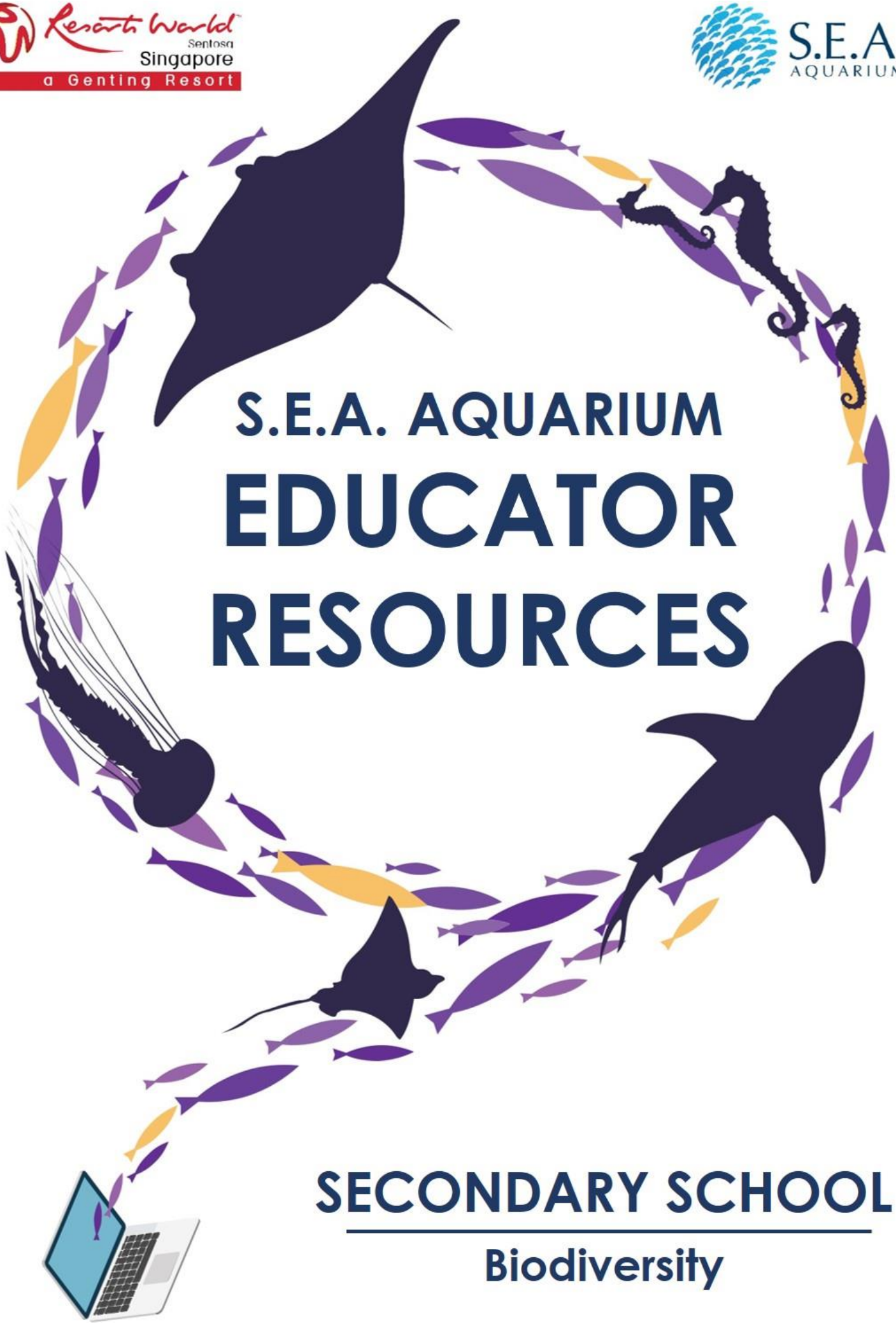
Resorts World Sentosa Singapore a Genting Resort

S.E.A. AQUARIUM



S.E.A. AQUARIUM EDUCATOR RESOURCES

SECONDARY SCHOOL

Biodiversity

Biodiversity

Biodiversity is an activity-based learning resource that allows students to understand the value of biodiversity and its ability to support an ecosystem. Students will take part in an activity with two different scenarios to recognise the resilience of a highly biodiverse ecosystem as compared to a less biodiverse one.

This resource aims to supplement students' understanding of biodiversity by illustrating how variety in species can sustain an ecosystem in the face of adversities. Students can extrapolate the understanding obtained to other biodiversity relevancies outside of the marine environment.

Target Group: Secondary 1 to 2

Duration: 50 to 60 minutes

Learning Objectives:

- Explain the importance of biodiversity in an ecosystem
- Explain the roles of different organisms in an ecosystem
- Discuss the impacts of human actions on marine biodiversity, and subsequently on the ecosystem

Materials required:

- Corresponding *Biodiversity* slides
- Animal playing cards (provided in the *Appendix*, to be printed out beforehand)

Introduction to Biodiversity

Slides 2 to 3:

Educators may begin by providing the definition and importance of biodiversity. Below are the main points:

- Biodiversity refers to the variety of life, including variety within and between species.
- Biodiversity is important and it indicates the health of an environment.
- Importance of biodiversity
    - Ecological services (e.g. recycling of nutrients, water filtration, decompose pollutants, etc.)
    - Provision of resources (e.g. food, medicine, fuel, raw materials, etc.)
- Loss of biodiversity would mean loss of these services that are important to ecosystems, our society and economy.

Educators can continue with these points to preempt the activity:

- Biodiversity is even more important to safeguard the stability of ecosystems when facing environmental changes.
- What are the differences in impacts of environmental changes in a highly biodiverse and a less biodiverse ecosystem?

Activity Introduction

Slide 5:

The aim of the following activity is to compare a highly biodiverse ecosystem with a less biodiverse one. Students will role play in two different scenarios to recognise how environmental changes affect individual organisms, and consequently the overall ecosystem balance and stability.

Students are encouraged to observe and understand that it is essential to have species variety in an ecosystem to ensure balance and stability. They should also recognise that actions of human beings can cause environmental shifts that could threaten the stability of an ecosystem.

Activity Instructions

There are 2 parts to this activity:

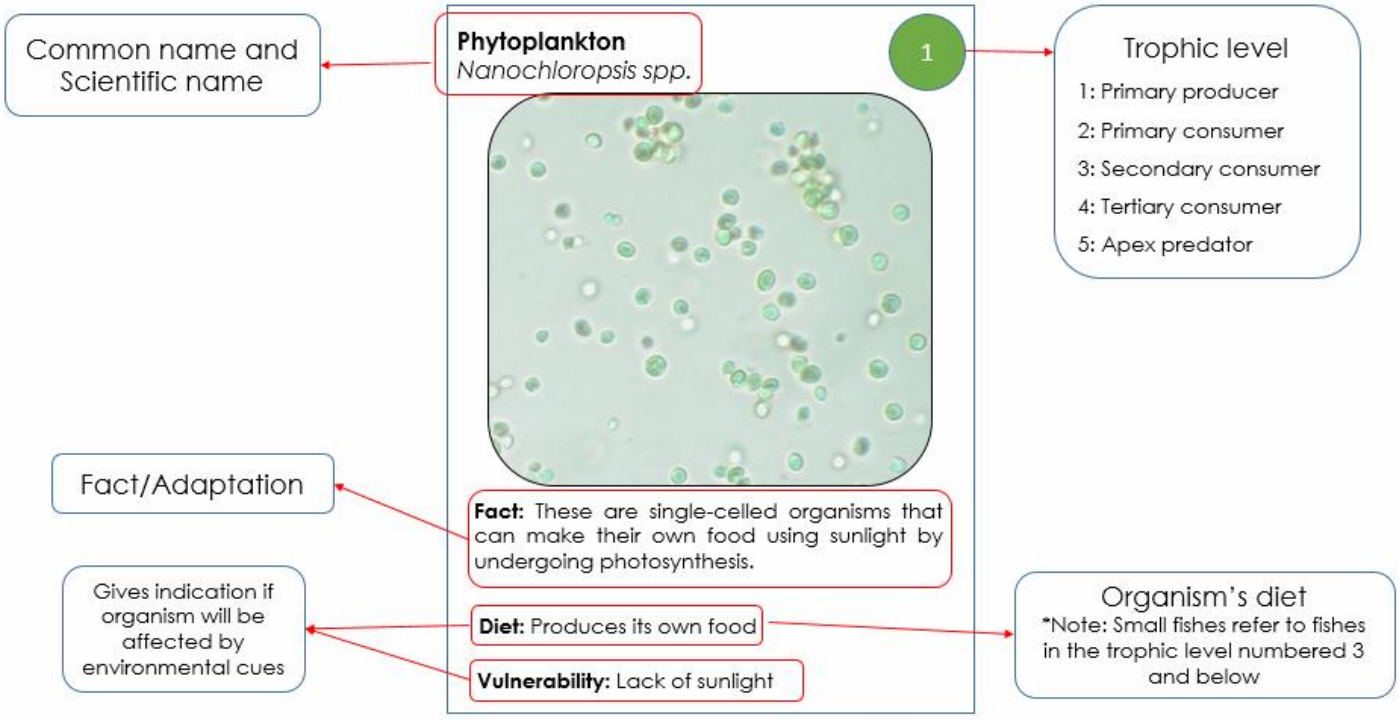
- Part 1 – Scenario of Ecosystem A with low biodiversity (4 species of organisms)
- Part 2 – Scenario of Ecosystem B with high biodiversity (15 species of organisms)

Parts 1 and 2 follow the same procedure but with different number of species and environmental cues in play. Educators are recommended to begin with Part 1, followed by a discussion before conducting Part 2.

Procedure:

1. Each student will be given a playing card of an organism living in Ecosystem A (Part 1) or B (Part 2).
   - Educators should print out the playing cards in the *Appendix* beforehand.

2. Educators should run through various features on the card (as shown below) to ensure students can understand the given information.



3. Educators are to facilitate discussions for students to think about the importance of each organism.

- Suggested discussion questions:
    - What role does your organism play in the ecosystem?
    - Is your organism the most important in this ecosystem?
- Students may discuss among those assigned with the same organism and answer as a group.

4. After the discussion, have all students to stand up with their respective playing cards in hand.

5. Educators are to read out environmental cues occurring in the respective ecosystems, starting with Part 1 – Ecosystem A. Suggested cues for each part can be found in the *Appendix*.

6. Students are to identify organisms that are directly and indirectly affected and respond in the following ways:
    - Species that are affected become extinct:
        - All students assigned to these species are to take a seat.
    - Species that are indirectly affected do not become extinct, but the population size decreases:
        - Half of the students assigned to these species are to take a seat.
    - Species that are largely unaffected:
        - Students may remain standing.

7. Educators should encourage students to justify if their organisms will be affected by the environmental cue. Educators may refer to the *Appendix* for suggested pointers to evaluate students' responses and explanations.

8. Educators are to repeat steps 6 and 7 until all environmental cues for Part 1 – Ecosystem A has been played out. Educators may choose to 'reset' the ecosystems (by having all students to stand again) either:
    - After each environmental cue, or
    - After consecutive environmental cues resulting in most species becoming extinct

9. At the end of Part 1 – Ecosystem A, the class is to count the number of students who are still standing and tally the number of surviving species.

10. Repeat steps 3 to 9 with added organisms and environmental cues in Part 2 – Ecosystem B.

11. At the end of the activity, educators are to discuss with students their observations. Educators may refer to following the discussion questions and suggested answers can be found in the *Appendix*.
    - Discussion questions for Part 1:
        - What happens when 1 species is no longer present in Ecosystem A?
        - Does it have a great impact on the rest of the organisms? How so?
        - Is it healthy for an ecosystem with low biodiversity but high population numbers? Why?
        - How did human actions change Ecosystem A?

    - Discussion questions for Part 2:
        - How was the outcome in Part 2 different from that in Part 1?
        - Is having high biodiversity important for an ecosystem to be resilient against environmental changes? Why?
        - Will there be any situations whereby human actions can significantly affect ecosystems with high biodiversity?

Conclusion

Slide 26:

Conclude the whole activity with the following learning points:

- Having high biodiversity allows ecosystems to be resilient against environmental changes
    - A variety of species allows different functions within an ecosystem to be satisfied even when a species becomes extinct
    - Impact on other species is reduced
- Every species has its role in an ecosystem and can influence the survival of other species
    - Removal of one species can have cascading effects on others in the same ecosystem
- As human actions accelerate environmental changes, there is a need for efforts to conserve biodiversity

- Loss of biodiversity due to human actions will eventually affect human beings e.g. insufficient food sources, pollutants remain
- It is important to protect the environment and its inhabitants by being sustainable i.e. practice the 3Rs – Reduce, Reuse, Recycle

Appendix

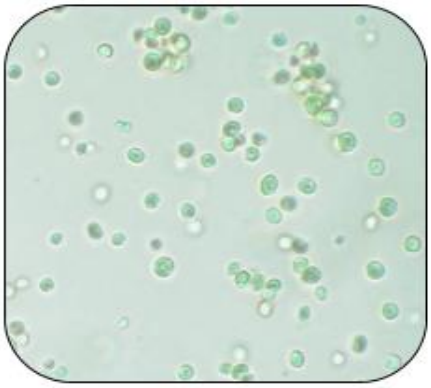
Organisms in Ecosystem A

Educators may assign the organisms to the students according to the table below. Number of students are allocated based on a class of 40 students.

Organism	**Number of students assigned**
Nannochloropsis spp.	16
Krill	12
Indian mackerel	8
Pickhandle barracuda	4

Phytoplankton
Nanochloropsis spp.

1



Fact: These are single-celled organisms that can make their own food using sunlight by undergoing photosynthesis.

Diet: Produces its own food

Vulnerability: Lack of sunlight

Zooplankton
Krill

2

Fact: Krill are small shrimp-like crustaceans that are important food sources for animals of various sizes.

Diet: Phytoplankton & other zooplankton

Vulnerability: Warmer oceans

Indian Mackerel
Rastrelliger kanagurta

3

Fact: Found swimming in schools, and feeds mainly on plankton and small fish larvae. Its forked tail and streamlined body help it to swim quickly.

Diet: Zooplankton/shrimp & fish larvae

Vulnerability: Overfishing

Pickhandle Barracuda
Sphyraena jello

4

Fact: Possess a forked tail and an elongated body shaped like a torpedo to cut through the water in sprints of high speeds

Diet: Small fishes/smaller barracudas

Vulnerability: Exploited for sport fishing

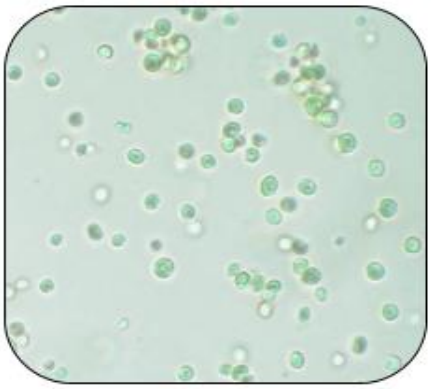
Organisms in Ecosystem B

Educators may assign the organisms to the students according to the table below. Number of students are allocated based on a class of 40 students.

Organisms	**Number of students assigned**
Trophic level 1 (Primary producers)	
Nannochloropsis spp.	5
Dinoflagellate	5
Brown algae	4
Trophic level 2 (Primary consumers)	
Krill	3
Copepod	3
Bluespine unicornfish	3
Blue tang	3
Trophic level 3 (Secondary consumers)	
Indian mackerel	4
Orange-striped hermit crab	2
Copperband butterflyfish	2
Trophic level 4 (Tertiary consumers)	
Pickhandle barracuda	2
Spotted eagle ray	2
Spotted moray eel	2
Trophic level 5 (apex predators)	
Scalloped hammerhead shark	1
Sand tiger shark	1

Phytoplankton
Nanochloropsis spp.

1



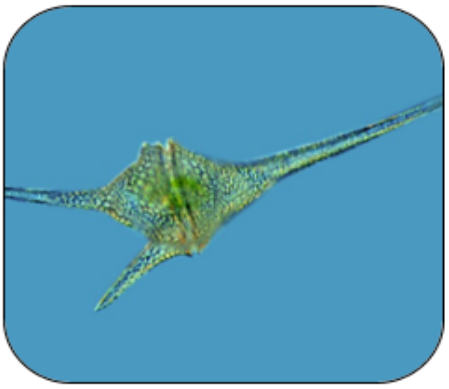
Fact: These are single-celled organisms that can make their own food using sunlight by undergoing photosynthesis.

Diet: Produces its own food

Vulnerability: Lack of sunlight

Phytoplankton
Dinoflagellate

1



Fact: These are single-celled organisms that can make their own food using sunlight by undergoing photosynthesis.

Diet: Produces its own food

Vulnerability: Lack of sunlight

Brown Algae

1

Fact: This algae not only serves as food but also shelter for marine organisms. Some species have holdfast which act as anchors to the sea floor.

Diet: Produces its own food

Vulnerability: Lack of sunlight

Zooplankton
Krill

2

Fact: Krill are small shrimp-like crustaceans that are important food sources for animals of various sizes.

Diet: Phytoplankton & other zooplankton

Vulnerability: Warmer oceans

Bluespine Unicornfish
Naso unicornis

2

Fact: Named after horn-like protrusion on its head. This herbivorous fish also has tiny spines near their tails for defense.

Diet: Primarily algae

Vulnerability: Overfishing

Zooplankton
Copepod

2

Fact: Commonly found plankton in the ocean that is an important food source for many animals. A pair of prominent antennules allows it to avoid predators efficiently.

Diet: Phytoplankton & other zooplankton

Vulnerability: Warmer oceans

Blue tang
Paracanthurus hepatus

2

Fact: A Flat-bodied grazer that is important to coral reef health. By feeding on algae, it prevents algae overgrowth, which is detrimental to reef health.

Diet: Primarily algae/phytoplankton

Vulnerability: Habitat loss (coral reef)

Indian Mackerel
Rastrelliger kanagurta

3

Fact: Found swimming in schools, and feeds mainly on plankton and small fish larvae. Its forked tail and streamlined body help it to swim quickly.

Diet: Zooplankton/shrimp & fish larvae

Vulnerability: Overfishing

Orange-striped Hermit Crab
Clibanarius infraspinatus

3

Fact: A type of crustacean that seeks shells along the coast for protection. As it grows, it needs to constantly look for larger shells.

Diet: Zooplankton/shrimp & fish larvae

Vulnerability: Aquarium trade

Copperband Butterfly Fish
Chelmon rostratus

3

Fact: A brightly coloured fish with an elongated mouth. This mouth shape allows it to capture prey in small reef crevices that are hard to reach.

Diet: Zooplankton & algae

Vulnerability: Diseases and parasites

Pickhandle Barracuda
Sphyraena jello

4

Fact: Possess a forked tail and an elongated body shaped like a torpedo to cut through the water in sprints of high speeds

Diet: Small fishes/smaller barracudas

Vulnerability: Exploited for sport fishing

Spotted Eagle Ray
Aetobatus narinari

4

Fact: A cartilaginous fish with a flattened body and is a type of ray. It possesses 1 or more stinging barbs on top of its tail to defend itself.

Diet: Small fishes/crustaceans

Vulnerability: Overfishing

Spotted Moray Eel
Gymnothorax isingteena

4

Fact: It has a snake-like body and does not have scales. A protective mucus layer on its skin enables it to slide and hide in tight crevices and caves.

Diet: Small fishes/crustaceans/molluscs

Vulnerability: Habitat destruction

Scalloped Hammerhead Shark 5
Sphyrna lewini

Fact: Named after its hammer-shaped head, this shark is an efficient apex predator. It actively hunts its prey and can use its head to pin down prey.

Diet: Fishes/crustaceans/cephalopods

Vulnerability: Overfishing/bycatch

Sand Tiger Shark 5
Carcharias taurus

Fact: A predator with long and sharp teeth that protrude from its mouth even when its jaws are closed. It usually hunts at night and sometimes observed to hunt in groups

Diet: Fishes/rays/cephalopods

Vulnerability: Overfishing/bycatch

Part 1: Environmental cues and suggested answers

Part 1 consists of 3 environmental cues. Educators may refer to the suggested answers below to evaluate students' responses and provide explanations.

1. **Overfishing of Indian mackerel has caused the species to be considered extinct as they are rarely found in the ocean**.

   Direct effect:

   - **Indian mackerel** becomes extinct
     Students with Indian mackerel card are to take a seat

   Subsequent effects on other organisms:

   - **Pickhandle barracuda** becomes extinct
     Students with pickhandle barracuda card are to take a seat
     - Lack of prey due to extinction of Indian mackerel – the only small fish in Ecosystem A and food source for the barracuda

   - ***Nannochloropsis spp.* and krill** populations decrease drastically
     Students with Nannochloropsis spp. and krill cards are to take a seat
     - Extinction of Indian mackerel leads to lack of predators and uncontrolled increase in krill population
     - Increase in krill population depletes their food source – *Nannochloropsis spp.*
     - Eventually there will be insufficient *Nannochloropsis spp.* to support the increase in krill population

2. **Global warming increases light intensity and water temperature in the ocean.**

   Direct effects:

   - **Krill** becomes extinct
     Students with krill card are to take a seat
     - Vulnerable to warm ocean temperature

   - ***Nannochloropsis spp.*** becomes extinct
     Students with Nannochloropsis spp. card are to take a seat
     - Environmental changes favour growth of *Nannochloropsis spp.*

- Uncontrolled population increase due to lack of the only consumers – krill
- Uncontrolled increase may result in depletion of resources required for growth e.g. carbon dioxide and nitrogen
- Eventually there will be insufficient resources available to support the population increase

Subsequent effects on other organisms:

- **Indian mackerel** becomes extinct
  Students with Indian mackerel card are to take a seat
  - Extinction of krill leads to lack of prey which cannot support population of Indian mackerel

- **Pickhandle barracuda** becomes extinct
  Students with pickhandle barracuda card are to take a seat
  - Lack of prey due to extinction of Indian mackerel – the only small fish in Ecosystem A and food source for the barracuda

3. **Sudden increase in sport fishing and fishermen are catching the largest fish as trophies.**

Direct effect:

- **Pickhandle barracuda** becomes extinct
  Students with pickhandle barracuda card are to take a seat
  - High fishing frequency prevents population from recovering

Subsequent effects on other organisms:

- **Indian mackerel and krill** become extinct
  Students with Indian mackerel and krill cards are to take a seat
  - Uncontrolled increase in Indian mackerel population due to lack of their only predator – pickhandle barracuda
  - Leads to greater predation pressure on their prey - krill
  - Eventually, krill population declines drastically and leads to depletion of food source for the Indian mackerel
  - Insufficient krill will eventually lead to the inability to support Indian mackerel population

- ***Nannochloropsis spp.*** becomes extinct
  Students with Nannochloropsis spp. card are to take a seat
  - Uncontrolled population increase due to lack of the only consumers – krill
  - Uncontrolled increase may result in depletion of resources required for growth e.g. carbon dioxide and nitrogen
  - Eventually there will be insufficient resources available to support the population increase

<u>Part 1: Discussion points</u>

What happens when 1 species is no longer present in Ecosystem A?

- All species in the ecosystem are adversely affected.
- Species that are not predators or prey of the removed species can be affected indirectly too.

Does it have a great impact on the rest of the organisms? How so?

- With only 4 organisms in the ecosystem, their survival are heavily dependent on each other, especially for nutrients.
- Organisms in Ecosystem A form a linear food chain, where the removal of 1 species is sufficient to break the chain.
- Each species depends on only 1 species for food and does not have alternatives if its only food source is removed.

Is it healthy for an ecosystem with low biodiversity but high population numbers? Why?

- Such ecosystem is not healthy.
- Having high population numbers does not provide organisms with alternatives when facing environmental changes.
- High population numbers with limited food sources may cause additional stress to population due to greater competition and depletion of food.

How did human actions change Ecosystem A?

- Organisms interact with the environment and each other in an ecosystem – for example, to find shelter and food.
- Such interactions influence the survival of organisms.

- Human actions changed the environmental conditions (e.g. global warming) and species variety (e.g. by overfishing) in the ecosystem.
- With these changes, organisms living in the ecosystem cannot survive.

Part 2: Environmental cues and suggested answers

Part 2 consists of 4 environmental cues. First 2 cues are identical to that in Part 1. Most direct effects are the same unless otherwise stated. Subsequent effects on other organisms will differ as Ecosystem B has higher biodiversity.

1. Overfishing of Indian mackerel has caused the species to be considered extinct as they are rarely found in the ocean.

   Direct effect:

   - **Indian mackerel** becomes extinct
     Students with the Indian mackerel card are to take a seat

   Subsequent effects on other organisms:

   - Decrease in populations of **tertiary consumers** (trophic level 4)
     For each species in trophic level 4, half of the assigned students must take a seat while the rest remain standing
     - Even with the extinction of Indian mackerel, there are still other prey species that the tertiary consumers can consume
     - Populations of tertiary consumers are affected but not to the extent that they will become extinct as there is still sufficient alternative food source to support populations

   - Decrease in populations of **small fishes and crustaceans** (trophic levels 2 and 3)
     For each species in trophic levels 2 and 3, half of the assigned students must take a seat while the rest remain standing
     - With one less prey choice for predators, there may be higher chances for the remaining prey species to be targeted
     - However, there still exists a variety of prey species so predation is not focused on just a single species which can lead to extinction

   - **Zooplankton** populations survive
     Students with zooplankton cards to remain standing
     - Other than the mackerel, the hermit crab, butterflyfish and blue tang are also predators of zooplankton

- Other predators keep the population size in check
- Loss of Indian mackerel as a predator does not lead to uncontrolled increase in zooplankton population

- **Primary producer** populations survive
  Students with primary producers cards to remain standing
  - Primary producers are largely not affected

2. Global warming increases light intensity and water temperature in the ocean.

Direct effects:

- **Zooplankton** populations become extinct
  Students with zooplankton cards are to take a seat

- Growth in population size of **primary producers**
  Students with primary producers cards to remain standing
  - Environmental changes favour growth of primary producers as in Part 1
  - Even without zooplankton as consumers, there are still other consumers – the unicornfish, blue tang and butterflyfish to keep the population size in check
  - Population size does not increase exponentially as in Part 1 and would not deplete their resources for growth

Subsequent effects on other organisms:

- **Indian mackerel and hermit crab** become extinct
  Students with Indian mackerel and hermit crab cards to take a seat
  - Both species depend primarily on zooplankton for nutrients
  - Extinction of zooplankton leads to lack of sufficient prey which cannot support population of both species

- Decrease in populations of **small fishes** (trophic levels 2 and 3) and **tertiary consumers** (trophic level 4)
  For each species in trophic levels 2 to 4, half of the assigned students must take a seat while the rest remain standing

- Similar cascading effect due to the extinction of Indian mackerel in the overfishing environmental cue
- Most populations can sustain themselves due to the diversity of prey and predator species in Ecosystem B

3. **Dynamite fishing is increasingly being used by fishermen to harvest Indian mackerel and bluespine unicornfish in Ecosystem B. It is an efficient fishing method that uses explosives to stun schools of fish. As a result, most underwater caves and other structures are also destroyed.**

<u>Direct effects:</u>

- **Indian mackerel and bluespine unicornfish** become extinct
  Students with Indian mackerel and bluespine unicornfish cards are to take a seat
  - Long term and frequent dynamite fishing does not give the populations enough time and a safe environment to recover

- Decrease in **all other populations** in Ecosystem B
  For each species, half of the assigned students must take a seat while the rest remain standing
  - Surrounding organisms are vulnerable to injuries as explosives may also stun them
  - The explosive force may be too strong for plankton to survive
  - Destruction of surrounding structures may deprive the animals of shelter to hide from predators

- **Spotted moray eel** becomes extinct
  Students with spotted moray eel cards are to take a seat
  - Moray eels are more vulnerable to destruction of caves and other underwater structures as they spend most of their time in those structures
  - Habitat loss will make them more vulnerable to predation and difficult for them to ambush prey

<u>Subsequent effects on other organisms:</u>

- **Zooplankton and primary producers** populations survive

Remaining students with zooplankton and primary producers cards to remain standing

- Other than mackerel and unicornfish, the hermit crab, butterflyfish and blue tang are also consumers of zooplankton and primary producers
- Having other consumers keep the population size in check
- Loss of the mackerel and unicornfish as consumers does not lead to uncontrolled increase in zooplankton and primary producer populations

- Further decrease in populations of **small fishes** (trophic levels 2 and 3) and **tertiary consumers** (trophic level 4)
  For each species in trophic levels 2 to 4, the remaining half of the assigned students must take a seat
  - Similar cascading effect due to the extinction of Indian mackerel in the overfishing environmental cue
  - Most populations can sustain themselves due to the diversity of prey and predator species in Ecosystem B

4. **Red lionfish, a non-native species in Ecosystem B, has been frequently released into the habitat. The species was brought in for aquarium trade and now has been released into the habitat after injuring many owners with their venomous spines.**

   Background information of red lionfish:

   - Predator of small fishes and crustaceans
   - Possess venomous spines on dorsal and pelvic fins
   - Sharks are known to be their natural predators

   <u>Direct effect:</u>

   - Decrease in populations of **small fishes** (trophic levels 2 and 3) and **hermit crab**
     For the hermit crab and each species of small fish, half of the assigned students must take a seat while the rest remain standing
     - Presence of additional predators increases chances of small fishes and hermit crabs to be consumed

- Decrease in population of **tertiary consumers** (trophic level 4)
  For each species in trophic level 4, half of the assigned students must take a seat while the rest remain standing
  - Diet of tertiary consumers in Ecosystem B is similar to that of red lionfish – small fishes and crustaceans
  - Introduction of red lionfish gives the tertiary consumers additional competition for prey

- **Shark** (trophic level 5) populations survive
  Students with shark cards are to remain standing
  - As natural predators of lionfish, sharks will feed on the lionfish
  - Sharks help to keep population size of the lionfish in check and prevent extreme negative impacts on populations of secondary and tertiary consumers

<u>Subsequent effects on other organisms:</u>

- Increase in **zooplankton** populations
  Students with zooplankton cards are to remain standing
  - Decrease in the populations of small fishes and hermit crab
  - Less predators of zooplankton

- Decrease in **primary producer** populations
  For each species of primary producer, half of the assigned students must take a seat while the rest remain standing
  - Increase in zooplankton populations
  - Increase in consumption of primary producers

Part 2: Discussion points

How was the outcome in Part 2 different from that in Part 1?

- Although some populations were negatively affected to some degree in Ecosystem B, most populations still survived.
- Removal of a few species from Ecosystem B did not lead to widespread extinction of other species as observed in Ecosystem A.
- High biodiversity in Ecosystem B allowed the ecosystem to withstand environmental changes.

Is having high biodiversity important for an ecosystem to be resilient against environmental changes? Why?

- Having high biodiversity is important for the resilience of an ecosystem.
- Every organism has a role to play in an ecosystem – such as predators to keep prey population size in check or prey to provide nutrients.
- A variety of species allows each trophic level to be represented by more than 1 species connected by a food web instead of singular food chain.
- Even with the removal of a prey species, there are other prey species as alternative food sources for predators.
- As long as effects of environmental changes are not widespread across most species, there would be sufficient alternatives for survival.
- Eventually, this prevents the ecosystem from collapsing as most species will still be able to support each other and survive.

Will there be any situations whereby human actions can significantly affect ecosystems with high biodiversity?

- Ecosystems may be resilient to environmental changes but they are not immune to the impacts.
- Situations where ecosystems with high biodiversity can be affected:
    - Multiple environmental changes happening at the same time
    - Changes happen frequently
    - Changes last for a long period of time
- In such situations, many different populations may not have the opportunity to recover from the changes and having high biodiversity is insufficient to support the whole ecosystem.
- For example, if populations of most prey species are affected at the same time, it still leaves limited alternative food sources for predators.