Fishing for the Future

Marine Conservation and Resource Management

Teacher's Guide for Milne Bay Province
National Fisheries Syllabus
Vocational Secondary Schools of Papua New Guinea

KNCF

Milne Bay Provincial Government

Conservation International
Papua New Guinea

Global Environment Facility

UNDP

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Credits

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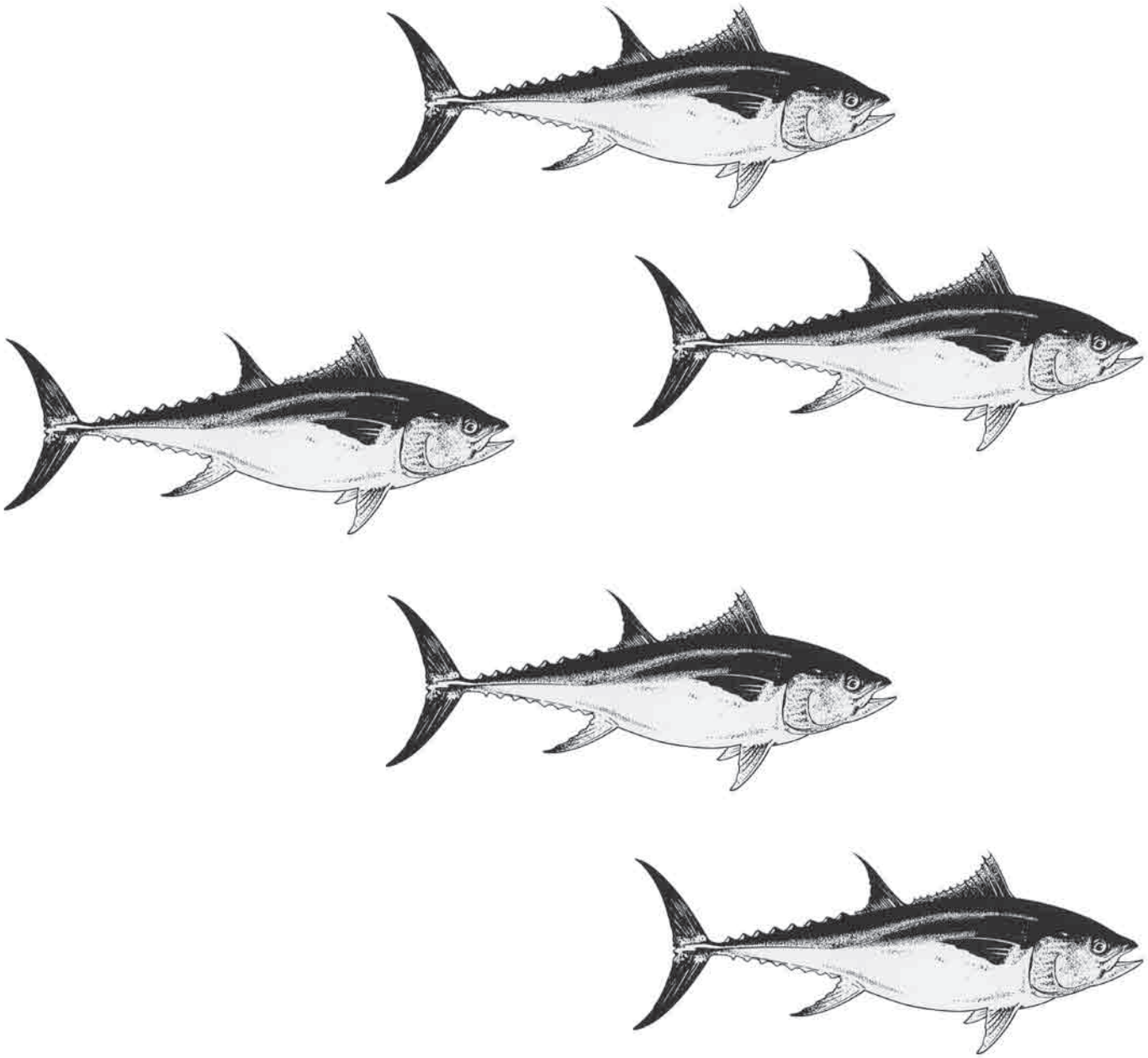


Purpose and Background

Education delivered through schools and at home plays an important role in preparing the next generation to care for and manage our **natural resources*** sustainably. While PNG's Vocational Secondary Schools include a Fisheries Syllabus, the existing course did not include a **module** for marine **conservation** and management issues. In June 2003, the National Department of Education hosted a participatory workshop to revise the National Fisheries Syllabus. During the workshop, participants developed a framework for the Conservation and Resource Management module that integrates concepts of basic marine ecology and **sustainable** fishing and harvesting practices into the fisheries syllabus.

This module will be piloted in Milne Bay Province, as part of the Milne Bay Community Based Coastal and Marine Conservation Project. This teacher's guide will aid educators in incorporating this module into their fisheries and resource management courses. The guide includes a curriculum framework for the module, background information on marine conservation in PNG, advice on developing interactive lesson plans, and sample lesson plans on module topics.

Objectives

The primary objectives of the Marine Conservation and Resource Management Module are to:

1. Strengthen environmental education
2. Raise awareness of marine resource management and conservation to support sustainable use of these resources;
3. Help integrate simple scientific monitoring concepts into local management initiatives; and
4. Equip students with basic marine resource management principles for application to their local areas

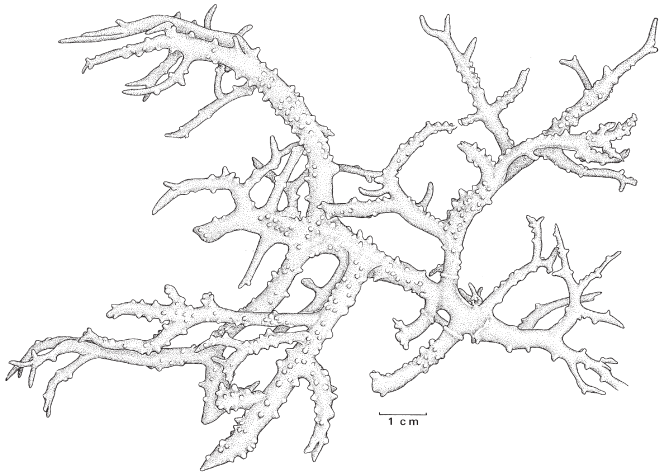
Background

The initiative for the development of this module came from National Department of Education policies that set out the following guidelines:

> "To develop an education system to meet the needs of Papua New Guinea and its people, which will provide appropriately for the return of children to the village community, for formal employment, or for continuation to further education" (National Education Plan 1996).

A key feature of this reform that directs the focus of this module is to:

> "Provide a new and more relevant curriculum which emphasizes skills development and the use and maintenance of local knowledge and materials for community development" (Curriculum Management plan 2001-2005).



* Words in bold appear in the glossary in Appendix I.

PNG Vocational Secondary Schools Fisheries Syllabus Overview

Year One

No.	Module	Sub Modules	
1.1	INTRODUCTION TO FISHERIES	1.1.1	Basic Seamanship
		1.1.2	Fishing Gear and Methods
		1.1.3	Post Harvest Operations
		1.1.4	Fish Farming
		1.1.5	Conservation & Resources Management
1.2	BASIC SEAMANSHIP	1.2.1	Safety at Sea
		1.2.2	Rope Work
		1.2.3	Boat Building
		1.2.4	Basic Navigation
1.3	FISHING GEAR & METHODS	1.3.1	Introduction to Fishing Gear Technology
		1.3.2	Classification of Fishing Gear
		1.3.3	Braiding
		1.3.4	Netting Theory
1.4	FISH FARMING	1.4.1	Aquaculture
		1.4.2	Mariculture
1.5	MARINE CONSERVATION AND RESOURCE MANAGEMENT	1.5.1	Marine resources
		1.5.2	Local Conservation Initiatives
		1.5.3	Marine Resource Management Legislation
1.6	POST HARVEST OPERATIONS	1.6.1	Nutrition
		1.6.2	Fish Handling
		1.6.3	Fish Processing
		1.6.4	Processing of Crabs & Crayfish

Year Two

No.	Module	Sub Modules	
2.1	INTRODUCTION TO FISHERIES II	2.1.1	Fishing Gear and Methods 2
		2.1.2	Post Harvest 2
		2.1.3	Starting a Fishing Business
2.2	FISHING GEAR & METHODS	2.2.1	Gear Design
		2.2.2	Gear Construction
		2.2.3	Gear Operations
		2.2.4	Gear Maintenance
2.3	POST HARVEST OPERATIONS	2.3.1	Safety & Effective Working Practices
		2.3.2	Fish Handling
		2.3.3	Fish Processing
		2.3.4	Hygiene & Sanitation
2.4	STARTING A FISHING BUSINESS	2.4.1	Fish Business Idea – Awareness
		2.4.2	Planning a Fishery Business Idea
		2.4.3	Business Proposal Action Plan
		2.4.4	Business Registration
2.5	SMALL ENGINE	2.5.1	Outboard Motor (O.B.M.) Operations
		2.5.2	Manual Water Pump
		2.5.3	Electrical Water Pump
		2.5.4	Solar Water Pump
		2.5.5	Small Generator

Module Rationale and Structure

Module Rationale

Basic knowledge of marine ecosystems and fisheries management is essential for residents of coastal villages in PNG. This **module** provides introductory knowledge and skills for maintaining healthy **populations** of **marine resources**, contributing to PNG's goal of ensuring a readily available food source for its coastal and island villages. Marine management and **conservation** education can promote the connections between traditional Melanesian culture and spirituality and the preservation of the beauty and complexity of marine and coastal ecosystems.

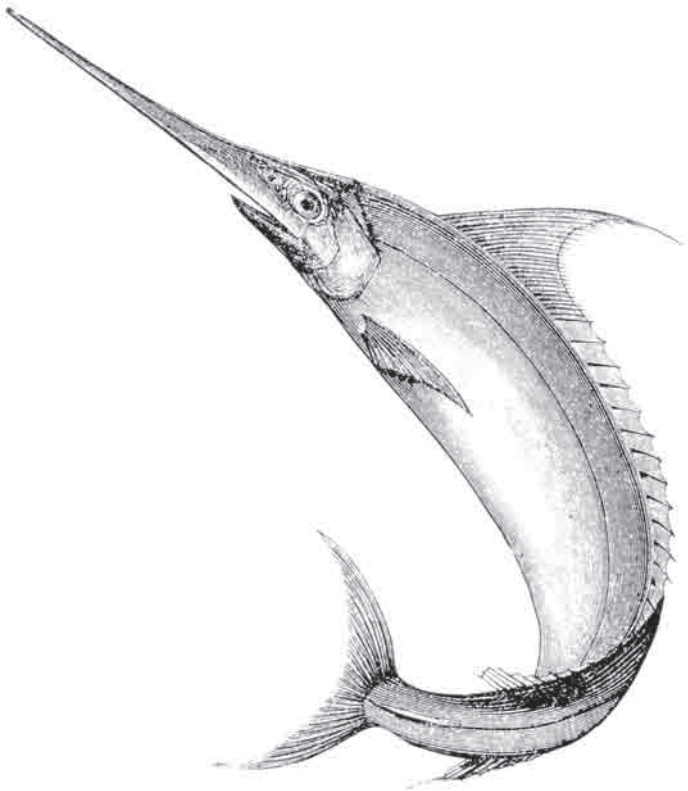
Additionally, this module supports the implementation of other PNG national policies, including:

- Food security for PNG citizens under the food security policy
- Sustainable development under the National Sustainable Development Charter
- Good governance and local participation

Module Overview

1.5 Marine Conservation & Resource Management

- 1.5.1 Marine resources
- 1.5.2 Local Conservation Initiatives
- 1.5.3 Marine Resource Management Legislation



Module Structure

The Conservation and Resource Management Module will be taught as part of the first-year program of the Vocational Secondary Schools Fisheries Syllabus. The module has four strands covering various topics. Lesson plans for topics under the first three strands cover marine conservation and resource management and will be developed and refined through a process of teacher in-servicing and pilot testing in Milne Bay Province.

This module requires approximately 70 percent classroom work and a minimum of 30 percent practical or field excursions. The course is also designed to accommodate year-long projects that cover a broad spectrum of marine resource survey and monitoring techniques, along with other student-led projects related to marine conservation.

1.5.1 Marine resources

Purpose:

Learners will be able to identify the common fish and non-fish resources in PNG. Non-fish resources apply to the marine plants and other animals either exploited for food or economic value. The strand will help students understand basic fisheries biology, ecology and resource management. Additionally they will examine the commercial use and value of fishery resources as well as their vulnerability under commercial exploitation, marine **pollution**, urban development, mining activities, deforestation, and destructive fishing methods. The strand will emphasize the values of maintaining healthy and reproductively viable **populations** of **marine resources**, ecosystem maintenance and balance, income generating opportunities and traditional management practices and resource usages. Thus, student learning objectives for this strand are:

1. Describe marine biodiversity;
2. Identify and classify fish and non-fish resources based on their nutritional, economic, and ecological values;
3. Describe the habitats of common fish and non-fish resources;
4. Identify and explain the life cycles and spawning behaviours of common fish and non-fish species; and
5. Describe common threats to marine resources and their habitats, including unsustainable fishing methods and practices that threaten fish or non-fish resources.

Fish resources	Non-fish resources
Silvertail spiny foot	Giant clams
Oxeye scad	Beche-de-mer
Tuna	Trochus shell
Shark	Crab
Coral cod	Crayfish
Coral trout	Seaweed
Mangrove jack	Mangroves
	Oysters
	Coral

1.5.2 Local Conservation Initiatives

Purpose:

Marine resource **conservation** can be achieved primarily by managing the many ways in which humans make use of the ocean environment and the animals and plants that live in the marine and coastal ecosystems of PNG. Strand 1.5.2 will cover a broad spectrum of learning skills designed to help students understand the basics of fishery management practices that are used in PNG. The concepts and skills attained from this **module** will help students carry out simple and innovative approaches to managing traditional fishing grounds, reef ecosystems, lagoon and mangrove areas, as well as to help spread these management concepts to their community elders and other resource owners. By successfully completing this module, learners will be able to identify and describe various local conservation initiatives and management techniques. Specifically, the learning objectives are:

Sustainable Harvesting Methods

1. Define the concept of **sustainable** use;
2. Introduce and explain traditional and modern harvesting gear and methods for key marine resources;
3. Identify common local harvesting methods (traditional or modern) and how they affect the sustainability of marine resource use and their impacts on habitat quality;
4. Discuss traditional conservation initiatives (fishing methods and seasons, fishing restrictions, and traditional customs such as taboos);
5. List and compare the advantages and disadvantages of traditional and modern harvesting methods;
6. Identify and give reasons for preserving and using traditional harvesting gear and methods;
7. Demonstrate the construction of traditional harvesting gear or the use of traditional harvesting methods; and
8. Discuss modern management practices that mitigate threats and sustainably manage marine resources.

Assessment and Monitoring Techniques

9. Identify, explain and demonstrate the process of various stock assessment methods; and
10. Demonstrate monitoring survey techniques of fish / and non-fish resources to determine changes in populations and habitats.

Community Mobilisation

11. Identify and explain the roles and methods involved in carrying out a successful community mobilisation and awareness program for marine conservation; and
12. Plan and demonstrate a community mobilisation project to encourage a particular conservation practice.

Examples of Management Practices:

- Locally Managed Marine Areas (LMMAs)
- Fishery management plans
- Fishery set-asides
- Seasonal closures
- Imposition of catch limits
- Gear restrictions
- Fish Aggregation Devices

This strand describes various types of appropriate management tools, and includes limits or restrictions on:

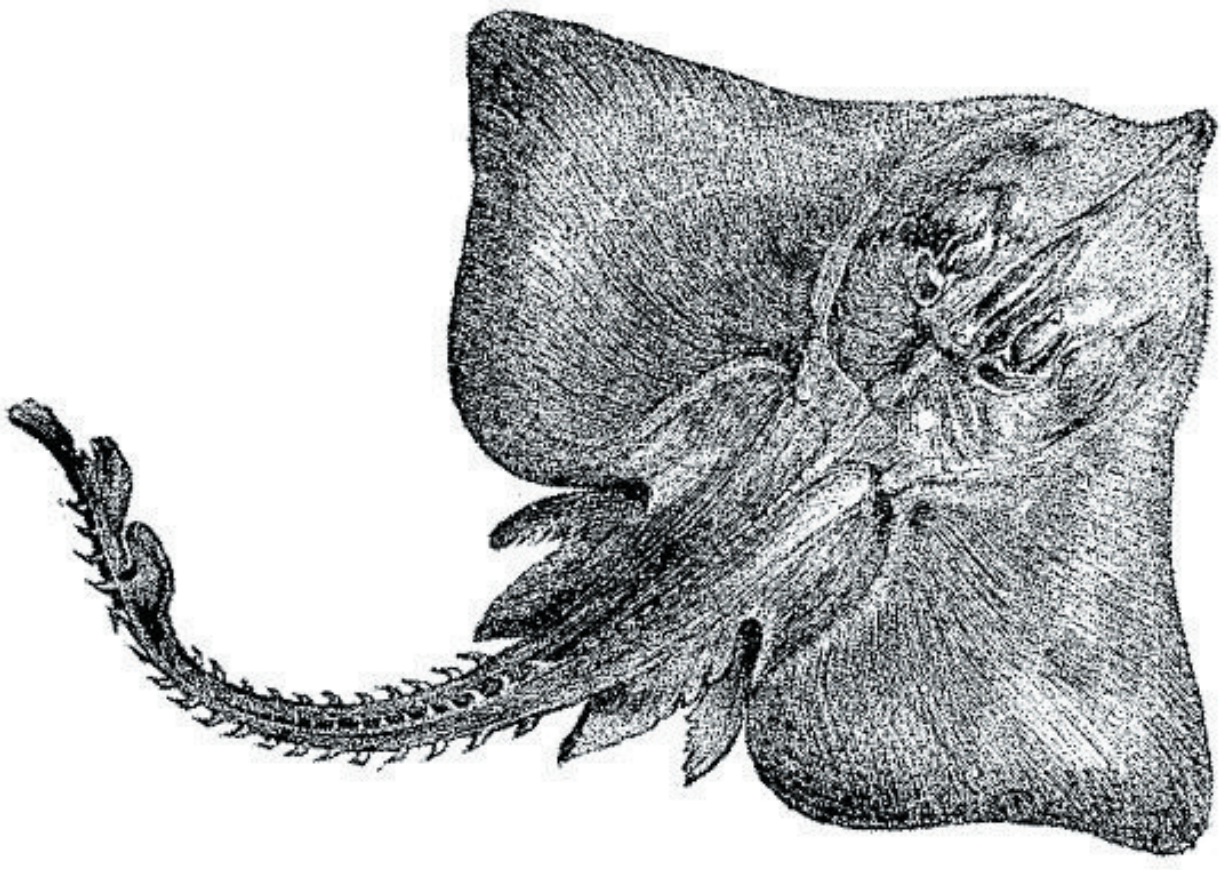
- Fishing gear usage
- Number of users
- Catch size and number limits
- Various categories of closures

1.5.3 Marine Resource Management Legislation

Purpose:

Learners will be able to understand the legislative acts governing fish and other **marine resources** and their **habitats** within PNG. Specifically, learners will be able to:

1. Identify and explain the specific legislation pertaining to marine conservation;
2. Discuss marine resource management policies and their purposes;
3. Identify authorities that govern various aspects of marine resource use, including policy development and enforcement;
4. Discuss roles of the provincial and local level governments as major mediators between the state and resource owners and among resource owners;
5. Discuss responsibilities associated with industry participants as major users and employment generators;
6. Discuss roles, rights and responsibilities of resource owners in development and gazettal of local laws and enforcement protocols through local level governments;
7. Analyse existing fisheries management plans for key marine species to assess their purpose and effectiveness; and
8. Develop recommendations for improving management plans for key species.



Marine Conservation and Resource Management Module
Suggested Course Structure

Learner Outcomes	Suggested Classroom / Practical Exercises*	Time Estimate (minutes)
1.5.1 Marine Resources		
▪ Describe marine biodiversity	1 classroom lesson and/or field trip: ▪*Marine Biodiversity Word Web*	120
▪ Identify and classify fish and non-fish resources for their nutritional, economic, cultural and ecological values	2 classroom lessons: ▪*Valuing Marine resources* ▪*Sea Cucumber Connections*	80
▪ Describe the habitats of common fish and non-fish resources	3 classroom lessons covering coral reefs, mangroves, mudflats/sea grass beds, lagoons/bays, and open sea ▪*Habitat is a Home*	120
▪ Identify and explain the life cycles and spawning behaviours of common fish and non-fish species	3 classroom lessons and/or field trip: fish life cycles focusing on key species 5 classroom lessons on non-fish life cycles (sea cucumber, trochus, turtles, etc) ▪*Life cycle Stories*	320
▪ Describe common threats to marine resources and their habitats, including unstainable fishing methods and practices that threaten fish or non-fish resources	1 classroom lesson: threats to habitats 1 classroom lesson: threats to species ▪*Resources at Risk* ▪*Marine Quiz Game*	80
1.5.2 Local Conservation Initiatives		
Sustainable Harvesting Methods		
▪ Define the concept of sustainable use	Classroom lesson on sustainable use of resources ▪*Thinking About Tomorrow*	40
▪ Identify common harvesting methods (traditional or modern) and how they affect the sustainability of marine resource use and impact on habitat quality	Classroom lessons: ▪*Fishing for Futures* ▪*Adding it All Up*	160

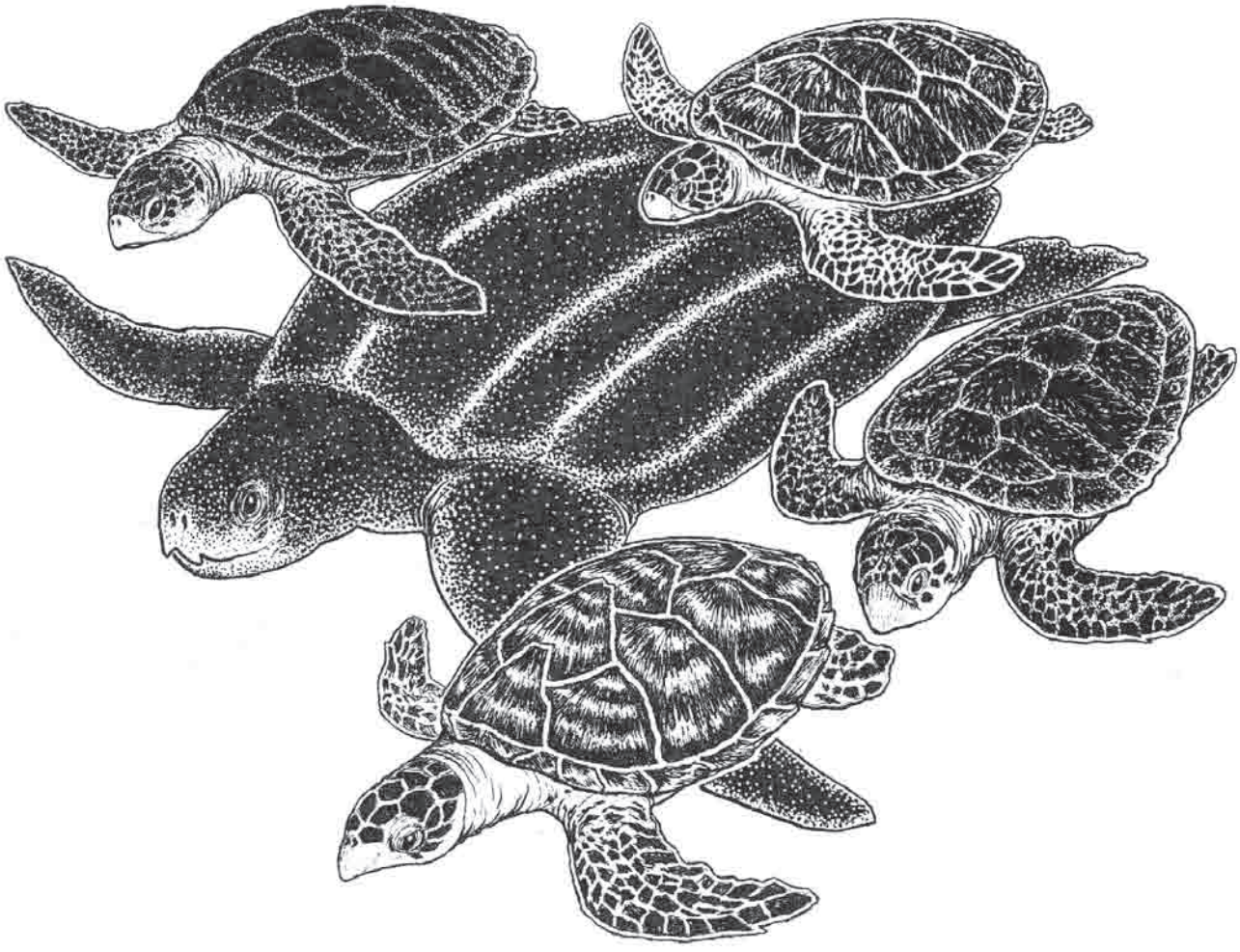
▪ List and compare the advantages and disadvantages of traditional and modern harvesting methods ▪ Identify and give reasons for preserving and using traditional harvesting gear and methods	Classroom lesson: debate ▪*Eco Journalists*	80
▪ Discuss traditional conservation initiatives (fishing methods and seasons, fishing restrictions, and traditional customs such as taboos)	Interviews and classroom presentation/reports ▪*Looking for Solutions*	80
▪ Demonstrate the construction of traditional harvesting gear or use of a traditional harvesting method	Practical project	Term project
▪ Discuss modern management practices that mitigate threats and sustainably manage marine resources	Classroom lesson: case studies	80
Assessment and Monitoring Techniques		
▪ Identify, explain and demonstrate the process of various stock assessment methods	Classroom lessons on methods: Fish counts, non-fish counts Practical: Market surveys based on fishermen's catch	120
▪ Demonstrate monitoring survey techniques of fish and non-fish resources to determine changes in population and habitat	Reef check for corals and fishes Catch, mark and release for trochus	Term project
Community Mobilisation		
▪ Explain roles and methods involved in carrying out a successful community mobilisation and awareness program for marine conservation	Classroom lesson: Case studies ▪*Campaign for Change*	120
▪ Plan and demonstrate a community mobilisation project to encourage a particular conservation practice	Practical	Term project

1.5.3 Marine and Fisheries Legislation

▪ Identify and explain the specific legislation pertaining to marine conservation	Classroom lesson: ▪*Choosing the Right Path: Fisheries*	40
▪ Discuss marine resource management policies and their purposes ▪ Identify authorities that govern various aspects of marine resource use, including policy development and enforcement	Classroom lesson: review policies	40
▪ Discuss roles of the provincial and local level governments as major mediators between the state and resource owners and among resource owners ▪ Discuss responsibilities associated with industry participants as major users and employment generators ▪ Discuss roles, rights and responsibilities of resources owners in development of local laws and enforcement through local level governments	Classroom lesson: role play and discussion ▪*Coming to Consensus*	80
▪ Analyse existing fisheries management plans for key marine species to assess their purpose and effectiveness	Case studies: Sea cucumber Crab	120
▪ Develop recommendations for improving management plans for key species	Homework/group work	120

* Lessons in italics can be found under Sample Lesson Plans.

Background Information

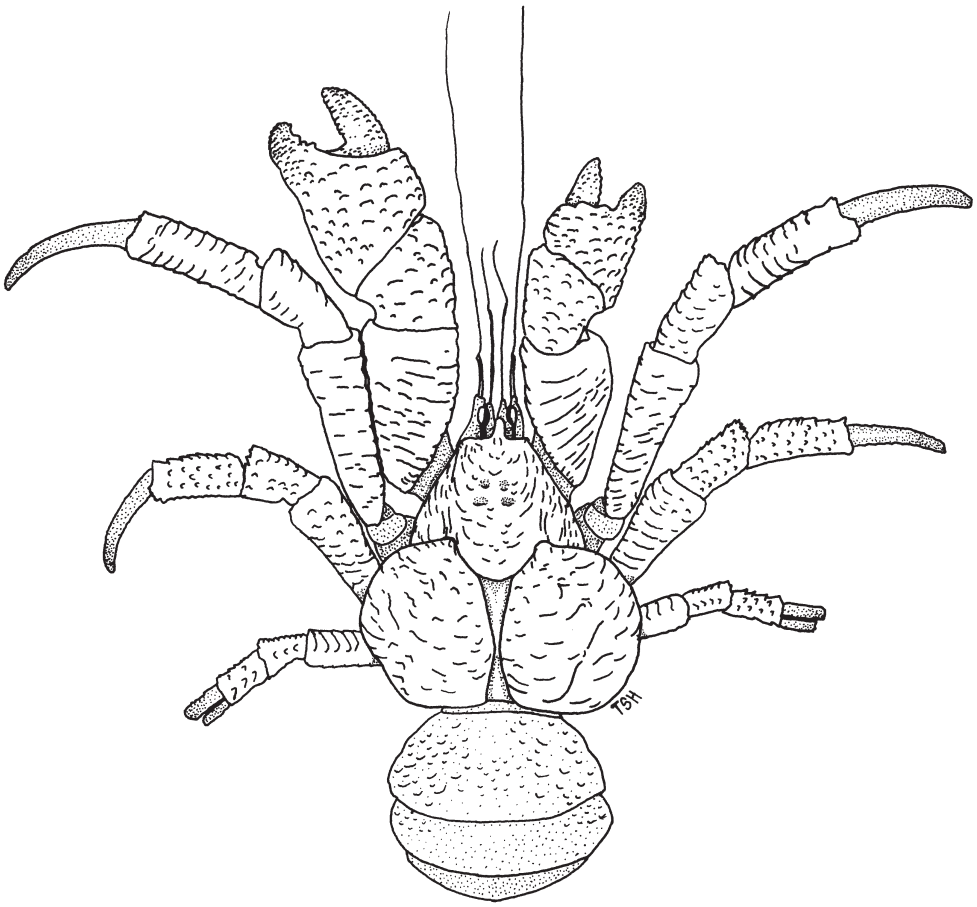


Introduction

The ocean is home to most of the life on Earth, including nearly all major groups of animals, plants and microbes. A three-dimensional realm with an average depth of 4 kilometres - every drop filled with life - the ocean is a living system absolutely critical to how our world works. The ocean contains 97 percent of Earth's water, drives climate and weather, shapes planetary chemistry, regulates temperature, generates more than 70 percent of the oxygen in the atmosphere, absorbs much of the carbon dioxide, and replenishes fresh water to land and sea through formation of clouds bearing rain, sleet and snow. Our planet's marine environments also provide us with abundant **marine resources**, supporting fishing economies and coastal communities around the world.

Papua New Guinea (PNG) is home to some of the most **pristine** marine environments in the world. **Species** found nowhere else on Earth live among the **coral reefs**, **mangroves** and ocean waters surrounding our island. Our economy depends on these marine ecosystems and the resources they provide. People from around the world visit PNG to marvel at the beauty and **diversity** of our reefs, islands and forests. Fishermen harvest fish, trochus, clams and sea cucumbers, providing food and income for their families.

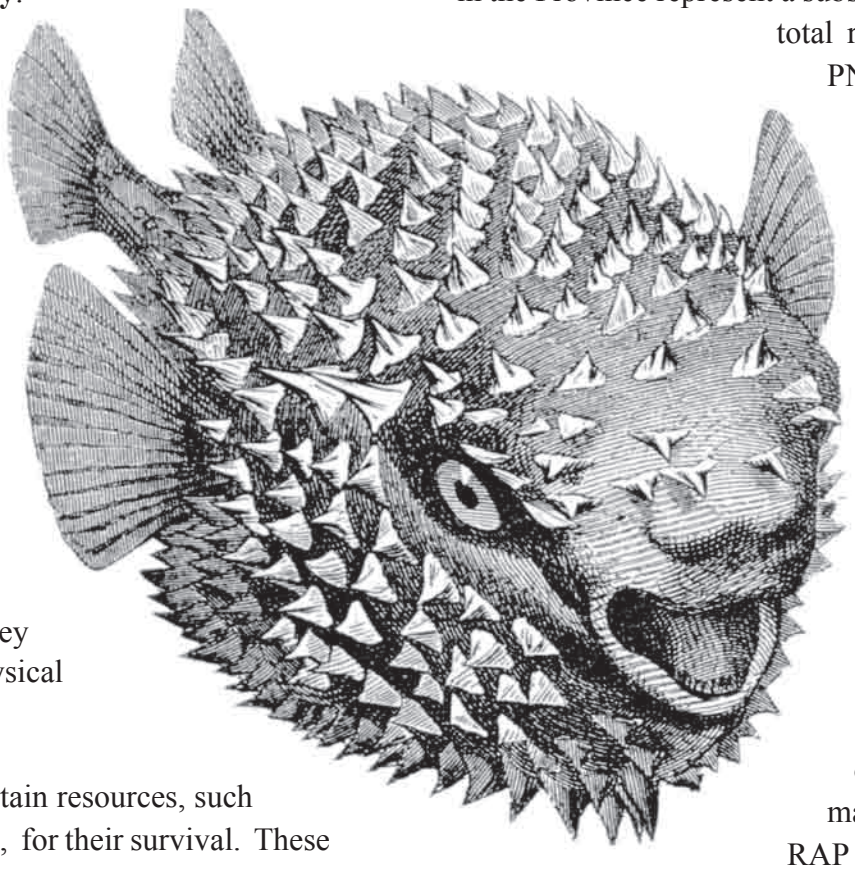
However, the ocean does not provide unlimited resources. If we use too much, or damage marine environments through our daily activities, we risk losing these valuable resources. We must take care of PNG's rich marine resources and its **biodiversity** -- all the life below the surface of the ocean. If we manage these resources carefully and **sustainably**, we can protect them for both present and future generations to use.



1.5.1 Marine Resources

What is Marine Biodiversity?

Over 70 percent of the earth's surface is covered by oceans, which hold about 97 percent of all the water on the planet. The ocean holds much more life than all the life on land. Oceans are home to thousands of different creatures including fishes, **marine mammals**, birds, **molluscs**, **crustaceans**, seaweed and **plankton**. Over 3.5 billion years of **evolution** and a unique combination of physical factors have created this astonishing **diversity** of life, collectively known as **biodiversity**.



Biodiversity is represented in numerous **ecosystems**, such as **coral reefs**, **mangroves**, and **seagrass beds**. Ecosystems are made up of both the **species** - or types of plants, animals and other **organisms** - and their **habitats** – or the places where they live, including the physical environment.

People depend on certain resources, such as water, air, and food, for their survival. These are called **natural resources**, or when they originate from the ocean or coastal environments, **marine resources**.

What is Special About PNG and Milne Bay?

PNG makes up the eastern half of the island of New Guinea (the world's largest tropical island) and over 600 offshore islands. It has an extensive coastline that stretches over 17,110 km and an immense area of ocean encompassing 3,120,000 km² (of which 40,000 km² is coral reef). PNG's marine ecosystems are generally in excellent environmental condition and have some of the best remaining examples of the world's most biologically rich coral reefs.

Milne Bay, as PNG's largest maritime province, has a sea area of approximately 110,000 km² that contains 13,000 km² of coral reefs – equivalent to 32 percent of PNG's total reef area. Given the proportionately large area of reef present in Milne Bay, marine resources in the Province represent a substantial portion of the total resource potential in PNG. These resources are important economicallyand socially because they contribute directly to PNG communities in terms of employment and food.

In 1997 and 2000, scientists conducted a **rapid assessment program** (RAP) of Milne Bay's marine biodiversity.[i] A RAP expedition allows scientists to identify and record the species they find in a particular area. RAP scientists recorded approximately 945 species of molluscs, over 429 species of reef coral and 1,109 known species of reef and shore fish in Milne Bay. This inventory work continues to uncover species found nowhere else on Earth, new species of coral, fish and other **fauna** (animal life), and many globally rare species, including endangered marine fauna such as the dugong, marine turtles, giant clams and black coral. Due to its rich biodiversity, Milne Bay is a key conservation priority both within PNG and on a global scale.

Regional Comparison of the Estimated Total Number of Fish and Coral Species[ii]				
Type	PNG	Milne Bay Province	Indonesia	Philippines
Reef fish species	1,419	1,109	1,656	1,525
Corals species	500	429	427	411

Marine Habitats

Habitats are the places where animals, plants and other species find what they need to survive, including food, water, shelter and space. For marine resource **populations** to stay healthy, species need healthy and diverse habitats. Some species might be born in one habitat, but feed and mate in another. Understanding habitats is critical to understanding marine resources, and habitat protection is key to the conservation of marine biodiversity. Some of Milne Bay's key marine habitats include:

- Coral Reefs
- Mangroves
- Bays and lagoons
- Mudflats and seagrass beds
- Coral islands and cays

Coral reefs

Coral reefs are some of the most valuable and spectacular places on our planet. These amazingly complex underwater communities are composed of stony structures built by living plants and animals. They are the most diverse communities on the planet; scientists estimate that coral reefs are home to approximately 25 percent of the ocean's species.

Contrary to popular belief, corals are not mineral formations. They are made up of colonies of tiny animals (most are less than 1cm in diameter), called **coral polyps**. Polyps are generally **nocturnal** animals that live in groups or colonies and look like tiny interconnected sea anemones. Some coral polyps feed on plankton and some also get food from tiny algae (simple plants) that live inside the coral and produce food for the coral using the sun's energy.

Coral reefs form the following main structures:

Fringing reefs: usually present along mainland shores and around the edges of islands.

Barrier reefs: coral reefs separated from nearby land by open water.

Atolls: are usually formed from circular reefs growing upwards from an underwater volcanic peak with a lagoon in the center.

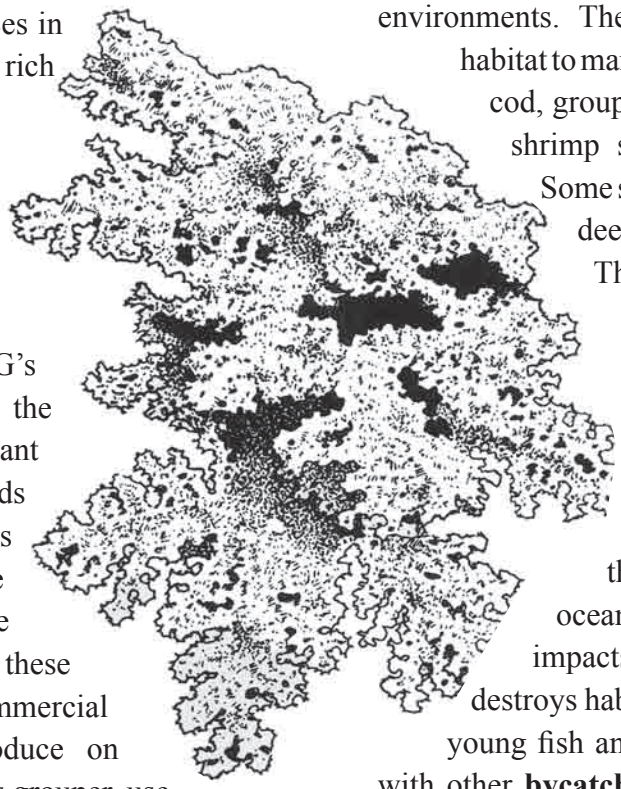
There are hundreds of different types of corals, including both **hard and soft corals**. In the case of hard, reef-building coral, as the polyp grows it leaves behind its skeleton. These layers of old polyp skeletons covered with live corals growing on their surface provide the rocky frameworks and massive branching structure of coral reefs. Coral reefs grow very slowly, and many of them are actually the oldest communities on earth. Most of the reefs we see now have been growing for over 5,000 years! Since they grow so slowly, reef **ecosystems** are very fragile, and cannot recover quickly from damage.

Coral reefs are full of life; they provide homes for a huge variety of animals including fish, sharks, sea turtles, urchins, lobsters, giant clams, sea cucumbers, and much more. Marine creatures find food, protection and shelter in coral reefs. Scientists estimate that more than 25,000 species live in reef habitats – many more types of animals than live in tropical rain forests!

Coral reefs in PNG

PNG is fortunate to have one of the longest coastlines in the world, with over 600 islands surrounded by coral reefs. Coral reefs occur along most of PNG's coasts and include many offshore reefs and atolls. The coastal areas and reefs in PNG support some of the richest marine biodiversity in the world!

Milne Bay Province has been recognised by scientists as exceptional in terms of reef biodiversity. There are over 429 species of corals, more than 1,100 species of fish and 900 species of molluscs in Milne Bay. Other coastal provinces in PNG also have exceedingly rich and pristine coral reefs [iii].



People in PNG depend on coral reefs for food, income, materials, traditional medicines, and cultural practices. PNG's fishing industry, one of the country's most important sources of income, depends on healthy reefs for its survival. Reefs provide critical habitat to all marine species associated with these systems. Most of PNG's commercial species live and/or reproduce on reefs. Some species, such as grouper, use reefs to aggregate in large numbers to reproduce. The young of many species, such as fish and lobster, hide from predators in the reefs' nooks and crannies. The adults of many species use the reefs to gather, rest, and feed.

Reefs also provide physical protection for coastal villages and coastlines from waves caused by cyclones and storms by breaking the force of the waves before they reach the shore. The skeleton remains of coral are eventually broken down into sand by waves, helping to continually build up our beaches and islands. Beaches and healthy coral reefs are potentially worth millions of kina in tourism to PNG — no tourist wants to dive in a dead reef with no fish. Finally, organisms found associated with coral reefs can help save lives, since certain important medicines derived from reef organisms are being developed to help cure people around the world of diseases like cancer. We still have much to learn about coral reefs — some reef inhabitants have never even been named!

Deep-sea corals

Corals are not only found in coastal areas. Scientists have discovered coral reef structures in deep-sea environments. These deep reefs provide critical habitat to many marine species such as Atlantic cod, groupers and snappers, lobsters, some shrimp species, and Pacific rockfishes. Some species, such as grouper, use these deep reefs to aggregate and **spawn**. The young of many species, such as cod and lobster, hide from predators in the reefs' nooks and crannies. The adults of many species use the reefs to gather, rest and feed. Bottom trawling, a fishing method that drags a large net across the ocean floor, is having devastating impacts on deep-sea corals. Trawling destroys habitat and indiscriminately catches young fish and other marine **juveniles**, along with other **bycatch**, or marine life that the fishers did not intend to catch.

Mangroves

Mangroves are another ecosystem that is essential for the health of our marine resources. Mangroves are woody plants that live in shallow salt water or tidal areas along coasts. The term "mangrove" is used to refer either to the mangrove plant itself (of which there are numerous species) or the ecosystem containing communities of mangrove trees. Mangrove forests are found along the coastal regions of PNG, particularly in and around the deltas of major rivers.

These tidal forests are usually inundated daily by salt or **brackish** (slightly salty) water. Species that depend on these ecosystems **range** from the small **invertebrates** (molluscs, crustaceans, etc.) that live in the mangrove's roots, to the numerous ocean fish and larger invertebrate species for which these habitats are the principle **nursery areas** for the **larvae** and young. An estimated 75 percent of fish caught commercially spend at least part of their lives in mangroves or are dependent on a food chain based in mangrove habitat. PNG's mangrove ecosystems are some of the most diverse in the world.

Besides supporting PNG's fisheries, mangroves also protect the coast by absorbing the energy of waves and wind from storms. While providing a buffer for the land on one side, mangroves also help to keep the ocean clean by trapping **sediments** that run off of land in their elaborate root systems. If it weren't for the mangroves, cloudy water from **siltation** might cause corals to die. In addition, mangrove plants and sediments have been shown to absorb **pollution**, including heavy metals.

Worldwide, vast areas of mangroves have been destroyed for development. We are lucky to still have significant areas of mangroves along our coasts; these deserve our protection!

Bays and lagoons

Estuaries are areas where saltwater from the ocean mixes with fresh water from the land, such as the mouth of a river, a bay, or a lagoon. A **bay** is a body of water partially enclosed by land, but with a large outlet to the ocean. A **lagoon** is a broad, shallow body of water separated from the ocean by a reef or barrier island, with limited exchange with the sea through inlets. These coastal lagoons may contain either salt or brackish waters.

Bays and lagoons are critical for the survival of many species of fish, birds, mammals, and other wildlife. These brackish water ecosystems provide marine life with shelter, food and opportunities for reproduction. Shellfish depend on the protection of estuaries to spawn. Fishermen go to bays and lagoons to catch either finfish or shellfish such as prawns. Saltwater grasses and other estuarine plants help prevent **erosion** and stabilize shorelines, which helps to lessen the devastating effects of storms.

Mudflats and seagrass beds

Two more important intertidal ecosystems are **mudflats** and **seagrass beds**. Mudflats can be found along coastlines in areas where the shore is protected from waves and the sediments are fine, creating an open expanse of mud. These areas are often associated with **estuaries** - areas where fresh water meets the ocean. At low tide, the mud is exposed as a mudflat, leaving water only in certain permanent channels. At high tide, the mudflat is completely covered with water. Mudflats are very productive habitats with many organisms including invertebrates like crabs and shellfish living along the edges, on top of the mud, under the mud between tides, and in channels of permanent water.

Seagrass beds are also areas of high productivity. They are made up of high concentrations of specially adapted marine plants such as turtlegrass (Thalassia hemprichii), tape seagrass (Enhalus acoroides) and others. Seagrass beds are found just below the low-tide mark and are common in PNG's reef flats and coastal lagoons, especially where these are found near small river estuaries. These ecosystems provide habitat for shrimp and shellfish, and a nursery ground for **juveniles** of many economically important fish species. The seagrass' root network helps to anchor the fine **silts** in which they grow, providing a stable habitat for many species of marine worms, which themselves form the basis of a complex **food web**. The world's last dugong (Dugong dugong) populations depend almost entirely on seagrass for food and habitat. Seagrass beds also help to purify the water by absorbing excess nutrients.

Coral islands and cays

In addition to the principal islands, Milne Bay Province also has more than 500 cays and coral islands. A **cay** is an island composed of debris from a coral reef. As coral polyps die, wave and wind action grind the hard coral's limestone structure and it eventually builds up on the leeside of the reef and becomes a cay. As the cay grows larger and more stable, birds begin to nest on its peak. Over time, birds carry seeds to the island and plants begin to grow, drawing nutrients from bird excrement on the cay's surface. Some cays are covered with as many as 30 plant species.

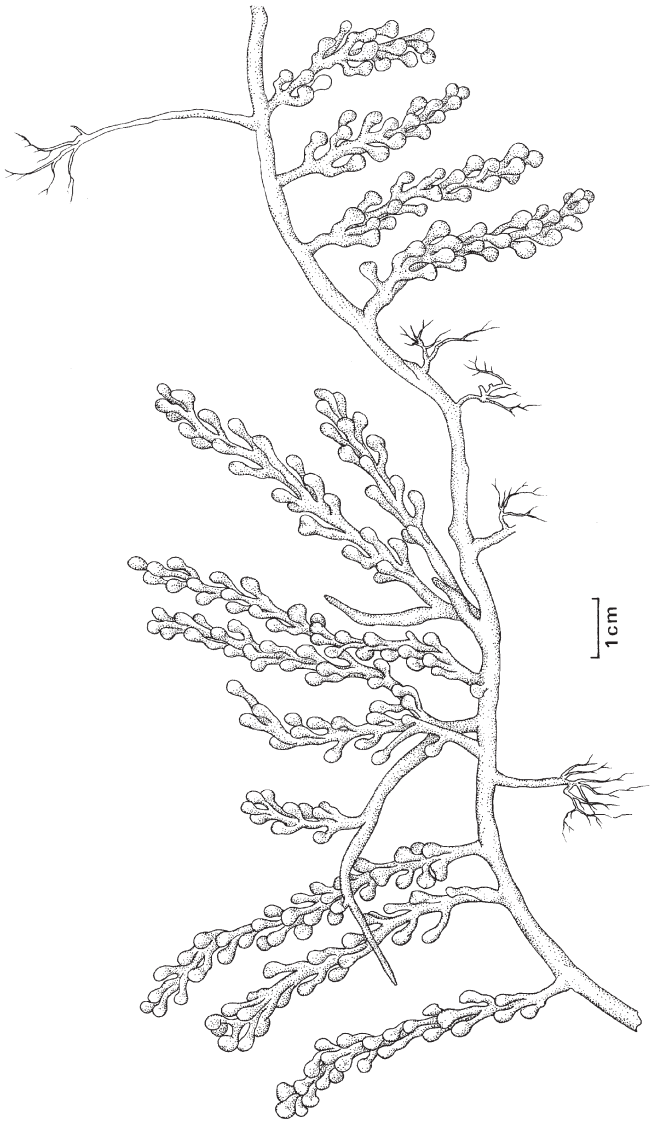
A **coral island** is an island formed from built-up coral fragments. If this island contains a central lagoon it is called an **atoll**. Many coral islands are eventually colonized by plants, insects, birds, and other life.

Key Commercial Marine Resources in Milne Bay

Marine resources have been and remain today an integral component of the daily lives of all people within Milne Bay. These resources fill a wide range of traditional subsistence and artisanal community and individual needs, as well as serving as a commercial resource.

The commercial harvesting and subsequent sale of marine resource products was first undertaken in the 1980s under the control of the Milne Bay Fishing Authority (MBFA). In subsequent years several commercially owned and licensed fishing companies have undertaken this task within the province. During 1994-1996 Coral Sea Fisheries actively purchased marine products throughout the Calvados area. Since the late 1990s, two subsidiaries companies, Nako and Kiwali, of the Alotau-based Masurina Company and the company Asiapac have been buying and exporting marine produce from Milne Bay Province.

For many people in remote areas, these companies, through their buying programs, offer the only source of cash income. In the past, **management plans** to ensure **sustainable** harvesting of these valuable resources had not been developed. In some cases this has led to **over-harvested** resource stocks. For example, scientific assessments of the **standing stocks** of commercially harvested sea cucumbers within the Province show that these resources have indeed been harvested at levels that are not sustainable. Carefully developed community and provincial management plans that regulate these activities need to be in place in order to protect community livelihoods and to ensure continued benefits from our marine resources.



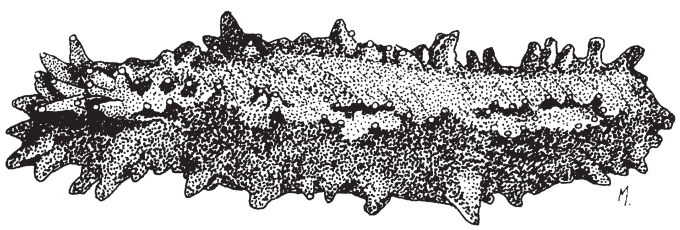
China's entry into the free market economy, with its great rate of industrialisation and resulting increase in wealth and purchasing power, has dramatically increased the demand for seafood and other marine products. This demand has significant impacts on exports and prices. The growing Asian market can lead to both threats and opportunities for the development of economically and environmentally sustainable marine fishery operations. Poor management of valuable marine resources will lead to decreased production, affecting both food security and national wealth in PNG. Good management will mean that highly valued marine resources will continue to be available for export, bringing increased prosperity and food security.

The following section provides basic information on several key marine resources in Milne Bay, including:

- Beche-de-mer
- Shark
- Trochus
- Giant Clam
- Lobster
- Finfish

Beche-De-Mer Fishery

Commercially processed sea cucumbers are refereed to as beche-de-mer (or trepang), and have been consumed as a traditional food and medicine in China and other parts of South East Asia for many centuries. Due to the expansion of the economy of China and neighbouring countries, the demand for this product has greatly increased over the past several decades, resulting in a huge expansion of the beche-de-mer fisheries in all tropical nations.



A commercial artisanal fishery for sea cucumbers has been operating within Milne Bay since 1988, which involves the villages around the coast and island communities collecting a wide range of species, processing and selling the end product. There are many species of sea cucumbers found in the area, however less than a dozen species command high prices and are sold commercially. The commercially valuable sea cucumbers (such as sandfish, white teatfish, black teatfish, and others) are all relatively large species with thick body walls.

Sea cucumbers are bottom dwellers that eat decaying matter and bacteria that float in the water or are found in the sand. Where certain species are found (**distribution**) and how many are found within a certain area (**density**) depends on availability of suitable habitat and each species' preferences. The large commercial species, such as black teatfish (*Holothuria nobilis*), tend to have lower densities than the smaller species, such as lollyfish (*Holothuria atra*). Lower density means that fewer black teatfish are found than lollyfish in a given area.

Sea cucumbers can reproduce through either sexual or asexual reproduction. Scientific information on which species undertake the different forms of reproduction is unknown for the majority of species. In sexual reproduction, the male sea cucumbers release sperm and the female sea cucumbers release eggs into the water. Once the egg is fertilized, it develops into a **larva**, which floats in the ocean currents as plankton. As the larva floats, it **metamorphoses**, or changes forms, several times. Eventually, the larvae will settle onto the ocean floor where it will develop into an adult. The amount of time the sea cucumber spends as a larva before becoming an adult varies from species to species and place to place. In asexual reproduction by fission,

one sea cucumber is able to "split" in two, and then regenerate to form two whole animals.

Sea cucumbers are harvested in Milne Bay by hand-collection or free diving, which require little or no capital investment. In deeper waters, people use lead weights with small harpoons attached. Divers swimming on or just under the surface drop the weight. The hooked animal is then brought back to the surface. A process of boiling, cleaning, drying and in some cases smoking produces beche-de-mer. The final, export-quality products have a hard rubber texture and weigh from 10-20 percent of the original live specimen. This finished product is normally rehydrated before consumption.

The nature of the product and the simple low technology utilised to harvest and process these animals makes them very appealing to remote atoll communities, as found in Milne Bay Province. There are, however, some aspects that must be addressed to keep the beche-de-mer fishery sustainable. For example, in some areas, the number and diversity of sea cucumbers in the wild has greatly diminished due to high harvest levels.

Beche-de-mer processing requires a large supply of fuelwood, which may not be available in large quantities on small islands and can lead to severe deforestation. Ten tonnes of firewood may be needed to process 1 tonne of beche-de-mer. Sea cucumbers are usually boiled for a period of 2-3 hours to produce beche-de-mer. After boiling, the stomach is removed either by cutting down the length of the body in the case of black teat, white teat and prickly redfish, or by reaming a stick down the inside of them in the case of black and greenfish. The final, export-quality products weigh from 10-20 percent of the original live specimen. The water remaining from beche-de-mer processing can be harmful to marine organisms if dumped in shallow waters near shore. The water contains a concentration of toxic substances that can result in fish kills.

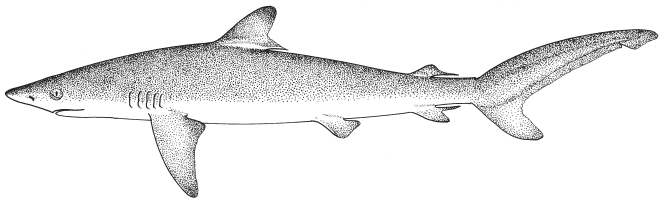
The beche-de-mer fishery provides important income-earning opportunities for rural communities. However, in order to maintain sustainable beche-de-mer stocks, PNG law regulates this fishery. One of the oldest laws for the protection of beche-de-mer stocks in PNG is the Pearl, Pearl Shell and Beche-de-mer Ordinance 1911-1932 (Papua). These were passed with the aim of protecting villager rights to make a living from these resources. Today, in Milne Bay, the National Fisheries Authority (NFA) has also gazetted the Milne Bay Beche-de-mer Management plan (2000) for regulation of the industry and a Provincial Beche-de-mer Management Committee has been put in place. For example, according to the plan, it is illegal to use underwater breathing apparatus or underwater lights to collect sea cucumbers. The plan also recommends allowable sea cucumber wet lengths, to ensure that undersized sea cucumbers are not collected, because that would jeopardize future stocks. Additionally, the management plan outlines closed seasons and bans on collection in some areas. Following these regulations ensures that sea cucumber populations remain healthy, and that communities do not lose income from stock depletion.

However, few people are aware of these laws. Also, because of the high price paid for beche-de-mer, it is difficult to enforce bans and closed seasons. Public awareness is required about the laws and enforcement protocols regulating this fishery and their impact on sustainable management. Together, the community can work towards stopping unlawful practices and protecting Milne Bay's beche-de-mer fishery.

Shark Fishery

Sharks are the ocean's top predators and therefore are vital to the health of the ocean ecosystem. Sharks feed on sick, injured or older animals, leaving the healthier individuals to reproduce. They also help to take care of any population booms in prey species, keeping them from out-competing other species.

Sharks have been utilised in Milne Bay for many years as a source of food and traditional and customary activities. Commercial exploitation of shark resources within Milne Bay is also now common. A wide range of species has been targeted, from shallow water reef dwelling species to their open-ocean dwelling cousins. Sharks are utilised in Milne Bay as a source of food and medicine, and in more recent times have been targeted for their fins to supply an ever-increasing international demand for shark fins in Asia.



Shark fins contain fibres of elastin and collagen, called fin needles, which are highly prized in Asian markets, primarily for their use in the production of shark-fin soup. In Hong Kong, for example, people will pay up to US$90 for a bowl of shark-fin soup, making shark an expanding income-earning opportunity for people through the preparation of dried fins. This demand for shark- fin soup is having devastating results for shark populations around the world. The most common species taken in tropical reef systems include the blacktip reef shark (*Carcharhinus melanopterus*), the lemon shark (*Negaprion acutidens*) and the whitetip reef shark (*Triaenodon obesus*), Grey reef sharks (*Carcharhinus amblyrhychos*), tiger sharks (*Galeocerdo cuvieri*) and hammerhead species (*Sphyrna spp.*).

Other shark products include shark livers as a source of lubricants, vitamins, and cosmetics. Sharkskin is made into leather products. And some areas of the world, powdered shark cartilage is considered to be a powerful cure-all for everything from sore eyes to cancer. While there is no reliable evidence which shows it is an effective medicine, powdered shark cartilage can sell for as much as US$100 per bottle.

In Milne Bay the main artisanal method for fishing sharks is the use of vertical drop lines. The drop lines are made up of a single line (mainline) that is buoyed at the surface and contains a single baited hook suspended from beneath. Common baits are turtles, moray eels, stingrays and fish. When catching sharks for their fins, many fishers will simply slice off the shark's fins and throw the shark back into the water alive. These injured sharks soon drown or die of starvation, infection or predation.

Additionally, it has been reported that a growing number of sharks are also being caught as **bycatch** (as an unintentional consequence of fishing for different species). Fishers' nets and hooks accidentally catch sharks and other marine species such as fish, sea turtles, birds, and marine mammals. Most of this bycatch eventually dies. Longline fishing for tuna is the biggest cause of bycatch of sharks. Many sharks that are caught are immature and have not yet lived long enough to produce offspring. Depending on the species, it may take 3 to 20 years for a shark to mature.

Trochus Fishery

The trochus or top shell (*Trochus niloticus*) is a reef associated marine snail that occurs naturally over a wide area of the Indo-Pacific. The trochus shell has external mottled red-green and white bands and a thick inner layer of mother-of-pearl (nacre). This particular species is **endemic** to the waters of PNG (meaning it is only naturally found here), however it has been introduced to many Pacific islands over

the past 5 decades to provide an additional source of food and revenue.

Trochus are found on reef flats, in **surge channels** (deep channels in the windward side of coral reefs through which water moves in and out of the reef) in surf zones, back reef lagoon areas and also on reefs located close to main lagoon passes where there is good growth of the algae on which they feed. They are most abundant on the windward reef in shallow habitats that are exposed at low tide and are rarely seen below 8 meters. Although most active at night, trochus are quite conspicuous and relatively easy to collect at any time.

Juvenile trochus live on the reef flats and move towards the reef edge and surge channels as they grow and mature. Maturity is normally attained at a size of 6 to 7 cm (across their base), or approximately 3 years of age. They attain a maximum size of 15 cm (diameter at their base) at about 15 years of age. Trochus are either male or female. These snails release sperm and eggs into the water on nights during the dark phase of the moon. In the tropics, there is always some portion of the population that is able to reproduce year-round. Once the eggs are fertilized, the trochus enter a three-day **larval** stage, and then they settle onto a surface and begin the transformation into their adult form.

Trochus are collected by hand, usually while the collector walks along the reef at low tide, or by free diving. Despite their tendency to disguise themselves and inconspicuous algae-covered shells, they are easily spotted by experienced divers and are susceptible to **over-fishing**. Trochus are also slow moving which makes them easier to catch. The shell is usually boiled to extract the edible meat, which generally comprises 15 per cent of the live weight. The shell is then dried, bagged, and sold to trade stores in the village, collected by traders, or in some cases sold directly to exporters.

Trochus have been harvested for subsistence purposes within Milne Bay for many years, yet they have only been commercially harvested since the early part of the twentieth century. Trochus are collected for the nacreous (mother of pearl) inner layer of the shell, which is mainly used in the production of buttons for clothing, jewellery and ornaments, ceramics, cosmetics and luminescent paints. The demand for trochus shell has fluctuated over the last century and remains dependent on outside market forces, such as the fashion industry. The current global demand for trochus shell is estimated at 7,000 tonnes annually, worth about US$50 - $60 million.

Due to an increasing value and demand for the shell, trochus stocks on many reefs in Australia and the Indo-Pacific have been over-exploited. This trend has fuelled much research on mass production of juveniles in hatcheries and restocking techniques, which aim to enhance the local stock.

Trochus harvesting is an active fishery within Milne Bay, as it doesn't require expensive equipment or vessels and fishers do not need to travel far to sell the shells. The marketed product, "the shell" doesn't require preservation and can be easily packed and stored. Trochus shell is easy to export because it is not a perishable product. However, the relative ease of capture can lead to over harvesting of resources. Trochus harvesting and sale is regulated by the National Fisheries Authority, which includes a size restriction of the shell.

Giant Clam Fishery

There are currently eight species of giant clams within two **genera** that occur within the tropical Pacific and Indian oceans. Of these, seven species are found in Milne Bay. These species are *Tridacna gigas, T. derasa* (*Tridacna derasa*), *T. maxima, T. squamosa, T. crocea, Hippopus hippopus and H. porcellanus*. Each species of giant clam has a preferred habitat on the reef. However, clams in Milne Bay are predominantly found on the sheltered sides of fringing reefs, followed by the sheltered sides of barrier reefs, with smaller numbers found on exposed barrier reefs and lagoon reefs, on the rocky bottom surrounded by live corals.

All species of giant clam share a unique cooperative relationship with a microscopic organism known as **zooxanthellae**. Zooxanthellae live freely inside the blood passages that are located along the surface of the clam's skin. The zooxanthellae perform **photosynthesis**, producing sugars from sunlight that then serve as food for their giant clam "host." This means that the availability of sunlight is the most important environmental factor determining how well a clam grows and survives. Clams occur from the intertidal zone down to approximately 25 metres deep. This lower depth depends on how clear the water is (in other words how much sunlight is able to filter through for the zooxanthellae to use for photosynthesis). Each species exhibits different habitat and depth preferences on coral reefs.

All giant clams are able to fulfill both male and female roles, with the same individual releasing sperm and then later releasing eggs into the open water. Once one individual has started this process, others nearby are also triggered to begin reproduction. This process happens year-round, because a percentage of the clam population is always ready to reproduce. The larval stage of giant clams lasts less than two weeks in the Milne Bay area.

The harvesting of giant clams in Milne Bay is mainly carried out by men with the occasional help of women. Fishing methods for clams are remarkably simple. The flesh is simply removed from the shells by slipping a knife along the inner surface of the shell to cut one end of the adductor muscle, the muscle that opens and closes the shell. The shell is then left attached to the reef. Smaller clams may be collected opportunistically during reef gathering activities, while larger ones are collected by free diving. In some communities (e.g. Brooker Island), weights attached to ropes are lowered into the open clam, the clam shuts and it is then hauled to the surface where the animal is then cut out of the shell.

Export of giant clam from Milne Bay Province started in 1983 through the International Food and Agricultural Development (IFAD) funded Milne Bay Fishing Authority (MBFA) fisheries development program. It was estimated that in the five years that MBFA was exporting clam muscle, an average of 14.28 metric tonnes of meat was taken each year. The commercial harvesting of clam meat in Milne Bay includes all species, however the clam adductor muscle was the target commodity. Large muscle attained higher commodity prices and therefore provided an incentive for fisherman to target the larger species of clams. The muscle accounts for about 10 percent of the clam's soft tissue weight and 1 to 2 percent of its total weight in the large T. gigas and T. derasa that are fished. From stock assessments undertaken in the 2000-2003 within Milne Bay stock populations of the largest two species were low indicating high harvesting pressures.

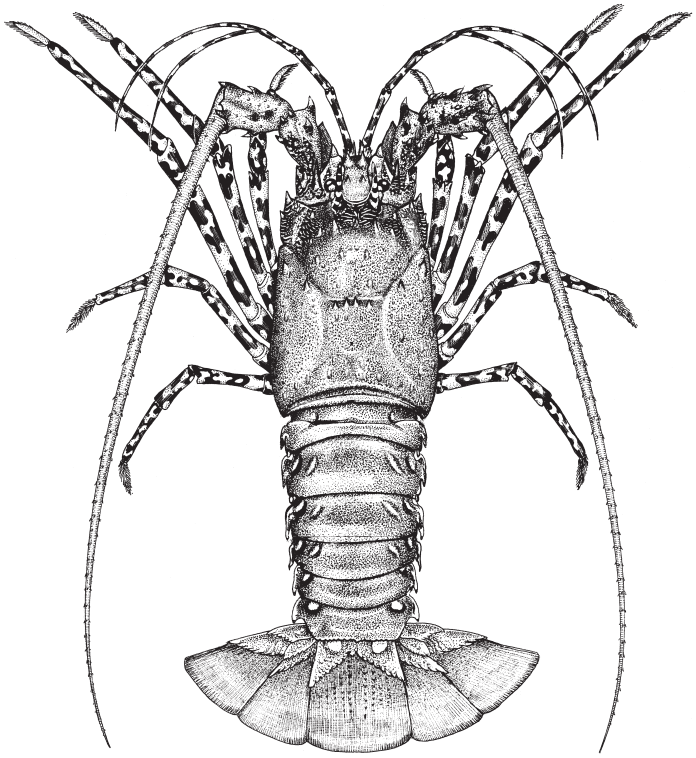
Studies of giant clam fisheries have indicated that sufficient numbers to guarantee reproductive success cannot be maintained when population densities fall below certain levels due to **over-harvest**. If a reef is entirely stripped of clams, repopulation will depend entirely on planktonic larvae brought in from other reefs by ocean currents. Once the population is reduced below a certain level, though, even subsistence harvesting can affect the clams' **recruitment** levels, or ability to recover to a sustainable population level through birth or immigration. When the small size of a clam population means that they cannot produce enough offspring, and there are not enough larvae coming into the reef from the open ocean, the local giant clam fishery could be threatened for many years to come For example, if the reef is isolated or the direction of the current is unfavourable, then the re-establishment of the giant clam stock could take as many as 20 to 50 years, and in some cases stocks never return.

The export of giant clams is currently regulated by the National Fisheries Authority through a specific management plan. All giant clams are registered as Appendix II tradable commodity under the Convention on International Trade of Endangered Species (CITES). The purchase and export of clam muscle was halted in May 1988 by a ruling from the Department of Environment for **conservation** reasons. The ban on exporting clam muscle was lifted in 1995 with an annual export of clam meat of 1,000 kgs with a value of 20,000 kina for the same year. The export of clam meat was again banned in 2000. Another recent development is that all giant clam species are now being artificially cultured in both the sea and at land-based facilities to help with restocking and commercial activities.

In order to help stabilize giant clam populations within Milne Bay, specific management plans based on stock assessment data need to be developed that allows harvest while maintaining healthy reproductive clam populations. These plans could also be used to encourage individuals or communities to develop clam gardens, in which undersized clams could be grown out to a saleable size.

Lobster Fishery

The most abundant lobster **species** found and exploited in Milne Bay are the doubled spined lobster, *Panulirus penicillatus* and the spiny lobster *P. ornatus* (*Panulirus pencillatus*). Two other species, the long legged spiny lobster, *P. longipes fermoristriga*, and the painted coral lobster *P. versicolor* and are also present in Milne Bay and are caught and traded, but at much lower levels than the two previously mentioned species.



All tropical spiny lobsters are crustaceans belonging to the family Palinuridae. The 19 spiny lobster species that occur in the tropics belong to the **genus** *Panulirus*. Each species of *Panulirus* occupies a different habitat and has different preferences for depth, **turbidity** (cloudiness of the water), coral cover, and food.

P. penicillatus, the doubled spined lobster, shows the strongest habitat preference, and it is only found in windward surf zones and reef passages of oceanic reefs. This species avoids sunlight, and, during the day, hides in dark places in the reef in shallow water. At night these lobsters move onto the reef crest and flat to feed[iv].

P. ornatus, the spiny lobster, has a wider range of acceptable habitat, and has been located in water as deep as 200 meters and differing water quality ranging from oceanic conditions through reef conditions to **turbid** and sheltered waters of river mouths and estuaries. This species is migratory with some individuals walking as far as 500-600 km. An annual **migration** of this species occurs in the Torres Strait moving into the Gulf of Papua and to reefs west of Port Moresby to breed[v].

P. longipes fermoristriga, the long legged spiny lobster, is found on the windward reef slopes, though usually deeper that *P. penicillatus* and in areas of weaker waves and more coral abundance. This species also avoids sunlight and seeks shelter during the day. This species does not move up onto the reef crest or flat at night to feed, instead it forages on the reef slope[vi].

P. versicolor, the painted coral lobster, is most commonly found within lagoons among coral gardens of plate and massive corals. This species tends to stay in water deeper than 10 meters, but can sometimes be found in exposed reef slopes. The painted coral lobster is also **nocturnal** and seeks shelter during daylight hours. During the day, however, they can still be seen in groups hiding under live corals with their long white antennae protruding[vii].

The four **s**pecies mentioned above are opportunistic scavengers that eat a wide variety of foods. Little documented information is available for the specific food items each of these lobsters consume most.

The different species of *Panulirus* have relatively similar **life cycles** and breeding behaviour. Male lobsters mate with females that have developing ovaries. The male deposits a sperm package (dark brown to black in colour) near the female's genital opening on her underside. The females release several hundred thousand eggs, which are fertilised as the female scrapes open the sperm package. The fertilised eggs stick to the small hairs on the underside of her tail. The female carries the eggs for about one month before the tiny larvae, called phyllosomae, are released. The larvae may remain as plankton for 4 to 12 months before they change into the puerulus stage, which looks like a miniature (colourless) version of the adults and is found on the reef[viii]. The reproductive season of these lobsters in Milne Bay is unknown, but scientists expect that there is a seasonal or a slight decrease during the winter months.

Lobsters are most commonly caught by spearing while free diving on the reef-slope and crest. Collection at night using underwater torches is often more effective than during the day when lobsters tend to hide in crevices in the reef. Spearing is an unsatisfactory technique, as it tends to discolour the tail. However, this is overcome by soaking the cray tail in a brine solution for a few minutes, which essentially bleaches the meat white. At present only tails are purchased with the bodies. Lobster legs are discarded or eaten by villagers.

Finfish Fishery

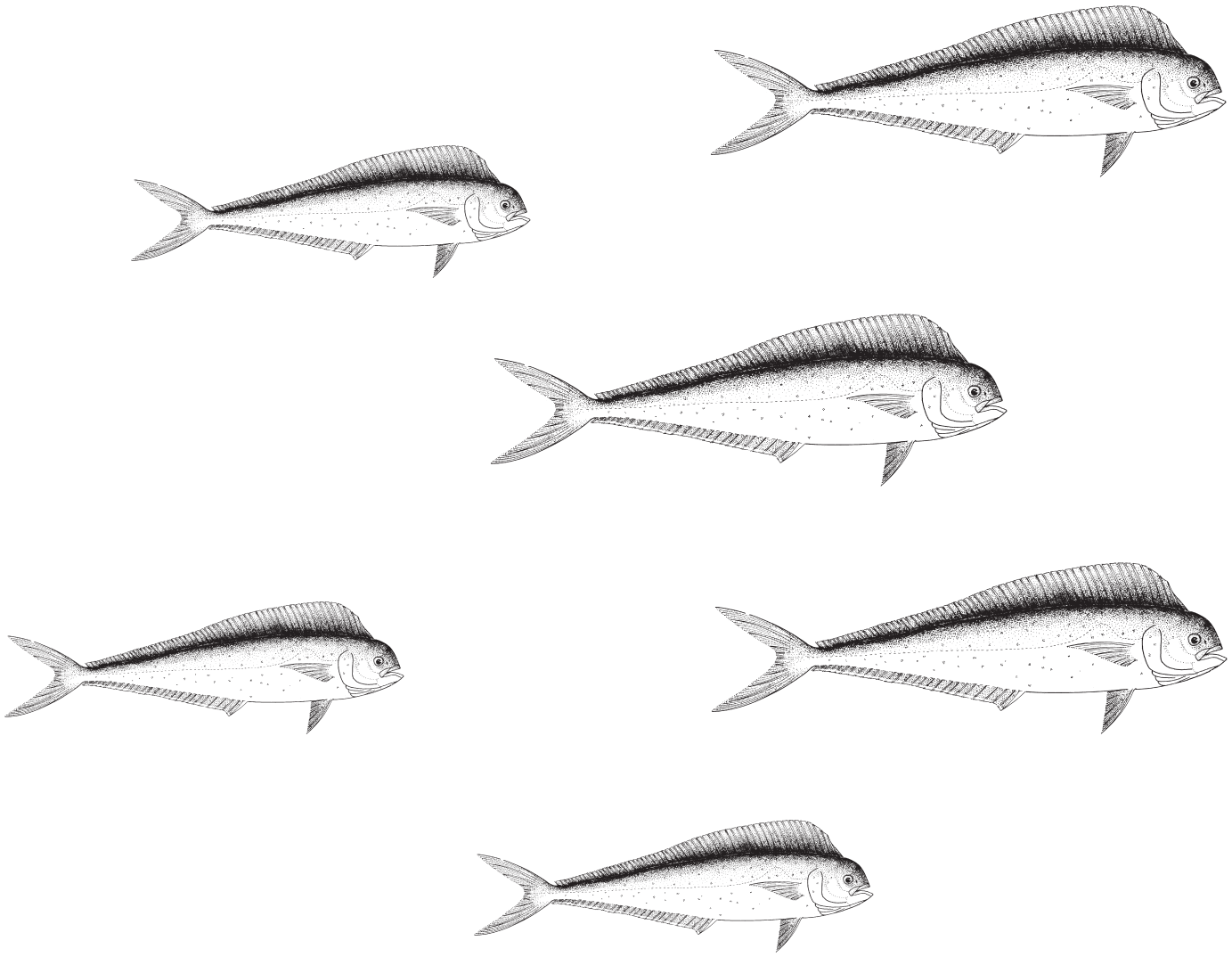
Milne Bay Province has PNG's largest reef area (32 percent) and contains the largest reef fish potential yield by Province, which is estimated at 10,296 tonnes per year. It has been estimated that there are a total of 1,762 verified fish species in PNG waters, with an additional 80 species unverified. At present, there are 1,313 fish species known from Milne Bay waters including shallow and deepwater species. Fish consumption in Milne Bay is seasonally dependent, and generally dependent on prevailing weather conditions. In the months of June and July, for example, silvertail spiny foot and mullet make

up a greater portion of fish consumed.

Spawning Aggregations

Most reef fish that are harvested commercially, such as groupers and snappers, gather in large groups called **spawning aggregations** to mate. These fish aggregate every year at the same place and time in order to release their eggs and sperm to reproduce. There may be as many as 5,000 fish in a single spawning aggregation, making aggregation sites a prime target for fishermen. The resulting offspring from these spawning aggregations directly assist to repopulate local fish stocks.

Spawning aggregation sites are key areas for marine conservation. Ocean currents link these sites together, maintaining the delicate balance of marine fish communities and marine **food webs**. Many fish species only reproduce at these aggregation sites, and over harvesting is a threat if large volumes of egg-bearing females and other adult fish are caught before they are able to breed. On the other hand, if spawning aggregation sites are conserved and well-managed, **threatened species** may be able to recover.



Live Food Fish Trade

What's the Problem?

Recent expansions of the economies of East Asian countries (e.g. Hong Kong, mainland China, Singapore, Malaysia, and Thailand) have resulted in an increase in demand for high priced seafood commodities, in particular live food fish. Recent estimates have indicated that the industry currently exports an estimated 25,000 tonnes of live reef food fish per year (from all countries associated with this trade), which is estimated to be worth US$1 billion annually. Approximately 60 percent of the fish entering this trade are captured from the wild. To date, Hong Kong is the largest consumer, but demand is growing rapidly in southern China. Innovations in harvesting methods, food processing technology and cargo transport have contributed to this increase in demand and consumption. Fishers also have more incentive to supply live fish because they can earn greater profits in this trade.

As **target species** are depleted in one part of the world, market demand puts more pressure on countries that can still provide these species. Fish stocks in Asia have been depleted to levels from which they might never recover, and therefore fishing companies are expanding to other nations, including PNG to provide the fish. The industry in the past has tended to over-exploit one reef area or fishing ground and then move onto a new area, resulting in **unsustainable** fishing practices.

Impact on Species and Habitats

The live fish trade affects targeted species, **bycatch** and **habitats**. As the demand for live fish increases, the **populations** of these species in the wild decrease. Fishermen who mechanically break corals in order to capture live fish damage the reef structure. Additionally, some divers fish in the reef by spraying sodium **cyanide**, a toxic chemical, into small places to immobilise and capture fish, which they later revive and sell in the live fish market. While cyanide immobilises the larger target species, smaller fish, shellfish and other species including corals that weren't targeted often die as a result of the poison. Cyanide also bleaches and kills coral, affecting the entire reef habitat. The use of chemicals in this manner in PNG is prohibited. In PNG, intensive hook and line and trap fishing for the live fish trade has also depleted localised **spawning aggregations** of groupers. These spawning aggregation sites are vulnerable to depletion when commercially targeted by fishers.

Impact on People

The live fish trade not only impacts marine species and their habitats, but people as well. Community members engaged in diving for LRFF companies have in the past suffered illness and in a few cases death due to improper training in the use of diving equipment. Communities as a whole are also affected by the live fish trade. As fish populations decrease, there are less fish for community members to harvest for local consumption, limiting their primary source of animal protein. Species have a harder time replenishing, and when fewer fish are available, fishers are more likely to use any fishing method that will help them harvest even if it means depleting the resource or severely damaging the habitat.

If properly managed, the live food fish industry, which is a relatively small volume, high value fishery could make contributions to the **sustainable** economic development of Milne Bay and PNG. However if not managed correctly it also can cause negative environmental, economic and social impacts that can far outweigh any benefits. The sustainability of this fishery is of upmost importance to Milne Bay.

Managing the Live Fish Trade

For the future of people, village economies, species, habitats, and tourism, the live fish trade must be regulated for long-term **sustainability** of the resources and environment. All people, marine species and habitats will benefit over time if this is done. The following list identifies a number of activities that would help to ensure proper management of the live fish trade. These are[ix]:

- Increase communities' knowledge of all relevant information pertaining to government regulations that are associated with the live reef food fish trade.
- Provide villagers with the incentive to protect their marine resources by giving them the legal right to exclude outsiders from their fishing grounds, or, where that right already exists, provide stronger government backing. Train, deputise and support selected village fishermen as fish wardens.
- Declare a moratorium on all fishing for live reef fish in areas where stocks are depleted and manage fishing in all other areas.
- Instruct live reef fishing companies on inexpensive ways of reducing very high mortality rates of live reef fish due to unsatisfactory catching, holding and shipping practices.
- Enforce the PNG ban on the possession of cyanide on boats.
- Where logistics permit, set up cyanide detection laboratories (in import destinations such as Hong Kong, as well as source areas) in order to monitor live reef food fish operations.
- Carry out research to improve non-destructive methods of catching species targeted by the trade.
- Ban the export of wild-caught fingerlings of target species.

What are the Values of Marine Resources?

Milne Bay Province's economy depends on marine **ecosystems** and **marine resources** in many ways. Marine resources provide economic and nutritional value through fishing or harvesting. But marine resources also have value beyond their consumption, for example for their role in maintaining ecological processes, for their connection to traditional culture and as tourist attractions.

Ecological Value

The biological **diversity** of the oceans rivals that of tropical forests. Scientists estimate that less than 10 percent of the ocean's **biodiversity** has ever been measured, yet marine resources and their **habitats** help maintain important ecological processes that, in turn, help support all life on Earth. For example, **mangroves** protect coastal communities from waves and storms, control **erosion** and **siltation** and are the **nursery grounds** for a wide range of marine **organisms**. Many other **species** on land and in the water depend on marine resources for food. The web of life in a **coral reef** is one of the richest on Earth, with thousands of species connected in countless ways.

Nutritional Value

Marine resources are a staple protein source for many communities throughout PNG, particularly coastal villages in Milne Bay Province.

Economic Value

People throughout Milne Bay depend on the sale of marine resources, an activity that has expanded greatly in recent years. The market for non-perishable marine resources like processed beche-de-mer and trochus shell has increased to fill the gap of copra, and at present they continue to be some of the few reliable sources of cash for communities. The challenge for all levels of government and the Milne Bay Province is to prevent the over-exploitation of these important marine resources. Management through appropriate community management protocols that allow the community to maintain their livelihood options will help to prevent resource degradation and the subsequent threat this would pose to the protection of Milne Bay's biodiversity.

Tourism is one way to gain economic benefit from marine resources without exploiting them. Approximately 1,000 dive tourists visited Milne Bay Province in 2000 on the three live-aboard vessels based in Alotau. Milne Bay's reputation for **pristine** coral reefs and abundant marine wildlife, as well as the 'last frontier' reputation that PNG enjoys among the dive community, draws many tourists. In the Caribbean, another coral reef hotspot, revenues from travel and tourism have reached US$34 billion and are expected to reach US$74.1 billion by 2012. **Ecotourism**, or responsible travel that promotes the **conservation** of nature and sustains the well-being of local people, is the fastest growing sector of the tourism industry.

Cultural Value

The culture of Milne Bay Province is closely linked with its marine resources. Fishing communities have evolved a way of life that revolves around the sea. The use of marine resources is the backbone of traditional lifestyles and culture of Milne Bay, providing inspiration and provoking curiosity and imagination expressed through art, music, and dance.

What is the State of PNG's Marine Resources?

The problem of marine **biodiversity** loss is widespread. It is widely acknowledged that the general health of the oceanic realm is in serious decline as a result of direct and indirect human influence. **Coral reefs** and other marine **habitats** are some of Earth's most fragile environments. Many animals and plants depend on coral reefs for protection, food and survival. Yet coral reefs around the world are under serious threat both from natural and human causes.

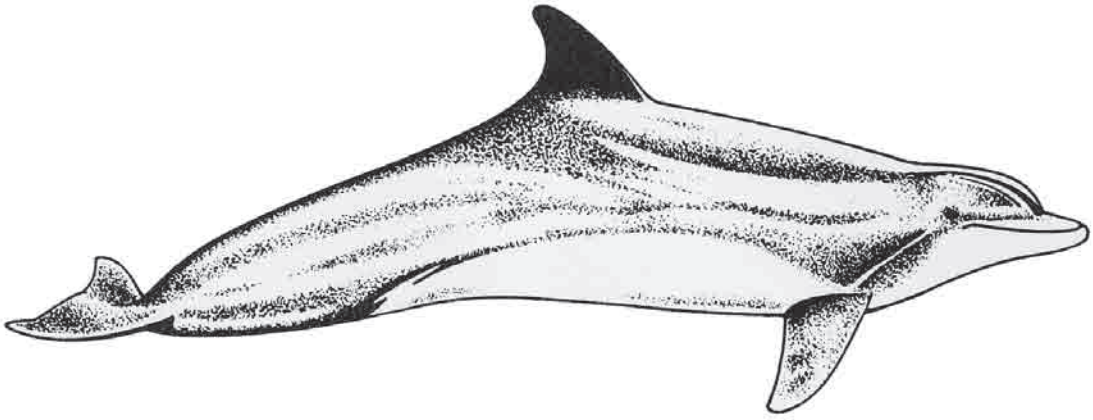
In 2002, a wave of devastation from **coral bleaching** (coral that dies out due to stressful environmental conditions) started in the Great Barrier Reef and spread across the world's tropics. These large-scale disasters have large-scale impacts on the world's coral reefs and the communities they support. Perhaps most worrisome of all, centuries of over-exploitation of **marine resources** through human activities has caused biological and ecological resource depletions in all oceans and seas and in some cases **extinction** of **species** has occurred. As human populations increase, the need for resources correspondingly increases and therefore urgent management practices need to be implemented to allow future generations to continue to utilise these resources.

Generally speaking the majority of marine resources in PNG and Milne Bay are in relatively good condition. However, commercial harvests show that several economically valuable **species** have been heavily exploited in the past. In order to allow natural stocks to recover and ensure **sustainable** fisheries, current harvesting practices need to be managed with a long-term goal of healthy populations and habitats.

The following are examples of human activities that have the potential to negatively affect the long-term health of marine resources in PNG.

Over-Harvesting

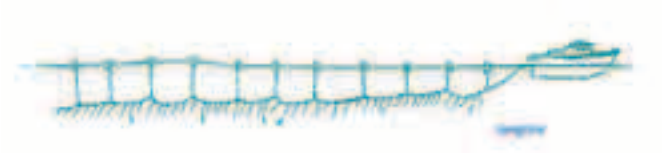
Various species of fish and other marine animals are disappearing from oceans around the world due to **over-fishing** (fish being harvested at a faster rate than they are reproducing). This is the greatest current threat to PNG's marine resources. In PNG, due to increasing demand pressure, traditional fishing methods are being replaced with modern technologies that have drastically increased the rate at which fish and non-fish resources are caught. **Over-harvesting** one type of animal from the reef often has a negative effect on the delicate balance between species on the reef. Over-harvesting of resources is concentrated near human population centres and commercial interests.



Destructive Fishing Practices

Longlines

Longline fishing is a fishing technique used to target fish in open waters, including those that live near the sea floor. A longline includes a main fishing line of up to 100 kilometres in length, with secondary lines containing baited hooks branching off of it. The mainline and fishing gear are supported at the surface by floats set at regular intervals. The floats and branch lines are set at various depths depending on the **species** targeted. Gear set along the seabed targets bottom living fish while gear suspended from the surface targets a wide range of open ocean dwelling fish. Longlining is passive (stationary) fishing relying on the chance that the target fish takes the baited hook.



Longline fishing within PNG is used to target a variety of species of tuna and sharks, however longlines can be adapted to target a wide range of species and **habitats**. Due to the nature of this fishing method, many **bycatch** species are indiscriminately caught. These include several species of shark, sea turtles, sea birds and billfish. Longline fishing systems have no technique in place to avoid or reduce bycatch and therefore this fishing method has a negative impact on numerous marine species, some of which are critically endangered, such as the leatherback turtle.

Dynamite Fishing

Dynamite is used illegally to supply the high demand for fresh fish to Port Moresby and to other countries. Using dynamite to fish kills all living things in the area, including young fish and corals. Dynamite destroys the reefs, and makes them susceptible to further breakage by storms and waves. Many corals die when the reef is broken, and broken reefs provide less **habitat** for other marine species. Dynamite fishing also kills or injures many fish and marine animals in the area, not just the ones the fishermen want to catch. This fishing method is illegal in PNG. Compliance and enforcement of this law helps protect marine biodiversity.

Derris Root and Cyanide

Derris root and **cyanide** poisoning are used illegally to aid in collecting fish. Cyanide is a chemical poison, and it is dangerous not only to marine life, but also to humans. These methods not only kill fish, but also kill the **coral polyps** and other marine life.

Trawling

In PNG, commercial prawn trawlers work off the Gulf of Papua, Torres Strait Protected Zone, and Orangerie Bay with numerous small-scale operators working along coastal areas. Trawling is a fishing method whereby a large trawl net is dropped into the open ocean and dragged just above or along the ocean bottom by a boat. Because many shrimp species slightly burrow into the ocean floor, boats tend to drag the cone-shaped nets through the top layer of **sediment** or beds of seagrass on the ocean floor to collect the target species. When shrimp trawlers' heavy nets drag across the ocean floor, they inadvertently destroy **coral reefs**, sea grasses and other marine life; flatten terrain; and kill numerous fish, turtles, starfish and crabs, among other creatures. The trawl nets are then hauled to the surface and emptied onto the deck of the boat where fishers sort through the catch.

Many medium-sized animals too large to fit through the net's holes are caught, resulting in a high percentage of bycatch. It has been estimated that for every one kilogram of wild prawns caught using trawling nets, 10 or more kilograms of other marine

life are caught and killed as bycatch. Bycatch is generally tossed back into the ocean, but most of the marine species thrown back don't survive.

Recent innovations can reduce some bycatch collection and death rates. The capture and subsequent death of sea turtles was a common occurrence for trawlers, however a new device that is fitted into the top of a trawl net (a Turtle Exclusion Device – TED) has greatly reduced the accidental capture of turtles. Additional technological advances in fishing gear and methods are needed to further reduce bycatch.

Pollution

An important threat to marine, estuarine and freshwater environments worldwide is **pollution** from industrial chemicals, sewage, agricultural chemicals, and household wastes. After it rains, water running over the ground carries rubbish, oils and other pollutants from the land into the rivers and eventually into the sea. Large quantities of pollution are toxic (poisonous) to corals. In addition to chemical and toxic waste, litter consisting mostly of plastic waste piles up in PNG's **mangroves**, reefs and coastal areas. Many species die when they become entangled in old discarded nylon fishing lines, nets and plastic. Sea birds and turtles can also suffocate after feeding on plastic bags and balloons that look like jellyfish - one of their favourite food sources.

Coral Collection

A significant threat to corals in some areas of PNG is the collection of live corals. The corals are killed and the remaining skeleton is used for a variety of purposes. For example, **hard coral** are used for construction, crushed and processed for lime for use with betel nut (buai) and sold as souvenirs to tourists. Additionally, live coral specimens are sometimes harvested from the ocean and sold live to the international aquarium industry. When corals are taken from reefs, the habitat of many marine species is damaged.

Deforestation

Cutting down trees from coastal forests can cause soil to erode and wash down into the ocean with the rains. When the soil gets to the ocean, it clogs up the coral reefs with sediment, or soil particles, and suffocates the corals by depriving the coral polyps of necessary nutrients and oxygen. This is called **siltation**. Furthermore, silty waters prevent sunlight from reaching the corals, so **photosynthesis** cannot occur and coral growth stops.

Unchecked Coastal Development

The development of infrastructures including roads, sewerage systems, rubbish dumps, storm water systems, buildings and houses can all contribute to an ever-increasing degradation of the environment. For example, the destruction of mangroves for development can seriously affect fish, since mangroves serve as breeding and **nursery areas** for many fish. All development, whether small or large, needs to be carefully planned and managed to reduce negative environmental impacts.

Boats and Divers

Anchoring or poling boats on top of reefs can damage the corals and cause widespread physical damage. The use of permanent mooring systems and wise anchor placement considerably reduces this threat to our coral reefs. Also, people who dive or snorkel can damage reefs if they accidentally break off pieces with their gear. Physical damage to coral reefs is a major concern for PNG and the nation requires a considerable public awareness campaign to educate the community on best practices to reduce this threat.

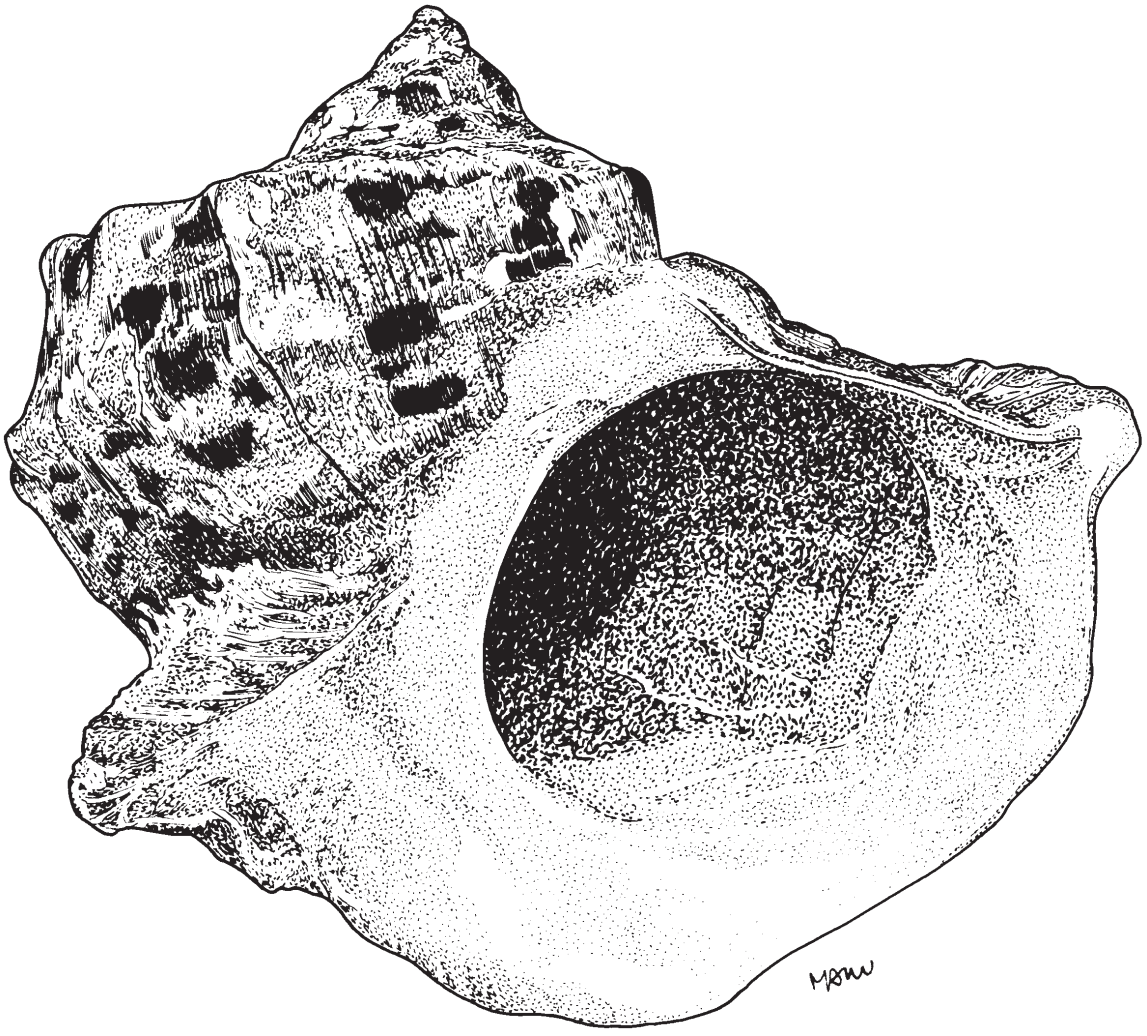
Coral Bleaching and Climate Change

Global warming, or the potential warming of the Earth's climate due to greenhouse gas emissions (such as carbon dioxide), poses a great threat to coral reefs. As the surface water temperature rises, corals become stressed. As a result of this stress, the tiny

tiny algae that live in the coral tissues, which provide the coral with food and bright colours, die, turning the corals white and thus giving the appearance of having been "bleached." Corals can eventually recover from a bleaching event, but in severe cases they die. In 1996 and 1997, Milne Bay experienced a severe **coral bleaching** event, with approximately 55 percent of our hard corals bleaching. Recovery rates of corals from a bleaching event are difficult to predict because recovery is dependent on the severity of bleaching and the availability of coral offspring to move back into the bleached areas. However, scientists estimate that, on average, it takes between 20 and 50 years for a reef to recover from bleaching. Additionally, scientists believe that coral reefs may be among the first **ecosystems** to clearly reveal the potential impacts of global climate change.

Dredging

Dredging is the act of clearing a deep channel in the water to enable shipping and to shape marinas and ports. Dredging ships also work to gather sand and coral rock for road building, airport runways, and other coastal construction activities. When the dredgers scrape along the floor of the ocean, they produce huge clouds of **silt** in the water and break off pieces of coral and marine plants. The silt is then swept along the coast in ocean currents, often smothering coral reefs that are a considerable distance away from where the dredging occurred.

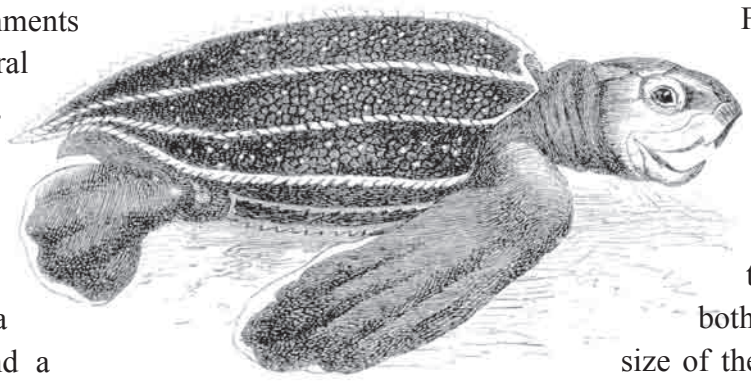


1.5.2 Local Conservation Initiatives

If we don't act quickly to protect and subsequently manage the unique marine environments and resources of PNG, destructive practices could threaten the survival of marine life and the future of fisheries in our country. In Indonesia and the Philippines, people have destroyed most of their **coral reefs**. Without reefs, people have less fish left to feed their families or to sell to make a living. The following are some practical steps people around the world are taking to protect marine **biodiversity**:

Education

The most important thing people can do to help save marine biodiversity is to maximise their role as educators. In order to protect marine environments, people need to understand the important role these environments play in the natural balance of the Earth, and in the **diversity** of life that they hold. Understanding often leads to concern, concern leads to a desire to protect, and a desire to protect leads to positive action – the ultimate goal.



Fishing Reserves and Marine Protected Areas

A **fishing reserve** is a place where fishing is prohibited in certain areas or times of year, thus providing a safe area for fish breeding. These reserves allow **over-fished** areas to regenerate target fish **populations**. The success of the reserves depends on the involvement of local people, particularly fishers. Conservation International (CI), along with the PNG government and other organisations, are working toward the establishment of community-based **marine protected areas** (areas of the sea especially dedicated to the protection and maintenance of biological diversity and of natural and associated cultural resources, and managed through legal or other effective means) in Milne Bay Province.

Marine Zoning

Different uses can be assigned to different areas of a reef. This process is called **marine zoning**. For example, locals and officials can decide that one area will be granted total protection from humans, while another area can be used for tourism, and another for fishing. Traditional taboos are a type of informal zoning, since under the taboo, villagers are not allowed to enter certain areas of the reef at certain times.

Traditional Fishing Methods

Fishing methods can have a big impact on marine **species** and **habitats**. In order to maintain healthy populations of **marine resources**, it is important to reduce **bycatch** and to limit both the amount as well as the size of the marine animals harvested.

Some fishers continue to use older fishing methods such as the use of bows and arrows. The use of bows and arrows, for example, has minimal effects on marine animal populations because a fisher catches only one fish at a time, is very efficient in catching the targeted species, and does not affect the seabed habitat. Turning to traditional fishing methods such as bows and arrows, spear fishing, traditional fishing baskets, locally made fishing nets made from bush ropes and hook and line fishing, reduces bycatch and the volume of marine animals harvested.

Pollution Prevention

Preventing **pollution** is a much better solution than cleaning it up later. Some companies are looking for new ways to produce their products without generating potential pollutants. Consumer

pressure plays a key role in pressuring companies to stop polluting. Another way to reduce industrial pollution is through carefully designed government regulations. New regulations to protect marine environments can be founded on the "polluter pays principle," which says that whoever is engaged in activities that harm the environment should pay for the installation of equipment to prevent such pollution. Polluters can also be held accountable for cleaning up environments that their activities have damaged.Another way to reduce industrial pollution is through carefully designed government regulations. New regulations to protect marine environments can be founded on the "polluter pays principle" which says that whoever is engaged in activities that harm the environment should pay for the installation of equipment to prevent such pollution. Polluters can also be held accountable for cleaning up environments that their activities have damaged.

Moorings, Not Anchors

To protect reefs, boats can use permanent mooring buoys that are drilled into the sea floor instead of using anchors along the reef.

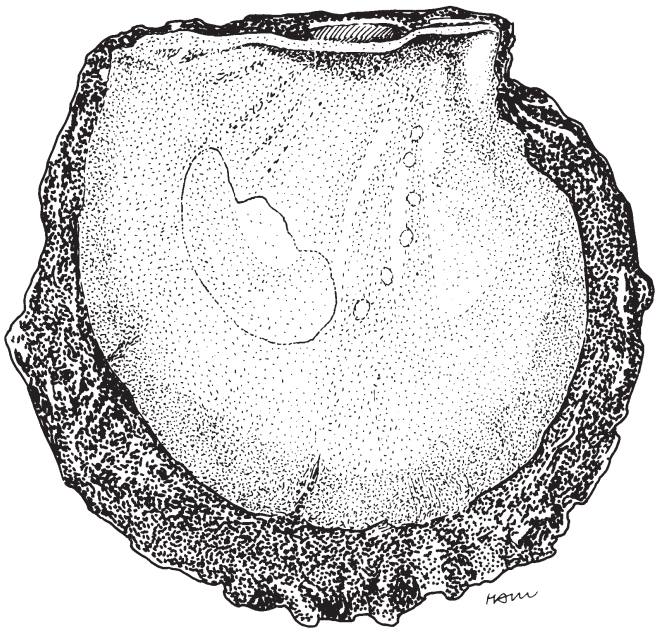
Decrease Deforestation

One strategy to prevent **siltation** on coral reefs is to stop cutting trees on steep slopes near water bodies. Tree roots hold the soil in place and when trees are cut, the loose soil can erode or wash away when it rains. Logging on steep slopes is particularly damaging, since **erosion** occurs faster on steep inclines.

However, if communities carefully choose the best places to cut, such as on flatter areas farther from streams or the coast, logging can provide wood and income to communities. Community-based **management plans** can help minimize the destructive effects of logging and prevent coastal erosion.

Government Regulations

The fourth goal of PNG's constitution pledges to safeguard PNG's environment, including marine **ecosystems**. The government also has several legislative acts protecting marine resources, like the Fauna Protection and Control Act (1982), which declares the dugong and leatherback turtle protected species. Under the Fisheries Management Act (1998), the use of destructive fishing methods, such as explosives and poisonous chemicals, is prohibited. Effective monitoring and enforcement are keys to successful regulations.



1.5.3 Marine Resource Management Legislation

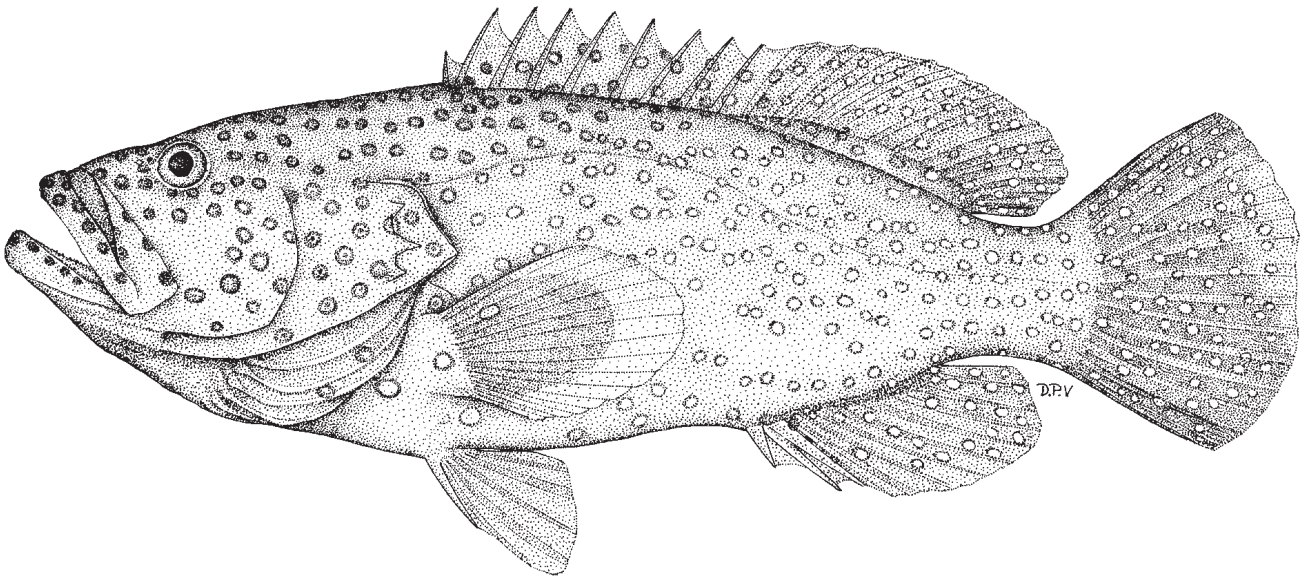
People have always depended on resources from the ocean. Some people fish in order to feed their families; some harvest fish and other marine products in order to make money; and some have jobs on large-scale fishing boats. Around the world, and especially in PNG, many peoples' lives depend on fishing. In order to have a healthy fishing industry, it is important to have healthy oceans, reefs, **mangroves** and other **habitats** or homes, for marine life. It is also important to make sure that when taking fish out of the sea, enough adult fish remain in their habitats to reproduce. That way there will always be enough fish to go around, both now and in the future. This concept of using a resource while leaving plenty for the future is called **sustainability**, or **sustainable** resource management.

Governments and communities can play a role in making sure that people take care of their **marine resources**. Fishing communities can decide on management practices for their fishing grounds. But since it is hard to always know at a local level what is best for the resource in the long term, the government also passes laws that provide guidelines for how to manage different fisheries. Both economics and **conservation** should be considered when deciding how to best manage a fishery.

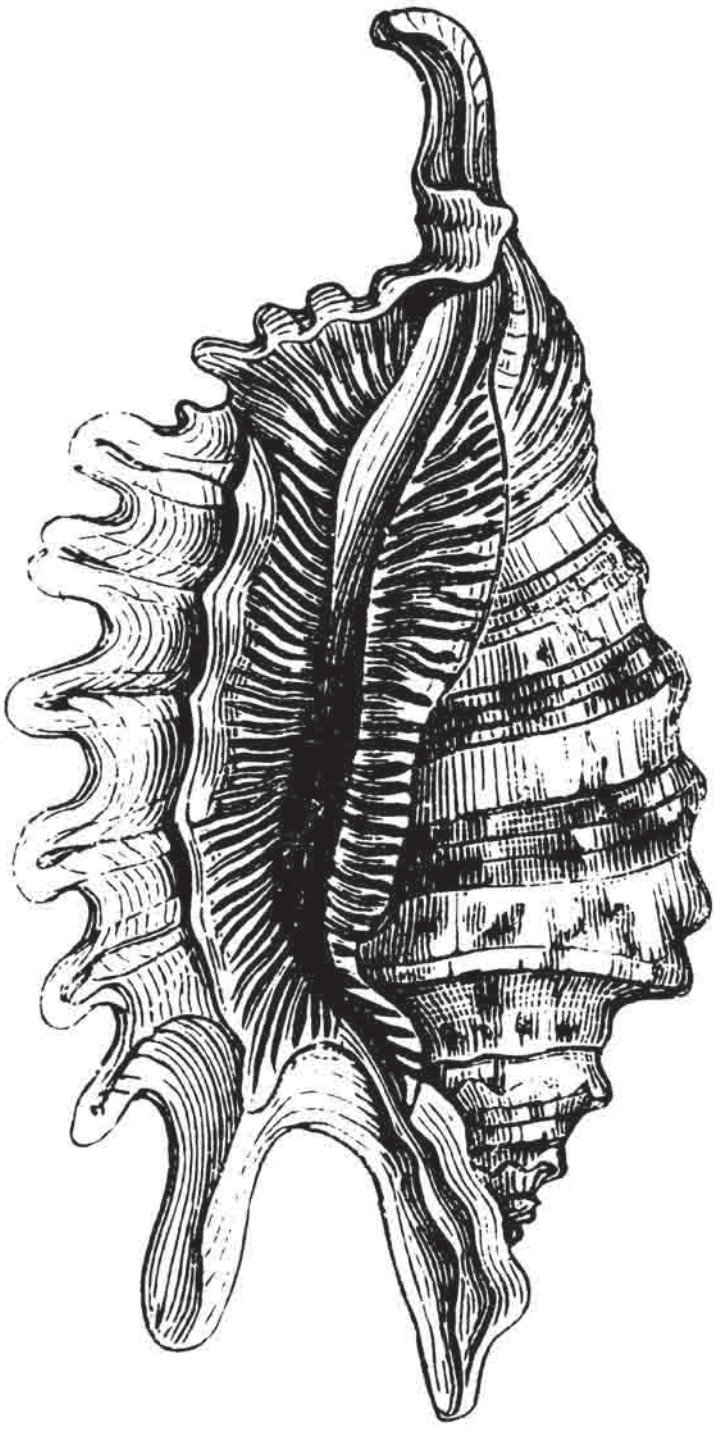
PNG's Fisheries Management Act passed in 1999 is a set of laws that outline the things people can do (permitted) and can't do (prohibited) in regards to fishing. The Act outlines regulations for each fishery that describe how people are allowed to fish, when they can fish, where they can fish and how much they can catch. The Milne Bay Provincial Government has the responsibility to enforce the laws set forth in this Act.

In the case of **species** that are threatened by over harvesting, the government also develops fisheries **management plans**. A management plan uses the best available scientific information on the species, such as **population**, **spawning** or breeding behaviour, habitat and **life cycle**, to define how much of the resource can be harvested, at what time of year, and from what place. Well-researched and enforced management plans can help ensure sustainable harvests.

Local communities can also develop their own management plans for their marine resources. In order to develop these plans, communities need to assess the status of local fisheries stocks and monitor these resources over time to ensure that management practices are sustainable.



Sample Lesson Plans



Interactive Lesson Plans

Interactive lessons can introduce and reinforce new concepts by engaging students to participate in the learning process. This section focuses on interactive teaching methods such as leading student debates, conducting surveys, and performing a drama. No matter what method is used, it's helpful to create a lesson plan outline. A lesson can teach the *what*, *why* and *how* about a particular topic. For example, a teaching activity might introduce the **life cycle** of the Giant clam through the creation of a poster; the economic importance of the Giant clam through a debate; or management techniques through a field trip.

Considering that you will choose a topic and research it for background information, this Lesson Planning for Interactive Learning section includes the following information:

- Guidelines for adapting existing activities to meet your students' needs
- Suggested types of activities to help teach a topic
- Example for how to document a lesson plan

Making Adaptations

Many environmental education lesson plans already exist that incorporate interactive learning. Before you begin to develop a lesson plan, it's helpful to research **Environmental Education** (**EE**) materials and find activities that can be adapted for your students, topic or region. Existing activities can be found in magazines, books and on the Internet. Another helpful resource might be the education departments of organizations who may have already developed educational materials that can be changed slightly to fit your needs.

An activity may need to be adapted to fit any of the following:

1) Region
2) Student grade level or age
3) Topic
4) Availability of materials
5) Curriculum goals and objectives

Types of Teaching Methods

Demonstrations

Students can learn techniques by observing others. Demonstrations are usually conducted by one person in front of a group and then repeated by the students in the group. It allows students to do the activity themselves.

Investigations and Experiments

Conducting investigations and experiments allows students to answer their own questions about the environment. Students may wonder how a food chain works or why rain is important to the **watershed**. Through investigations and experiments, they will develop critical thinking skills such as how to form a hypothesis (educated guess), collect information, analyse data, and develop conclusions.

Role Plays

Role plays allow students to step into the role of someone or something else and gain a new perspective. Students take on the role of a person, animal, plant or thing in order to understand and learn more about how the person, animal or plant feels and is affected by a given issue.

Guided Imagery

Guided imagery allows students to experience something by forming mental visual images. The teacher reads a story aloud while students close their eyes and pretend they are experiencing it. This gives students a chance to feel and think about an issue on a personal level. For example, a teacher reads a story about fire and students focus on their feelings and senses surrounding this topic.

Writing

A great way for students to learn more about their environment is to research a specific topic and write a story about it. Students get more involved in an issue through this investigative reporting. And by writing an article and publishing it, students teach others as well.

Sensory Activities

Sight, smell, touch, taste, and hearing are the five senses people use to learn more about the world around them. Sensory activities incorporate the senses to teach about environmental issues. Students may touch a leaf to learn that each one is different. They may see a burned tree to understand that it's a fuel for fire. Sensory activities allow students to discover information on their own.

Music/Rap/Dance/Drama

Drama is a fun way to teach and learn environmental concepts. Students can be actors and actresses that mimic real life situations. And by focusing on problems and creating solutions, students develop opinions about different topics. Students can share their knowledge by performing dramas at town meetings, surrounding schools or in the classroom.

Moral Dilemmas

Humans act based on a set of morals (values and beliefs) they develop over time. It is important to foster respect for both other people and for the environment. Moral dilemmas stimulate moral growth by presenting students with moral conflict situations to resolve. Students resolve problems by making decisions that affect their life, family, community and environment.

Case Studies

Case studies are reports written about events that have occurred or fictional events that help students analyse specific aspects of an environmental problem. Students read a case study and outline the environmental issue through its successes and failures. This allows students to evaluate real life situations and help them develop skills to make decisions about specific issues in the future.

Field Trips

Some students learn best when they experience the topic they are learning. Field trips allow students to visit the site where they can obtain more information. Students may travel to a forest and study trees or may go to seashore to observe turtles. Field trips can also mean traveling to a water treatment plant to learn how it operates.

Debates

Environmental issues can be difficult to understand because they may contain many perspectives. Debates allow students to choose a side of an issue, research it in depth, and present its pros and cons to other students. Debates promote good research and writing skills. Students practice public speaking skills because they are expected to present their side to the class.

Surveys

Surveys are a list of questions meant to collect facts and opinions about a specific issue. Students collect information from people by asking questions and analyse the data to assess the responses. Many types of surveys exist to measure different depths of knowledge and attitudes of people in a given area. It allows students to gather and analyse data as well as work on math skills.

Games

Games are a great way to teach students about an environmental issue while serving as a tool to break up lectures. Many types of games exist such as running games, tag, board games, quiz-show games and game-show games. Local traditional games can be adapted to incorporate an environmental issue. It's important to establish

a clear objective for each game focusing on new environmental information students will learn.

Documenting Lesson Plans

There are many ways to develop a lesson plan. Documenting your lesson plans makes them an excellent resource and guideline for other teachers and organisations involved in outreach and education. Here is an example of how a lesson plan can be developed and documented:

Lesson 1: Title

Time Required

Specify the estimated time in hours or minutes and how many sessions it will take to complete the activity. One lesson plan is usually one session of 30 to 45 minutes long.

Materials

It is important to list all supplies needed to conduct the activity. Examples may be chalk, chalkboard, paper, scissors, nets, and tape measures. Think carefully to ensure that all materials are listed. If an adapted activity requires materials that can't be obtained, adapt the activity with different materials or develop an entirely different activity that requires different or fewer materials.

Background

Background information is the basic information that teachers need to know in order to teach students about the topic. It includes new vocabulary words and their definitions. It's also a good idea to address misconceptions students may have about a particular concept in order to provide new information to change the misconceptions.

Teacher Preparation

This section explains what needs to be done before beginning the activity. It describes gathering and preparing all materials to conduct the lesson plan. For example, this section may ask a teacher to write lesson questions on the chalkboard or make copies of handouts.

Learner Outcomes

The objectives, or learner outcomes, of a lesson plan is what you want students to do or learn. It should be measurable.

Lesson Steps

The lesson is broken down into an outline to lead the teacher through the activity. The outline is numbered steps that work to achieve the measurable objectives. Each step should be one action. Be careful not to combine two or more steps into one because it may be confusing. Steps should have a simple title and clear text. The format should be simple and clear. When questions are asked, it is important to provide the answers within the text.

Assessment

This section concludes the lesson by reviewing its purpose and assessing what students learned. Be sure to include opportunities for students to apply their knowledge and skills such as discussions, homework, presentations, quizzes, etc.

Handouts

Be sure to attach any necessary handouts at the end of the activity. Handouts may include reading materials or data collection forms.

Marine Biodiversity Word Web

Learner Outcomes

- Define marine biodiversity and create a word web that illustrates some of the complex connections in the web of life.
- Discuss at least one way marine biodiversity can affect people's lives.

Time

80 minutes

Materials

Chalkboard, pencils, container for key words, and key words on separate pieces of paper

Background

Biodiversity is the variety of life around us — and much more. It covers all life on the planet at all levels –from genes, to **species**, to entire ecosystems. It's also everything that living things do — the grand total of interactions of living things among themselves and with their environment. These interactions can be as simple as a sea turtle's dependence on jellyfish for food or a coral cod's dependence on a coral reef for protection. At another level, the sea turtle, the jelly fish, the cod and the coral polyps also depend on all of the elements that make up their ecosystem — from clean water to the right climate. At still another level, this ecosystem interacts with other ecosystems to form a huge, global system of interacting parts.

This introductory activity is a great way to start the marine **conservation** and resource management **module** because it focuses on connections, which are the heart of understanding marine biodiversity. By making word webs with the words provided, students can begin to consider the complex connections that characterise life on Earth. The activity can also give you an idea of how your students are thinking about **marine resources** at the beginning of the course, and can provide a way to evaluate their progress.

Teacher Preparation

Write each of the key words (on page 40) on a separate piece of paper, and put all four key words into a container. Write the web words (on page 40) on a chalkboard. Each key word can form the hub or centre of a web. The web words will connect to the key word or to other web words in a concept map.

Lesson Steps

1. As a group, create a sample word web.

Use the word "school" as a key word to create a word web on the chalkboard. Ask the students what other words they think of when they think of their school. Some examples might be teacher, student, books, desks, and homework. Make sure you write down the connections between each web word. For example: Students learn from teachers. Teachers give out homework, and so on.

2. Introduce marine biodiversity.

Write the term "marine biodiversity" where everyone can see it and ask the students for their ideas on its meaning. Use the glossary and background information to familiarise the students with the two words. Explain that biodiversity is the ultimate web because it includes all life on Earth. And specifically, marine biodiversity refers to all life forms in the marine environment. Ask students what the difference is between the terms marine biodiversity and marine resources. Explain that marine resources are those species, or life forms, that humans use, such as food fish, trochus or sea cucumbers.

3. Review vocabulary and divide the class into groups.

Go over any key words and web words that the students aren't familiar with, and then have someone from each group pick a key word from the container. Tell the groups to write that key word in the centre of a piece of paper. Next, give them time to create a web using as many of the web words as possible.

Tell them they can add their own web words if they want. Encourage them to also write in words that describe the connections they're creating. Examples include verbs and phrases such as "influences", "affects", "benefits", "is helped by", "can lead to", and "can cause". For example: people benefit from fish resources, fish are protected by coral reefs, human **population** growth can cause loss of natural **habitats**, **pollution** can affect **threatened species**, and so on.

4. Discuss the webs.

Each group should be able to explain the connections that they drew between the key word and the web words, as well as between the different web words. Ask the students if they notice any similarities among different groups' webs and have them work as a group to identify and write down two or more of these similarities. You might also want to have them write down any differences they notice. Use their ideas to start a discussion.

Assessment

This activity can be used as an assessment for other activities. You can have your students create webs after doing other activities in the guide to see if they understand the basic concept of biodiversity and how it is linked to other issues.

Sample Word Web

Key Words

Marine biodiversity
Marine resources
Marine habitats
Marine conservation

Web Words

Fisheries Management Plan	Earth	Marine mammals
Plants	People	Energy
Technology	Natural habitats	Crops
Rubbish	Consumption	Soil
Solutions	Pollution	Twenty-first century
Pesticides	Food	Ocean
Money	Water	Human population growth
School	Sustainable harvesting	Threatened species
Organic farming	Atmosphere	Future generations
Air	Medicine	Trees
Biodiversity	Food web	Mangroves
Fish	Sea	Coral Reefs
Non-fish resources	Boats	Fishing gear
Traditional fishing methods	Modern fishing methods	Overharvesting
Climate	Locally managed marine areas	Local communities
Rituals	Lime production	Fisheries Management Act
Deforestation	Siltation	Economic growth
Tourism	Diving	Taboos

Adapted (with permission) from "All the World's a Web," an activity in Biodiversity Basics ©1999, published by World Wildlife Fund as part of *Windows on the Wild*, an international biodiversity education program.
Visit www.worldwildlife.org for more information.

Habitat is a Home

Learner Outcomes

- Define habitat.
- Describe types of common habitats and organisms that live in each habitat.
- Suggest ways in which habitat can be restored.

Time

80 minutes

Materials

Butcher paper, markers, and rulers

Background

Everywhere you look around the coastline or ocean, there are living things. How many and what kind of **organisms** there are depends on where you go — that is, on the specific nature of the **habitat**.

Habitats are the places where animals and plants and other **species** find what they need to survive, including food, water, shelter and space. For marine resource **populations** to stay healthy, species need healthy diverse habitats. Some species might be born in one habitat, but feed and mate in another. Understanding habitats is key to understanding **marine resources**, and habitat protection is key to **conservation** of marine biodiversity.

Every environment has distinct characteristics that determine which organisms live there and which do not. The amount of light for example, determines whether plants can grow. The type of bottom, temperature and salinity of the water, waves, tides, currents, and many other aspects of the environment profoundly affect marine life. Equally important are the ways that organisms affect each other.

Around the world, individuals, governments, and organizations are leading efforts to restore marine habitats to as close as possible to what they were before humans damaged them. This effort is called habitat restoration. People have organised to remove invasive species (species that are not native to the area) to restore natural coastal communities. When rubbish covers beaches along coasts where **threatened** birds and **marine mammals** live, people have gathered to clean up the debris and have worked to limit the amount of trash that finds its way into the sea.

Getting Ready

Create a list of habitats and the plants and animals that can be found in each of them. If necessary, research different habitats to obtain this information. This will serve as a guide to help students complete posters created as part of this lesson. Some examples include the deep sea, seashore, reef, **seagrass beds**, **estuaries**, and **mangroves**. Some plants and animals include sharks, sea cucumbers, turtles, skipjacks, parrotfish, prawns, cray fish, dugongs, groupers, and seaweed.

Gather butcher paper, markers and rulers that students will use to create the posters. If possible, identify areas where students can go to observe different habitats to determine which plants and animals live in each.

Lesson Steps

1. Discuss habitats.

Open a discussion with students about habitats. Begin by asking them where they live. They may say in a home or the name of the village. Ask them what they need in order to live. List their answers on the board. Some possible responses may be water, air, food, and shelter. Tell them that they find all of these things in a habitat. Explain that habitats are the places where animals and plants and other species find what they need to survive, including food, water, shelter and space.

Tell students that there are many different types of habitats including the deep sea, seashore, reef, seagrass beds, estuaries, and mangroves. Explain

that they will discuss different types of habitats and the plants and animals that live in them.

2. Divide students into groups.

Divide students into groups of 4-6. Provide each group with a sheet of butcher paper, markers, and rulers.

3. Explain the activity.

Tell students that each group will be assigned a habitat, but that they must keep it a secret from other groups. Explain that the group will discuss and decide which animals and plants are found in their assigned habitat. Ask them to draw all of the plants and animals that live in, find food in, and or mate in the habitat. Tell them that each group will present their poster to the class and the other students will have to guess which habitat it is.

3. Create habitat posters.

Tell them to draw the plants and animals on the butcher paper to create the habitat. If possible, allow students to walk outside to observe a habitat. Tell them that if they are unable to draw an animal or plant, they can write it on the poster.

4. Present the posters.

Ask each group to present their habitat. Tell them to name each plant and animal in the habitat. After they are done, then all other students should try to guess which habitat is being represented by the poster. When all habitats have been identified, ask students to name the differences between the habitats.

Assessment

Review the habitats discussed during the activity. Explain that there are many other marine habitats in the world that were not mentioned. As a follow up activity, ask students to research a different habitat and create a poster for it to teach classmates or community members.

Students can add the habitat name to their habitat posters and put them up around the community to help teach others about the different types of habitats and their value as a source of shelter, food, water, and space for marine species.

Life Cycle Stories

Learning Outcomes

- Identify and explain the life cycles and spawning behaviours of common fish and non-fish species.

Time

80 minutes

Materials

- Photographs of the animals to be studied
- Factsheets on specific species (if available)
- Information cards on the life cycles of a number of species
- Sellotape or glue
- Large sheets of paper
- Chalk/white board and chalk or markers

Background

The different stages of an animal's life are known as its **life cycle**. Life cycles of animals differ from **species** to species. For example, some fish prefer to **spawn** (release eggs and sperm into the water) inside the safety of the **lagoon** while others will migrate out into the ocean to spawn. Some fish build "nests" and protect their eggs until they hatch. Certain types of sea cucumber reproduce by simply dividing themselves into two while other types of sea cucumber will spawn. Other differences, include the age at which an animal is ready to reproduce (i.e. is sexually mature), the number of times a year that it will reproduce, etc.

Knowing about the different stages of a marine animal's life and how (and when) it reproduces can help us make decisions about how to harvest **marine resources** while allowing more of the **population** to grow. This is known as **sustainable** harvesting.

When discussing life cycles of marine species, the following issues should be considered:

- Age of maturity (how old is the animal before it can breed?); are there specific features about the animal that help identify its age/stage of the life cycle?
- Visual differences between male and female
- Mating behaviour
- Where (and how) are the young reproduced? If spawning occurs, where does it occur (inside the lagoon, at sea, on land). Do the parents care for the eggs/young?
- How long is the gestation period (how long from mating to birth?)
- What dangers/threats do the young face?
- How many young are expected to survive to adulthood?

This lesson explores the life cycles of some key marine species in Papua New Guinea and provides an opportunity to discuss good practices with regard to their sustainable management.

Additional Resources

- Indo-Pacific Coral Reef Field Guide. Allen, G.R. and Steene, R. Tropical Reef Research (1999).
- Reef Fishes of New Guinea: A Field Guide for Divers, Anglers and Naturalists. Allen, G.R., and Swainston, R. Christensen Research Institute (1992).
- The Secretariat of the Pacific Community. www.spc.int, ph: 687 26 2000, fax: 687 26 3818
- International Marinelife Alliance. www.marine.org, ph: 1 808 523 0143, fax: 1 808 523 0140
- Fishbase. www.fishbase.org

Teacher Preparation

Photocopy or copy one set each of the life cycle cards provided and cut them up. Remember to keep each set separate! There should be one set of cards per group.

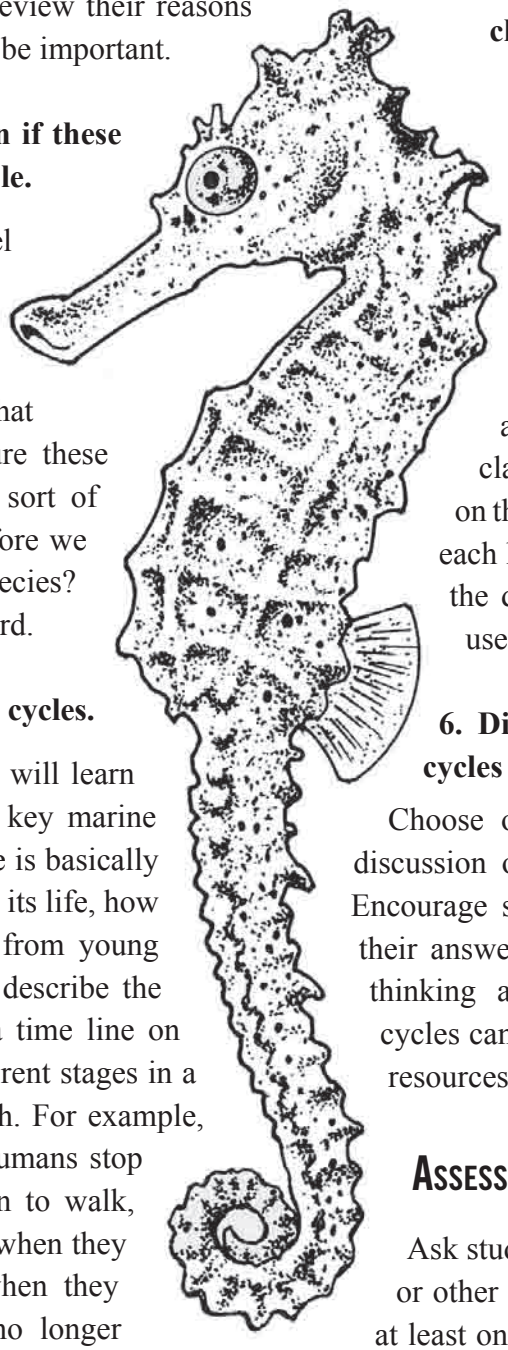
Lesson Steps

1. Make a list of key marine species.

Begin the lesson by making a list of key species that students have identified as being of value (see Valuing Marine Resources). Review their reasons for considering these **species** to be important.

2. Discuss what would happen if these species were no longer available.

Ask students how they would feel if we lost these species. What would it mean economically? Would it affect health and/or well-being of people? Ask what we might do to help make sure these species don't disappear. What sort of things do we need to know before we can properly manage these species? Note their comments on the board.



3. Introduce the concept of life cycles.

Explain that in this lesson they will learn about the life cycles of a few key marine species. Explain that a life cycle is basically the story of how an animal lives its life, how it reproduces, how it changes from young to adult, etc. Ask students to describe the life cycle of a human. Draw a time line on the board and label it with different stages in a human's life from birth to death. For example, they could think about when humans stop breast-feeding, when they learn to walk, when they go through puberty, when they start dating or get married, when they have babies, when they can no longer reproduce, etc.

4. Divide students into small groups of five or less.

Give each group one set of the (shuffled) cards. Explain that each set of cards tells us something about a stage in the life cycle of one animal. Together the cards make up the life cycle story for that animal. The challenge for each group is to place the cards in the correct order so that they can teach the others about their specific animal.

5. Share each life cycle story with the class.

Check the group work as they finish and ensure they do have the correct sequence. Use tape or glue to stick the cards into place on a large sheet of paper. If they wish, they can decorate the paper and add more information on the paper. When the groups are done, ask them to talk about their animal to the rest of the class. Display the different life cycles on the wall. Note: students can either copy each life cycle into their own notebooks or the displays can be left on the wall and used as reference throughout the term.

6. Discuss the connection between life cycles and management.

Choose one of the key species and lead a discussion on the best time to catch/collect it. Encourage students to provide explanations for their answers. This is a good way to get them thinking about how knowledge of fish life cycles can assist in better management of such resources.

Assessment

Ask students to use story, song, poem, drama or other methods to describe the life cycle of at least one of the species discussed during the lesson and present this to the rest of the group.

Turtle Life Cycle

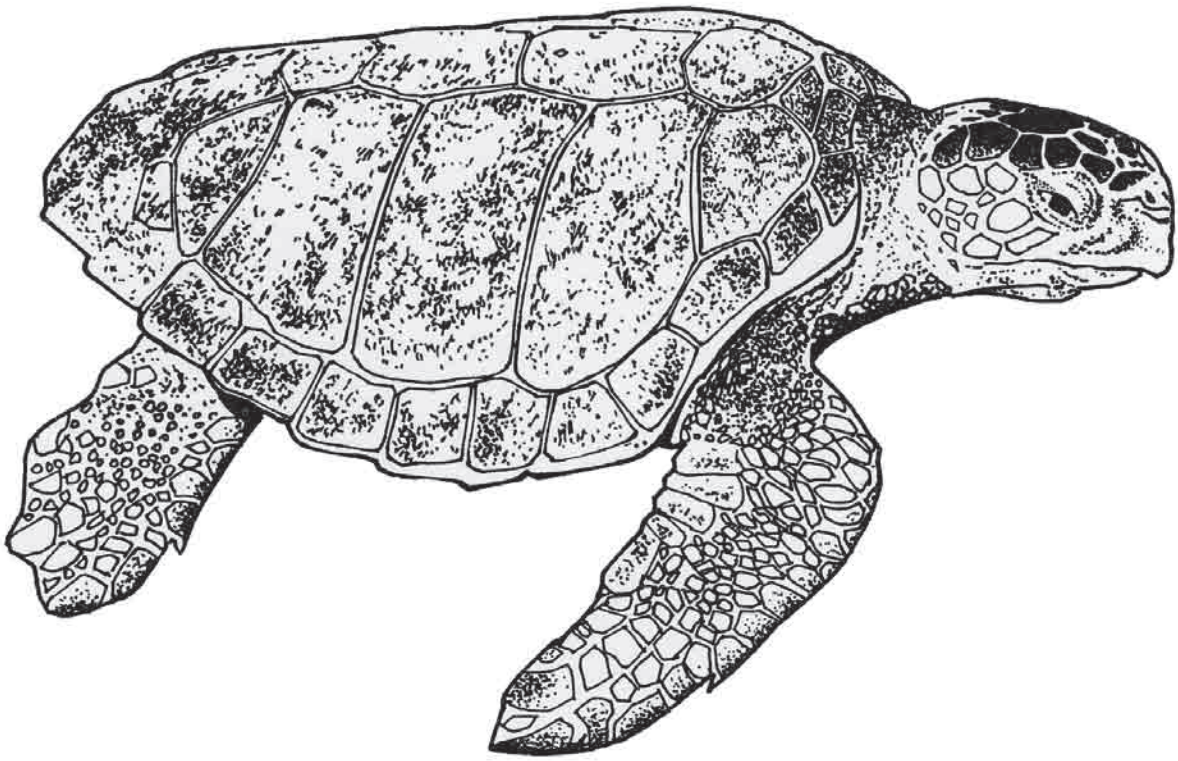
I have just hatched out of a small white egg. About 60 days ago, my mother laid almost 120 eggs in the sand. I am still in the nest with the rest of my brothers and sisters. We will wait until dark before we all climb out of the nest together.

Now we are all out in the open - where do we go? I see bright light on the horizon. My instinct tells me that is the way to go. We all run towards the light in the distance. It is hard to run on the sand – I am so small.

I am now in the warm ocean. Many of my brothers and sisters got caught by birds as they ran towards the sea. But there are still plenty of us in the water. Now, all we have to do is find a place to hide and a current to carry us safely away…our tiny flippers are still not very strong and our soft shells make us easy food for fish.

Many years have passed and I am now a mature female. I have spent almost 25 years swimming from place to place in the deep ocean. I have managed to avoid all the big animals that would eat me – including my worst enemy – the human. Now it is time to find a mate. To do this, I have to come closer to land. I swim back to the place where I was born. I have a special instinct that allows me to find my way back even though I have been traveling hundreds of miles across the Pacific Ocean!

I am back in the waters of Milne Bay where I met a male of my species to mate with. At night I crawl up to the same beach where I was born and dig a hole to lay my eggs. If no human finds me, I will be able to return safely to the deep ocean where I will be safe. I hope my babies will also make it to the ocean one day.



Sea Cucumber Life Cycle

You probably think I am the most ugly thing in the ocean. You are probably right. But I do have some uses. For example, I make very tasty food. In fact, I am so tasty, that people will pay a lot of money for me. If you learn about how I grow, you may be able to make money off me one day, too! Another thing I am good at is cleaning sand. I crawl slowly along the bottom of the ocean eating large amounts of sand. As the sand particles pass through my intestine, I digest the food from it and then pass out clean sand.

There are many different types of sea cucumbers and we reproduce in different ways. Some of us can simply divide ourselves into two. If we think there needs to be more of us, we double up and then divide. So there is an exact copy of the original! This is known as asexual reproduction.

Other types of sea cucumbers have to reproduce sexually. This means that we produce eggs, which must be fertilized. When conditions are right, spawning occurs and larvae are formed.

The larva floats around in the ocean for about two weeks before it comes to rest inside the lagoon area where it grows slowly into a sea cucumber.

In the warm Pacific ocean, it takes about 2 years for a sea cucumber to become fully grown. Then it is ready to reproduce again. We can reproduce two or three times a year.

Giant Clam Life Cycle

I am a giant clam. There are not many of us left in the world. This is because we take a long time to grow and people like to eat us.

Clams reproduce sexually. This means that females lay eggs while males produce sperm, which have to meet in order for fertilisation to take place.

Since we cannot move from one place to another, we rely on currents to help bring eggs and sperm together.

Mature female clams release eggs, which are carried downstream by currents.

If there are male clams present downstream, chemicals from the eggs cause the male clams to spawn (release sperm). In this way, the egg is able to be fertilised.

The tiny larvae (fertilised eggs) then float off and settle onto the reef. If the conditions are right, baby clams will grow.

It takes the largest giant clam almost 40 years to reach its maximum size. The largest clams can grow up to 137cm long and weigh over 200kg!

Coral Trout Life Cycle

I am a very nice tasting fish. I taste so good that people from other countries will pay a lot of money for me.

My life cycle is quite complicated and, in fact, humans are still learning a lot about how we reproduce!

Coral trout reproduce sexually. This means that females lay eggs while males produce sperm, which have to meet in order for fertilisation to take place.

In an established population of coral trout, the babies are all females.

When we are about 3 years old, we are able to release mature eggs, which are fertilised by sperm from older male fish. Normally, the females are smaller in size than the older males.

At different stages in our life, for various reasons, some of us change into males. Instead of laying eggs, we can now provide sperm to fertilize eggs laid by the young females!

Some males can change back into females later on in life.

We change sex in order to make sure that we always have enough breeding males and females to keep producing young. If there are not enough males, the eggs won't be fertilized. And if the females are too small, there won't be enough eggs. So we have figured out a way to try and keep our populations stable!

Note to Teacher

The life cycle of the group of fish commonly known as cods, trouts and groupers is quite complicated and management plans for these fish are difficult to develop since there is still insufficient information about their life cycles. The information below may help students to understand why it is so important to fully understand fish life cycles for management purposes.

- If sex change were triggered by social cues (such as the ratio of males to females), when males were removed, the female could change sex at an earlier and smaller stage to balance the sex ratio. The result would be smaller and younger fish, both male and female, in fished populations. Smaller females produce fewer eggs than larger fish and therefore, fewer young; an important consideration for the fishery in the future.
- If sex change in coral trout is fixed at a certain age or size, fishing will have no affect on this, and fished populations would presumably have less males than females. This could also affect reproduction if there were not enough males in the population to fertilise the female's eggs at spawning time.

Valuing Marine Resources

Learner Outcomes

- Identify and classify fish and non-fish resources for their nutritional, economic, cultural and ecological values.
- Explore personal beliefs and values about conserving marine resources. List several reasons it is important to conserve marine resources.

Time

80 minutes

Materials

Chalkboard, large pieces of paper, chalk and markers

Background

People's feelings about marine issues depend on many things. The importance people place on **marine resources** and their **habitats**, and whether they think these resources should be conserved, do not depend on just their knowledge of these issues and the sciences that relate to them (ecology, biology, sociology, political science, economics, and so on). People's feelings also depend on personal belief systems and values.

The most common way that people value marine resources is for their nutritional value or for their economic value. However marine resources can also be valued for their link to traditional cultures and for the role they play in local ecosystems. All of these values should be considered when making decisions about the **conservation** or management of a particular resource.

Teacher Preparation

Cut out or copy each of the six "Why Care About Marine Resources?" statements on page 51 and paste them onto separate large pieces of paper. Also include the word "other" on a seventh piece of paper. Write large enough so the students can read the statements from all areas of the room. Be sure to also read through and familiarise yourself with the "Valuing Marine resources" list on page 52.

Lesson Steps

Session 1

1. Create a list of common marine resources in Milne Bay.

Ask students to brainstorm a list of both fish and non-fish resources. Write their answers on the board. Add other ideas you feel are necessary.

2. Ask your students whether conserving marine resources is important and why they feel the way they do.

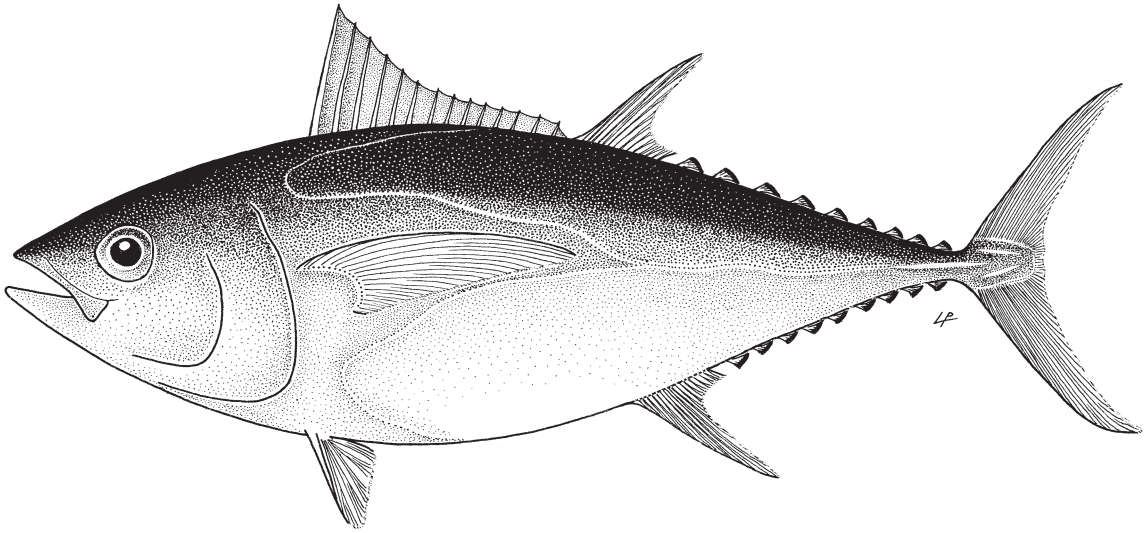
Explain that many people feel that it's important to conserve marine resources and that they have diverse reasons for thinking so. Ask your students how they feel. What reasons can they give to conserve marine resources? Write their ideas on a chalkboard. It might also help to give them a few minutes to write their ideas before talking.

3. Put up the statements and read each one aloud.

Tape each of the ten statements you copied earlier in different places around the room. Place each one high enough for everyone to see. Explain that the statements represent many of the key reasons people have given for why it is important to conserve marine resources. As a group, review each of the statements. Compare the ideas represented in the statements with the lists that the students generated.

4. Students choose a statement to stand near.

Ask your students to carefully consider all of the statements. Have each of the students pick one of the statements and then go and stand near it. Explain that the statement the students choose should be one



that they feel strongly about — either because they think it is an important reason to conserve marine resources or because they disagree with it. If they don't see a sign that reflects their viewpoint, they can stand at the sign marked "Other". Explain that there is no correct answer and that it's OK to stand either alone or with a group.

5. Discuss the choices that students made.

After everyone has made a selection, have the students at each statement discuss among themselves why they chose that particular statement. After about five minutes of discussion, ask one person from each group to summarise the discussion. You might want to record each group's points on a chalkboard, especially any ideas that came from the group who stood under "Other".

6. Open up the discussion to the entire class.

After all the groups have given their summaries, use the guiding questions to spur a group discussion of some of the arguments that local communities, biologists, conservationists, ecologists, economists, and others have put forth for conserving marine resources. Read one of the numbered questions in "Guiding Questions" and have the students react to it. You do not need to ask the class all the guiding questions, and the students do not need to discuss each of the numbered questions in turn.

During the course of the discussion, make sure that the students confront the issues highlighted by each numbered question and that they explain why they feel the way they do. Have them give examples whenever they can, and be sure to challenge their ideas—especially when the students reach answers quickly or all of them seem to be agreeing with each other. Allow enough time for the students to fully discuss their points of view. Also give them an opportunity to research issues that come up.

Session 2

7. Create a chart showing values of common marine resources.

Draw the following chart on the chalkboard. In the column on the left, include the list of marine resources students generated in step 1. Ask students to copy the chart into their notebooks. Explain that each student should complete the chart by assigning a number value from 1-10 in the boxes for the value they see in a particular **species**, with 10 as highest and 1 as lowest. An example chart for tuna is on the next page.

Marine resource	Nutritional Value	Economic Value	Ecological Value	Cultural Value	TOTAL
Tuna	10	10	10	3	33

After they have filled in the chart, students should add up the total points in the last column, and then identify the species that have the highest total values.

8. Discuss the ways we value specific species.

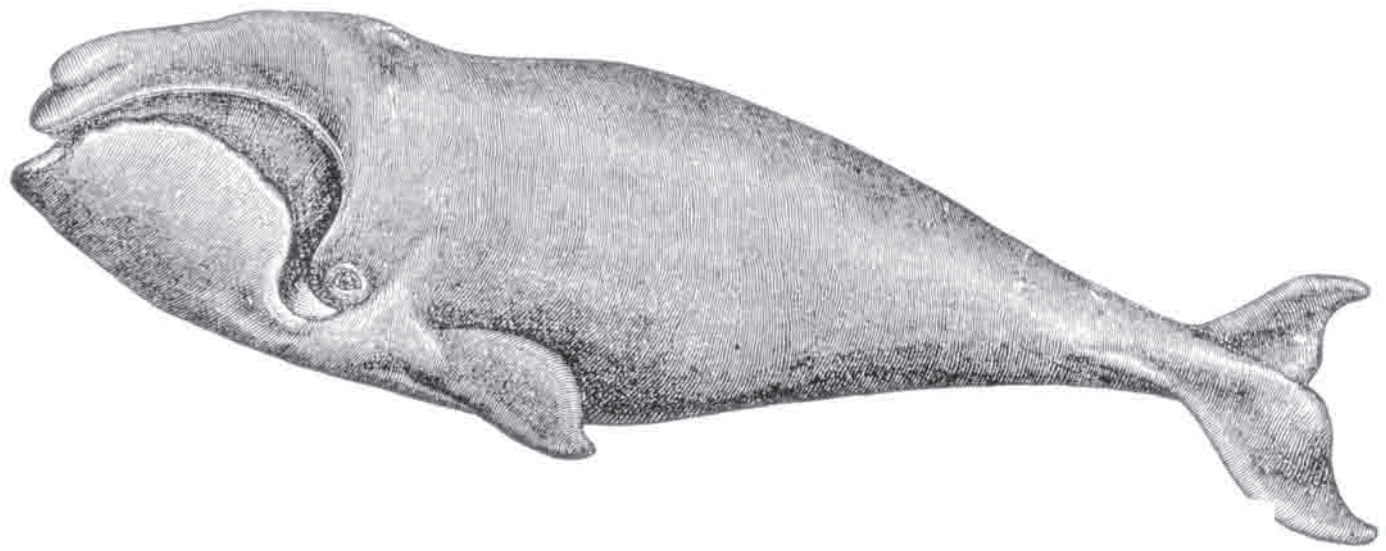
Divide students into small groups. Ask them to compare their charts and discuss the resulting valuations of marine resources. Ask one person from each group to report back to the class on their discussion. With all the students talk about how society normally values marine resources, and why it might be important to also consider other values such as ecological and cultural values.

Assessment

Let the students choose between the following two writing activities:

1. Have the students write one to three sentences that state their personal views about the importance of conserving marine resources. Explain that there are no right or wrong answers to this assignment—and that they don't even have to think conserving marine resources is important at all. However, they should carefully consider everything they've learned about as well as all of the points made during their discussion to make a well-reasoned and well-supported statement. Encourage the students to consider nutritional, economic, cultural and ecological implications of marine resource conservation, as well as any obligations of present generations to future ones. Tell them to use examples to illustrate their points.

2. Have the students write a dialogue between two people who have different viewpoints on conserving marine resources.



Why Care About Marine Resources Statements

It is important to conserve marine resources for economic reasons. Many people in PNG sell fish and non-fish resources to make money for their families. Income from fisheries contributes to development.

It is important to conserve marine resources because fish and other species are a primary source of food for many families in PNG.

It is important to conserve marine resources for medical reasons. Marine resources could provide us with new medicines that will save lives and benefit society. Hundreds of marine species have medicinal properties, many of them from coral reefs. Drugs derived from marine resources include antibiotics, tumour inhibitors, pain suppressants, anti-inflammatory treatments, skin care, sunscreens, and medicines for heart and nerve conditions.

It is important to conserve marine resources and their habitats because they help maintain important ecological processes that, in turn, help support all life on Earth. For example, mangroves protect coastal communities from waves and storms and help control erosion and siltation. Plankton help balance gases in the atmosphere so we can breathe. Many other species on land and in the water depend on marine resources for food.

Our lives would not be as rich if we lost species such as sharks, tuna, crabs, sea cucumbers, trochus, or turtles and the habitats where they live.

The rich diversity of marine life allows for important recreational activities such as diving, snorkelling, or fishing. Tourism generated by these activities can be an important source of income.

It is important to protect marine resources because no generation has the right to destroy the environment and resources on which future generations will depend. It is our responsibility to take care of marine resources.

It is important to protect marine resources because they provide inspiration and provoke curiosity and imagination. Many cultural traditions in PNG are inspired by the diversity of marine life and use of marine resources, including art, music, and dance. The use of marine resources is the backbone of traditional lifestyles and culture of Milne Bay.

It is important to conserve marine resources because all species have a right to exist.

Other

Guiding Questions – Valuing Marine Resources

1. Is it important to conserve marine resources for medical and economic reasons?

- Do people actually need marine resources for either medicinal or economic reasons?
- Can people make the medicines they need in a laboratory?
- If a plant or animal species is not known to have any medical or economic benefit to people, is it then OK to let the species die out?

2. Do marine resources help maintain important ecological processes that help support life on Earth?

- What sorts of ecological processes do marine resources help maintain?
- People have developed an amazing array of technologies to deal with particular problems—everything from water treatment plants that purify sewage water to scrubbers that can take pollutants out of the air from factory smokestacks. Isn't it fair to assume that people will be able to develop technologies that can perform essential ecological processes in place of marine resources?
- Are there any negative effects of technological solutions?

3. Would your life be affected in any way if we lost species such as sea cucumbers?

- Is there anything about these species that makes them special?
- How would you feel if sea urchins, sting rays, sharks, sea snakes, jelly fish, and other harmful species became extinct?
- Are there species that you think are more important to protect than others? Which ones? Why?

4. Do all species have a right to exist?

- Do people have the right to use any of the oceans's resources however they want? Why or why not?
- Does the right to exist apply to ugly species that are of no use to people?
- Some species have been around for millions of years — and have survived incredible periods of destruction and change on the planet. Should that influence whether we decide to protect a species?

5. Some people argue that no generation has the right to destroy the environment and resources that future generations will depend on. Do you agree or disagree with this idea?

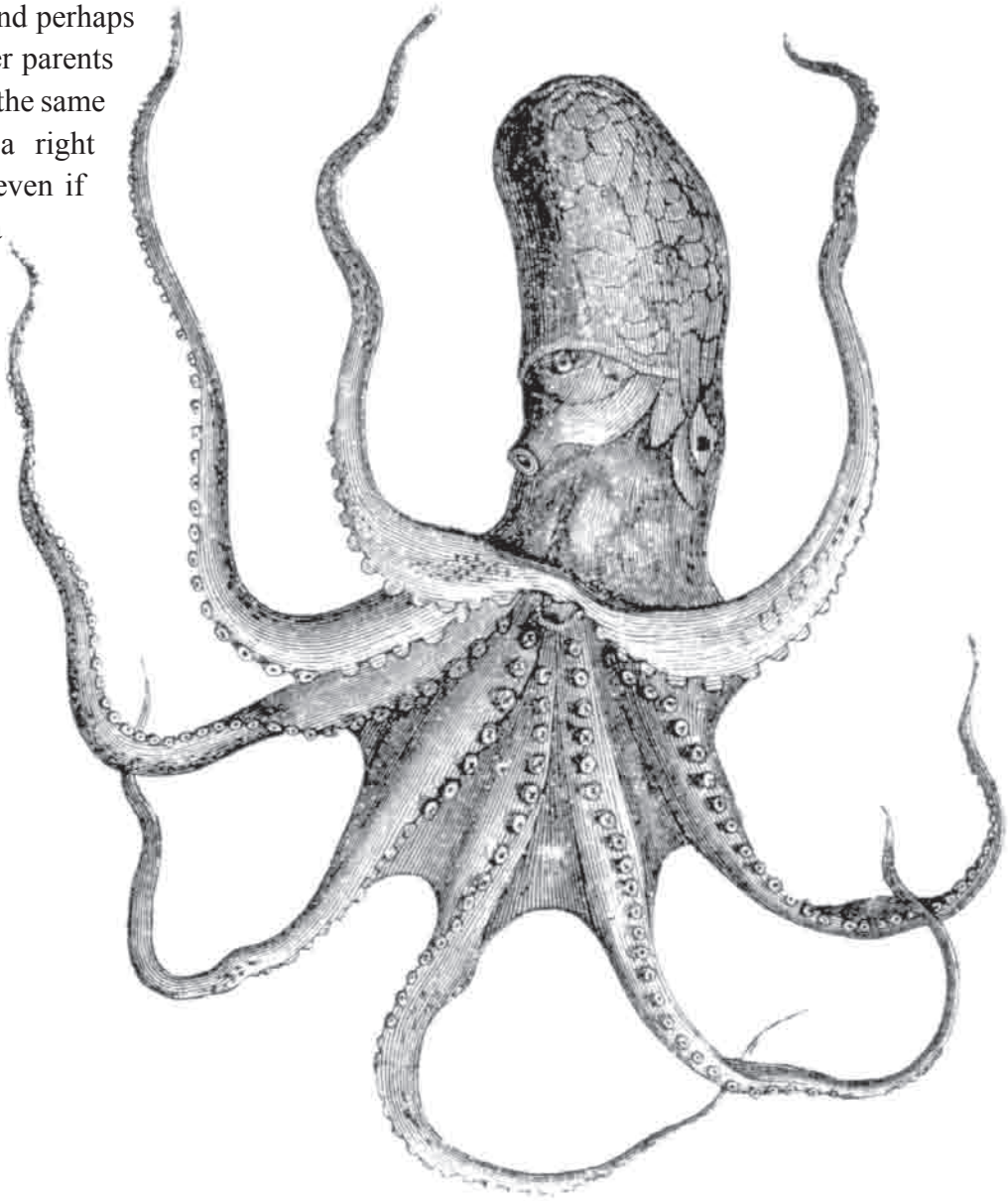
- Why should people today do without things they want when we don't even know what future generations will need or want?
- Do you feel that past generations have left you with the environment and resources you need to live?
- Many species have already become extinct. Has your life been affected in any way by the absence of these species? Will future generations really care about species that disappeared before they were born?

6. Is the diversity of life important for inspiring inventors and artists and for spurring curiosity and imagination?

- What human activities are inspired by marine resources?
- What inventions, stories, or works of art can you think of that were inspired by living things from the sea? Could these have been produced without the inspiration of nature?
- Will photographs and films that have been made of wild plants and animals be sufficient to provide inspiration to future writers and artists?

7. Is the diversity of life important for recreational activities?

- What kinds of recreational activities rely on marine resources?
- Is it right to save an area so people can dive and snorkel if it means that other people lose their jobs? What types of jobs could be affected by a marine protected area?
- Does the fact that someone has done a particular job all his or her life—and perhaps one or more of his or her parents or grandparents also did the same job—give the person a right to keep doing that job even if it means wiping out a species or harming the environment? What kind of jobs could this relate to?
- Should people be allowed to take part in anyrecreationalactivity even if it harms the environment? How do we balance the rights of individuals and the rights of society as a whole?



Adapted (with permission) from "Spice of Life," an activity in Biodiversity Basics ©1999, published by World Wildlife Fund as part of Windows on the Wild, an international biodiversity education program. Visit www.worldwildlife.org for more information.

Sea Cucumber Connections

Learner Outcomes

- Demonstrate examples of the many uses of and ways to value sea cucumbers.
- Describe the connection between sea cucumbers and marine ecology, people and marine animals.

Time

40 minutes

Materials

Paper for making role cards, chalk, and chalkboard

Background

Sea cucumbers are important marine animals with many uses. They can serve as income, food, and medicine and are a key player in the marine ecosystem. With many uses, it's easy to understand why fishermen are gathering more sea cucumbers than the **sustainable** amount, also known as **over-harvesting**. This means that fishermen take more sea cucumbers than can reproduce to maintain their **population** level.

As sea cucumbers continue to be over-harvested, their population decreases. This has a negative impact on the marine ecosystem, marine animals and people as well. One way students can learn about these impacts is by studying the different uses of sea cucumbers and describing what happens when their population decreases. This activity allows students to identify the relationships between sea cucumbers and marine ecosystems, people and marine animals and to understand what happens when the sea cucumber link disappears.

Sea Cucumbers in the Marine Ecosystem

Sea cucumbers have been called the "earthworms of the sea" because just like earthworms, they consume and grind materials into finer particles. Bacteria then breaks down these particles, making them even smaller. This is an essential link in the nutrient cycles of the ocean. Sea cucumbers move along the ocean floor and eat sand and waste. In one year, a sea cucumber can eat up to 200 pounds of sand and turn over as much as 90 percent of the biomass (plant materials and animal waste) on the sea floor. Sea cucumbers also feed on sea grass and algae. They play an important role in filtering **sediments** and recycling nutrients back into the **food web**. Without sea cucumbers to eat and grind particles, the sea floor hardens, eliminating **habitat** for other bottom-dwelling **organisms**.

Sea Cucumbers as Food

Sea cucumbers are a source of food for marine animals and humans. Their eggs provide nutrients for a large number of marine **species**. Fish, crustaceans (lobsters, crabs, etc), mollusks (oysters, muscles, etc.), and sea turtles eat young sea cucumbers. Humans consume sea cucumbers as well. In Melanesia, sea cucumbers are especially popular when served in soup.

Sea Cucumbers as Medicine

Sea cucumbers are highly valued for their potential medicinal uses. Scientists are studying sea cucumbers to determine if they can help detect tumors or serve as a cure for HIV/AIDS. Some studies isolate compounds of the sea cucumbers to determine if they can be used as anti-inflammatories (used to stop swelling) and anticoagulants (used to stop blood from clotting).

Sea Cucumbers as Income

Many fishermen rely on these marine animals as a source of income, selling them as food and or for medicinal purposes. The demand for sea cucumbers has been increasing over time as their uses have increased as well as the number of humans who are demanding them. Fishermen have been fishing more to try and keep up the supply. As a result, sea cucumber populations have decreased.

Teacher Preparation

Make role cards for sea cucumbers and all of the things and people that depend on them. First, count the number of students in your class. Half of them will be sea cucumbers. Write the words "sea cucumbers" on a card to give to them. The second half of your students will make up the people, marine animals and marine ecosystem. Write the name of the person or thing and how it is affected by a reduction in sea cucumbers. You may need to play two rounds to make sure all of your students get a chance to participate. Listed below are examples of role cards you can use with your students.

Lesson Steps

1. Brainstorm.

Ask students if they can name some uses of sea cucumbers. Write student responses on the chalkboard. Help students develop the list by asking the following questions:

- What do sea cucumbers eat?
- Who eats sea cucumbers?
- What role do sea cucumbers have in the marine ecosystem?
- Which marine animals eat sea cucumbers?
- How do people use sea cucumbers?

2. Pass out role cards.

Pass out a role card to each student. Explain that each one of them is either a sea cucumber, person, marine animal or thing connected to sea cucumbers. Tell students that each non-sea cucumber will link arms together with a sea cucumber. All of the students will connect together to make a complete and closed chain.

3. Make the chain.

Go outside to an area with space for students to spread out and make a circle. Tell students to link their arms together to complete a full, closed chain. Make sure that there is a sea cucumber in between each person, marine animal or thing.

4. Break the link.

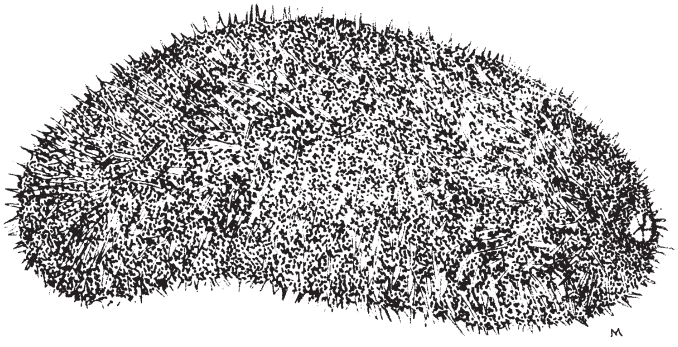
All students should be connected as a link in the chain. Now you need to show what happens when sea cucumbers are over-harvested. Explain to students that you will take out one sea cucumber at a time and the role card to its right must read his card aloud. In this way, students learn the connection between the reduction of sea cucumbers and all of the people, marine animals and things affected by this change. For example, you take out a sea cucumber and the person to his right must read his role card. If the student is holding the fish role card, then he reads aloud the following:

"I'm a fish. I eat young sea cucumbers, but lately it's been difficult to find them. I've been traveling far and looking everywhere, but I can't find any to eat. I'm very hungry."

Continue with the activity until each sea cucumber is taken away and the chain is destroyed.

5. Discuss.

Return to the classroom and ask students what will happen in each scenario if sea cucumbers disappear. Start the discussion by asking questions. A few sample questions are listed below. Be sure to develop some of your own.



Pharmaceutical company representative: I am a pharmaceutical company representative. Many scientists work for my company and are researching the medicinal value of sea cucumbers. They think they've found that some of their components work as an anti-inflammatory (used to reduce swelling). Scientists want to continue their research, but they are finding it harder to buy sea cucumbers from fishermen.

Fisherman: I'm a fisherman and I use sea cucumbers to spear fish and octopus. I put the natural poisons of the sea cucumbers into the places where fish and octopus live. The fish and octopus will come out of their places and that makes them easy for me to spear. They help me catch more fish.

Marine ecosystem: I am the marine ecosystem. Sea cucumbers are important to me and without them, I'm out of balance. Sea cucumbers eat sea grass and fish eat sea cucumbers. When there are no sea cucumbers, there is more sea grass and fewer fish. Sea grass can grow out of control and can kill other plant species. Fewer fish means there are less for bigger fish to eat.

Sea floor: I am the sea floor. Sea cucumbers consume and grind my sand so bacteria can break it down into smaller pieces. Without sea cucumbers, I will become a hardened sea floor and nothing will be able to live in me.

Scientist: I am a scientist. I began researching sea cucumbers to determine if they can help detect tumors caused by cancer. I need more sea cucumbers and more time to complete my research, but it's difficult for me to buy them lately because fishermen aren't selling as much. The fishermen say sea cucumbers are becoming harder to find.

Fish: I'm a fish. I eat young sea cucumbers, but lately it's been difficult to find them. I've been traveling far and looking everywhere, but I can't find any to eat. I'm very hungry.

Crab: I am a crab. I love to eat sea cucumber eggs. I find less these days and I'm getting tired of looking for them. I'm afraid one day they will all be gone.

Fisherman: I'm a fisherman and whenever I have a wound that's bleeding, I use the sticky stuff (Cuvierian tubes) from sea cucumbers as a bandage. What will I use instead of a sea cucumber since I can't seem to find many these days?

Business Man/Woman: I'm a business man/woman. I love to go to restaurants and eat soup made from sea cucumbers. The soup used to be inexpensive, but then they started raising the price. I asked why and they told me it's because fishermen are selling less for more money. Now I go to the restaurant and they don't sell it at all.

Fisherman: I'm a fisherman. I fish for sea cucumbers to sell to Asian markets. I make money for my family by selling these animals. This year, there are fewer sea cucumbers in the ocean and so I don't sell as many. But the ones that I do sell, I get more money for since so many different people want to buy them. What will I do if I don't sell enough of them to support my family?

- What will happen to the fish if it can't find young sea cucumbers to eat? If the fish dies from hunger, then what affect does it have on bigger fish who usually eat it?
- Will the scientist be able to continue his or her research?
- What might happen to the marine ecosystem if there aren't any sea cucumbers to grind sand? What other marine animals does this affect? What other marine animals live on the sea floor?
- If the fisherman over-harvests sea cucumbers, what will he do when they run out? What will he do to raise money?

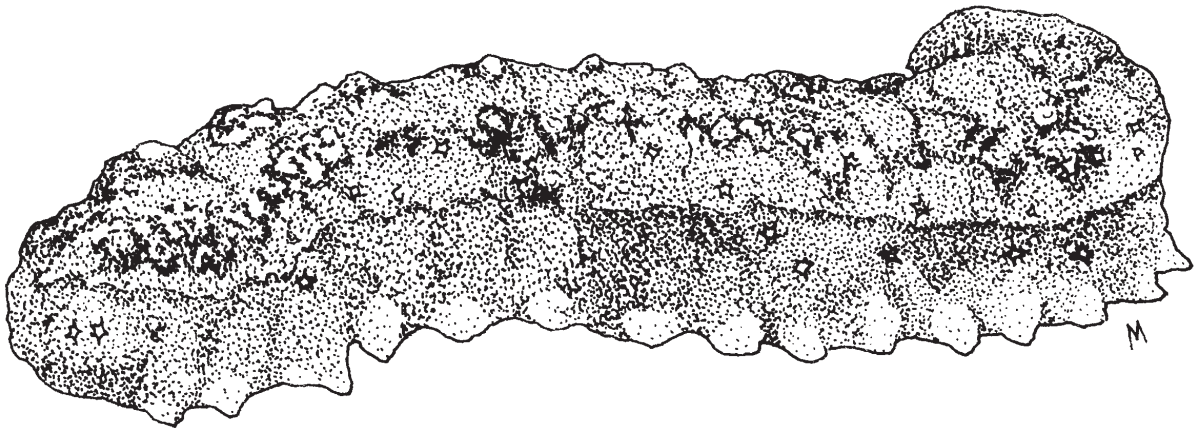
Assessment

Review with students that sea cucumbers are very important marine animals and that it is important to avoid over-harvesting them. Expand your students knowledge about sea cucumbers and other marine life through the following activities.

1. Students can have a debate about the pros and cons surrounding laws to limit the number of sea cucumbers a fishery can harvest.

2. Discuss the sea cucumber's protective mechanisms for survival. For example, when a predator threatens a sea cucumber's life, the sea cucumber pushes out its organs to confuse or entangle its predator. New organs grow to replace expelled ones. Explore other marine animal protective mechanisms for survival.

3. Discuss symbiotic (cooperative or beneficial) relationships between two sea organisms and their importance to the organisms involved. For example, sea anemones and clownfish protect each other. The clownfish hides in the anemone's tentacles in order to be safe from predators. The clownfish is territorial and drives out any fish that tries to eat the anemone. The clownfish also drops pieces of food among the tentacles for the anemone to eat. Ask students to research other symbiotic relationships and write a short poem or drama about each one.



Resources at Risk

Learner Outcomes

- Describe common threats to marine resources and their habitats

Time

40 minutes

Materials

Charts, markers, chalk, rulers, pads, paint glass of water, sand, coffee, rubbish, sponge

Background

Provide students with a brief attention-capturing demonstration. Using the background information in this manual as a guide, tell the students a story about threats that can happen to marine **habitats** and resources. As you tell the story, add one of the "threats" materials to a clear container full of water. If you want, you can personalize the story by giving a name to the fish and asking students how each threat affects it. Suggested threats for the story include:

- Siltation as a result of logging activity uphill (add soil)
- Cyanide fishing (add paint)
- Pollution (add small bits of rubbish)
- Toxic water from boiling beche-de-mer poisons the water (add coffee)
- Dynamite fishing (shake the container)
- Over-harvesting (take the fish out of the container)

Teacher Preparation

Fill a glass container full of water. Make a fish cut out of a sponge and add the fish to the container. Also bring items such as sand, soil, coffee, small bits of plastic, or colored water to represent threats to **marine resources**. Copy the following table on the chalkboard:

Resource	Habitat	Threats

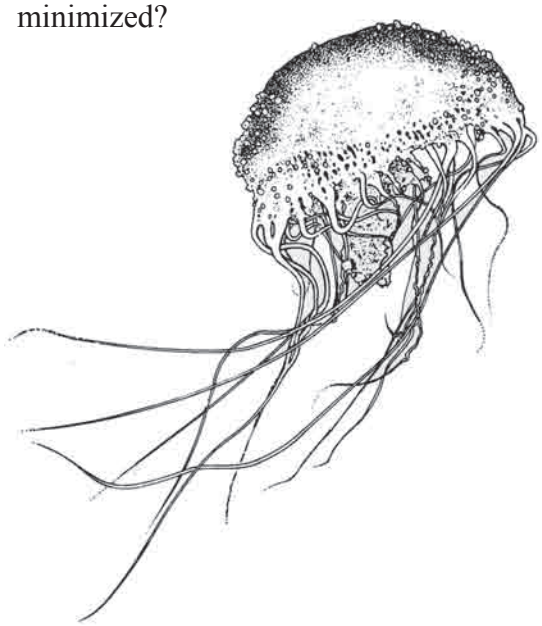
Lesson Steps

1. Ask students to list key marine resources and habitats in the table on the chalkboard.
2. Divide students into four groups.
3. Ask each group to nominate a scribe and a leader for the discussions.
4. Ask students to discuss among the group members about potential threats to each resource and habitat listed on the table.
5. Ask each group leader to present discussion findings to the class.
6. Record the threats on the table as they are presented.

Assessment

Lead students in a discussion using the following questions as guides:

1. From the group discussions, what are some common threats in your local area?
2. Name some marine resources you think are under immediate threats in your area.
3. Have local people raised any concern regarding threats that have occurred to their resources and their habitat? If yes, how was it done?
4. How do you think these problems can be minimized?



Fishing for Futures

Learner Outcomes

- Identify common harvesting methods (traditional or modern) and how they affect the sustainability of marine resource use and impact on habitat.

Time

120 minutes

Materials

Strip of cloth, soft objects, two 1 meter ropes/ strings, 8 to 12 clothespins, paper, pen, charts, small nets, dry mixed beans, dry corn, 4 containers

Background

As fishing methods change over time, so do marine animal **populations**. Fishing methods such as trawling allow fishers to catch large quantities of marine animals. The catch includes **species** they intended to catch as well as species they didn't intend to catch, called **bycatch**. Bycatch can also be defined as under-sized fish or species of little or no commercial value. One fisher's bycatch may be another's intended catch.

More than 200 million people worldwide depend on fish as a main source of income. Some scientists estimate that more than 30 million tonnes of **marine mammals**, sea turtles, seabirds, sharks, and other fish are inadvertently caught by fishers and then thrown back into the oceans annually. Most of this bycatch eventually dies.

Other fishing methods such as using **cyanide**, dynamite or **derris roots** do allow fishers to catch the fish they intend to catch but may also kill or injure fish not intended for the catch.

As market demands increase and fishing methods improve in efficiency, the number of marine species caught increases. These practices can result in **over-harvesting**.

Over-harvesting of **marine resources** means taking too many fish and or non-fish resources out of the ocean, and not leaving enough to ensure healthy productive populations.

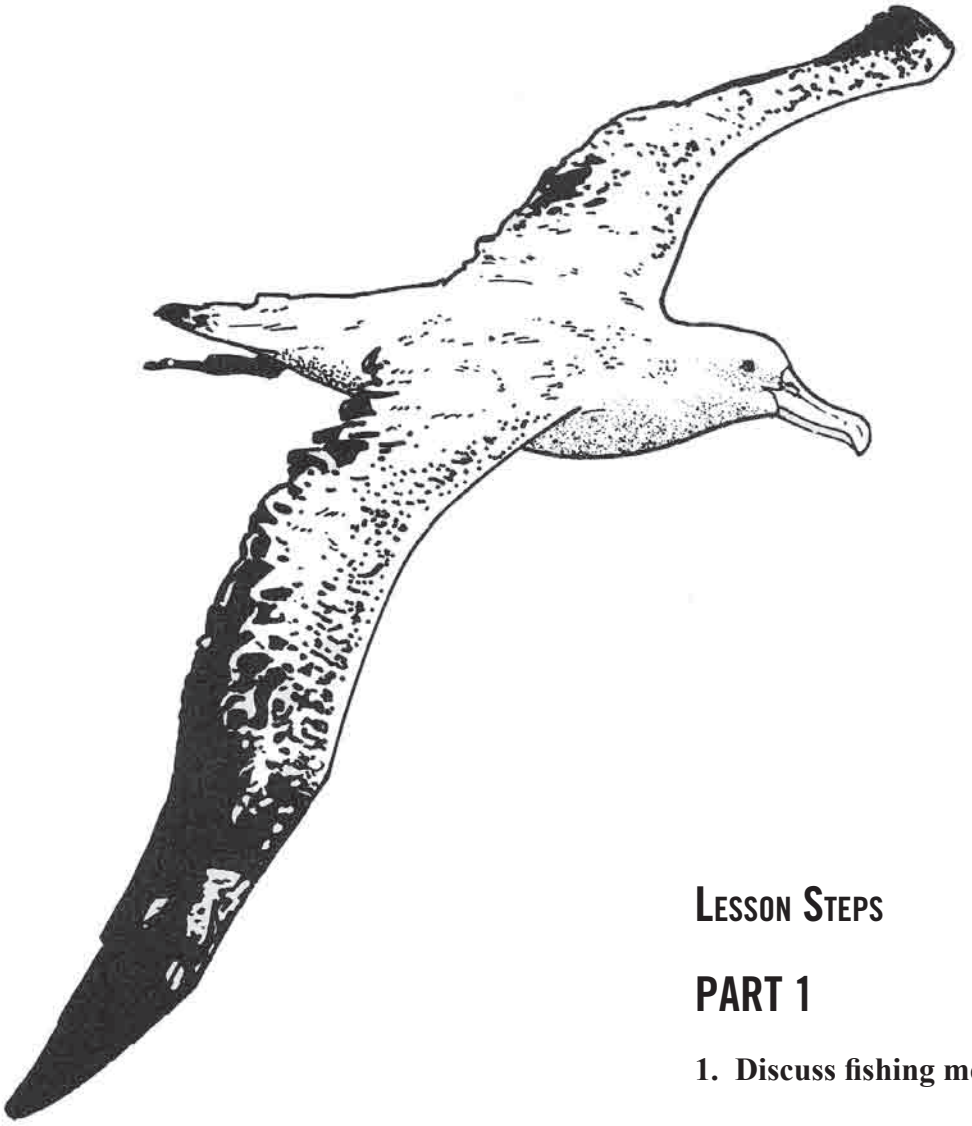
It's important to understand different fishing methods in order to better understand their role in over-harvesting and bycatch and to identify their effect on marine animal populations.

In Papua New Guinea, many species such as sea cucumbers and trochus are over-harvested. To harvest these species, local fishers use many different fishing methods that include the following:

- Spear fishing
- Traditional fishing basket
- Derris root
- Fishing with light (palm leaves at night)
- Locally made fishing nets made from bush ropes
- Blocking reef during low tides
- Bow and arrows

Fishing companies use fishing methods that include use of **longlines**, gill nets, and trawling.

Different methods can contribute to the decrease in marine animal populations to varying degrees. In this activity, students will explore the different fishing methods that contribute to overharvesting and bycatch with their advantages and disadvantages.



Teacher Preparation

The activity is divided into two parts. For **PART 1**, copy the Method Chart (listed in step 2) on the board.

For **PART 2**, before starting the demonstrations, push all desks and chairs to the sides of the classroom, leaving a large open space in the middle of the room that will serve as the ocean. Gather rope, soft objects, strips of cloth, clothespins, small nets, dry beans, dry corn, and 4 containers. Copy the charts (included at the end of this activity) onto the chalkboard.

Lesson Steps

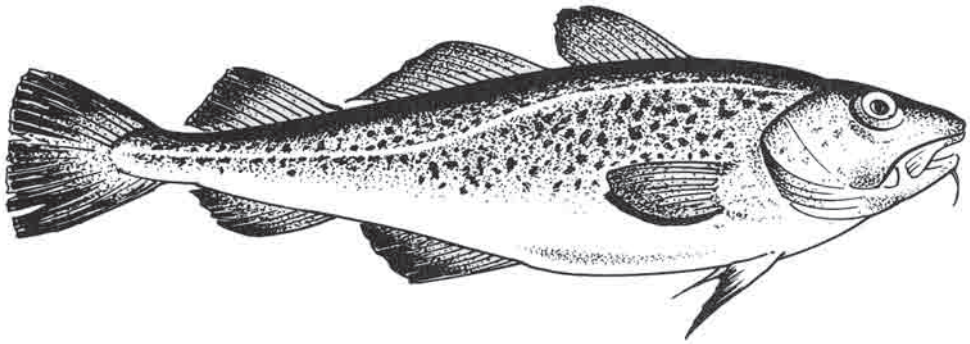
PART 1

1. Discuss fishing methods.

Ask students to brainstorm all the different ways that people catch fish in the open ocean. Write their responses on the board. Explain to students that they will discuss different fishing methods and conduct a series of classroom exercises to demonstrate them. The discussions and demonstrations will show methods' effectiveness in catching **targeted species** (the species the fisher intends to catch) and bycatch.

Write any of the fishing techniques listed on pages 61-62 on the board that weren't previously mentioned and explain their definition. Note that fishing methods differ by village, so it's important to mention all variations.

Fishing Methods



▪ Bow and arrows – A fisher targets and catches one fish at a time.
▪ Traditional fishing basket – A fisher uses a locally-made basket to fish for needle fish, butterfly fish, reef fish, and rabbit fish found along the sea grass beds. The basket size ranges in length between 1 and 2.5 metres. The basket is left in the ocean for as much as one half to two days depending on the targeted fish.
▪ Derris root and cyanide – Derris root and cyanide are dropped into the water to either stun or kill a fish. Fishers collect the fish that float to the top of the water. Unwanted animals called bycatch will also be stunned or killed. Derris root is mainly used in streams and on reef flats during low tides. Recent information suggests that derris root has the same effect as cyanide. Chemicals in the root stun and kill fish and coral polyps. Derris root are commonly used in Western Province, Solomon Islands and some coastal communities in PNG.
▪ Dynamite fishing – Dynamite fishing is illegal in PNG. However, reports of high frequency, illegal use of dynamite have been recorded in Musau and Emirau in New Ireland, Manus and Port Moresby area, and in the national capital district and Central Province. Dynamite for fishing is often sourced from World War II bomb dumpsites and from mining and road construction sites. Dynamite fishing causes coral breakages, and destabilizes the reef structure. A broken reef is at risk for even more damage by waves and strong winds. Many corals die when the reef is broken, and broken reefs provide less habitat for other marine species. Dynamite fishing also kills or injures many fish and marine animals in the area, not just the ones the fishermen want to catch.
▪ Spear fishing – A fisher dives into the water with a spear and targets one animal at a time.
▪ Fishing with light (palm leaves at night) – Fishers light palm leaves at night to attract fish and other marine species that are attracted to light such as squid.
▪ Reef fishing – Fishers block the reef at night to fish for reef fish species such as coral cods, grouper, and skip jack. Fishers use nets made from vines.
▪ Hook and line – A nylon string is usually connected to a wooden or plastic pole. A hook is attached to the end of the string and baited. A person usually fishes from a boat or offshore and catches one fish at a time.

- Gill nets and drift gill nets – Gill nets are used to fish in open ocean. They allow a fish to fit its head and gill covers, but not its fins or other parts of its body, through the net holes. The fish's gill covers get caught in the net and prevent the fish from wriggling loose. Any fish larger at the gills than the holes in the net will get stuck. When the net is pulled onto the boat deck, the fish quickly die. It is estimated that thousands, possible millions, of sea creatures such as dolphins, whales, seals, seabirds and turtles accidentally get caught each year and die in gill nets by fishers that are targeting other fish. Corals can be damaged when nets become entangled on them and further damaged by the efforts of fishers trying to free their nets. When fishers work to disturb and frighten the fish towards their gill nets by driving poles or paddles, they may cause indirect damage to corals. Some gill nets are fixed in one place and collect fish until they're hauled in. Other nets, called drift nets, are allowed to float through the open water. Sometimes drift nets get lost; they can float for years gathering fish and other sea creatures in them that eventually die. According to reports, the nets are mainly used by fishing fleets from Japan, Taiwan, and South Korea to catch squid, salmon, and tuna.
- Longlines – Longlines are long, thin cables or monofilament strands that stretch as far as 100 kilometers in length across the ocean. There is a float attached to the cable every few hundred feet and a baited hook every few feet. Longlines are often used to capture tuna and billfish such as swordfish, but they also unintentionally catch many sharks, seabirds such as albatross and petrels, sea turtles, other fish, and seals. Longlines do not have any technique in place to avoid or reduce bycatch. According to some animal rights organizations, an estimated 400 albatross seabirds die every week by drowning on longlines.
- Trawling – Trawling is a fishing method whereby a large trawl net is dropped into the open ocean. The trawl nets are dragged just above or along the ocean bottom by a boat. Because many shrimp species slightly burrow into the ocean floor, boats tend to drag the nets through the top layer of sediment or beds of seagrass, often destroying habitats on the ocean floor. The trawl nets are then hauled to the surface and emptied onto the deck of the boat where fishers sort through the catch. Many medium-sized animals too large to fit through the net's holes, are caught resulting in a high percentage of bycatch. Bycatch is thrown back into the ocean, but most marine species don't survive. Sea turtles are one species of bycatch that often drowns in trawling nets. In Papua New Guinea, prawn fisheries work off the Gulf of Papua, Torres Strait Protected Zone, and Orangerie Bay. Small-scale operators also work along coastal areas.
- Reef gleaning – Fishers use various fishing tools such as knives and metal rods to extract burrowing and attached organisms such as the giant clam (*Tridacna crocea)*, from the reefs. This method can damage reefs and sea grass habitats when the fishers trample on the corals and sea grass.

2. Complete the chart.

Divide students into groups of 4-6. Give groups 5-10 minutes to discuss fishing methods and fill out a chart to answer questions regarding each method. Tell them to leave space on their paper for two more columns that they will fill out at the end of the activity. A chart is listed below.

Common Harvesting Methods	Is it a traditional method? (Yes or No)	Is it a modern method? (Yes or No)		
1.				
2.				
3.				
4.				

3. Discuss the chart results.

Ask one student from each group to present the group's chart. Tell students that after the discussion is complete, students will simulate a few fishing methods to learn more about their effectiveness and impact on marine resources.

Part 2

1. Explain the simulation rules.

Tell students that they are going to simulate (imitate) fishing with hook and line; gill nets and drift gill nets; longlines; trawling; and trapping fishing methods. Explain that simulations will be different with each method and some students will act as fishers and others as sea creatures such as mammals, fish, and crustaceans. One student will record how many of each sea creature is caught during each simulation on a chart.

Just as fishing methods differ, so will the manner in which the fishers fish. Students will conduct at least five simulations, one simulation for each fishing method. Remind students to observe the advantages and disadvantages of each method. They will be asked to discuss these at the conclusion of the simulations.

2. Conduct the simulations.

Play each simulation listed at the end of this activity. Be sure to record all results.

3. Review the results.

After completing the simulations, ask students if they have any questions about them. Read aloud how many fish and sharks were caught with each fishing method. Ask students the following questions:

- Which fishing method caught the most marine animals?
- Which fishing method caught the fewest marine animals?
- Which fishing method caught the most of its targeted species?
- Did fishers always catch the fish they wanted?
- Did fishers only catch the fish they wanted?
- Which fishing method caught the most bycatch?
- Which fishing method caught the least bycatch?

Based on the answers to these questions, explain the advantages and disadvantages of each fishing method considering the amount of bycatch, amount of marine animals caught, and the concept of over-harvesting.

Assessment

1. Discuss the threats of each fishing method and reasons why there could be a threat. If students have trouble discussing the threats, begin a discussion by using the questions below.

- Who or what is affected by the fishing method?
- What is bycatch? (species accidentally caught by fishers)
- Does the fishing method always catch the fish it intends to catch?
- How does the fishing method impact the habitat (reef, etc.)?

Ask students to return to their original groups to complete two new columns about each fishing method *(Is it a threat to marine resources and if it is a threat, what are the reasons why)*. After students have finished completing the charts, ask them to share their ideas with the class.

2. Ask students to think about some ways to reduce bycatch. For example, a new longline method has just been invented to reduce turtle bycatch. The J-shaped hook is changed to a circle hook which is rounder and has a smaller opening and the bait has changed from squid (a favourite turtle food) to mackerel. Ask students if they can think of some new fishing methods or modifications to existing ones. Be sure to have students think about the advantages and disadvantages of each new method introduced.

3. Ask students to invent simulations for other fishing methods such as using local nets, using derris roots, and blocking reefs during low tide. Be sure to have them develop a chart to record results that they will discuss at the conclusion of the simulations.

Common Harvesting Methods	**Is it a traditional method? (Yes or No)**	**Is it a modern method? (Yes or No)**	**Is it a threat to marine resource(s)? (Yes or No)**	**If it is a threat, what are the reasons why?**
1.				
2.				
3.				
4.				

Simulation 1: Hook and Line

1. Assign roles.

Ask for three volunteers to be the fishers. Have the fisher stand aside while you divide the remaining members of the class as follows:

- Recorder: One student records how many of each fish is caught for each round
- Adult Tuna: 2 to 3 pairs of students. A pair of students with arms linked makes one adult tuna
- Juvenile Tuna: 3 to 4 students. One student is equal to a juvenile tuna
- Adult Sharks: 3 pairs of students. A pair of students with arms linked makes one adult shark
- Juvenile Sharks: 3 to 4 students. One student is equal to a juvenile shark
- The remaining students will be other fish.

Tie a strip of cloth around the arm of every tuna to identify it. Ask students to remember what fish they've been assigned.

2. Record the results.

As students play the simulation, the recorder will write down how many fish are caught using this chart. The recorder may choose to record data onto the chart on the chalkboard or copy it onto a piece of paper before the simulation starts.

	Adult Tuna	**Juvenile Tuna**	**Adult Shark**	**Juvenile Shark**	**Other Fish**
Round One					
Round Two					

3. Conduct the simulation.

Ask all fish students to spread out in the classroom that serves as the sea. Once they have found a spot, they cannot move. Tell fisher students that they have one minute to "fish" for Adult Tuna from the group, but they must stand against the walls of the classroom. The fishers will fish by throwing a soft ball or other soft object at the Adult tuna they want to catch. Anything the fishers hit is considered "caught," and must leave the playing area to tell the recorder they were hit. Any non-adult tuna should then return to the ocean. Any Adult Tuna that are caught should stand next to the fisher who caught them. The fisher who has caught the most Adult Tuna when the minute is over wins the simulation.

If time allows, play another round and record the data.

4. Discuss advantages and disadvantages.

Once students have completed the simulation and the recorder has filled out the chart, determine the advantages and disadvantages of the fishing method by completing the questions on page 66.

Question	Answer
Did fishers always catch the Adult Tuna as they intended?	
Did fishers only catch Adult Tuna?	
How many marine animals other than Adult Tuna were caught?	

Simulation 2: Gill Nets and Drift Gill Nets

1. Assign roles.

Ask for one volunteer to be the fisher. Have the fisher stand aside while you divide the remaining members of the class as follows:

- Recorder: 1 student records how many of each fish is caught for each round
- Adult Tuna: ¼ of the students (one student is equal to an Adult Tuna)
- Juvenile Tuna: ¼ of the students (one student is equal to a Juvenile Tuna)
- Sea Turtle: 1 student
- Dolphin: 1 student
- Small Fish: 2 to 4 students
- Adult Sharks: ½ of remaining students
- Seabirds: other ½ of remaining students

Ask students to remember what fish they've been assigned.

2. Record the results.

As the students play the simulation, the recorder will write down how many fish are caught using this chart. The recorder may choose to record data onto the chart on the chalkboard or copy it onto a piece of paper before the simulation starts.

	Adult Tuna	Juvenile Tuna	Sea Turtle	Dolphin	Small Fish	Adult Shark	Seabirds
Round One							
Round Two							

3. Conduct the simulation.

One student is designated the fisher. He or she will place two ropes down on the floor to create three equal-sized "lanes." The fisher must secretly decide which lane will be the gill net before the other students begin "swimming." The fisher is trying to catch Adult Tuna.

Ask each fish student to choose a lane and to "swim" into it. Tell them that the fisher has placed a gill net across one of the lanes, but since fish cannot see gill nets, neither can the students. Tell them that once they have selected their lane they cannot change it.

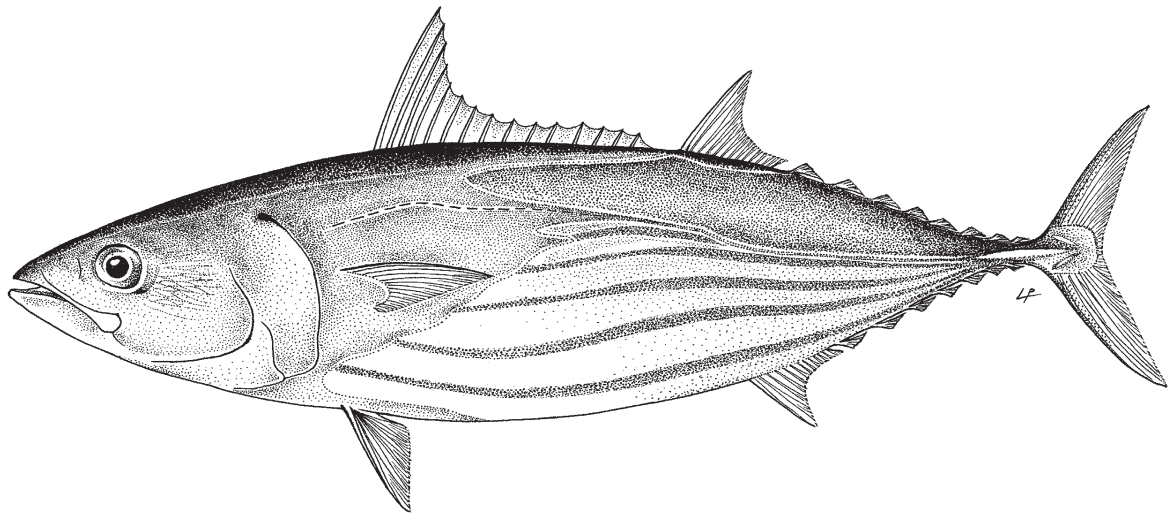
Once all fish are in lanes, ask the fisher to announce which lane had the gill net, and have him or her count up the catch. All the small fish are able to swim through the gill net so will not be considered caught. The remaining creatures should be considered caught and recorded on the chart.

If time allows, play another round and record the data. Remember that three students were designated as fishers.

4. Discuss advantages and disadvantages.

Once students have completed the simulation and the recorder has filled out the chart, determine the advantages and disadvantages of the fishing method by completing the questions on the following chart.

Question	Answer
Did fishers <u>always</u> catch the Adult Tuna as they intended?	
Did fishers <u>only</u> catch Adult Tuna?	
How many marine animals other than Adult Tuna were caught?	



Simulation 3: Longlines

1. Assign roles.

Choose two students to be longline fishers. Give them one rope, the clothespins, and 10 pieces of paper. Ask them to leave the room and clip the paper on the rope anyway they want to without the other students seeing them.

Divide the remaining members of the class as follows:

- Recorder: 1 student records how many of each fish is caught for each round
- Adult Tuna: ¼ of the students (one student is equal to an Adult Tuna)
- Juvenile Tuna: ¼ of the students (one student is equal to a Juvenile Tuna)
- Sea Turtles: 2 students
- Dolphin: 1 student
- Adult Sharks: ½ of remaining students
- Seabirds: other ½ of remaining students

Ask students to remember what fish they've been assigned.

2. Record the results.

As the students play the simulation, the recorder will write down how many fish are caught using this chart. The recorder may choose to record data onto the chart on the chalkboard or copy it onto a piece of paper before the simulation starts.

	Adult Tuna	**Juvenile Tuna**	**Sea Turtles**	**Dolphin**	**Adult Sharks**	**Seabirds**
Round One						
Round Two						

3. Conduct the simulation.

While the fishers are still in the hall, ask the fish to stand around the room anywhere they want except directly behind another fish. Bring the two fishers in and have them stand at the front or back of the room with their rope stretched out across the classroom. Explain that the papers on their longline represent baited hooks and that the fisher is trying to fish for Adult Tuna. They should hold the rope so that the papers pass over the heads of some fish and brush against others. Then have them walk slowly down the length of the classroom, being sure not to shift their longline just to hit a particular fish. The fish may not duck or shift their bodies to avoid a hook. Every time a fish is touched by a piece of paper, that student should remove the paper and tell the recorder what type of fish he or she is.

If time allows, play another round and record the data.

4. Discuss advantages and disadvantages.

Once students have completed the simulation and the recorder has filled out the chart, determine the advantages and disadvantages of the fishing method by completing the questions on the following chart.

Question	Answer
Did fishers always catch the Adult Tuna as they intended?	
Did fishers only catch Adult Tuna?	
How many marine animals other than Adult Tuna were caught?	

Simulation 4: Trawling

1. Assign roles.

Divide the students into four teams. Each team will represent one shrimp fisher. Give each team two nets and a container filled with dry corn and a variety of dry mixed beans of different sizes. The smallest beans represent shrimp and remaining beans and corn are other marine animals including mammals, fish, and other crustaceans.

2. Record the results.

As the students play the simulation, the current fisher will write down how many fish are caught and how many shrimp were caught using this chart.

	Shrimp	Marine Animals
Round One		
Round Two		

3. Conduct the simulation.

Students from each team should take turns dragging the net through the beans. After each turn, have the person count the number of shrimp caught as well as the number of marine animals caught and record it on the chart.

If time allows, play another round and record the data.

4. Discuss advantages and disadvantages.

Once students have completed the simulation and the recorder has filled out the chart, determine the advantages and disadvantages of the fishing method by completing the questions on the following chart.

Question	Answer
Did fishers always catch shrimp as they intended?	
Did fishers only catch shrimp?	
How many marine animals other than shrimp were caught?	

Simulation 5: Trapping

1. Assign roles.

Select two students to be the trap. Ask these two students to leave the room and divide the remaining students following the list below. Tell these students to keep their role a secret from the trap students.

- Recorder: 1 student records how many fish were caught and freed for each round
- Big fish: Assign 6 students to be big fish that usually can not enter the trap, so can't be caught
- Small fish: Assign 4 students to be small fish that can usually swim out of the trap, so can't be caught
- Trap-sized fish: Assign 5 students to be fish that usually get caught in the trap.

2. Record the results.

As the students play the simulation, the current fisher will write down how many fish are caught and how many were freed using this chart.

	Caught	Freed
Round One		
Round Two		

3. Conduct the simulation.

Students assigned as the trap should face each other at arm's length apart. They should hold hands while facing each other and raise their arms up above their heads. All of the students assigned as marine animals, walk under the trap one at a time. The trap gets five chances to catch a trap-sized fish.

The trap students lower their arms when they've decided to catch a marine animal. The marine animal then tells the trap what type of marine animal they are. If the marine animal is trap-sized, then he or she is caught. If the student is a big fish, he or she is too big to be captured in the trap and must be released. If the student is a small fish, he or she is too small to be captured in the trap and must be released. If time allows, play another round and record the results.

4. Discuss advantages and disadvantages.

Once students have completed the simulation and the recorder has filled out the chart, determine the advantages and disadvantages of the fishing method by completing the questions on the following chart.

Question	Answer
Did fishers always catch the trap-sized fish as they intended?	
Did fishers only catch trap-sized fish?	
How many marine animals other than trap-sized fish were caught?	

Simulation 6: Cyanide

1. Assign roles.

Select two students to be the cyanide. Ask these two students to leave the room and divide the remaining students according to the list below. Tell these students to keep their role a secret from the cyanide students.

- Recorder: 1 student records how many fish were killed by cyanide for each round
- Target species: Assign half of the students to be the targeted species, the species that the fishers want to catch
- Bycatch: Assign the remaining the students to be bycatch, the **species** that the fishers don't want to catch

2. Record the results.

As the students play the simulation, the recorder will write down how many targeted species are killed and how many bycatch are killed using this chart.

	Targeted Species	Bycatch
Round One		
Round Two		

3. Conduct the simulation.

Find an open space outside where students can spread out. Mark boundaries to the area. Ask students assigned as targeted species and bycatch to spread out in the open space. Explain that the cyanide students will try to tag as many students as possible in two minutes. Students should run away from the cyanide to avoid being tagged. Any student that is tagged by a cyanide student must leave the game and tell the recorder whether they were a targeted species or bycatch.

If time allows, play another round and record the results.

4. Discuss advantages and disadvantages.

Once students have completed the simulation and the recorder has filled out the chart, determine the advantages and disadvantages of the fishing method by completing the questions on the following chart.

Question	Answer
Did fishers <u>always</u> catch the targeted species as they intended?	
Did fishers <u>only</u> catch the targeted species?	
How many students assigned bycatch were killed?	
How many students assigned targeted species were killed?	

Adapted (with permission) from "Catch of the Day" and "Sharks in Decline", activities in Oceans of Life: An Educator's Guide to Exploring Marine Biodiversity ©2003, published by World Wildlife Fund as part of *Windows on the Wild,* an international biodiversity education program. Visit www.worldwildlife.org for more information.

Adding it All Up

Learner Outcomes

- Describe and rank the economic, social, and ecological costs of shark-fin soup.

Time

40 minutes

Materials

Chalk, chalkboard, Costs Associated with Shark-fin Soup sheet, soup bowl, coloured paper

Background

How much does a bowl of shark-fin soup cost? Most people automatically think of the economic cost, but some costs may also be social or ecological. In Asia where there is demand for shark-fin soup, customers pay up to K275 (US $90) per bowl at a restaurant. The process of making shark-fin soup impacts both people and the environment. Consider who harvested the shark and how and think about where it came from.

Ecologically, sharks are slow growing, and are under threat of being overharvested. Sharks are an essential part of the marine ecosystem as predators on the **food web**.

Socially, fishers and local communities that become dependent on income from the sale of shark fin will also be negatively affected once shark **populations** are depleted. If large fishing companies are fishing off of coastal villages, then coastal communities lose a potential resource.

Currently, there is a moratorium on commercial shark fishing in PNG, however, in 2001, PNG Customs apprehended K376,000 in illegally transported shark fins. The demand for shark fins continues to drive the supply with its many costs. This activity allows students to explore these different costs.

Teacher Preparation

Obtain a soup bowl to place in the classroom to symbolize shark-fin soup.

Prepare cards out of coloured paper that will serve as the "ingredients" of the shark-fin soup and put them next to the bowl. The "ingredients" are the three categories of costs.

- Social Costs
- Economic Costs
- Ecological Costs

Lesson Steps

1. Discuss the uses of shark.

Explain to students that sharks are an important **species** for many reasons. They have an important role in the food web as predators. Sharks feed on sick, injured or older animals, leaving the healthier individuals to reproduce. They also take care of any population booms in prey species, keeping them from outcompeting other species.

Sharks are also used for food and products. Shark products include shark livers as a source of lubricants, vitamins, and cosmetics. Sharkskin is made into leather products. And some areas of the world, powdered shark cartilage is considered to be a powerful cure-all for everything from sore eyes to cancer. While there is no reliable evidence which shows it is an effective medicine, powered shark cartilage can sell for as much as $100 per bottle.

Tell students that another popular use of sharks is for food. Explain that shark-fins contain proteinaceous fibres of elastin and collagen, called fin needles, which are highly prized in Asian markets, primarily for their use in the production of shark-fin soup. In Hong Kong, for example, people will pay a lot of money for a bowl of shark-fin soup, making shark an expanding income-earning opportunity for people

through the preparation of dried fins. This demand for shark-fin soup is having devastating results for shark populations around the world.

2. Explain the costs of shark-fin soup.

Ask students how much a bowl of shark-fin soup costs. If students can't guess, tell them it costs up to US $90 in Asia where there is demand for the soup. Ask them if there are any other costs associated with shark-fin soup. Write their answers on the chalkboard. If they don't mention more than economical costs (i.e. preparation and sale of soup), ask them to name some possible social and ecological costs. As students suggest costs, add the pieces of colored paper to the soup bowl to represent the type of cost. Some questions are listed below to help students get started:

- What happens to the shark when fishers cut off its fin? (Fishers slice off the shark's fins and throw the shark back into the water alive. The injured sharks drown or die of starvation, infection, or predation.)
- What role do sharks play in the food web? (Sharks play an important role in the food web as predators by controlling fish populations and targeting weak fish.)
- How much money does a fisher make from selling shark fin for market in Asia?
- How many sharks does a fisher harvest in a month? How many fishers harvest shark?
- Are sharks being overfished? (As demand increases, fishers are under more pressure to supply shark fin, resulting in overfishing.)
- What will happen to families who depend on selling sharks when shark populations are depleted? (Families will lose a source of income.)

A list of costs associated with shark-fin soup is included on page 77 in case students need more help.

3. Discuss the activity.

Tell students that they will work in groups to create a list of all the costs associated with shark-fin soup listed by "ingredient" categories: Social Costs, Economic Costs and Ecological Costs. Explain that they will present their lists to the class and one master list will be created from all the ideas from each group. Each student will vote on the costs from the master list. They will be voting on how much value they place on each cost. After the voting has ended, students will analyze the results to determine which cost was valued the most and the least by students.

Social Costs	Economic Costs	Ecological Costs

4. Create the lists.

Divide students into groups of 4-5 students. Give students 10 minutes to list all the costs associated with shark-fin soup in columns of social, economical, and ecological costs as listed below.

5. Present the lists.

Ask one representative from each group to present their group's ideas to the class. Write down each cost on the chalkboard. It is not necessary to divide the costs by categories. Allow each group to present their ideas, but only write down a cost once so no ideas are duplicated on the board. Once all ideas are written on the board, number them starting with 1 and continuing until the last idea has an assigned number. An example is listed below.

1.	Large companies pay fishers to fish for shark fins.
2.	Shark-fin soup costs up to $90 a bowl in a restaurant in Asia.

6. **Vote on the costs.**

Ask students to get out a piece of paper and number it 1 through the last number assigned to the ideas on the board. Explain that each person will vote on the ideas using a scale between 0 and 3. Students will vote according to the chart below:

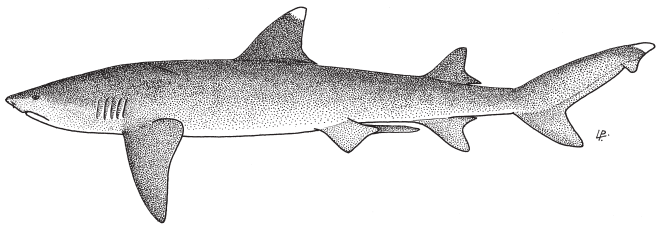
Vote 0	if student thinks the cost is not important at all
Vote 1	if the student thinks the cost is somewhat important
Vote 2	if the student thinks the cost is important
Vote 3	if the student thinks the cost is very important

Read each cost aloud and ask students to vote on a piece of paper in columns such as the ones below:

Cost by Number	**Vote in Points**
1	3 points
2	0 points
3	1 point

7. Analyse the data.

If the group of students is small, it's possible to have them read their votes aloud and record them on the chalkboard next to the cost. If the class is large, divide students into their groups again and ask them to add up the votes for each cost. For example, if 4 students are in a group, then they will add up how many points each student of the group gave for the first cost and continue until all costs are added up. Once students have finished, collect the group scores and add them up per cost. Write the costs on the chalkboard.



Group 1

	Total Points of Group
1	13 points
2	10 points
3	11 points

Group 2

	Total Points of Group
1	12 points
2	11 points
3	12 points

To find out which cost received the most points, compare the points. The cost with the most points is valued as the most important cost by students. The cost with the least amount of points is valued by the students as least important. In the above example, cost 1 received 25 points, cost 2 received 21 points and cost 3 received 23 points. That means cost 1 was the most important, then cost 3 and lastly cost 2. An example of the totals is listed below:

*TOTAL

	Total Points
1	13+12 = 25 points
2	10+11 = 21 points
3	11+12 = 23 points

8. Discuss the results.

Ask students if they were surprised at which cost got the most amount of points and which got the least amount of points. Why do they think other students voted the way they did.

Assessment

During the activity, students had a chance to find out what other students thought was the most important cost of a bowl of shark-fin soup. A follow-up activity can be finding out what other people in the community think about the costs related to shark-fin soup and what value they assign to each. Students can write the list of costs on a piece of paper and ask communities members to vote on each one using the same scale. Once all votes are taken, students can repeat the same analysis by adding up the votes to find out which cost community members thought was the most important and least important. It's also a great way to educate communities about all of the costs associated with shark finning.

Students can expand on the same idea to study the costs of marine resource harvesting, mangrove destruction, and the oil palm industry.

Another important side to shark finning and other harvests are the benefits. Benefits can be economical or social. Ask students to repeat the activity to focus on all of the benefits associated with shark finning. After completing this activity, students can compare the costs and benefits to decide if shark finning has more costs or benefits.

Sample Costs Associated with Shark-Fin Soup

Economic Costs	Social Costs	Ecological costs
Shark-fin soup costs up to $90 a bowl in a restaurant in Asia.	Fishers become dependent on selling shark fins because of high demand which can be risky in case demand or supply changes.	Fishers slice off the shark's fins and throw the shark back into the water alive. The injured sharks drown or die of starvation, infection, or predation.
Large companies pay fishers to fish for shark fins.	When shark populations decrease, fishers dependent on fishing them lose work and income for their family.	Most shark species grow slowly and mature late and that makes it difficult for decreasing shark populations to revive .
Commercial shark fishing companies fish near coastal communities that lose this potential economic resource.	Fishers spend time fishing for shark fin instead of other jobs.	Bycatch: Some other species are caught by accident while fishers fish for shark. Bycatch species usually die.
Restaurants spend time and ingredients preparing the soup.	Fishing for shark fins is not part of cultural traditions.	Potential extinction of some species of sharks due to overharvesting.
Shark-fin market spends money transport fins.	Some fishers travel on boats for long periods of time, away from their families.	Threat to biodiversity: Sharks play an important role in the food web as predators by controlling fish populations and targeting weak fish (that would otherwise breed more weak fish that are more vulnerable than strong fish).
Other?	Other?	Other?

Thinking About Tomorrow

Learner Outcomes

- Explore the issue of sustainable use of fisheries resources.
- Describe several consequences of unsustainable use of natural resources for both people and other species.
- Recognise the need for management processes to maintain fisheries resources for the future.

Time

40 minutes

Materials

Chalkboard, dry beans, trays or flat containers for beans, a stopwatch or clock

Background

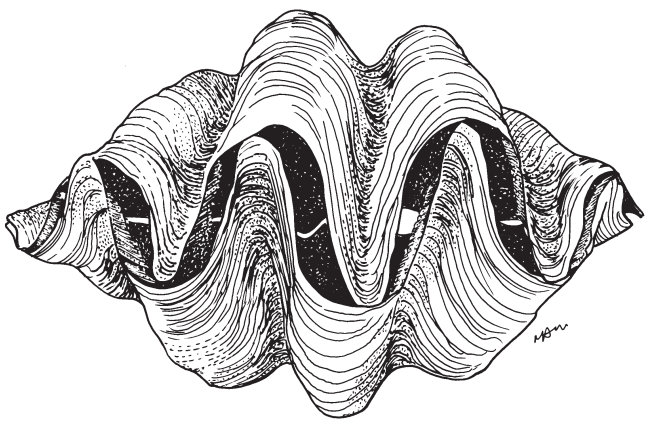
Natural resources are the raw materials that we use every day. That includes the fish we eat and sell, as well as the materials we use to build our houses and make our clothes, tools, and many other things. The air we breathe, the water we drink, and the land we use to grow our food are also natural resources. Natural resources are all the things that humans as well as other **species** depend on for their survival.

Since natural resources encompass so many different things, scientists have created two categories for talking about them. **Renewable resources** are those that can be replenished, either naturally or through human processes. Trees, for example, are a renewable resource since they can either be replanted by humans or naturally reseeded. Fish and other marine species are renewable resources because they can reproduce and replenish themselves. Sunlight is also a renewable resource because we always have a steady supply of it, no matter how much we use. For a resource to be considered truly renewable, it must either be constantly generating itself (such as sunlight), it has to replenish itself in a couple of generations or less, or we have to be able to replenish it in the same amount of time.

Non-renewable resources, on the other hand, exist only in definitive quantities. This means that once they are used up, they may take millions of years to be replenished, or they may be gone forever. This includes the fossil fuels that our factories, power plants, and vehicles run on and the minerals we use to make metals and other materials. It also includes the topsoil that we need to grow our crops.

Many scientists would agree that we are using our natural resources faster than they can be replenished. Since we rely on natural resources for our survival, we can neither afford to use them all up nor to stop using them completely. Between the two extremes, however, is **sustainable** use. Sustainably using natural resources means using the resources in a way that allows people and other species to get what they need today while ensuring that future generations will also get what they need.

However, figuring out how to sustainably use a natural resource is not easy. For example, different kinds of **marine resources** have many different uses that require different management techniques. Since the speed with which we consume natural resources is always changing, it is sometimes difficult to tell whether a resource is being used sustainably at any particular moment. Especially for marine resources, it is sometimes hard to know exactly how many fish of a particular kind or a particular age are in an area. Scientists and resource managers monitor the reefs and marine species so that they can decide on the best management strategies for those species or for those areas.



Teacher Preparation

Make sure you have plenty of room in the classroom. Pour half a bag of beans onto a tray and place the tray on a table in an open area of the room.

Read step 1 in the "What to do" section and do a trial run on your own to figure out how many beans you'll need for each group. This is how you will find out how many beans you will need for the rounds. Pick up beans from the tray using two of your fingers (the tips of your index finger and thumb) for ten seconds. Make sure you time yourself accurately. Repeat this for the number of people you'll have in each family (usually four or five students). Count the total number of beans you've collected from the tray. If you have four families, you'll need four times as many beans as you have collected to cover the entire class. Playing the game with too many beans won't illustrate the concepts as clearly.

For a family of four, you should start with approximately one cup of beans.

On the chalkboard, copy this chart:

Make separate "condition cards". The individual cards should read as follows:

- Breeding individuals over-harvested (remove ½ cup of beans)
- Average catch (add ½ cup of beans)
- Dynamite-fishing destroys reef (remove ½ cup of beans)
- Nursery mangrove cut down (remove 1 cup of beans)
- Cyanide used to capture fish (remove ½ cup of beans)
- Marine protected area ensures safe spawning (add 1 cup of beans)
- Fishermen stay within catch limits (add ½ cup of beans)
- Coral bleaching occurs, damaging the reef habitat (remove ½ cup of beans)
- Blank card

Round 1, 2, or 3	**Family Name**			**Family Name**			**Family Name**			**Family Name**		
Great-great grandparent												
Great-grandparent												
Grandparent												
Parent												
Children												
Total beans remaining												

Lesson Steps

1. Create student groups.

Divide the students into four equal-sized groups (there can be four or five students in each group, but the groups need to be equal in size). Tell the students that each group represents a family. Have each group select a family name and then have each group member select a generation of the family to represent (a great-great-grandparent, a great-grandparent, a grandparent, a parent, and a child). Make sure that each student remembers his/her family name and the generation that he/she represents. Place the tray at the centre of the room on a table and ask each family to form a line at a different side of the tray of beans.

2. Explain the first round.

Ask students if they can think of some renewable natural resources that people use (fish, non-fish resources, food crops, trees, and so on). Tell the students that the tray of beans represents a renewable fisheries resource (sea cucumbers, trochus snail, giant clam, milkfish, etc.) that their "families" rely on. Each family member will have the opportunity to fish for the resource (beans) using only the tips of two fingers (index and thumb). To survive, a family member must harvest at least 10 beans.

As they collect the beans for ten seconds they should place them into a container that must not be lifted from the table. Beans that fall on the floor do not count. They represent wasted resources. When the ten seconds are up, ask students to count the number of beans they have collected and to record their results on the chalkboard.

3. Play round 1.

Have the first family member (great-great-grandparent) from each family put one arm behind his/her back and use the other to collect the beans. Remind students of the rules of the game: ten seconds to collect beans, use only tips of index finger and thumb, and at the end of the ten seconds count the beans and record results on the chalkboard. Next, allow the second family member to repeat the same steps. When they are done ask the third group to go while the second calculates and records their results. This process should be repeated until all family members have had a chance to "extract resources." The amount of beans remaining represents the amount of natural resources left for future generations.

4. Begin round 2.

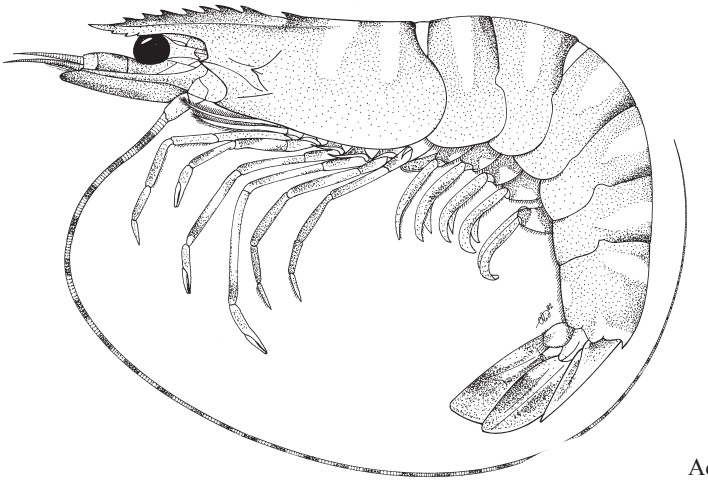
Using the same rules, play the next round, but this time introduce a different condition card at the end of each round (for each generation). Explain that most renewable resources have limits to their rate of replenishment. Physical, environmental, and human conditions can change how much a resource is renewed every generation. This round will illustrate sustainability under different conditions.

Place the beans back in the tray. Follow the same procedure for collecting the beans as in rounds 1 and 2. In this round, however, after each generation, adjust the bean amounts according to the five conditions on the cards you prepared earlier. All the conditions represent situations that can affect fisheries resources. Your students can also create their own situation on the blank card. Shuffle the condition cards. When the ten seconds are up, ask someone to draw a card and add or subtract beans accordingly from their trays. (At each turn in round 3, all families should be following the same condition card that was read out loud). After each generation's turn, the cards should be replaced in the deck and the deck should be reshuffled. Students should count their beans and record their results. Other family members can begin collecting beans while the previous generation counts and records their results.

5. Discuss the results of the rounds.

Using the following questions, have the students discuss their observations about the game.

- What will happen if we use our natural resources faster than they can be replaced? (They will eventually run out.)
- What happens when generations do not use a cooperative strategy for natural resource use? (Future generations might not have enough resources.)
- Why might a particular generation consume more natural resources than they need? (People many not realise they are depleting natural resources, or they may think they really need to use them to survive. Or, in other cases, people are indifferent or just greedy.)
- Are there any reasons a particular generation would want to conserve its natural resources? (People may feel it is important to save enough resources for their children or grandchildren to use. They may also feel it's necessary to conserve natural resources for the benefit of their community and culture, the future health of the environment, or for the sake of other species.) Explain to students that using natural resources in a way that protects them for future generations and other species is called sustainable use.



- Who did not survive? How did it feel? Who got too much of a resource? Did it affect whether the next generation of the family got enough of the resource?
- Did the condition cards affect the number of beans you collected? (Some students may have decided not to take so many beans if a card was drawn that limited the resource available (cyanide, dynamite, etc). Some may have decided to collect more beans after a surplus card was drawn.)
- Did knowing how much of a natural resource you need to survive help your students decide how much to collect from the tray? (Students who want to make sure that all of their family members get enough beans might take only as much as they need to survive.)

Assessment

Have students investigate resource use and management issues for common fisheries species. Their research report should discuss:

- A marine resource that has been reduced in size because of over-harvesting
- Community management strategies to conserve the resource
- Laws to protect the resource
- Ways to balance the use of marine resources with conservation

Adapted (with permission) from "Thinking about Tomorrow", an activity in Biodiversity Basics ©1999, published by World Wildlife Fund as part of *Windows on the Wild,* an international biodiversity education program. Visit www.worldwildlife.org for more information.

Coming to Consensus

Learner Outcomes

- Discuss roles of the provincial and local level governments as major mediators between the state and resource owners and among resource owners.
- Discuss responsibilities associated with industry participants as major users and employment generators.
- Discuss roles, rights and responsibilities of resource owners in development of local laws and enforcement through local governments.

Time

80 minutes

Materials

Paper for making role cards, chalk, and chalkboard

Background

Conflicts over the use of **natural resources** don't always have an easy solution. There are often many different perspectives to consider such as analysing the situation, thinking critically and making informed decisions.

Through a role-play exercise, students will examine the roles and responsibilities of provincial and local level governments. This leads to a discussion of the roles of these authorities as mediators between the state and resource owners and among resource owners and users, as well as of the rights and responsibilities of all **stakeholders** in marine resource conflicts.

Educators should take a neutral role and help students see environmental problems from different points of view. Nobody has all the information and nobody has the right answer. But, together, we can often find creative solutions to problems. Through this process, your students gain analytical and conflict resolution skills.

Teacher Preparation

Copy the role cards onto separate sheets of paper to pass out to students.

Lesson Steps

1. Talk about resource conflicts.

Open up a discussion about the most common conflicts people have over **marine resources** in PNG. Use the following questions to guide the discussion:

- What kinds of conflicts do people have over marine resources?
- Why do conflicts arise?
- How are they resolved?
- Who has responsibility for mitigating (resolving) conflicts in communities?
- How do resource conflicts affect the community? How do they affect marine resources?
- Why is it important to resolve conflicts over marine resources?

2. Describe the situation.

Explain to students that they are going to imagine that several members of their community are in the midst of a conflict over ownership and use of a particular section of reef. A representative of a fisheries company is seeking to establish the rightful (principal) owner of the reef, because he wants to gather fish and needs permission from the owner. Two men claim to own the reef and therefore to have the right to decide how resources from that reef are used and by whom. They have been arguing publicly and each has been trying to make deals with the fishing company representative to sell the rights to harvest marine resources from the reef. The representative, unable to move forward with his business, has taken the issue to the local level government councillor for resolution. The councillor of the community has decided to have a meeting for everyone in the community to discuss and decide how the issue should be resolved.

He has asked the community to not only advise on the ownership of the reef, but also to develop a plan for management of the reef's marine resources.

3. Explain the rules.

Tell students that they will play the roles of different community members and pretend to be in the meeting. Explain that they will read their role cards and act out the person. Pass out role cards to the students who will act out different people in the community who have different experiences, opinions and points of view that they will communicate during the meeting. Those students who do not receive role cards will be community members who will participate at the meeting as well. The Local Level Government (LLG) councillor will facilitate the meeting. Give students a couple of minutes to read over their role cards. Remind students not to talk about their role cards before the meeting starts.

4. Set up the meeting.

Now that the students have read their role cards, begin the meeting. Each student with a role card will have the opportunity to present his or her case to everyone else. The LLG councillor should choose someone to start. The students should explain in their own words what they think and why. After listening to all of the presentations, the other students, who are the community members, should give their opinions and ask questions about what was presented.

Ask students to offer suggestions of actions to take to resolve the conflict, and list those on the board. Students should negotiate as representatives of their roles. The goal is to arrive at a plan that everyone in the community agrees on.

5. Talk about roles and responsibilities.

Create a chart on the chalkboard using the model that is listed below. Have students fill in some of the principal actors involved in resource conflicts, from the role-play or from their own experiences. Then ask them to list the primary rights and responsibilities of that member of society. This may be done as a group exercise or as homework.

Actor	Rights	Responsibilities

Assessment

Talk with students about the game. Could they arrive at a common plan? What did they learn? Did the situation seem realistic? Why or why not? Do they think they should do the same thing in the community to manage marine resources? How can they resolve disputes of opinion among community members? Who played a particularly important role in this situation? What are some ways that communities can manage the balance between the right to use marine resources and the responsibility to manage those resources wisely?

Role Cards*

Fisheries businessman

You represent a company that wants to buy the rights to capture live fish on a particular reef. Your company has been fishing on other islands, but there are less and less fish of the species you want to catch available there. So you have come to Sidea Village, where you know there are still many fish to catch. But you need permission from the reef owners in order to fish, and now they are fighting over ownership rights. You want to resolve the conflict and start fishing as soon as possible, because your company is losing business by waiting. There are many people in Taiwan who want to buy the live fish you catch. You can fish many places, so if you don't find fish here, you can go somewhere else. However, every time you go to a new village, you have to waste time on discussions like these, so it would be easier to stay here and continue to catch fish for a longer time.

Reef Owner 1

Your great grandfather owned this reef and resources in and around it and your family has always fished there. As the first-born son, you know you are the rightful owner, having inherited ownership from your father. Any business deals or anything to do with resources found under this reef should come through you. You have three sons and two daughters and you need money for them to be able to study. You would also like to buy some cargo for your house to make life easier for your wife. The fishing company man has offered you one thousand kina every month for the right to fish on your reef and that is more than you could earn by just catching and selling fish. Besides, it is nobody else's business what you do with your own property.

Local Level Government Councillor

You hope that this issue may serve as an example for other reef owners and fishermen. You are very interested in the idea of having a marine resource management plan for this community, since you hope that the management plan will provide a model for other communities in your jurisdiction. You know that key people in the community need to be involved in making a decision about how reefs should be managed, or the decision won't stick. You hope that everyone at the meeting can come to consensus on ownership of the reef, and on how the community's reefs should be managed. Although you want to hear all views on this matter, you particularly need the clan chief's political support in the next election. Additionally, you know that the government wants to promote the development of ecotourism as a way to supplement local economies.

Provincial Fisheries Officer

You work for the Milne Bay Provincial Government and are familiar with PNG's fisheries laws and are responsible for enforcing them. While the government wants to encourage the development of the fishing industry as a key component of the provincial economy, they also understand that marine resources must be managed sustainably in order to provide benefits to communities now and in the future. There are limits on the sizes and numbers of fish that either individuals or companies can catch. Some species are protected by law and cannot be caught, such as the dugongs. It is illegal to use derris root or cyanide to capture fish. You want to help communities learn how to monitor their coral reefs, and can provide technical input for the development of management plans. However, you are the only fisheries officer for Milne Bay, and most of the time you don't have any funds to travel to remote communities.

Local Conservation NGO Officer

Your primary concern is the conservation of marine biodiversity. Scientific studies have shown that Milne Bay has some of the richest marine life on the planet, with many species found nowhere else on Earth. The coral reefs and marine life of the province are still mostly in good condition, but you have seen how reefs in the Philippines and Indonesia have been destroyed, and are afraid that eventually the same thing could happen in PNG. You know that the company was caught last year using cyanide to stun and capture live reef fish. They were fined, but you are afraid they will keep using the same destructive fishing practices, especially since there is very little enforcement on these remote islands. You think that the only way Milne Bay's marine biodiversity will be conserved is if local communities take responsibility for protecting their reefs and managing their fisheries resources well. You have the scientific expertise and some funding to help communities develop their own management plans. You can even provide assistance in setting up new conservation enterprises, like ecotourism.

Reef Owner 2

For the last 20 years you have been fishing around this place, and your grandfather is the chief of this clan, and so he has the final say over the use of this reef. As a descendant of a chief of this clan, you think you should be regarded as the owner. You think that rights to fish on the reef should not be sold to the fisheries company because they will not take care of the community's marine resources. They might take out too many fish, or destroy the coral with their anchors and nets. Besides, the company doesn't pay very much, and then they sell all the fish and make money. You think it would be better to bring tourists over to your island – you have heard that in other communities tourists pay to snorkel on the reef and that sounds like a good idea to make money and keep the reef safe and full of fish.

Local Village Person

You think that having a plan to manage how marine resources are used is very important. You want to form a committee in the community to decide where and when people can sell marine resources to large outside companies. You want to collaborate with other fishermen.

Teacher

You know that your community is rich in biodiversity – all the fish and animals and other living things in the reefs and on the land. There are species in your village that have disappeared from other parts of the world and are threatened, such as marine turtles, and dugongs and dolphin. You think it's important to conserve these resources for future generations so that they too know their richness. You know a little bit about what species are threatened and how they live and reproduce, but you would like to learn more. You are available to teach and help community members to learn to manage marine resources sustainably.

Child

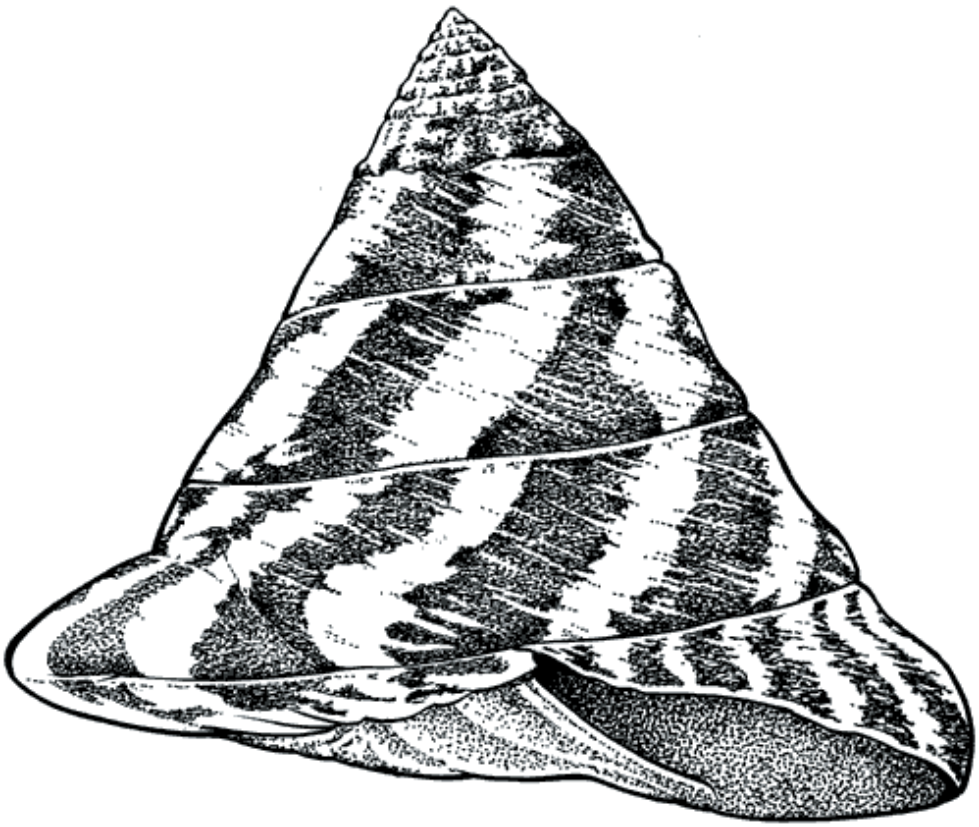
You learned at school about the importance of conserving marine resources. You have seen pictures of damaged coral reefs from other countries, and you don't want that to happen here. You like to swim and look at all the fish and other sea creatures under water. You plan on being a fisherman like your father and you want to know that there will always be fish in the sea for you to catch.

Clan Chief/Grandfather

You remember what it was like when you were young. There were more fish in the sea then. People followed the taboos and other cultural traditions that helped to protect the reefs and marine resources. Now people seem to be more concerned with getting cargo than taking care of the community's resources. You're worried that if the community sells all its fish to the big companies, the marine environment will be damaged, there will be less fish for the community and you'll lose part of your culture. You don't know what all this talk of management plans is about, but you think that it's necessary to learn more before selling off the community's resources.

Fish

You live in the coral reef. It is where you find food, and a place to live and breed. You used to live on another reef, but the fishing companies took the older bigger fish that could reproduce, and then they took the young fish too. You are young and cannot breed yet but you hope to live long enough to be able to make baby fish so you have moved to this reef. You are worried too because you have heard stories about fishermen who use poisons like derris root and cyanide to capture fish, killing everything alive on the reef. You would like it if people were more responsible in their fishing practices, and if they took care of the coral reefs where so many fish like you live.



* Students may make up names for each of their characters.

Choosing the Right Path: Fisheries

Learner Outcomes

- Discuss modern management practices that mitigate threats and sustainably manage marine resources.
- Identify and explain the specific laws pertaining to marine conservation.
- Identify authorities that govern various aspects of marine resource use, including policy development and enforcement.

Time

40 minutes

Materials

Chalk, scissors, paper

Background

People have always depended on resources from the ocean. Some people fish in order to feed their families; some people harvest fish and other marine products in order to make money; and some have jobs with large-scale fishing boats. Around the world, and especially in Papua New Guinea, many peoples' lives depend on fishing.

In order to have a healthy fishing industry, it is important to have healthy oceans, reefs, **mangroves** and other **habitats** or homes, for marine life. It is also important to make sure that when taking fish out of the sea, enough adult fish remain in their habitats to reproduce. That way there will always be enough fish to go around, now and in the future. This concept of using a resource while leaving plenty for the future is called **sustainability**, or **sustainable** resource management.

Governments and communities can play a role in making sure that people take care of their **marine resources**. Fishing communities can decide on management practices for their resource. But since it is hard to always know at a local level what is best for the resource, the government also passes laws that provide guidelines for how to manage different fisheries. Both economics and **conservation** should be considered when deciding how to best manage a fishery.

Teacher Preparation

Cut out paper cards and copy a situation from the situation table (on page 89) on each card. Also copy the number in parentheses at the end of each situation.

Lesson Steps

1. Talk about fisheries.

Ask students what they think would happen if there were no laws to control fishing. Would there be more or less fish in the ocean? Explain that the National Fisheries Authority created laws that outline the things people can do (permitted) and can't do (prohibited) in regards to fishing. Talk about the impacts of over-fishing, illegal fishing, and illegal fishing methods. A few examples are listed below:

- Extinction of species
- Decrease in consumption of fish
- Loss of fisheries jobs
- Imbalance of the marine ecosystem
- Contamination of fish
- Degradation of the coastline
- Decrease in populations of fish
- Degradation of coral reef

2. Build the playing board.

Three options are listed below.

Option 1

Find an open area with a concrete floor, or a large dirt area. Using chalk or a stick, mark about 70 squares to form a path that winds around the playing area. Each square should be large enough for one student to stand in. With the students, decide where the path starts and ends. To play, students will move themselves along the path, each in his/her turn.

Option 2

Divide the class into four groups of 4-8 students and go outside. Using a sandy terrain, ask each group to make a model of their community. The model should be about two meters by one meter in area. With the sand and other natural objects, form hills, rivers, pastureland, farms. Then, mark about 70 spots to form a path that winds through the model. With the students, decide where the path starts and ends. Place a small stone in the starting spot. To play, students will move the stone forward or backward along the path.

Option 3

Draw game boards on pieces of paper, and play in small groups.

3. Explain the rules of the game.

The objective of the game is to get to the end first. Taking turns, each student will select a card from the set, and will read the situation on the card. With the group, he/she should discuss and decide whether to move forward or backward. Forward moves mean that the situation described would help manage the fishery sustainably. Backward moves occur when the situation could cause the marine resource to decline, such as over-fishing or damaging the habitat. The number on the card indicates how many spaces to move.

4. Play "Choosing the Right Path."

Play together. If the students don't understand the situation, explain why that particular action would be a good or a bad fisheries management decision. Use the situation table listed at the end of this activity for guidance.

Assessment

After the game, talk with students about the situations. Has anyone seen any of the situations on the cards? Do they know people who practice marine conservation in their community? What types of methods do they use to take care of or manage the marine environment and its resources? Ask students if they know of any laws that tell people what to do and not to do when they fish. List their answers on the board.

Explain that laws are one way that people try to manage resources sustainably. Ask students what kinds of things they would need to think about regulating to make sure that marine resources were used well if they were legislators. Divide students into groups and ask them to discuss their ideas and write them down. Each group should then report back to the class, and all ideas should be listed on the board. Explain that Papua New Guinea has a Fisheries Management Act passed in 1999 that sets out laws outlining regulations for each fishery that describe how people are allowed to fish, when they can fish, where they can fish and how much they can catch.

Choosing the Right Path: Situation Table

Backward

- You fished with poisons or explosives (15)
- You fished without a fishing license (8)
- You refused to allow a Fishery Officer to search your vessel (10)
- You had a fish in your possession that was prohibited by notice of the National Gazette (10)
- You exceeded the total allowable catch for fisheries in the fisheries waters as declared by the National Fisheries Authority (10)
- You fished prohibited females from a specified class of crustaceans that have eggs or spawn attached to them (15)
- You sold a fish that is prohibited from fishing (10)
- You took protected or endangered species of fish from their area (15)
- You told lies to Fishery Officers (8)
- You illegally fished sea cucumber (12)
- You fished prawns inside a restricted area that is within three nautical miles of the coastline (8)
- You used a 7-inch mesh gill net and caught barramundi mothers, so fewer were left to give birth (10)
- You dumped trash at sea (8)
- You disposed of fish carcasses by throwing them overboard and it degraded water quality (6)
- Other?

Forward

- You stored away fishing gear on board when you weren't authorized to fish in the area (8)
- You appealed for a vessel license after your application was refused by the Board (6)
- You fished the specified size fish by notice from the National Fisheries Authority (12)
- You allowed a Fishery Officer to board and search your vessel (10)
- You used authorized methods and gear to fish (15)
- You fished barramundi between 14-18 inches in total length that is the minimum size limit (10)
- You sailed your vessel away from coral reef to avoid hitting and damaging it (10)
- You did not fish an endangered fish (8)
- You did not fish female crustaceans that have eggs or spawn attached to them (12)
- You fished outside of prohibited areas (15)
- You fished only the total allowable catch for tuna (12)
- You obtained a fishing license before fishing (10)
- You used an anchor in a sandy area away from coral and seagrasses to avoid damaging the sea bottom (10)
- You threw back the live fish you couldn't eat or sell (10)
- You reported someone for using dynamite to fish (15)
- Other?

Eco-Journalists

Learner Outcomes

- Investigate and discuss traditional conservation initiatives (fishing methods and seasons, fishing restrictions, and traditional customs such as taboos).

Time

40 minutes + homework

Materials

Notebook and pens, paper, tape

Background

Communities throughout Milne Bay have many traditional **conservation** practises. For example, some communities follow taboos that do not allow fishing in particular parts of a reef at certain times of year. These taboos serve as conservation measures because the no-take practice allows marine resource **populations** to regenerate in that area.

Other traditional practises include fishing restrictions that limit the amount of each kind of fish a fisherman can catch, or at what time of year people can or cannot harvest particular **species**. Traditional fishing gear and methods can also contribute to conservation by limiting the total harvest or targeting only fish of a certain size, letting the **juveniles** and other non-target species escape. There may be many other ways that local communities manage their **marine resources** well, ensuring **sustainable** populations and protecting **habitats**. Although they may not use the word "conservation" to describe these practises, the end result is the same.

As cultural traditions are lost over time and in part due to western influence, these traditional conservation initiatives are also disappearing. By renewing interest in and knowledge of past traditions, PNG coastal communities can continue to manage their marine resources for today and for the future.

One way students can learn more about their resources and their cultural traditions is to research a specific traditional conservation initiative and write a story about it. Through investigative reporting, students get more involved in an issue by researching a topic and asking good questions. And by writing an article and publishing it, students teach others as well.

Teacher Preparation

Cut paper into squares (optional).

Lesson Steps

Session 1

1. Brainstorm traditional conservation practises.

Pass out squares of paper. Ask each student to write down on their paper square at least one example of a traditional conservation practice in his/her community. Explain that these practises could be related directly to marine resource use or to land use affecting marine habitats. Ask students to come to the front of the room and stick their paper to the chalkboard or the wall.

2. Read examples with the class and discuss.

Read some of the examples out loud to the class. If there are repeated ideas, mention them, and continue to the next example. Point out the most common types of initiatives. Ask students if it was difficult for them to think of examples.

3. Introduce investigative reporting assignment.

Ask students how they might be able to find out more about traditional conservation practises that are less common or no longer in use. After students respond, suggest interviewing elders in the village. Tell them that for this assignment, they will be journalists who will conduct an investigation and write an article about a traditional conservation initiative of their choice.

4. Design a set of interview questions.

Divide students into groups and ask them to create a list of questions for an interview with elders about traditional conservation initiatives. Some examples might include:

- Does the village have any traditional rules about fishing?
- Are there any taboos related to fishing or harvesting marine resources?
- What kinds of traditional fishing gear did people use before?
- How were fishing methods different in the past compared to now?
- Are there any areas where people are not allowed to fish? If so, why?

5. Conduct interviews (homework).

Remind students that while they should start by gathering broad information about traditional conservation initiatives, they will have to choose a particular topic to cover. Explain that the quality of information journalists gather depends on the quality of the questions they ask and the notes they take. Students should have a good list of potential questions that they bring to an interview. Remind them that they should take good notes during the interview, and should fill in additional thoughts right after completing the interview while information is still fresh in their minds.

Session 2 or Additional Homework

6. Make a story outline.

Before writing their stories, students should make outlines. Ask students to answer the following questions about the topic in the outline:

- What is your objective?: What you want to accomplish
- Who is your audience?: The people who will read your article
- What are you trying to communicate?: Your main message

7. Write the story.

The story should include the following:

- **Lead:** This is the most important information that includes: who, what, when, where, why and how. For example, "Many cultural traditions have been lost in X Village. One of those traditions, the X taboo was an important conservation practice since it banned fishing during the spawning season of the X fish. Now that people no longer follow the taboo, the population of the X fish is declining."
- **Body:** The body elaborates on the lead to include quotes from people and background information on the topic collected from books, interviews, observations and experiments.
- **Closing:** This is the least important information and if the reader doesn't finish reading the article, this extra information will not affect the objective of the story.

8. Write the headline.

Students should write a headline that is concise and clear. Keep it simple. Make sure it grabs the reader's attention. Some examples include: "No More Taboos, No More Fish," or "Village Elder Tells of Lost Traditions"

9. Proofread.

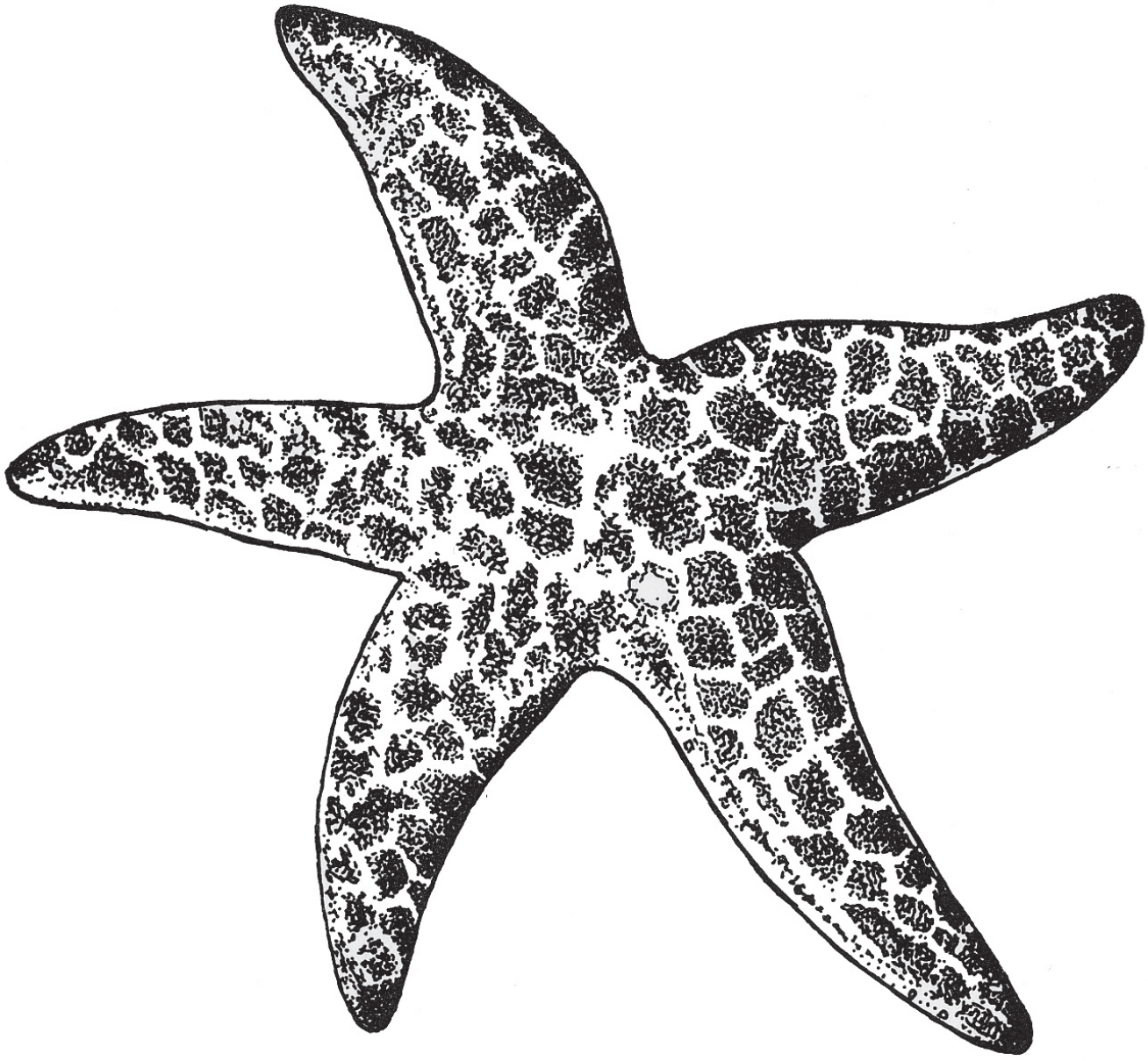
Tell students to review stories for spelling and grammar errors as well as factual errors. Have students exchange drafts and provide feedback to make sure the story is clear even for someone who didn't previously know anything about the topic.

Assessment

Reserve time for students to read their stories to the class. Collect stories and bind them in a class book for the school library.

Other Ideas Include:

- Submit the best stories to Conservation International (CI) for the Milne Bay Newsletter.
- Create a radio program about traditional conservation initiatives for Radio Milne Bay.
- Investigate other topics related to marine conservation or traditional culture and publish a school newsletter.
- Post news stories on a News Billboard at the school.
- Send copies of your articles to another school in the province for posting on their billboard.



Mapping MPAs

Learner Outcomes

- Define Marine Protected Areas
- Differentiate between Zones in a Marine Protected Area
- Create models of Marine Protected Areas

Time

80 minutes

Materials

Charts/butcher paper, glue tags, scissors, coloured markers, pencils, and rulers

Background

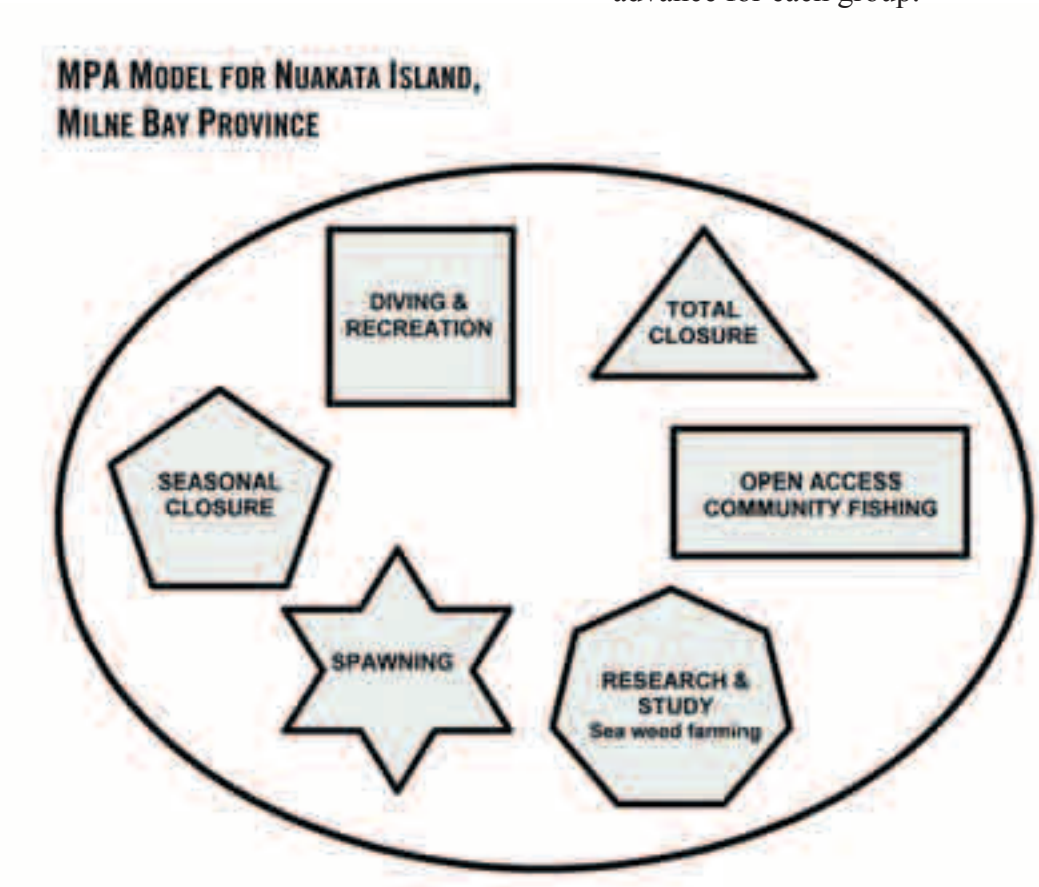
In this lesson students will learn about modern methods of **conservation** and make reference to traditional methods. They will construct models of a **Marine Protected Area** (MPA).

A Marine Protected Area is an area of inter-tidal or sub-tidal terrain, together with its overlying waters and associated flora, fauna, historical and cultural features, which has been reserved by legislation to protect part or the entire enclosed environment. MPAs can provide for the primary goal of marine conservation and management, i.e. the protection, restoration, wise use, understanding and enjoyment of the marine heritage of the world. MPAs are an important method to achieve **sustainable** fisheries.

MPAs can be small or large. They can be established for a single purpose, or multiple purposes, or have zones for different uses. Therefore, communities can use them to achieve many goals. They may be for long-term protection of sustainable local fishing, to improve tourist facilities, to protect a world heritage site, or to maintain biological diversity.

Teacher Preparation

Read through the "Reasons for MPAs" chart on page 95. Make sure that all the materials are prepared in advance for each group.



1. Define MPAs.

Ask students if they have visited a national park or other **protected area**. What was special about that area? Discuss the reasons some areas may be set aside as protected areas. Explain that marine areas can also be legally protected.

Tell students that MPAs work toward the protection, restoration, wise use, understanding and enjoyment of the marine heritage of the world. Explain that MPAs can be small or large, and they may have many different uses, such as tourism, fishing, or as a protected breeding area. Explain that different parts of an MPA with different uses are called zones.

2. Explain the difference between Protected areas and Marine protected areas.

It's important to explain how to select an MPA. First explain to students that the mechanisms to select which part, and how much, of a marine area to put into an MPA are different from those used in selecting areas on the land. The reasons may be similar, such as:

- To maintain the ecosystem so that it will continue to support biodiversity
- To ensure that use of species (such as fishing and gathering shellfish) is sustainable
- To preserve biodiversity

Tell students that the difference between land and marine protected areas is that with MPAs, water can flow in all directions, so **habitats** in the sea do not have clear boundaries and cannot be precisely defined as with land protected areas. In water, most **species** are not restricted to a specific site and many free-swimming animals have large habitat **ranges**.

Explain that tropical marine conservation has concentrated more on the following:

- Protecting areas with good examples of natural habitat, particularly areas to be visited by locals and tourists or for world heritage;
- Special protected areas for breeding birds, turtles and mammals; and
- Habitats where important commercial or recreational species live and breed, and where conservation of stocks is necessary.

3. Discuss reasons for MPAs.

Tell students that MPAs can be created for many different reasons. Ask them to name some reasons why an MPA might be created. Some questions are listed below to begin the discussion.

- How many species are found in the area?
- How many fishers work in the area?
- Are there species there that are not found anywhere else in the world?

You can also use the "Reasons for MPAs" chart on page 95.

4. Explain the activity to the students.

Now that students have a better understanding of MPAs and why they are created, explain that they will create their own model MPAs in groups. First they will sketch their ideas and then they will cut out shapes and paste them onto paper to represent different uses or zones of a protected area.

Tell the students to discuss the types of threats they think might face their area. Then ask them to talk about the types of zoning or uses they think they will need to conserve and manage their MPA. Tell them to then cut out five to six shapes and label each with the type of zone it represents. Using glue, students should paste the shapes representing the zones onto a chart that represents the total MPA. Tell the students to give a title to the MPA model they have created. Tell them that if they want, they can also draw different elements of their protected area on the chart, such as a mangrove area, or **spawning aggregation** site.

Reasons for MPAs

Biogeography/biodiversity importance: Does the area contain rare habitats or represent a good example of a special habitat in the world? Does it contain unique or unusual geological features that should be protected?
Ecological importance: Is the area important for the maintenance of ecological processes or life support systems, for example, as a source of larvae for downstream areas? Is the area a complete ecosystem, or can it be combined with another protected area to form a complete ecosystem?
Economic importance: Would the area make an economic contribution to traditional users if fishing or gathering were controlled, ensuring a maximum contribution of juvenile or adult marine species to surrounding areas? Does the area have value as a tourist attraction?
Social importance: Is the area valuable to local, national, or international communities because of its heritage, historical, cultural, traditional, aesthetic, educational or recreational qualities?
Scientific importance: Is the area valuable for biological research and monitoring?
International or national significance: Could this area be listed as a United Nations World Heritage Site, declared a national park or biosphere reserve, or considered part of international or national conservation agreements such as the Ramsar Convention on Wetlands?
Practicality and feasibility: How isolated is the area from outside destructive forces? Will local and regional people accept the area as an MPA and support its use for education, tourism or recreation? Can the area be managed to include some existing local uses that fit in with existing management regimes?

5. Create Marine Protected Areas.

Divide the class into groups of 5-6 students. Give each group 15 minutes to create their MPA. Remind them to be prepared to explain their reasons for choosing particular resource management zones for their area.

6. Present the Marine Protected Areas.

Ask students to do a five-minute group presentation to the class about their MPA. Ask other groups to pose a few questions to the presenting group.

Assessment

Once all the groups have presented, review the learner outcomes with reference to the MPA model of Nuakata Island. Focus questions on the outcome of the lesson initially stated.

Campaign for Change!

Learner Outcomes

- Design an awareness campaign to educate people about the effects of over-harvesting and other environmental issues.

Time

80 minutes

Materials

Chalk, chalkboard

Background

How does change occur in a community? It happens when people learn more about a topic and are motivated to change their behaviour. An awareness campaign is a tool to educate a group of people, also called a public, about an issue in order to change what they know and their actions. For example, by creating **conservation** messages designed to increase people's awareness about the effects of **over-harvesting** on the local economy and food source, community members become aware of how problems like over-harvesting affect their lives and may change the way they harvest fish.

There are many issues that can be addressed through an awareness campaign such as destructive fishing practices, endangered **species**, over-harvesting and illegal fishing. Students can choose any issue for a campaign. This activity focuses on over-harvesting as an example to help teach students how to create their own awareness campaigns that reinforce their understanding of an issue while introducing it to others.

Teacher Preparation

Research which species are overharvested in your community.

Lesson Steps

1. Describe an awareness campaign.

Ask students if they know what an awareness campaign is. Explain that it is similar to Coca-Cola's marketing campaign to get people to buy coke through its advertisements or like a presidential campaign where a candidate raises awareness in a community about himself to get you to vote for him. Unlike a marketing or presidential campaign, an awareness campaign focuses on a social issue. Tell students that they will develop a campaign to raise awareness about a **marine resources** issue. Explain that in this activity, students will practice creating a campaign by focusing on the harmful effects of overharvesting with the goal of a decrease in overharvesting on the part of a particular community. Explain that students will explore the problems related to overharvesting, the people who are involved, and some ways to raise awareness and change people's behaviour.

2. Define the problems.

The first step of the activity is defining the problems. Ask students to answer the following questions to better understand overharvesting and brainstorm all the possible problems associated with it. Write their answers on the board. Here are a few questions to get them started:

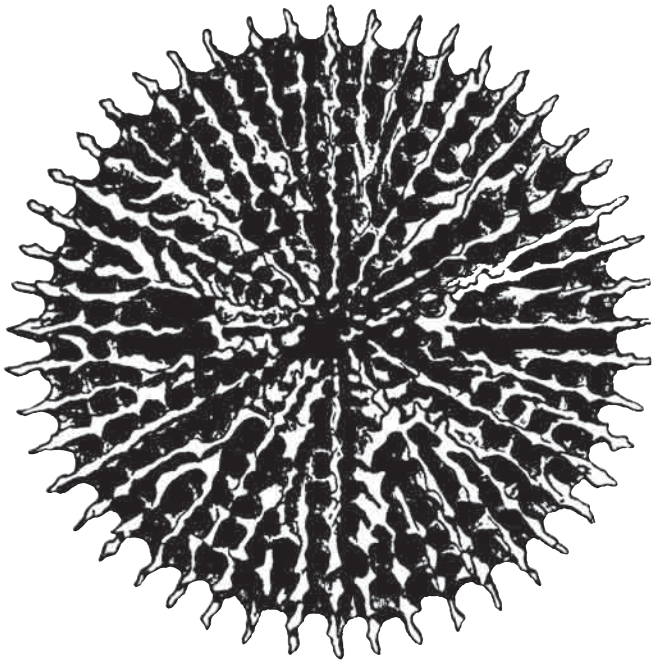
- What do people use marine animals for? (Food, money, medicine, jewelry, art, etc.)
- Why is there a change in fish populations? (Overharvesting; use of poison such as cyanide to fish; damaged habitats; new fishing methods that catch more fish than before; etc.)
- What is the definition of overharvesting? (Overharvesting in terms of fishing, is fishing more marine animals than are available to continue healthy fish populations for future generations.)

- What causes overharvesting? (Higher market demands, new fishing methods that catch more fish quicker, more people fishing, larger human populations needing more food, etc.)
- What are some negative effects of overharvesting? (Less fish for food because as more fish are caught, fewer exist to spawn eggs to create new generations of fish for food. Threat of extinction for overharvested species. Loss of income because there is less product to sell at market. Imbalance in the food web.)
- Who is affected by decreasing marine animal populations? (People, nutrition and money, fish, non-fish marine animals, birds that eat marine animals, etc.)

3. Define publics.

Now that students have created a list of problems related to over-harvesting, ask them to name all of the people, marine animals and non-marine animals involved in or affected by over-harvesting. The listings for marine animals and non-marine animals is only mentioned to get students thinking about all things that overharvesting affects. For the rest of this activity, students will only focus on people. The following list is a guide to help students get started. Write student responses on the board.

- Fishers who over-harvest
- Fishers who don't over-harvest
- Families who depend on fish for food
- Children who depend on fish for much needed protein for a healthy diet
- Marine animals being over-harvested
- Birds that rely on overharvested marine animals for food supply
- Local level government counsellor
- Students
- Teachers
- Church groups
- Local level government
- Local non-governmental organizations
- Marine animal fishing companies
- Live fish traders
- Law enforcement
- Youth groups



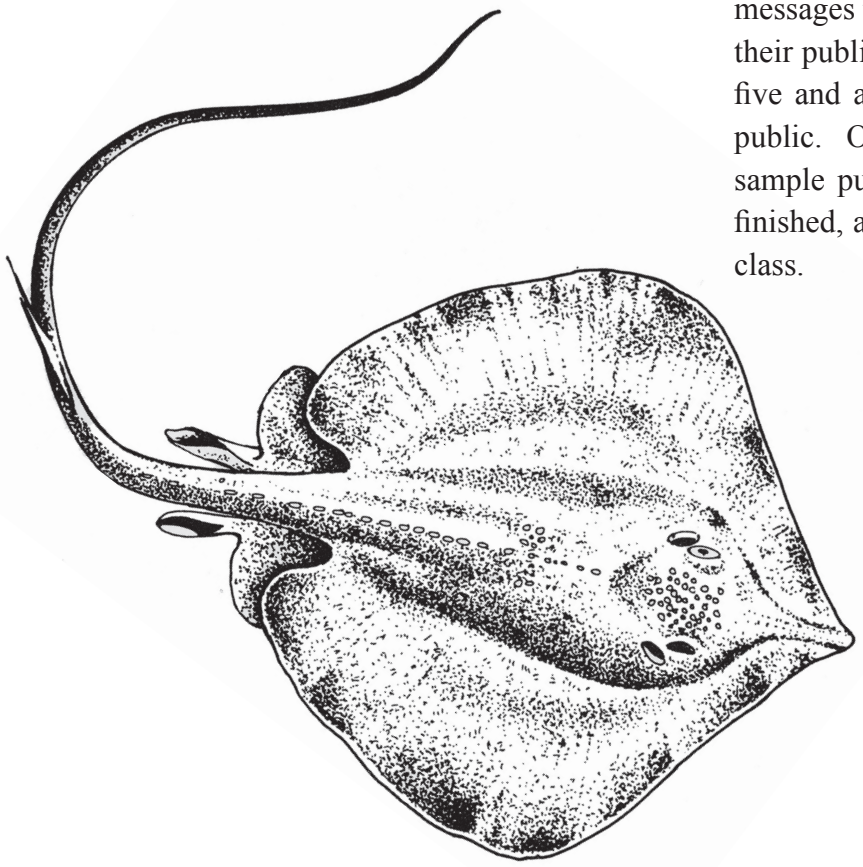
4. Select the publics.

In this section, students will focus on people affected by over-harvesting. In order to create an awareness campaign, it's important to develop messages for specific groups of people also called publics. Tell students they will vote to choose which public they think is the most important to focus on for a campaign addressing overharvesting to work on as a class. To vote, ask students to write down on paper three publics from the previous list they'd like to focus on for the awareness campaign. Count up the number of votes each public receives, and select the public that received the most votes. In subsequent campaigns, students can choose different publics, but for this exercise, they will focus on one.

5. Define the public.

It's important to understand the public you want to communicate a message to. To better know the selected public, divide students into groups of four to answer the questions listed below about the public. Once the groups have finished, ask one representative from each group to present the answers to the class.

1. Who is the public? (Where do they live? What is their education, occupation, goals, sources of information, habits? What do they know about the issue? How are they affected by over-harvesting?)
2. What should the public do or not do regarding over-harvesting? (What barriers exist that keep them from doing or not doing something?)
3. What incentives does the public have to do or not do something? (What benefit does the public receive? Why should they care about over-harvesting?)



6. Brainstorm messages for public.

The list of problems and publics should be listed on the board. Now that students have a better understanding of all the problems related to over-harvesting and who is involved, they can develop the messages and products for the main public of their awareness campaign.

Before the students begin, have them brainstorm about characteristics that make messages effective. Among other things, a good message:

- is simple and clear
- relates to people's lives
- is attractive, clever, and interesting enough to grab people's attention
- connects to people's values and what they care about most

Explain that messages should be clear and inform a public about what is happening, what will happen, what to stop doing, and or what to start doing. In the case of over-harvesting, students should create messages that address the questions listed below for their public. Divide students into groups of four or five and ask them to fill out the questions for the public. One public is listed as an example in the sample public chart on page 99. Once they have finished, ask them to present the information to the class.

Sample Public Chart

	Public: Youth Group
What is over-harvesting?	Over-harvesting related to marine animals, is fishing more than is available to continue healthy fish populations for future generations.
What marine animal(s) is being over-harvested?	Some examples include tuna, shark, coral trout, crab, grouper, lobster, trochus, and crayfish.
Why is over-harvesting happening?	— New markets offer cash for certain marine animals. — New fishing methods also catch more marine animals than previous methods. New methods also cause fishers to catch what they want as well as marine animals fishers didn't intend to catch (by-catch). — Human populations are rising and so there is a greater demand for marine animals as a food supply.
What will happen to me in the future if over-harvesting continues?	Once a marine animal population is depleted, there will be no more to eat nor to sell at market.
What effect does it have on me?	— Decrease in food source and decrease in protein that is much needed for a healthy diet, especially with youth. — Less fish to catch means less money earned from fishing. — Extinction of a species that you and your children will not know.
What am I doing to cause the problem?	Some youth may contribute to over-harvesting through fishing. Others may have no direct cause.
What can I do to prevent the problem?	Raise awareness in your family about the different fishing methods to reduce over-harvesting.
What can I do to solve the problem?	— Reduce the amount you eat of marine animals that are being over-harvested. — Stop fishing species that are over-harvested. — Monitor key species that are being over-harvested. — Investigate sustainable harvesting methods to teach to fishers.
What is the main message for me?	— Save marine resources for future generations. Teach your family about sustainable fishing methods to avoid over-harvesting.

7. Message to the public.

Once students have completed the message chart, it's important to think about how to reach the public. For example, in some areas, messages are created for radio. If the selected public listens to a radio station, it would be a good idea to read a message or invite someone else to speak about an issue during a program. Another way to get the message to the public is through posters or fliers. Both can be hung up outside of homes, churches, stores, schools or municipal buildings. As people pass by, they can read the information. Speeches at town meetings are also a great way to reach some publics. Ask students to brainstorm ways to communicate the messages for the public. A list is provided below to help students get started. Once students have made a list, decide which ways are the best to communicate with the selected public.

- Plays, drama
- Speeches at town meetings
- Hand-outs / brochures / fliers
- Posters
- Radio
- T-shirts
- Brochures
- Music (message in lyrics)
- Parade
- Drawing contest
- Event or exhibition

8. Develop plans.

Now that students have prepared messages and ways to communicate them, begin creating a plan with dates and people responsible in order to complete the campaign. A chart is listed below to help organize the plans. Be sure to think of important dates when planning events.

Assessment

As a group, talk about how your class could help raise awareness in their community about other environmental issues such as destructive fishing methods. Decide issues based on what problems are affecting the community or region. Think about creating messages spoken by a non-human species such as a fish asking fishers to stop polluting water. Target an awareness campaign to different publics. A list of potential publics is listed below:

- General public
- Decision / Policy-makers
- Community leaders
- International multilateral organizations
- Donor organizations
- Local non-governmental organizations
- Journalists / Media professionals
- Educators
- Housewives
- Students
- Scientific community
- Youth groups or clubs
- Religious groups
- Local businesspeople
- National industry / Private sector
- International business
- International government officials
- Tourists
- Tourism / Hotel operators
- Law enforcement agencies

Problem	Public	Message	Communication Tool	Person Responsible	Date
Over-harvesting	Youth group	Save marine resources for future generations	Posters hung around school that explain and show sustainable fishing methods	Teacher Students	Days during school year

Marine Quiz Game: Guess What!

Learner Outcomes

- Describe marine biodiversity.
- Identify and explain the life cycles and spawning behaviours of common fish and non-fish species.
- Describe common threats to marine resources and their habitats.
- Describe the habitats of common fish and non-fish resources.

Time

80 minutes

Materials

Chalk, chalkboard, Questions and Answers sheet, small prizes (optional)

Background

Throughout the course students learn many facts about **marine resources** and their **habitats**. This quiz game provides a review of information about marine **species**, their habitats and the threats that face them.

Teacher Preparation

1. Look over the Question and Answer sheet.

From the list at the end of this activity, choose five questions, in each of the four categories for each game session. Choose questions based on the topics you have already covered with your students through classroom lessons, field trips or individual research. There are more questions and answers than you need for one game, so that the game can be played multiple times to review different topics throughout the course. Feel free to create new questions and answers or ask students to submit their own questions. Keep a copy of the questions and answers available to read aloud to students during the game.

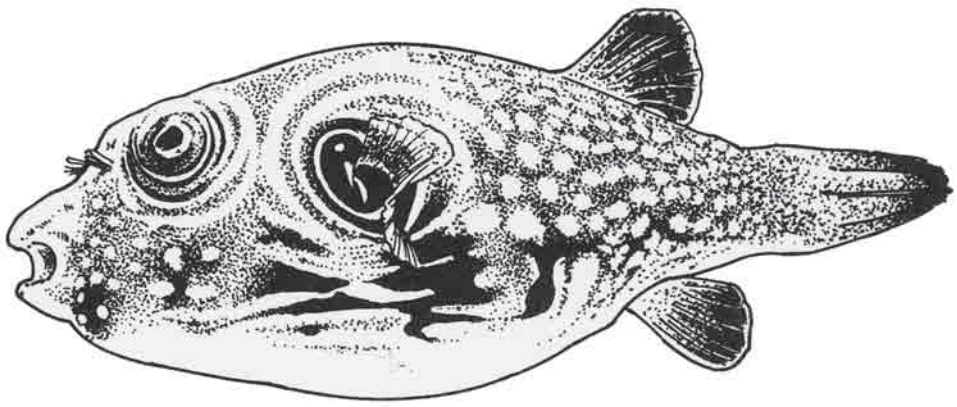
2. Assign a "monetary" value to each question.

Depending on each question's difficulty level, decide on a monetary value. For example, the easiest question for each category could be listed as 25 Kina. The most difficult question could be listed as 100 Kina. Fill in the corresponding monetary value in the column on the left of the Question and Answer sheet.

3. Make a chart on the chalkboard that lists the categories and money value for each question.

The chart should look like this:

Marine Resources	Marine Habitats	Threats	Miscellaneous
25	25	25	25
50	50	50	50
75	75	75	75
100	100	100	100



Lesson Steps

1. Explain the game.

Tell students that they will review facts about marine biodiversity by playing a quiz show game. Explain that students will be divided into teams and will compete by answering questions about marine biodiversity. At the end of the game the team with the most Kina wins. Explain that each team will designate a spokesperson and will take turns choosing a question from one of the categories listed on the chalkboard. Explain that the easiest questions are listed for the least amount of money and that the most difficult questions have a higher value. Tell them that when a team chooses a question, you will erase the money amount in the table, because there is only one question per category and value.

Once a team chooses a Kina value, explain that you will read the corresponding question out loud. Tell students that the team will have 30 seconds to discuss their answer before the team spokesperson must give an answer to the teacher. Each team gets only one guess per question. Review the answer and announce if they answered correctly or incorrectly. If the team answers correctly, you will write the money they won on the chalkboard. Then it is the next team's turn to choose and answer a question. If a team gives an incorrect answer, then the other teams can try to answer the question. The first of the remaining teams to raise their hand gets the first chance to answer, and if correct, will win the money for the question. If no team can answer a question, you should tell students the answer, and mark it to review at the end of the game.

2. Divide students into teams.

Divide students into teams of 4-6 students depending on the number of students in the class. Ask them to choose a team name (for example, the Sea Turtles). Write team names on the chalkboard and leave space to the right to record the "money" won.

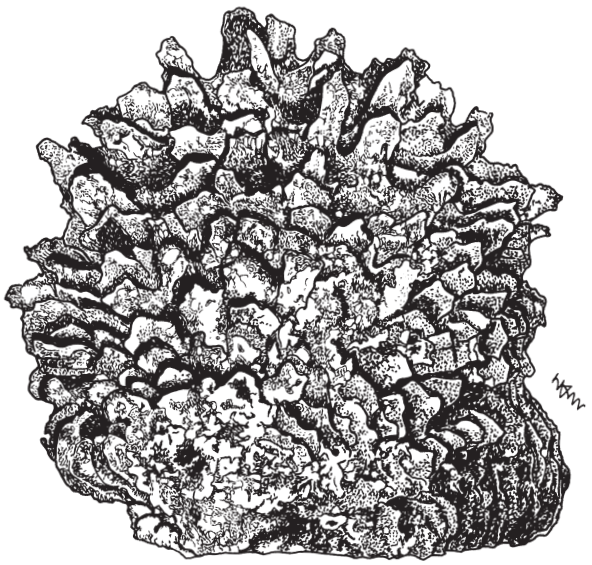
Team Name	Money Won

3. Play the game.

Roll a die to choose the first team. Begin the game by allowing the first team to choose a question. Continue this process until all questions have been asked. Teams do not need to choose questions in any order. They may choose any money amount from any category each turn. Take time to discuss questions that students are unfamiliar with. If no team can answer a question, provide them with the answer. After all questions have been read, re-read the questions that teams could not previously answer. The team with the most money wins.

Assessment

Another activity students can do to reinforce new information is to research a question and answer to provide more in-depth information. Students can present this information as a report or exhibit.



Marine Quiz Game: Questions and Answers

Marine Resources

Kina	Questions	Answers
	What is marine biodiversity?	All the variety of life in the ocean, reflected in the variety of ecosystems and species, their processes and interactions, and the genetic variation within and among species
	Where are Giant Clams found?	Giant Clams are found on the sheltered sides of fringing reefs and barrier reefs
	What marine animal(s) eat trochus?	Hermit crabs, bailershell, stingrays, and sharks
	Which marine species prefers rocky bottoms surrounded by live corals?	Giant Clam
	Which marine species releases babies in the months between November and February?	Lobster
	Which marine species mates when they are about 18 months to 2 years old or when their shell width is about 14 to 15 centimetres long?	Mudcrabs
	When is the high nesting season of turtles in PNG?	December and January
	What is the main body part of sharks sold to exporters?	Shark-fins are the main item sold to exporters. Shark-fins contain fibres of elastin and collagen, called fin needles which are highly prized in Asian markets, primarily for their use in the production of shark-fin soup.
	Which marine species migrates thousands of kilometers to its feeding grounds and hatching beaches?	Turtles
	On average, how many eggs does a female marine turtle usually lay?	120 eggs
	Can sharks smell blood?	Yes, sharks can smell blood. They can also sense the presence of fish through their movements in the water.
	How long do turtle eggs incubate in the sand?	7 to 12 weeks
	Where are trochus usually found?	Trochus are generally found in depths up to about 7 metres but can sometimes be found as deep as 24 metres.
	How long does it take for Giant Clam offspring to float to reefs with the ocean's currents?	Sometimes over a hundred years or more
	What determines the sex of a baby turtle?	The temperature of the sand. Warm sand produces females and cold sand produces males.

	How old must a marine turtle be to lay eggs?	20-40 years old
	When do mudcrabs mate?	Mating occurs in the summer months.
	How many eggs does a female lobster produce?	She produces thousands of eggs, which she holds under her belly with her flippers.
	When do trochus give birth?	Trochus give birth around the new moon and full moon, which is linked to the tidal movements of the sea.
	Are mudcrabs cannibalistic?	Yes. They will eat younger mudcrabs.
	Approximately how old is a trochus measuring 8 cm?	Approximately 3 years old
	Can lobster with a tail length under 10 cms be fished legally?	No
	When did sharks first appear in the Earth's oceans?	Sharks first appeared in the Earth's oceans about 350 million years ago.
	How long does a shark usually live?	Most sharks live to between 20 and 30 years old with some living to be as old as 70 years.
	Do turtles lay eggs every year?	No, most turtles migrate back to beaches every two to eight years to lay eggs.
	How many species of shark exist in the world today?	There are now almost 500 species or kinds of shark in the world today but some of these are becoming extinct because of overfishing.
	How long will lobster babies float on the currents before settling down on a patch of reef?	Lobster babies will float on the currents for 4 to 12 months before settling down on a patch of reef.
	Where are mudcrabs found?	Mudcrabs are found in muddy areas associated with mangroves.
	When do sharks become reproductive adults?	Sharks are generally slow growing and depending on the species of shark, it may take from 3 to 20 years to mature.
	What is a non-fish resource?	Refers to marine plants and other animals either exploited for food or economic value
	Which marine species are in high demand in Milne Bay?	Beche-de-mer, Shark, trochus
	How many species of sea turtle exist in the world?	7 species exist in the world.
	What is the world's largest fish?	The whale shark
	What are coral polyps?	Coral polyps are nocturnal animals that live in groups or colonies and look like tiny interconnected sea anemones. Some coral polyps feed on plankton and some also get food from tiny algae (simple plants) that live inside the coral and produce food for the coral using the sun's energy.

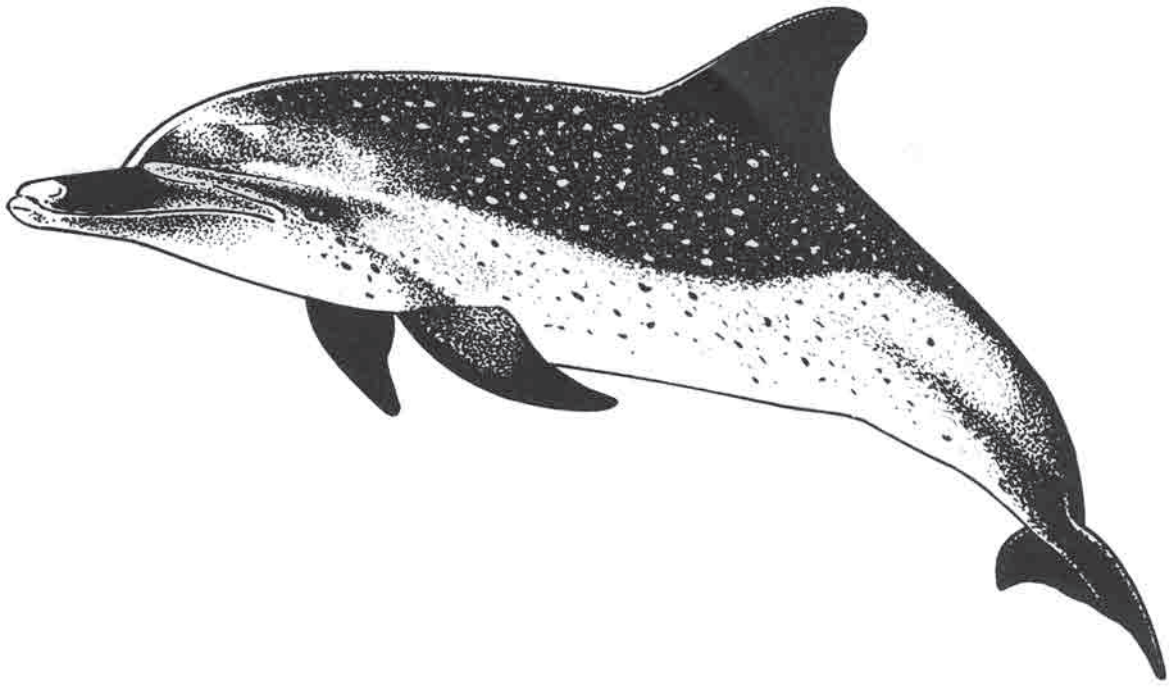
Marine Habitats

Kina	Questions	Answers
	Where are seagrass beds found?	Seagrass beds are found in the shallow coastal waters of every sea in the world, and large areas of these important marine plants occur in Milne Bay.
	What is a habitat?	A habitat is a place where animals and plants and other species find what they need to survive, including food, water, shelter and space.
	How many species of seagrass exist worldwide?	Worldwide there are 57 species with about 10-15 species in Milne Bay.
	Scientists estimate that what are home to 25% of the ocean's species?	Coral reefs
	What are some animals that eat seagrasses?	Many animals eat seagrasses. Some include parrot and surgeon fishes, turtles, sea urchins and dugongs.
	What percentage of marine species live in coral reefs?	Scientists estimate that coral reefs are home to approximately 25% of the ocean's species.
	How does the ocean generate oxygen?	The ocean generates more than 70% of the oxygen in the atmosphere through the process of phytoplankton producing oxygen through photosynthesis like terrestrial plants.
	Are corals mineral formations or colonies of tiny animals?	Corals are colonies of tiny animals (less than 1cm in diameter), called coral polyps.
	How many types of coral are there?	There are hundreds of different types of coral, including hard and soft corals.
	What marine plant lives its entire life underwater?	Seagrass
	Where do mangroves grow?	Mangrove plants are trees and shrubs that grow in inter-tidal lands. They grow on sheltered shores on tidal flats, in estuaries and bays, on the backside of offshore islands away from the wind and on some coral reefs.
	How do mangroves reproduce?	Mangroves are flowering plants and they generally flower in the spring and summer months. The seed forms from this flower and later falls into the water and floats with the tides and waves. If the seed lodges in a suitable place on the mud or sandbank it will start to grow.
	How do mangroves help coastlines?	Mangrove roots hold the soil in place and help stop the coastline from being washed away by storms, currents and waves.
	Of all the water in the world, what percentage makes up the ocean?	97% of the Earth's water is in the ocean.

Threats

Kina	Questions	Answers
	What is the main source of oil pollution?	Oil spilled from ships running aground on reefs and shallow areas
	What rubbish do sea turtles often mistake for jellyfish?	Plastic bags. Turtles can choke on the plastic and die.
	Does oil damage aquatic plants?	Yes, it can destroy seagrass beds, mangroves, and corals by smothering them and cutting off their oxygen supply.
	What is bycatch?	By-catch are non-target species that are accidentally caught on hooks or in nets.
	How long does it take for nylon fishing lines and nets to break down?	600 years
	What is the primary threat to sea cucumbers?	Over-harvesting
	Name three threats to coral reefs	Coral bleaching from global warming, siltation from coastal development, boat anchors
	What is trawling?	Trawling is a fishing method whereby a large trawl net is dropped into the open ocean. The trawl nets are dragged just above or along the ocean bottom by a boat, often destroying ocean bottom habitats and catching tons of bycatch.
	What is overharvesting?	Overharvesting is fishing more of a species than can reproduce to maintain healthy populations.
	How many kilometres from shore is considered inshore?	5 km. Coastal communities have the right to protect and manage their inshores resources.
	How many tonnes of live reef food fish are exported for the live fish trade each year?	On average, 25,000 tonnes of live reef food fish are exported annually with about 60 percent from wild capture.

	Name one reason why people collect coral?	In some areas, people collect live coral to sell to tourists as souvenirs, for jewelry, for lime production for betel nut chewing, or for construction material.
	What is deforestation?	Deforestation is the practice of cutting down forests.
	What does threatened or endangered mean? (name one threatened or endangered species in PNG)	Endangered means that it has been assessed as having a high probability of extinction in the medium term future (20% probability of extinction in the next 20 years). Threatened means a species that is either 'Critically Endangered', 'Endangered', or 'Vulnerable'. Dugongs are threatened in PNG.
	Name a fishing method that poses a threat to marine organisms and explain why.	Dynamite fishing, use of derris roots, cyanide fishing, etc
	What are the common threats to mangroves in coastal zones?	The use of trees for housing, affecting fish and prawn ponds and the use of mangroves in port constructions
	How does clear-cutting of tropical forests and intensive agriculture on slopes threaten marine resources?	Silt runoff and sedimentation smother coral reefs.
	What does extinction mean?	Extinction refers to a species that no longer exists. Local extinction occurs when every member of a particular population has died. Global extinction occurs when every member of a species has died.

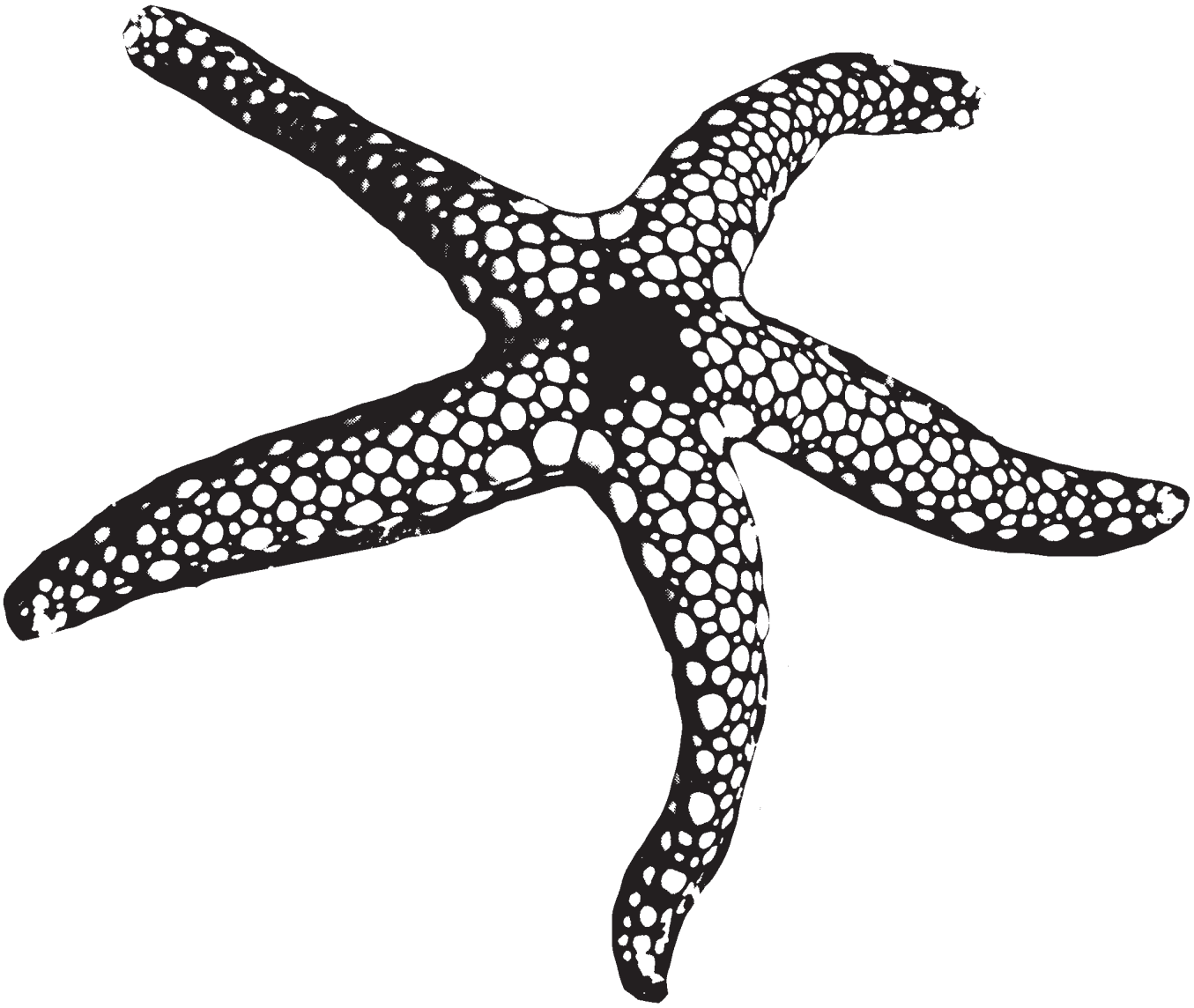


Solutions

Kina	Questions	Answers
	What is one goal of an awareness campaign?	An awareness campaign works to educate people and change their behaviour.
	What is sustainability?	A concept of using a resource while leaving plenty for the future
	What are Marine Protected Areas?	They are areas where fishing or marine activities are restricted, banned and or closely monitored.
	Name one traditional fishing method.	Bow and arrows, spear fishing, traditional fishing baskets, locally made fishing nets made from bush ropes and hook and line
	Name one reason for developing a management plan?	A management plan uses the best available scientific information on the species population, spawning and breeding behaviour, habitat and life cycle to define: - how much of a resource can be harvested - at what time of year - and from what place
	Which is better for reefs, moorings or anchors?	Moorings. To protect reefs, boats can use permanent mooring buoys that are drilled into the sea floor instead of using anchors that damage the reef.
	How can siltation (settling out of soil particles) of coral reefs be reduced or stopped?	One strategy to prevent siltation on coral reefs is to stop cutting trees on steep slopes near water bodies. Logging and exposing loose soil on steep slopes is particularly damaging, since erosion occurs faster on steep inclines.
	Why should you educate people about marine biodiversity?	In order to protect marine environments, people need to understand the important role they play in the natural balance of the Earth, and in the diversity of life that they hold. Understanding often leads to concern, concern leads to a desire to protect, and a desire to protect leads to action – the ultimate goal.

	How does the term “alternative” relate to conservation?	Alternative is a different way of doing something or something different all together. One solution to overharvesting is for fishers to find alternative methods of fishing or alternative methods of making money such as a job in eco-tourism.
	What does PNG’s Fauna Protection and Control Act (1982) protect?	The Fauna Protection and Control Act (1982) declares certain threatened species such as the dugong and leatherback turtle, protected species.
	What is a taboo?	Traditional taboos are a type of informal zoning, since under the taboo, villagers are not allowed to enter certain areas of the reef at certain times.
	How does a fishing reserve help marine species?	A fishing reserve is a place where fishing is prohibited in certain areas or times of year, thus providing safe areas for breeding. In many cases, reserves allow areas that have been over-fished to regenerate damaged fish populations.
	How can traditional fishing methods help protect marine resources?	Traditional fishing methods such as bow and arrows, spear fishing, traditional fishing baskets, locally made fishing nets made from bush ropes and hook and line, reduce bycatch and the volume of marine animals harvested.
	What does PNG’s Fisheries Management Act (1999) focus on?	The Fisheries Management Act passed in 1999 sets out laws outlining regulations for each fishery that describe how people are allowed to fish, when they can fish, where they can fish and how much they can catch.
	What is total allowable catch?	It is the total amount of fish and non-fish species that can be harvested as declared by the National Fisheries Authority.
	What determines the success or failure of a fishing reserve?	The success of the reserve depends on the involvement and commitment of local people, particularly fishers.
	What is ecotourism?	Ecotourism is responsible travel that promotes the conservation of nature and sustains the well-being of local people. It is the fastest growing sector of the tourism industry.

Appendices



Appendix I: Glossary of Terms

Atoll	A circular reef that encloses a relatively shallow *lagoon*. An atoll forms when an oceanic island ringed by a barrier reef sinks below sea level.
Bay	A body of water partially enclosed by land, but with a large outlet to the sea or ocean.
Biodiversity	The variety of life on Earth, reflected in the variety of *ecosystems* and *species*, their processes and interactions, and the genetic variation within and among species.
Brackish	Slightly salty or briny. Brackish water is saltier than fresh water but less salty than seawater.
Bycatch	Non-target species that are accidentally caught on hooks or in nets while fishing for another species. Some bycatch is used or sold as a byproduct, but most is thrown back overboard. Most bycatch species do not survive this process.
Cay	A small, low coastal island or emergent reef of sand or coral.
Conservation/ conservationist	The protection and planned management of a *natural resource* to prevent exploitation, destruction, or neglect. /Conservationists are people who work to achieve conservation. Conservationists include scientists, teachers, economists, policy-makers, and others.
Coral bleaching	The process in which a *coral polyp*, under environmental stress such as increased water temperature or pollution, expells its *zooxanthellae* (the algae that nourish the coral). The affected coral colony appears whitened.
Coral polyp	A small individual *invertebrate* marine animal with a tube-shaped body and a mouth surrounded by tentacles.
Coral reef	A complex habitat composed of reef-building *hard corals* and a broad group of soft corals that carry tiny limestone crystal structures embedded in their tissue.
Crustacean	Aquatic gill-breathing animals often having a hard carapace or shell (e.g.: lobster, crab, prawn, etc.).
Cyanide	An extremely dangerous chemical product, composed of nitrogen and carbon, used by fishermen to stun reef fish.
Deforestation	The practice of cutting down entire areas of forest.
Density	The number of individuals per unit area or volume.
Derris root	A woody vine with bright green leaves and rose-tinted white flowers; the swollen roots contain rotenone, a substance that is toxic to fish and insects. In some areas derris root is used for fishing, where it is added to the water and the fish are collected as they float to the surface.
Distribution	Where a *species* can be found (i.e. its geographical *range*).
Diversity	A great variety of different things such as species of plants and animals.
Ecological or ecosystem services	Valuable services provided by natural systems. Examples of ecological services include flood control, air purification, and climate control.
Ecosystem	A community of plants, animals, and microorganisms that are linked by energy and nutrient flows and that interact with each other and with the physical environment. Rain forests, deserts, *coral reefs*, grasslands, and a rotting log are all examples of ecosystems.
Ecotourism	Responsible travel that promotes the *conservation* of nature and sustains the well being of local people.

Endemic	Exclusive to or belonging only to one area or region; for example, Goldies Bird of Paradise is endemic to Ferguson Island in Milne Bay.
Erosion	The wearing down or washing away of the soil and land surface by the action of water, wind, or ice.
Environmental education (EE)	A process of developing a world population that is aware of and concerned about the total environment and its associated problems, and which has the knowledge, skills, attitudes, motivation and commitment to work individually and collectively toward solutions of current problems and the prevention of new ones (UNESCO 1978).
Environmental issue	A disagreement about how to resolve a particular environmental problem or a negative interaction between man and the environment.
Extinct / extinction	Refers to a *species* that no longer exists. /Local extinction occurs when every member of a particular population has died. Global extinction occurs when every member of a species has died.
Fauna	The animals that live in a particular area.
Food web	A sequence of *organisms* from producers (plants and some bacteria) to consumers (other plants, animals, and fungi), in which the producers create food energy and all consumers feed on or get nutrients from the producers or other consumers.
Fishing reserve	A place where fishing is prohibited in certain areas or at certain times of the year in order to provide safe areas for breeding and regeneration of *over-harvested* fish *populations*.
Genus (pl. = genera)	A group of closely related *species*. A group in the classifcation of *organisms*. Genus is the classification level above the *species* group. It consists of similar species. Similar genera (plural form of genus) are grouped into a family.
Global warming	The theory that the average temperature of the Earth's atmosphere is rising, mainly because of the release of "greenhouse gases" such as carbon dioxide. These gases are released into the air from burning petrol, oil, coal, wood, and other resources and trap heat in an action similar to that of the walls of a greenhouse. Global climate change is a broader term that describes other changes in the Earth's climate beyond average temperature rise.
Greenhouse effect	The trapping of heat in the Earth's atmosphere by certain gases such as carbon dioxide, nitrous oxide and methane. Some scientists predict that the rise in atmospheric temperature, sea level rise, and other changes associated with *global warming* could adversely affect *biodiversity*.
Habitat	The area where an animal, plant, *microorganism*, or other life form lives and finds the nutrients, water, sunlight, shelter, living space, and other essentials it needs to survive. Habitat loss, which includes the destruction, degradation, and fragmentation of habitats, is the primary cause of biodiversity loss.
Hard corals	Reef-building *coral polyps* that excrete external limestone skeletons and typically have tentacles in multiples of six.
Inshore	An area along the coastline that extends to 3 miles or is sometimes referred to as traditional fishing grounds.
Introduced species	An *organism* that has been brought into an area where it doesn't naturally occur. Introduced *species* can compete with and cause problems for *native species*. Introduced species are also called exotic, non-native, and alien species. Invasive alien species often spread quickly and take a heavy toll on native species.

Invertebrate	An *organism* that does not have a backbone.
Juvenile	Young, not having reached reproductive maturity.
Lagoon	A body of water cut off from a larger body by a barrier island or *coral reef*.
Larva / larvae / larval	A sexually immature *juvenile* - an early stage in an animal's life cycle. [Note: the plural of larva is *larvae*. The adjective form is *larval*.]
Life cycle	The different stages of an animal's life, such as when, where and how it reaches maturity, mates and reproduces.
Longline / longliners	Ocean fishing boats that use very long fishing lines, up to 100k in length, baited with regularly spaced hooks. The primary threat of longline fishing is the amount of unwanted species or bycatch that get caught on the lines.
Management plan	A management plan uses the best available scientific information on the species, such as population, spawning or breeding behaviour, habitat and life cycle to define how much of the resource can be harvested, at what time of year, and from what place. Well-researched and enforced management plans can help ensure sustainable harvests.
Mangroves	A coastal tropical forest, where trees have special above-ground roots to keep them out of the water. Mangroves are important *nursery areas* for marine life, and can help keep *pollution* and *sediment* run-off from reaching coral reefs.
Marine mammals	Warm-blooded animals that need to surface regularly in order to breathe air, give birth to live offspring, have a four-chambered heart, a body covered with very small hair, and/or feed their young on milk from the breast (e.g.: dugongs, dolphins and whales).
Marine protected area	An area of sea especially dedicated to the protection and maintenance of biological diversity, and of natural and associated cultural resources, and managed through legal or other effective means.
Marine resources	Animals or plants or other natural materials found in or near the ocean and used by humans.
Marine zoning	The process of assigning different uses to different areas of a *coral reef* or other marine *ecosystem*. For example, one zone might be for tourism, another for fishing, and another might be designated for total protection from humans.
Metamorphose	To change in body shape, e.g., the change from a *larval* form to a *juvenile* or adult form.
Microorganism	A living *organism* too small to be seen with the naked eye. Bacteria, protozoans, viruses, microscopic algae, and some types of fungi are all microorganisms.
Migration	The movement of animals in response to seasonal changes or changes in the food supply. Examples of migratory animals include marine turtles, hummingbirds, monarch butterflies, and elephants.
Module	A standardized part of a course that satisfies requirements for a particular study program.
Molluscs	Soft-bodied animal usually enclosed in a hard shell (e.g.: mussel, oyster, snail).
Mudflat	Sheltered parts of *estuaries* that are covered by water at high tide and exposed at low tide.
Native species	A *species* that occurs naturally in an area or a *habitat*. Also called indigenous species.

Natural resource	Any aspect of the environment that *species* depend on for their survival. People depend on natural resources such as fish, forests, minerals, soil, fossil fuels, and fresh water.
Natural selection	The process by which detrimental genetic traits are slowly removed from each successive generation. Over time, natural selection helps *species* become better adapted to their environment. Also known as "survival of the fittest", natural selection is the driving force behind the process of evolution.
Nocturnal	Term used to describe animals that become active during the night.
Non-renewable resources	Resources that accumulate over such a long period of time that they must be considered as fixed, such as minerals or fossil fuels.
Nursery area	Area (often seagrass beds and mangrove areas) where the young of a marine animal grow up before moving out to join the adults.
Organism	Any individual life form.
Over-fishing	Fishing a body of water so extensively as to upset the ecological balance or exhaust the supply of fish or shellfish.
Over-harvesting	Taking so many of a *species* of fish or other marine life that the *population* cannot sustain itself. *Marine resources* may be over-harvested in a particular region or globally over-harvested.
Pesticides	Chemicals that kill or inhibit the growth of *organisms* that people consider undesirable. Fungicides (which kill fungi), herbicides (which kill plants), and insecticides (which kill insects) are types of pesticides.
Photosynthesis	The process by which green plants, algae, and other *organisms* that contain chlorophyll use sunlight to produce carbohydrates (food). Oxygen is released as a byproduct of photosynthesis.
Plankton	Minuscule plants and animals floating in the ocean currents.
Planktonic larvae	The *juvenile* form of many marine *species* such as clams. These *larvae* travel through the oceans as *plankton*.
Poaching	Hunting, trapping, fishing, or taking illegally.
Pollution	Harmful substances deposited in the air, land or water.
Population	(1) The number of people in a country or region (2) a group of individuals of the same *species* that live in a specific geographic area.
Pristine	Virgin, unspoiled.
Protected area	An area of land and/or sea especially dedicated to the protection and maintenance of biological diversity, and of natural and associated cultural resources, and managed through legal or other effective means. National parks, marine reserves, wildlife preserves, and forest reserves are all types of protected areas.
Range	The area in which an *organism* may travel in its lifetime. Range also refers to the geographic *distribution* of a particular *species*.
Rapid assessment	A quick scientific survey or count that helps measure *biodiversity* in a particular area.
Recruitment	Additions to a *population*, either through birth or immigration.

Reintroduce	To return members of a *species* to their historical *range*. This strategy is sometimes used when a species has become locally *extinct* or if its *population* is threatened.
Renewable resources	Resources that are capable of being replaced over a relatively short time period by natural ecological cycles or sound management practices.
Seagrass beds	An underwater meadow of sea grasses — any of various flowering plants that grow underwater in marine or *estuarine* waters. Most seagrass *species* are rooted in soft *sediments*. However, some species are attached directly to rocks.
Sediment	Fine particles of solid matter (often soil) suspended in water, or settling to the bottom of a body of water.
Silt / siltation	A type of *sediment* composed of fine mineral particles intermediate in size between sand and clay. / When *sediment* settles out of the water, covering the bottom of a body of water or the surface of *coral reefs*.
Soft corals	*Coral polyps* that secrete flexible skeletons.
Spawn	To release eggs and sperm into the water.
Spawning aggregation	A group of fish that gather in one place each year to mate.
Spawning area	Area where animals such as fish and mollusks reproduce by depositing or releasing their eggs and sperm.
Species	A distinct group of animals or plants able to breed among themselves but unable to breed with other groups.
Standing stock	The number of *organisms* per unit area or per unit volume of water at the moment of sampling.
Sustainable / sustainability	Meeting the needs of the present without diminishing the ability of people, other species, or future generations to survive.
Stakeholder	A person who has an interest or stake in a particular issue.
Symbiotic	Refers to an ecological relationship between two *organisms*. The relationship may be beneficial or detrimental to one or both *organisms*. For example, corals have a symbiotic relationship with tiny plants that live inside the corals called *zooxanthellae*; corals provide protection and the zooxanthellae produce food through *photosynthesis*.
Surge channel	A deep channel in the windward side of a *coral reef* through which water moves in and out of the reef.
Threatened species	A species threatened with *extinction*.
Turbid / turbidity	Cloudy from stirred up *sediments*. A measure of water cloudiness caused by suspended particles of sediment.
Wetlands	Areas that, at least periodically, have waterlogged soils or are covered with a relatively shallow layer of water. Bogs, freshwater and saltwater marshes, and freshwater and saltwater swamps are examples of wetlands.
Watershed	A geographic area that drains into a single river system and its tributaries.
Zooxanthellae	Tiny plants that live in a *symbiotic* relationship with certain corals, clams, and some sponges. They receive nutrients from their host and provide a food source in return through *photosynthesis*. It is the zooxanthellae that are responsible for the brilliant green, yellow, and blue colors in corals and clams.

Appendix II: References

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Internet Resources

Conservation International
www.conservation.org

FishBase. www.fishbase.org.

International Coral Reef Network
www.icran.org

International Marinelife Alliance
www.marine.org

International Sea Turtle Society
www.seaturtle.org

Marine protected areas of the United States
http://mpa.gov

Reefbase:
A Global Information System on Coral Reefs
www.reefbase.org

South Pacific Regional Environment Programme
www.SPREP.org.ws

The Secretariat of the Pacific Community
www.spc.org.nc

Traffic
www.traffic.org

United Nations Development Programme
www.undp.org

United Nations Environment Programme
www.unep.org

United Nations Food and Agriculture Organization
www.fao.org

World Conservation Union
www.iucn.org

World Wildlife Fund
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[v] Ibid.
[vi] Ibid.
[vii] Ibid.
[viii] Ibid.
[ix] The list of suggested tips for managing the live fish trade stems from research supported by the Nature Conservancy and the South Pacific Forum Fisheries Agency, as well as a fellowship from the Pew Foundation.