CHAPTER 5:

Challenges to Ocean Health

(What threatens marine systems)

Section	Topic	What Students Will Learn
1	Climate Change and Ocean Health	Ocean warming, ocean. Acidification, coral bleaching, sea-level rise and changing ecosystems
2	Marine Pollution	How pollution and its different types affects marine life
3	Habitat Loss and Degradation	Coastal development, mangrove loss and ecosystem change
4	Overfishing, Bycatch and Illegal Fishing	Human pressures on marine populations
5	Invasive Species	How introduced species affect ecosystems
6	Biodiversity Loss and Extinction Risk	Understanding species declines and conservation concerns

By the end of this chapter students will understand the major challenges facing oceans today and why urgent conservation action is needed.

Coral reefs

SECTION 1:

Climate Change and Ocean Health:

What Might Oceans Look Like in the Future?

Oceans are constantly changing. Tides shift daily, seasons influence currents and marine species move across enormous distances. However, scientists have observed that human-driven climate change is now altering oceans more rapidly and on much larger scales than many natural changes in the past.

Oceans absorb large amounts of heat and carbon dioxide from Earth's atmosphere. In fact, oceans help slow global warming by storing much of the excess heat produced by greenhouse gas emissions. While this reduces warming on land to some extent, it also creates major changes within marine ecosystems.

One of the clearest signs of climate change in oceans is:

Rising Ocean Temperatures

Marine heatwaves are becoming more common in several regions, and warmer waters are already affecting coral reefs, fisheries and marine food webs.

Many marine species survive only within certain temperature ranges. As oceans warm, organisms may shift toward cooler waters, deeper regions or entirely new habitats. Scientists have already observed changing migration patterns in:

- fish,
- whales,
- plankton,
- and seabirds.

Some species may adapt successfully, while others may struggle if suitable habitats disappear.

Research in marine climate science shows that ocean warming is already influencing species distributions and ecosystem structure worldwide.

Future Ocean Scenarios

One of the most visible impacts of warming oceans is:

Coral Bleaching

Corals live in partnership with microscopic algae that provide much of their energy. When ocean temperatures become too warm, corals may expel these algae, causing reefs to turn white.

Repeated bleaching events may weaken or kill coral reefs, affecting thousands of marine species that depend on these ecosystems for food and shelter.

Scientists are now studying:

- heat-resistant corals,
- reef restoration,
- and conservation strategies

to help reefs survive changing conditions.

Climate change is also causing:

Sea-Level Rise

As oceans warm, seawater expands slightly. At the same time, melting glaciers and ice sheets add more water into oceans.

Rising sea levels may increase:

- coastal flooding,
- erosion,
- saltwater intrusion,
- and storm damage,

especially in low-lying coastal regions and island communities.

Millions of people worldwide live near coastlines, meaning sea-level rise affects both ecosystems and human societies.

Sea-Level Rise and Coastal Cities

Another major climate-related challenge is:

Ocean Acidification

As carbon dioxide dissolves into seawater, oceans become slightly more acidic. This may affect organisms that build shells or skeletons from calcium carbonate, including:

- corals,
- oysters,
- mussels,
- and some plankton species.

Because many marine food webs depend on these organisms, acidification may create wider ecosystem effects over time.

Climate change may also influence:

- ocean currents,
- storms,
- oxygen levels,
- and marine productivity.

Scientists are especially concerned about ecosystems already facing multiple pressures from pollution, habitat destruction and overfishing.

Spotlight

Polar Ecosystems

Rapidly Changing Oceans

Polar marine ecosystems are warming faster than many other parts of the planet.

Sea ice loss affects organisms such as penguins, seals, polar bears and krill which depend directly or indirectly on ice-associated habitats.

Changes in polar oceans may also influence global climate systems and ocean circulation.

Species Range Shifts and Ocean Change

Despite these challenges, scientists and communities around the world are also working on:

Climate Adaptation and Resilience

Adaptation involves preparing ecosystems and societies for changing environmental conditions.

Examples include:

- restoring mangroves to reduce storm damage,
- protecting climate-resilient ecosystems,
- improving fisheries management,
- and reducing greenhouse gas emissions.

Renewable energy, habitat restoration and sustainable conservation strategies may help reduce future climate impacts on oceans.

Importantly, climate change does not mean all future ocean outcomes are already fixed. The future depends heavily on decisions humans make now about:

- energy use,
- conservation,
- pollution,
- and environmental management.

Many scientists emphasise that protecting marine ecosystems can also strengthen their resilience to climate change.

Healthy ecosystems are often better able to recover from disturbances and environmental stress.

Climate Solutions and Ocean Resilience

Things to Remember

1. Oceans absorb large amounts of heat and carbon dioxide from the atmosphere.
2. Ocean warming is already affecting marine ecosystems and species distributions.
3. Sea-level rise may increase flooding and coastal erosion.
4. Ocean acidification affects shell-forming organisms and marine food webs.
5. Future ocean conditions depend strongly on human actions and climate solutions.

Key Terms

Climate change: Long-term changes in Earth's climate systems caused largely by greenhouse gas emissions

Marine heatwave: Period of unusually warm ocean temperatures

Sea-level rise: Increase in average ocean height over time

Ocean acidification: Increasing acidity of oceans caused by dissolved carbon dioxide

Climate resilience: Ability of ecosystems or communities to recover from environmental change

Adaptation: Adjustments helping organisms or societies respond to changing conditions

Quick Quiz

1. Why are oceans warming?
2. How does climate change affect coral reefs?
3. What causes sea-level rise?
4. What is ocean acidification?
5. Why are healthy ecosystems important for climate resilience?

SECTION 2:

Human Impacts on Marine Ecosystems:

How Are Humans Changing Oceans?

For centuries, oceans appeared too vast for humans to damage significantly. Waves washed away pollution, fish populations seemed endless, and deep oceans remained largely unexplored. However, over the past hundred years, scientists began recognising that human activities can affect marine ecosystems on enormous scales.

Today, oceans face growing pressures from pollution, overfishing, habitat destruction and climate change. These impacts often overlap and interact with one another, making marine conservation increasingly complex.

Importantly, human impacts do not affect only marine organisms. Changes in ocean ecosystems may also influence:

- food systems,
- coastal protection,
- livelihoods,
- tourism,
- and global climate regulation.

Understanding these impacts helps explain why healthy oceans are important not only for biodiversity, but also for human societies.

One of the most visible forms of marine pollution is plastic waste. Every year, large amounts of plastic enter rivers, coastlines and oceans from cities, industries and human activities. Some plastic floats on the ocean surface, while other pieces sink to the seafloor or break into tiny fragments called:

Microplastics

Marine animals may accidentally swallow plastic or become entangled in discarded fishing gear and debris. Sea turtles sometimes mistake floating plastic bags for jellyfish, while seabirds may feed plastic fragments to their chicks.

Scientists have now detected microplastics in many marine environments, including deep oceans, polar regions and even marine food webs. Research in marine pollution science suggests that plastic pollution is now present across nearly all major ocean ecosystems.

Plastic Pathways into Oceans

Another major challenge facing oceans is habitat destruction. Coastal ecosystems such as mangroves, coral reefs and seagrass beds are often damaged by:

- coastal development,
- dredging,
- pollution,
- destructive fishing,
- and land-use change.

These ecosystems are extremely important because they support biodiversity, fisheries and coastal protection. Mangroves help reduce shoreline erosion, while coral reefs provide habitat for thousands of marine species.

When these habitats decline, marine ecosystems may become less productive and less resilient to environmental change.

Coral reefs are especially vulnerable to rising ocean temperatures caused by climate change. Corals live in partnership with microscopic algae that provide much of their energy through photosynthesis. When ocean temperatures become too warm, corals may expel these algae, causing:

Coral Bleaching

Bleached corals appear white because the colourful algae are gone. If stressful conditions continue for too long, corals may die.

Mass coral bleaching events have increased globally in recent decades due to rising ocean temperatures.

Coral Bleaching and Habitat Loss

Human activities also affect oceans in less visible ways. Large ships, underwater construction and industrial activities create:

Noise Pollution

Many marine organisms depend heavily on sound for communication, navigation and hunting. Whales, dolphins and some fish species may be affected by increasing underwater noise levels.

Climate change is creating additional pressures across marine ecosystems. Oceans absorb large amounts of heat and carbon dioxide from the atmosphere, which influences ocean temperatures and chemistry.

As oceans warm:

- species distributions may shift,
- storms may intensify,
- sea levels may rise,
- and marine food webs may change.

Some fish populations are already moving toward cooler waters, affecting fisheries and coastal communities.

Oceans are also becoming more acidic as carbon dioxide dissolves into seawater. This process is called:

Ocean Acidification

Acidification may affect organisms that build shells or skeletons from calcium carbonate, including corals, oysters and some plankton species.

Spotlight

Ghost Nets

Fishing Gear That Continues Catching Animals

Lost or abandoned fishing gear is often called **Ghost Gear**. These drifting nets may continue trapping fish, turtles, sharks and marine mammals long after they are discarded.

Ghost gear is now considered one of the major forms of marine debris affecting ocean wildlife.

Ghost Nets and Marine Pollution

Human impacts are not distributed evenly across oceans. Coastal ecosystems near large cities and industrial regions often experience especially intense pressure. Deep-sea ecosystems, once considered relatively isolated, are now also facing growing interest from industries such as deep-sea mining.

Scientists continue studying how multiple stressors interact across marine ecosystems. Pollution, warming, habitat destruction and overfishing may together create cumulative impacts larger than any single threat alone.

Despite these challenges, there are also growing efforts to reduce human impacts on oceans. Many countries and organisations are working to:

- reduce plastic waste,
- restore habitats,
- improve fisheries management,
- and expand marine conservation.

Individuals can also contribute through choices related to:

- waste reduction,
- seafood consumption,
- and environmental awareness.

Understanding human impacts on oceans is important because marine ecosystems are deeply connected to planetary health. Healthy oceans regulate climate, support biodiversity and sustain millions of people worldwide.

Protecting oceans therefore means protecting systems that all life on Earth depends upon.

Climate Change and Oceans

Things to Remember

1. Human activities can affect marine ecosystems on very large scales.
2. Plastic pollution is now found across nearly all major ocean environments.
3. Coral bleaching is strongly linked to rising ocean temperatures.
4. Noise pollution and ocean acidification are important but less visible marine threats.
5. Healthy oceans are essential for biodiversity, climate regulation and human livelihoods.

Key Terms

Microplastics: Tiny plastic particles formed when larger plastics break down

Coral bleaching: Loss of symbiotic algae from corals due to environmental stress

Ocean acidification: Decrease in ocean pH caused by absorption of carbon dioxide

Ghost gear: Lost or abandoned fishing gear that continues trapping marine organisms

Habitat destruction: Damage or loss of natural ecosystems

Noise pollution: Human-generated underwater sound affecting marine organisms

Marine debris: Human-made waste found in marine environments

Quick Quiz

1. What are microplastics and how do they form?
2. Why does coral bleaching occur?
3. How can ghost nets affect marine organisms?
4. What is ocean acidification?
5. Why are healthy marine ecosystems important for humans?

SECTION 3

Habitat Loss and Degradation:

When Marine Homes Disappear

Imagine arriving home one day to find that your house has disappeared.
Your food, shelter, family and safety would all be affected.
For marine organisms, habitats serve a similar purpose. Coral reefs provide shelter for reef fish, mangroves protect juvenile fish and crustaceans, and seagrass meadows offer feeding grounds for dugongs and sea turtles. Every marine habitat supports a unique community of species that depend on it for survival.
When these habitats are damaged, altered or destroyed, marine organisms may lose the resources they need to survive.
Habitat loss and degradation are among the most significant threats facing marine biodiversity today.
According to the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), habitat change remains one of the leading causes of biodiversity decline globally.[1]

What is Habitat Loss?

Habitat loss occurs when a natural habitat is completely removed or transformed into something else.
Examples include:

- Clearing mangroves for coastal development
- Reclaiming wetlands for construction
- Destroying coral reefs through destructive fishing practices
- Converting coastal habitats for ports and infrastructure

When habitats disappear, species that depend on them may also decline.
Some organisms can move elsewhere.
Others cannot.
Species with highly specialised habitat requirements are often most vulnerable.

What is Habitat Degradation?

Habitats do not need to disappear completely before problems occur.
Sometimes they remain physically present but become less suitable for the organisms that depend upon them.
This is called habitat degradation.
Examples include:

- Coral reefs affected by bleaching
- Seagrass meadows damaged by sedimentation
- Mangroves polluted by industrial waste
- Estuaries altered by changes in freshwater flow

Degraded habitats often support fewer species and provide fewer ecosystem services.

Mangroves and seagrass meadows are declining in many parts of the world because of Coastal development, Pollution, Dredging, Anchoring and Poor water quality

Global analyses suggest that seagrass habitats are disappearing at rates comparable to some tropical forests.

Coastal Development:

Expanding Human Footprints

Human populations are increasingly concentrated along coastlines.
As coastal cities grow, demand increases for:

- Ports
- Roads
- Tourism infrastructure
- Housing
- Industry

While development can provide important economic benefits, poorly planned projects may damage marine habitats.
Examples include:

- Dredging seabeds
- Filling wetlands
- Removing mangroves
- Increasing sediment runoff

Balancing development and conservation remains one of the major challenges facing coastal ecosystems worldwide.
UNEP Coastal Ecosystems Programme.[6]

Did You Know?

Nearly 40% of the world's population lives within 100 kilometres of a coastline.

This means that decisions made along coastlines can influence both human communities and marine ecosystems on a massive scale.
United Nations Ocean Conference.[7]

Habitat Fragmentation:

When Ecosystems Become Isolated

Even if some habitat remains, breaking ecosystems into smaller disconnected pieces can create problems.
This process is known as habitat fragmentation.
Fragmented habitats may:

- Support fewer species
- Reduce breeding opportunities
- Limit movement
- Increase vulnerability to disturbance

Many marine species depend on connected habitats throughout their life cycles.
For example:
A fish may use mangroves as a nursery, seagrass as a juvenile habitat and coral reefs as an adult habitat.
If one of these habitats disappears, the entire life cycle may be affected.

Threat Alert

Losing Nature's Safety Nets

Healthy habitats provide important ecosystem services.
When habitats decline, people may lose:

- Coastal protection
- Fisheries productivity
- Carbon storage
- Water quality benefits
- Tourism opportunities

Habitat loss therefore affects both biodiversity and human well-being.

Hope for the Future

Conservation successes demonstrate that damaged habitats can recover.
Examples include:

- Mangrove restoration projects in India and Southeast Asia
- Coral reef restoration initiatives
- Seagrass transplantation programmes
- Community-led habitat protection efforts

While restoration cannot replace prevention, it shows that conservation action can help ecosystems recover when given the opportunity.

Things to Remember

1. Habitat loss occurs when ecosystems are removed or transformed.
2. Habitat degradation occurs when habitats remain but function less effectively.
3. Coral reefs, mangroves and seagrasses are among the most important marine habitats.
4. Habitat fragmentation can affect species even when some habitat remains.
5. Healthy habitats support biodiversity and human well-being.
6. Habitat conservation often benefits many species simultaneously.

Key Terms

Habitat: Natural environment where an organism lives
Habitat loss: Complete removal of a habitat
Habitat degradation: Decline in habitat quality
Habitat fragmentation: Breaking habitats into smaller isolated areas
Restoration ecology: Scientific study of ecosystem recovery
Ecosystem engineer: Organism that modifies its environment
Coastal resilience: Ability of coastal systems to withstand disturbance

Quick Quiz

1. What is the difference between habitat loss and habitat degradation?
2. Why are mangroves important for coastal communities?
3. How do seagrass meadows support marine biodiversity?
4. What is habitat fragmentation?
5. Why are coral reefs often called biodiversity hotspots?
6. How can coastal development affect marine ecosystems?

SECTION 4

Overfishing, Bycatch and Illegal Fishing:

Taking More Than Oceans Can Replace

For thousands of years, oceans have provided food, livelihoods and cultural identity for people around the world. Today, fish and other seafood remain an important source of protein for billions of people. Fisheries also support millions of jobs, from fishers and processors to traders, exporters and coastal businesses.
For a long time, oceans were often viewed as limitless resources. Fish populations seemed so vast that many people believed they could never be depleted. However, scientific research has shown that marine resources are not unlimited. Like forests, grasslands or freshwater systems, marine populations require time to grow, reproduce and recover. When harvesting occurs faster than populations can replenish themselves, declines can occur. Fisheries Science.[1]

What is Overfishing?

Overfishing occurs when fish are removed from a population at a rate faster than they can naturally replace themselves.
Imagine a fish population as a bank account.
If fish reproduce and add 100 new individuals each year, but humans remove 200 individuals annually, the population gradually declines.
At first, these declines may be difficult to notice. Fishers may simply travel farther or fish longer to catch the same amount of fish. Over time, however, populations can become severely depleted.
Some of the world's most famous fisheries have experienced dramatic declines because of overfishing. One well-known example is the collapse of Atlantic cod fisheries in eastern Canada during the 1990s. Despite decades of fishing success, populations eventually fell so low that large-scale fishing closures became necessary.

Why Are Some Species More Vulnerable?

Not all species respond to fishing pressure in the same way.
Some species:

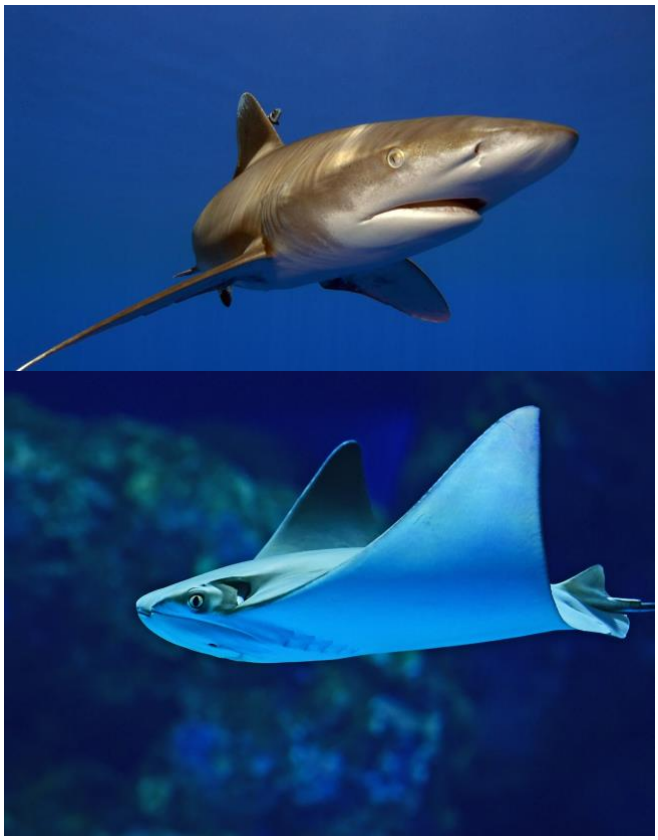
- grow quickly,
- mature early,
- and produce many offspring.

Others:

- grow slowly,
- mature late,
- and produce relatively few young.

Species in the second group are generally much more vulnerable to overfishing.

Species Spotlight



Sharks and Rays

Ocean Predators Under Pressure

Many sharks and rays are particularly susceptible to overfishing because they have slow life histories.
For example:

- Whale sharks may take decades to mature.
- Manta rays typically produce only one pup every few years.
- Some deep-sea sharks may live for more than 100 years.

When these species decline, populations may take decades to recover. Recent global assessments found that more than one-third of shark and ray species face an elevated risk of extinction, with overfishing identified as the primary threat.

India Spotlight

India supports one of the world's largest marine fisheries and is home to diverse shark and ray

species. Researchers, fishers and conservation organisations are increasingly working together to improve fisheries monitoring, understand bycatch and promote sustainable fishing practices.

Bycatch:

The Unintended Catch

Fishing gear is designed to catch target species. However, many fishing methods also capture animals that fishers did not intend to catch.
This accidental capture is called **bycatch**.
Bycatch may include:

- sea turtles,
- dolphins,
- whales,
- seabirds,
- sharks,
- rays,
- juvenile fish.

In some cases, bycaught animals are released alive. In others, injuries or stress may prevent survival.
Research suggests that bycatch is one of the most significant conservation threats affecting marine megafauna worldwide. FAO; Marine Policy.

Spotlight

Sea Turtles and Fishing Nets

Sea turtles must regularly surface to breathe air. When turtles become entangled in fishing gear, they may be unable to reach the surface and can drown.
To reduce this risk, some fisheries use Turtle Excluder Devices (TEDs), specially designed openings in trawl nets that allow turtles to escape while retaining the target catch.
TEDs are considered one of the most successful examples of technology helping reduce bycatch.

Illegal, Unreported and Unregulated Fishing

Another major challenge facing oceans is Illegal, Unreported and Unregulated (IUU) fishing.

Illegal Fishing

Occurs when fishing activities violate laws or regulations.
Examples:

- fishing in closed areas,
- catching protected species,
- using prohibited gear.

Unreported Fishing

Occurs when catches are not accurately recorded.

Unregulated Fishing

Occurs where management systems are weak or absent.
IUU fishing can make it difficult for scientists and governments to understand the true status of fish populations.
It may also undermine sustainable fisheries and reduce income for fishers who follow regulations.
The FAO estimates that IUU fishing costs the global economy billions of dollars annually.

Sustainable Fisheries:

Finding Balance

The goal of sustainable fisheries is not to stop fishing.
Instead, it is to ensure that marine resources remain available for future generations.
Scientists and fisheries managers may use:

- catch limits,
- seasonal closures,
- size restrictions,
- protected breeding areas,
- gear modifications,
- community-based management.

When implemented effectively, these approaches can help support both marine ecosystems and coastal livelihoods.

Threat Alert

Empty Oceans Syndrome

Even when oceans appear healthy from the surface, fish populations may have declined dramatically beneath the waves.

Scientists sometimes refer to this as "empty oceans syndrome"—a situation where habitats remain but many large animals have disappeared.

Things to Remember

1. Overfishing occurs when populations are harvested faster than they can recover.
2. Sharks and rays are particularly vulnerable because they reproduce slowly.
3. Bycatch affects many non-target marine species.
4. Turtle Excluder Devices can help reduce turtle bycatch.
5. IUU fishing undermines sustainable fisheries management.
6. Sustainable fisheries aim to balance ecological health and human livelihoods.

SECTION 5

Invasive Species:

When New Arrivals Change Entire Ecosystems

Marine ecosystems are shaped by millions of years of evolution. Species adapt to local conditions, predators, competitors and food sources, creating complex ecological relationships. Sometimes, however, organisms are introduced into places where they do not naturally occur. When these introduced species spread rapidly and cause ecological, economic or social harm, they are known as invasive species.
Not every species transported to a new environment becomes invasive. Many fail to survive or establish populations. However, some species thrive in their new environments because they face fewer predators, parasites or competitors than they did in their native range. Once established, invasive species can alter food webs, damage habitats and reduce biodiversity.
Biological Invasions.[1]

How Do Marine Invasive Species Spread?

The world's oceans are more connected than ever before.
Modern shipping, aquaculture and global trade have increased opportunities for species to move between regions.
Common pathways include:

Ballast Water

Large ships often take in seawater as ballast to improve stability.
This water may contain:

- plankton,
- larvae,
- small fish,
- bacteria,
- and other marine organisms.

When ballast water is released elsewhere, these organisms may enter entirely new ecosystems.

Hull Fouling

Many marine organisms attach themselves to ship hulls.
Barnacles, algae and mussels can travel thousands of kilometres before being released into new environments.

Aquaculture

Species introduced for farming purposes sometimes escape into surrounding waters.
Escaped organisms may establish wild populations and compete with native species.

Aquarium Releases

Occasionally, aquarium species released into the wild can become invasive.
Although seemingly harmless, these introductions can have long-term ecological consequences.

Species Spotlight

The Lionfish Invasion

One of the most famous marine invasions involves the Indo-Pacific lionfish in the western Atlantic Ocean and Caribbean Sea.
Lionfish are striking predators with venomous spines and distinctive striped patterns.
Scientists believe they were introduced through aquarium releases.
Without many natural predators in their new range, lionfish populations expanded rapidly.
Lionfish consume a wide variety of reef fishes and can significantly alter reef ecosystems.
Research has shown that heavily invaded reefs may experience substantial declines in native fish populations.

Why Are Invasive Species a Problem?

Invasive species may:

Compete for Food

Introduced organisms may consume resources needed by native species.

Alter Habitats

Some invasive organisms physically change ecosystems.
For example, invasive algae can smother coral reefs and seagrass habitats.

Spread Diseases

Introduced species may carry parasites or pathogens that native organisms have never encountered before.

Disrupt Food Webs

Changes affecting one species can influence many others.
A single invasive predator may alter ecosystem dynamics across entire habitats.
Because marine ecosystems are interconnected, these impacts may spread beyond the initial area of invasion.

India Spotlight

Invasive Mussels Along Indian Coasts

Scientists have documented several introduced marine organisms in Indian waters, including invasive mussels and other fouling organisms associated with shipping activities.
Ports often serve as important entry points for non-native species because of international maritime traffic.
Researchers continue monitoring Indian coastal ecosystems to better understand and manage biological invasions.
National Centre for Coastal Research (NCCR); ICAR-CMFRI.[3]

Did You Know?

Some marine organisms can survive weeks inside ballast tanks while travelling across oceans.
This means a microscopic plankton in one part of the world may unexpectedly appear thousands of kilometres away.

Technology and Monitoring

Scientists use a variety of methods to detect invasive species:

- Underwater surveys
- Environmental DNA (eDNA)
- Remote sensing
- Citizen science observations
- Genetic analyses

Early detection is often the most effective way to prevent invasions from becoming established.
Once invasive species spread widely, eradication may become extremely difficult and expensive.

Threat Alert

Silent Ecological Changes

Unlike pollution events or storms, invasive species often spread gradually.
Their impacts may take years to become obvious.
By the time changes are noticed, populations may already be firmly established.

Things to Remember

1. Invasive species are organisms introduced outside their natural range that cause harm.
2. Ballast water and shipping are major pathways for marine invasions.
3. Invasive species can alter habitats, food webs and biodiversity.
4. Prevention is often easier than eradication.
5. Monitoring and early detection are critical for management.

Key Terms

Invasive species: Non-native organism causing ecological or economic harm
Ballast water: Water carried by ships for stability
Hull fouling: Organisms attached to ship surfaces
Biosecurity: Measures designed to prevent biological invasions
Introduced species: Species occurring outside their natural range
Eradication: Complete removal of an invasive population

Quick Quiz

1. What is an invasive species?
2. How can ballast water transport marine organisms?
3. Why do some invasive species spread rapidly?
4. Name two impacts invasive species can have on ecosystems.
5. Why is early detection important?

SECTION 6

Biodiversity Loss and Extinction Risk:

Why Every Species Matters

The oceans are home to an extraordinary diversity of life. From microscopic plankton drifting in the sunlit surface waters to giant whales crossing entire ocean basins, millions of species contribute to the functioning of marine ecosystems.
Each species plays a role.
Some species recycle nutrients. Others regulate prey populations, create habitats or help transfer energy through food webs. Together, these interactions support healthy ecosystems that provide food, oxygen, climate regulation and livelihoods for people around the world.
However, many marine species are facing increasing pressures from human activities.
Habitat destruction, climate change, pollution, invasive species and unsustainable fishing practices are causing declines in populations across many regions of the world. Scientists now recognise biodiversity loss as one of the most significant environmental challenges facing our planet.
Conservation Biology.[1]

What is Biodiversity?

The term **biodiversity** refers to the variety of life on Earth.
Scientists often describe biodiversity at three levels:

Genetic Diversity

Differences within a species.
For example, populations of sea turtles nesting on different beaches may possess unique genetic characteristics that help them adapt to local conditions.

Species Diversity

The variety of different species within an ecosystem.
A coral reef may support thousands of species of fish, corals, molluscs, crustaceans and microorganisms.

Ecosystem Diversity

The variety of habitats and ecosystems.
Examples include:

- coral reefs,
- mangroves,
- seagrass meadows,
- open oceans,
- deep-sea ecosystems.

Healthy biodiversity helps ecosystems remain productive, stable and resilient when environmental conditions change.

Why Do Species Matter?

Imagine removing every screw from an airplane one at a time.
At first, nothing obvious may happen.
However, eventually enough parts disappear that the entire system becomes unstable.
Marine ecosystems often work in similar ways.
Some species perform critical ecological functions:

- Predators regulate prey populations.
- Herbivores prevent algae from overwhelming reefs.
- Filter feeders improve water quality.
- Habitat-forming species create homes for countless organisms.

When species disappear, ecosystems may lose important functions.
This can affect many other organisms—including humans.

Extinction:

When a Species Disappears Forever

A species becomes **extinct** when the last individual dies.
Extinction is a natural process and has occurred throughout Earth's history.
However, scientists estimate that modern extinction rates are significantly higher than historical background levels because of human activities.
Unlike local declines, extinction is permanent.
Once a species disappears, it cannot be brought back.

Extinction vs Extirpation

These terms are often confused.

Extinction

The species disappears globally.
Example:
The Caribbean Monk Seal is extinct worldwide.

Extirpation

A species disappears from a particular area but survives elsewhere.

Example:
A shark species may disappear from one coastline while still existing in other parts of its range.
Understanding this difference helps conservationists determine where recovery efforts may still be possible.

Species Spotlight

Sawfish

Sharks' Extraordinary Relatives

Sawfishes are among the most distinctive marine animals on Earth.
Their long, flattened snouts are lined with tooth-like structures that resemble a saw.
Historically, sawfishes occurred throughout many tropical coastal ecosystems, including India.
Today, all species of sawfish are considered threatened with extinction.
Major threats include:

- habitat loss,
- bycatch,
- coastal development,
- and overfishing.

Because sawfishes often inhabit shallow coastal habitats, they are especially vulnerable to human activities.

IUCN Shark Specialist Group.[4]

India Spotlight

Dugongs: India's Sea Cows

Dugongs are gentle marine mammals that feed primarily on seagrass.
India supports important dugong populations in:

- the Gulf of Mannar,
- Palk Bay,
- Andaman and Nicobar Islands,
- Gulf of Kachchh.

Because dugongs depend heavily on healthy seagrass ecosystems, they are vulnerable to habitat degradation, accidental capture in fishing gear and coastal development.
Conservation efforts increasingly focus on protecting both dugongs and the seagrass habitats they depend upon. The Nature Conservation Foundation, WWF-India and scientists like Dr. Elrika D'Souza and Dr. Vardhan Patankar have been working to understand and research the Dugong for more than a decade in the Andaman and Nicobar Islands.

Did You Know?

Whale sharks were once constituted a large part of fisheries bycatch in India, but legal protection by its inclusion into India's Wildlife (Protection) Act and tremendous conservation efforts have helped improve its conservation outcomes.

Functional Extinction:

When Species Become Too Rare to Matter

A species does not need to disappear completely before problems begin.
Sometimes populations decline to such low levels that they can no longer perform their ecological role effectively.
Scientists call this **functional extinction**.
For example:
A predator may still survive in small numbers but no longer regulate prey populations.
Similarly, a reef-building coral species may remain present but no longer create the habitat structure needed by other organisms.
Functional extinction can affect ecosystem health long before a species disappears entirely.
Ecological Applications.[6]

The IUCN Red List:

Measuring Extinction Risk

Scientists use the **International Union for Conservation of Nature (IUCN) Red List** to assess extinction risk.
Species are classified into categories including:

- Least Concern
- Near Threatened
- Vulnerable
- Endangered
- Critically Endangered
- Extinct in the Wild

- Extinct

Assessments consider:

- population trends,
- geographic range,
- threats,
- habitat condition,
- and reproductive biology.

The Red List is one of the most widely used conservation tools in the world.
IUCN Red List Programme.[7]

Threat Alert

The Silent Disappearance of Marine Life

Many marine species decline gradually.
Unlike dramatic oil spills or storms, biodiversity loss often occurs quietly over decades.
Scientists may only recognise the scale of a decline after populations have already become severely depleted.
Long-term monitoring therefore plays a crucial role in conservation.

Hope for the Future

Although biodiversity faces many challenges, conservation successes demonstrate that recovery is possible.
Examples include:

- Several whale populations are recovering after international whaling bans.
- Improved protection for sea turtles on important nesting beaches.
- Restoration of mangrove ecosystems.
- Increased protection for whale sharks and dugongs.
- Community-led conservation initiatives across coastal regions.

These successes show that informed conservation action can make a difference.
Things to Remember

1. Biodiversity includes genetic, species and ecosystem diversity.
2. Every species contributes to ecosystem functioning.
3. Extinction is permanent, while extirpation occurs locally.
4. Functional extinction can occur before a species disappears completely.
5. The IUCN Red List helps scientists assess extinction risk.
6. Many marine species can recover when threats are reduced.

Key Terms

Biodiversity: Variety of life at genetic, species and ecosystem levels
Extinction: Permanent disappearance of a species
Extirpation: Local disappearance of a species
Functional extinction: Population decline to levels where ecological roles are no longer fulfilled
Endangered species: Species facing a high risk of extinction
IUCN Red List: Global system for assessing extinction risk
Ecosystem resilience: Ability of ecosystems to withstand and recover from disturbance