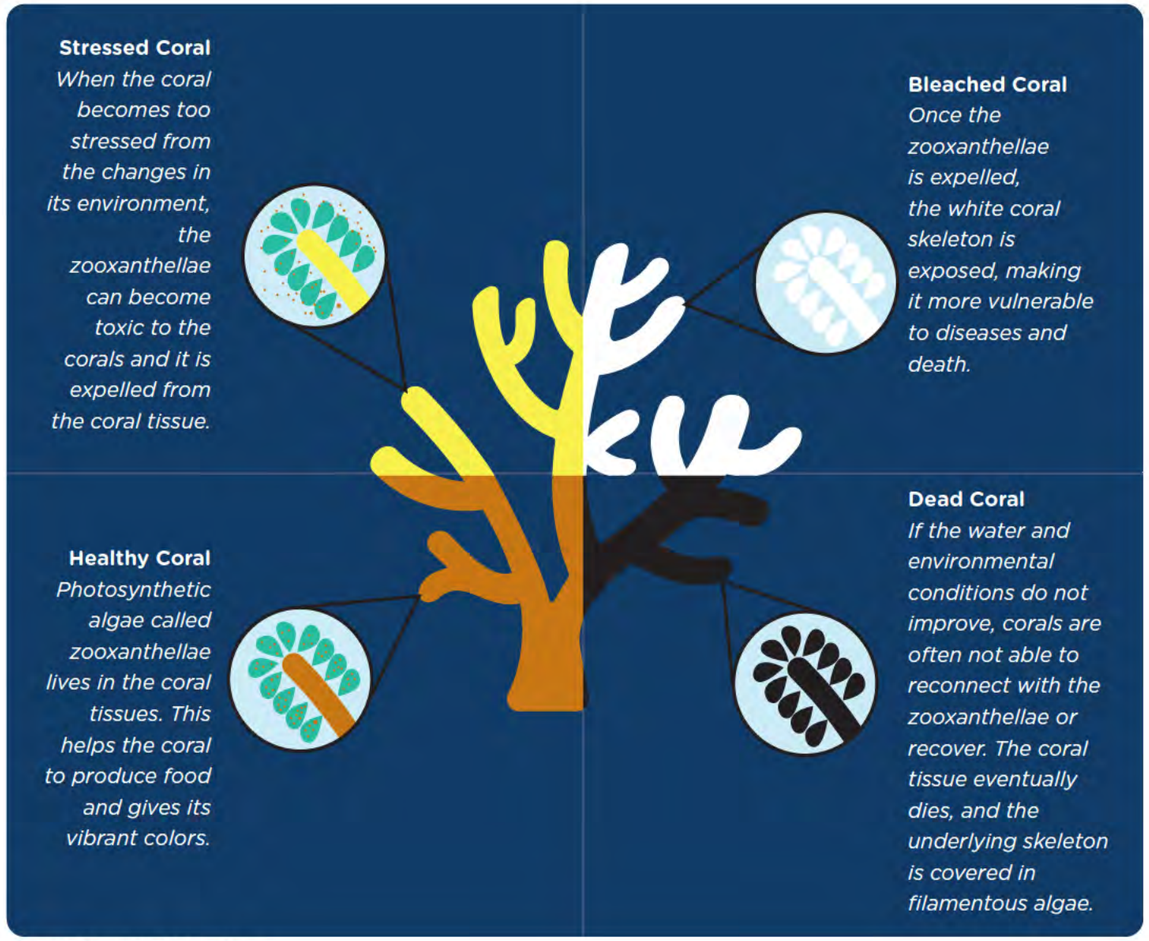


Figure:05 - Coral bleaching

Coral bleaching in Maldives

Globally, there have been three major global coral bleaching events: in 1998, 2010 and 2016. While the 1998 and 2016 bleaching events were considered major bleaching events in the Maldives, the 2010 bleaching event is classed locally as a minor event.

In 1998, every tropical coral region in the world was severely affected by coral bleaching. This was known as the first recorded global bleaching event. Prior to this, reefs were pristine with high coral cover of about 60-70% in most reefs.

During this bleaching event, coral cover decreased down to less than 5%. It took about 10-12 years for reefs to show recovery from the 1998 bleaching event. Maldivian reefs were hit by another bleaching event in 2016, where 50-80% coral death were recorded.

Activity

Coral reef crossword

Using what you have learned in this chapter, try and complete the crossword puzzle.

Across

1. Name of the stinging cells in coral tentacles

2. Group of corals which have 8 tentacles on the coral polyps

3. Single-sexed coral colonies

4. One of the most commonly found coral genera

5. The single celled algae living in coral tissues which carry out photosynthesis

6. A coral colony is made up of many tiny animals called ----------

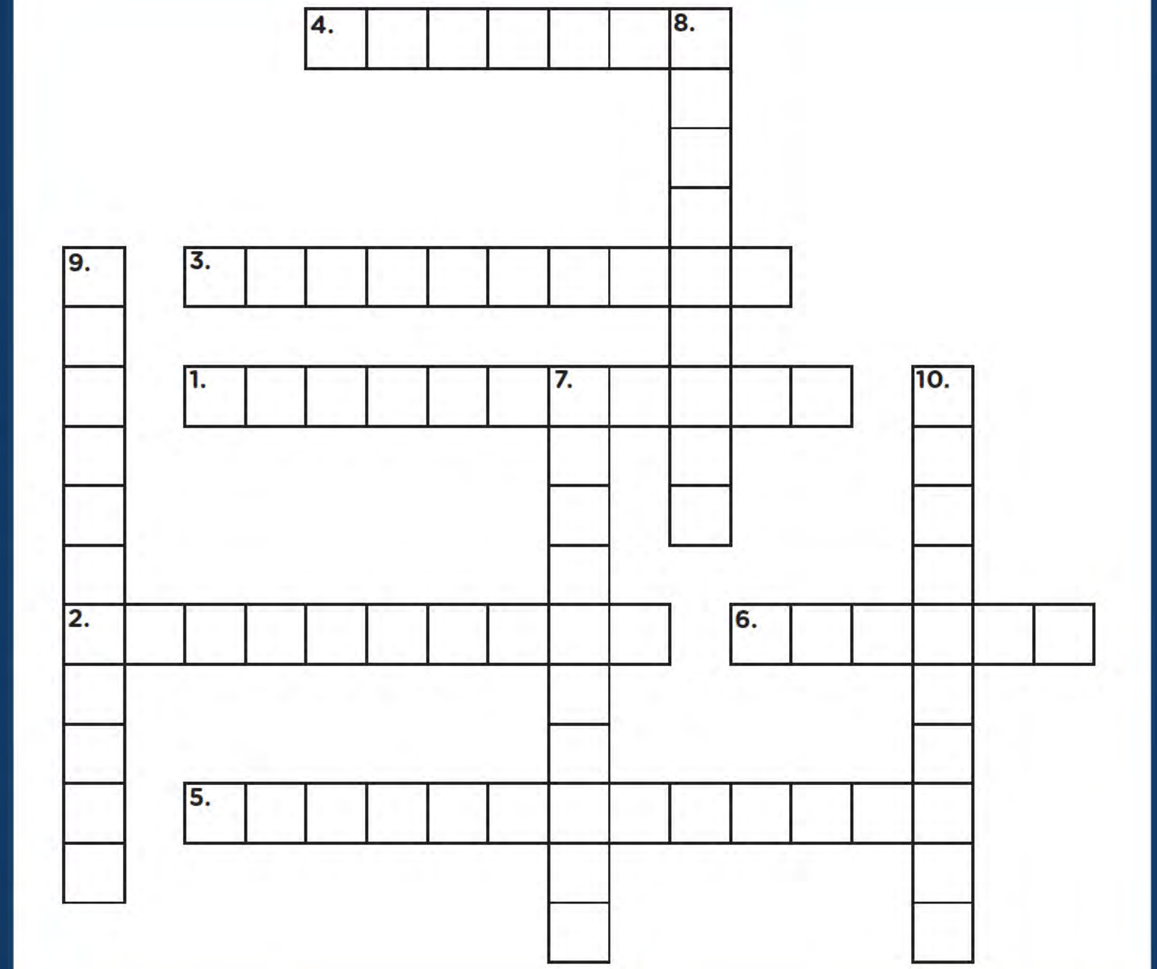
Down

7. Each coral polyp sits in a calcium carbonate cup shaped depression called ----------

8. What is the name of the relationship where difference species live together and help each other

9. Group of coral reef fishes that feed on plant materials like algae

10. Coral reefs are one of the most diverse --------- in the world



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Fisheries in Maldives

Questions

1. Tick the main threat(s) to Maldivian fisheries?

- ☐ Overfishing
- ☐ Pollution
- ☐ Global warming
- ☐ All of the above

2. Can you name the following tuna species?

(a) . _____

(b) . _____

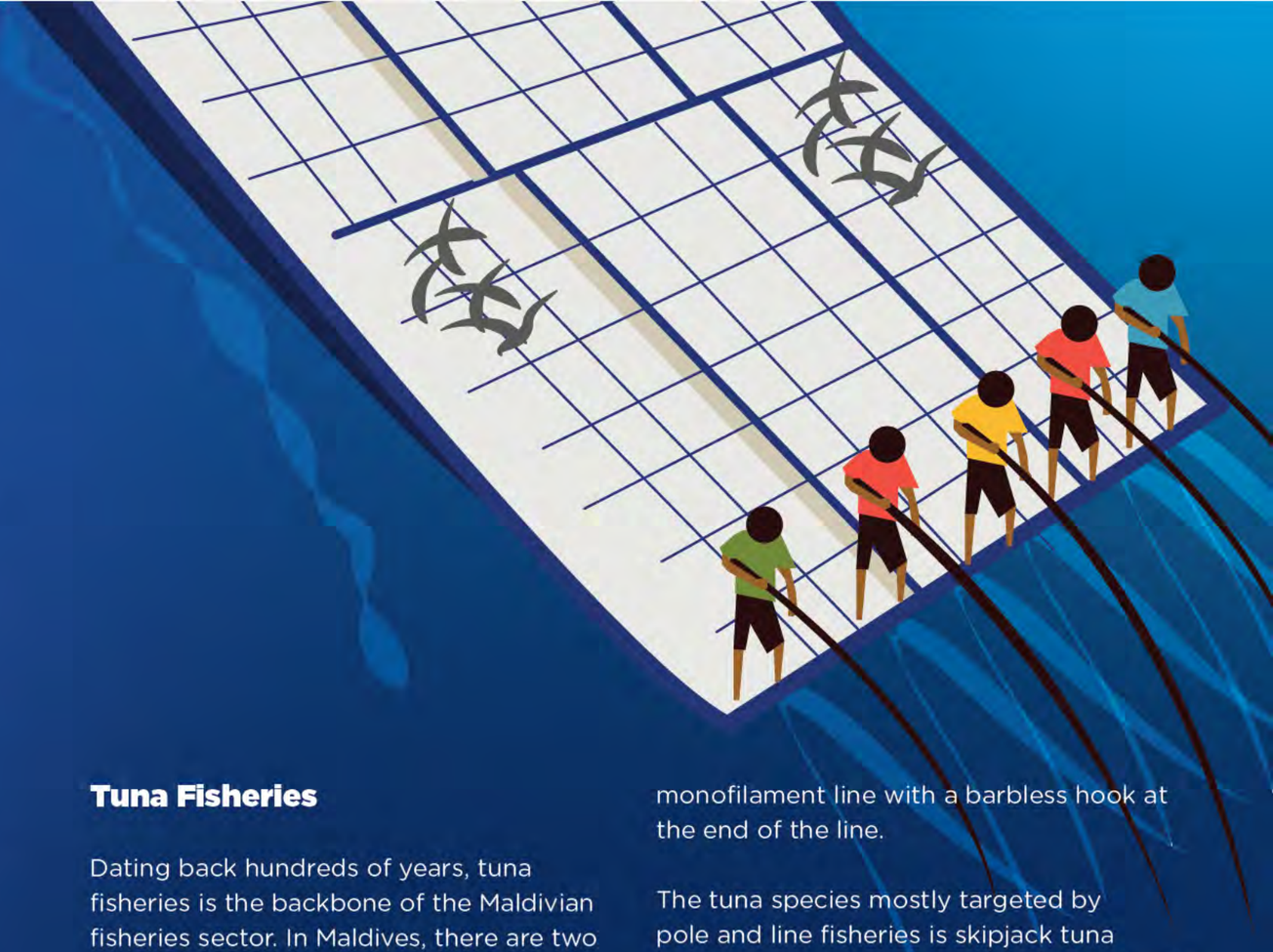
As an island nation that consists of 99% ocean, the wellbeing and livelihood of the nation is intricately linked with our seas. Fishing has long been the life blood of the Maldivian economy. Today, the fisheries sector is the second largest industry in the Maldives and prior to the introduction of tourism, the fishing industry was the number one contributor to the Maldivian economy.

Traditionally, the two main types of fisheries carried out in the Maldives were pelagic fisheries (mainly tuna fisheries) and reef fisheries.

Mariculture, the cultivation of fish and marine life for food, is considered a separate industry on its own in Maldives, and is not a very significant sector at present.

Fishing was traditionally carried out in small wooden boats called Masdhoni (10-15 m in length) with sails, vadhu dhoni (5-8 m) or bokkura (2-3 m).

Nowadays, fishing is carried out in large motorized dhonis built using fiberglass or wooden hulls.
The fisheries sector of Maldives contributes to around 6% of the country's GDP. (Source: FAO)



Tuna Fisheries

Dating back hundreds of years, tuna fisheries is the backbone of the Maldivian fisheries sector. In Maldives, there are two main methods of tuna fishing at present: pole and line and handline.

Traditional pole and line fishing with live bait is done by catching live bait from shallow areas inside the atoll. The bait is kept alive in bait wells in dhonis. Fishers then head out to the open ocean and look for sea birds congregating around tuna shoals or fish from the Anchored Fish Aggregating Devices installed around the Maldives.

Once the fishing boat reaches the tuna shoals, the fishers start throwing live bait fish at the shoal. The tuna is caught one by one using a fiberglass fishing pole and a monofilament line with a barbless hook at the end of the line.

The tuna species mostly targeted by pole and line fisheries is skipjack tuna (*Katsuwonus pelamis*) and juvenile yellowfin tuna (*Thunnus albacares*). Very small amounts of juvenile bigeye tuna (*Thunnus obesus*) is also caught along with yellowfin tuna by this method.

Handline method is generally used for large yellowfin tuna usually bigger than 70cm.

Skipjack tuna is the most important species caught from the tuna fisheries and they usually make up to 65-75% of the total fisheries catch, followed by yellowfin tuna, which makes up to 10-17% of the catch. Skipjack tuna and yellowfin tuna are mostly exported from Maldives as frozen, canned or as processed products to foreign countries.

Commonly caught tuna species

Common Name: Skipjack tuna
Dhivehi Name: Kalhubilamas
Scientific Name: *Katsuwonus pelamis*
IUCN Red list Status: Least Concern (LC)

Common Name: Yellowfin tuna
Dhivehi Name: Reendhoo uraha kanneli
Scientific Name: *Thunnus albacares*
IUCN Red list Status: Near Threatened (NT)

Common Name: Big eye tuna
Dhivehi Name: Loa bodu kanneli
Scientific Name: *Thunnus obesus*
IUCN Red list Status: Vulnerable (VU)

Common Name: Frigate tuna
Dhivehi Name: Raagondi
Scientific Name: *Auxis thazard*
IUCN Red list Status: Least Concern (LC)

Common Name: Kawakawa
Dhivehi Name: Latti
Scientific Name: *Euthynnus affinis*
IUCN Red list Status: Least Concern (LC)

Photos: Maldives Marine Research Institute / Ministry of Fisheries, Marine Resources and Agriculture.

Reef and Grouper Fishery

With an expansion of the tourism sector and increase in demand for local consumption and export, the reef fishery industry in Maldives has grown over the past several years.

The most common method for reef fishery is baited hand lines. The fishery targets a wide variety of fish species that are reef associated such as snappers, jacks, jobfish and emperors.

Reef and grouper fisheries are carried out in small motorized dhonis and fiberglass dinghies whereas recreational reef fishing is usually carried out in motorized dinghies.

The first export-based reef fishery in the Maldives was targeted for groupers in 1994. By 1997, the reef fishery was at its peak with exports of around 0.9 million groupers. Groupers are exported from Maldives as both frozen and live product.

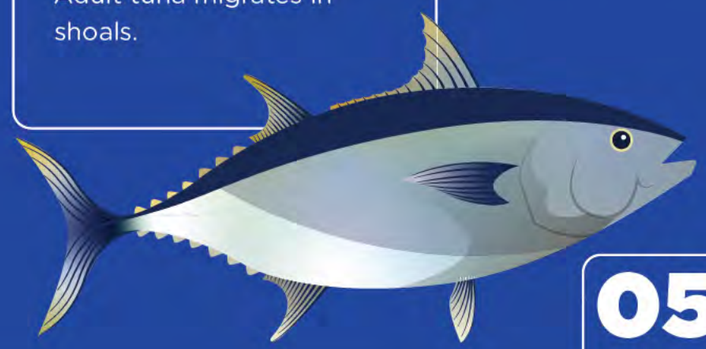
Grouper fisheries initially started in the central atolls of the Maldives, and due to its high market value and demand, quickly expanded to all over Maldives. Reef associated species such as groupers are heavily exploited by commercial fishers, and most grouper species exported from Maldives are now vulnerable to overfishing.

POP UP FACT

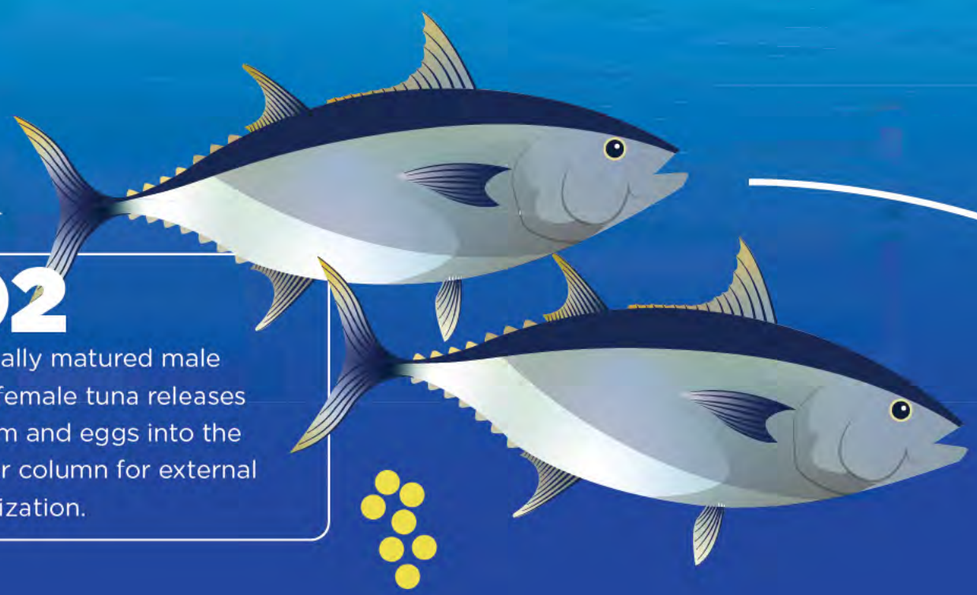
Did you know: pole and line fishing is one of the most sustainable methods of catching tuna as each fish is caught individually

A glance into yellowfin tuna life cycle

01
Adult tuna migrates in shoals.

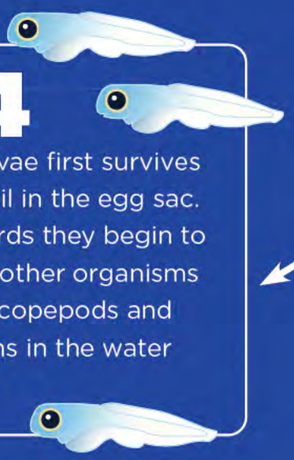


02
Sexually matured male and female tuna releases sperm and eggs into the water column for external fertilization.

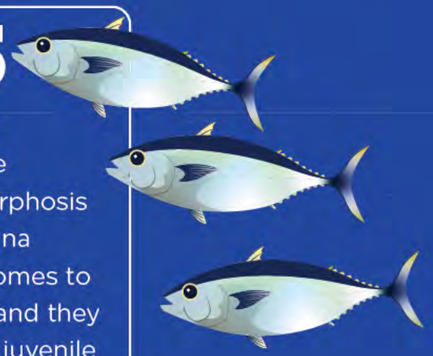


03
The fertilized eggs then hatch and tuna larvae of about 3 mm is born.

04
Tuna larvae first survives on the oil in the egg sac. Afterwards they begin to feed on other organisms such as copepods and planktons in the water column.



05
After 25 days, the metamorphosis of the tuna larvae comes to an end, and they become juvenile tuna. Juvenile tunas eat voraciously and travel in shoals together.



POP UP FACT

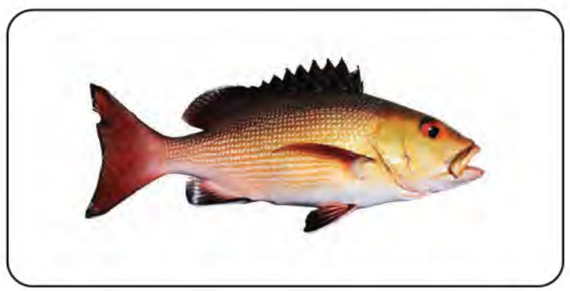
Did you know: yellowfin tuna can grow as large as 7ft in length. That's taller than an average human being! They are also one of the fastest fishes in the open ocean.

Commonly caught reef fish and grouper species

Common Name: Rainbow runner
Dhivehi Name: Maaniya mas
Scientific Name: *Elagatis bipinnulata*
IUCN Red list Status: Least Concern (LC)

Common Name: Green jobfish
Dhivehi Name: Giulhu
Scientific Name: *Aprion virescens*
IUCN Red list Status: Least Concern (LC)

Common Name: Humpback snapper
Dhivehi Name: Ginimas
Scientific Name: *Lutjanus gibbus*
IUCN Red list Status: Least Concern (LC)



Common Name: Red snapper
Dhivehi Name: Raiy mas
Scientific Name: *Lutjanus bohar*
IUCN Red list Status: Least Concern (LC)

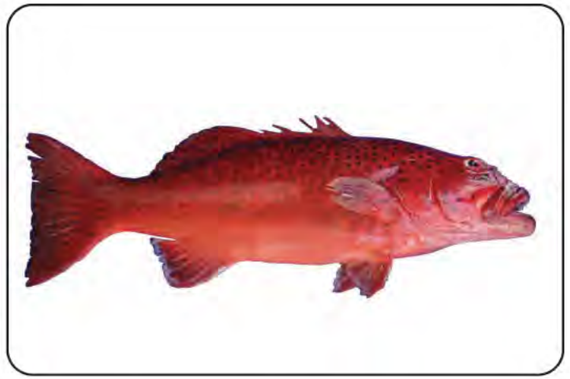
POP UP FACT

Did you know: giant grouper (muda faana) is the largest bony fish found in the coral reefs of Maldives. They can grow as huge as 8 feet and weigh up to 400 kg!

Common Name: Brown marble grouper
Dhivehi Name: Kas faana
Scientific Name: *Epinephelus fuscoguttatus*
IUCN Red list Status: Vulnerable (VU)

Common Name: Square tail coral grouper
Dhivehi name: Olhu faana
Scientific Name: *Plectropomus areolatus*
IUCN Red list Status: Vulnerable (VU)

Common Name: Blacksaddled coral grouper
Dhivehi name: Kula olhu faana
Scientific Name: *Plectropomus laevis*
IUCN Red list Status: Vulnerable (VU)



Common Name: Roving coral grouper
Dhivehi name: Dhon olhu faana
Scientific Name: *Plectropomus pessuliferus*
IUCN Red list Status: Vulnerable (VU)

Photos: Maldives Marine Research Institute / Ministry of Fisheries, Marine Resources and Agriculture.

FISHERIES IN MALDIVES

Threats to Maldivian fisheries

Overfishing

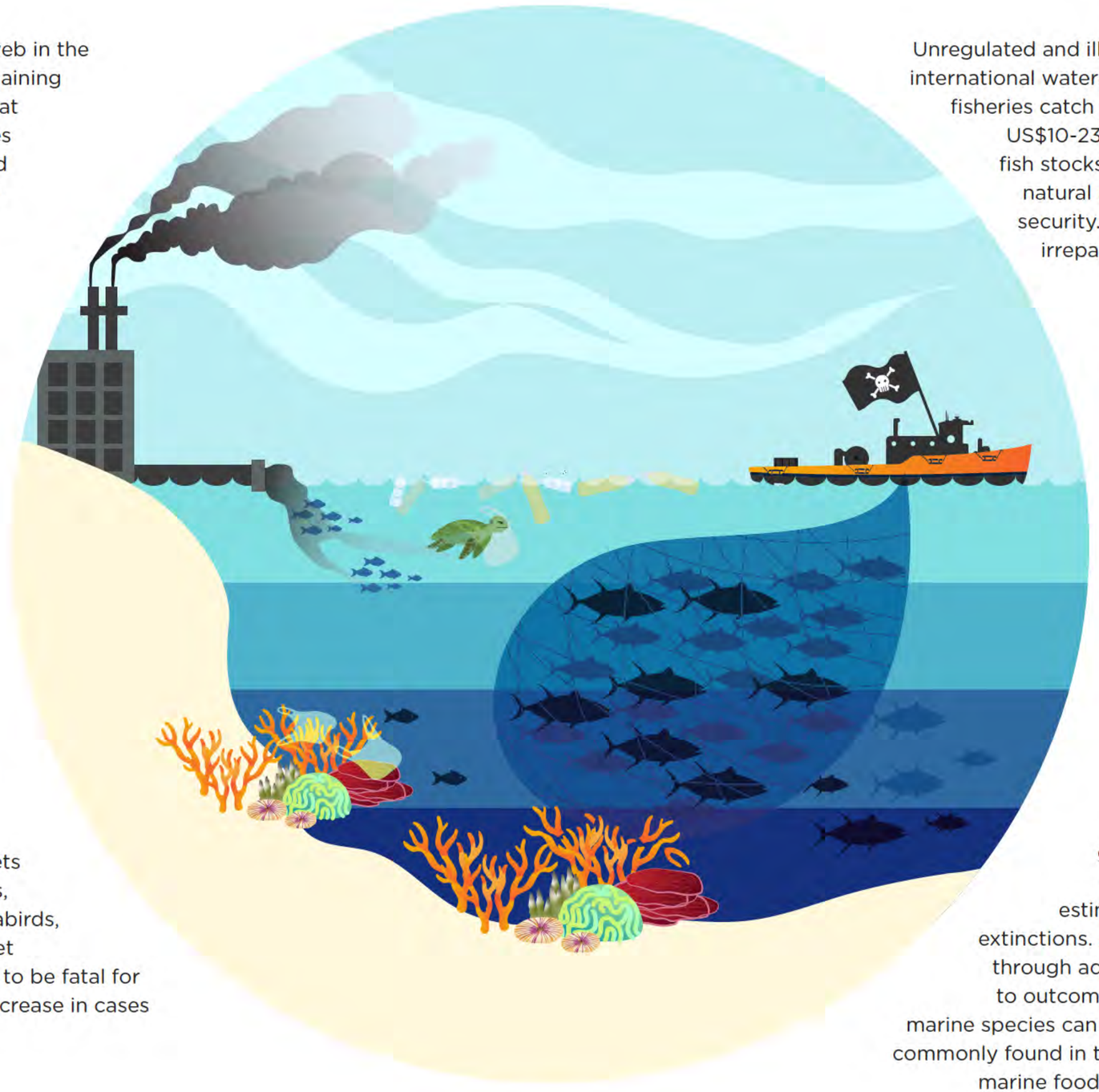
Overfishing can impact the entire food web in the oceans. It can change the size of the remaining fish, how they reproduce, and the speed at which they mature. When too many fishes are taken out before they can mature and reproduce, it creates an imbalance in the ecosystem and can lead to loss of key marine life.

Global warming

Climate change due to global warming can make oceans more acidic. The increase or decrease in water temperatures have an impact on the growth and reproduction of marine life and also changes the flow and chemistry of the water. High temperatures are also known to reduce oxygen levels in the water, making it inhospitable for many fishes.

Pollution and marine debris

Across the globe, thousands of marine animals are endangered due to marine plastic pollution every year. In the Maldives, even though net fishing is prohibited, discarded fishing gear and nets from other countries drift into our waters, harming our marine animals. As such, seabirds, turtles and other marine animals often get entangled in ghost nets which can prove to be fatal for them. Recently, there has also been an increase in cases of plastic ingestion in marine animals.



Unregulated and illegal fisheries

Unregulated and illegal fisheries occurring within national and international waters violate fishing regulations. Globally, illegal fisheries catch products are estimated to generate around US$10-23.5 billion annually. This can cause decline in fish stocks and threaten economic security, as well as natural resources that are important to global food security. Illegal fisheries have the potential to cause irreparable damage to fish stocks as it hinders its ability to recover from overexploitation.

Destruction of marine habitats

Destruction of marine habitats can impact entire ecosystems. It can prevent fish migrations for reproduction, shelter and feeding. Many marine fishes rely on different habitats such as seagrass meadows, mangroves and coral reefs for different phases in their life cycle. Loss of these habitats will cause loss of key species.

Introduction of alien and invasive marine species

Alien species are animals that are non-native to the local environment. Invasive alien species have a high potential to cause damage to the local ecosystem and biodiversity, and is considered one of the greatest threats to local biodiversity. Of the known causes, alien and invasive species is estimated to have caused nearly 40% of animal extinctions. Alien species that are imported to Maldives through aquarium trade and others have the potential to outcompete native species. Additionally, importing marine species can also introduce diseases and pathogens not commonly found in the wild, which can cause disruptions to the marine food web and decimation of vulnerable species.

What can we do to prevent these threats?

- Educate yourself on best practices and follow local fishing guidelines
- Establish and manage Marine Protected Areas (MPAs)
- Buy sustainably sourced seafood
- Take only what you need and don't catch too small or too large fish
- Stop littering into oceans and properly dispose waste

Tick the appropriate box

1. Available fish stocks can be significantly depleted and are often in decline because of

- ☐ Overfishing
- ☐ Pole and line fishing
- ☐ Lack of education

2. What is the most sustainable method of fishing tuna?

- ☐ Purse seine net
- ☐ Spear fishing
- ☐ Pole and line

3. Grouper species exported from Maldives are vulnerable due to

- ☐ Expansion of grouper fisheries and increase in demand
- ☐ Overfishing by industrial fishermen
- ☐ Catching of juvenile groupers
- ☐ All of the above

Field Activity

Go to a fish market (or a fishing vessel) near you and try to identify the species of fish caught and sold by fishers.

Try to find out which type of fisheries the species of fish belongs to (Tuna or Reef fishery) and compare which type of fishery had more species caught during that day.

Items needed:

- Paper and pen
- Camera
- Use 44, 48 & 49 page as a guide to identify the common species in Tuna and Reef Fisheries in the Maldives
- Access the www.mrc.gov.mv website to find the "Fishes of the Maldives" E-book to use as a reference guide:
https://www.mrc.gov.mv/assets/Uploads/fishes-of-the-maldives.pdf

Instructions:

1. Make 2 columns on your sheet of paper. Title them Tuna and Reef fish
2. Observe the fish caught by the fisherman

(a) Take a picture and note down the quantity caught
(b) If you can identify which species, note it down in the appropriate column. (Have your reference guide on hand with you or check your pictures later)
(c) After identifying the fisheries based on the fish species, tally up the total numbers.

What did you observe from this activity?

1. Were there more species related to tuna fisheries or reef fisheries? ☐
2. How many different species of fish were you able to identify? ☐

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MALDIVIAN FISHERIES IN NUMBERS

742*
NUMBER OF LICENSED FISHING VESSELS

7,907**
NUMBER OF FISHERMEN

127,000**
METRIC TONS OF TUNA CAUGHT EACH YEAR

64,300***
METRIC TONS OF TUNA EATEN IN THE MALDIVES EACH YEAR

140 MILLION**
USD VALUE OF MARINE PRODUCT EXPORTS PER YEAR

6 SPECIES
OF TUNA CAUGHT IN THE MALDIVES***

** Ministry of Fisheries and Agriculture, Fishing Vessels List 19th January 2017*

*** NBS, Statistical Pocketbook of Maldives 2016*

**** Ministry of Fisheries and Agriculture, Basic Fishery Statistics, 2013*

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Megafaunas of Maldives

The giants of the sea

Maldivian waters are home to a rich diversity of marine megafauna. From the largest animal on Earth, the blue whale, to green sea turtles can be sighted in waters surrounding Maldivian islands.

Marine megafauna consist of large bodied marine animals that have a body mass greater than 45kg. These large animals inhabiting the ocean are known to play a vital role in the functions of ecosystem.

However, many of these species are currently threatened with extinction due to exploitation by humans, habitat loss, global warming and pollution. In this chapter, we will be looking at key megafauna species found in Maldives, their importance to ecosystems, and the threats faced by these species.

All species highlighted in this chapter are protected in Maldives under the Environment Protection and Preservation Act (Law no. 4/93) and Fisheries law of Maldives (Law no. 5/87)

Questions

1. What is the largest shark species found in the Maldives?

- ☐ Nurse shark
- ☐ Whale shark
- ☐ Grey reef shark

2. How many species of sea turtles are found in the Maldives?

- ☐ 1
- ☐ 3
- ☐ 5

Sharks

Nearly 40 species of sharks have been recorded in Maldivian waters. The largest of them is the whale shark which feeds exclusively on planktons. Sharks are apex predators and play a crucial role in maintaining and balancing healthy and functional food webs. They do this by keeping the populations of their prey in check and feeding on animals below them in the food chain.

POP UP FACT

Did you know sharks have been around long before dinosaurs. They have been around for over 400 million years!

Worldwide, shark populations are in great decline. Sharks grow relatively slow and take many years to mature and reproduce, making them vulnerable to overexploitation. It is estimated that up to 73 million sharks are killed each year mainly for their fins. In addition to overfishing, habitat loss and pollution is also another major threat to shark species. Until the ban of shark fisheries in 2010, sharks were also harvested in the Maldives for their liver oil and fins. Sharks are still worth more alive then dead as millions of dollars could be made annually through tourism related activities such as shark watching by diving or snorkeling.

Why sharks matter

Sharks balance food webs: Sharks regulate the oceans by maintaining the structure of food webs and keeping other marine life in a healthy balance.

Sharks keep prey populations healthy: Predatory sharks target sick or injured prey, removing the weakest individuals. This prevents spread of disease, improve the gene pool and result in healthy ecosystems.

Sharks keep vital habitats healthy: For example, tiger sharks prevent sea turtles from overgrazing oxygen producing seagrass beds by patrolling such large areas.

Commonly found sharks in the Maldives

Common Name: Blacktip reef shark
Dhivehi Name: Falhu mathi dhon miyaru
Scientific Name: *Carcharhinus melanopterus*
IUCN Red List Status: Near Threatened

Common Name: Whitetip reef shark
Dhivehi Name: Faana miyaru
Scientific Name: *Ctriaenodon obesus*
IUCN Red List Status: Near Threatened

Common Name: Grey reef shark
Dhivehi Name: Thila miyaru
Scientific Name: Carcharhinus amblyrhynchos
IUCN Red List Status: Near Threatened

Common Name: Nurse shark
Dhivehi Name: Nidhan miyaru
Scientific Name: *Ginglymostoma cirratum*
IUCN Red List Status: Data deficient

Common Name: Tiger shark
Dhivehi Name: Femunu
Scientific Name: *Galeocerdo cuvier*
IUCN Red List Status:
Near Threatened

Common Name:
Whale shark
Dhivehi Name:
Fehurihi
Scientific Name:
Rhincodon typus
IUCN Red List Status:
Critically Endangered

Marine Turtles of Maldives

Long before humans settled in Maldivian islands, the marine turtles were already nesting and swimming around in the area. Seven species of marine turtles have been recorded around the globe and from this, five species are known to either forage, nest or breed in Maldivian waters. All marine turtle species are listed either as critically endangered or endangered by IUCN Red List of Threatened Species. Even though female turtles can lay hundreds of eggs while nesting, only 10% of the hatchlings survive for more than a year. Marine turtles feed on a variety of things such as sponges, jellyfish, seagrass and such, and help to keep the ecosystem in balance.

Most commonly sighted turtles

Common Name: Hawksbill turtle
Dhivehi Name: Kahanbu
Scientific Name: *Eretmochelys imbricata*
Weight: Approx. 70kg
IUCN Red List Status: Critically Endangered

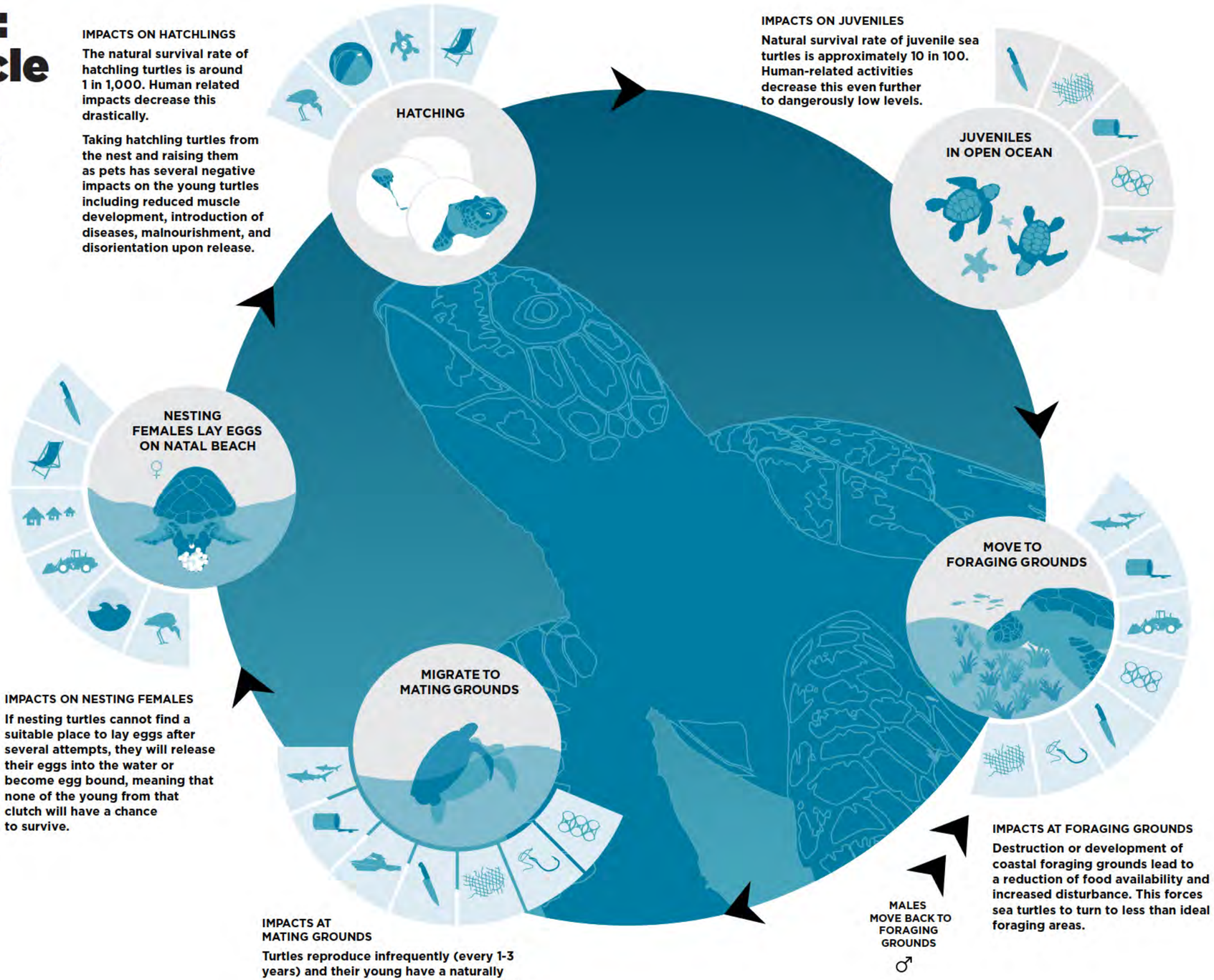
Common Name: Leatherback turtle
Dhivehi Name: Musinbi
Scientific Name: *Dermochelys coriacea*
Weight: upto 900kg
IUCN Red List Status: Vulnerable

Common Name: Olive ridley
Dhivehi Name: Vaavoshi Velaa
Scientific Name: *Lepidochelys olivacea*
Weight: Approx. 45kg
IUCN Red List Status: Vulnerable

Common Name: Loggerhead turtle
Dhivehi Name: Boabodu velaa
Scientific Name: *Caretta caretta*
Weight: upto 160kg
IUCN Red List Status: Endangered

Common Name: Green turtle
Dhivehi Name: Velaa
Scientific Name: *Chelonia mydas*
Weight: Approx. 135-160kg
IUCN Red List Status:
Endangered

Turtles: Life cycle and threats



IMPACTS ON HATCHLINGS

The natural survival rate of hatchling turtles is around 1 in 1,000. Human related impacts decrease this drastically.

Taking hatchling turtles from the nest and raising them as pets has several negative impacts on the young turtles including reduced muscle development, introduction of diseases, malnourishment, and disorientation upon release.

IMPACTS ON JUVENILES

Natural survival rate of juvenile sea turtles is approximately 10 in 100. Human-related activities decrease this even further to dangerously low levels.

IMPACTS ON NESTING FEMALES

If nesting turtles cannot find a suitable place to lay eggs after several attempts, they will release their eggs into the water or become egg bound, meaning that none of the young from that clutch will have a chance to survive.

IMPACTS AT MATING GROUNDS

Turtles reproduce infrequently (every 1-3 years) and their young have a naturally low survival rate. Therefore, every mating and nesting attempt is incredibly important to the local population.

MALES MOVE BACK TO FORAGING GROUNDS ♂

IMPACTS AT FORAGING GROUNDS

Destruction or development of coastal foraging grounds lead to a reduction of food availability and increased disturbance. This forces sea turtles to turn to less than ideal foraging areas.

NATURAL THREATS

- **Predation at sea**
- **Predation on the beach**
- **Floods**

HUMAN THREATS

- **Bycatch in fishing gear**
- **Ingestion of plastic and other debris**
- **Direct harvest**
- **Poaching of juveniles for pet trade (very common in Maldives)**
- **Contamination (oil spills, chemical spills, etc)**
- **Entanglement in fishing gear and marine debris**
- **Boat strikes**
- **Destruction or modification of foraging areas and nesting grounds (i.e., removal of seagrass)**
- **Disturbance caused by increased human activities on beaches**
- **Obstacles on the beach**
- **Disorientation due to light pollution**

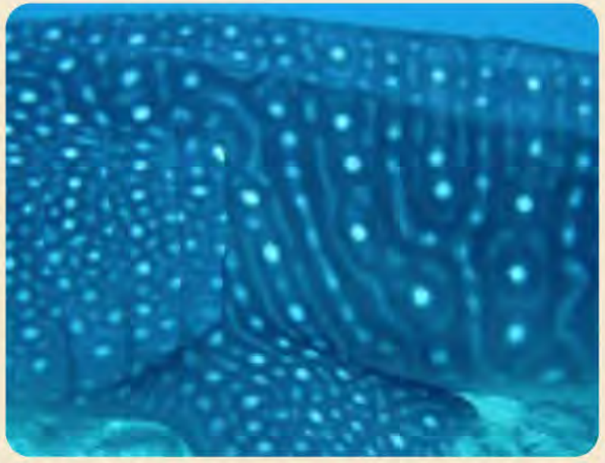
Activity

Photo-identification is a method used by researchers to identify individual marine megafauna such as whale sharks and sea turtles. These animals have unique markings on their body which work like a 'fingerprint' and allow researchers to identify individuals based on these markings, often by comparing photos.

Through this, important information can be collected over a period of time, which provides an opportunity to learn more about the populations of these species within an area.

Identifying whale sharks - researchers use the pattern of spots behind the gills on the right or left side of the whale shark. Each side of the shark has different markings.

WS079 Fernando is a whale shark found in the Maldives. Can you try and find him from the options given on the right?



WS079 Fernando.

Cetaceans

There is an abundant and diverse array of cetaceans found in Maldives. 'Cetaceans' is the collective name given for all types of whales, dolphins and porpoises. There are 90 species of cetaceans that are currently known to inhabit the world's oceans, lakes and rivers. Maldives is home to 3 species of baleen whales and 20 species of toothed whales. The largest animal in the world, the blue whale (bodumas in dhivehi) can also be sighted from the Maldivian waters.

Spinner dolphins and bottlenose dolphins are the most commonly sighted cetacean species in Maldives. They can form groups of up to 40-100 individuals. Similar to manta rays and turtles, using photographic identification, individual cetaceans can be identified by the shape of their dorsal fins and unique patterns or markings such as spots on them.

The great abundance of cetaceans sightings in Maldives is mainly due to nutrient rich waters, which supply these animals with food. Cetaceans are ecologically important to our marine ecosystems and livelihoods as well. Maldivian fishers are known to use the presence of dolphin schools to locate yellowfin tuna shoals.

Cetaceans worldwide are vulnerable to extinction as they are threatened by commercial whaling, entanglement in fishing gear, climate change, boat strikes, oil spills and contamination in the oceans.

Cetaceans found in the Maldives

These are some of the commonly sighted cetaceans in the Maldives

Common Name: Bottlenose dolphin
Dhivehi Name: Koamas
Scientific Name: *Tursiops*
Weight: 150 - 200 kg
IUCN Red List Status: Near Threatened (NT)

Common Name: Spinner dolphin
Dhivehi Name: Koamas
Scientific Name: *Stenella longirostris*
Weight: 23-79 kg
IUCN Red List Status: Least Concern (LC)

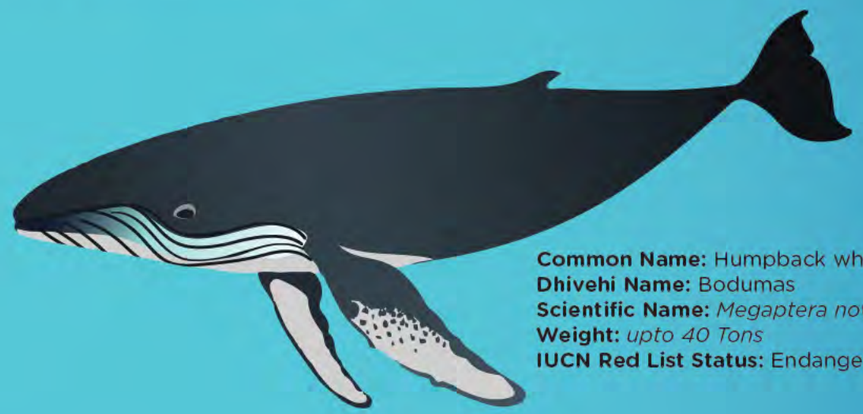
Common Name: False killer whale
Dhivehi Name: Bodumas
Scientific Name: *Pseudorca crassidens*
Weight: over 1000 kg
IUCN Red List Status: Near Threatened (NT)

Common Name: Short-finned pilot whale
Dhivehi Name: Bodumas
Scientific Name: *Globicephala macrorhynchus*
Weight: 1,000 – 3,000 kg
IUCN Red List Status: Least Concern (LC)

POP UP FACT

Did you know that ambergris (maavaharu) is produced by sperm whales? Ambergris is formed in the intestines of sperm whale and expelled as excretion.

Common Name: Sperm whale
Dhivehi Name: Bodumas
Scientific Name: *Physeter macrocephalus*
Weight: *35 to 40 Tons*
IUCN Red List Status: Endangered (EN)



Common Name: Humpback whale
Dhivehi Name: Bodumas
Scientific Name: *Megaptera novaeangliae*
Weight: *upto 40 Tons*
IUCN Red List Status: Endangered (EN)

Common Name: Blue whale
Dhivehi Name: Bodumas
Scientific Name: *Balaenoptera musculus*
Weight: *upto 200 Tons*
IUCN Red List Status: Critically Endangered (CR)

Manta rays

Manta rays are filter-feeding animals that live in tropical and subtropical regions of the world.

The oceanic mantas can grow up to 7 metres in body width, while the reef species can reach up to 4-5 meter in wingspan.

The two species of manta rays found in the Maldives are oceanic mantas and reef mantas. The largest known reef manta population is found in the Maldives, and it comprises of about 5,000 individuals. Some researchers estimate that a total of over 9,000 mantas are found in the Maldives.

They can be sighted year round in the Maldives migrating across the atolls depending on the monsoon. Manta rays gather near areas rich in nutrients to feed. In Baa atoll Hanifaru Bay, more than 150 mantas are known to aggregate at a time.

These animals are highly valued for tourism in Maldives, generating an estimated USD 8.1 million per year in direct revenue. So far, 4900 different individual reef manta rays have been identified in the Maldives by researchers from looking into the unique markings on their bellies.

Common Name: Oceanic manta
Dhivehi Name: Madi
Scientific Name: *Mobula birostris*
Average body width: 4-5 m
IUCN Red list status: Endangered (EN)

Common Name: Reef manta
Dhivehi Name: En Madi
Scientific Name: *Mobula alfredi*
Average body width: 3- 3.5 m
IUCN Red list status: Vulnerable (VU)

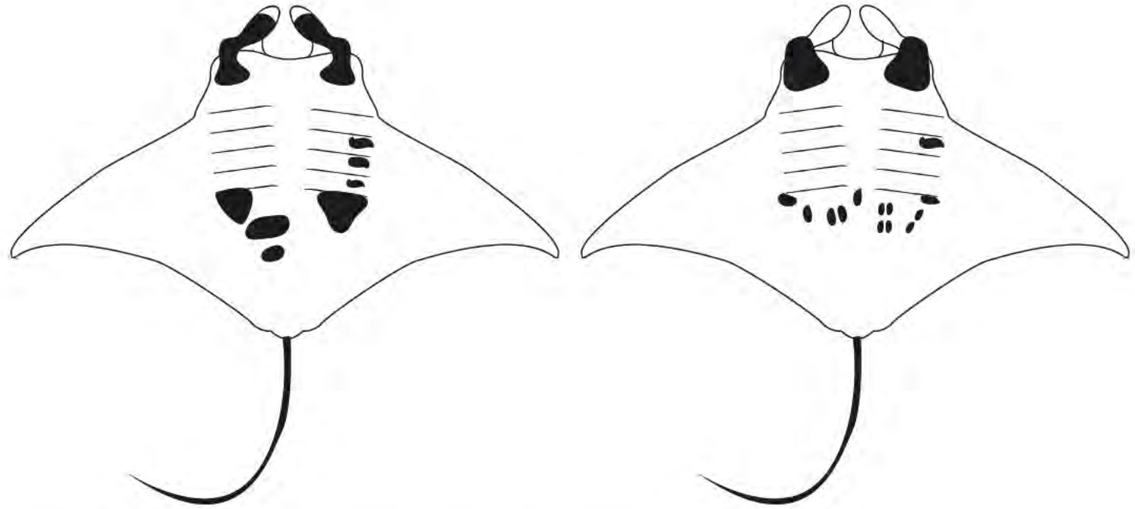


Figure:06- Ventral side of two manta rays showing the difference in markings on their belly.

These markings are unique to each individual, much like how the human fingerprint works. Key threats to manta rays worldwide include being caught for their gill plates, and being caught as bycatch, impacts of climate change on food availability to manta rays, habitat loss and also marine pollution.

Due to these threats and decline in populations, manta rays are classified as "Vulnerable (VU)" in the IUCN Red List of Threatened Species.

POP UP FACT

Manta rays have the largest brain to body ratio of any cold blooded fish living in the sea! They are highly intelligent and also curious.

Mind blowing facts about Maldivian megafauna

1. South Ari Atoll is one of the best places in the world to spot a whale shark
Since 2006, the Maldives Whale Shark Research Programme (MWSRP) has been undertaking research in the South Ari Marine Park (SAMPa) with the help of citizen scientists and volunteers. MWSRP has identified 210 individual whale sharks within the area. Resighting rates at SAMPa is also extremely high, with many sharks returning to the region year after year. In fact, although unconfirmed, it is probable that this is the highest re-sighting rate in the world. Similar to manta rays, whale sharks are identified by the skin patterning behind their gills.

2. Turtles have the ability to navigate back to the beach where they are born - from anywhere in the world
Turtles are not born in the ocean. Female turtles come ashore and deposit up to several hundred eggs into burrowed nests in the sand, where they remain for incubation. After a period of 40-60 days, the turtles hatch and head straight for the water. Now for the mind-blowing part: it is at this stage that these minutes-old turtles imprint a sort of magnetic signature of the beach into their minds, amuch like a mental map. How can they possibly do this? It's all down to their ability to sense the magnetic field of the Earth. The power, which they share with birds is akin to having an inbuilt satellite navigation device where 'home' is set to their birthplace. All turtles have it, both male and female, and it stays with them for their whole lives. This is the reason that female turtles return to where they were born to lay their own eggs, often traveling for thousands of miles. Exactly how they mange to do this still remains a mystery.

3) 23 species of whales and dolphins have been recorded in Maldivian waters
With so many incredible marine animals, it's easy to forget that the Maldives is one of the best countries in the world for dolphin watching. The most commonly sighted species is the spinner dolphin which can often be seen in numbers well over a hundred. Bottlenose dolphins are also frequently sighted, as are short-fin pilot whales. Orcas have been filmed across multiple atolls and Dr. Charles Anderson, an expert in Maldivian cetaceans, even recorded a sighting of an elusive Longman's beaked whale, thought by many to be the rarest whale in the world.

Activity

Nowadays, you don't need to be a researcher or scientist to contribute to marine research. By having access to basic equipment such as an underwater camera or a smart-phone you can submit vital information which can contribute to marine research and conservation efforts globally.

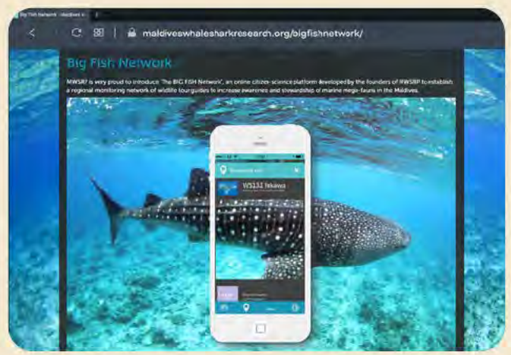
Try out the following citizen science platforms operated in the Maldives.

The Big Fish Network
This is an online citizen science platform developed by Maldives Whale Shark Research Programme for research, monitoring and to increase awareness on whale sharks in the Maldives.

Go to https://maldiveswhalesharkresearch.org/bigfishnetwork/ to find more information or download the MWSRP App on IOS.

ID the Manta
Through this website, contribute images and information about manta ray encounters you have. By using this platform, can contribute to the largest manta ray database in the world.

To find more information and to submit details of manta encounters, go to https://www.mantatrust.org/idthemanta



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Seagrass Ecosystems

The lush gardens underwater

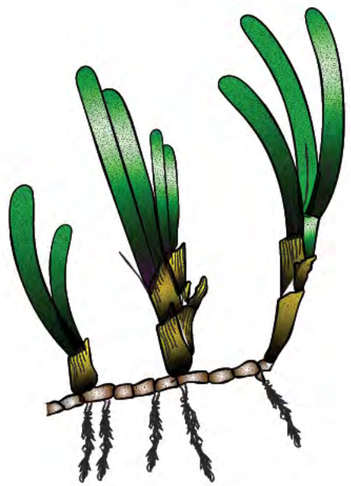
Questions

1. How many species of seagrass are found in the Maldives?

- ☐ 2
- ☐ 7
- ☐ 8
- ☐ 6

2. Can you identify the species of seagrass in the picture below?

- ☐ Halophila ovalis
- ☐ Thalassia hemprichii
- ☐ Halodule pinifolia



Found in nearly all the seas around the globe, usually in shallow waters adjacent to the coast or in depths up to 60m deep are underwater gardens made up of marine plants called seagrass.

They can spread and grow in large areas, often forming seagrass meadows of several species. Seagrass meadows are a highly diverse and important ecosystems that provide shelter and food for a variety of marine life and also keep our oceans healthy.

In tropical regions, seagrass ecosystems are interconnected to mangroves and coral reef ecosystems. These three habitats work together to keep their associated animals healthy, and support the different stages of lifecycles of marine animals.

What are seagrasses?

Oftentimes seagrasses are mistaken for seaweeds (a type of algae) due to their similar appearances. Seagrasses are actually flowering plants with roots, stems, and leaves, which produce flowers and seeds.

Seagrasses are also closely related to land plants. They evolved and adapted to life underwater around 100 million years ago.

There are around 60 different species of seagrass found around the world.

POP UP FACT

In a single day, a turtle can feed on up to 2 kilograms of seagrass!

Main distinguishing features to observe in seagrass species identification

This diagram has all the features of different species of seagrass

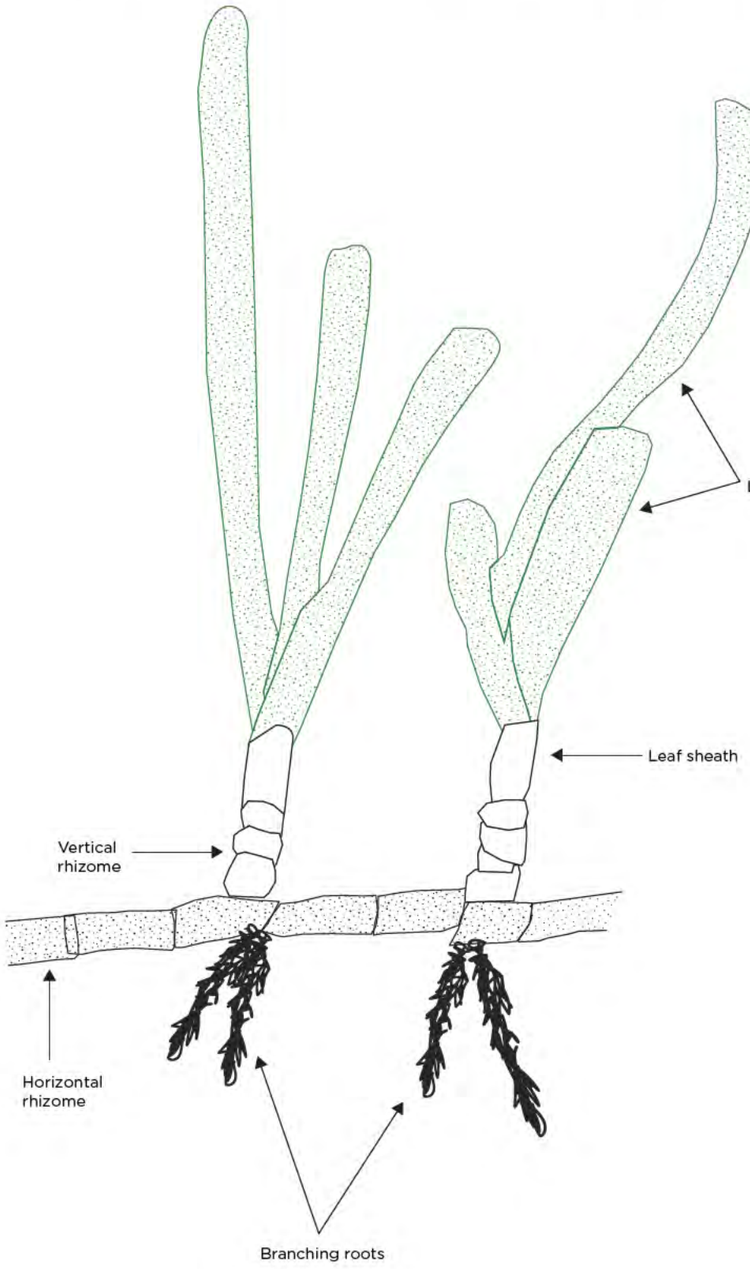


Figure:07- Features of different species of seagrass.

Seagrass species of Maldives

Tropical regions in the Indian and western Pacific oceans have the highest seagrass diversity in the world, with as many as 14 species growing together. This is probably because seagrasses evolved first in this part of the world, giving it more time to diversify in this region.

The western Indian ocean is home to 13 species of seagrasses, and in Maldives, 7 different species of seagrass have been recorded.

POP UP FACT

Seagrass plays an important role in the fight against climate change as seagrass meadows are known to absorb large amounts of carbon dioxide from the seawater.

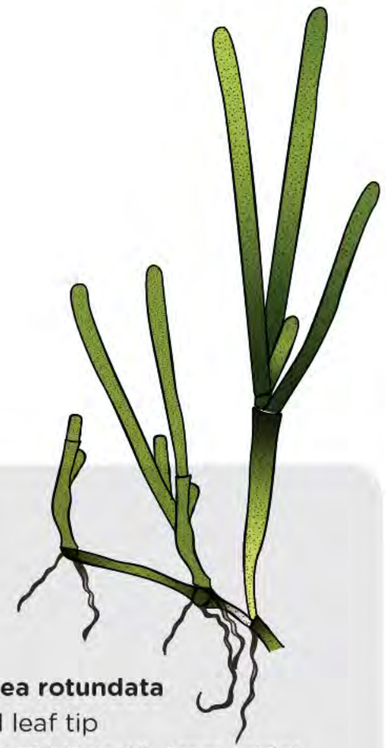
Cymodacea serrulata
- serrated leaf tip
- wide leaf blade (5-9mm wide)
- leaves 6-15cm long
- 13-17 longitudinal veins
- robust/strong rhizome

Halophila ovalis
- 8 or more cross veins
- no hairs on leaf surface
- leaf margins smooth
- leaf 5-20mm long

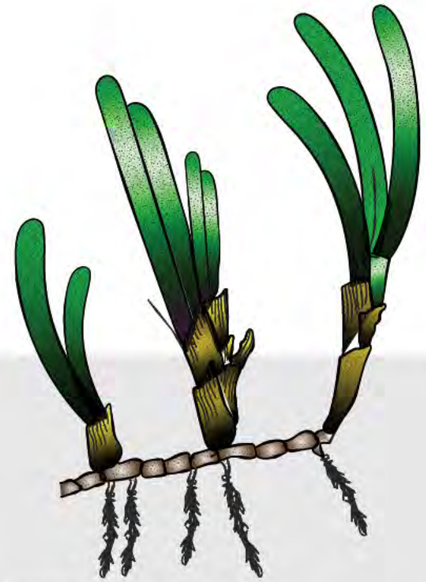
Halodule pinifolia
- rounded leaf tip
- 1 central vein
- usually pae rhizome, with clean black leaf scars

Thalassodendron ciliatum
- erect stem up to 65cm long bearing leaf cluster
- rhizome tough and woody
- ribbon-like, sickle-shaped leaves with ligule
- round, serrated leaf tip
- often found attached to rock or coral

Syringodium isoetifolium
- narrow spaghetti-like leaves
- cylindrical in cross section, 1-2mm diameter
- leaves contain air cavities
- leaf tip tapers to a point
- leaves 7-30cm long



Cymodocea rotundata
- rounded leaf tip
- narrow leaf blade (2-4mm wide)
- leaves 7-15cm long
- 9-15 longitudinal veins
- well developed leaf sheath

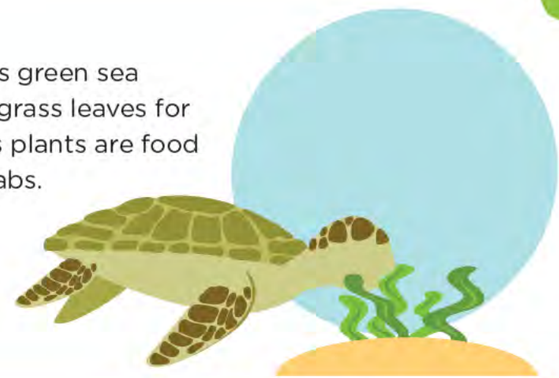


Thalassia hemprichii
- ribbon-like curved leaves 10-40cm long
- leaf tip rounded, slightly serrated
- short black tannin cells,
- 1-2mm long, in leaf blade
- thick rhizome with scars between shoots

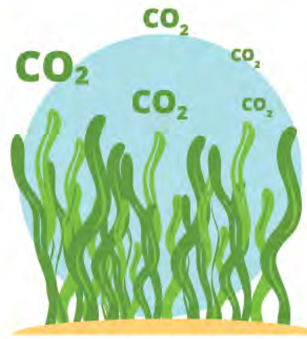
Ecological benefits of seagrass beds

Nursery habitat and shelter for marine animals
Seagrass beds provide juvenile fish and invertebrates with shelter and food to grow. After maturation, these fishes move out from the safety of seagrass beds and populate coral reefs and open oceans. Some animals such as crabs, shrimps, and molluscs inhabit seagrass habitats their whole life.

Food for grazers
Some endangered animals such as green sea turtles and dugongs graze on seagrass leaves for food. Detritus from dead seagrass plants are food for worms, sea cucumbers and crabs.



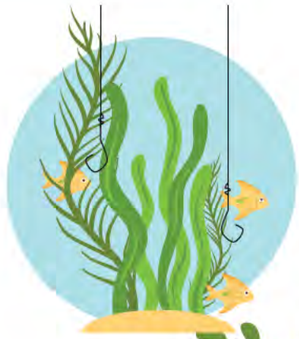
Increase water quality
Seagrasses help to trap fine sediments and particles that are suspended in the water column and increase the clarity of water. They also filter out nutrients from land based discharges such as sewage or storm-water runoff which helps to keep adjacent coral reefs healthy.



Primary productivity
Seagrasses take up carbon dioxide (CO_2) and convert it into food for the plant by the process of photosynthesis. They release oxygen (O_2) into the water which supports other marine life.

Coastal protection
The extensive root system of seagrasses help to stabilize and bind the sediment, reducing coastal erosion. This protects coastal communities from storms and floods.

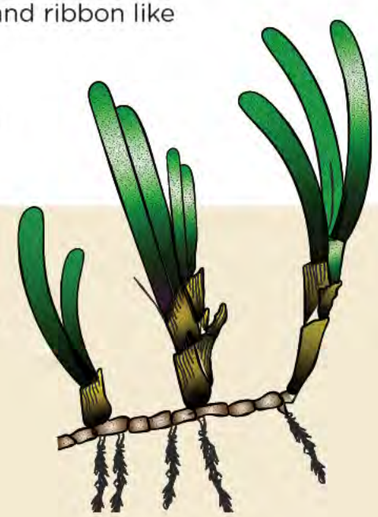
Fishing grounds for coastal communities
Fish that mature in seagrass beds help to provide food and income for coastal communities.



Activity

Identify the following seagrass species found in Maldives based on the features provided.

* Rounded leaf tips
* Leaves are 10-40 cm long in length, curved and ribbon like
*Slightly serrated leaf tips
*Thick rhizomes with scars between shoots
*Short black bars of tannin cells in leaf blades



Answer: _____

* 8 or more cross veins in the leaves
* Leaves are oval shaped
* Leaf margins are smooth
* 5-20mm long leaves
* No hairs on leaf surface

Answer: _____

* Serrated leaf tips
* Leaf blades are 5-9mm wide
* Leaves are 6-15cm long
* Rhizome is smooth and have fibrous roots on shoot
* 13-17 longitudinal leaf veins

Answer: _____

* Leaf tips are rounded
* One central vein
* Leaf blade is less than 20cm long and 0.02-0.1 cm wide
* Short erect stem with numerous leaf scars
* Very narrow leaf blade

Answer: _____

* Leaf blade 7-30cm long and 0.1-0.2 cm wide
* Leaf tips are tapers to a point
* Leaves blades are cylindrical
* Erect stem at each node bearing 2-3 leaves
* Smooth rhizome and has 1-3 small branded roots

Answer: _____

Threats to seagrass beds

Unfortunately, seagrass meadows are also lost at an alarming rate worldwide due to pollution, destruction of environment, dredging, modifications to water flow, climate change, and removal of seagrass beds for aesthetics.

Overfishing of seagrass associated fauna

Removal of seagrass related fish or fauna can cause disruption of the food web. When large predators are overfished, the balance of the food web is lost and causes decline of smaller organisms that helps to keep the blades of seagrass healthy.

Climate change

Seagrass is vulnerable to effects of climate change such as increase in ocean temperature, sea level rise and increase in frequency and intensity of storms. Severe storms can also uproot the seagrasses and kill them.

Coastal development, dredging and reclamation

These human activities can cause increase in water turbidity and direct removal of seagrass habitats. Being smothered by disposed debris and sediments also kill seagrass beds.

Lack of awareness on the importance of seagrass beds

Lack of awareness on the importance of seagrass beds by local communities and government officials can lead to approval of activities that cause destruction of these important ecosystems.

Land based pollution

Pollution from sewage and industrial waste can cause algal blooms due to excessive nutrient inputs. Overgrowth of algae consumes oxygen and blocks sunlight required for photosynthesis within seagrass beds. The increased amounts of pollution can also kill seagrass beds and hinders their growth.

Want to learn more about seagrass and help to conserve them?

Join **www.seagrasswatch.org,** which is a global seagrass observing network where scientists and local citizens can actively monitor the status and trends in seagrass conditions. You can sign up to be a seagrass spotter and help to contribute to the mapping of the vulnerable seagrass beds of Maldives.

Field Activity

Explore whether there is presence of seagrass in a particular area near you and identify the seagrass species present.

Items needed:
• Phone with GPS
• Waterproof camera
• Mobile application Seagrass Spotter installed / or go to the web portal https://seagrassspotter.org
• Use Pages 75 to 77 as a guide to identify the seagrasses

Instructions:
(1) Take a photograph of the seagrass you see.
(2) Note down the location by writing the GPS coordinates of the place where photograph was taken.
(3) Open the Seagrass Spotter app and select "Take a sighting" and follow the guidelines in the app or web portal.
(4) If you do not have access to the internet, refer to page 75 to 77 in the book to find out the different species of seagrass you have found in this area.

POP UP FACT

Maldives Underwater Initiative and Bluemarine Foundation have initiated a campaign to protect 80% of the seagrasses in the Maldives.

Follow the movement, #protectmaldivesseagrass / **www.maldivesresilientreefs.com**

Activity

Answer True or False for the following questions about seagrasses.

1. Seagrasses can help play an important role in fighting climate change
☐ True ☐ False

2. Maldives is home to 7 out of 13 species of seagrass found in the West Indian Ocean.
☐ True ☐ False

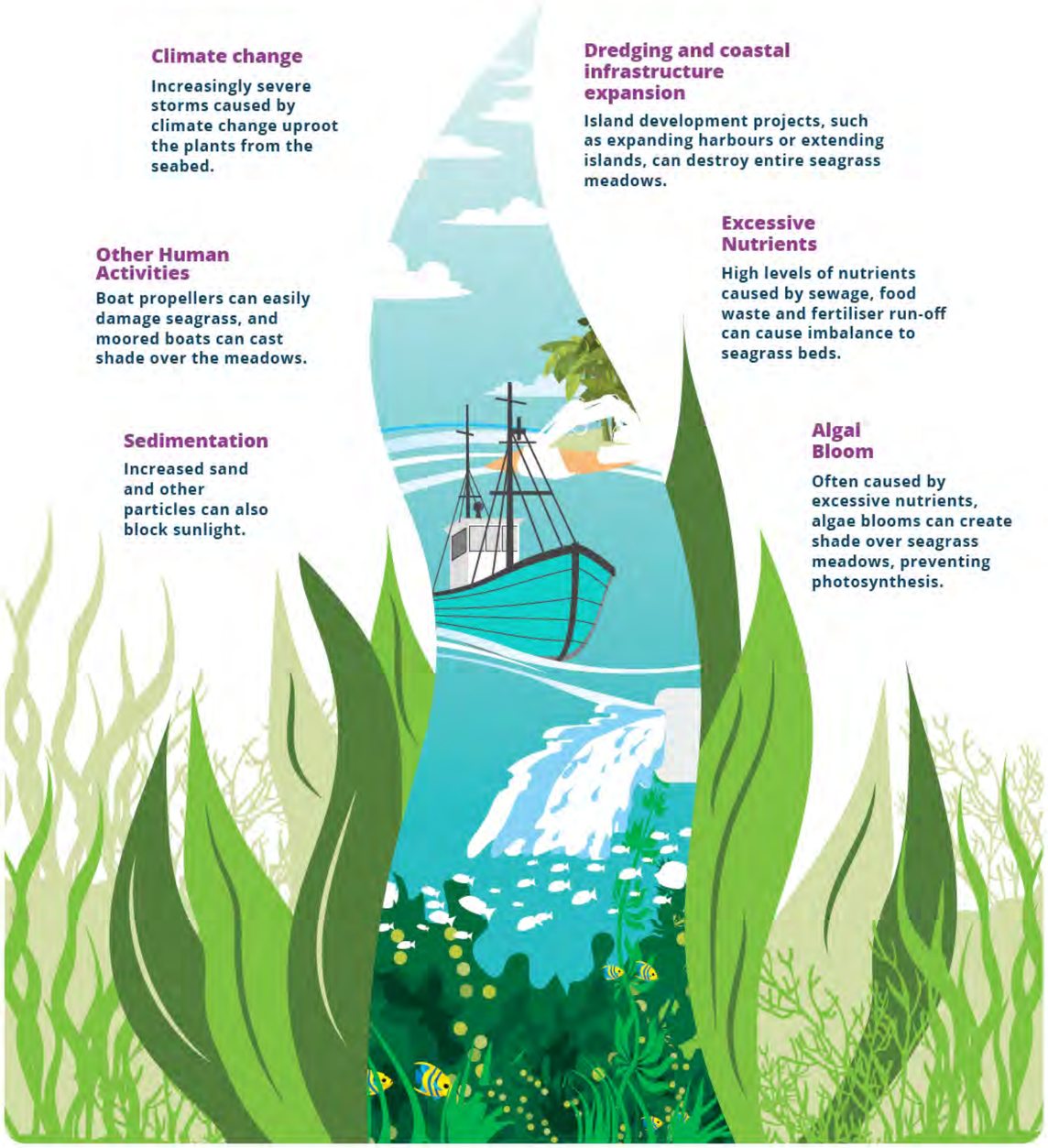
3. Seagrass provides food for keystone organisms such as green turtles.
☐ True ☐ False

4. Awareness of the importance of seagrass beds can help protect seagrass meadows
☐ True ☐ False

5. Seagrass can provide some coastal protection due to their extensive root systems
☐ True ☐ False

GLOBAL THREATS TO SEAGRASS

Seagrass meadows play an important role in the fight against climate change, and provide nutrients and shelter to many marine animals. Yet several factors threaten their survival, and we are losing global seagrass meadows at a rate of up to 7% per year.



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Mangroves

A field guide to mangroves in Maldives

Questions

1. Do you know any historical uses of mangroves in Maldives?

- ☐ Boat building
- ☐ Tourism
- ☐ Medicinal purposes

2. What kind of invertebrates would you expect to find in mangroves?

- ☐ Spiders
- ☐ Fiddler crab
- ☐ Mud creeper snail
- ☐ All of the above

What are mangroves?

The term mangrove may be used to refer to both an individual mangrove plant and to the habitat or ecosystem in which it lives. Mangrove forests are diverse communities growing in the chiefly tropical, intertidal coastal swamps. They have numerous tangled roots that grow above ground and form dense thickets.

Plants growing in the intertidal zone are subjected to a variety of challenges, such as changes in salinity, water temperature and supply of nutrients based on the tidal flow. Soils of the intertidal zone are usually soft and muddy and are often anaerobic (low in oxygen). Mangrove plants are unique in their ability to grow in such a dynamic environment.

How mangroves tolerate their environment (adaptations)

1. Waterlogged soils with low oxygen

The mangrove plants have adapted to these anaerobic conditions by developing special above-ground roots called pneumatophores, which stick out into the air even during high tide. These roots are covered in tiny pores called lenticels to allow the plants to breathe more effectively. Pneumatophores allow gaseous exchange and they also provide support to the plant.

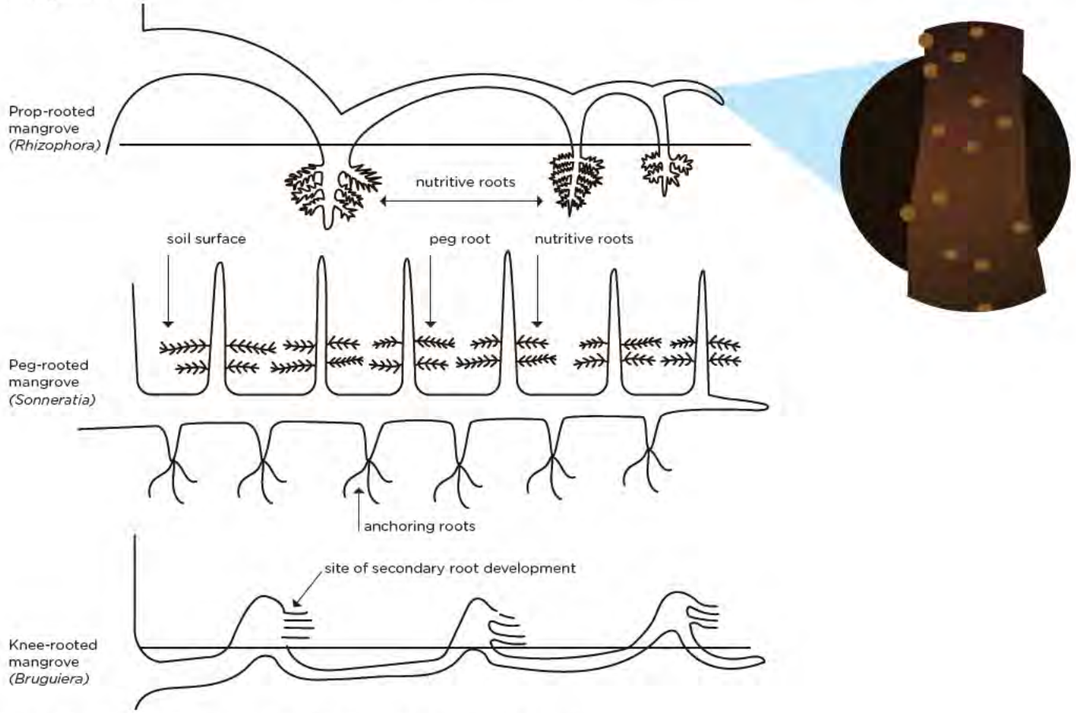


Figure:08 - Types of specialized roots found in mangrove trees.

2. Changes in salinity

Mangrove lakes and ponds are often saline due to the proximity to the sea. Most of the water is filtered by the roots before uptake, though some of the salt is still taken up. This salt is then stored within leaves, stems and roots.

In some species, salt is secreted from special leaf glands (e.g. grey mangrove), while others just store the salt until the leaves shed. Mangrove leaves can also orient themselves to avoid the midday sun and prevent water loss.

3. Seed dispersal and propagation

Unlike most seeds that germinate after parting with the parent plant, many mangrove plants are viviparous, which means that the seeds start growing while still attached to the tree. When the seedling is big enough to survive, it falls into the water or mud. The thin, pointy seedlings easily stick to the mud, or get carried by water to be planted elsewhere. The little plants growing in mangrove soil can withstand wave action and strong winds.

The propagule remains dormant until it finds good enough soil to grow in. Other species within the same group of plants, called the Rhizophoraceae family (including kandoo and randoo) reproduce in a similar way. However, there are mangrove plants that reproduce the conventional way such as Lumnitzera and Xylocarpus species.

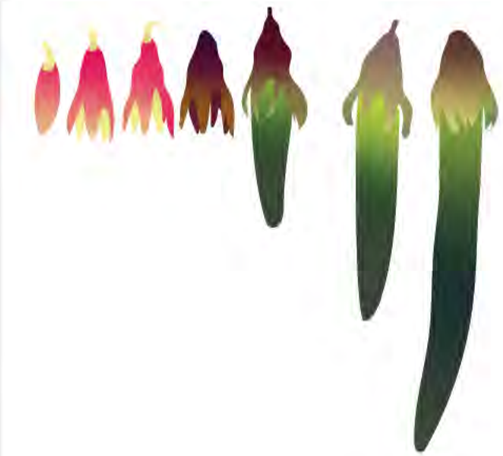


Figure:09 - Propagule formation process observed in some mangrove species.

Fill in the blanks

NAME OF THE MANGROVE STRUCTURE	FUNCTION
	To maximize breathing and provide physical support
Specialized leaves	
Buoyant seedling	
	To easily stick into the mud and grow

Mangrove species of Maldives

Mangroves in our islands are often found in enclosed or semi-enclosed brackish water bodies locally known as "kulhi" or in muddy areas without standing water known as "chasbin".

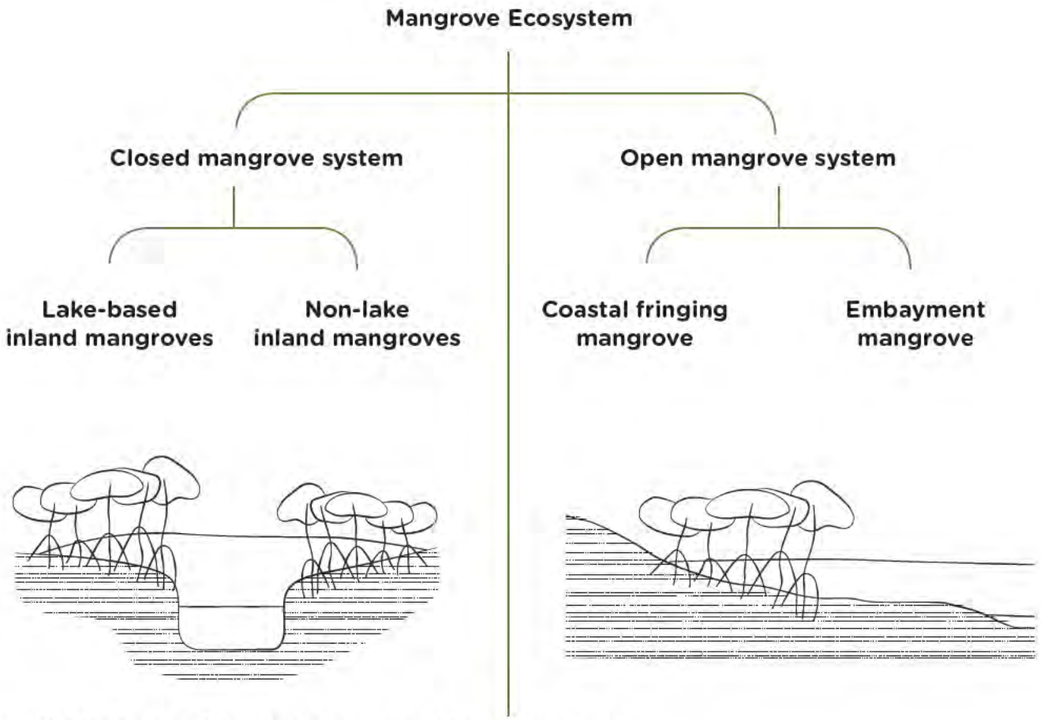


Figure:10 & 11 - Outline of the physical process within mangrove system

The mangrove habitats in Maldives are relatively small in size but show diversity in the species found in different islands. The composition, diversity and abundance of mangrove fauna vary from island to island, with most islands consisting about 4 to 5 true species of mangroves.

However, these trees are often found together with 'mangrove associate species' forming thick and healthy vegetation. Mangrove associate species such as **Hirundhu** (*Thespesia populnea*), **Kashikeyo** (*Pandanus sp.*) and **Kuredhi** (*Pemphis acidula*) are seen distributed in terrestrial habitats but they also occur in the mangrove ecosystem.

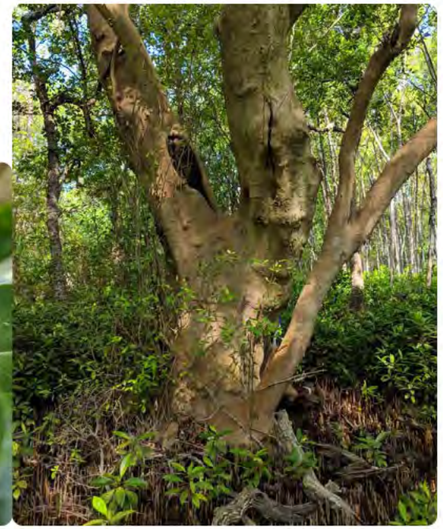
Do you know other species of trees often found near beaches and mangroves?

Mangrove species found in Maldives

	Common Name	Dhivehi Name	Scientific Name
01	Gray mangrove	ދަރު	Avicennia marina
02	Red mangrove	ތަނޑ	Rhizophora mucronata
03	Mangrove apple	ކުއްލަވަށް	Sonneratia caseolaris
04	Oriental mangrove	ދެއްވަސް	Bruguiera gymnorrhiza
05	Small leaved orange mangrove	ކަނޑ	Bruguiera cylindrica
06	Tall stilt mangrove	ތަކަވަހި	Rhizophora apiculata
07	Yellow mangrove	ކަނަދަސް	Ceriops tagal
08	Cedar mangrove	ދަރު	Xylocarpus moluccensis
09	Black mangrove	ހުއްޓި	Lumnitzera racemosa
10	Looking glass mangrove	ކަނަތުވަށް	Heritiera littoralis
11	Milky mangrove	ހުވަ	Excoecaria agallocha
12	Mangrove fern	ފަނާ	Acrostichum aureum
13	Mangrove vine	ހުވަފެން	Derris heterophylla
14	White burma mangrove	- - -	Bruguiera sp.
15	Haines's orange mangrove	ކުވަވަ	Bruguiera hainesii
16	Up river orange mangrove	ފަވަނު	Bruguiera sexangula

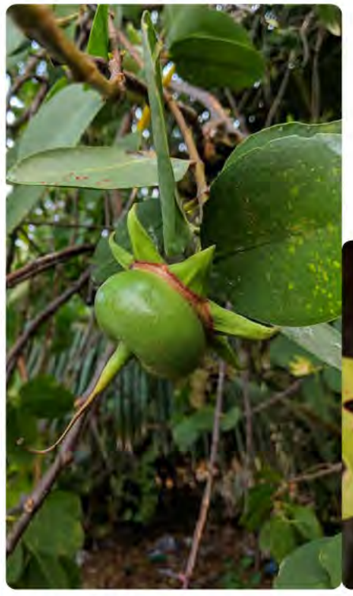
POP UP FACT

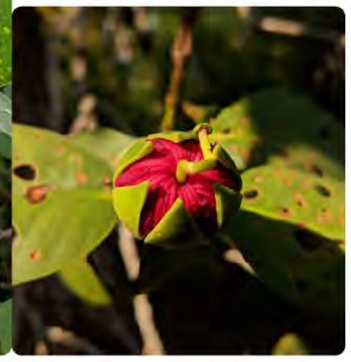
The first recorded observation of Haines's Orange Mangrove (ކުވަވަ) in the Maldives was in HA. Kelaa's protected area. Classified as Critically Endangered on IUCN Red List of Threatened Species, fewer than 300 trees have been recorded worldwide so far, and 4 of them are in Kelaa's mangrove ecosystem.



1. Gray mangrove

2. Red mangrove





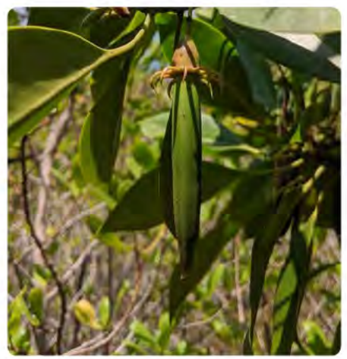
3. Mangrove apple

4. Oriental mangrove

5. Small leaved orange mangrove

8. Cedar mangrove

10. Looking glass mangrove



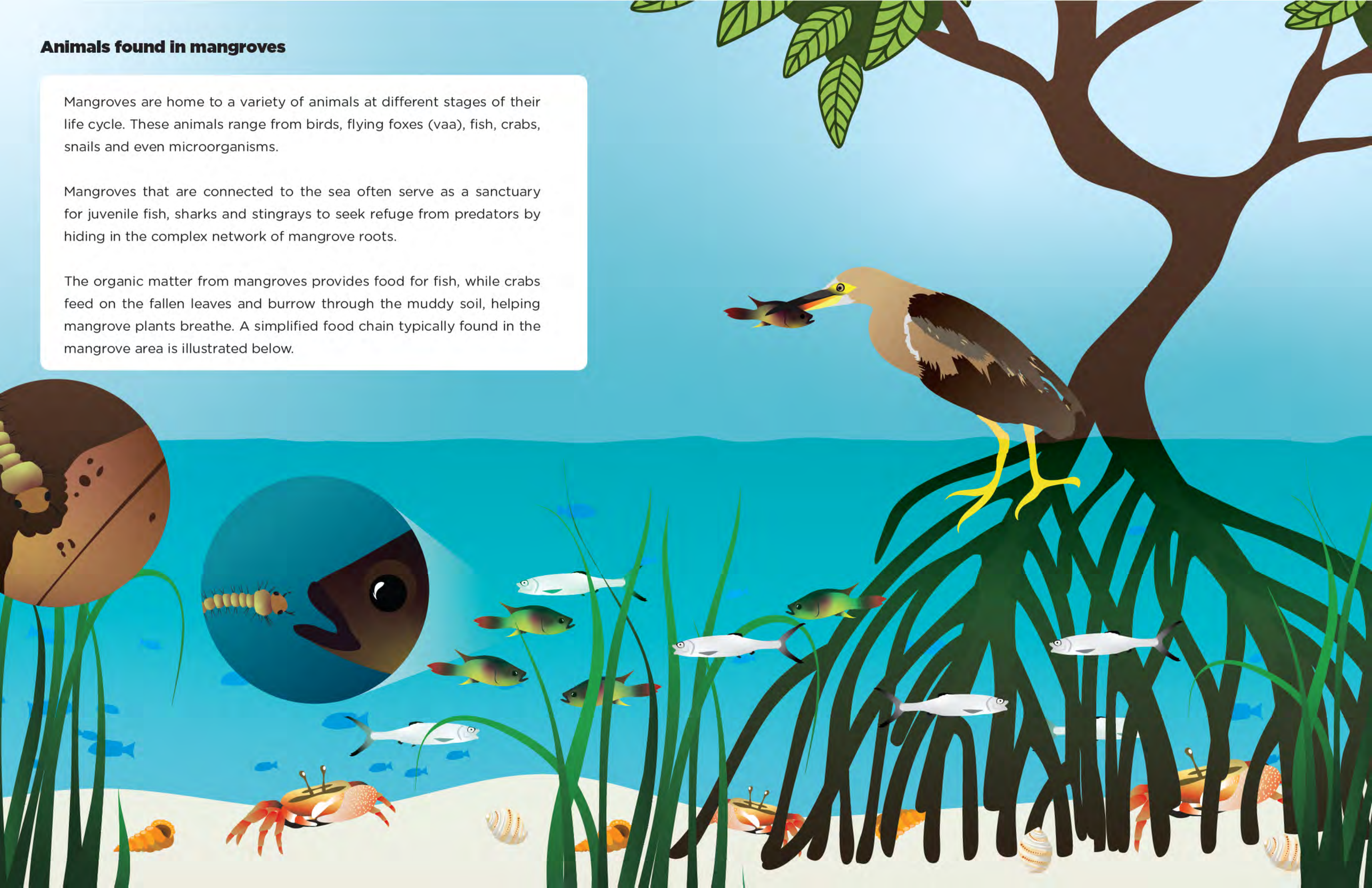
15. Haines's orange mangrove

Animals found in mangroves

Mangroves are home to a variety of animals at different stages of their life cycle. These animals range from birds, flying foxes (vaa), fish, crabs, snails and even microorganisms.

Mangroves that are connected to the sea often serve as a sanctuary for juvenile fish, sharks and stingrays to seek refuge from predators by hiding in the complex network of mangrove roots.

The organic matter from mangroves provides food for fish, while crabs feed on the fallen leaves and burrow through the muddy soil, helping mangrove plants breathe. A simplified food chain typically found in the mangrove area is illustrated below.



Can you name common species of animals found in mangroves?

01

_____

02

_____

POP UP FACT

*Mangroves are found to be the most important breeding and feeding grounds for the endemic **Huvadhoo raabondhi** (Ardeola grayii phillipsi). Seabirds such as the pond heron bring important marine nutrients to islands, connecting the marine and terrestrial habitats.*

Field Activity

Take a walk through a mangrove system.

Applying what you learned about food chains, complete the following activity.

(1) A producer (anything that can photosynthesize)
(2) Primary consumer (herbivore that feeds on the producer)
(3) Secondary consumer (a carnivore or an omnivore that feeds on the primary consumer)
(4) Decomposer (organisms feeding on decaying organic matter such as dead plants and animals)

Draw a food chain based on your observations

Why are mangroves important?

Until recently, a lot of the mangroves in islands have been viewed as wastelands to dirty 'mosquito ridden' places with little or no value. However, historically, mangroves have been used as an important source of timber and food, as well as integrated in traditional coir rope making.

Mangroves are slowly becoming popular as recreational sites celebrated for its natural beauty and potential for ecotourism. But perhaps the most important ecosystem service provided by mangroves lay in its ability to provide coastal protection and mitigate the effects of climate change.

POP UP FACT

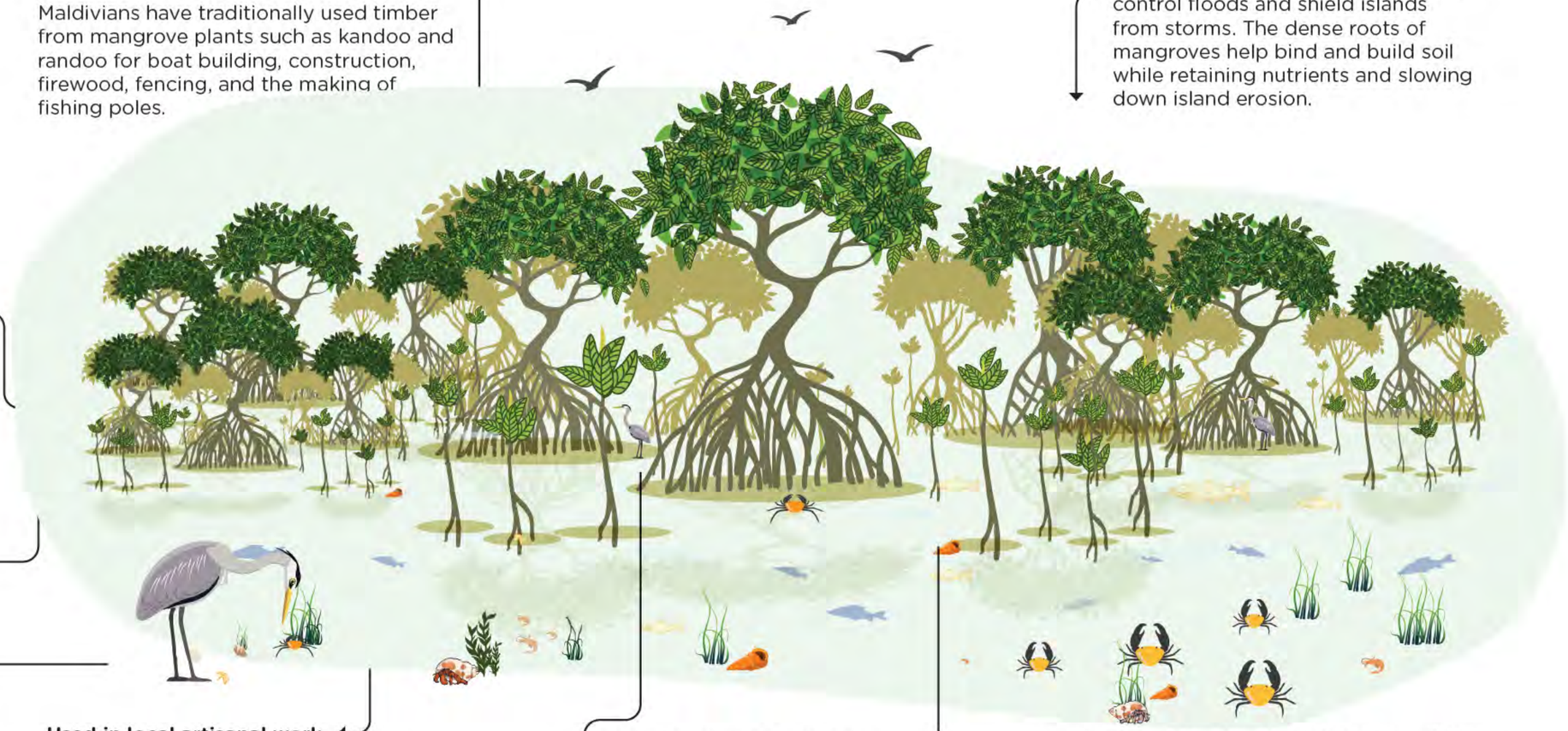
The mangrove pond located in Laamu Gan is often dubbed the 'Paree fengandu' or 'Naraka fengandu', with tales of local folklore on fairies that spend the night in the pond bathing, or things mysteriously disappearing into the pond only to emerge from the "Haddhoo Kandu" situated between Laamu and Thaa Atoll.

Timber harvesting

Maldivians have traditionally used timber from mangrove plants such as kandoo and randoo for boat building, construction, firewood, fencing, and the making of fishing poles.

Coastal defense by mangrove trees

The network of mangrove trees help control floods and shield islands from storms. The dense roots of mangroves help bind and build soil while retaining nutrients and slowing down island erosion.



Recreational use

Kids like to visit mangroves for picnics and to catch tilapia or play. More and more, mangroves are currently being managed as eco-parks for local tourism and for recreational purposes, providing important economic benefits.

Prevents sedimentation in coral reefs

Mangroves also have a special relationship with coral reefs, where mangroves benefit from the calmer water provided by the reefs while the filtered water from mangroves help coral stay healthy.

Important habitat supporting biodiversity

Mangroves contain many unique species of plants and animals, which help to sustain biodiversity. These habitats also connect the sea and the marine environment, and provide energy flow.

Used in local artisanal work

It is also a common practice to have coconut husks used for coir rope making to be soaked in mangrove ponds. The clay from mangrove ponds were also used for making pots in islands such as HDh. Kulhudhuffushi.

Climate change mitigation

The high rates of plant growth, coupled with anaerobic water-logged soils which slow decomposition result in more carbon dioxide being stored by mangroves than released into the atmosphere via respiration.

Source of food and traditional medicine

Kandoo, ku'lhavah and beyngu (milk fish) are still consumed to this day, while the bark of mangroves are used in local medicine. During the Second World War, the mangroves served as important food sources in islands such as HA.Kelaa

Threats to our Mangroves

Mangroves across the world are in danger of destruction, and there are a number of reasons their futures are at risk.

Lack of Awareness

Many people view mangroves with contempt; they're seen as smelly, useless and a breeding ground for mosquitos. This lack of understanding of the benefits that mangroves bring means that communities do not seek to protect them, and are quick to accept their destruction.

Pollution and Trash

Fertilizers and pesticides that drain into the mangroves from nearby fields can kill the creatures that inhabit them. Likewise, when oil leaks from boats it covers the mangrove roots in a thin film and suffocates the trees. Discarded household waste endangers the wildlife whilst sewage causes algal growth that in turn kills the marine life.

Rising Sea Levels

In order to survive long-term, mangroves rely on stable sea levels. The current rise in sea levels caused by global warming and climate change threatens the future of Maldivian mangroves.

Felling of Mangrove Trees

Felling of mangrove trees and habitat destruction, including the reclamation of land for human settlements, harbours, tourism developments and industrial areas has become a bigger threat than others.

Destruction of Coral Reefs

As well as protecting our islands, coral reefs also protect our mangroves by acting as a barrier against currents and strong waves. When they are destroyed, this can undermine the fine sediment in which the mangroves grow, which results in essential nutrients being washed away and seedlings failing to take root.

How are mangroves beneficial to islands?

Although mangroves might appear lifeless in comparison to the frenetic activity you can find along coral reefs, dismissing them as useless is a grave mistake.

Mangroves are actually complex ecosystems and are comparatively more productive than any other type of forest. Just like any other ecosystem, they provide a whole range of services and goods to their environments and to the people who live nearby.

These services are classified into four categories: provisioning, regulating, habitat and cultural.

Field Activity

Fiddler crab as a bioindicator for mangrove health survey

Materials needed:

2 measuring tapes
2 quadrats (1m x 1m)
2 clipboards with paper and pencils

For this activity, choose a part of the mangrove that seems to be left alone undisturbed (Site A), and compare it with a site that is obviously disturbed (Site B), with signs of trash, road making, development and such.

Methodology

Use a measuring tape to mark a 5m x 5m survey plot, and place a 1m x 1m quadrat in any 3 random points within the plot. Write down the number of crab burrows counted within each quadrat. Repeat the procedure for 2 more plots within the same site. The survey must be conducted in both Site A and Site B. Use the following table to write down your findings.

Site A (Undisturbed mangrove area)			Site B (Disturbed mangrove area)		
Plot 1	Plot 2	Plot 3	Plot 1	Plot 2	Plot 3
Total no. of crab burrows:			Total no. of crab burrows:		

The number of crab burrows observed indicate the number of crabs present in each site. Compare your observations to see which site had the higher number of crabs, and discuss among your peers why that might be.

1. What kind of stresses are visible from the sites?

- ☐ Agricultural development with potential use of pesticides
- ☐ Oil spills and garbage disposal
- ☐ Signs of deforestation
- ☐ Poor water quality (water covered in algae, or lack of fish)

2. How is the general health of the plants found in both sites?

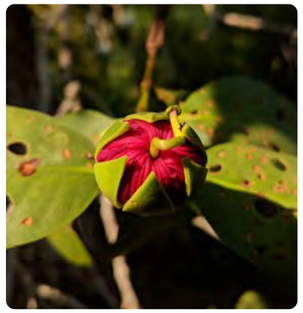
- ☐ Are there more big trees or saplings
- ☐ Signs of herbivory on leaves
- ☐ Weak or dying trees

Do you think the fewer number of crabs might have something to do with the stresses experienced by the mangrove system?

Post Assessment

1. Can you ID these mangrove species?

(a)



(b)

(c)

(a) _____

(b) _____

(c) _____

2. Write 3 adaptations of the mangrove root systems to its environment.

_____

3. Name 3 mangrove species that have tube like seedlings

_____

5. Describe some of the ecosystem functions provided by mangroves.

_____

_____

_____

_____

6. Identify threats to mangroves from the following list:

(a) Noise and light pollution

(b) Flooding and temperature changes due to climate change

(c) Land reclamation

(d) Garbage dumping

(e) Mosquitoes

(f) Pathogens

_____

_____

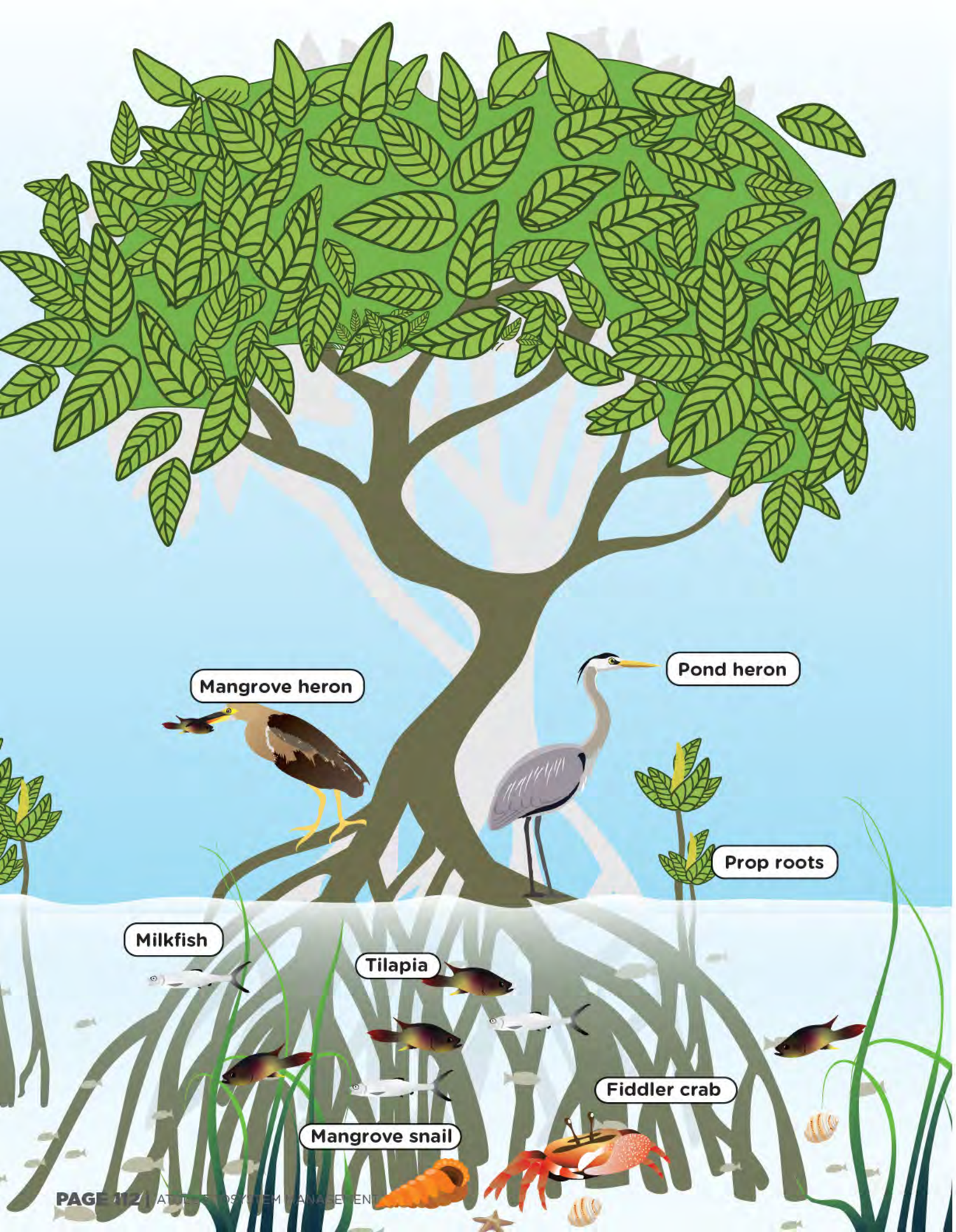
_____

_____

_____

_____

_____



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Effects of Climate Change

Questions

1. What do you think is the difference between climate and weather?

- ☐ The weather conditions describe the climate conditions that have been observed over time.
- ☐ Weather refers to short term changes in the atmosphere while climate describes the weather conditions that have been observed over an extended period of time

2. How do scientists learn about past climates?

- ☐ Ice cores
- ☐ Biological materials preserved in geological record
- ☐ Through diatoms

3. Name 3 factors that contributes to sea level change

(a) _____

(b) _____

(c) _____

Understanding Climate Change

Climate change may be the biggest challenge humanity has had to face since the Industrial Revolution. In this chapter, we will look into what climate change is, what is causing it, and its effects on the environment, as well as what could be done moving foward.

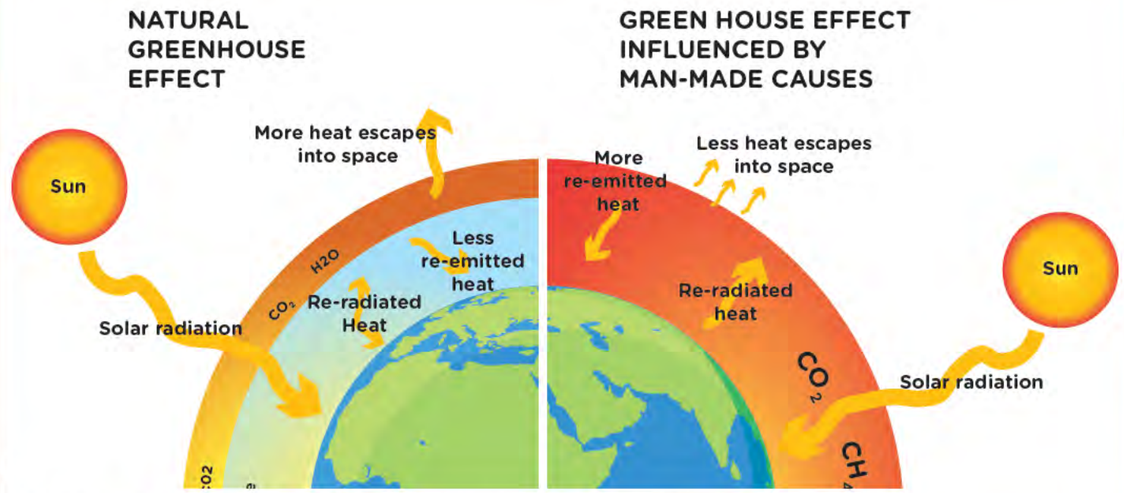


Figure:12 - Greenhouse effect: natural causes compared with human influence.

What is climate change?

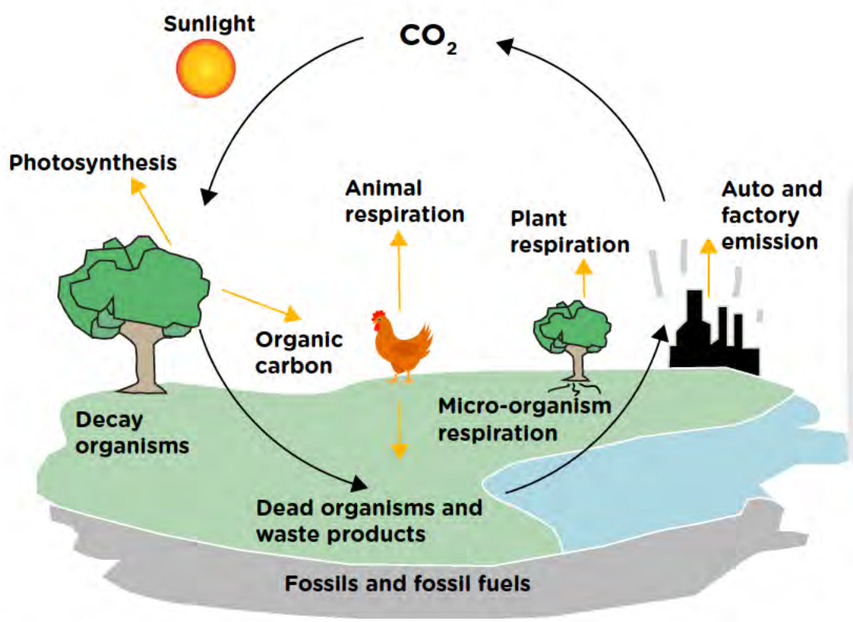
Climate describes the weather conditions that have been observed for many years and can be predicted for a particular region based on the time of the year. Weather is a temporary status of the atmosphere —its temperature, humidity, wind, rainfall and so on over the course of days.

Earth's climate depends on the delicate balance between how much heat energy is gained by Earth (incoming solar radiation), how much is given off (outgoing thermal radiation) and the composition of Earth's atmosphere which determines how much heat is trapped. The influence it has on the oceans, land surfaces and ice sheets, which together with the atmosphere form what is called the 'climate system'.

Climate change refers to the unnatural variations in Earth's average climate. These variations have been increasing at an alarming rate over the last century. This means that while some places are getting uncharacteristically warmer and drier, other places are experiencing heavier rain, or more intense storms. In general, weather patterns are becoming less predictable compared to before.

Drivers of global climate change

Before the Industrial era (pre-1780), human activities were not responsible for the release of large amounts of greenhouse gases into the atmosphere. There were only natural drivers that change Earth's climate then.



The carbon cycle maintains a balanced system that keeps Earth's temperature relatively stable.

Figure:13 - The Carbon Cycle

1. The Milankovitch cycles

Slight changes in Earth's orbit affects how much solar radiation is received by the planet, as well as where it reaches. The length of the Milankovitch cycles ranges between 19,000 and 100,000 years causing variations of up to 25% in the amount of sunlight is received, which in turn affects the climate.

2. Solar Intensity

Solar intensity is the amount of solar power or energy emitted by the sun. The sun goes through an average of 11 years of activity, changing between solar minimum and solar maximum which affects Earth's temperature by about 0.1 degree Celsius. In 2021, we are currently in a solar maximum period.

3. Volcanic eruptions

The dust particles and gases released by volcanic eruptions also influence the climate on Earth. While the dust particles and sulfur dioxide mostly have a cooling effect by blocking sunlight, large amounts of greenhouses gases such as carbon dioxide and water vapour have the opposite effect.

Greenhouse gases and global warming

Greenhouse gases such as carbon dioxide, methane and nitrous oxide in Earth's atmosphere absorb the sun's thermal energy and prevent the heat from escaping. Without this, Earth would be frozen and unable to sustain life.

However, with the advent of the Industrial Revolution, humans started burning so much coal and oil that Earth's atmosphere was suddenly bombarded with carbondioxide in huge amounts.

Clearing of forests, mangroves and peat bogs for developmental needs, and the large-scale farming of livestock have further contributed to an increase in greenhouse gases in the Earth's atmosphere.

As trees are natural carbon sinks, deforestation allowed for more carbon to stay in the atmosphere, rather than being locked away. Livestock farming also releases a large amount of methane and nitrous oxide, which add to the heating of the planet. Another source of methane is the melting of clathrates, which are frozen chunks of ice and methane found at the bottom of the ocean.

Global Carbon Dioxide Emissions, 1850–2040

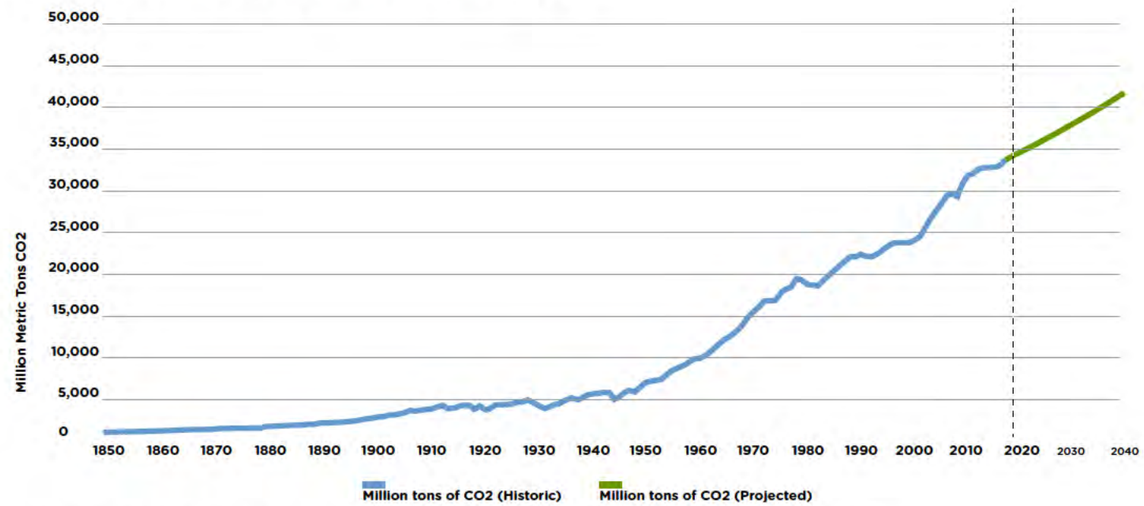


Figure:14 - Carbon Dioxide Information Analysis Center (Oak Ridge National Laboratory, 2017).

Activity

1. List out some of the activities that are responsible for global warming. You may look it up online.

1. _____

2. _____

3. _____

4. _____

2. Draw 2 pie charts using the information below and visualise the findings to understand the Global Man Made Greenhouse Gas Emissions by type of industry.

Greenhouse Gas Emission by Sector	**Emissions %**	**Greenhouse Gas Emission by Composition (2015)**
Energy (Electricity, heat & transport) Direct Industrial Processes Waste Agriculture, Forestry and Land Use	73.2 5.2 3.2 18.4	CO_2 accounts for about 76 percent of total greenhouse gas emissions. Methane, primarily from agriculture, contributes 16 percent of greenhouse gas emissions and nitrous oxide, mostly from industry and agriculture, contributes 6 percent to global emissions. The remaining 2 percent are mostly composed of hydrofluorocarbons which are primarily used in refrigeration, air conditioning, insulating foams and aerosol propellants.

Greenhouse Gas Emission by Sector

Greenhouse Gas Emission by Composition (2015)

Ways climate change is affecting the Maldives (and the world!)

Hotter days

The scientific community is in agreement that the world is getting warmer, and that this global warming is mainly due to human activities that emit greenhouse gases.

However, the world is not warming uniformly – not all places are getting warmer at the same rate. Some places, such as the Artic, are warming faster than others.

The Maldives Meteorological Service publishes a monthly Climate Report on their website in which they compare monthly maximum temperatures with long-term averages, and this is a great starting point for anyone looking to understand the changes in our temperatures.

Hotter temperatures can lead to species extinction, species migration such as fish stock and even force humans to migrate due to loss of vegetation and reduced availability of food and safe drinking water.

Threat to island biodiversity and water resources

Changes in climate makes the conditions of ecosystems less habitable for local species and more attractive to species and pests that may not be commonly found otherwise. Foreign species may find the changed conditions so favorable that they increase and multiply rapidly making driving out local habitants. Such species that have increased their range and proliferate rapidly are termed invasive species. Climate change therefore threatens the ability of local species to thrive and compete with foreign species, leading to loss of biodiversity.

In Maldives, the Nakaiy calender that has traditionally been observed to predict weather has become noticeably unpredictable in recent years. According to the National Meteorological Services, there is an overall decreasing trend in annual rainfall observed over the 3 regions of Hanimaadhoo, Malé and Gan.

Damage to coral reefs and coastal wetlands

The coral reefs in the Maldives were among the most affected in the 1998 El Nino bleaching event in the tropical Indian Ocean. The good news is that there is some evidence suggesting that coral reefs have a fighting chance to recover in the absence of other environmental stresses such as pollution of the habitat.

High temperatures, sea level rise and increased salinity of the ocean also threatens the survival of mangroves, making them more vulnerable to diseases and unable to tolerate the changing conditions. This can result in die back of mangrove forests.

Sea level rise, inundation, and shoreline change

Since the last century, the global mean sea level has been recorded to rise, with rates between 2.8 and 3.6 mm per year since 1993. While sea level rise poses the most widely recognized threat to small, low lying countries such as Maldives, extreme weather events such as storm surges, high tides, and heavy rain, together with rising sea surface temperatures have led to coastal inundation, beach erosion and the destruction of property in many areas.

In countries such as Maldives where much of the infrastructure is located in coastal zones with limited opportunities for relocation, it makes communities particularly vulnerable.

POP UP FACT

A large amount of CO_2 in air gets dissolved in the ocean, forming carbonic acid. This is called ocean acidification, which poses a risk to shelled organisms, as carbonic acid can cut through the material their shells are made of.

How does climate change affect people?

The issue of "coastal squeeze" is a concern for many small islands constantly struggling to manage the requirements for physical development against the need to maintain ecological balance. The degradation of beaches and coral reefs negatively impact important economic sectors such as fisheries and tourism, further risking the livelihoods of islanders.

With added stresses such as contaminated water lens, loss of crops, and the constant risk of households being flooded by stormwater, the people of small island nations are disproportionately more affected by the global changing climate. Most small island nations are also in tropical areas with weather conducive to the transmission of diseases such as malaria, dengue and such.

What can the government do?

1. Developing the skills of locals with traditional knowledge and technology

2. Adopting community-based climate adaptation strategies where island communities find solutions to manage water, food and other natural resources sustainably

3. Addressing long term climate impacts by integrating climate change adaptation, mitigation, and disaster management into national development policies

4. With support from the international community, Maldives has pledged to achieve an ambitious net-zero target on carbon emissions by 2030. This emissions reduction is set to come mainly from the energy and waste sector. Net zero means that the amount of emissions released is offset by an equivalent amount of removal

Exploring possible energy solutions

Much of the greenhouse gases emitted into the atmosphere is a direct result of burning fuel for energy which humans need for essential needs such as electricity and transportation.

However, this does not mean that people cannot opt for greener ways of living, such as using more energy efficient appliances at home and adopting renewable energy technologies.

What can we do?

Buy food grown in your home country, and opt for food with less packaging. This reduces emissions that come from transporting food from long distances, and minimizes waste related to food (waste incineration is powered by fossil fuel as well).

Walk or bicycle as much as possible, and avoid using motorbikes/cars that release greenhouse gases into the air.

Buy secondhand clothes, or clothes that last longer. The fashion industry releases a large amount of greenhouse gases and other toxins into the environment.

Eat less meat, as the livestock farming industry releases large amounts of methane into the atmosphere while keeping up with the demand for meat.

For electrical appliances, get more energy efficient products that don't use up as much energy. This lowers the household electricity bill and the amount of emissions released into the atmosphere.

Use less electricity at home, school or at work.

Create as little waste as possible in every aspect of life. This ensures that less energy is required to manage the waste, and therefore less emissions are released because of it.

Finally, learn about the different ways in which you can lower your carbon footprint and try to make these lifestyle changes.

POP UP FACT

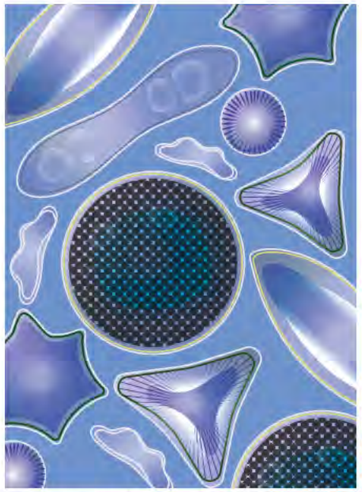


Illustration of diatoms

When studying past climates, scientists use records from physical, chemical and biological materials preserved within the geologic record.

The characteristics of preserved diatoms, foraminifera or corals can tell scientists what the weather conditions were like millions of years ago. Evidence can be found in other climate proxies such as ice cores, tree rings, and sediment cores.

Questions

1. Which of these statements best describe the greenhouse effect on Earth?

- ☐ The entrapment of heat energy in Earth's lower atmosphere by gases such as carbon dioxide, methane and water vapour
- ☐ The absorption of sun's radiation by the surface of the Earth, trapping heat in the land
- ☐ The reflection of sun's radiation back into the space using glaciers

3. List 3 impacts of climate change on low lying islands such as Maldives

Activity

Comparing the extent of coastal changes in a Maldivian island in the last 20 years.

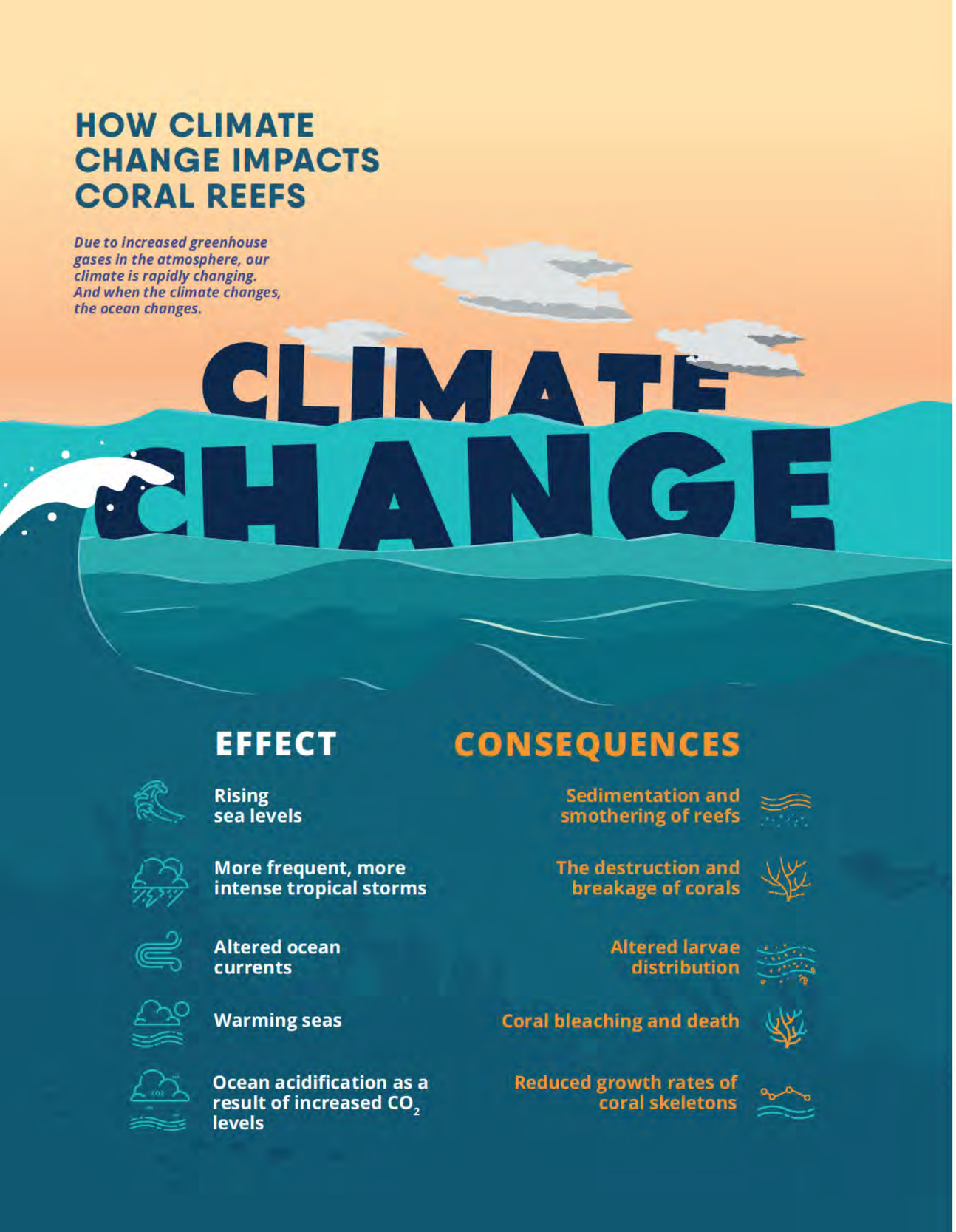
Materials needed:
Computer, paper and 2 pencils (optional), Google Earth Pro

Methodology:
1. Install Google Earth Pro on your computer (search and download from the Google Earth website)
2. Open Google Earth on your computer
3. Enter the name of the island you want to look at in the search bar. The island will appear on your screen
4. Go to View, and then select Historical Imagery
5. Observe the coastline of the chosen island, especially the beaches
6. Use the time slider to move between years (every 5 years or so for 20 years) and observe the changes in the beach and coastline.
7. Trace the outline of the island on a piece of paper at the present year, and again at 15 years ago on the same paper using a different color.

Discussion:
1. What did you observe, especially around the coastal line?

2. Do you see any signs of the above mentioned impacts of climate change, such as erosion and changes in the coastal area of islands?

3. Are there any visible coastal modifications made (harbor/breakwaters) within the time frame observed? If yes, why do you think it was built?



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Marine & Chemical pollution

Questions

1. What are some of the most common marine pollutants in Maldives ?

- ☐ Plastics, sewage water, food waste
- ☐ Oil, coconuts, industrial sludge
- ☐ Leaves, tar, metals

2. A major industry responsible for the release of chemical pollution in Maldives is

- ☐ Vehicle manufacturing industry
- ☐ Agriculture industry
- ☐ Film industry

3. What is responsible for eutrophication and algal bloom in Maldives?

- ☐ Plastic pollution from fishing nets
- ☐ Oil spills
- ☐ Food waste, sewage and runoff from fertilizers

The contamination of the marine environment results from a combination of harmful chemicals and trash that find their way into the ocean.

Until somewhat recently, it was widely assumed that the vastness of the ocean would prevent any real damage to the marine environment regardless of what had been dumped into the sea.

In this chapter, we will look into the different types of trash and hazardous chemicals that are damaging the marine environment in Maldives, and the effect it has on marine life as well as humans.

Sources of marine pollution in Maldives

1. Household waste
2. Industrial waste (tourism, agriculture, boat building, energy)
3. Untreated sewage
4. Burning of waste

Due to the short distance from land to sea in Maldives, pollutants from both land-based sources such as solid waste and untreated sewage disposal and sea-based sources such as oil pollution and ballast water can lead to pollution of the coastal zone and the sea. Waste management is among the most challenging environmental problems in Maldives, with more and more waste being generated in islands as a result of population growth and the expansion of guest house tourism.

POP UP FACT

During a study conducted in 2019 by Maldives Whale Shark Research Programme, whale shark poop was found to have microplastics which were likely ingested while feeding on plankton. About 90% of the microplastics extracted were comprised of fibrous materials, likely from clothing during washing and broken down fishing gear.

Majority of the islands lack basic waste management facilities, and routinely burn landfills in open air and dump food waste into the sea.

Trash from landfills, beaches, or discarded from liveaboards and boats also add to marine litter. Additionally, the untreated sewage discharged into the sea also contains a concoction of polluting agents including pathogens, organic substances, heavy metals, trace elements, and waste water.

Figure:15 - Waste disposed on the coastal area of an island, open burning of landfill. Photo: EPA

Chemical pollution

As there is no industrial production of chemicals in Maldives, most of the hazardous chemicals released into the environment are due to the mishandling of imported substances. A majority of these chemicals are used in the form of petroleum products for energy and transport, agriculture, construction, boat building, in the health sector and for domestic uses.

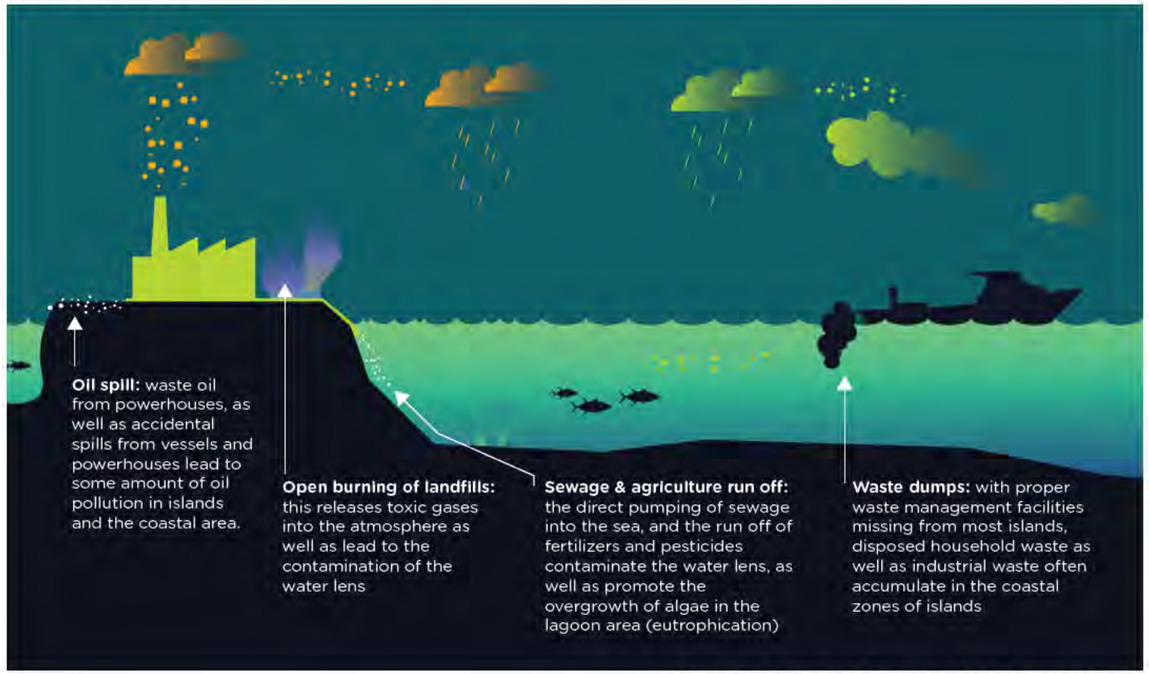


Figure:16 - sources of chemical pollution in islands

Chemical Pollutants: The Worst Offenders

Which chemicals cause the most damage to our oceans?

Insecticides

Used to kill insects, eggs and larvae, insecticides are a commonplace feature of modern life. They are not only used in agriculture either; some medicines are also classified as insecticides. And if we look under the kitchen sink, most of us will find a bottle of bug spray in our homes too.

Oil products and PAHs

It comes as no surprise that oil products such as diesel, crude oil and gasoline are damaging to the ocean. Polycyclic aromatic hydrocarbons (PAHs), on the other hand, are less well known. PAHs are found in oil products and are produced when substances such as wood and garbage are burnt.

Herbicides

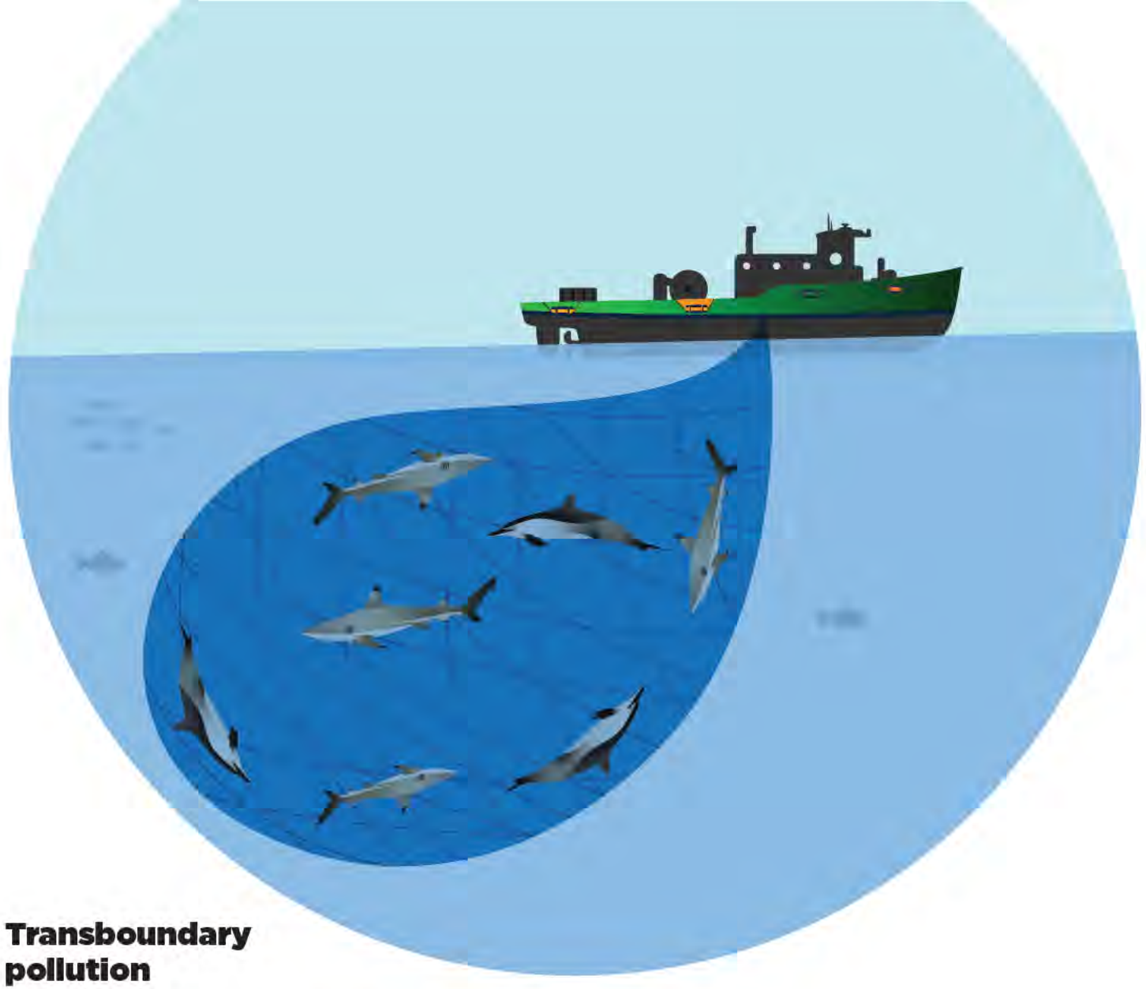
More commonly known as weed killers, herbicides are used to kill specific, unwanted species of plants. As well as being used in our own gardens, these chemicals are used on a wider scale in agriculture.

Metals

Certain metals such as mercury, lead, zinc and copper, are extremely toxic. Found in paints, anti-fouling agents and fungicides, these metals cause lasting damage at even at relatively low concentrations.

Anti-fouling agents

These industrial paints are applied on the hulls of sea vessels to prevent the growth of subaquatic organisms such as barnacles and algae. These agents are formulated from copper compounds and biocides, making them highly toxic.



Transboundary pollution

The connected nature of the oceans allow for marine litter from transboundary sources to affect the coastal environment and marine life in Maldives.

Some of these threats include persistent organic and heavy metal pollutants to the marine and coastal resources, accidental and deliberate oil spill along the tanker route in the region, and the continuous discharge and runoffs of pesticides and fertilizers from neighboring countries.

As the monsoon currents change, the island chain also acts as something of a trap for discarded drift nets, termed 'ghost nets', which trap and kill many marine species such as sea turtles, sharks, manta rays, and dolphins.

A large amount of these nets are used for trawling, as gillnets, purse seine and FADs (Fish Aggregating Devices) by different countries.

Plastic pollution

Plastic has become one of the most widely used materials globally and locally due to its convenience and cheap price. However, within only 100 years, plastics have become a monstrous environmental problem due its long-lasting nature, leading to pollution. Plastics are non-biodegradable and manufactured in large numbers to be used in almost every industry today.

At least 40 percent of the 8.2 billion tonne of plastics produced to this day have been used for packaging, to be used only once. From this, 79 percent is now piling up in landfills or spread out across the globe, especially in the oceans and coastal zones.

Figure:17 - Durability of debris

In Maldives about 291,733 plastic bags, 280,000 plastic bottles and 86,870 plastic straws are used every day. On average, each person in Male' generates about 1.7 kg of waste. In the rest of the inhabited islands, each person generates about 0.8 kg, and in resorts, it adds up to about 3.5 kg of waste per person.

A lot of this generated waste is sadly composed of plastics. Burning plastics release toxic fumes and Maldives does not have the capacity to recycle wasted plastics.Majority of it end up in landfills, coastal zones and the sea, where they degrade into microplastics.

Microplastics in their own right is another issue entirely, owing to its small size and susceptibility of ending up in everything from food, water, honey, to the air we breathe.

Microplastics are also a lot harder to clean up compared to its larger counterpart. It is estimated that currently there are over 51 trillion microplastics floating in the ocean. In fact, plastics are projected to outweigh the fish in the ocean by 2050.

Activity

1. List the types of waste created by each sector

Household	Agriculture	Tourism	Construction & Boat building

2. Analyzing microplastics found in the coastal zone

Materials needed:
1mm sieve mesh
Paper
Pen/Pencil

Methodology
1. Choose 3 different locations in the coastal zone of the island
2. Place the mesh on the soil, and scrape about 1kg of topsoil onto the mesh
3. Grab the mesh from all 4 corners and lift the sieve up into the air, and then move the sieve around till most of the fine sand gets sieved out
4. Place the mesh back on the ground, and collect the materials that remain
5. Make a list of all the different bits and pieces of foreign material you find
6. Repeat the process for the remaining 2 locations

Site 01

Site 02

Site 03

Discussion:
1. What are the most common materials sieved from the soil?
2. Did your findings surprise you?
3. What are some ways in which you can prevent these materials from ending up there?

Impacts of marine pollution

1. Food waste and sewage pumping in the sea

Municipal and industrial waste are known to increase the Biological Oxygen Demand (BOD) of marine waters. The nutrient rich food waste and sewage discharge have been linked to algal bloom and the unnatural growth of seagrass in some islands. Comparison of aerial photos from the 1960s and more recently in the 2000s show sudden growth of seagrass beds in the vicinity of islands following population growth. Mass fish kill events in Maldives have also been linked to poor water quality.

Figure:18 - Increase in the extent of seagrass with inhabitation and increase in population in B. Goidhoo (left) and K. Maafushi (right). Adapted from (BOBLME, 2010). Pic: EPA

2. Coastal landfills and open burning

Unmanaged landfills release harmful substances into the soil and water lens, which gets leached into the sea. Open burning releases Persistent Organic Pollutants (POPs) along with dioxins, furans and heavy metals into the soil and groundwater.

Due to the proximity of the land and sea in Maldives, these substances are likely to negatively impact marine life. Though the effects of POPs have not been assessed in Maldives, studies from other countries show that it may be related to population decline in a number of marine species.

3. Chemicals from industries

The heavy use of pesticides and fertilizers in islands have led to the degradation of soil and poor water quality. The excess amounts of nitrogen and phosphorus in groundwater has been linked to subsequent eutrophication. Leachates containing some fungicide are known to affect coral health by inhibiting fertilization and metamorphosis even at very low concentrations. Chemicals used in households, health industry and tourism industry also contribute to poor water quality. Some of the chemicals used in construction and boat building industries are harmful to human health, as well as marine life when washed into the sea by rain. There have also been instances of oil and tar spills into terrestrial and marine environments in recent years, which have led to the contamination of groundwater aquifers and marine life such as sea turtles being washed up with ingested tar.

4. Plastics and microplastics

The ‘single use and throw away’ culture of plastics have led to an alarming number of plastic waste being produced every day, especially in countries like Maldives where tourism is one of the main industries. The fact that plastics can breakdown into progressively smaller particles and easily enter the food stream, leading to bio accumulation of dangerous chemicals in humans and other living things is in itself a huge cause for concern. As most of the microplastics are found in the ocean, the contamination of sea food may have serious health implications for countries that rely on the sea for sustenance.

The presence of plastics on the beaches and the sea not only take away the aesthetics that bring happiness to many people, it can also be life threatening to a lot of animals that make use of these habitats every day. Of the 120 species marine species on the IUCN Red List of Threatened Species, 54 percent have been observed ingesting or been tangled in plastics. Different species of whales are frequently beached all over the world with their belly full of plastic bags, shoes, bottles and other marine debris.

In Maldives, more and more fish species caught for food are being reported to have plastics in their guts. Plastic marine debris along with discarded fishing gear also trap whales, dolphins, sharks, manta rays and turtles routinely. In the last 7 years alone, over 1000 sea turtles have been recorded trapped in these ghost nets in Maldives, with a lot of them sustaining serious injuries. In addition to marine species, 93 percent of sea birds are reportedly affected by plastics due to ingestion and entrapment. From the tiniest plankton to the largest whales, plastic poses a threat to all marine life like never before.

What can you do?

The problem of pollution started with people, and the good news is that it also gives us the power to reduce it. There are several things we can do even as individuals to lower pollution in our environment.

How to reduce your chemical footprint

Many of us try to minimise our carbon footprint by using eco-friendly means of transport and buying locally grown food. But what about our chemical footprint? It's easy to forget that many of the products we use on a daily basis are actually harmful to the environment. So follow these steps to reduce your impact on the oceans!

In Your Home

Use the minimum amount of detergent needed when washing your clothes.

Choose phosphate-free soaps.

Make your own natural cleaning products using baking soda, vinegar and lemon.

Avoid killing insects with bug spray.

Select organic produce at the supermarket.

Refrain from draining chemicals into the sewage system.

In Your GARDEN

Opt for natural fertilisers such as compost.

Apply pesticides only sparingly and follow best practice methods.

In Your CAR

Try to leave your vehicle at home when going short distances.

Clean up spilled brake fluid, oil, and grease.

On Your BOAT

Do not dump paint, oil, or anti-fouling agents into the ocean.

Service your engines regularly.

How chemical pollution is harming coral reefs

Unlike other forms of pollution, chemical pollutants are often invisible to the eye or soluble in water, making it easy to forget about the threat they pose to our oceans. But with an estimated 20% of coral reefs at risk from chemical pollution, the damage chemicals are causing is very real.

So how do chemicals reach the coral reefs in the first place?

Normally, the main way chemicals enter marine waters is through rivers and streams. When farmers use chemicals such as insecticides, herbicides or fertilisers, or when industries use chemicals to produce household goods, or even when we use cleaning products to clean our bathrooms, these substances contaminate the ground water and enter nearby freshwater sources. These rivers and streams then flow towards the ocean, carrying the chemical compounds with them, known as 'terrestrial runoff'. However, in the Maldives there are no such freshwater rivers. So the main way chemicals enter the ocean here is through island wetlands, the shore, sewage pipes and via oil spills, illegal dumping and marine activities that all contribute towards chemical pollution.

Why does this matter?

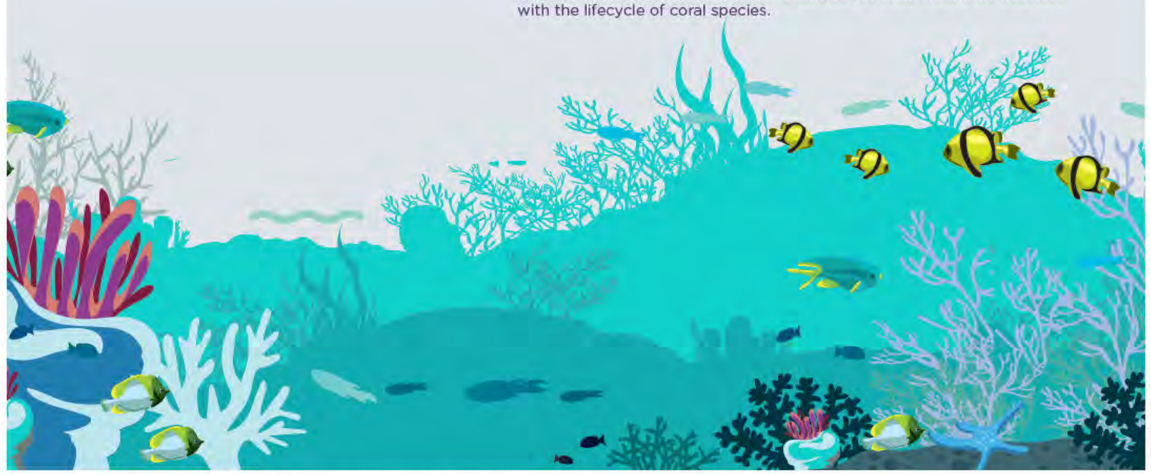
Many of these chemical substances, such as insecticides and herbicides, are specifically designed to kill. So it's unsurprising that coral species, which are renowned for being extremely sensitive to their surroundings, will react adversely to these compounds. And despite the fact that coral reefs are often in remote locations, far from urban development, the extent of pollution is such that approximately 20% of reefs are now at risk. In addition, their proximity to shipping lanes and often intense commercial activity, means coral reefs are at a higher risk of oil contamination.

But what if there's only a really small amount?

It's true that different chemicals cause different reactions in coral, and the severity of the reaction will depend on the concentration of the chemical in the water. However, insecticides, herbicides and fungicides have been shown to affect corals even at very low concentrations. Herbicides can easily penetrate coral tissues and in a matter of minutes, the tiny organisms that live inside coral, called zooxanthellae, are prevented from photosynthesising efficiently. As this is how coral gets its food, it begins to starve.

How else do chemicals harm coral?

Certain chemicals have been found to affect all life-history stages of corals. For example, scientists have shown that the fungicide Methoxyethyl mercury chloride inhibits fertilisation and metamorphosis, which then leads to coral bleaching. Similarly, phosphorous, which is often found in fertilisers has been linked with reduced coral growth and in some instances, death of entire coral colonies. Copper, a heavy metal, which is a major component of anti-fouling paint, can prevent the reproductive success of corals, while oil spillages can affect the success of spawning. These are just a few examples of how chemicals interfere with the lifecycle of coral species.



Learn more about Marine & Chemical pollution at: https://www.facebook.com/murakameehun/

Activity

1. DIY home cleaning products. Make cleaning products for your home!

Instead of	Try:
Air freshner	Combine 3/4 cup of water, 2 tablespoons of vanilla extract, and 5 drops of any 2 essential oils you like. Fill in a reusable spray bottle
Drain cleaner	Pour boiling water down the drain or use a plunger
Furniture polish	1 tsp. lemon oil in 1 pint mineral oil. Alternatively, rub crushed raw nuts on the wood for an oily polish.
Houseplant insecticides	Wash leaves with soapy water, then rinse.
Oven cleaner	Salt, baking soda, water (and elbow grease!).
Roach spray	Chopped bay leaves and cucumber skins, or boric acid (sold in powdered form)
Silver cleaner	Soak silver in 1 qt. warm water containing 1 tsp. baking soda, 1 tsp. salt, and a piece of aluminium foil.
Window cleaner	2 tbsp. vinegar in 1 qt. water

2. Household waste audit

Objective: Carrying out a waste audit for your household to see what kind of waste is produced at your home on average.

Materials needed:
Garbage
Reusable gloves
Paper
Pens/pencil

Methodology:

1. Gather one day's worth of trash from your home and empty it onto a tarp. Begin sorting items into piles (metals, food waste, plastics, etc.)

2. Observe the trash collected and sort and separate them into different types. The total amount of trash collected can be regarded as 100 percent. Now, have a look at the waste you have separated and estimate the percentage of each type of waste you have collected.

3. Draw a pie chart based on your estimates to see which type of waste makes up most of the trash collected

4. Clean up! Sort recyclables into recycling bins, and compost perishables if possible. Don't forget to wash your hands!

	Plastic	Metals	Organic	Hazardous	Others
Total no:					
Percentage					

Discussion:
1. Did you find any items that could have been recycled, composted, or reused instead of being thrown away?
2. Brainstorm ideas to reduce the amount of waste in your home: make a poster of what can and cannot be recycled and hang it up in your kitchen
3. Choose products with the least amount of packaging; start a compost bin; or opt for reusable containers to pack your lunch. Be creative!

Actions to reduce the amount of waste generated at your home:

Actions you will take	Time frame/date	Who is responsible	What are your targets? How will you know it is successful?

Post Assessment

1. What are some of the impacts of releasing sewage water and food waste into the lagoon?

- ☐ Unnatural growth of corals
- ☐ Algal bloom and uncontrolled growth of seagrass
- ☐ Obesity in reef fish

2. How does transboundary pollution affect megafauna in Maldives?

- ☐ Radioactive waste dumped from nuclear power plants enhance their size
- ☐ Oil spills from nearby countries lead to fish kill in Maldives
- ☐ Discarded fishing nets carried by the monsoon currents cause entrapment

3. What are some ways in which plastic pollution affect marine life?

4. Name 2 types of hazardous chemicals that pollute the environment in Maldives

5. Write 3 things you can do to reduce the amount of waste produced in your household.

Learn more about marine & chemical pollution at:

https://www.facebook.com/murakameehun/

Reference - Marine and Chemical Pollution

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Our Protected Areas

A key conservation tool to tackle biodiversity loss

Questions

1. What is a true comparison of traditional protected areas and modern protected areas?

- ☐ Traditionally people only protected natural areas
- ☐ Modern conservation science takes into account societal needs along with environmental sustainability
- ☐ Contemporary conservation science has no space for public participation

2) How many protected areas have been designated in Maldives

- ☐ 63 PAs
- ☐ 58 PAs
- ☐ 79 PAs

What are Protected Areas and why are they important?
The International Union for Conservation of Nature (IUCN) defines protected areas (PA) as 'a clearly defined geographical space, recognised, dedicated and managed, through legal or other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values.'

This means that a specific site is selected for safeguarding due to its notable biodiversity or cultural value. A marine protected area is located in the ocean or along the coastline, while land based protected areas such as forests or sea bird roosting sandbanks are considered terrestrial protected areas.

In contemporary conservation practices, protected areas have become a major instrument in preserving healthy ecosystems with high genetic richness and endangered species by managing ecosystem services with sustainable resource use plans.

Some of the functions of protected areas include:

• Maintaining healthy functioning ecosystems that serve as sanctuaries for specific biota and habitats, preserving ecological processes unable to survive without protection, and preventing ecosystem fragmentation.

• Promote and preserve valuable ecosystem services for the society, such as ecotourism, recreational activities, research, research and education, scenery, and religious grounds.

• Benchmark to assess the effects humans have on different environments. Well managed protected areas provide space for natural evolution and ecological restoration, and can be compared with areas that are not protected to understand the extent of anthropogenic impacts on nature.

Protected Areas in Maldives

To date, a total of 79 protected areas including 3 Biosphere Reserves consisting of marine, mangrove and terrestrial ecosystems have been designated under the Environmental Protection and Preservation Act (No. 4/93).

The first protected areas in Maldives were designated in 1995 with tourism as the major focus. Historically, Protected Areas (PAs) also served to ban the export of baitfish as aquarium fish, as well as fishing in resort house-reefs, and protecting threatened marine species.

As the characteristics and functions of Protected Areas vary, each site is designated a certain level of protection, with the management plan for each site formulated accordingly.

The categories of Protected Areas in the Maldives closely aligns with IUCN protected area categories. They are:

1. Internationally recognized sites
2. Strict Nature Reserves
3. Wilderness Areas
4. National Parks
5. Natural Monuments
6. Habitat/Species Management Areas
7. Protected Areas with Sustainable Use

Activity

Refer to the map on pages (07 to 19) and list down the PAs found in your atoll.

How MPAs achieve conservation objectives in Maldives

Marine Protected Areas (MPAs) are important heritage sites and designated areas for fishery research, as well as as buffers or insurance against overfishing, providing an alternative strategy for sustainable fisheries.

As more fish populations tend to live longer and grow bigger in the 'no take zones', they eventually move on to other areas of the ocean, including fishing grounds.

This is known as the 'spillover effect'. The increased fish biomass within MPAs also yield a dramatic reproductive output, with some of the larvae getting carried beyond the 'no take zones' leading to juvenile fish growth outside the MPAs. This net export of eggs/larvae outside a marine reserve is called 'recruitment subsidy'.

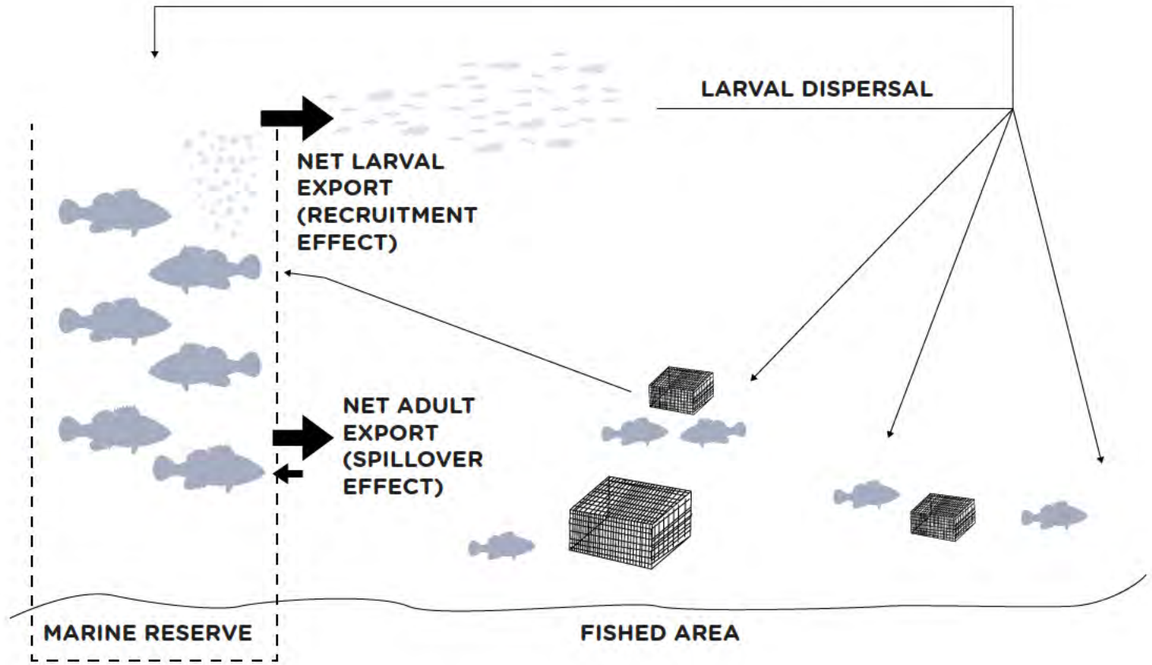


Figure:19 - The spillover effect observed in MPAs.

Protected Areas

With the PAs scattered throughout the country, every site serves a variety of ecosystem services and supports different aspects of the societal needs in addition to being a key component of marine conservation and sustainable fisheries.

Apart from generating significant revenue in tourism and fisheries sectors, the biodiversity of Maldives also stimulates considerable economic activity in construction, manufacturing, artisanal craftsmanship, transport, food, restaurants and entertainment sectors. In terms of household livelihoods, these biodiversity-dependent sectors account for a substantial proportion of national employment, food and earnings.

POP UP FACT

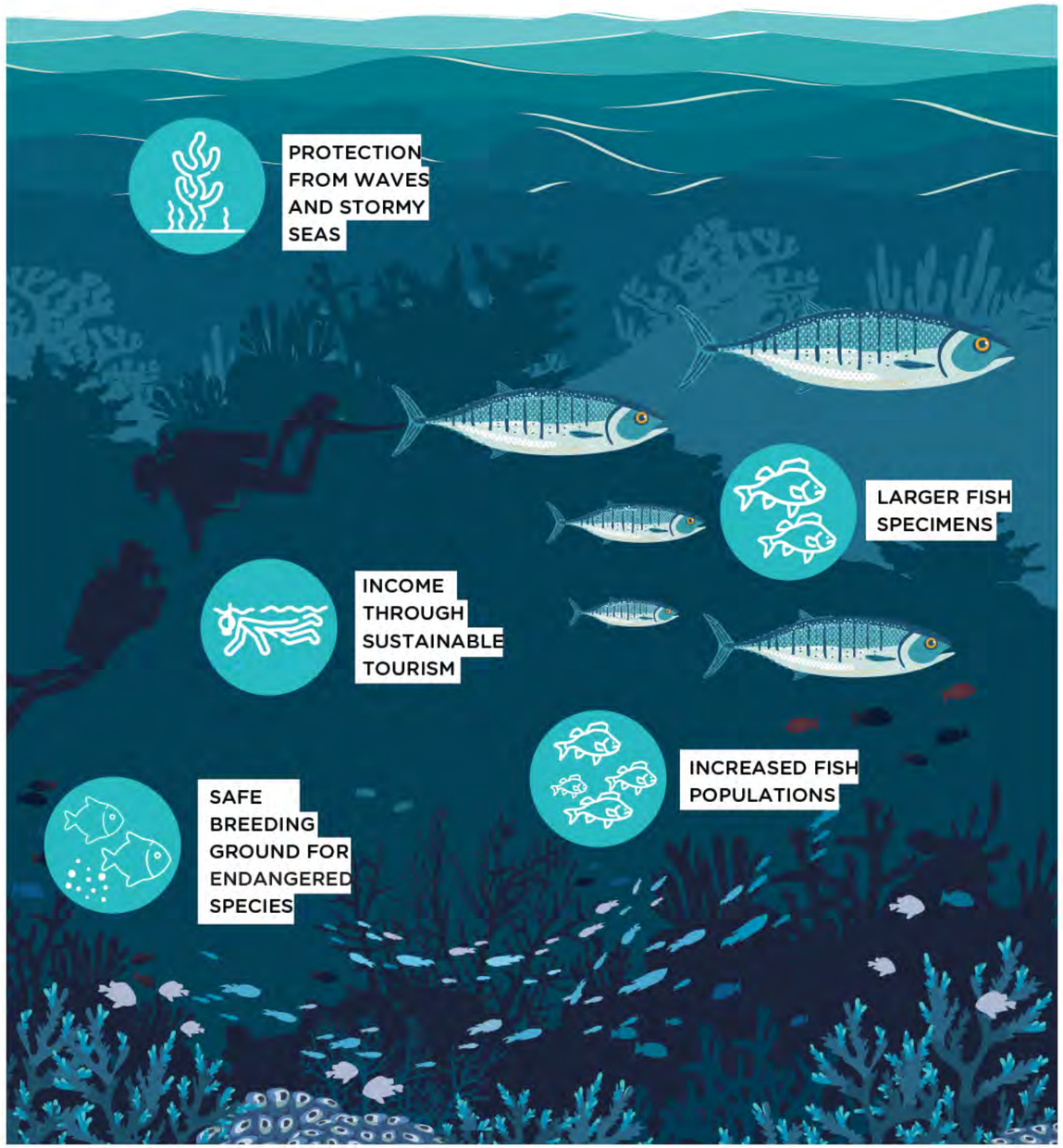
One of the more historically significant MPAs in Maldives include The Corbin Wreck, which was a French ship carrying a cargo of silver that met its demise in 1602 in Goidhoo atoll.

When news of the wreck and its silver reached Male', the merchandise from the wreck was declared property of the Sultan, and locals were prohibited from selling anything to the shipwreck victims. François Pyrard, the famous French navigator had covered the accounts of this wreck in his book about life in Maldives in the 1600s.

The Importance of Marine Protected Areas

MPAs are often selected due to their naturally occurring biodiversity and abundant marine life.

But they also serve a purpose that extends beyond the boundary of their sites. In effect, it is them that are protecting us!



Where are the Protected Areas in the Maldives?

The government of Maldives is currently on a mission to identify and protect ecologically significant sites in all atolls, representing at least one reef system, lagoon, sandbank, wetlands or mangrove site. Some of the existing protected areas include whole islands, such as HA. Gallandhoo, a famous lesser noddy aggregation site, and GDh. Dhigulaabaadhoo, an island with an extensive mangrove system.

PAs such as the South Ari Marine Park (SAMPa) regulate tourist boats and human interactions with whale sharks that inhabit the area. Boats, snorkelers and divers have specific guidelines on how to behave in this area.

Smaller PAs include famous dive sites such as Banana Reef (Male' atoll) with specular caves and overhangs, with an array of reef fish and invertebrates, as well as predatory fish such as sharks, barracudas and trevallies converging around big rocks.

South Ari Marine Park (SAMPa)

- Designated on June 5th, 2009
- Covers 42km²
- The boundary extends for 1km seaward from the outer reefs
- One of the world's most important habitats for whale sharks
- 271 individual whale sharks have been sighted within the MPA
- Approximately 65,000 tourists join whale sharks excursion annually
- The estimated value of whale shark tourism in the mpa is USD 8.5 million (Cagua et al. 2014).

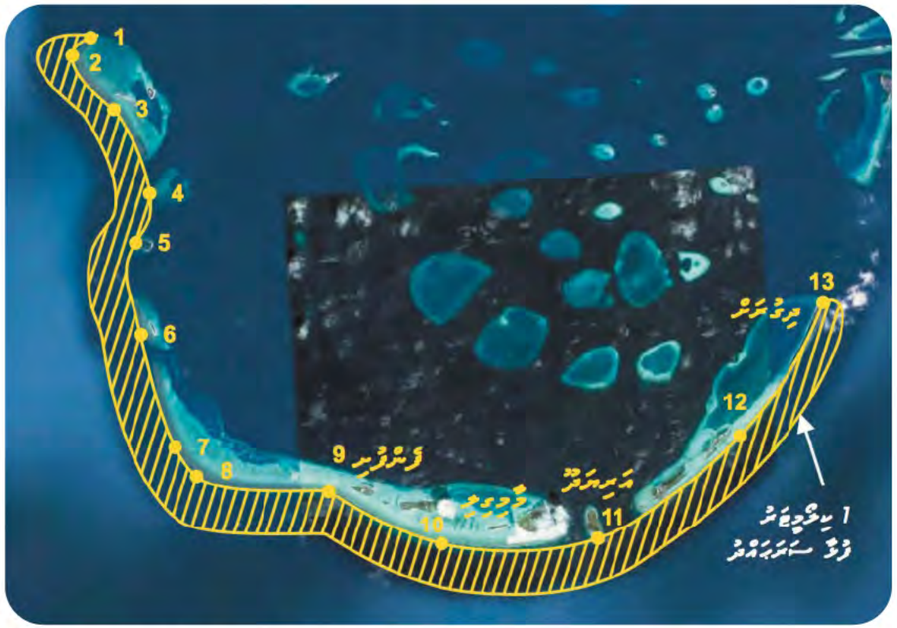


Figure:20 - South Ari Marine Park (SAMPa). Pic: EPA

Figure:21 - Banana reef - Kaafu atoll. Pic: EPA.

UNESCO Biosphere Reserves

The United Nations Educational, Scientific and Cultural Organization (UNESCO) defines Biosphere Reserves as 'learning places for sustainable development'. These sites are selected to understand and manage changes, natural resource use and find local solutions to human-wildlife conflicts to pave the way for conservation and sustainable development with the environment and society at its forefront.

Across the world, there are 257 million people living in Biosphere Reserves, spanning across of 6,812,000 km² in 129 countries, together making up the World Network of Biosphere Reserves (WNBR). Not only are they areas of outstanding beauty and unique biodiversity, each region is also noted for its commitment to fostering a harmonious balance between people and nature.

How are Biosphere Reserves designated?

1. High biodiversity sites with cultural significance are nominated as Biosphere Reserves by the national government.

2. Nominations are taken for consideration by the Advisory Committee for Biosphere Reserves to be recommended to International Coordinating Council (ICC).

3. ICC of the Man and Biosphere program takes a decision on the designation of the Biosphere Reserve.

4. Countries are informed of the designation by the Director-General of UNESCO.

Functions of Biosphere Reserves:

Biosphere Reserves are created with the following functions at the epicenter, and are planned and managed by the collaborative efforts of government, private sector and local communities.

1. Conservation of biodiversity and cultural diversity
2. Economic development that is socioculturally and environmentally sustainable
3. Logistic support underpinning development through research, monitoring, education and training

To achieve these functions, the Biosphere Reserves are classified into 3 main zones.

1. Core Area
A strictly protected zone set aside for the conservation of ecosystems, target species, landscapes and genetic variation.

2. Buffer Zones
Surrounds the Core Area and supports sound ecological practices such as scientific research, monitoring, education and other permitted activities.

3. Transition Area
This is where communities foster socio-culturally and ecologically sustainable economic and human activities such as fisheries, tourism and developmental activities.

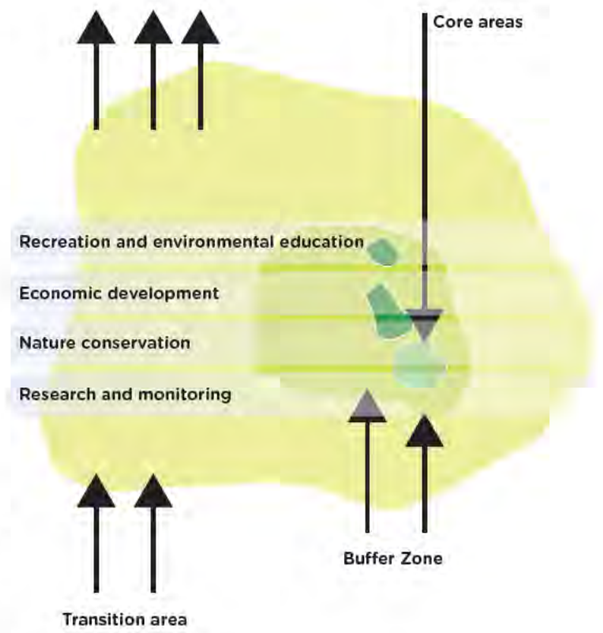
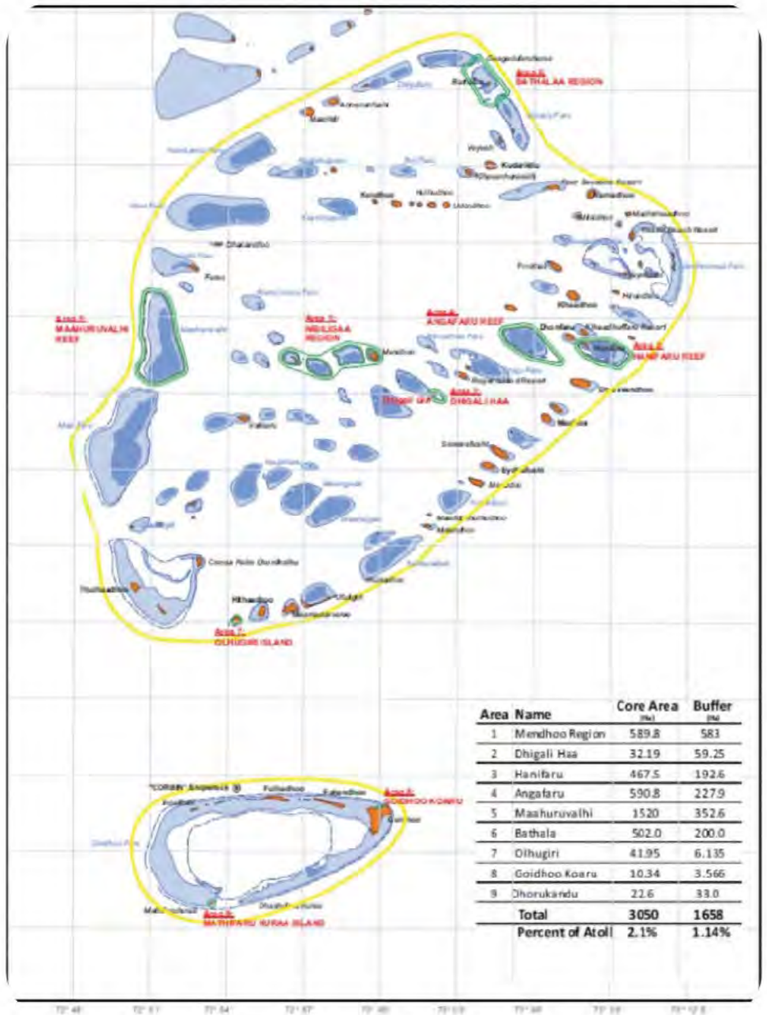


Figure:22 - Zonation in a Biosphere Reserve

Biosphere Reserves in Maldives

Baa Atoll Biosphere Reserve

In recognition of the outstanding natural values of this atoll and the commitments being made by local communities and resort Baa Atoll was declared the first United Nations Educational Scientific Cultural Organization (UNESCO) Biosphere Reserve in the Maldives in 2011. Some of the core areas in this Biosphere Reserve include breeding sites for sea birds and manta aggregation sites.



Area	Name	Core Area (ha)	Buffer (ha)
1	Mendhoo Region	589.8	583
2	Dhigali Haa	32.19	59.25
3	Hanifaru	467.5	192.6
4	Angafaru	590.8	227.9
5	Maahuruvalhi	1520	352.6
6	Bathala	502.0	200.0
7	Olhugiri	41.95	6.135
8	Goidhoo Koaru	10.34	3.566
9	Dhorukandu	22.6	33.0
	Total	3050	1658
	Percent of Atoll	2.1%	1.14%

Figure:23 - Baa atoll biosphere.
Pic - Ministry of Environment, Climate Change and Technology

Fuvahmulah Biosphere Reserve

The unique geological features and the healthy ecosystems of Fuvahmulah along with the potential for sustainable resources have led to Fuvahmulah being designated a UNESCO Biosphere Reserve in 2020.

In addition to the wetlands found in the atoll, the waters surrounding it is a hotspot for marine megafauna such as oceanic mantas, adult whale sharks, tiger sharks and rarely seen fish such as sunfish.

Figure:24 - Fuvahmulah Biosphere Reserve.
Pic - Ministry of Environment, Climate Change and Technology

Addu Atoll Biosphere Reserve

Designated as a UNESCO Biosphere Reserve in 2020, the majority of this site is composed of marine ecosystems with highly diverse reef ecosystems. There are 30 islands here, with about 17 of them uninhabitated.

Addu Atoll is divided by four channels; Gan Kandu, Viligilikandu, Maakanda and Kodakanda and the islands are formed by the peripheral reef.

Figure:25 - Addu Atoll Biosphere Reserve.
Pic - Ministry of Environment, Climate Change and Technology

Case Study: Baa Atoll Biosphere Reserve

(28 June 2012)

Baa atoll comprises of ecosystems as most atolls in Maldives, with a combination of coral reefs, islands, seagrass meadows and mangroves, owing to a rich biodiversity.

The position of Baa atoll in the Indian ocean and the large groups of coral reefs in the atoll act as a stepping stone for the transport of planktonic larvae of reef fauna from the western and eastern Indian Ocean.

There are 9 core areas within Baa Atoll Biosphere Reserve: Mendhoo Region; Dhigali Haa; Hanifaru; Angafaru; Maa huruvalhi; Bathala; Olhugiri; Goidhoo Koaru; and Dhorukandu. While some of these sites are notable for sea turtle nesting, sea bird roosting and rich reef biodiversity, the most famous of all is perhaps the Hanifaru Bay.

At the heart of ecotourism and megafauna research, Hanifaru Bay is a key aggregation site for reef rays *(Mobula alfredi)*, with over 1800 individuals identified at this location within 15 years. The structure of Hanifaru outer reef allows for plankton rich water to get trapped within the shallow bay area during the Southwest Monsoon (Hulhangu). This makes it of the few sites where manta cyclone feeding is routinely observed worldwide, with up to 247 individuals recorded at once at these mass feeding events.

Hanifaru Bay at Baa Atoll - Pic - EPA Maldives.

BAA ATOLL
UNESCO
BIOSPHERE
RESERVE
MALDIVES

The three key programmes through which the Biosphere Reserve Strategy is adopted include:

Outreach program:
Awareness and education regarding conservation, sustainability and the functions of the Biosphere Reserve using participatory approaches.

Conservation program:
This includes allocating a zonation system and implementing it with government oversight, and effectively managing the core areas to monitor the natural resources by enforcing necessary regulations. A key aspect of this also includes regularly updating the strategic action plans to reduce key threats to biodiversity.

Livelihood and sustainable development program:
This program aims to support community livelihood and developmental initiatives that are in line with the objectives of the Biosphere Reserve. This mainly includes working with key sectors such as fisheries, tourism and agriculture with 'sustainability' at its core principle, while addressing climate change mitigation.

How do local communities come into play in protected areas and Biosphere Reserve management?

Traditionally, the idea of setting aside pristine environments for conservation was done with the belief that people were bad for natural resources. However, MPAs, and especially Biosphere Reserves are now designed with the inclusion of local participation at different stages that allow for communities to take ownership in all aspects of protecting their environments. The skills, knowledge and needs of local people are to be combined with the conservation objectives in place. Local communities not only safeguard and protect, they also need to be at the forefront of conducting scientific studies, planning and decision making.

Activity

Design your own Biosphere Reserve

1. Draw a map marking all 3 necessary zones in your Biosphere Reserve, and explain the important features that allow it to be a Biosphere Reserve, and mark the activities allowed in each zone.

2. Explain how the spillover effect works in MPAs and helps fisheries

_____

_____

_____

_____

_____

_____

_____

3. List down the 3 zones required in a Biosphere Reserve

_____

_____

_____

_____

_____

_____

4. What are the features of a core area in a Biosphere Reserve

- ☐ Specialized for resource extraction such as fisheries and aquaculture
- ☐ Strict nature reserve
- ☐ Is outside the buffer zone

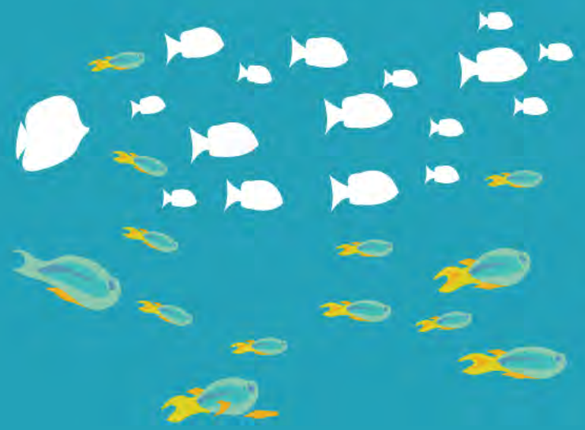
Hanifaru Bay: An Example of a Core Zone

Where is it?
In some biosphere reserves, such as in Baa Atoll, there are multiple core areas. Hanifaru Bay, a small inlet that welcomes thousands of feeding mantas each year, is undoubtedly its most famous.

What's restricted?
The Baa Atoll Biosphere team has created special regulations for accessing Hanifaru Bay, and what activities can be conducted there.

In the core area, for example:

- **Fishing is banned**
- **Scuba diving is not allowed**
- **Snorkelling is allowed but only with an entrance pass**
- **Resorts, liveaboards and guesthouses can only access the bay on allocated days of the week**
- **Boats cannot enter the core area and must drop guests off in a specified zone**
- **Guests can enter the buffer zone, but fishing is also prohibited there**
- **Those who wish to fish must stay in the transitional area**



Who's in charge?
Rangers patrol the zone to ensure rules are adhered to, and conduct awareness programs to ensure residents understand the regulations. They also collect entrance tickets.

Where does the money go?
The fees collected for entering the bay fund the biosphere's small grants scheme. These grants are awarded to community groups, such as the Women's Committee in Maalhos that have successfully implemented a composting scheme in their island.

Reference - Our Protected Areas

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Ministry of Environment Maldives
https://twitter.com/MoEnvmv/status/1321739307762110464

Ecotourism in the Maldives

Questions

1. Identify 2 principles of ecotourism as per the International Ecotourism Society below.

- ☐ Foster respect and awareness of the environment and local culture
- ☐ Harvest natural resources as much as possible to benefit the tourism sector
- ☐ Guarantee minimal impact during construction and operation of tourism facilities

2. Ecotourism helps coral reef conservation initiatives in the Maldives

- ☐ True
- ☐ False

With the various impacts on the environment caused due to human activities, there is a growing concern that people need to act and take responsibility to minimize their impact on the environment.

Ecotourism can be defined as a type of tourism that emphasizes responsible travel, and ensures that the impact on the environment is minimal, and resources are being sustained. Oftentimes, finding the balance between the growth of tourism and environmental conservation is a challenge.

Looking at the Maldives, with the growth of the tourism industry in the last 50 years, over 100 islands have been developed as tourist resorts. Under the Maldives Tourism Act, islands are at times leased up to 99 years to develop tourism.

Due to the nature of this arrangement, resorts are able to at times better manage the health of the coral reefs and associated organisms within their islands much better.

Furthermore, as the world continues to develop, businesses too, seek environmentally friendly, sustainable business opportunities. As such, resorts find themselves in a unique position to use their business to create awareness through educational programmes and conservation initiatives targeted towards guests and travellers.

For example, today, several tourist resorts in the Maldives have marine biologists based on the island often leading educational programmes as well as conservation initiatives such as coral reef restoration with the involvement of their guests. More and more, resorts are also looking into innovative and sustainable waste management mechanisms.

For a country like the Maldives, finding the balance between economic growth and also environmental conservation is vital. This is where the model of ecotourism can play a big role as it combines both to ensure that customers get a fulfilling and learning experience while making sure that the impact they have on the environment is minimal.

5 ways ecotourism helps to keep coral reefs healthy in the Maldives

There is more to being an environmentally conscious tourist than simply making sure you do not stand on corals when snorkeling. By opting to stay at a resort or hotel that practices ecotourism, visitors can have a lasting, positive impact on the local environment and community.

The spending power of eco-tourists is shaping the luxury market
In 2015, travel consultancy firm IPK International and Booking.com both published reports stating that luxury travelers were over 50% more likely to choose a hotel which had a positive relationship with the local environment and communities. Put simply, it is now a financial imperative for hotels and resorts to practice ecotourism in order to attract clients. By making spending decisions based on sustainable practices in hotels, especially in the luxury market, which is so dominant in the Maldives, eco-tourists can make a significant difference.

They are changing how resorts interact with their marine environment
IIn order to provide guests with the luxury, eco-friendly experiences they are looking for, many hotels and resorts in the Maldives have invested in long-term conservation projects and initiatives run by qualified marine biologists and conservationists. These often involve protecting the coral reef ecosystems through coral plantation programs, awareness campaigns, and adhering to snorkeling and diving best practices. What's more, eco-tourists insist on a holistic approach and expect the environment to be considered at all levels of the hotel operations.

Eco-tourists can potentially provide financial support for coral conservation efforts
Guests now have the chance to sponsor coral frames and to donate to ongoing projects. They have the opportunity to purchase locally-made souvenirs, crafted from sustainable materials rather than harmful keepsakes made of marine flora and fauna.

They ask questions and educate themselves
Eco-tourists are those that are willing to learn something new while on holiday, and are open to other ways of life and new environments. Ecotourism offers will offer opportunities to experience the local eco-system and culture in a memorable way that minimizes impact and foster respect and awareness.

They spread the word about the plight of our ecosystems
The impact of an eco-tourist does not stop when they leave the resorts. Their experiences remain with them when they return to their own country. An educated tourist with an awareness of the environmental issues is more likely to speak to their friends and family on the subject and to encourage others to become eco-tourists.

The Principles of Ecotourism

Many types of travel are now being classified as ecotourism. However, to be truly considered ecotourism, a trip must adhere to the following principles set out by the International Ecotourism Society:

- Minimise impact at a physical, social, behaviour, and psychological level
- Foster respect and awareness of the environment and local culture
- Create positive experiences for guests and hosts
- Invest financially in conservation projects
- Ensure local people and businesses benefits from tourist activities
- Curate meaningful experiences that offer insight into the local political, environment, and social climate
- Guarantee minimal impact when constructing and opening tourism facilities
- Empower ingenious communities by working in partnership with them whilst acknowledging their rights and spiritual beliefs

Activity

Find out what the tourist resorts near you are doing to conserve the environment.

Task:
1. Find out and list down 4 tourist resorts near your island.
2. Call each resort and find out 1 conservation initiative being carried out by the resort (eg: coral restoration, educational and outreach activities, research).
3. List out the answers from each resort on the table.

1. Resort Name: _____
Atoll:
Activity carried out:

2. Resort Name: _____
Atoll:
Activity carried out:

3. Resort Name: _____
Atoll:
Activity carried out:

4. Resort Name: _____
Atoll:
Activity carried out:

Reference - Ecotourism

https://www.facebook.com/murakameehun

Answers

CORAL REEFS

Questions

Page 24

1. ☒
   ☑
   ☒

2. ☑
   ☑
   ☑

Questions

Page 34

1. ☒
   ☑

2. ☒
   ☑
   ☒
   ☑

Crossword Puzzle

Page 42

Across
1. nematocysts
2. octocorals
3. gonochoric
4. porites
5. zooxanthellae
6. polyps

Down
7. corallites
8. symbiosis
9. herbivorous
10. ecosystems

FISHERIES IN MALDIVES

Questions

Page 46

1. ☑
   ☑
   ☑
   ☑

2. Skipjack tuna
   Big eye tuna

Tick the appropriate box

Page 56

1. ☑
   ☑
   ☑

2. Pole and line

3. All of the above

MEGAFAUNAS OF MALDIVES

Questions

Page 60

1. ☒
   ☑
   ☒

2. ☒
   ☒
   ☑

Activity

Page 66

1. ☑
   ☒
   ☒

SEAGRASS ECOSYSTEMS

Questions

Page 76

1. ☒
   ☑
   ☒
   ☒

2. ☒
   ☑
   ☒

Activity

Page 84

Thalassia hemprichii
Halophila ovalis
Cymodacea serrulata
Halodule pinifolia
Syringodium isoetifolium

Activity

Page 89

1. True
2. True
3. True
4. True
5. True

MANGROVES

Questions

Page 92

1. ☑
   ☒
   ☑

Questions

Page 92

2. ☒
   ☑
   ☑
   ☒

Fill in the blanks

Page 95

1. Pneumatophores

2. Can orient themselves to avoid mid-day sun, prevent water loss and secrete salt

3. Get carried away by water to be planted elsewhere

Can you name some common species of animals found in mangroves?

Page 102

1. Fiddler crab

2. Mud creeper snail

Post Assessment

Page 110

1. (a) Oriental mangrove
   (b) Mangrove apple
   (c) Haines's orange mangrove

2. • Adaptation to anaerobic conditions with above ground roots named pneumatophores

Post Assessment

Page 110 *(continued)*

- Mangrove leaves can orient themselves to avoid mid-day sun and prevent water loss. And in some species, salt is secreted from leaf glands

- Thin pointy seedlings easily stick to mud.

3. Oriental mangrove, Haines's orange mangrove, small leaved orange mangrove

4. They are home to birds, flying foxes, fish, crabs, snails and microorganisms. They serve as a sanctuary for juvenile fish, and the organic matter and fallen leaves are food for fish and crabs.

5. b, c, d, and e

EFFECTS OF CLIMATE CHANGE

Questions

Page 114

1. ☒
   ☑

2. ☑
   ☑
   ☑

3. Excess greenhouse gases in the atmosphere, burning of coal and oil, deforestation, livestock farming, melting of clathrates

Questions

Page 124

1. ☑
   ☒
   ☒

2. Hotter days, damage to coral reefs and coastal wetlands, sea level rise and shoreline change

MARINE & CHEMICAL POLLUTION

Questions

Page 128

1. ☑
   ☑
   ☒

2. ☒
   ☑
   ☒

3. ☒
   ☒
   ☑

Post Assessment

Page 43

1. ☑
   ☑
   ☒

2. ☒
   ☑
   ☑

3. Marine animals can ingest plastic, fishing gear and ghost nets trap turtles, dolphins and other megafauna, accumulation of dangerous chemicals in marine life due to plastic pollution

4. Pesticides, insecticides, herbicides, metals found in paint and anti-fouling agents, polycyclic aromatic hydrocarbons in oil products

5. Making household cleaning products at home, avoiding items packaged in plastic, reusing and recycling, using natural fertilizers and avoiding pesticides as much as possible while gardening, use the minimum amount of detergent when doing laundry

OUR PROTECTED AREAS

Questions

Page 146

1. ☒
   ☑
   ☒

2. ☒
   ☒
   ☑

Activity

Page 161

2. As more fish grow and live longer in no take zones, they move to other areas such as fishing grounds and helps fisheries.

3. Core area, buffer zones, transition area

4. ☒
   ☑
   ☒

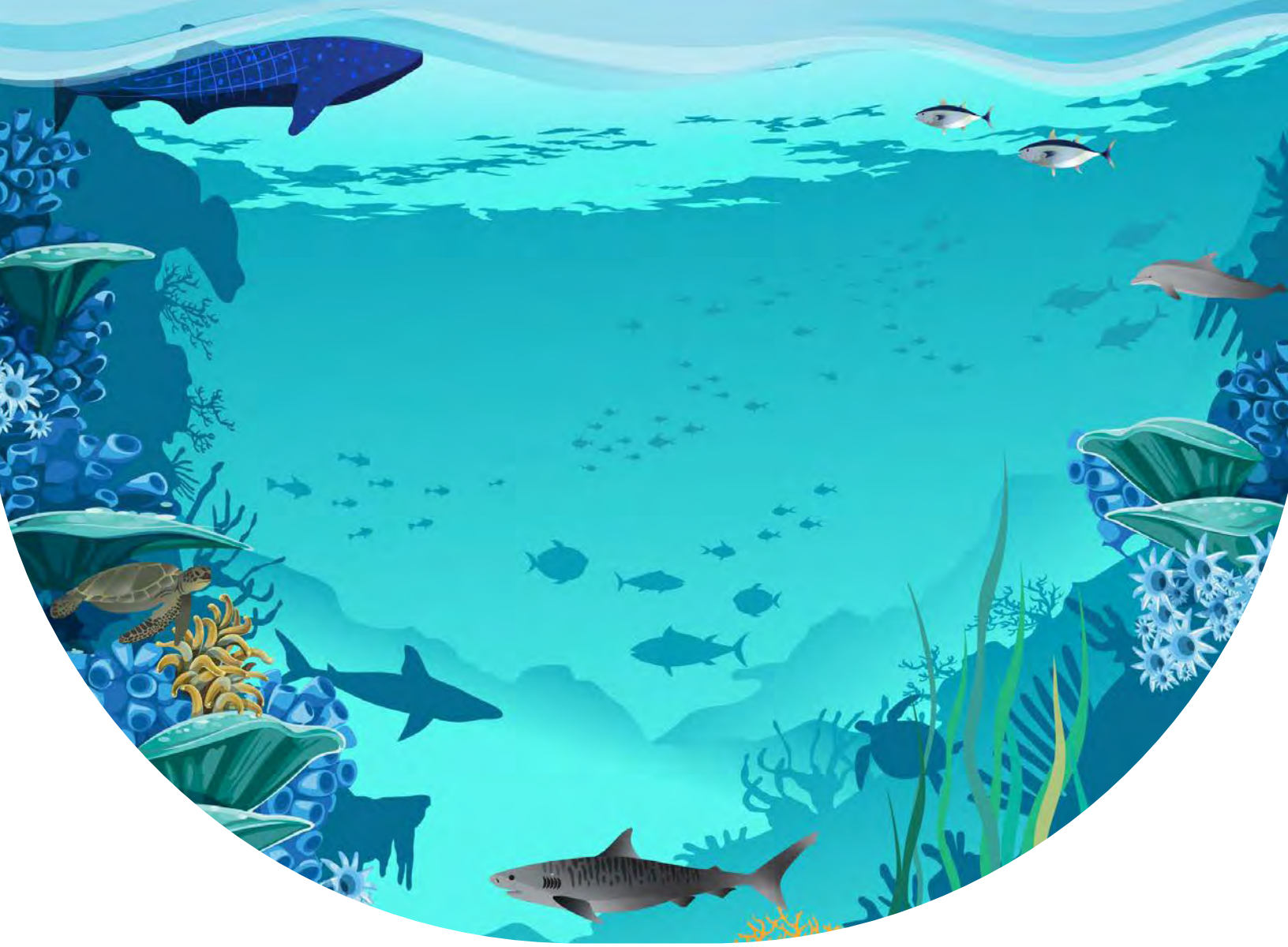
ECOTOURISM IN THE MALDIVES

Questions

Page 164

1. ☑
   ☒
   ☑

2. ☑
   ☒



MINISTRY OF ENVIRONMENT,
CLIMATE CHANGE AND TECHNOLOGY

ECOSYSTEMS OF THE MALDIVES WORKBOOK

FEBRUARY 2023

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Megafaunas of Maldives

The giants of the sea

Maldivian waters are home to a rich diversity of marine megafauna. From the largest animal on Earth, the blue whale, to green sea turtles can be sighted in waters surrounding Maldivian islands.

Marine megafauna consist of large bodied marine animals that have a body mass greater than 45kg. These large animals inhabiting the ocean are known to play a vital role in the functions of ecosystem.

However, many of these species are currently threatened with extinction due to exploitation by humans, habitat loss, global warming and pollution. In this chapter, we will be looking at key megafauna species found in Maldives, their importance to ecosystems, and the threats faced by these species.

All species highlighted in this chapter are protected in Maldives under the Environment Protection and Preservation Act (Law no. 4/93) and Fisheries law of Maldives (Law no. 5/87)

Questions

1. What is the largest shark species found in the Maldives?

- ☐ Nurse shark
- ☐ Whale shark
- ☐ Grey reef shark

2. How many species of sea turtles are found in the Maldives?

- ☐ 1
- ☐ 3
- ☐ 5

Sharks

Nearly 40 species of sharks have been recorded in Maldivian waters. The largest of them is the whale shark which feeds exclusively on planktons. Sharks are apex predators and play a crucial role in maintaining and balancing healthy and functional food webs. They do this by keeping the populations of their prey in check and feeding on animals below them in the food chain.

POP UP FACT

Did you know sharks have been around long before dinosaurs. They have been around for over 400 million years!

Worldwide, shark populations are in great decline. Sharks grow relatively slow and take many years to mature and reproduce, making them vulnerable to overexploitation. It is estimated that up to 73 million sharks are killed each year mainly for their fins. In addition to overfishing, habitat loss and pollution is also another major threat to shark species. Until the ban of shark fisheries in 2010, sharks were also harvested in the Maldives for their liver oil and fins. Sharks are still worth more alive then dead as millions of dollars could be made annually through tourism related activities such as shark watching by diving or snorkeling.

Why sharks matter

Sharks balance food webs: Sharks regulate the oceans by maintaining the structure of food webs and keeping other marine life in a healthy balance.

Sharks keep prey populations healthy: Predatory sharks target sick or injured prey, removing the weakest individuals. This prevents spread of disease, improve the gene pool and result in healthy ecosystems.

Sharks keep vital habitats healthy: For example, tiger sharks prevent sea turtles from overgrazing oxygen producing seagrass beds by patrolling such large areas.

Commonly found sharks in the Maldives

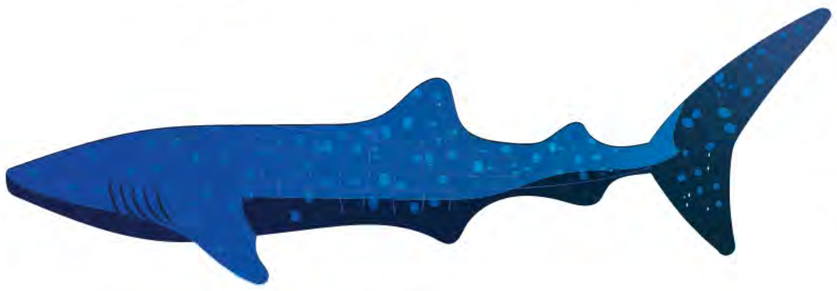
Common Name: Blacktip reef shark
Dhivehi Name: Falhu mathi dhon miyaru
Scientific Name: *Carcharhinus melanopterus*
IUCN Red List Status: Near Threatened

Common Name: Whitetip reef shark
Dhivehi Name: Faana miyaru
Scientific Name: *Ctriaenodon obesus*
IUCN Red List Status: Near Threatened

Common Name: Grey reef shark
Dhivehi Name: Thila miyaru
Scientific Name: Carcharhinus amblyrhynchos
IUCN Red List Status: Near Threatened

Common Name: Nurse shark
Dhivehi Name: Nidhan miyaru
Scientific Name: *Ginglymostoma cirratum*
IUCN Red List Status: Data deficient

Common Name: Tiger shark
Dhivehi Name: Femunu
Scientific Name: *Galeocerdo cuvier*
IUCN Red List Status:
Near Threatened



Common Name:
Whale shark
Dhivehi Name:
Fehurihi
Scientific Name:
Rhincodon typus
IUCN Red List Status:
Critically Endangered

Marine Turtles of Maldives

Long before humans settled in Maldivian islands, the marine turtles were already nesting and swimming around in the area. Seven species of marine turtles have been recorded around the globe and from this, five species are known to either forage, nest or breed in Maldivian waters. All marine turtle species are listed either as critically endangered or endangered by IUCN Red List of Threatened Species. Even though female turtles can lay hundreds of eggs while nesting, only 10% of the hatchlings survive for more than a year. Marine turtles feed on a variety of things such as sponges, jellyfish, seagrass and such, and help to keep the ecosystem in balance.

Most commonly sighted turtles

Common Name: Hawksbill turtle
Dhivehi Name: Kahanbu
Scientific Name: *Eretmochelys imbricata*
Weight: Approx. 70kg
IUCN Red List Status: Critically Endangered

Common Name: Leatherback turtle
Dhivehi Name: Musinbi
Scientific Name: *Dermochelys coriacea*
Weight: upto 900kg
IUCN Red List Status: Vulnerable

Common Name: Olive ridley
Dhivehi Name: Vaavoshi Velaa
Scientific Name: *Lepidochelys olivacea*
Weight: Approx. 45kg
IUCN Red List Status: Vulnerable

Common Name: Loggerhead turtle
Dhivehi Name: Boabodu velaa
Scientific Name: *Caretta caretta*
Weight: upto 160kg
IUCN Red List Status: Endangered

Common Name: Green turtle
Dhivehi Name: Velaa
Scientific Name: *Chelonia mydas*
Weight: Approx. 135-160kg
IUCN Red List Status:
Endangered

Cetaceans found in the Maldives

These are some of the commonly sighted cetaceans in the Maldives

Common Name: Bottlenose dolphin
Dhivehi Name: Koamas
Scientific Name: *Tursiops*
Weight: 150 - 200 kg
IUCN Red List Status: Near Threatened (NT)

Common Name: Spinner dolphin
Dhivehi Name: Koamas
Scientific Name: *Stenella longirostris*
Weight: 23-79 kg
IUCN Red List Status: Least Concern (LC)

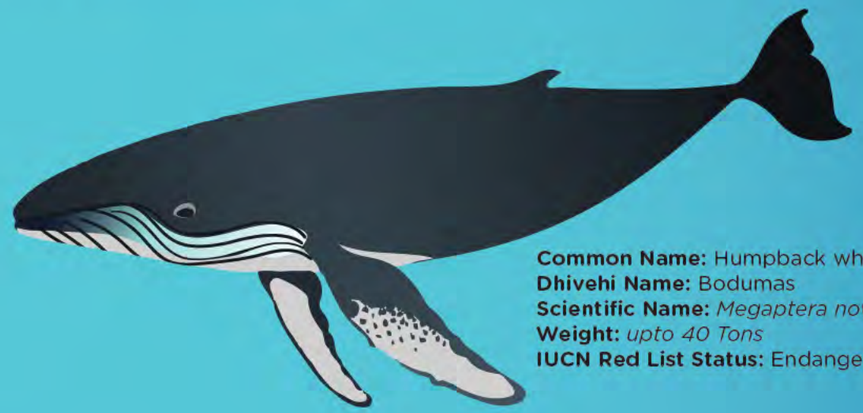
Common Name: False killer whale
Dhivehi Name: Bodumas
Scientific Name: *Pseudorca crassidens*
Weight: over 1000 kg
IUCN Red List Status: Near Threatened (NT)

Common Name: Short-finned pilot whale
Dhivehi Name: Bodumas
Scientific Name: *Globicephala macrorhynchus*
Weight: 1,000 – 3,000 kg
IUCN Red List Status: Least Concern (LC)

POP UP FACT

Did you know that ambergris (maavaharu) is produced by sperm whales? Ambergris is formed in the intestines of sperm whale and expelled as excretion.

Common Name: Sperm whale
Dhivehi Name: Bodumas
Scientific Name: *Physeter macrocephalus*
Weight: *35 to 40 Tons*
IUCN Red List Status: Endangered (EN)



Common Name: Humpback whale
Dhivehi Name: Bodumas
Scientific Name: *Megaptera novaeangliae*
Weight: *upto 40 Tons*
IUCN Red List Status: Endangered (EN)

Common Name: Blue whale
Dhivehi Name: Bodumas
Scientific Name: *Balaenoptera musculus*
Weight: *upto 200 Tons*
IUCN Red List Status: Critically Endangered (CR)

Manta rays

Manta rays are filter-feeding animals that live in tropical and subtropical regions of the world.

The oceanic mantas can grow up to 7 metres in body width, while the reef species can reach up to 4-5 meter in wingspan.

The two species of manta rays found in the Maldives are oceanic mantas and reef mantas. The largest known reef manta population is found in the Maldives, and it comprises of about 5,000 individuals. Some researchers estimate that a total of over 9,000 mantas are found in the Maldives.

They can be sighted year round in the Maldives migrating across the atolls depending on the monsoon. Manta rays gather near areas rich in nutrients to feed. In Baa atoll Hanifaru Bay, more than 150 mantas are known to aggregate at a time.

These animals are highly valued for tourism in Maldives, generating an estimated USD 8.1 million per year in direct revenue. So far, 4900 different individual reef manta rays have been identified in the Maldives by researchers from looking into the unique markings on their bellies.

Common Name: Oceanic manta
Dhivehi Name: Madi
Scientific Name: *Mobula birostris*
Average body width: 4-5 m
IUCN Red list status: Endangered (EN)

Common Name: Reef manta
Dhivehi Name: En Madi
Scientific Name: *Mobula alfredi*
Average body width: 3- 3.5 m
IUCN Red list status: Vulnerable (VU)

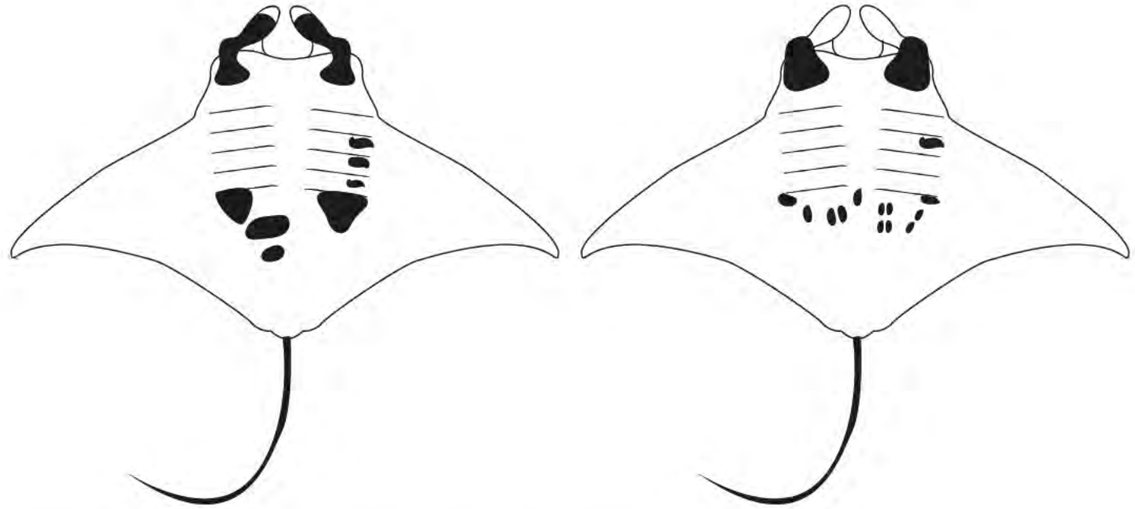


Figure:06- Ventral side of two manta rays showing the difference in markings on their belly.

These markings are unique to each individual, much like how the human fingerprint works. Key threats to manta rays worldwide include being caught for their gill plates, and being caught as bycatch, impacts of climate change on food availability to manta rays, habitat loss and also marine pollution.

Due to these threats and decline in populations, manta rays are classified as "Vulnerable (VU)" in the IUCN Red List of Threatened Species.

POP UP FACT

Manta rays have the largest brain to body ratio of any cold blooded fish living in the sea! They are highly intelligent and also curious.

Seagrass Ecosystems

The lush gardens underwater

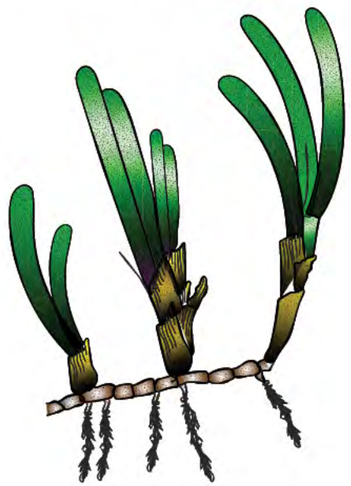
Questions

1. How many species of seagrass are found in the Maldives?

- ☐ 2
- ☐ 7
- ☐ 8
- ☐ 6

2. Can you identify the species of seagrass in the picture below?

- ☐ Halophila ovalis
- ☐ Thalassia hemprichii
- ☐ Halodule pinifolia



Found in nearly all the seas around the globe, usually in shallow waters adjacent to the coast or in depths up to 60m deep are underwater gardens made up of marine plants called seagrass.

They can spread and grow in large areas, often forming seagrass meadows of several species. Seagrass meadows are a highly diverse and important ecosystems that provide shelter and food for a variety of marine life and also keep our oceans healthy.

In tropical regions, seagrass ecosystems are interconnected to mangroves and coral reef ecosystems. These three habitats work together to keep their associated animals healthy, and support the different stages of lifecycles of marine animals.

What are seagrasses?

Oftentimes seagrasses are mistaken for seaweeds (a type of algae) due to their similar appearances. Seagrasses are actually flowering plants with roots, stems, and leaves, which produce flowers and seeds.

Seagrasses are also closely related to land plants. They evolved and adapted to life underwater around 100 million years ago.

There are around 60 different species of seagrass found around the world.

POP UP FACT

In a single day, a turtle can feed on up to 2 kilograms of seagrass!

Main distinguishing features to observe in seagrass species identification

This diagram has all the features of different species of seagrass

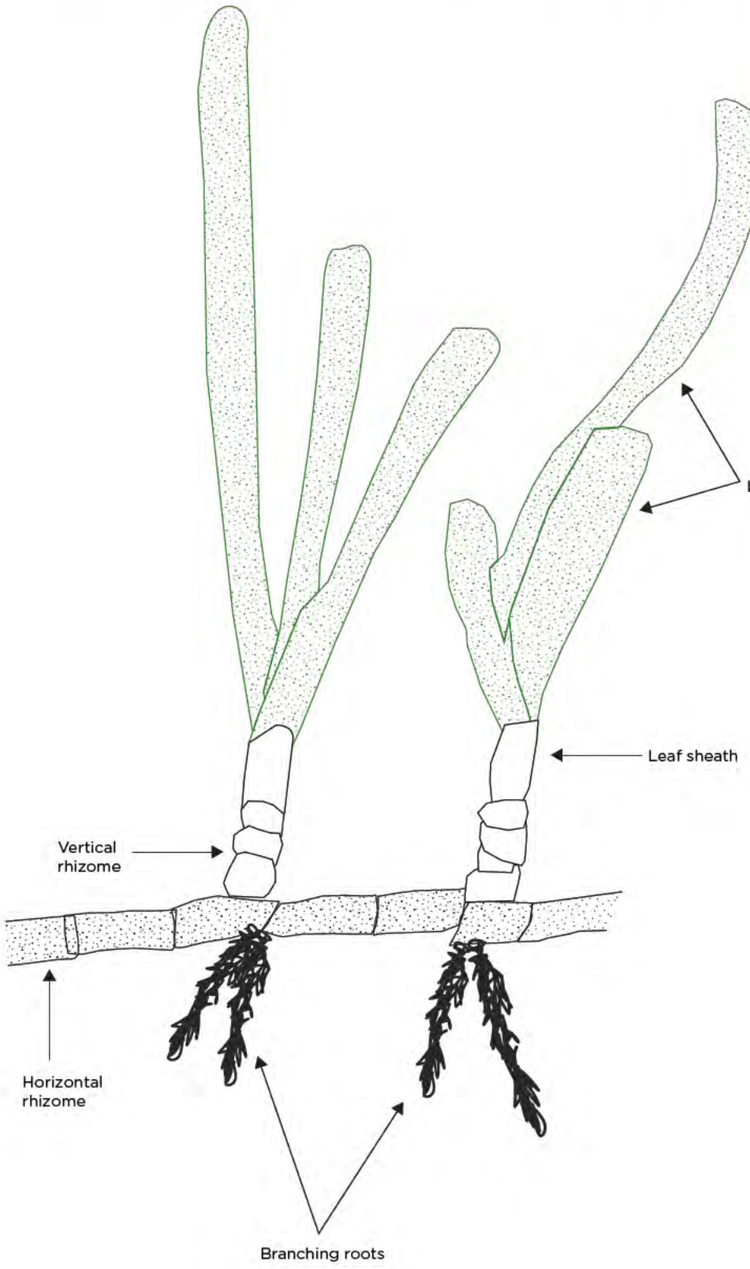


Figure:07- Features of different species of seagrass.

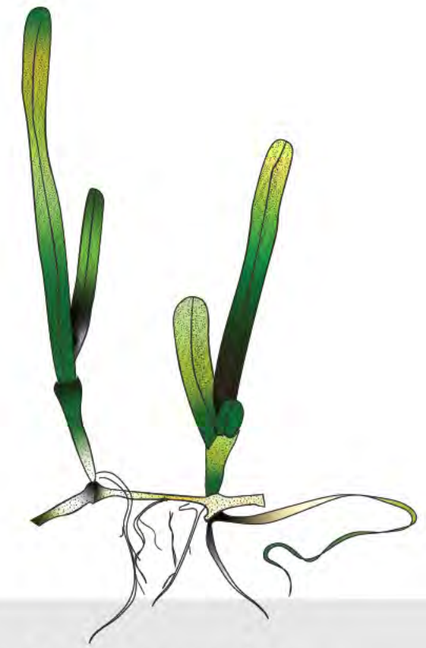
Seagrass species of Maldives

Tropical regions in the Indian and western Pacific oceans have the highest seagrass diversity in the world, with as many as 14 species growing together. This is probably because seagrasses evolved first in this part of the world, giving it more time to diversify in this region.

The western Indian ocean is home to 13 species of seagrasses, and in Maldives, 7 different species of seagrass have been recorded.

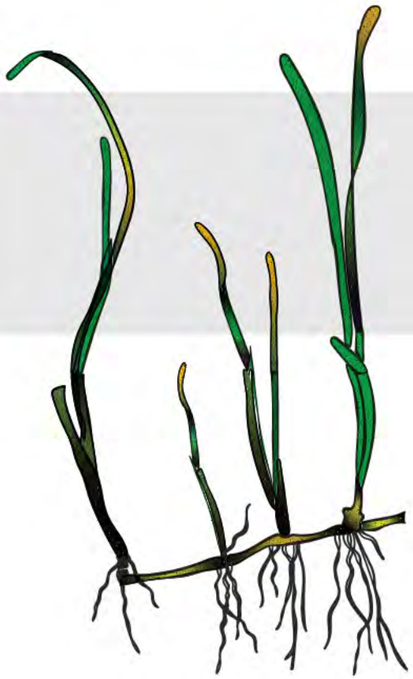
POP UP FACT

Seagrass plays an important role in the fight against climate change as seagrass meadows are known to absorb large amounts of carbon dioxide from the seawater.



Cymodacea serrulata
- serrated leaf tip
- wide leaf blade (5-9mm wide)
- leaves 6-15cm long
- 13-17 longitudinal veins
- robust/strong rhizome

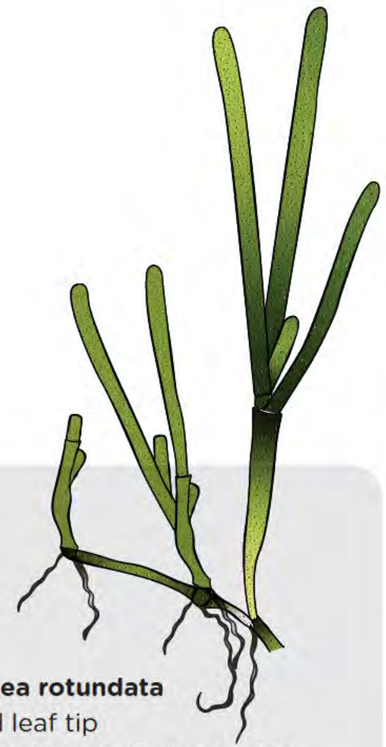
Halophila ovalis
- 8 or more cross veins
- no hairs on leaf surface
- leaf margins smooth
- leaf 5-20mm long



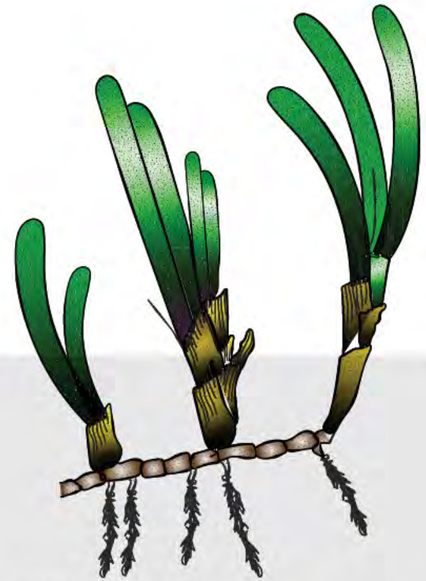
Halodule pinifolia
- rounded leaf tip
- 1 central vein
- usually pae rhizome, with clean black leaf scars

Thalassodendron ciliatum
- erect stem up to 65cm long bearing leaf cluster
- rhizome tough and woody
- ribbon-like, sickle-shaped leaves with ligule
- round, serrated leaf tip
- often found attached to rock or coral

Syringodium isoetifolium
- narrow spaghetti-like leaves
- cylindrical in cross section, 1-2mm diameter
- leaves contain air cavities
- leaf tip tapers to a point
- leaves 7-30cm long



Cymodocea rotundata
- rounded leaf tip
- narrow leaf blade (2-4mm wide)
- leaves 7-15cm long
- 9-15 longitudinal veins
- well developed leaf sheath

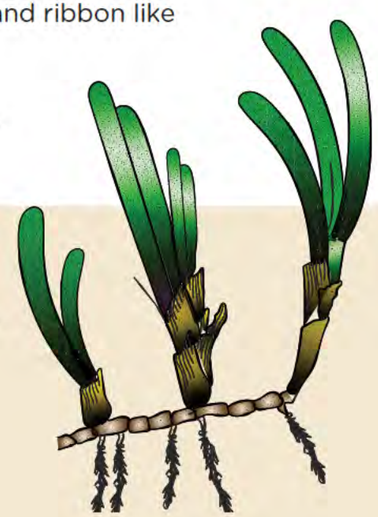


Thalassia hemprichii
- ribbon-like curved leaves 10-40cm long
- leaf tip rounded, slightly serrated
- short black tannin cells,
- 1-2mm long, in leaf blade
- thick rhizome with scars between shoots

Activity

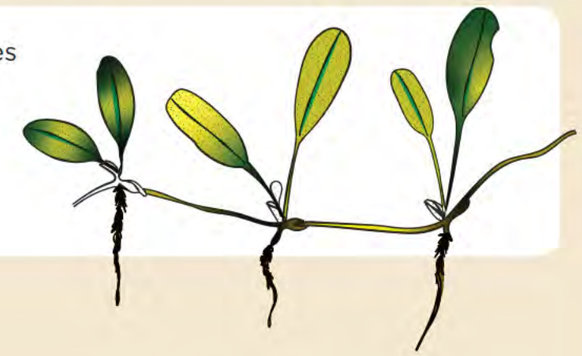
Identify the following seagrass species found in Maldives based on the features provided.

* Rounded leaf tips
* Leaves are 10-40 cm long in length, curved and ribbon like
*Slightly serrated leaf tips
*Thick rhizomes with scars between shoots
*Short black bars of tannin cells in leaf blades



Answer: _____

* 8 or more cross veins in the leaves
* Leaves are oval shaped
* Leaf margins are smooth
* 5-20mm long leaves
* No hairs on leaf surface

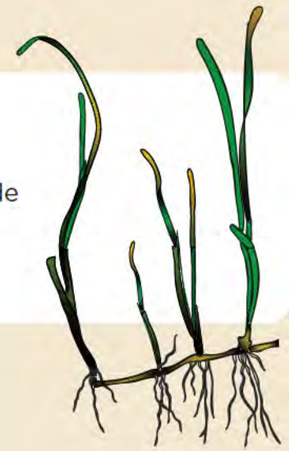


Answer: _____

* Serrated leaf tips
* Leaf blades are 5-9mm wide
* Leaves are 6-15cm long
* Rhizome is smooth and have fibrous roots on shoot
* 13-17 longitudinal leaf veins

Answer: _____

* Leaf tips are rounded
* One central vein
* Leaf blade is less than 20cm long and 0.02-0.1 cm wide
* Short erect stem with numerous leaf scars
* Very narrow leaf blade



Answer: _____

* Leaf blade 7-30cm long and 0.1-0.2 cm wide
* Leaf tips are tapers to a point
* Leaves blades are cylindrical
* Erect stem at each node bearing 2-3 leaves
* Smooth rhizome and has 1-3 small branded roots

Answer: _____

Threats to seagrass beds

Unfortunately, seagrass meadows are also lost at an alarming rate worldwide due to pollution, destruction of environment, dredging, modifications to water flow, climate change, and removal of seagrass beds for aesthetics.

Overfishing of seagrass associated fauna

Removal of seagrass related fish or fauna can cause disruption of the food web. When large predators are overfished, the balance of the food web is lost and causes decline of smaller organisms that helps to keep the blades of seagrass healthy.

Climate change

Seagrass is vulnerable to effects of climate change such as increase in ocean temperature, sea level rise and increase in frequency and intensity of storms. Severe storms can also uproot the seagrasses and kill them.

Coastal development, dredging and reclamation

These human activities can cause increase in water turbidity and direct removal of seagrass habitats. Being smothered by disposed debris and sediments also kill seagrass beds.

Lack of awareness on the importance of seagrass beds

Lack of awareness on the importance of seagrass beds by local communities and government officials can lead to approval of activities that cause destruction of these important ecosystems.

Land based pollution

Pollution from sewage and industrial waste can cause algal blooms due to excessive nutrient inputs. Overgrowth of algae consumes oxygen and blocks sunlight required for photosynthesis within seagrass beds. The increased amounts of pollution can also kill seagrass beds and hinders their growth.

Want to learn more about seagrass and help to conserve them?

Join **www.seagrasswatch.org,** which is a global seagrass observing network where scientists and local citizens can actively monitor the status and trends in seagrass conditions. You can sign up to be a seagrass spotter and help to contribute to the mapping of the vulnerable seagrass beds of Maldives.

Field Activity

Explore whether there is presence of seagrass in a particular area near you and identify the seagrass species present.

Items needed:
• Phone with GPS
• Waterproof camera
• Mobile application Seagrass Spotter installed / or go to the web portal https://seagrassspotter.org
• Use Pages 75 to 77 as a guide to identify the seagrasses

Instructions:
(1) Take a photograph of the seagrass you see.
(2) Note down the location by writing the GPS coordinates of the place where photograph was taken.
(3) Open the Seagrass Spotter app and select "Take a sighting" and follow the guidelines in the app or web portal.
(4) If you do not have access to the internet, refer to page 75 to 77 in the book to find out the different species of seagrass you have found in this area.

POP UP FACT

Maldives Underwater Initiative and Bluemarine Foundation have initiated a campaign to protect 80% of the seagrasses in the Maldives.

Follow the movement, #protectmaldivesseagrass / **www.maldivesresilientreefs.com**

Activity

Answer True or False for the following questions about seagrasses.

1. Seagrasses can help play an important role in fighting climate change
☐ True ☐ False

2. Maldives is home to 7 out of 13 species of seagrass found in the West Indian Ocean.
☐ True ☐ False

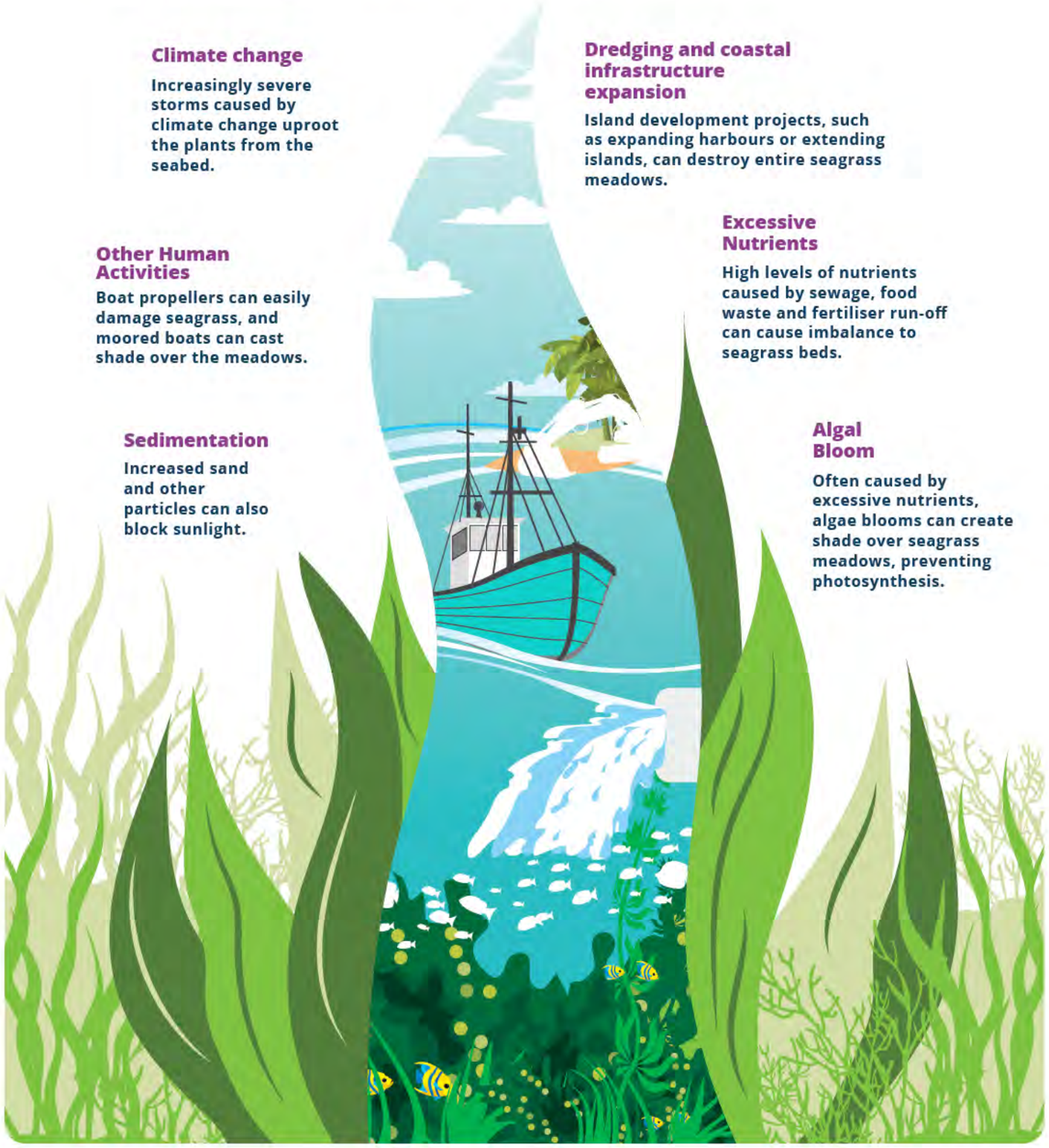
3. Seagrass provides food for keystone organisms such as green turtles.
☐ True ☐ False

4. Awareness of the importance of seagrass beds can help protect seagrass meadows
☐ True ☐ False

5. Seagrass can provide some coastal protection due to their extensive root systems
☐ True ☐ False

GLOBAL THREATS TO SEAGRASS

Seagrass meadows play an important role in the fight against climate change, and provide nutrients and shelter to many marine animals. Yet several factors threaten their survival, and we are losing global seagrass meadows at a rate of up to 7% per year.



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Mangroves

A field guide to mangroves in Maldives

Questions

1. Do you know any historical uses of mangroves in Maldives?

- ☐ Boat building
- ☐ Tourism
- ☐ Medicinal purposes

2. What kind of invertebrates would you expect to find in mangroves?

- ☐ Spiders
- ☐ Fiddler crab
- ☐ Mud creeper snail
- ☐ All of the above

What are mangroves?

The term mangrove may be used to refer to both an individual mangrove plant and to the habitat or ecosystem in which it lives. Mangrove forests are diverse communities growing in the chiefly tropical, intertidal coastal swamps. They have numerous tangled roots that grow above ground and form dense thickets.

Plants growing in the intertidal zone are subjected to a variety of challenges, such as changes in salinity, water temperature and supply of nutrients based on the tidal flow. Soils of the intertidal zone are usually soft and muddy and are often anaerobic (low in oxygen). Mangrove plants are unique in their ability to grow in such a dynamic environment.

How mangroves tolerate their environment (adaptations)

1. Waterlogged soils with low oxygen

The mangrove plants have adapted to these anaerobic conditions by developing special above-ground roots called pneumatophores, which stick out into the air even during high tide. These roots are covered in tiny pores called lenticels to allow the plants to breathe more effectively. Pneumatophores allow gaseous exchange and they also provide support to the plant.

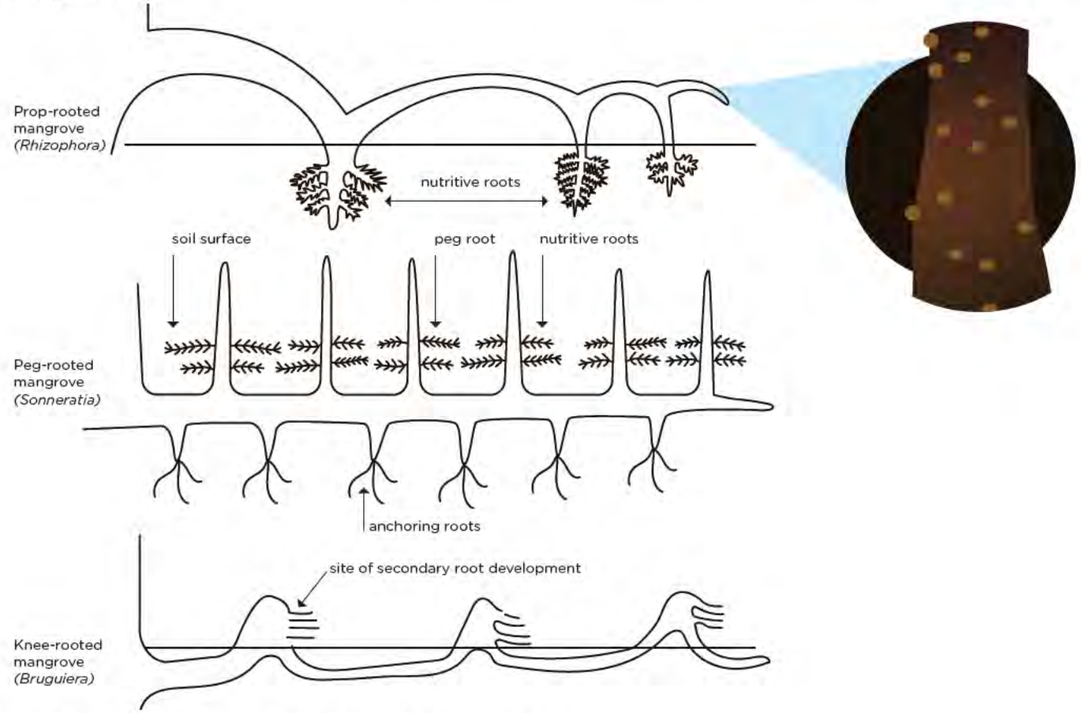


Figure:08 - Types of specialized roots found in mangrove trees.

2. Changes in salinity

Mangrove lakes and ponds are often saline due to the proximity to the sea. Most of the water is filtered by the roots before uptake, though some of the salt is still taken up. This salt is then stored within leaves, stems and roots.

In some species, salt is secreted from special leaf glands (e.g. grey mangrove), while others just store the salt until the leaves shed. Mangrove leaves can also orient themselves to avoid the midday sun and prevent water loss.

3. Seed dispersal and propagation

Unlike most seeds that germinate after parting with the parent plant, many mangrove plants are viviparous, which means that the seeds start growing while still attached to the tree. When the seedling is big enough to survive, it falls into the water or mud. The thin, pointy seedlings easily stick to the mud, or get carried by water to be planted elsewhere. The little plants growing in mangrove soil can withstand wave action and strong winds.

The propagule remains dormant until it finds good enough soil to grow in. Other species within the same group of plants, called the Rhizophoraceae family (including kandoo and randoo) reproduce in a similar way. However, there are mangrove plants that reproduce the conventional way such as Lumnitzera and Xylocarpus species.

Figure:09 - Propagule formation process observed in some mangrove species.

Fill in the blanks

NAME OF THE MANGROVE STRUCTURE	FUNCTION
	To maximize breathing and provide physical support
Specialized leaves	
Buoyant seedling	
	To easily stick into the mud and grow

Mangrove species of Maldives

Mangroves in our islands are often found in enclosed or semi-enclosed brackish water bodies locally known as “kulhi” or in muddy areas without standing water known as “chasbin”.

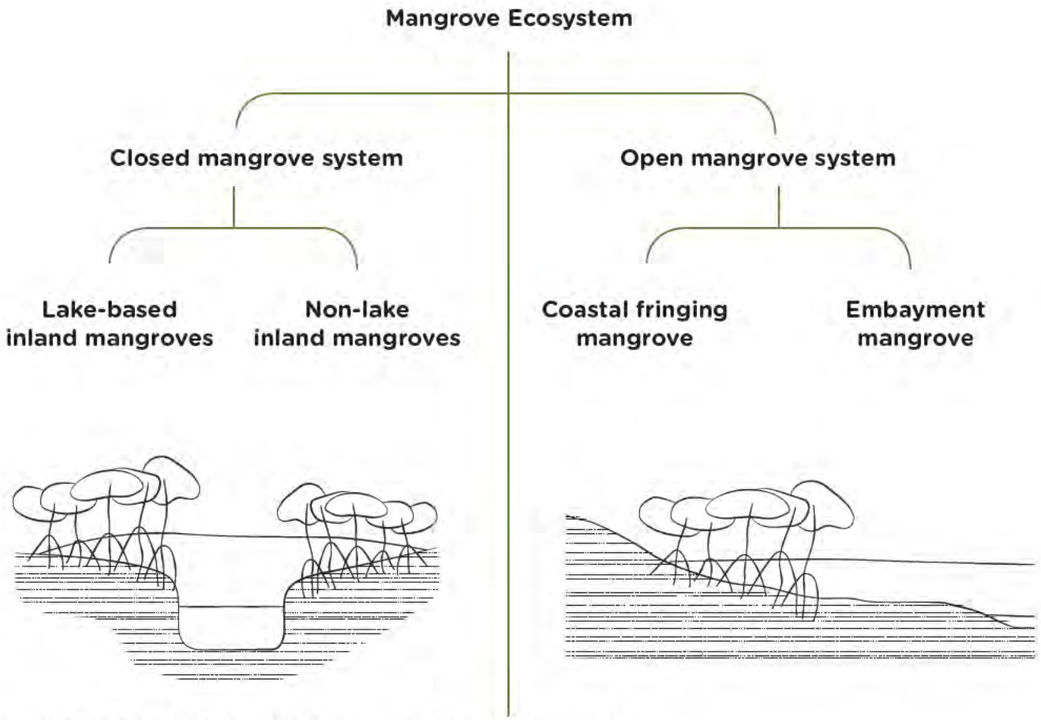


Figure:10 & 11 - Outline of the physical process within mangrove system

The mangrove habitats in Maldives are relatively small in size but show diversity in the species found in different islands. The composition, diversity and abundance of mangrove fauna vary from island to island, with most islands consisting about 4 to 5 true species of mangroves.

However, these trees are often found together with ‘mangrove associate species’ forming thick and healthy vegetation. Mangrove associate species such as **Hirundhu** (*Thespesia populnea*), **Kashikeyo** (*Pandanus sp.*) and **Kuredhi** (*Pemphis acidula*) are seen distributed in terrestrial habitats but they also occur in the mangrove ecosystem.

Do you know other species of trees often found near beaches and mangroves?

Mangrove species found in Maldives

	Common Name	Dhivehi Name	Scientific Name
01	Gray mangrove	ދަރު	Avicennia marina
02	Red mangrove	ތަނޑު	Rhizophora mucronata
03	Mangrove apple	ގަނޑަވަމް	Sonneratia caseolaris
04	Oriental mangrove	ދެއަވަށ	Bruguiera gymnorrhiza
05	Small leaved orange mangrove	ހަނޑު	Bruguiera cylindrica
06	Tall stilt mangrove	ތަކަވަށ	Rhizophora apiculata
07	Yellow mangrove	ހަތަދަހަ	Ceriops tagal
08	Cedar mangrove	ދަރު	Xylocarpus moluccensis
09	Black mangrove	ދުންފަ	Lumnitzera racemosa
10	Looking glass mangrove	ހަހަތަވަމް	Heritiera littoralis
11	Milky mangrove	ތުވަ	Excoecaria agallocha
12	Mangrove fern	ފަނާ	Acrostichum aureum
13	Mangrove vine	ތުވަވައްރ	Derris heterophylla
14	White burma mangrove	- - -	Bruguiera sp.
15	Haines’s orange mangrove	ހުވަވަށ	Bruguiera hainesii
16	Up river orange mangrove	ފަވަނާ	Bruguiera sexangula

POP UP FACT

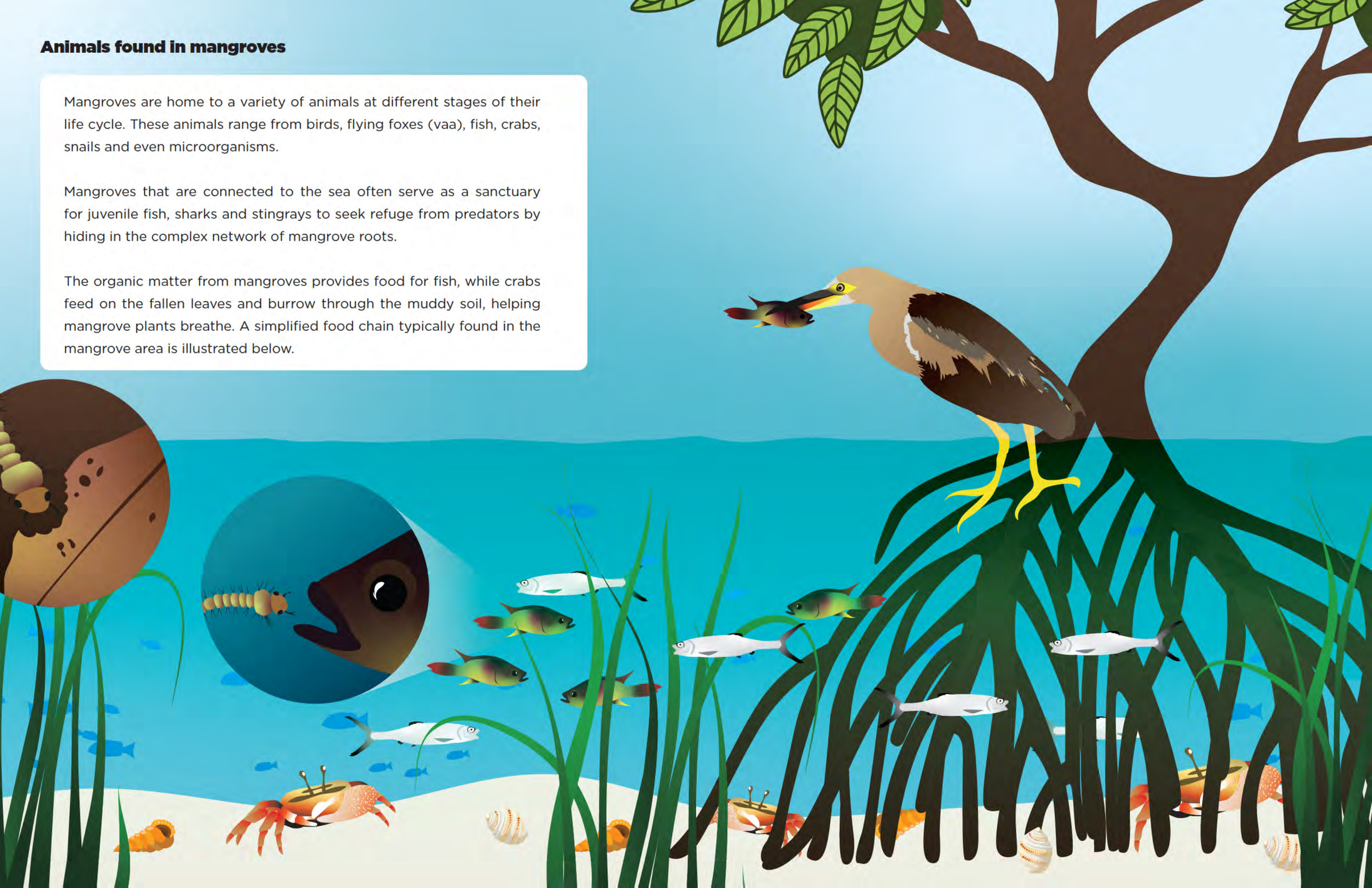
The first recorded observation of Haines’s Orange Mangrove (ހުވަވަށ) in the Maldives was in HA. Kelaa’s protected area. Classified as Critically Endangered on IUCN Red List of Threatened Species, fewer than 300 trees have been recorded worldwide so far, and 4 of them are in Kelaa’s mangrove ecosystem.

Animals found in mangroves

Mangroves are home to a variety of animals at different stages of their life cycle. These animals range from birds, flying foxes (vaa), fish, crabs, snails and even microorganisms.

Mangroves that are connected to the sea often serve as a sanctuary for juvenile fish, sharks and stingrays to seek refuge from predators by hiding in the complex network of mangrove roots.

The organic matter from mangroves provides food for fish, while crabs feed on the fallen leaves and burrow through the muddy soil, helping mangrove plants breathe. A simplified food chain typically found in the mangrove area is illustrated below.



Can you name common species of animals found in mangroves?

01

_____

02

_____

POP UP FACT

*Mangroves are found to be the most important breeding and feeding grounds for the endemic **Huvadhoo raabondhi** (Ardeola grayii phillipsi). Seabirds such as the pond heron bring important marine nutrients to islands, connecting the marine and terrestrial habitats.*

Field Activity

Take a walk through a mangrove system.

Applying what you learned about food chains, complete the following activity.

(1) A producer (anything that can photosynthesize)
(2) Primary consumer (herbivore that feeds on the producer)
(3) Secondary consumer (a carnivore or an omnivore that feeds on the primary consumer)
(4) Decomposer (organisms feeding on decaying organic matter such as dead plants and animals)

Draw a food chain based on your observations

MANGROVES

Why are mangroves important?

Until recently, a lot of the mangroves in islands have been viewed as wastelands to dirty 'mosquito ridden' places with little or no value. However, historically, mangroves have been used as an important source of timber and food, as well as integrated in traditional coir rope making.

Mangroves are slowly becoming popular as recreational sites celebrated for its natural beauty and potential for ecotourism. But perhaps the most important ecosystem service provided by mangroves lay in its ability to provide coastal protection and mitigate the effects of climate change.

POP UP FACT

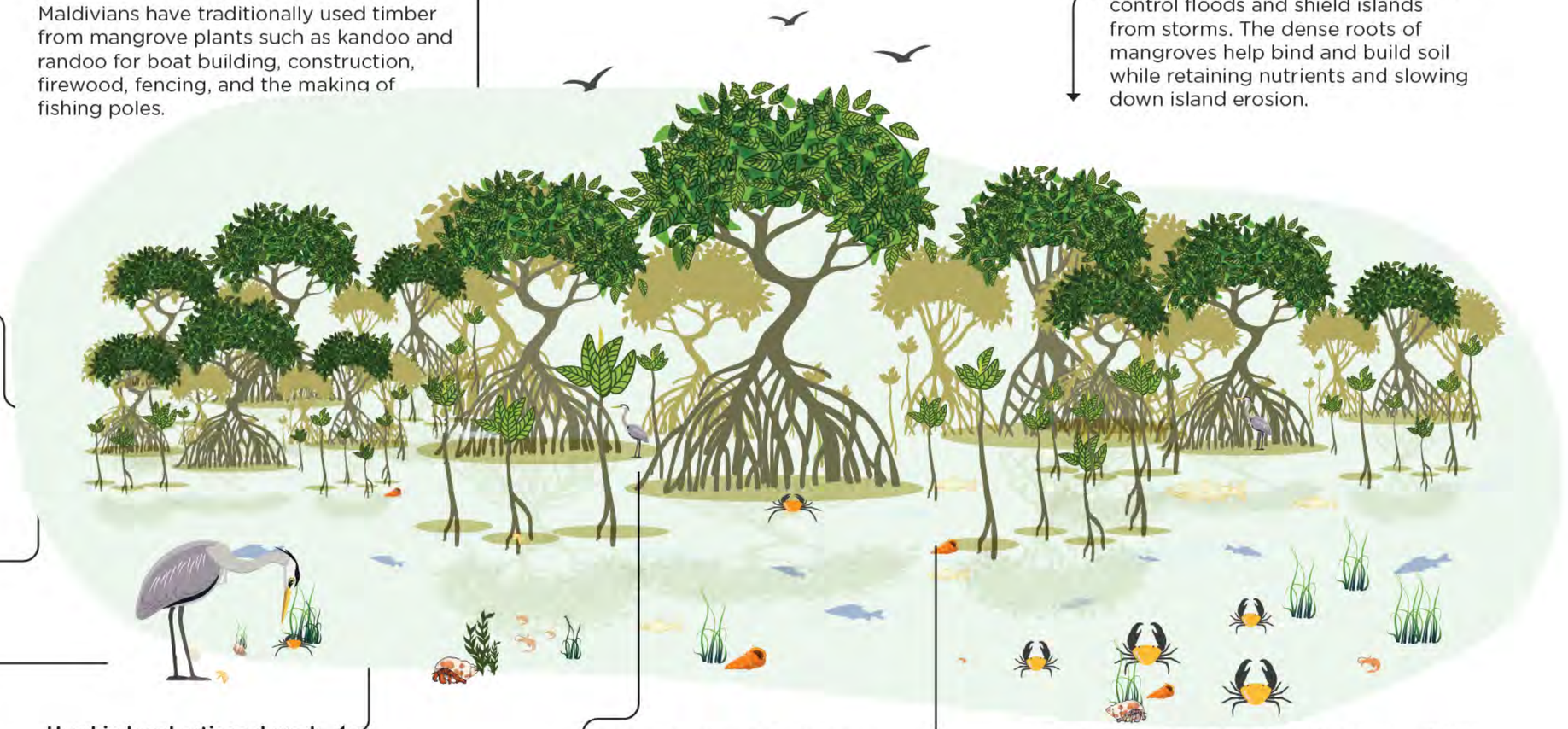
The mangrove pond located in Laamu Gan is often dubbed the 'Paree fengandu' or 'Naraka fengandu', with tales of local folklore on fairies that spend the night in the pond bathing, or things mysteriously disappearing into the pond only to emerge from the "Haddhoo Kandu" situated between Laamu and Thaa Atoll.

Timber harvesting

Maldivians have traditionally used timber from mangrove plants such as kandoo and randoo for boat building, construction, firewood, fencing, and the making of fishing poles.

Coastal defense by mangrove trees

The network of mangrove trees help control floods and shield islands from storms. The dense roots of mangroves help bind and build soil while retaining nutrients and slowing down island erosion.



Recreational use

Kids like to visit mangroves for picnics and to catch tilapia or play. More and more, mangroves are currently being managed as eco-parks for local tourism and for recreational purposes, providing important economic benefits.

Prevents sedimentation in coral reefs

Mangroves also have a special relationship with coral reefs, where mangroves benefit from the calmer water provided by the reefs while the filtered water from mangroves help coral stay healthy.

Important habitat supporting biodiversity

Mangroves contain many unique species of plants and animals, which help to sustain biodiversity. These habitats also connect the sea and the marine environment, and provide energy flow.

Used in local artisanal work

It is also a common practice to have coconut husks used for coir rope making to be soaked in mangrove ponds. The clay from mangrove ponds were also used for making pots in islands such as HDh. Kulhudhuffushi.

Climate change mitigation

The high rates of plant growth, coupled with anaerobic water-logged soils which slow decomposition result in more carbon dioxide being stored by mangroves than released into the atmosphere via respiration.

Source of food and traditional medicine

Kandoo, ku'lhavah and beyngu (milk fish) are still consumed to this day, while the bark of mangroves are used in local medicine. During the Second World War, the mangroves served as important food sources in islands such as HA.Kelaa

Threats to our Mangroves

Mangroves across the world are in danger of destruction, and there are a number of reasons their futures are at risk.

Lack of Awareness

Many people view mangroves with contempt; they're seen as smelly, useless and a breeding ground for mosquitos. This lack of understanding of the benefits that mangroves bring means that communities do not seek to protect them, and are quick to accept their destruction.

Pollution and Trash

Fertilizers and pesticides that drain into the mangroves from nearby fields can kill the creatures that inhabit them. Likewise, when oil leaks from boats it covers the mangrove roots in a thin film and suffocates the trees. Discarded household waste endangers the wildlife whilst sewage causes algal growth that in turn kills the marine life.

Rising Sea Levels

In order to survive long-term, mangroves rely on stable sea levels. The current rise in sea levels caused by global warming and climate change threatens the future of Maldivian mangroves.

Felling of Mangrove Trees

Felling of mangrove trees and habitat destruction, including the reclamation of land for human settlements, harbours, tourism developments and industrial areas has become a bigger threat than others.

Destruction of Coral Reefs

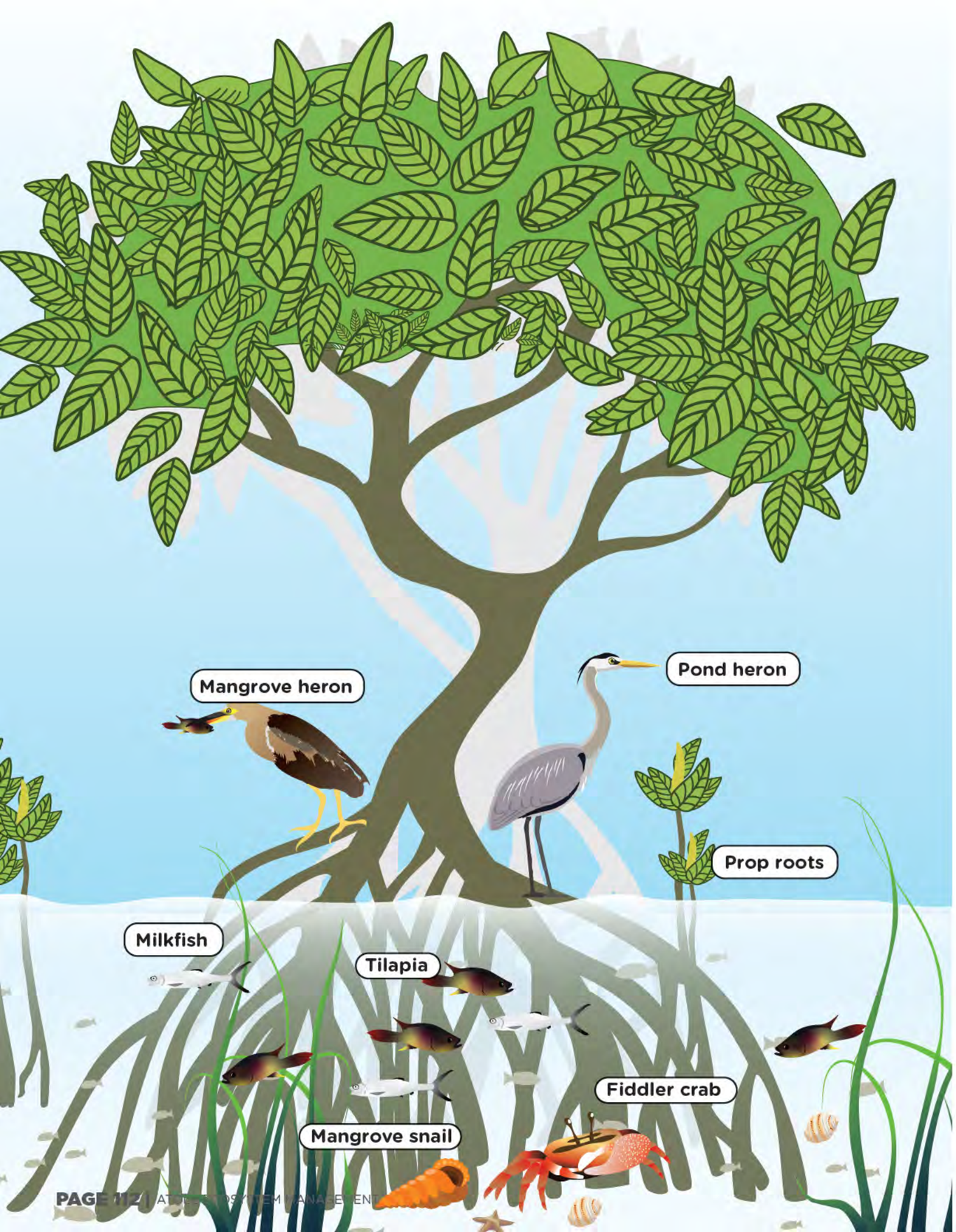
As well as protecting our islands, coral reefs also protect our mangroves by acting as a barrier against currents and strong waves. When they are destroyed, this can undermine the fine sediment in which the mangroves grow, which results in essential nutrients being washed away and seedlings failing to take root.

How are mangroves beneficial to islands?

Although mangroves might appear lifeless in comparison to the frenetic activity you can find along coral reefs, dismissing them as useless is a grave mistake.

Mangroves are actually complex ecosystems and are comparatively more productive than any other type of forest. Just like any other ecosystem, they provide a whole range of services and goods to their environments and to the people who live nearby.

These services are classified into four categories: provisioning, regulating, habitat and cultural.



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Effects of Climate Change

Questions

1. What do you think is the difference between climate and weather?

- ☐ The weather conditions describe the climate conditions that have been observed over time.
- ☐ Weather refers to short term changes in the atmosphere while climate describes the weather conditions that have been observed over an extended period of time

2. How do scientists learn about past climates?

- ☐ Ice cores
- ☐ Biological materials preserved in geological record
- ☐ Through diatoms

3. Name 3 factors that contributes to sea level change

(a) _____

(b) _____

(c) _____

Understanding Climate Change

Climate change may be the biggest challenge humanity has had to face since the Industrial Revolution. In this chapter, we will look into what climate change is, what is causing it, and its effects on the environment, as well as what could be done moving foward.

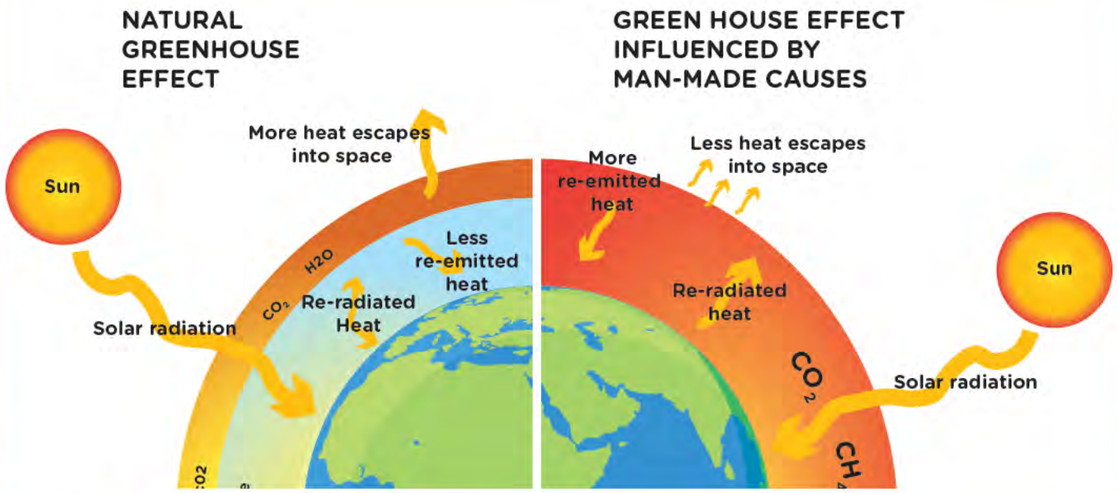


Figure:12 - Greenhouse effect: natural causes compared with human influence.

What is climate change?

Climate describes the weather conditions that have been observed for many years and can be predicted for a particular region based on the time of the year. Weather is a temporary status of the atmosphere —its temperature, humidity, wind, rainfall and so on over the course of days.

Earth's climate depends on the delicate balance between how much heat energy is gained by Earth (incoming solar radiation), how much is given off (outgoing thermal radiation) and the composition of Earth's atmosphere which determines how much heat is trapped. The influence it has on the oceans, land surfaces and ice sheets, which together with the atmosphere form what is called the 'climate system'.

Climate change refers to the unnatural variations in Earth's average climate. These variations have been increasing at an alarming rate over the last century. This means that while some places are getting uncharacteristically warmer and drier, other places are experiencing heavier rain, or more intense storms. In general, weather patterns are becoming less predictable compared to before.

Ways climate change is affecting the Maldives (and the world!)

Hotter days

The scientific community is in agreement that the world is getting warmer, and that this global warming is mainly due to human activities that emit greenhouse gases.

However, the world is not warming uniformly – not all places are getting warmer at the same rate. Some places, such as the Artic, are warming faster than others.

The Maldives Meteorological Service publishes a monthly Climate Report on their website in which they compare monthly maximum temperatures with long-term averages, and this is a great starting point for anyone looking to understand the changes in our temperatures.

Hotter temperatures can lead to species extinction, species migration such as fish stock and even force humans to migrate due to loss of vegetation and reduced availability of food and safe drinking water.

Threat to island biodiversity and water resources

Changes in climate makes the conditions of ecosystems less habitable for local species and more attractive to species and pests that may not be commonly found otherwise. Foreign species may find the changed conditions so favorable that they increase and multiply rapidly making driving out local habitants. Such species that have increased their range and proliferate rapidly are termed invasive species. Climate change therefore threatens the ability of local species to thrive and compete with foreign species, leading to loss of biodiversity.

In Maldives, the Nakaiy calender that has traditionally been observed to predict weather has become noticeably unpredictable in recent years. According to the National Meteorological Services, there is an overall decreasing trend in annual rainfall observed over the 3 regions of Hanimaadhoo, Malé and Gan.

Damage to coral reefs and coastal wetlands

The coral reefs in the Maldives were among the most affected in the 1998 El Nino bleaching event in the tropical Indian Ocean. The good news is that there is some evidence suggesting that coral reefs have a fighting chance to recover in the absence of other environmental stresses such as pollution of the habitat.

High temperatures, sea level rise and increased salinity of the ocean also threatens the survival of mangroves, making them more vulnerable to diseases and unable to tolerate the changing conditions. This can result in die back of mangrove forests.

Sea level rise, inundation, and shoreline change

Since the last century, the global mean sea level has been recorded to rise, with rates between 2.8 and 3.6 mm per year since 1993. While sea level rise poses the most widely recognized threat to small, low lying countries such as Maldives, extreme weather events such as storm surges, high tides, and heavy rain, together with rising sea surface temperatures have led to coastal inundation, beach erosion and the destruction of property in many areas.

In countries such as Maldives where much of the infrastructure is located in coastal zones with limited opportunities for relocation, it makes communities particularly vulnerable.

POP UP FACT

A large amount of CO_2 in air gets dissolved in the ocean, forming carbonic acid. This is called ocean acidification, which poses a risk to shelled organisms, as carbonic acid can cut through the material their shells are made of.

POP UP FACT

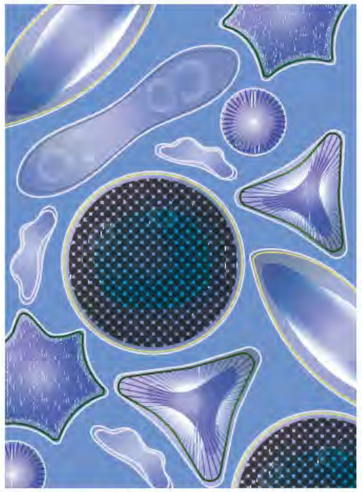


Illustration of diatoms

When studying past climates, scientists use records from physical, chemical and biological materials preserved within the geologic record.

The characteristics of preserved diatoms, foraminifera or corals can tell scientists what the weather conditions were like millions of years ago. Evidence can be found in other climate proxies such as ice cores, tree rings, and sediment cores.

Questions

1. Which of these statements best describe the greenhouse effect on Earth?

- ☐ The entrapment of heat energy in Earth's lower atmosphere by gases such as carbon dioxide, methane and water vapour
- ☐ The absorption of sun's radiation by the surface of the Earth, trapping heat in the land
- ☐ The reflection of sun's radiation back into the space using glaciers

3. List 3 impacts of climate change on low lying islands such as Maldives

Activity

Comparing the extent of coastal changes in a Maldivian island in the last 20 years.

Materials needed:
Computer, paper and 2 pencils (optional), Google Earth Pro

Methodology:
1. Install Google Earth Pro on your computer (search and download from the Google Earth website)
2. Open Google Earth on your computer
3. Enter the name of the island you want to look at in the search bar. The island will appear on your screen
4. Go to View, and then select Historical Imagery
5. Observe the coastline of the chosen island, especially the beaches
6. Use the time slider to move between years (every 5 years or so for 20 years) and observe the changes in the beach and coastline.
7. Trace the outline of the island on a piece of paper at the present year, and again at 15 years ago on the same paper using a different color.

Discussion:
1. What did you observe, especially around the coastal line?

2. Do you see any signs of the above mentioned impacts of climate change, such as erosion and changes in the coastal area of islands?

3. Are there any visible coastal modifications made (harbor/breakwaters) within the time frame observed? If yes, why do you think it was built?

Marine & Chemical pollution

Questions

1. What are some of the most common marine pollutants in Maldives ?

- ☐ Plastics, sewage water, food waste
- ☐ Oil, coconuts, industrial sludge
- ☐ Leaves, tar, metals

2. A major industry responsible for the release of chemical pollution in Maldives is

- ☐ Vehicle manufacturing industry
- ☐ Agriculture industry
- ☐ Film industry

3. What is responsible for eutrophication and algal bloom in Maldives?

- ☐ Plastic pollution from fishing nets
- ☐ Oil spills
- ☐ Food waste, sewage and runoff from fertilizers

The contamination of the marine environment results from a combination of harmful chemicals and trash that find their way into the ocean.

Until somewhat recently, it was widely assumed that the vastness of the ocean would prevent any real damage to the marine environment regardless of what had been dumped into the sea.

In this chapter, we will look into the different types of trash and hazardous chemicals that are damaging the marine environment in Maldives, and the effect it has on marine life as well as humans.

Sources of marine pollution in Maldives

1. Household waste
2. Industrial waste (tourism, agriculture, boat building, energy)
3. Untreated sewage
4. Burning of waste

Due to the short distance from land to sea in Maldives, pollutants from both land-based sources such as solid waste and untreated sewage disposal and sea-based sources such as oil pollution and ballast water can lead to pollution of the coastal zone and the sea. Waste management is among the most challenging environmental problems in Maldives, with more and more waste being generated in islands as a result of population growth and the expansion of guest house tourism.

POP UP FACT

During a study conducted in 2019 by Maldives Whale Shark Research Programme, whale shark poop was found to have microplastics which were likely ingested while feeding on plankton. About 90% of the microplastics extracted were comprised of fibrous materials, likely from clothing during washing and broken down fishing gear.

Majority of the islands lack basic waste management facilities, and routinely burn landfills in open air and dump food waste into the sea.

Trash from landfills, beaches, or discarded from liveaboards and boats also add to marine litter. Additionally, the untreated sewage discharged into the sea also contains a concoction of polluting agents including pathogens, organic substances, heavy metals, trace elements, and waste water.

Figure:15 - Waste disposed on the coastal area of an island, open burning of landfill. Photo: EPA

Chemical pollution

As there is no industrial production of chemicals in Maldives, most of the hazardous chemicals released into the environment are due to the mishandling of imported substances. A majority of these chemicals are used in the form of petroleum products for energy and transport, agriculture, construction, boat building, in the health sector and for domestic uses.

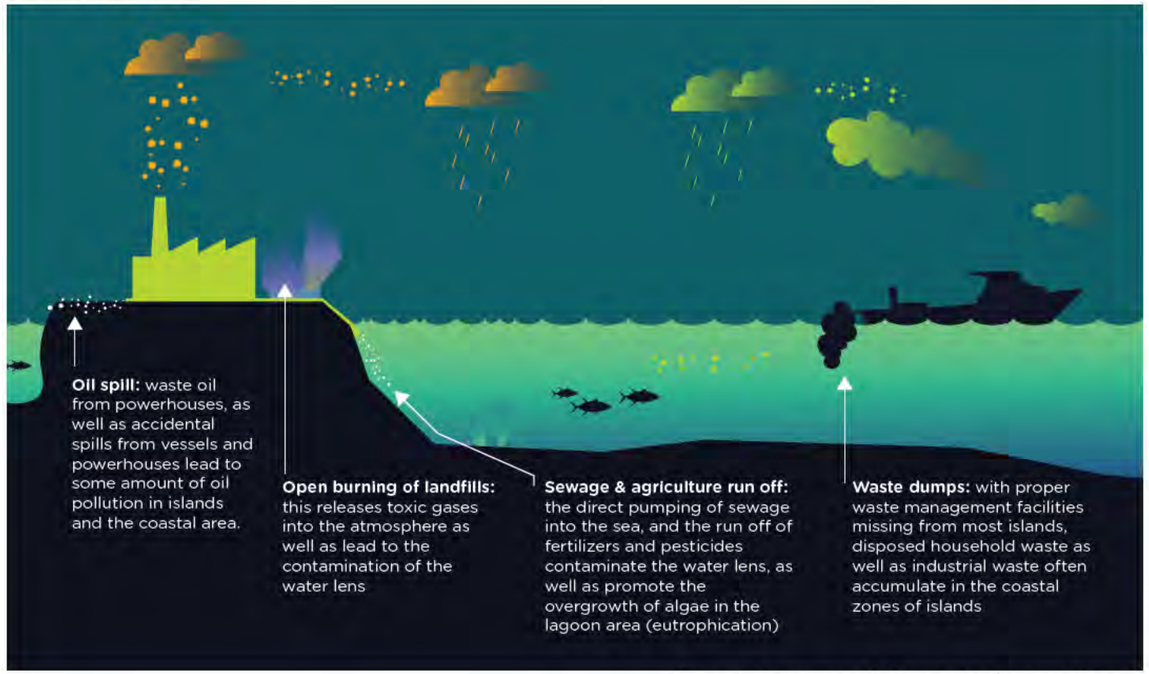


Figure:16 - sources of chemical pollution in islands

Chemical Pollutants: The Worst Offenders

Which chemicals cause the most damage to our oceans?

Insecticides

Used to kill insects, eggs and larvae, insecticides are a commonplace feature of modern life. They are not only used in agriculture either; some medicines are also classified as insecticides. And if we look under the kitchen sink, most of us will find a bottle of bug spray in our homes too.

Oil products and PAHs

It comes as no surprise that oil products such as diesel, crude oil and gasoline are damaging to the ocean. Polycyclic aromatic hydrocarbons (PAHs), on the other hand, are less well known. PAHs are found in oil products and are produced when substances such as wood and garbage are burnt.

Herbicides

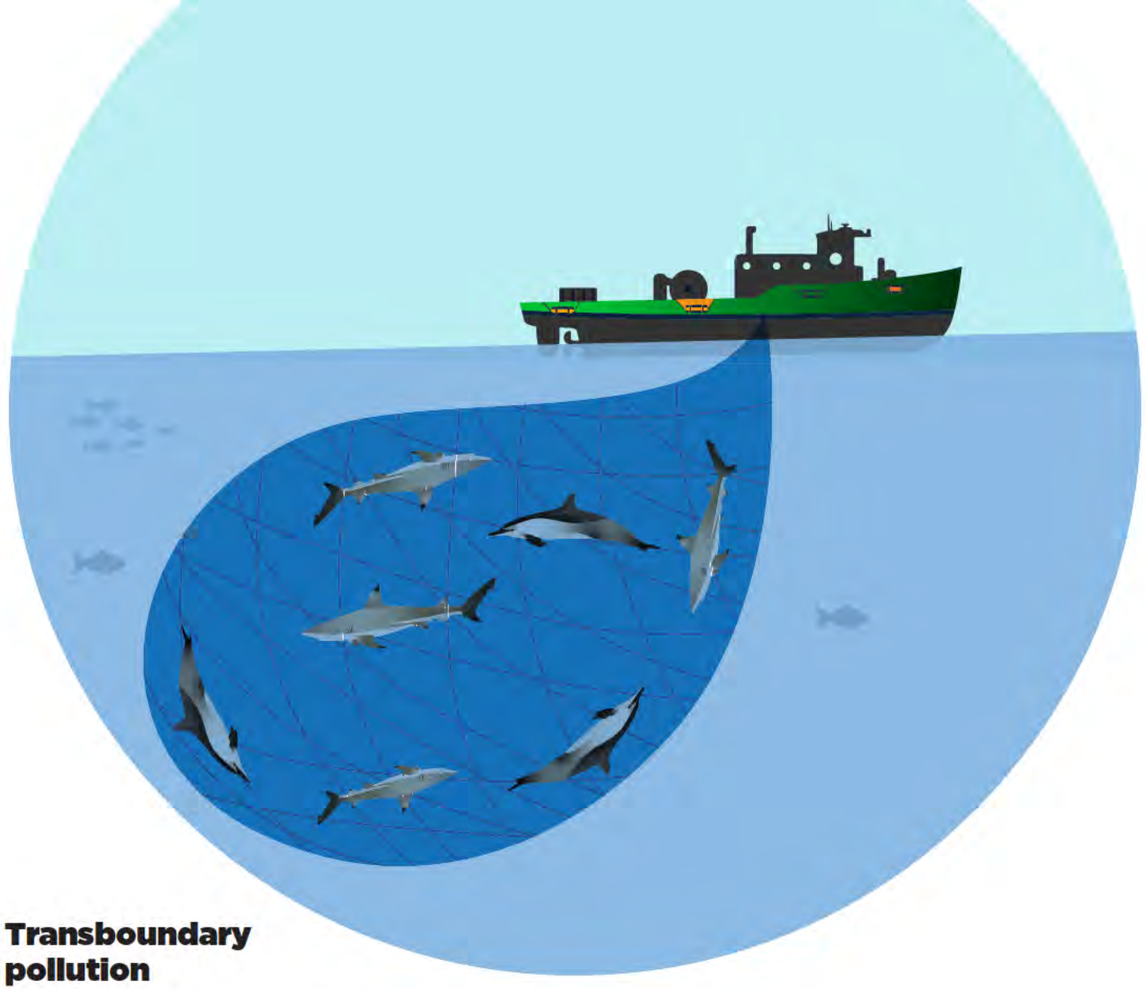
More commonly known as weed killers, herbicides are used to kill specific, unwanted species of plants. As well as being used in our own gardens, these chemicals are used on a wider scale in agriculture.

Metals

Certain metals such as mercury, lead, zinc and copper, are extremely toxic. Found in paints, anti-fouling agents and fungicides, these metals cause lasting damage at even at relatively low concentrations.

Anti-fouling agents

These industrial paints are applied on the hulls of sea vessels to prevent the growth of subaquatic organisms such as barnacles and algae. These agents are formulated from copper compounds and biocides, making them highly toxic.



Transboundary pollution

The connected nature of the oceans allow for marine litter from transboundary sources to affect the coastal environment and marine life in Maldives.

Some of these threats include persistent organic and heavy metal pollutants to the marine and coastal resources, accidental and deliberate oil spill along the tanker route in the region, and the continuous discharge and runoffs of pesticides and fertilizers from neighboring countries.

As the monsoon currents change, the island chain also acts as something of a trap for discarded drift nets, termed 'ghost nets', which trap and kill many marine species such as sea turtles, sharks, manta rays, and dolphins.

A large amount of these nets are used for trawling, as gillnets, purse seine and FADs (Fish Aggregating Devices) by different countries.

Plastic pollution

Plastic has become one of the most widely used materials globally and locally due to its convenience and cheap price. However, within only 100 years, plastics have become a monstrous environmental problem due its long-lasting nature, leading to pollution. Plastics are non-biodegradable and manufactured in large numbers to be used in almost every industry today.

At least 40 percent of the 8.2 billion tonne of plastics produced to this day have been used for packaging, to be used only once. From this, 79 percent is now piling up in landfills or spread out across the globe, especially in the oceans and coastal zones.

Figure:17 - Durability of debris

In Maldives about 291,733 plastic bags, 280,000 plastic bottles and 86,870 plastic straws are used every day. On average, each person in Male' generates about 1.7 kg of waste. In the rest of the inhabited islands, each person generates about 0.8 kg, and in resorts, it adds up to about 3.5 kg of waste per person.

A lot of this generated waste is sadly composed of plastics. Burning plastics release toxic fumes and Maldives does not have the capacity to recycle wasted plastics.Majority of it end up in landfills, coastal zones and the sea, where they degrade into microplastics.

Microplastics in their own right is another issue entirely, owing to its small size and susceptibility of ending up in everything from food, water, honey, to the air we breathe.

Microplastics are also a lot harder to clean up compared to its larger counterpart. It is estimated that currently there are over 51 trillion microplastics floating in the ocean. In fact, plastics are projected to outweigh the fish in the ocean by 2050.

Activity

1. List the types of waste created by each sector

Household	Agriculture	Tourism	Construction & Boat building

2. Analyzing microplastics found in the coastal zone

Materials needed:
1mm sieve mesh
Paper
Pen/Pencil

Methodology
1. Choose 3 different locations in the coastal zone of the island
2. Place the mesh on the soil, and scrape about 1kg of topsoil onto the mesh
3. Grab the mesh from all 4 corners and lift the sieve up into the air, and then move the sieve around till most of the fine sand gets sieved out
4. Place the mesh back on the ground, and collect the materials that remain
5. Make a list of all the different bits and pieces of foreign material you find
6. Repeat the process for the remaining 2 locations

Site 01

Site 02

Site 03

Discussion:
1. What are the most common materials sieved from the soil?
2. Did your findings surprise you?
3. What are some ways in which you can prevent these materials from ending up there?

Impacts of marine pollution

1. Food waste and sewage pumping in the sea

Municipal and industrial waste are known to increase the Biological Oxygen Demand (BOD) of marine waters. The nutrient rich food waste and sewage discharge have been linked to algal bloom and the unnatural growth of seagrass in some islands. Comparison of aerial photos from the 1960s and more recently in the 2000s show sudden growth of seagrass beds in the vicinity of islands following population growth. Mass fish kill events in Maldives have also been linked to poor water quality.

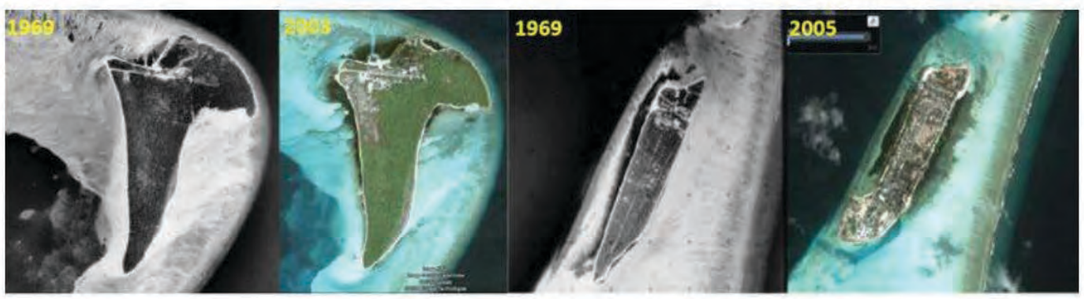


Figure:18 - Increase in the extent of seagrass with inhabitation and increase in population in B. Goidhoo (left) and K. Maafushi (right). Adapted from (BOBLME, 2010). Pic: EPA

2. Coastal landfills and open burning

Unmanaged landfills release harmful substances into the soil and water lens, which gets leached into the sea. Open burning releases Persistent Organic Pollutants (POPs) along with dioxins, furans and heavy metals into the soil and groundwater.

Due to the proximity of the land and sea in Maldives, these substances are likely to negatively impact marine life. Though the effects of POPs have not been assessed in Maldives, studies from other countries show that it may be related to population decline in a number of marine species.

3. Chemicals from industries

The heavy use of pesticides and fertilizers in islands have led to the degradation of soil and poor water quality. The excess amounts of nitrogen and phosphorus in groundwater has been linked to subsequent eutrophication. Leachates containing some fungicide are known to affect coral health by inhibiting fertilization and metamorphosis even at very low concentrations. Chemicals used in households, health industry and tourism industry also contribute to poor water quality. Some of the chemicals used in construction and boat building industries are harmful to human health, as well as marine life when washed into the sea by rain. There have also been instances of oil and tar spills into terrestrial and marine environments in recent years, which have led to the contamination of groundwater aquifers and marine life such as sea turtles being washed up with ingested tar.

4. Plastics and microplastics

The ‘single use and throw away’ culture of plastics have led to an alarming number of plastic waste being produced every day, especially in countries like Maldives where tourism is one of the main industries. The fact that plastics can breakdown into progressively smaller particles and easily enter the food stream, leading to bio accumulation of dangerous chemicals in humans and other living things is in itself a huge cause for concern. As most of the microplastics are found in the ocean, the contamination of sea food may have serious health implications for countries that rely on the sea for sustenance.

The presence of plastics on the beaches and the sea not only take away the aesthetics that bring happiness to many people, it can also be life threatening to a lot of animals that make use of these habitats every day. Of the 120 species marine species on the IUCN Red List of Threatened Species, 54 percent have been observed ingesting or been tangled in plastics. Different species of whales are frequently beached all over the world with their belly full of plastic bags, shoes, bottles and other marine debris.

In Maldives, more and more fish species caught for food are being reported to have plastics in their guts. Plastic marine debris along with discarded fishing gear also trap whales, dolphins, sharks, manta rays and turtles routinely. In the last 7 years alone, over 1000 sea turtles have been recorded trapped in these ghost nets in Maldives, with a lot of them sustaining serious injuries. In addition to marine species, 93 percent of sea birds are reportedly affected by plastics due to ingestion and entrapment. From the tiniest plankton to the largest whales, plastic poses a threat to all marine life like never before.

What can you do?

The problem of pollution started with people, and the good news is that it also gives us the power to reduce it. There are several things we can do even as individuals to lower pollution in our environment.

How to reduce your chemical footprint

Many of us try to minimise our carbon footprint by using eco-friendly means of transport and buying locally grown food. But what about our chemical footprint? It's easy to forget that many of the products we use on a daily basis are actually harmful to the environment. So follow these steps to reduce your impact on the oceans!

In Your Home

Use the minimum amount of detergent needed when washing your clothes.

Choose phosphate-free soaps.

Make your own natural cleaning products using baking soda, vinegar and lemon.

Avoid killing insects with bug spray.

Select organic produce at the supermarket.

Refrain from draining chemicals into the sewage system.

In Your GARDEN

Opt for natural fertilisers such as compost.

Apply pesticides only sparingly and follow best practice methods.

In Your CAR

Try to leave your vehicle at home when going short distances.

Clean up spilled brake fluid, oil, and grease.

On Your BOAT

Do not dump paint, oil, or anti-fouling agents into the ocean.

Service your engines regularly.

How chemical pollution is harming coral reefs

Unlike other forms of pollution, chemical pollutants are often invisible to the eye or soluble in water, making it easy to forget about the threat they pose to our oceans. But with an estimated 20% of coral reefs at risk from chemical pollution, the damage chemicals are causing is very real.

So how do chemicals reach the coral reefs in the first place?

Normally, the main way chemicals enter marine waters is through rivers and streams. When farmers use chemicals such as insecticides, herbicides or fertilisers, or when industries use chemicals to produce household goods, or even when we use cleaning products to clean our bathrooms, these substances contaminate the ground water and enter nearby freshwater sources. These rivers and streams then flow towards the ocean, carrying the chemical compounds with them, known as 'terrestrial runoff'. However, in the Maldives there are no such freshwater rivers. So the main way chemicals enter the ocean here is through island wetlands, the shore, sewage pipes and via oil spills, illegal dumping and marine activities that all contribute towards chemical pollution.

Why does this matter?

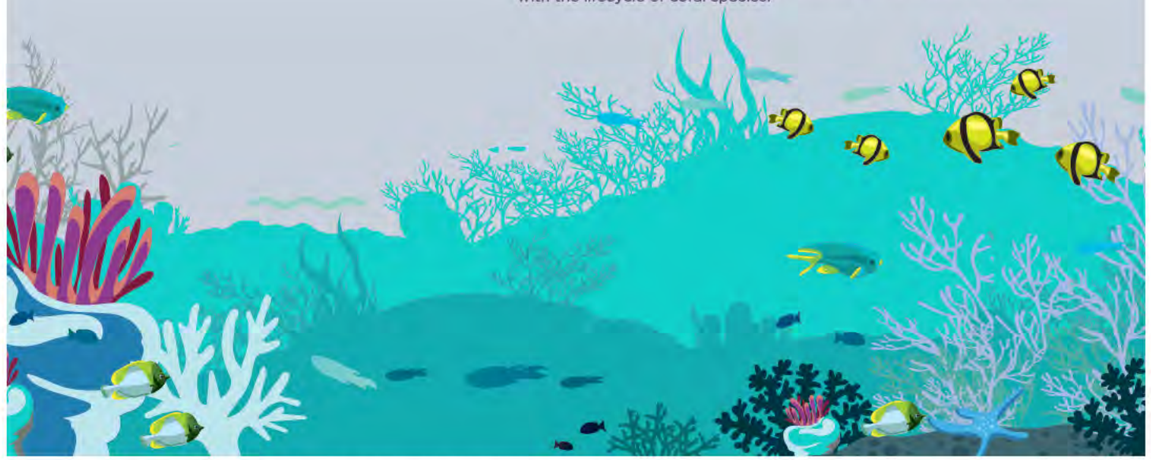
Many of these chemical substances, such as insecticides and herbicides, are specifically designed to kill. So it's unsurprising that coral species, which are renowned for being extremely sensitive to their surroundings, will react adversely to these compounds. And despite the fact that coral reefs are often in remote locations, far from urban development, the extent of pollution is such that approximately 20% of reefs are now at risk. In addition, their proximity to shipping lanes and often intense commercial activity, means coral reefs are at a higher risk of oil contamination.

But what if there's only a really small amount?

It's true that different chemicals cause different reactions in coral, and the severity of the reaction will depend on the concentration of the chemical in the water. However, insecticides, herbicides and fungicides have been shown to affect corals even at very low concentrations. Herbicides can easily penetrate coral tissues and in a matter of minutes, the tiny organisms that live inside coral, called zooxanthellae, are prevented from photosynthesising efficiently. As this is how coral gets its food, it begins to starve.

How else do chemicals harm coral?

Certain chemicals have been found to affect all life-history stages of corals. For example, scientists have shown that the fungicide Methoxyethyl mercury chloride inhibits fertilisation and metamorphosis, which then leads to coral bleaching. Similarly, phosphorous, which is often found in fertilisers has been linked with reduced coral growth and in some instances, death of entire coral colonies. Copper, a heavy metal, which is a major component of anti-fouling paint, can prevent the reproductive success of corals, while oil spillages can affect the success of spawning. These are just a few examples of how chemicals interfere with the lifecycle of coral species.



Learn more about Marine & Chemical pollution at: https://www.facebook.com/murakameehun/

	Plastic	Metals	Organic	Hazardous	Others
Total no:					
Percentage					

Discussion:
1. Did you find any items that could have been recycled, composted, or reused instead of being thrown away?
2. Brainstorm ideas to reduce the amount of waste in your home: make a poster of what can and cannot be recycled and hang it up in your kitchen
3. Choose products with the least amount of packaging; start a compost bin; or opt for reusable containers to pack your lunch. Be creative!

Actions to reduce the amount of waste generated at your home:

Actions you will take	Time frame/date	Who is responsible	What are your targets? How will you know it is successful?

Post Assessment

1. What are some of the impacts of releasing sewage water and food waste into the lagoon?

- ☐ Unnatural growth of corals
- ☐ Algal bloom and uncontrolled growth of seagrass
- ☐ Obesity in reef fish

2. How does transboundary pollution affect megafauna in Maldives?

- ☐ Radioactive waste dumped from nuclear power plants enhance their size
- ☐ Oil spills from nearby countries lead to fish kill in Maldives
- ☐ Discarded fishing nets carried by the monsoon currents cause entrapment

3. What are some ways in which plastic pollution affect marine life?

4. Name 2 types of hazardous chemicals that pollute the environment in Maldives

5. Write 3 things you can do to reduce the amount of waste produced in your household.

Learn more about marine & chemical pollution at:

https://www.facebook.com/murakameehun/

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Our Protected Areas

A key conservation tool to tackle biodiversity loss

Questions

1. What is a true comparison of traditional protected areas and modern protected areas?

- ☐ Traditionally people only protected natural areas
- ☐ Modern conservation science takes into account societal needs along with environmental sustainability
- ☐ Contemporary conservation science has no space for public participation

2) How many protected areas have been designated in Maldives

- ☐ 63 PAs
- ☐ 58 PAs
- ☐ 79 PAs

What are Protected Areas and why are they important?
The International Union for Conservation of Nature (IUCN) defines protected areas (PA) as 'a clearly defined geographical space, recognised, dedicated and managed, through legal or other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values.'

This means that a specific site is selected for safeguarding due to its notable biodiversity or cultural value. A marine protected area is located in the ocean or along the coastline, while land based protected areas such as forests or sea bird roosting sandbanks are considered terrestrial protected areas.

In contemporary conservation practices, protected areas have become a major instrument in preserving healthy ecosystems with high genetic richness and endangered species by managing ecosystem services with sustainable resource use plans.

Some of the functions of protected areas include:

• Maintaining healthy functioning ecosystems that serve as sanctuaries for specific biota and habitats, preserving ecological processes unable to survive without protection, and preventing ecosystem fragmentation.

• Promote and preserve valuable ecosystem services for the society, such as ecotourism, recreational activities, research, research and education, scenery, and religious grounds.

• Benchmark to assess the effects humans have on different environments. Well managed protected areas provide space for natural evolution and ecological restoration, and can be compared with areas that are not protected to understand the extent of anthropogenic impacts on nature.

Protected Areas

With the PAs scattered throughout the country, every site serves a variety of ecosystem services and supports different aspects of the societal needs in addition to being a key component of marine conservation and sustainable fisheries.

Apart from generating significant revenue in tourism and fisheries sectors, the biodiversity of Maldives also stimulates considerable economic activity in construction, manufacturing, artisanal craftsmanship, transport, food, restaurants and entertainment sectors. In terms of household livelihoods, these biodiversity-dependent sectors account for a substantial proportion of national employment, food and earnings.

POP UP FACT

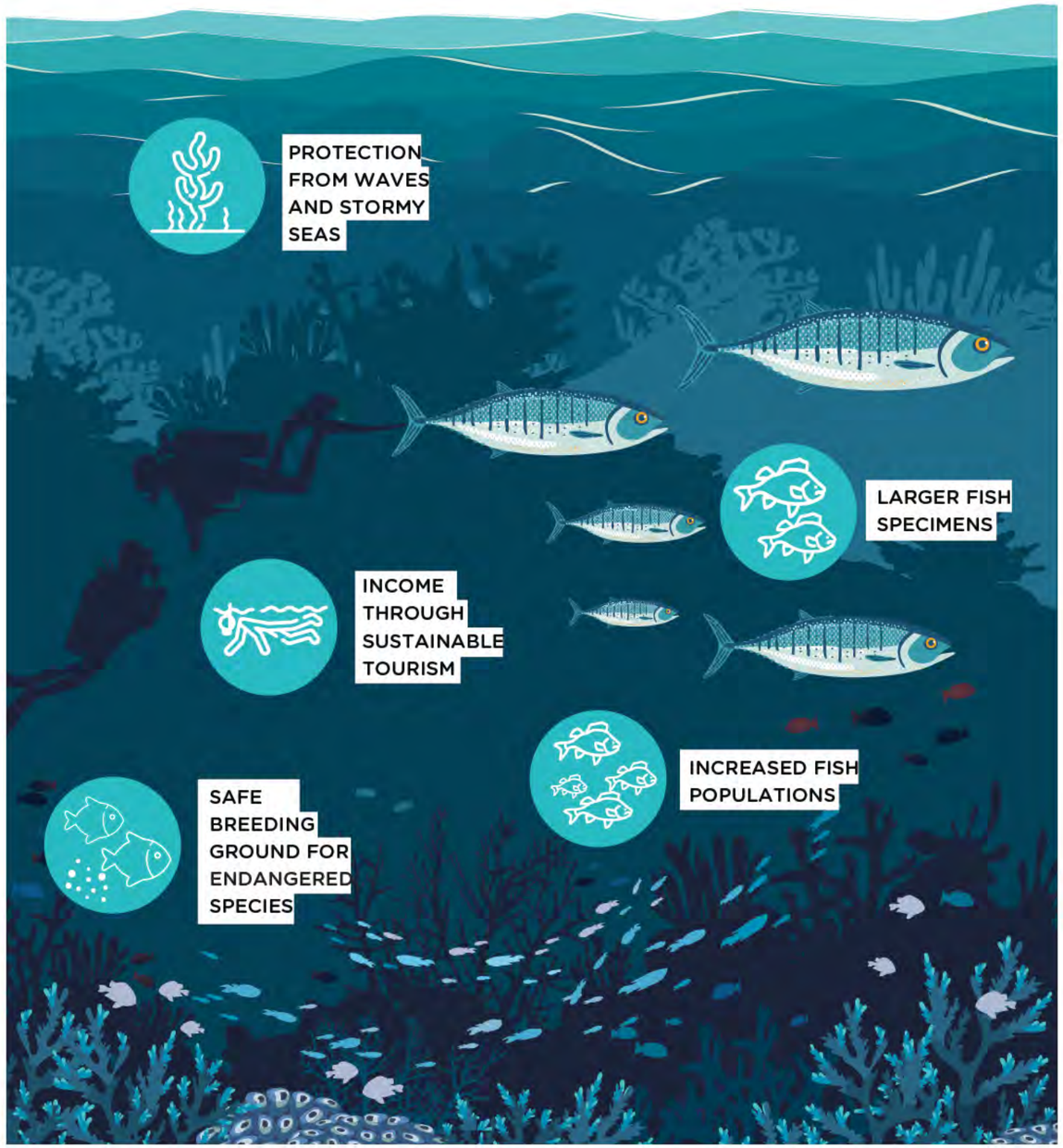
One of the more historically significant MPAs in Maldives include The Corbin Wreck, which was a French ship carrying a cargo of silver that met its demise in 1602 in Goidhoo atoll.

When news of the wreck and its silver reached Male', the merchandise from the wreck was declared property of the Sultan, and locals were prohibited from selling anything to the shipwreck victims. François Pyrard, the famous French navigator had covered the accounts of this wreck in his book about life in Maldives in the 1600s.

The Importance of Marine Protected Areas

MPAs are often selected due to their naturally occurring biodiversity and abundant marine life.

But they also serve a purpose that extends beyond the boundary of their sites. In effect, it is them that are protecting us!



Where are the Protected Areas in the Maldives?

The government of Maldives is currently on a mission to identify and protect ecologically significant sites in all atolls, representing at least one reef system, lagoon, sandbank, wetlands or mangrove site. Some of the existing protected areas include whole islands, such as HA. Gallandhoo, a famous lesser noddy aggregation site, and GDh. Dhigulaabaadhoo, an island with an extensive mangrove system.

PAs such as the South Ari Marine Park (SAMPa) regulate tourist boats and human interactions with whale sharks that inhabit the area. Boats, snorkelers and divers have specific guidelines on how to behave in this area.

Smaller PAs include famous dive sites such as Banana Reef (Male' atoll) with specular caves and overhangs, with an array of reef fish and invertebrates, as well as predatory fish such as sharks, barracudas and trevallies converging around big rocks.

South Ari Marine Park (SAMPa)

- Designated on June 5th, 2009
- Covers 42km²
- The boundary extends for 1km seaward from the outer reefs
- One of the world's most important habitats for whale sharks
- 271 individual whale sharks have been sighted within the MPA
- Approximately 65,000 tourists join whale sharks excursion annually
- The estimated value of whale shark tourism in the mpa is USD 8.5 million (Cagua et al. 2014).

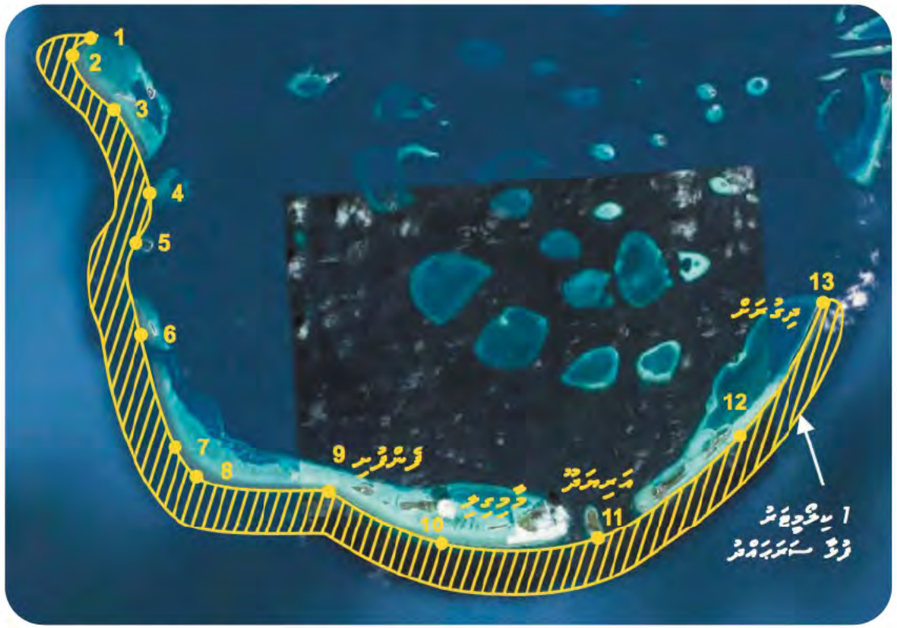


Figure:20 - South Ari Marine Park (SAMPa). Pic: EPA

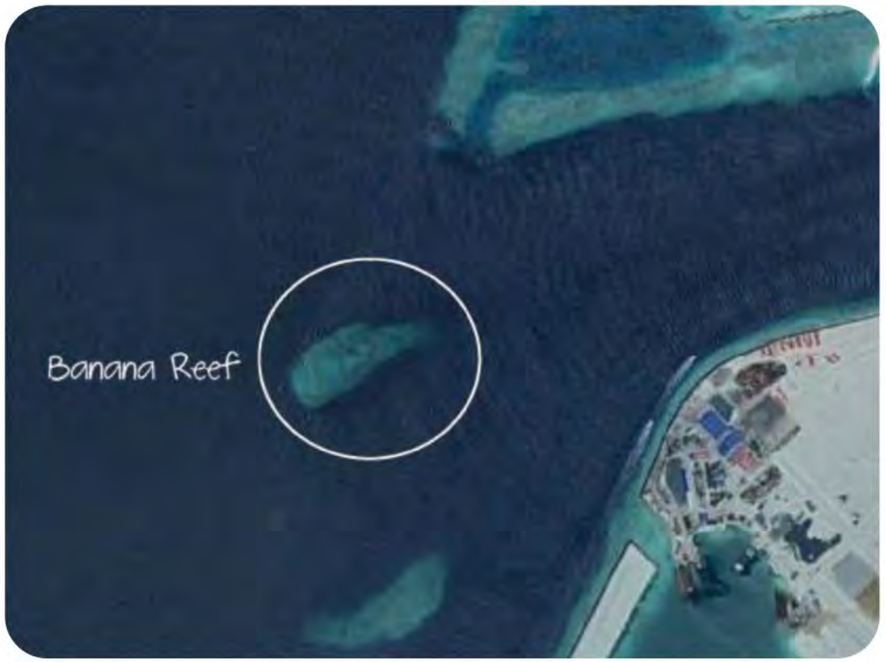


Figure:21 - Banana reef - Kaafu atoll. Pic: EPA.

UNESCO Biosphere Reserves

The United Nations Educational, Scientific and Cultural Organization (UNESCO) defines Biosphere Reserves as 'learning places for sustainable development'. These sites are selected to understand and manage changes, natural resource use and find local solutions to human-wildlife conflicts to pave the way for conservation and sustainable development with the environment and society at its forefront.

Across the world, there are 257 million people living in Biosphere Reserves, spanning across of 6,812,000 km² in 129 countries, together making up the World Network of Biosphere Reserves (WNBR). Not only are they areas of outstanding beauty and unique biodiversity, each region is also noted for its commitment to fostering a harmonious balance between people and nature.

How are Biosphere Reserves designated?

1. High biodiversity sites with cultural significance are nominated as Biosphere Reserves by the national government.

2. Nominations are taken for consideration by the Advisory Committee for Biosphere Reserves to be recommended to International Coordinating Council (ICC).

3. ICC of the Man and Biosphere program takes a decision on the designation of the Biosphere Reserve.

4. Countries are informed of the designation by the Director-General of UNESCO.

Functions of Biosphere Reserves:

Biosphere Reserves are created with the following functions at the epicenter, and are planned and managed by the collaborative efforts of government, private sector and local communities.

1. Conservation of biodiversity and cultural diversity
2. Economic development that is socioculturally and environmentally sustainable
3. Logistic support underpinning development through research, monitoring, education and training

To achieve these functions, the Biosphere Reserves are classified into 3 main zones.

1. Core Area
A strictly protected zone set aside for the conservation of ecosystems, target species, landscapes and genetic variation.

2. Buffer Zones
Surrounds the Core Area and supports sound ecological practices such as scientific research, monitoring, education and other permitted activities.

3. Transition Area
This is where communities foster socio-culturally and ecologically sustainable economic and human activities such as fisheries, tourism and developmental activities.

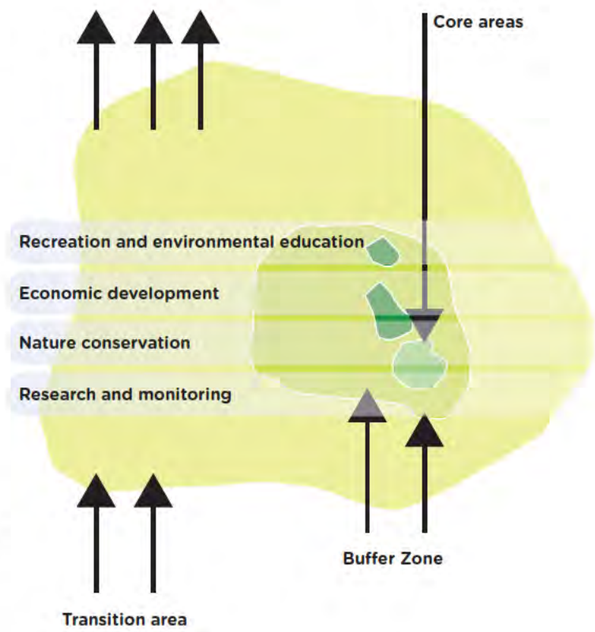
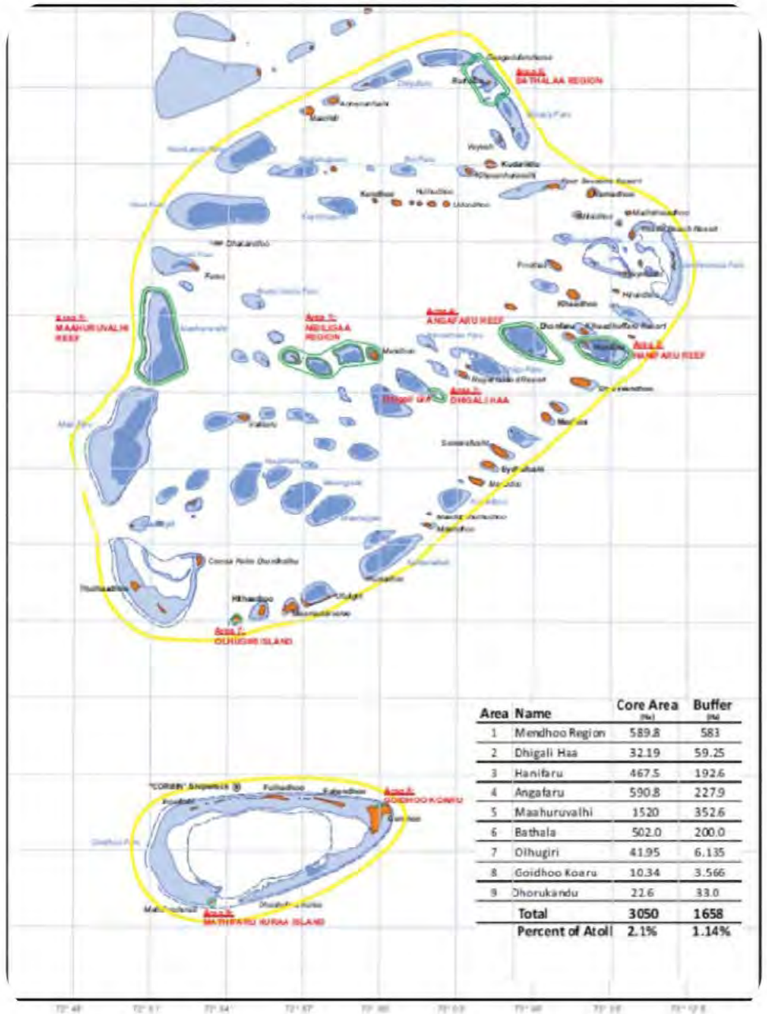


Figure:22 - Zonation in a Biosphere Reserve

Biosphere Reserves in Maldives

Baa Atoll Biosphere Reserve

In recognition of the outstanding natural values of this atoll and the commitments being made by local communities and resort Baa Atoll was declared the first United Nations Educational Scientific Cultural Organization (UNESCO) Biosphere Reserve in the Maldives in 2011. Some of the core areas in this Biosphere Reserve include breeding sites for sea birds and manta aggregation sites.



Area	Name	Core Area (ha)	Buffer (ha)
1	Mendhoo Region	589.8	583
2	Dhigali Haa	32.19	59.25
3	Hanifaru	467.5	192.6
4	Angafaru	590.8	227.9
5	Maahuruvalhi	1520	352.6
6	Bathala	502.0	200.0
7	Olhugiri	41.95	6.135
8	Goidhoo Koaru	10.34	3.566
9	Dhorukandu	22.6	33.0
	Total	3050	1658
	Percent of Atoll	2.1%	1.14%

Figure:23 - Baa atoll biosphere.
Pic - Ministry of Environment, Climate Change and Technology

Fuvahmulah Biosphere Reserve

The unique geological features and the healthy ecosystems of Fuvahmulah along with the potential for sustainable resources have led to Fuvahmulah being designated a UNESCO Biosphere Reserve in 2020.

In addition to the wetlands found in the atoll, the waters surrounding it is a hotspot for marine megafauna such as oceanic mantas, adult whale sharks, tiger sharks and rarely seen fish such as sunfish.

Figure:24 - Fuvahmulah Biosphere Reserve.
Pic - Ministry of Environment, Climate Change and Technology

Addu Atoll Biosphere Reserve

Designated as a UNESCO Biosphere Reserve in 2020, the majority of this site is composed of marine ecosystems with highly diverse reef ecosystems. There are 30 islands here, with about 17 of them uninhabitated.

Addu Atoll is divided by four channels; Gan Kandu, Viligilikandu, Maakanda and Kodakanda and the islands are formed by the peripheral reef.

Figure:25 - Addu Atoll Biosphere Reserve.
Pic - Ministry of Environment, Climate Change and Technology

Case Study: Baa Atoll Biosphere Reserve

(28 June 2012)

Baa atoll comprises of ecosystems as most atolls in Maldives, with a combination of coral reefs, islands, seagrass meadows and mangroves, owing to a rich biodiversity.

The position of Baa atoll in the Indian ocean and the large groups of coral reefs in the atoll act as a stepping stone for the transport of planktonic larvae of reef fauna from the western and eastern Indian Ocean.

There are 9 core areas within Baa Atoll Biosphere Reserve: Mendhoo Region; Dhigali Haa; Hanifaru; Angafaru; Maa huruvalhi; Bathala; Olhugiri; Goidhoo Koaru; and Dhorukandu. While some of these sites are notable for sea turtle nesting, sea bird roosting and rich reef biodiversity, the most famous of all is perhaps the Hanifaru Bay.

At the heart of ecotourism and megafauna research, Hanifaru Bay is a key aggregation site for reef rays *(Mobula alfredi)*, with over 1800 individuals identified at this location within 15 years. The structure of Hanifaru outer reef allows for plankton rich water to get trapped within the shallow bay area during the Southwest Monsoon (Hulhangu). This makes it of the few sites where manta cyclone feeding is routinely observed worldwide, with up to 247 individuals recorded at once at these mass feeding events.

Hanifaru Bay at Baa Atoll - Pic - EPA Maldives.

BAA ATOLL
UNESCO
BIOSPHERE
RESERVE
MALDIVES

The three key programmes through which the Biosphere Reserve Strategy is adopted include:

Outreach program:
Awareness and education regarding conservation, sustainability and the functions of the Biosphere Reserve using participatory approaches.

Conservation program:
This includes allocating a zonation system and implementing it with government oversight, and effectively managing the core areas to monitor the natural resources by enforcing necessary regulations. A key aspect of this also includes regularly updating the strategic action plans to reduce key threats to biodiversity.

Livelihood and sustainable development program:
This program aims to support community livelihood and developmental initiatives that are in line with the objectives of the Biosphere Reserve. This mainly includes working with key sectors such as fisheries, tourism and agriculture with 'sustainability' at its core principle, while addressing climate change mitigation.

How do local communities come into play in protected areas and Biosphere Reserve management?

Traditionally, the idea of setting aside pristine environments for conservation was done with the belief that people were bad for natural resources. However, MPAs, and especially Biosphere Reserves are now designed with the inclusion of local participation at different stages that allow for communities to take ownership in all aspects of protecting their environments. The skills, knowledge and needs of local people are to be combined with the conservation objectives in place. Local communities not only safeguard and protect, they also need to be at the forefront of conducting scientific studies, planning and decision making.

Ecotourism in the Maldives

Questions

1. Identify 2 principles of ecotourism as per the International Ecotourism Society below.

- ☐ Foster respect and awareness of the environment and local culture
- ☐ Harvest natural resources as much as possible to benefit the tourism sector
- ☐ Guarantee minimal impact during construction and operation of tourism facilities

2. Ecotourism helps coral reef conservation initiatives in the Maldives

- ☐ True
- ☐ False

With the various impacts on the environment caused due to human activities, there is a growing concern that people need to act and take responsibility to minimize their impact on the environment.

Ecotourism can be defined as a type of tourism that emphasizes responsible travel, and ensures that the impact on the environment is minimal, and resources are being sustained. Oftentimes, finding the balance between the growth of tourism and environmental conservation is a challenge.

Looking at the Maldives, with the growth of the tourism industry in the last 50 years, over 100 islands have been developed as tourist resorts. Under the Maldives Tourism Act, islands are at times leased up to 99 years to develop tourism.

Due to the nature of this arrangement, resorts are able to at times better manage the health of the coral reefs and associated organisms within their islands much better.

Furthermore, as the world continues to develop, businesses too, seek environmentally friendly, sustainable business opportunities. As such, resorts find themselves in a unique position to use their business to create awareness through educational programmes and conservation initiatives targeted towards guests and travellers.

For example, today, several tourist resorts in the Maldives have marine biologists based on the island often leading educational programmes as well as conservation initiatives such as coral reef restoration with the involvement of their guests. More and more, resorts are also looking into innovative and sustainable waste management mechanisms.

For a country like the Maldives, finding the balance between economic growth and also environmental conservation is vital. This is where the model of ecotourism can play a big role as it combines both to ensure that customers get a fulfilling and learning experience while making sure that the impact they have on the environment is minimal.

5 ways ecotourism helps to keep coral reefs healthy in the Maldives

There is more to being an environmentally conscious tourist than simply making sure you do not stand on corals when snorkeling. By opting to stay at a resort or hotel that practices ecotourism, visitors can have a lasting, positive impact on the local environment and community.

The spending power of eco-tourists is shaping the luxury market
In 2015, travel consultancy firm IPK International and Booking.com both published reports stating that luxury travelers were over 50% more likely to choose a hotel which had a positive relationship with the local environment and communities. Put simply, it is now a financial imperative for hotels and resorts to practice ecotourism in order to attract clients. By making spending decisions based on sustainable practices in hotels, especially in the luxury market, which is so dominant in the Maldives, eco-tourists can make a significant difference.

Eco-tourists can potentially provide financial support for coral conservation efforts
Guests now have the chance to sponsor coral frames and to donate to ongoing projects. They have the opportunity to purchase locally-made souvenirs, crafted from sustainable materials rather than harmful keepsakes made of marine flora and fauna.

They are changing how resorts interact with their marine environment
IIn order to provide guests with the luxury, eco-friendly experiences they are looking for, many hotels and resorts in the Maldives have invested in long-term conservation projects and initiatives run by qualified marine biologists and conservationists. These often involve protecting the coral reef ecosystems through coral plantation programs, awareness campaigns, and adhering to snorkeling and diving best practices. What's more, eco-tourists insist on a holistic approach and expect the environment to be considered at all levels of the hotel operations.

They ask questions and educate themselves
Eco-tourists are those that are willing to learn something new while on holiday, and are open to other ways of life and new environments. Ecotourism offers will offer opportunities to experience the local eco-system and culture in a memorable way that minimizes impact and foster respect and awareness.

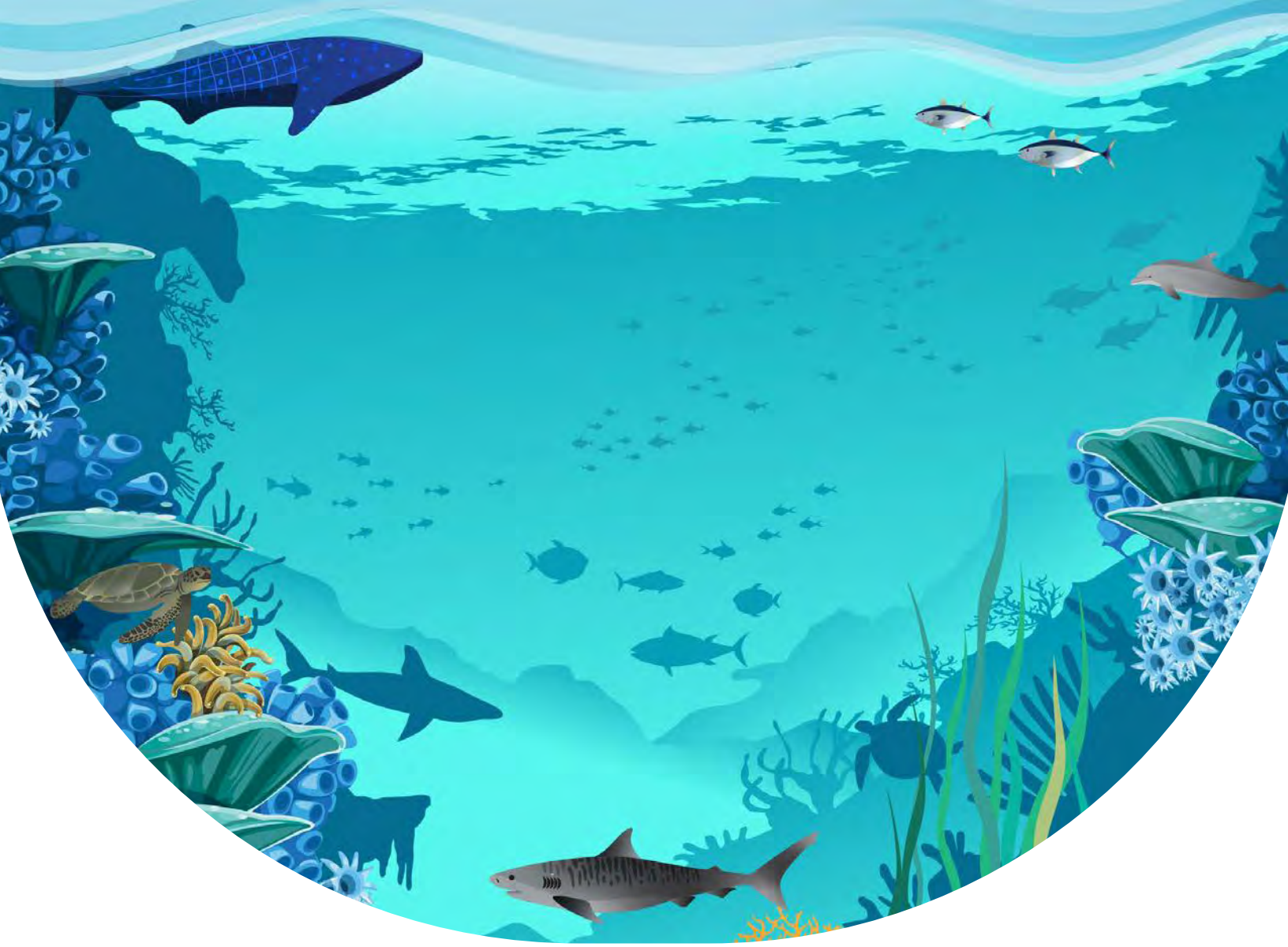
They spread the word about the plight of our ecosystems
The impact of an eco-tourist does not stop when they leave the resorts. Their experiences remain with them when they return to their own country. An educated tourist with an awareness of the environmental issues is more likely to speak to their friends and family on the subject and to encourage others to become eco-tourists.

ECOTOURISM IN THE MALDIVES

The Principles of Ecotourism

Many types of travel are now being classified as ecotourism. However, to be truly considered ecotourism, a trip must adhere to the following principles set out by the International Ecotourism Society:

- Minimise impact at a physical, social, behaviour, and psychological level
- Foster respect and awareness of the environment and local culture
- Create positive experiences for guests and hosts
- Invest financially in conservation projects
- Ensure local people and businesses benefits from tourist activities
- Curate meaningful experiences that offer insight into the local political, environment, and social climate
- Guarantee minimal impact when constructing and opening tourism facilities
- Empower ingenious communities by working in partnership with them whilst acknowledging their rights and spiritual beliefs



MINISTRY OF ENVIRONMENT,
CLIMATE CHANGE AND TECHNOLOGY

ECOSYSTEMS OF THE MALDIVES WORKBOOK

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