GRADE 11 GEOGRAPHY

UNIT MODULE 11. 3

OCEANOGRAPHY

11.3.1	Features of the World's Oceans
11.3.2	Ownership and Control of Oceans and Marine Resources
11.3.3	Use of Oceans

ACKNOWLEDGEMENT

We acknowledge the contributions of all Secondary Teachers who in one way or another have helped to develop this Course.

Our profound gratitude goes to the former Principal of FODE, Mr. Demas Tongogo for leading FODE team towards this great achievement. Special thanks to the Staff of the Social Science Department of FODE who played an active role in coordinating writing workshops, outsourcing lesson writing and editing processes, involving selected teachers of Central Province and NCD.

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DIANA TEIT AKIS

PRINCIPAL

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SECRETARY'S MESSAGE

Achieving a better future by individuals, students, their families, communities or the nation as a whole, depends on the curriculum and the way it is delivered.

This course is a part of the new Flexible, Open and Distance Education curriculum. The learning outcomes are student-centred and allows for them to be demonstrated and assessed.

It maintains the rationale, goals, aims and principles of the National OBE Curriculum and identifies the knowledge, skills, attitudes and values that students should achieve.

This is a provision of Flexible, Open and Distance Education as an alternative pathway of formal education.

The Course promotes Papua New Guinea values and beliefs which are found in our constitution, Government policies and reports. It is developed in line with the National Education Plan (2005 – 2014) and addresses an increase in the number of school leavers which has been coupled with a limited access to secondary and higher educational institutions.

Flexible, Open and Distance Education is guided by the Department of Education's Mission which is fivefold;

- to facilitate and promote integral development of every individual
- to develop and encourage an education system which satisfies the requirements of Papua New Guinea and its people
- to establish, preserve, and improve standards of education throughout Papua New Guinea
- to make the benefits of such education available as widely as possible to all of the people
- to make education accessible to the physically, mentally and socially handicapped as well as to those who are educationally disadvantaged

The College is enhanced to provide alternative and comparable path ways for students and adults to complete their education, through one system, many path ways and same learning outcomes.

It is our vision that Papua New Guineans harness all appropriate and affordable technologies to pursue this program.

I commend all those teachers, curriculum writers and instructional designers, who have contributed so much in developing this course.

DR. UKE KOMBRA
Secretary for Education

Dear Student,

Welcome to the Grade 11 Geography Course. This COURSE consists of four unit modules:
UNIT MODULE 1 : THE STRUCTURE OF THE EARTH
UNIT MODULE 2 : NATURAL PROCESSES AND DISASTERS
UNIT MODULE 3 : OCEANOGRAPHY
UNIT MODULE 4 : POPULATION STUDIES

The Grade 11 Geography Course is a follow up from what students have studied in Grade 10. It has been designed using learning outcomes that identify the knowledge, skills, attitude and values that all students achieve or demonstrate by the end of Grade 12.Grade 11 Geography course comprises of four modules.

11.1 : THE STRUCTURE OF THE EARTH

11.2 : NATURAL PROCESSES AND DISASTERS

11.3 : OCEANOGRAPHY

11.4 : POPULATION STUDIES

Assessments

- **Activities**
  Each Unit Module has activities for you to do. Answers to the activities will be found at the end of each Unit after the Unit Summary

- **Assignments**
  Each Unit has an Assignment which you will do and then send to FODE Provincial Center for marking. The marked Assignment will be returned to you with comments and advice from your tutor. A mark will be given which will be counted towards your final internal mark.

- **Examinations**
  After the completion of the course, you will sit for an internal exam which will make up 70 % of your total internal mark. You will now be ready for the Grade 12 National Examination which is held in October each year.

For more information refer to the **Study Guide**.

STUDY GUIDE

Below are the steps to guide you in your course study.

Step 1: Carefully read through each module. In most cases, reading through a lesson once is not enough. It helps to read something over several times until you understand it.

Step 2: There is an instruction below each activity that tells you to check your answers. Turn to the marking guide found at the end of each module and mark your own written answers against those listed under the **Answers to Activities**. Do each activity and mark your answers before moving on to the next part of the module.

Step 3: After reading the summary of the unit module, start doing the Practice Exercise. Refer to the module notes. You must do only one practice exercise at a time.

Step 4: Below each Learning activity, there is an instruction that says:

> **CHECK YOUR WORK. ANSWERS ARE AT THE END OF COURSE MODULE 1.**

Turn to the marking guide at the end of the Module Unit and mark your own written answers against those listed under the Answers to Learning Activity.

Step 5: When you have completed a practice exercise and marked your answers, go back to the module and correct any mistakes you may have made before moving on to the next module.

Step 6: Study the entire module following Steps 1, 2, 3, 4 and 5.

Here is a sample Study Timetable for you to use as a guide. Refer to it as a reminder of your study times.

TIME	MON	TUE	WED	THU	FRI
8:00-10:00	F O D E S T U D Y				
10:00-11:00					
1:00-2:00					
2:00-4:00					
6:00-7:00					
7:00-9:00	Listen to or watch current affairs programs. Write your diary or read a book.				

A timetable will help you to remember when you should be doing your FODE studies each day.

UNIT MODULE 11.3: OCEANOGRAPHY

INTRODUCTION

Welcome to this Unit module on Oceanography. It is the third Unit Module in your Grade 11 Geography Course. There are three Topics in this Unit Module:

Topic 1: Features of the World's Oceans
Topic 2: Ownership and control of Oceans and Marine Resources
Topic 3: Use of Oceans

Each topic is made up of sub-headings and learning activities. Throughout this course you will find the lessons and activities all correspond to the Theme Sustainable Resource Use and Management of the Marine Ecosystem.
Through the learning activities we hope that you grasp the concept of the use of oceans and their importance to man.

Objectives or Aims

On successful completion of this module, you will be able to:

1. observe that oceans make up about 70 per cent of the earth's surface and that Papua New Guinea is located in the Pacific Ocean, the largest ocean in the world.
2. demonstrate an understanding that oceans have many ecosystems and provide many resources that sustains human life directly and indirectly.
3. identify and explain that oceans help regulate atmospheric cycles that are essential for life on earth.
4. appreciate the importance of oceans to life and address issues related to ownership and care of the ocean as a resource.

Time Frame

This unit should be completed within 10 weeks.

If you set an average of 3 hours per day, you should be able to complete the unit comfortably by the end of the assigned week.

Try to do all the learning activities and compare your answers with the ones provided at the end of the unit. If you do not get a particular exercise right in the first attempt, you should not get discouraged but instead, go back and attempt it again. If you still do not get it right after several attempts then you should seek help from your friend or even your tutor. Do not pass any question without solving it first.

TOPIC 11.3.1: FEATURES OF THE WORLD'S OCEANS

INTRODUCTION

Welcome to Topic 1 Features of the World's Oceans. This topic contains five lessons and five learning activities.

Objectives or Aims

On completion of this topic you will be able to:

1. describe the physical features and influences of oceans around the world.
2. demonstrate an understanding of the importance of the ocean as a resource.
3. outline the economic and social importance and ownership of the sea areas and resources.
4. describe and compare marine systems.
5. interpret and create maps and diagrams that illustrate aspects of oceanography.
6. investigate and explain issues relating to the use of oceans.

This topic should be completed within (4) weeks.

If you set an average of 3 hours per day, you should be able to complete the unit comfortably by the end of the assigned week.

Try to do all the learning activities and compare your answers with the ones provided at the end of the unit. If you do not get a particular exercise right in the first attempt, you should not get discouraged but instead, go back and attempt it again. If you still do not get it right after several attempts then you should seek help from your friend or even your tutor. Do not pass any question without solving it first.

11.3.1.1: Where are the World's Oceans?

Oceanography is the scientific study of the physical, chemical, and biological processes that maintain the structure and motion of water in the oceans. It is a vast body of salt water that covers about three-quarters of our Earth.

Oceanography does not only deal with the body of salt water, it is also concerned with the boundaries of the ocean, with the atmosphere above, the seafloor below, the coastlines and the ice caps.

These vast expanses of water are forbidding, full of mystery and danger. For centuries people have been frightened and intrigued by their depths and the creatures that lurk in them. Oceans are the highways along which goods travel from one continent to another. They are also one of the worlds' most valuable resources used by millions of people for cruising, sailing, fishing and just messing about.

Oceans provide many communities with valuable food resources such as fish, and mineral resources such as oil. But oceans are now becoming increasingly polluted as these same communities dump more and more of their waste into them.

Do you know much about oceans? Let's explore this mysterious environment and find the answers to these questions.

How big are the oceans?

You may be surprised to discover that over 70 per cent of the earth's surface is covered by the ocean. The five oceans of the world are:

- the Pacific
- the Atlantic
- the Indian
- the Arctic, and
- the Southern Ocean

These oceans hold about 97 per cent of the earth's water. Most people think that the oceans are separated by the continents. However, if you examine Fig. 11.31a, you will notice that all the oceans are connected to form one continuous ocean surface surrounding the continents. Close to the continents and sometimes separating them from each other are:

- **seas**, small areas of ocean partly enclosed by land
- **bays**, wide indentations of sea into the land
- **gulfs**, long narrow inlets reaching far into the land and
- **straits**, narrow stretches of sea between land surfaces connecting two large areas of sea.

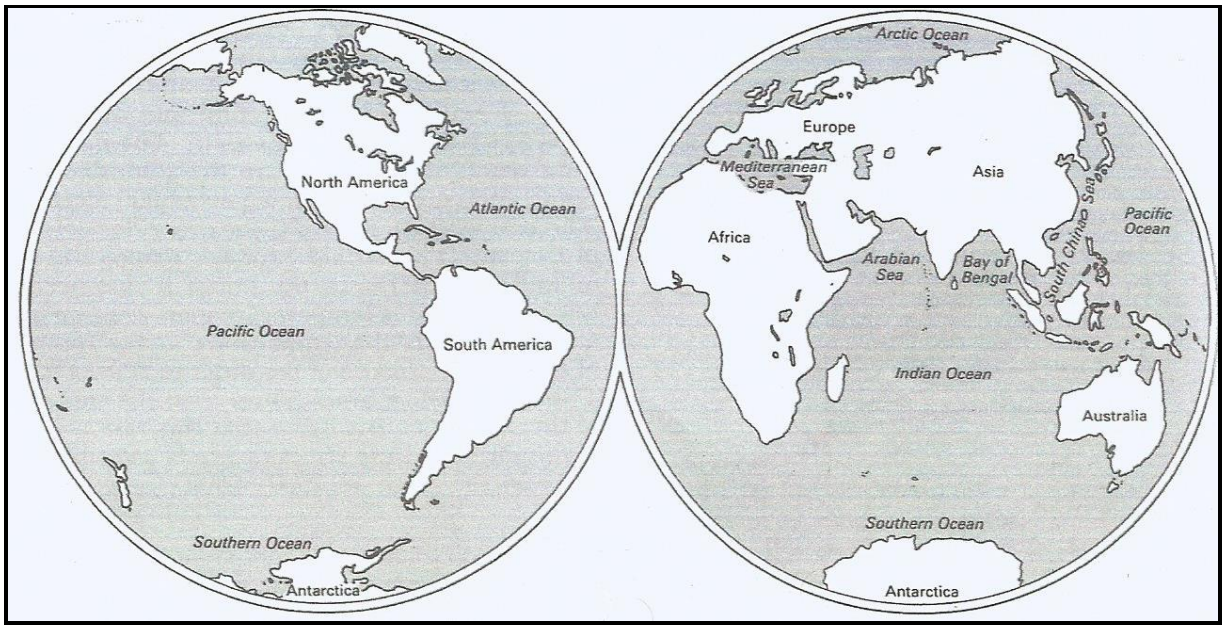


Fig: 1: The continents and oceans of the World

Why are the oceans salty?

Have you ever been dumped by a wave and ended up with a mouth full of water? Your taste buds tell you that you should not drink it because it is salty. It is salty because water which falls as rain transports dissolved minerals called salts across the earth's surface to the oceans. Waves also erode rock surfaces along the coasts and salts are dissolved into the ocean. Some parts of the oceans are more salty than others. This happens because:

- high evaporation rates and low rainfall increase the salt content.
- low evaporation rates, high rainfall and large quantities of fresh water brought in by rivers and glaciers reduce the salt content.

For example, the Baltic Sea which receives large quantities of fresh water from rivers and melting snows has a low salt content. Like-wise are the oceans near the mouth of great rivers like the Ganges and the Amazon. The Red Sea is the saltiest because no large rivers flow into it and evaporation rates are high.

Learning Activity 1

Study Fig 2 on page 12 to answer these questions. You will also need an atlas to do this.

1. Name the continents marked :
   a. _____ e. _____
   b. _____ f. _____
   c. _____
   d. _____

2. Name the oceans marked:
   A. _____ D. _____
   B. _____
   C. _____

3. Name the seas marked:
   E. _____ K. _____
   F. _____ L. _____
   G. _____ M. _____
   H. _____ N. _____
   I. _____ O. _____
   J. _____

4. Name the bays marked:
   P. _____
   Q. _____
   R. _____

5. Name the gulfs marked:
   S. _____ U. _____
   T. _____ V. _____

6. Name the straits marked:
   W. _____
   X. _____
   Y. _____
   Z. _____

7. Use your answers from questions 1 to 6 and label the map below, Fig 2. Color the continents brown and the oceans blue, and give your map a suitable title.

   Title: _____

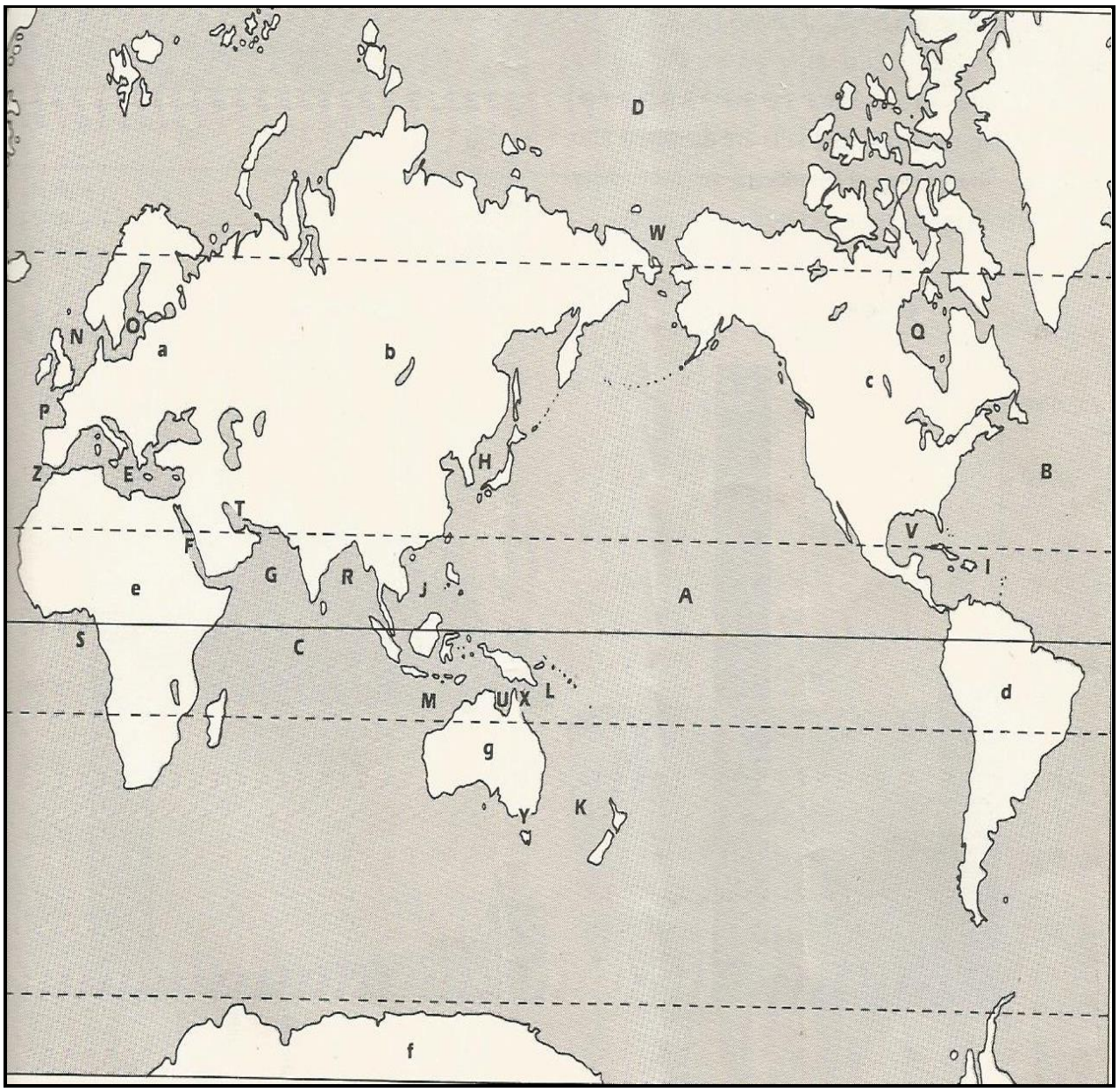


Fig: 2: The oceans of the World

CHECK YOUR ANSWERS AT THE END OF THE UNIT SUMMARY

11.3.1.2: Zones of the Ocean

The ocean floor like the surface of the continents, haS relief features which are called sea bed landforms. Where the land meets the sea is called the **coast** (**coastline, seashore, shore**). Between the continents and the ocean basins is a series of relief features that are submerged by the seas but are actually parts of the continents. These are the continental shelves, continental slopes, continental rises, abyssal plain, ocean trenches or deeps and oceanic ridges. It extends from the coastline to depths of some 200 metres.

Ever since people started to sail across the ocean they wondered what the ocean floor was like. Because light penetrates only about 200 metres or so beneath the surface and water pressure increases with depth, people found it a difficult environment to explore. However, in recent years with development and advancement in Marine Science and Technology, **oceanographers** have explored the ocean depths and what they observed as shown in Fig 3.

A diagrammatic representation of continental shelf, slope, rise and the abyssal plain of the sea floor:

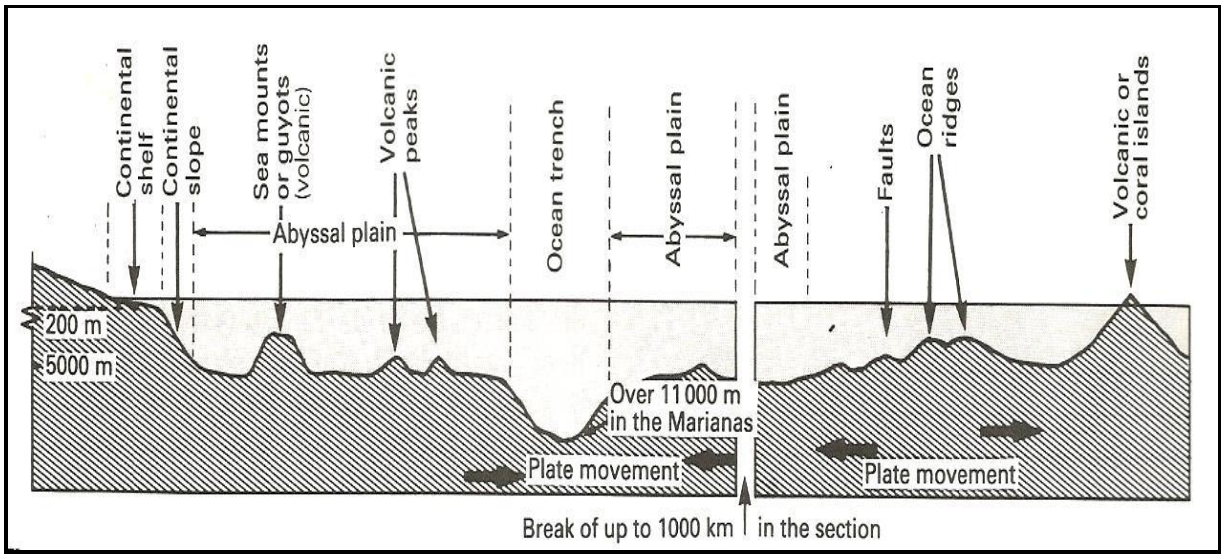


Fig: 3: Sea bed landforms

A. Continental Shelf

The oceans are shallow around the continents. The water around the continents is only about 200 meters deep at its deepest. This shallow water covers a gentle sloping platform of land which is the continental shelf. It is about 7.6% of the ocean floor which is of great economic value such as:

- Oil and gas exploration, and extraction
- Waste disposal
- Increasing the height of tides and improving shipping facilities

- Sunlight penetrating the sea on continental shelves, and therefore there is an abundance of **plankton** or small green marine plants resulting in an abundance of fish for commercial fishing activities.

Most of the fish we eat come from the shallow waters of the continental shelf. The shallow water makes it possible for sunlight to penetrate all the way to the bottom. Nutrients are supplied by erosion of the land and the shelves support an abundant **marine food chain**.

B. Continental Slope

Where the continental shelf ends, is a steep slope known as the continental slope. It plunges downward like a cliff to a depth of about 3000 meters then it becomes less steep and finally levels out to a depth of about 4000 meters.
Water and mud flowing from rivers on land have carved deep valleys in the continental slope with continuous **sliding and slumping** of marine sediments.

C. Continental Rise

Below the continental slopes are the collection of sediments washed from the land and deposited in deep water. From the foot of the continental slopes down to the deep ocean floor are the continental rises that are gentle sloping.

D. Abyssal Plain

It stretches from the base of the continental rise at depths of 4000 meters or more are the deep ocean floor which is called the abyssal plain or the abyss. It is covered with a thick layer of slimy mud known as abyssal deposits such as red clay.
Temperature here does not exceed 4°C. The abyss is dark and cold because sunlight cannot reach these great depths and because the water hardly moves.

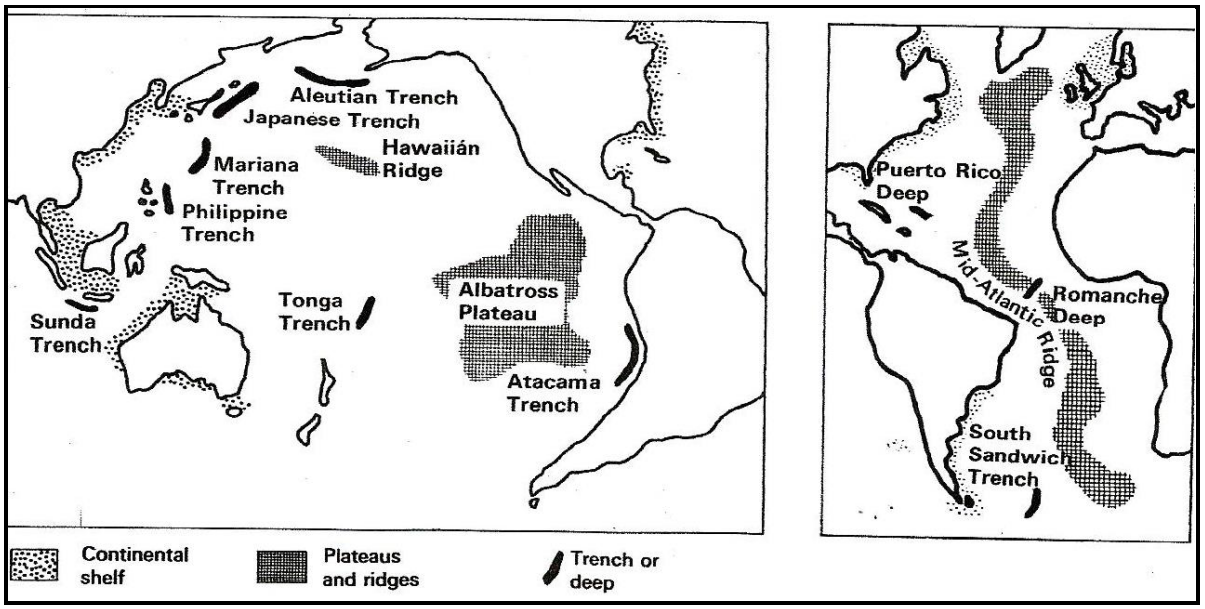
E. Oceanic Ridges

Ocean Ridges are formed above the surface of the ocean floor as volcanic islands during plate movements, especially around **spreading boundaries**.

F. Ocean Trenches or Deeps

These are found below the ocean floor and are created during **plate collision**. They are the deepest parts of the ocean basins of the world.

What lies beneath the ocean



Source: Physical Geography in Diagrams, R.B. Bunnet

Fig: 4: Nature of the ocean floor

Learning Activity 2

1. Why is the ocean a difficult environment for people to explore?

   _____

2. What is an oceanographer?

   _____

3. In which ocean are the deepest trenches located?

   _____

4. Which trench is the deepest and how many meters deep is it?

   _____

5. The mid-Atlantic Ridge runs through the Atlantic Ocean from north to south. It is surrounded by four continents. What are they?

   _____

   _____

6. What is the highest mountain on the land surface? How many meters high is it and in which country is it located?

   _____

7. Explain the economic importance of the continental shelf?

   _____

   _____

8. List the seabed landforms.

   _____

   _____

9. How are they formed?

   _____

   _____

10. Draw a cross-section of the seabed landforms and correctly label it with the correct relief features?

    _____

    _____

    _____

    _____

CHECK YOUR ANSWERS AT THE END OF THE UNIT SUMMARY

11.3.1.3: The Physical Landforms in the Oceans

For hundreds of years scientists have observed the shape of the Earth and tried to explain what they see, the mountains, the valleys and so on. Until very recently no single theory was able to explain satisfactorily most of these features but over the last 50 years or so, more and more evidence has supported the idea known as **plate tectonics**. Scientists had known for a long time that the Earth consisted of different layers and that the Earth's crust was only a thin layer "floating" on denser liquid rocks beneath. What was missing was an explanation of the actual shape of the crust and the movements that take place.

Theory of Plate Tectonics:

In 1968 W.J. Morgan put forward the idea that the earth's crust is made up of a number of rigid plates which move slowly in various directions. This is known as the Theory of Plate Tectonics. These plates are of different sizes and they move around slowly in various directions from each other. The surface of the plate may be continent, or continent and ocean, or just ocean. The energy for this movement comes from **convection currents** in the mantle. Convection currents are movements in the hot layers beneath the crust caused by the fact that heat rises, refer to Fig 5.

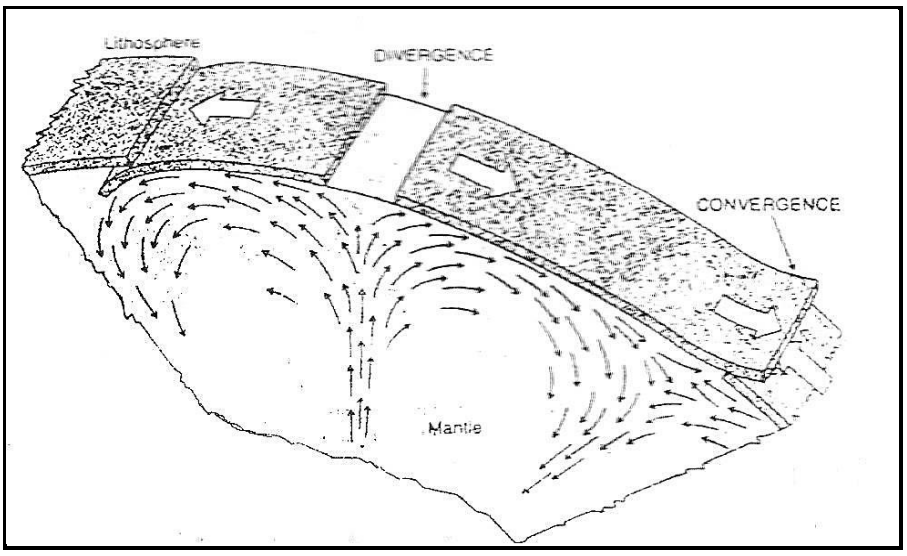


Fig: 5: How convection in the earth's mantle causes movement in the lithosphere

The **Sial** (continents) and **Sima** (ocean floor) that make up the **lithosphere** (earth's crust) are made mainly of igneous rocks as in Fig 6 on page 18. They may **diverge** (be drawn apart) or **converge** (be pushed together). Where plates meet (**plate boundaries**) the earth's crust is unstable. Earthquakes, volcanoes and crustal deformation (faulting & folding) occur at plate boundaries.

Refer to Unit 1 for more information on volcanoes.

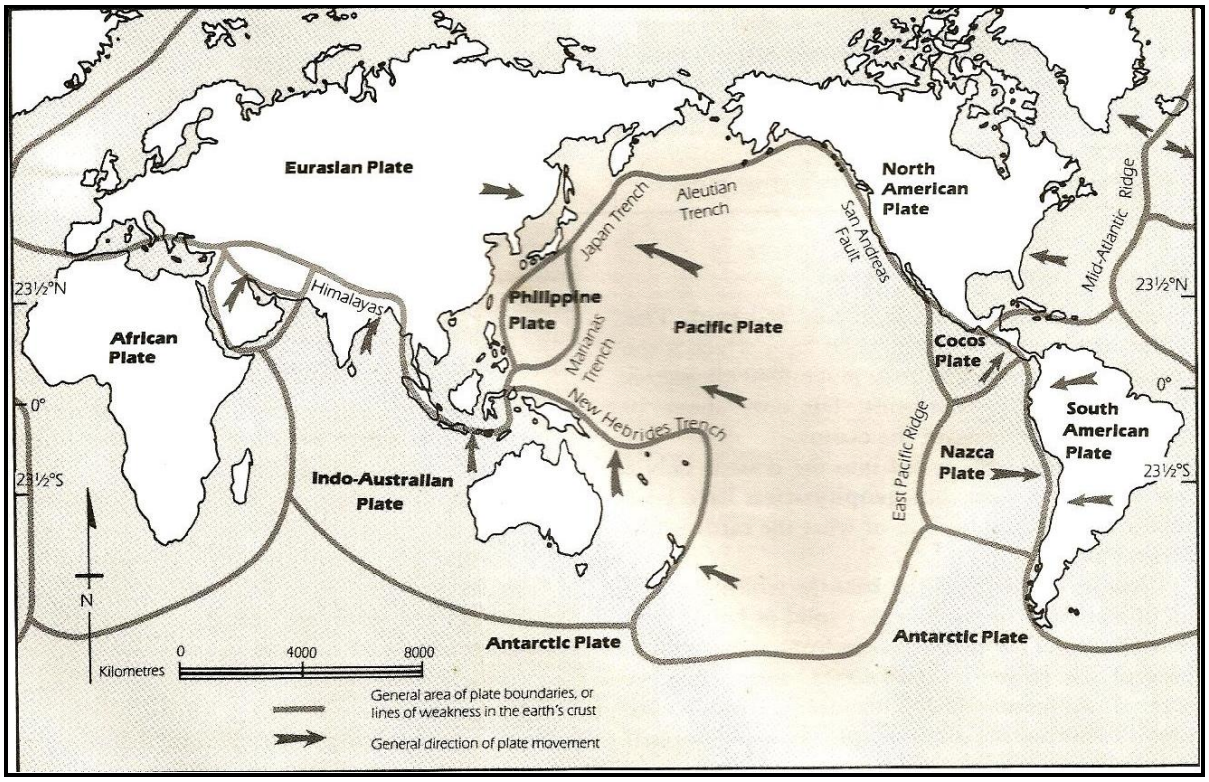


Fig: 6: The location of the major plates in the earth's crust, their approximate boundaries and general direction of movement.

The importance of these discoveries to our study of the earths' surface is that it is now realized that the movement of the plates is responsible for earthquakes, mountain building, volcanoes, trenches, ocean ridges and many other features of the earth's crust.

What happens when the earth's crust moves?

The plates that make up the crust were formed millions of years ago due to **lines of weakness** around plate boundaries. This happened because the convection currents of molten magma beneath the crust were putting enormous stress and strain on the crust. The zone of contact between two plates is called a **fold** or a **fault**. A fold is usually caused by the forces of **compression**. A fault on the other hand is usually and more often caused by the forces of **tension**. Rocks may fault or fold depending on whether they are **brittle** or **flexible** under stress.

- Folding – when layers of rocks are compressed (squeezed together) at the edges of or between tectonic plates they tend to bend or buckle. This process known as folding has been responsible for the formation of most of the world's great mountain ranges such as the Himalayas, Andes and Rocky mountains.

- Faulting – the process that involves the fracture (cracking) and displacement of rocks when subjected to thrust (pushing) or tension (pulling) forces is called faulting. The blocks that are formed may be displaced horizontally or vertically.

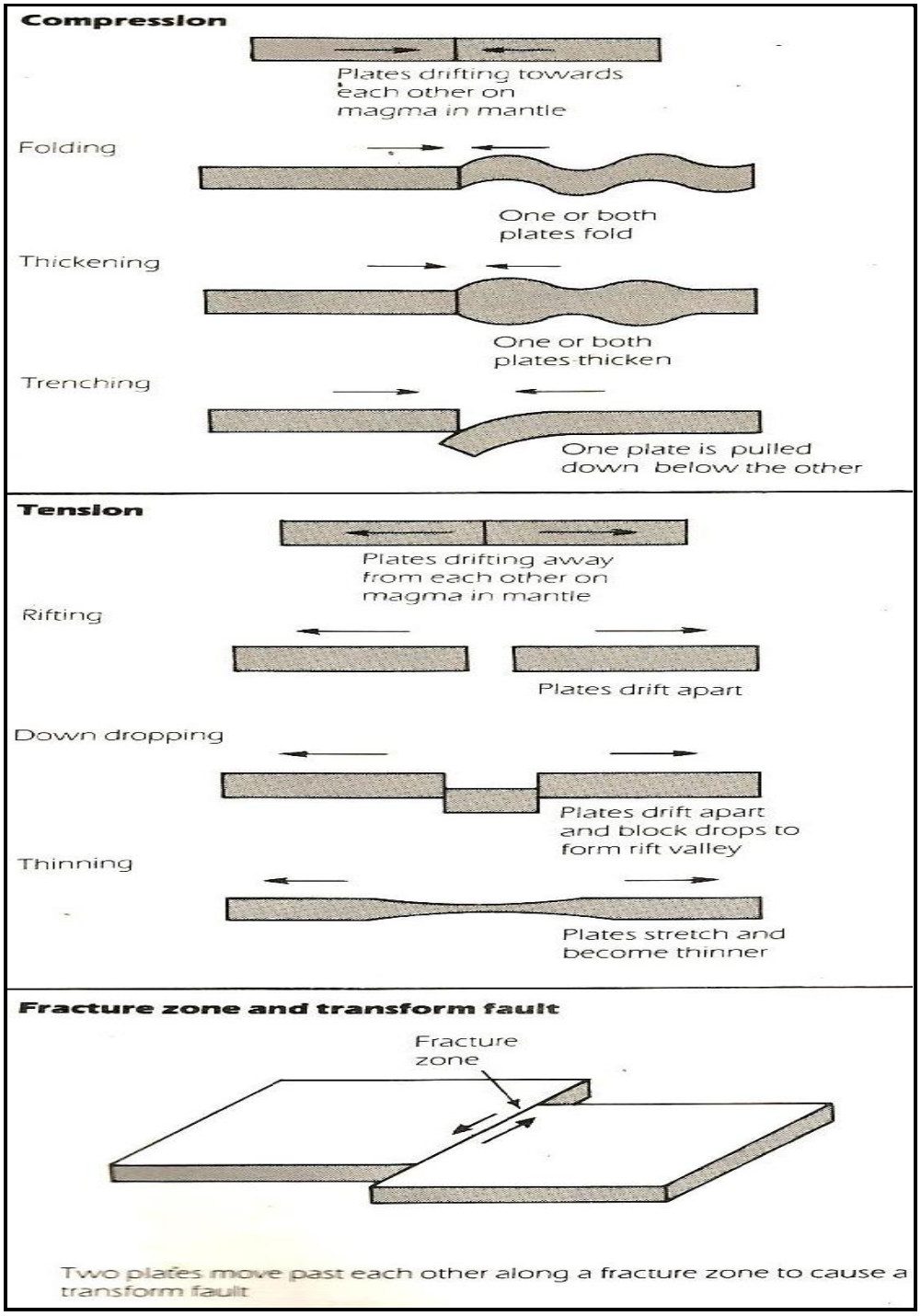


Fig: 7: The effect of compression and tension

The direction in which the plates move determine the types of landforms that are created. When plates move they may:

- collide or **converge** with each other and the edges of the plates are compressed.
- move apart or **diverge** so that the boundaries of the plates are stretched or tensioned, causing thinning or rifting of the earth's crust.
- slide pass each other along a fracture zone, a zone where the earth's crust has a distinct fault or break.

When two plates collide (see Fig. 8), one plate is compressed when it cannot continue its forward movement. It thickens or folds to form a mountain range.

The other plate is pulled down by the convection current into the mantle layer below the compressed plate where it melts and is added to the magma in the convection currents. This **process is called subduction**. A deep ocean trench is usually created along the subduction zone between the two plates. In this case, the crust is destroyed and there is no new crustal formation. For this reason the boundary around here is called a **destructive plate boundary**.

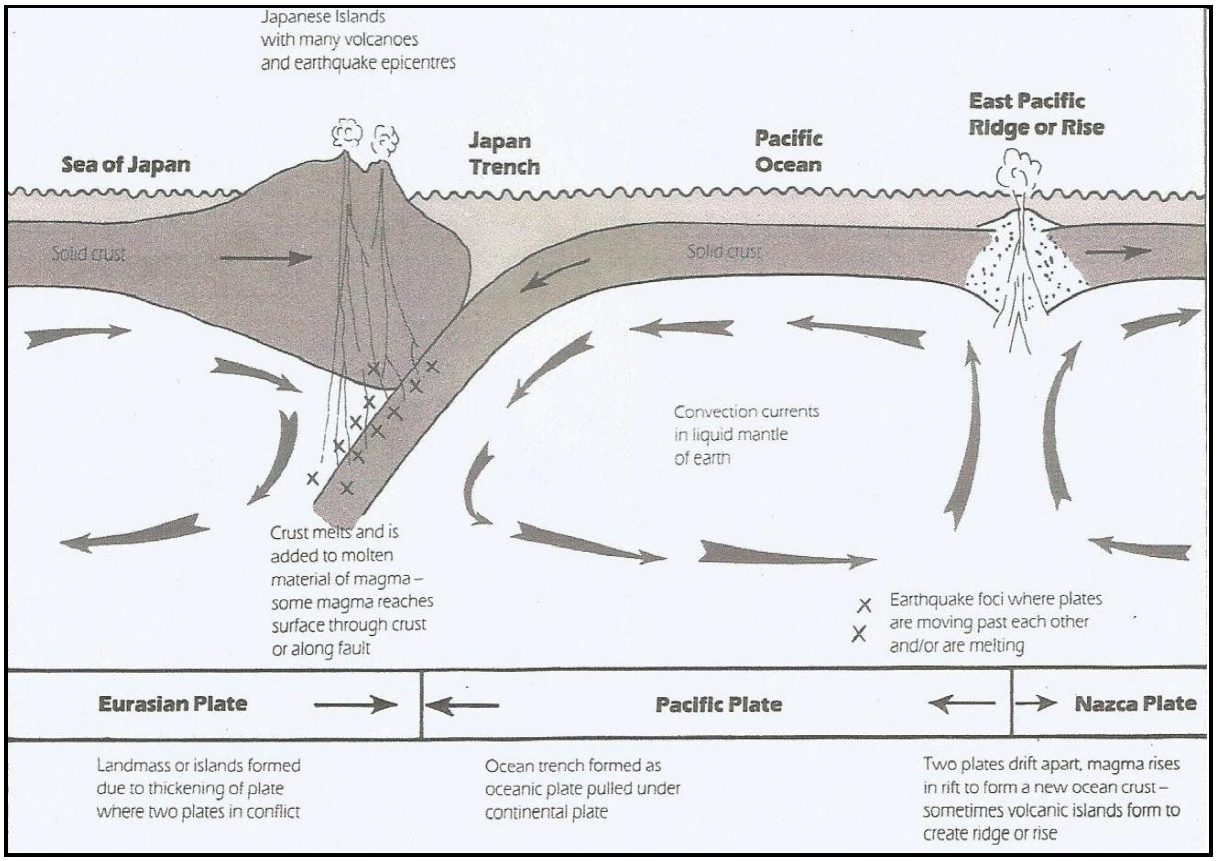


Fig: 8: The movement of plates and the development of islands, ocean trenches, volcanoes and earthquakes with particular reference to Japan.

When two plates are drifting apart the crust is stretching or thinning along the line of weakness. This allows magma in the mantle to escape from beneath the Earth's crust. On the ocean floor the magma forms a new layer of crust which is added to the plates as they move apart. This process on the ocean floor is known as **sea-floor spreading**. Often a mid-ocean ridge or rise develops. This situation is common under the Atlantic and Pacific Ocean. Volcanic islands such as Iceland or Hawaii are often found along the rise.

When two plates collide, **earthquakes** and **volcanic activity** are common. Earthquakes are caused when one plate rubs or slide pass the other (see Fig.7, Pg.19). The San Andreas Fault in Carlifonia, USA was formed through this process. The zone of movement may be as deep as 700 kilometres causing very deep earthquakes. As the plate melts, gases are produced under tremendous pressure. The gases often escape to the surface along the line of weakness, forming a zone of volcanoes and volcanic activity such as the Pacific Ring of Fire.

Learning Activity 3

Study Fig. 6 on page 18 to do this activity.

1. Name the plate on which Australia is located?

   _____

2. Is Australia located close to the edges of this plate or is it more centrally located?

   _____

3. Which plates are located to the north-east, south, north-west, and west of Australia?

   _____

4. Make a list of continental and oceanic plates:

Continental Plates	**Oceanic Plates**

5. List five constructive and five destructive boundaries:

Constructive	Destructive

6. Complete the table below:

Type of Plate Boundary	Description of Change
Constructive	
Collision	
Destructive	
Conservative /Passive	

CHECK YOUR ANSWERS AT THE END OF THE UNIT SUMMARY

11.3.1.4: Ocean Currents and their Influence on the Climate

There are two types of water movements in the oceans:

- Horizontal – the horizontal movement of ocean water on the surface is called ocean currents. These currents are powered by the prevailing wind systems and their patterns. Ocean current is an important factor that affects temperature. Temperature on the other hand is a very important feature of the climate system of the world.

- Vertical – the vertical movement of ocean water is called tides, which is the rising of bottom water and the sinking of surface water. This rising and sinking effect of ocean water very much depends on the **density** of sea water itself. Density in this case refers to the weight or volume of sea water. The density of sea water depends upon the **temperature** and the **amount of salt** (salinity) in the water.
  The salinity or saltiness of sea water is one of its very important chemical properties. It contains two of the most important mineral salts which are necessary for the formation of shells and bones of marine organisms. These are sodium chloride (NACL) and calcium carbonate (CaCO3). Salinity depends on the rate of evaporation and the amount of fresh water brought in by rivers. Sea water is more salty when evaporation is high, rainfall is low and there is no inflow of fresh water from rivers. For example, the Red Sea. When this happens sea water is less dense, therefore, it is lighter in volume. The rising and lowering of sea water is easier.

What are ocean currents?

Ocean currents are usually referred to as 'the rivers of the seas' because they move water around the world's oceans.

The main ocean currents are shown on Fig. 9. Each of the major currents can be identified or labelled as cold or warm currents. Warm currents move from the equator to the poles. Cold currents move from the poles to the equator. A current is termed warm or cold only when it is warmer or colder than the surrounding waters of that latitude. We can generalize the temperatures of the ocean currents as:

A. Warm Currents
   - Equatorial current, equatorial counter current associating warm waters in low-latitudes.
   - Pole ward moving currents on the western side of ocean basin carry warm water towards higher latitudes.
   - Kuroshio/North Pacific Current in the Pacific ocean and Gulf Stream/North Atlantic Drift in the Atlantic Ocean carry warm water toward the north and east.

- Bring warm air (high temperature) and transfer the heat along with it as it flows towards the poles.

B. Cool Currents

- Southern hemisphere the currents are influenced by Antarctic waters and are essentially cool.
- Equator ward moving currents on the eastern side of the ocean basins carry cool water toward the equator. For example, Benguela Current and Peru Current.

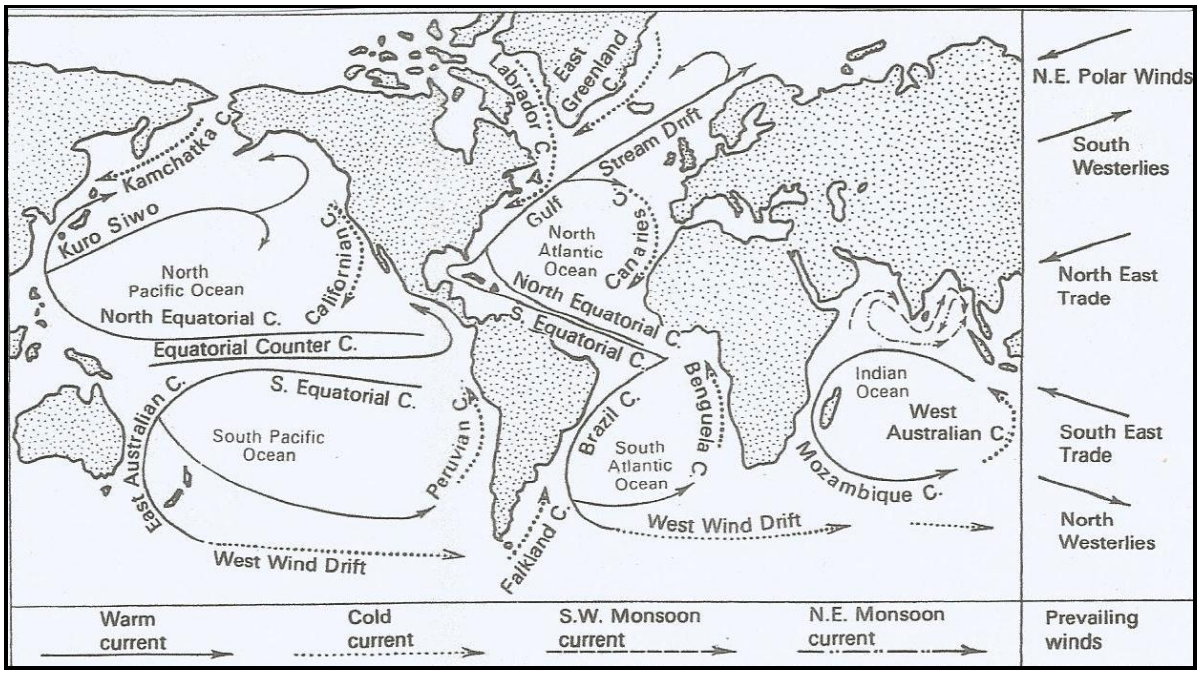


Fig: 9: The surface currents of the world

Warm current flows above while cold current flows beneath. They do not mix, except in El Nino conditions

The movement of ocean currents and the pattern created by those movements are very important because they act as agents of heat transfer. They spread the heat evenly on the earth's surface. Warm currents increase temperature and rainfall around adjacent land surfaces. Cold currents decrease temperature and rainfall around adjacent land surfaces. This effect creates a balance in heat transfer from the equator to the poles between land and sea surfaces.

How do ocean currents move?

The way the water moves is affected by:

- The rotation or spinning of the earth from west to east every 24 hours.
- The prevailing wind systems which help move the water around in the oceans.

As a result the water in the world's oceans circulates in giant paths called **gyres**. They move from west to east (clockwise direction) in the Northern Hemisphere and east to west (anti-clockwise direction) in the Southern Hemisphere.

Until recently oceanographers have found that apart from surface currents there are also deep ocean currents. In polar oceans the cold water sinks to the bottom and travels towards the tropics. This deep cold water rises to the surface in the tropics. This is called **upwelling**. It brings to the surface nutrients from near the bottom of the ocean to near the surface. Upwelling is very important for all life in the sea. The water is then heated and returns as warmer water to polar areas.

What causes tides?

When you were younger you probably built sand castles on the beach. Did it ever bother you to see your hours and hours of handy work being destroyed by waves all in one go when the water level rose? Your sand castle would have been washed away by the waves of the rising tide.

Tides are caused by the gravitational pull of the moon on the earth's ocean surface (Fig.10). The gravitational pull of the sun also has an effect on tides. On most shores the level of the ocean rises and falls every 24 hours 50 minutes. This is the time it takes for the moon to make one orbit of the earth.

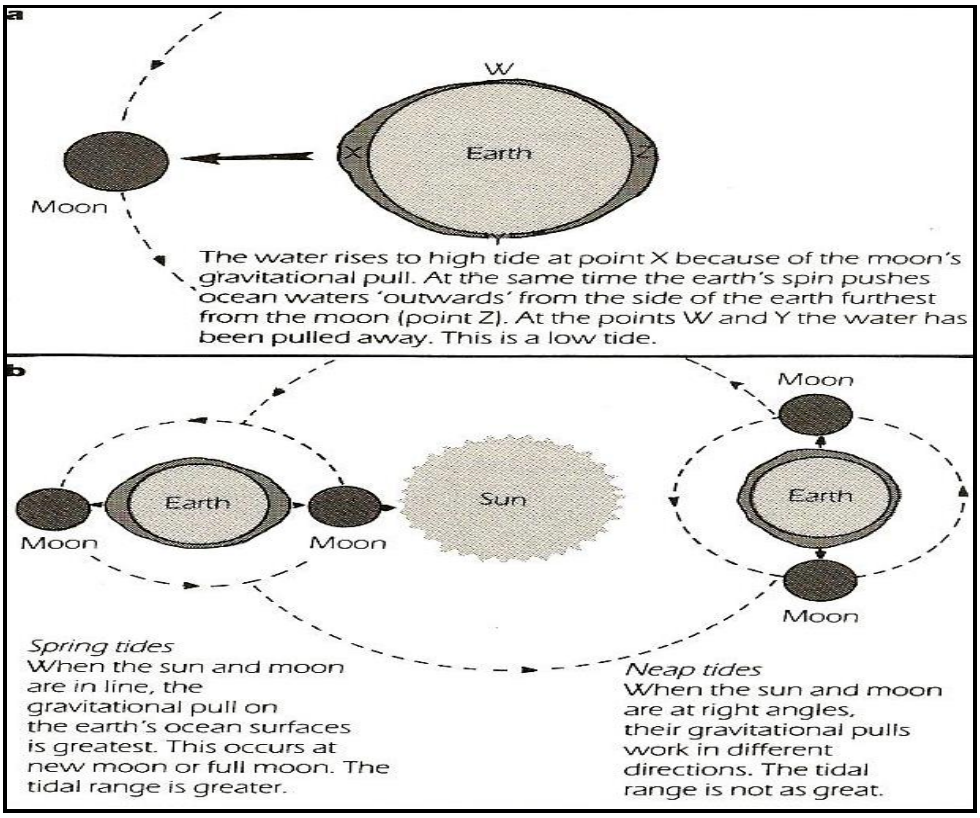


Fig: 10: Spring tides and neap tides

When the sun, earth and moon are in a straight line, as they are at Full Moon and New Moon, the gravitational force is at its greatest because the sun and the moon are “pulling” together. At these times, high tides are very high and low tides are very low, and they are called **spring tides**. When the sun, earth and moon are not in a straight line, the sun and moon are not “pulling” together and the gravitational force is less. At half moon, that is, when the sun and the moon are “pulling” at right angle, the force is at its least and the difference between high and low tides is not large. These tides are called **neap tides**. The difference between high tide and low tide is called the **tidal range**. At spring tides it is high and at neap tides it is low.

On the ocean surface, the tidal range is no more than a metre or so. In some coastal locations the tidal range is great while at others it is hardly noticeable. This happens because of the shape and slope of the coast line. In large enclosed basins like the Mediterranean Sea, the tidal range is low. But in some coastal areas, long narrow deep bays called **estuaries** have great tidal ranges. In some estuaries **tidal bores** occur. These are like walls of water that surge up and down estuaries as the tide rises.

Student Learning Activity 4

1. Explain the difference between the horizontal and vertical movements of ocean water?

   _____
   _____
   _____

2. How does density and winds affect these water movements?

   _____
   _____
   _____

3. On which sides of continents do the warm ocean currents flow? In which direction do they flow in the northern hemisphere?

   _____
   _____
   _____

4. Find a country in South America called Chile. You may need to use your atlas. If you had a boat and you put to sea off the coast of Chile, what current would carry you along? Is it a warm or cold current? Where would it take you?

   _____
   _____
   _____
   _____
   _____

5. What is a tide? Why do tides occur?

   _____
   _____
   _____
   _____
   _____

6. Which tide, a spring tide or a neap tide, has the greater tidal range? Why?

   _____
   _____
   _____
   _____
   _____

7. Define these words:
   a. Gyres_____
   _____

   b. Spring tide_____
   _____

   c. Neap tide_____
   _____

   d. Tidal range_____
   _____

   e. Inter-tidal Zone_____
   _____

   f. Estuary_____
   _____

CHECK YOUR ANSWERS AT THE END OF THE UNIT SUMMARY

11.3.1.5: Marine Resources and their Ecosystems

An **ecosystem** is composed of a **biome** and the environment with which it interacts. A biome on the other hand refers to different communities of plants and animals and the different environments in which they live in. Therefore, when we talk about marine ecosystems we are referring to plants and animals that are part of life forms in the oceans and the different environments they live in. Marine environments can be places such as mangrove swamps, coral reefs, salt marshes, estuaries, lagoons, bays, deltas and islands. They are all part of the coast and the continental shelf.

Marine resources simply refer to anything useful and valuable in the oceans that can generate income and bring about economic change and progress in a person's life. For example, minerals, oil and gas, fish, crabs, lobsters and prawns. These can all be harnessed into economic ventures and activities for individuals and countries who own those resources.

What lives in the oceans?

Every part of the ocean has some form of life in it. Life in the sea that exists in the upper levels of the oceans depends on light. Light can penetrate to about 200 metres in the open oceans. In coastal areas, sediments in the water may restrict the light to a few metres. The lighted zone of the ocean is called the **photic zone**. See Fig. 11.

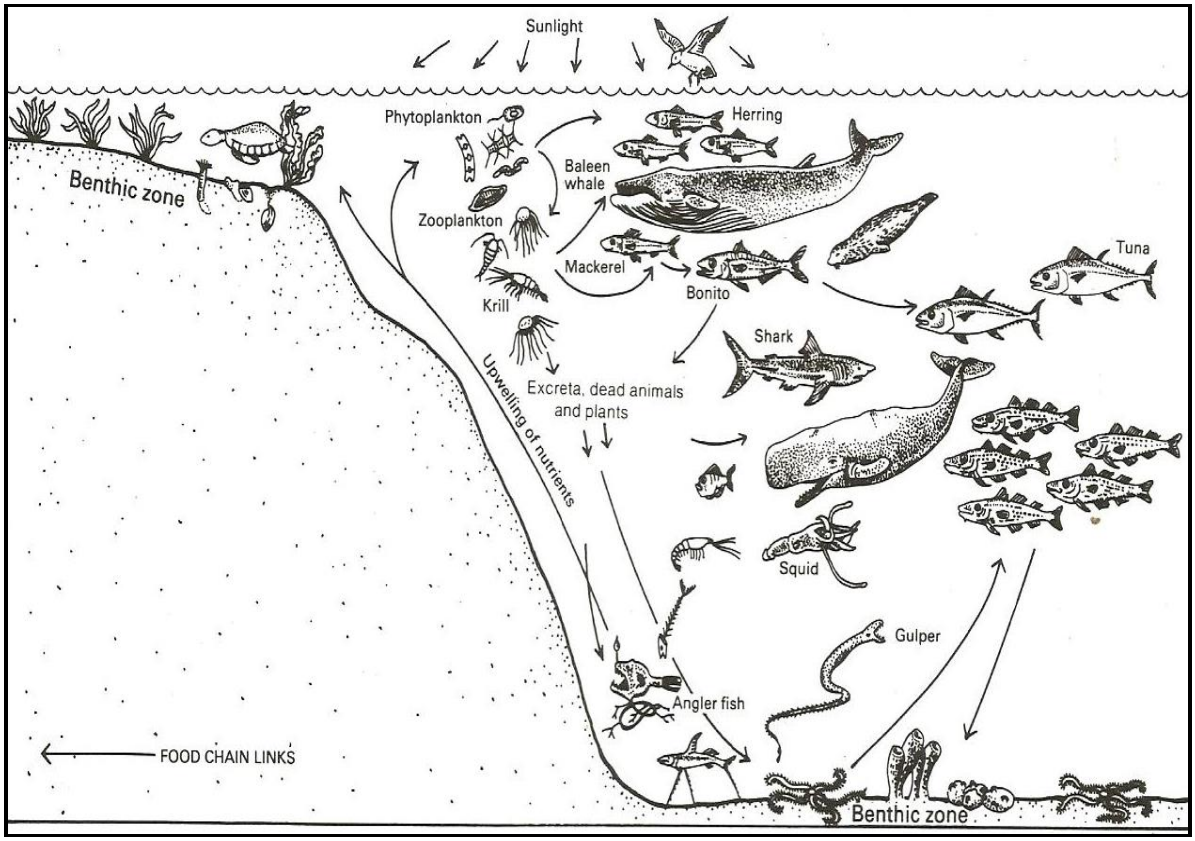


Fig: 11: Life forms in the Ocean

Since light is essential for nearly all plant life, most plants can live only in the **photic** zone. The sea creatures that depend on these plants will also be restricted to this zone. There are a few types of plants that can live without light and which gain their energy from chemicals given off by the hot water springs on the ocean ridges where there is igneous activity. These plants provide food for sea life near the ridges and produce 'oases of life' within the oceans. With differences in the surface temperatures of the oceans there is great difference in the plant and animal life from one place to another. There is very little variation in temperatures below the surface or at depth both latitudinally or seasonally.

Marine life ranging from microscopic **plankton** to the largest of earth's creatures, the whales, can be divided into two groups. **Pelagic** life lives within the water and **benthic** life lives on the ocean floor.

Pelagic life forms are free swimming (**nektonic**) and they drift with the ocean currents. Benthic life forms are attached to the sea floor, for example coral, move over it like a starfish, or burrow in the sediments that cover the floor like an anglerfish.

Food chains and food webs in the ocean

Plants are the basis of all life in the ocean and represent the first level of what is called a **food chain**. Most simple plant forms in the ocean are tiny planktonic organisms known as **phytoplankton**. For example, green, brown algae, and seaweed. These exist in large numbers and are eaten by small animals called **zooplankton**. This is the first link in the food chain. Small fish then feed on the zooplankton and they in turn are eaten by large fish (see Fig. 12).

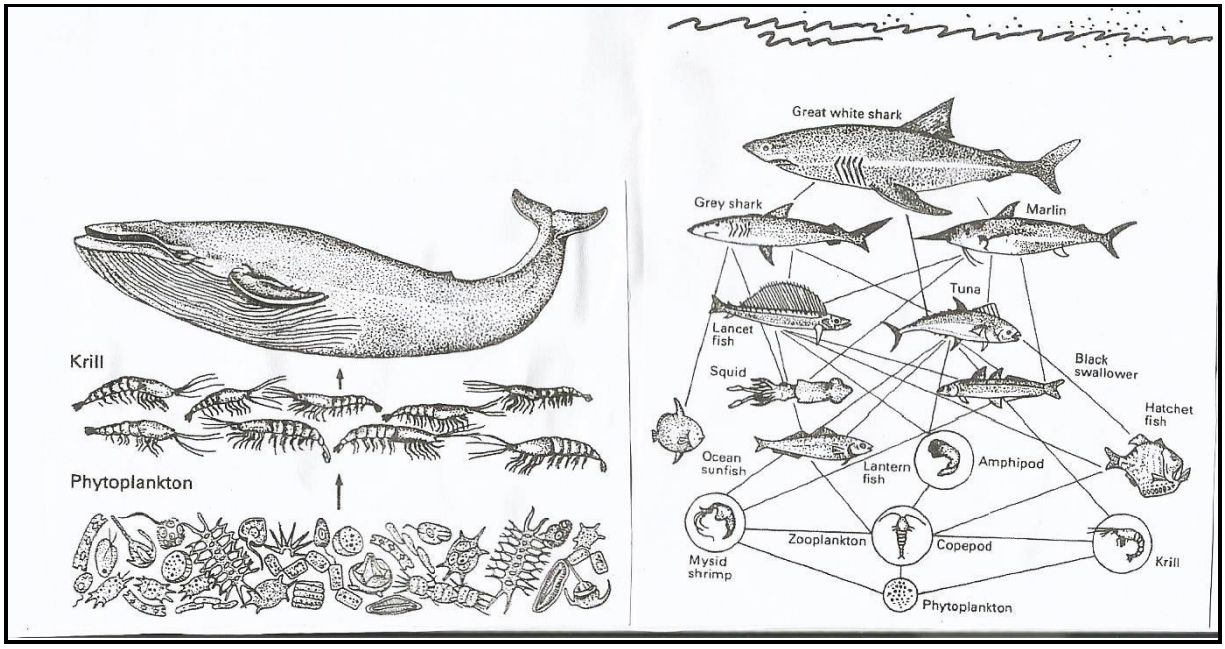


Fig: 12: A simple food chain of the baleen whale and food web of the great white shark

Food chains are not usually simple straight lines. Instead each plant or animal may link with and be part of many other food chains. This more complicated relationship is called a food web. A food web summarises the living part of an ecosystem.

All living things are connected to each other in food chains and food webs. That is why upsetting one part of an ecosystem can produce huge effects somewhere else. The way in which the numbers of plants and animals in an ecosystem depend upon each other is called the **Balance of Nature**.

Exploitation of ocean resources

The ocean is full of both food and energy resources. Most of the ocean's food resources are harvested from the continental shelves using different methods.

Fish and crustaceans are caught with lines, nets and traps. The ever increasing need for food because of rapid growth in world population and improved technology in harvesting of fish resources has led to a dramatic decline in the fish population. Many of the long established fishing grounds of the world have been overfished.

Fishing is now taking place far out to sea, beyond the continental shelf in the waters of the continental slopes and ocean depths. Large fishing nations such as Japan, Russia and the USA have fleets of **trawlers** that operate in these areas using the latest technology such as:

- Special underwater radar equipment to locate and track schools of fish.
- Lights and electric currents which are sent into the water on a large tube – the light attracts the fish and as they swim towards it the electric current stuns and kills them, a powerful pump scoops up the fish.
- Spotter aircraft to locate fish
- Large processing ships on which the catch is cleaned and canned or frozen – these large ships can stay at sea for many months and act as a base from which trawlers operate.

Mineral and energy resources are also being explored and mined from the ocean floor. Oil and natural gas are extracted from beneath the ocean floor. Sand and gravel are dredged from the ocean floor. Salt and magnesium are extracted from sea water by evaporation. Oil is the world's most scarce non-renewable resource. Despite its scarcity the demand for oil continues to increase because it provides the fuel to power motor vehicles, aircrafts and ships. It is also used for a wide range of products including plastic and synthetic fibres.

As it became more and more difficult to find oil on land, the shallow waters of the continental shelfs were explored. Today about 20 per cent of the world's known oil reserves

are in these **offshore** areas. Countries such as Australia and the USA have most of their oil and natural gas extracted from the continental shelfs.

How are oil and natural gas extracted from the ocean?

Finding oil beneath the earth's land surface is difficult enough – finding it and extracting it from beneath the ocean is even more difficult.

- A **seismic survey** is used to examine the rock structure beneath the ocean floor (Fig. 13). This gives oil searchers their first clues as to where **oil traps** or reservoirs are located.

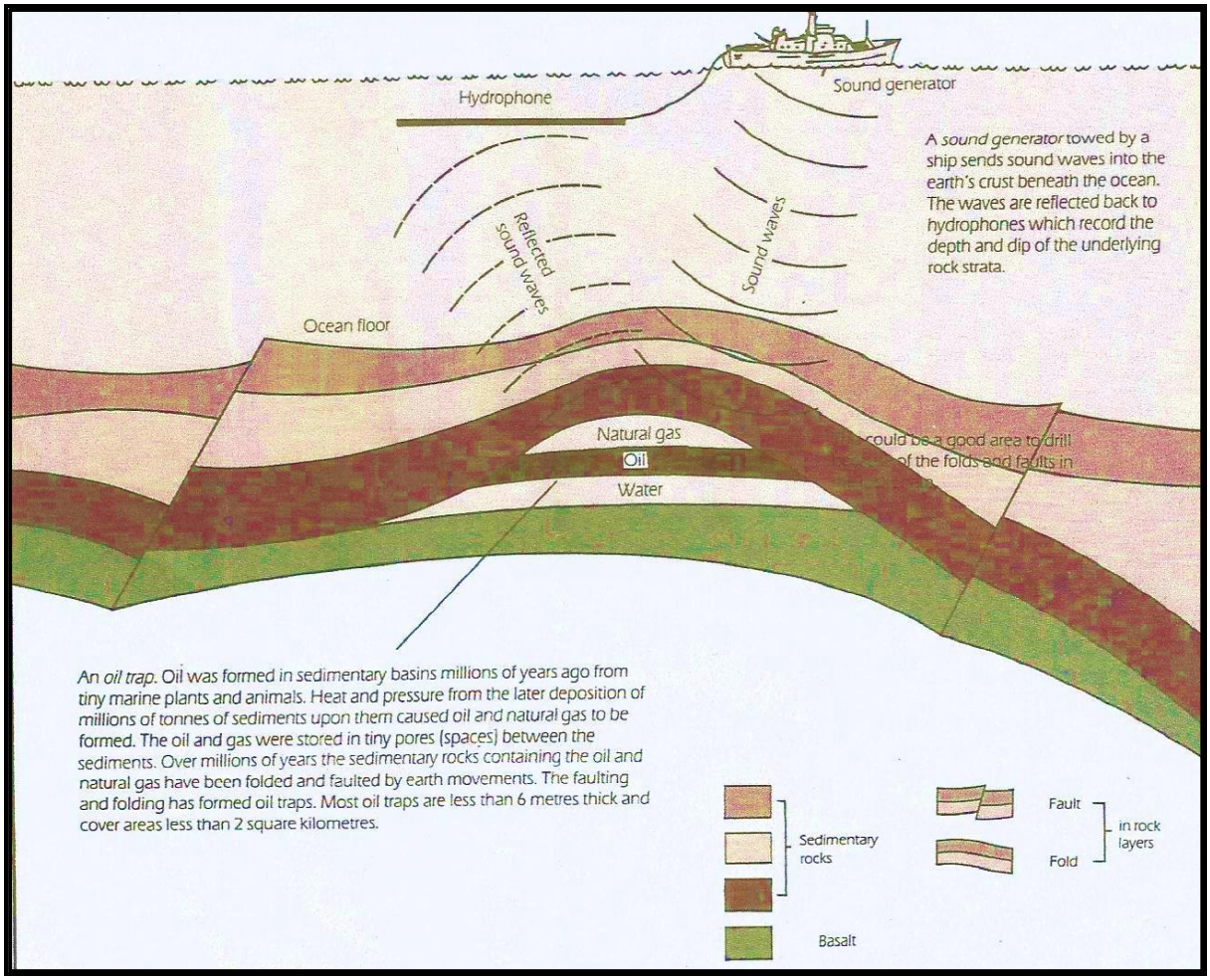


Fig: 13: Seismic survey

- From the survey a number of possible oil trap sites are selected and a series of wild cat wells are drilled using a drill ship or a large drilling rig. The rig floats on the surface. When drilling, the hulls below the water are filled with water which settles the rig beneath the surface.

- If there is oil or natural gas samples are collected to measure the flow and check the quality. If it is valuable enough to be mined, the well is capped and the rig or drill ship leaves.
- Before production begins a drilling platform and supporting jacket are erected above the well (Fig. 14).

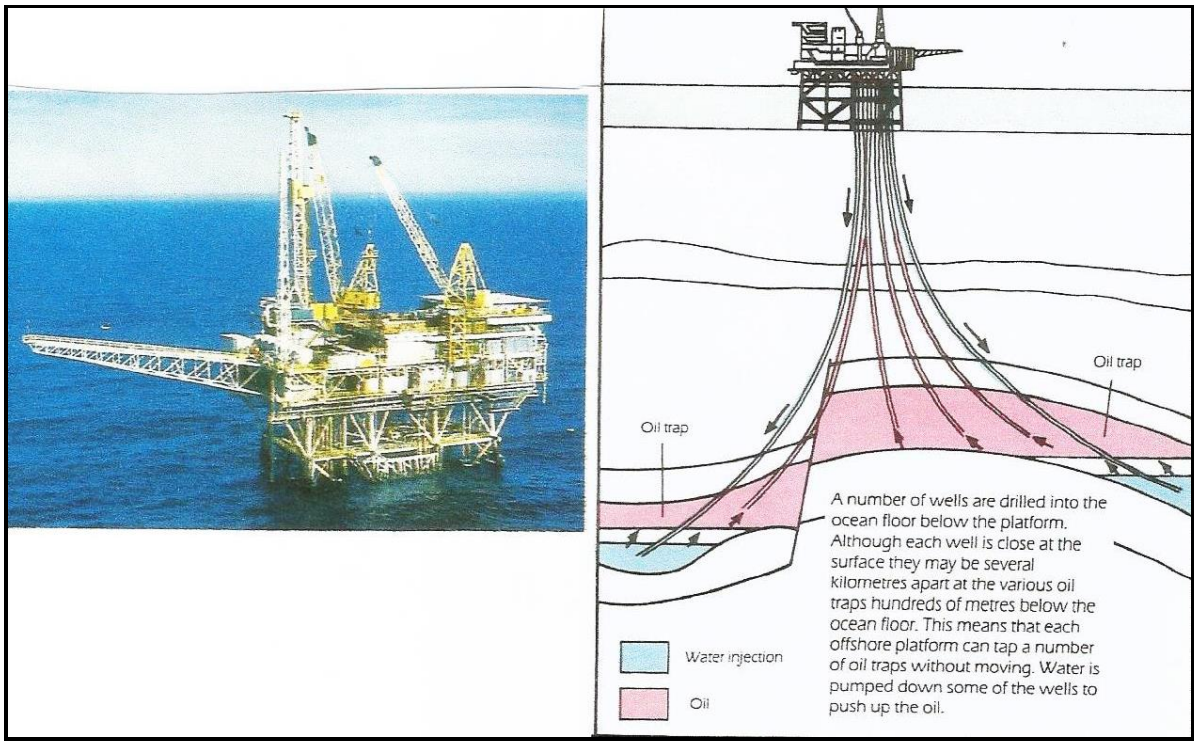


Fig: 14: An offshore platform

- Once established, drilling to extract the oil and natural gas can begin. A method called **directional drilling** is used. This allows the oil and natural gas to be extracted from as many traps as possible.
- The oil and natural gas are transported ashore by pipelines laid on the ocean floor. Once onshore the oil and gas are stored in large storage tanks ready to be refined into petroleum and other products.

Learning Activity 5

1. Define these words:

a. Marine ecosystem_____
_____

b. Benthic life_____
_____

c. Pelagic life_____
_____

d. Photic zone_____
_____

e. Plankton
_____
_____

f. Phytoplankton
_____
_____

g. Zooplankton
_____
_____

h. Nektonic
_____
_____

i. Food chain
_____
_____

j. Food web

_____

_____

_____

2. What is dynamite fishing?

_____

_____

3. Name four other seafood that are harvested from the oceans apart from fish?

_____

_____

4. What does it mean by 'sustainable and unsustainable' use of ocean resources?

_____

_____

CHECK YOUR ANSWERS AT THE END OF THE UNIT SUMMARY

END OF TOPIC 11.3.1

TOPIC 11.3.2: OWNERSHIP AND CONTROL OF OCEANS AND MARINE RESOURCES

INTRODUCTION

Welcome to Topic 2 Ownership and control of Oceans and Marine Resources. This topic contains three lessons and three learning activities.

Objectives or Aims

On completion of this topic you will be able to:

1. demonstrate an understanding of the importance of the ocean as a resource
2. outline the economic and social importance and ownership of the sea areas and resources
3. describe and compare marine systems
4. interpret and create maps and diagrams that illustrate aspects of oceanography
5. investigate and explain issues related to the use of oceans

This topic should be completed within (2) weeks.

If you set an average of 3 hours per day, you should be able to complete the unit comfortably by the end of the assigned week.

Try to do all the learning activities and compare your answers with the ones provided at the end of the unit. If you do not get a particular exercise right in the first attempt, you should not get discouraged but instead, go back and attempt it again. If you still do not get it right after several attempts then you should seek help from your friend or even your tutor. Do not pass any question without solving it first.

11.3.2.1: Ocean / Sea Pollution

Ocean or sea pollution is the dumping and disposing of unwanted waste products into the sea or the ocean. The ocean has traditionally been used as a support for ships, as a source of food, and as a sink for waste. There is such a large volume of ocean that dumping unwanted material is attractive to industries and to cities that wish to avoid paying the extra cost of dumping on land, or do not wish to process or recycle their waste products. More than three quarters of sea pollution comes from sources on land and a third of it is airborne, including some pollutants from vehicle emissions. About 12 per cent comes from ships and boats, as a result of operational discharges, accidents or general rubbish.

Different categories of ocean pollution and their effects

The oceans are becoming more and more polluted from:

- Sewage disposal
- Industrial wastes and slugdes
- Pesticides, herbicides and fertilizers used in farming
- Garbage dumping (includes plastic and general solid waste disposal)
- A wide variety of household and industrial chemicals
- Oil spills

Some of the effects of continuous and excessive dumping of waste into the oceans are:

- Habitat degradation
- Eutrophication (includes algae bloom)
- Toxic pollution
- Aerosol contamination
- Emerging diseases (such as typhoid)
- Coral reef destruction and reef damage

Causes and effects of oil spill

Polluted water not only affects the plant and animal life of the oceans but also affects those animals that get food from the oceans. The most publicised ocean pollutant is oil. Each year nearly 4 million tonnes of oil enter the oceans of the world. Of this, about 2.5 million tonnes

escape into the ocean from waste disposal and run-off from the land surfaces. The rest of the oil enters the ocean:

- From tankers colliding or running aground at sea
- From oil spills which occur when oil is being discharged into storage areas near refineries located in ports or bays.

When oil is spilt in the ocean it stays on the surface because it is lighter than water. Because oil and water do not mix, even small amounts spread rapidly across the ocean surface and then get washed up on large areas of shorelines. Attempts to chemically treat or sink the oil may further disrupt marine and beach ecosystems. If the oil spill is left untreated for a while it floats as a **slick.** Slicks create problems for:

- Surface feeding birds because the oil sticks to their feathers and stops them from flying.
- All sea life near the surface can either be killed or severely damaged by the toxic effects of oil. The oil kills life and harms birds and marine mammals by causing feathers and fur to lose their natural waterproof quality, which causes the animals to drown or die of cold. Also these animals can become sick or poisoned when they swallow the oil while preening (grooming their feathers and fur).
- Beach resorts which depend heavily on tourism.

Oil spills often occur through accidents, such as the wrecks of the tanker Amoco Cadiz off the coast of France in 1978 and the Exxon Valdez in Alaska in 1992.

Major oil spills in history

Type of oil spill	Date	Location	Cause	Effects
Amoco Cadiz	1978	France	An accident caused by human error due to poor navigation.	Loss of marine life and destruction to coastal ecosystems around Gulf of Lions and into the Mediterranean sea.
Ixtoc 1	1979	Gulf of Mexico	An accident caused by human error in navigation.	Second largest oil spill on record. Spilled 530 million litres (140 million gallons)
Gulf War oil spill	1991	Kuwait	Iraqi forces destroyed eight tankers and onshore terminals, releasing 910 million litres (240 million gallons)	Devastating impact on the marine ecosystem around the Arabian sea and the Indian ocean. The largest oil spill ever on record.
Exxon Valdez	1989	USA	An accident	Loss of marine life and wildlife destruction. Environmental damage to Prince William Sound and other areas of Alaska.

Table 1: Major oil spills in history

Learning Activity 6

1. Why have the oceans often been used as dumping grounds?

   _____
   _____
   _____

2. How can ocean pollution affect us?

   _____
   _____
   _____

3. What is an oil slick?

   _____
   _____
   _____

4. Describe the ways in which an oil slick can appear on the ocean surface?

   _____
   _____
   _____

5. What type of damage is caused by oil slicks?

   _____
   _____
   _____

6. What is eutrophication?

   _____
   _____
   _____

7. Explain the term ‘algae bloom’?

   _____
   _____
   _____

CHECK YOUR ANSWERS AT THE END OF THE UNIT SUMMARY

11.3.2.2 INTERNATIONAL TREATIES/AGREEMENTS AND ORGANISTIONS

Ownership and control of oceans and marine resources is now a major global concern. In an overpopulated world with a rapid decline in non-renewable resources such as oil and gas, and an ever increasing demand for huge quantities of energy consumption, it is important for us to address questions such as:

'Why marine conservation and preservation'?

The oceans are a very important part of our environment because

- They are the source of all our fresh water through the water cycle
- They provide us with millions of tonnes of food each year
- They absorb carbon dioxide from the air and help prevent global warming
- They break down much of the waste produced by human activities such as sewage.

Over the past twenty years, people's activities have expanded so rapidly that they have begun to affect the oceans. People are putting so much waste into the oceans (oil, sewage, chemicals etc), that in some places the oceans are becoming unsuitable for living things. For example, the coastal regions of the North Sea between the United Kingdom and Northern Europe are now so heavily polluted that fish cannot live there.

The oceans are not being exploited in a sustainable manner. Fish are being caught in such great numbers that they cannot renew their populations. Many types of fish have been so heavily fished they are at risk of becoming extinct.

It is mainly the developed, industrial nations that are responsible for polluting and overfishing the oceans. The oceans are a resource that **everybody** in the world should share. All countries of the world have a duty to ensure that the oceans are not over exploited. It is important that nations **co-operate** to preserve our marine resources.

International co-operation, treaties and agreements

Disputes and disagreements between nations over their rights to territorial waters have become increasingly common. For centuries there was a tradition known as 'the freedom of the high seas'. This meant that any nation had the right to exploit the resources of the oceans.

This situation has changed as coastal nations have made claims to the ocean waters off their coast. These are called **territorial waters**. Agreements have been made between some countries to control exploitation of the ocean resources. Some international laws and agreements have also been introduced.

The first major international conference under the United Nations Convention on the oceans took place in 1930. Two main issues were raised and have been the centre of debate ever since and these are:

- How extensive should territorial zones be?
- Should the open oceans be a common world heritage?

The third UN Conference on the Law of the Sea (UNCLOS III) provides a model for all coastal nations to follow:

- It placed 40 per cent of the oceans under the control of coastal states.
  These countries were granted territorial waters 12 nautical miles (18 kilometres) from land. This means that any coastal country had territorial rights and ownership over sea surface and below surface from their shores, as far as 18 kilometres out to sea.
- The convention also gives responsibility to each coastal nation for the management of the oceans within 200 nautical miles (370 kilometers) offshore. This is called an Exclusive Economic Zone (EEZ). This means that coastal countries have exclusive rights to manage, protect and develop their marine resources within this zone without interference from others. It has the sole discretion to get into trade agreements with any independent nation to develop and trade its marine resources. Anything outside of this is not within their reach and is outside of their national and international sea borders.
- The convention also encourages nations to co-operate in the conservation and management of living marine resources such as fish, prawns, shell fish. Coastal nations must now make laws to prevent industrial waste from polluting the oceans and destroying the marine life.
- Papua New Guinea is one of the 159 countries that have signed the convention. It is important that people in PNG are aware that they have a responsibility to conserve their marine resources within the EEZ.
- Of the remaining 60 per cent of the oceans which is outside national EEZ is international territory. This seabed area and its marine resources have been declared the **common heritage of mankind**. Any mining of the seabed that takes place in this international zone must be controlled by the **International Seabed Authority**.

This proposal led to disagreements. The developed world countries are reluctant to share their technological expertise in deep-ocean mining of future resources such as manganese nodules, with the developing nations.

Several major maritime nations including the USA and the UK have refused to sign any such declaration. It seems that this proposal and others which aim to better manage the oceans have little future.

Papua New Guinea is a signatory to several international treaties and agreements:

- International Maritime Organization – it provides surveillance, monitors and manages all shipping and navigation issues worldwide.

- United Nations Convention on the Law of the Sea – provides and set regulations for all coastal nations to follow. It also carries out regulatory checks on the over exploitation of marine resources by certain developed countries.
  The **United Nations Convention on the Law of the Sea** (**UNCLOS**), also called the **Law of the Sea Convention** or the **Law of the Sea treaty**, is the international agreement that resulted from the third United Nations Conference on the Law of the Sea (UNCLOS III), which took place between 1973 and 1982. The Law of the Sea Convention defines the rights and responsibilities of nations with respect to their use of the world's oceans, establishing guidelines for businesses, the environment, and the management of marine resources.
  The Convention, concluded in 1982, replaced four 1958 treaties. UNCLOS came into force in 1994, a year after Guyana became the 60th nation to sign the treaty. As of August 2013, 165 countries and the European Union have joined in the Convention. However, it is uncertain as to what extent the Convention will set out customary international law.

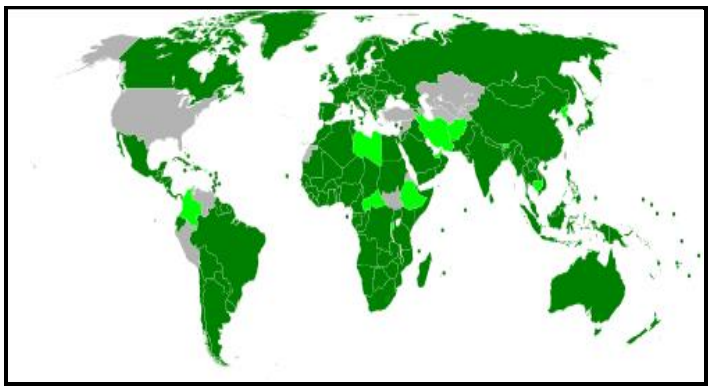


Fig: 15: Countries part of UNCLOS, August 2013

- Basel Convention – the **Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal**, usually known as the **Basel Convention**, is an international treaty that was designed to reduce the movements of hazardous waste between nations, and specifically to prevent transfer of hazardous waste from developed to less developed countries (LDCs).
  It does not, however, address the movement of radioactive waste. The Convention is also intended to minimize the amount of toxicity of wastes generated, to ensure their environmentally sound management as closely as possible to the source of generation, and to assist LDCs in environmentally sound management of hazardous and other wastes they generate.
  The Convention was opened for signature on 22 March 1989, and entered into force on 5 May 1992. As of February 2014, 180 states and the European Union are parties to the Convention. Afghanistan, Haiti, and the United States have signed the Convention but not ratified.

As of 2014 there are 181 parties to the treaty. The UN member states that are not party to the treaty are Angola, Burma, East Timor, Fiji, Grenada, Haiti, San Marino, Sierra Leone, Solomon Islands, South Sudan, Tajikistan, Tuvalu, United States, and Vanuatu.

- Marpol Agreement – **Marpol 73/78** is the **International Convention for the Prevention of Pollution From Ships, 1973 as modified by the Protocol of 1978**. ("Marpol" is short for marine pollution and 73/78 short for the years 1973 and 1978.) Marpol 73/78 is one of the most important international marine environmental conventions. It was designed to minimize pollution of the seas, including dumping, oil and exhaust pollution.
  Its stated objective is to preserve the marine environment through the complete elimination of pollution by oil and other harmful substances and the minimization of accidental discharge of such substances.
  The original MARPOL was signed on 17 February 1973, but did not come into force due to lack of ratifications. The current convention is a combination of 1973 Convention and the 1978 Protocol. It entered into force on 2 October 1983. As of May 2013, 152 states, representing 99.2 per cent of the world's shipping tonnage, are parties to the convention.
  All ships flagged under countries that are signatories to MARPOL are subject to its requirements, regardless of where they sail and member nations are responsible for vessels registered under their respective nationalities.
- London Convention – the **London Convention** was a treaty made in 1884 between the United Kingdom, as a paramount power in South Africa, and the South African Republic. The London Convention superseded the 1881 Pretoria Convention.
  Historical Background
  The treaty governed the relations between the ZAR and the United Kingdom, following the retrocession of the South African Republic in the aftermath of the First Boer War.
  Content of the Convention

  The convention incorporated the bulk of the earlier Pretoria Convention, but with two major differences:
  1) **Name of the Country** – it corrected the name of the country, from the Transvaal Territory used in the 1881 Pretoria convention, to the **South African Republic** at the request of the South African republic Volksraad.
  2) **Suzerainty** – the main and most important aspect of the London Convention is that British suzerainty (*dominion*) over the South African Republic, was relinquished (*given up*).

The Papua New Guinea government is very much aware of issues of climate change and global warming affecting some of its island communities such as Manam and Kataret Islanders. It is committed to adhere by these agreements and is enforcing these regulations through organisations such as:

- National Maritime Authority
- National Fisheries Authority
- Office of Climate Change and Monitoring

- Department of Mining and Petroleum
- Department of Environment and Conservation

Activity 7

1. What does the phrase 'Common Heritage of Mankind' mean?

   _____
   _____
   _____

2. Explain the importance of the EEZ to all coastal nations?

   _____
   _____
   _____

3. What are territorial waters?

   _____
   _____

4. What does the abbreviation UNCLOS stand for?

   _____
   _____

5. Define these terms
   a. Exploit

      _____
      _____

   b. Heritage

      _____
      _____

   c. Off-shore

      _____
      _____

   d. On-shore

      _____
      _____

CHECK YOUR ANSWERS AT THE END OF THE UNIT SUMMARY

11.3.2.3: Indigenous Rights to Seas and Resources

What are Indigenous Rights?

Every indigenous coastal community, especially in the islands of the Pacific including Papua New Guinea, have their traditional ownership rights over marine resources, within their traditional fishing and diving grounds.

Throughout generations, there have always been a common understanding and a clear demarcation of sea or coastal boundaries commonly agreed and observed by neighbouring clans or tribes. Any trespassing usually resulted in disagreements and disputes. Of the many island and coastal communities of the islands of the Pacific, there had always been this oral tradition and unwritten law, guided by peoples' morals and ethics that allowed people to respect one another.

There was this state of interdependency that people had the obligation to protect, and preserve one another's resources so that there was enough to support, and help each other in times of disasters or emergencies. There was this spirit of sharing and caring for one another. If people overfished, they always shared with another family so that what was harvested on a particular day was not wasted. With this spirit of community, indigenous people had a way of preserving and conserving their marine resources for the future generation.

Traditional management techniques

Most indigenous communities, though illiterate, used simple technologies that were effective and practical. Some of the techniques that were used include:

- Selective fishing
- Traditional nature friendly techniques such as diving, use of fishing guns, nets, baskets, harpoons
- Reserved specific areas for specific purposes

Why is there a need of management of protected areas?

It is very important that indigenous people participate effectively in the management of protected areas established on their lands or territories. For example, in Papua New Guinea, land is owned by the clan. The land is very important as it supplies all their needs for survival. Without the land, people would perish. Traditionally, resources had always been divided equally among members of the clan.

Today, with increasing population and the increasing demand for resources, Papua New Guineans have a huge problem of resource management. We must think globally and act

locally, when it comes to resource use and management. If people, especially our indigenous communities are not made aware of the fact that, if we don't take positive steps and measures to control the way we consume our resources, they will all run out in less than 50 years. Our future generations will be left with nothing and the world will be a very chaotic place to live.

When people's needs and wants are not met through the resources that are available, the socio-economic impacts will be far greater than the government can handle and even society itself. Socio-economic issues such as:

- Lawlessness and lack of law and order will be on the rise
- Crimes like murder and rape will escalate
- Consumption of drugs, alcohol and substance abuse will increase.
- Unemployment rate will increase

Papua New Guinea Conservation Laws

Papua New Guinea's marine environment can be affected by mine waste, sewage disposal, overfishing, and reef damage. The Conservation Areas Act was enacted in 1978 and was passed in 1980. It regulates and governs wildlife management areas. Nothing workable and practical is in place yet about the marine resources and management practices, control and usage within the EEZ. (Exclusive Economic Zone refers to the waters/seas from a Pacific country's shores to about 360 kilometres from the shore)

Problems:

- Some mines dispose of their waste rock into the sea which can cause damage to coral reefs, fish, and other marine resources
- Untreated sewage can cause pollution because it contains poisonous chemicals and bacteria which can lead to disease in both humans and the marine environment.

Possible Solutions:

1. Mines:
    - Keeping waste on the land
    - Using nets to stop mine waste from spreading out to sea(e.g. Ramu Nico)
2. Sewage:
    - Treating sewage before it is released into the sea
    - Preventing industrial waste entering the sewage system
    - Not using chlorine to disinfect the water supply
    - Conserving water

Activity 8

1. Complete the table.

Papua New Guinea Fishing Methods	
Traditional	**Modern**

2. Briefly explain these concepts.

A. Deep Sea Mine Tailings?

_____
_____
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B. Deep Sea Mining?

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CHECK YOUR ANSWERS AT THE END OF THE UNIT SUMMARY

END OF TOPIC 11.3.2

TOPIC 11.3.3: USE OF OCEANS

INTRODUCTION

Welcome to Topic 3. Use of Oceans. This topic contains six lessons and six learning activities.

Objectives or Aims

1. demonstrate an understanding of the importance of the ocean as a resource.
2. outline the economic and social importance and ownership of the sea areas and resources.
3. interpret and create maps and diagrams that illustrate aspects of oceanography.
4. investigate and explain issues related to the use of oceans.

This topic should be completed within (4) weeks.

If you set an average of 3 hours per day, you should be able to complete the unit comfortably by the end of the assigned week.

Try to do all the learning activities and compare your answers with the ones provided at the end of the unit. If you do not get a particular exercise right in the first attempt, you should not get discouraged but instead, go back and attempt it again. If you still do not get it right after several attempts then you should seek help from your friend or even your tutor. Do not pass any question without solving it first.

11.3.3.1: Fishing Methods and Their Sustainability

The planet earth's various oceans form one single ecosystem which covers 361 million square kilometres, or 70% of the earth's surface. Exploitation of renewable and non-renewable resources has steadily increased. No sooner do we realise that their potential are threatened by over-exploitation.

The oceans supply about 80% of all living aquatic resources amounting to 110 million tonnes. The rest comes from inland waters. At sea, production relies to a large extent (80%) on fishing, simply harvesting natural resources.

Fishing is the practice of acquiring fish. It has been common to men since we understood how to use machines. Fisheries and aquaculture are directly or indirectly a source of livelihood for over 500 million people mostly in developing countries like Papua New Guinea in terms of food consumption, employment or economic purposes. This shows the interaction between man and his environment for survival.

Conditions necessary for fish breeding

Environmental conditions necessary for fish breeding:

- sea water contains two very important mineral salts which are sodium chloride and calcium carbonate. They are necessary for the formation of skeletons and bones of some fish species.
- The shallow waters of the continental shelves where cold currents interchange with warm currents.
- The water temperature should not be too hot or too cold.
- There should be an abundance of food and nutrient supply for fish to breed and multiply.
- Areas where corals and coral reefs are dominant.

Methods of fishing used by fishermen

- Traditionally, PNG clans have developed indigenous fishing methods using vines and bamboos sewn together into nets to harvest and share with the entire village. The other method was the use of bamboo spears to go spear-diving, which they usually catch a handful of fish for their families. People also use hooks with baits attached to catch fish.

- Most common modern commercial fishing method is trawling. Trawling is simply towing a net through the water. A trawl net is funnel shaped, and can harvest bottom dwelling fish when dragged along the ocean floor. Pelagic fish can be caught by mid-water trawling, in which the net is towed through the water column between the surface and the bottom.

- Gillnetting can also be used to harvest bottom or pelagic fish, but is a passive fishing method. A gillnet is a wall of netting set in a straight line, equipped with weights at the bottom and floats at the top, and usually anchored at each end. Fish swim through the invisible net and are entangled when their gills are caught in the webbing, hence the name gillnetting. If allowed to drift freely, the method is referred to as drift net fishing.

- Rather than a net, long lining uses baited hooks on off shoots of a single main line to catch any fish at any level. The line can be anchored at the bottom in areas too rough for trawling, or set drift, suspended by floats. It is currently used to catch swordfish.

- Purse seines are walls of netting, used to encircle entire schools of fish or near the surface. A drawstring cable is threaded through the bottom of the net. When the cable is pulled tight, enclosing the fish in a pouch, the catch is hurled on board with a clip net in a process called brailing.

- A weir is a passive fishing method consisting of brush or twine fences permanently attached to the bottom. Two prolonged fences called leaders divert fish to swim voluntarily into successive enclosures known as the heart, pound and pocket.

- Jigging is the setting of a line, with baited hooks or lures that is continually jerked. The motion achieved by a hand or jigging machine induces fish to take the hook.

- Used extensively in whaling days, harpoons are still used today to catch swordfish, shark and tuna. Thrown by hand or shot by mounted guns, harpoons are each tipped with a barb and attached to a long line with a buoy at the end. The line is free of the boat, and fish are followed with assistance of the buoy until they tire and can be hauled aboard. This method involves a hand line or a rod and reel, and sometimes with more than one hook. Line fish are used on commercial ski boats and sometimes larger deck boats. It is a fairly selective method. By varying hook sizes, bait types and carefully selecting localities, species can be specifically targeted thereby reducing by catch. The fish caught are also of very good quality as they are individually handled.

Sustainability and unsustainability of the different fishing methods

All these methods developed have improved the standard of people in terms of catching and storing of fish and other marine resources. However, they all have certain effects on the environment. With the availability of these methods for usage and the advancement of technology in aquaculture and fisheries, the issue of over fishing is a global concern nowadays.

Overfishing is traditionally defined as harvesting so many fish that the yield is less than it would be if fishing were reduced. This has resulted in the oceans declining fish stock and some species of fish are in danger of becoming extinct. The declining number of fish in the oceans has become a real concern for environmentalists and marine scientists. Although the marine resources are renewable, they are limited. Overfishing has reduced some species of

fish to near extinction and has depleted numerous populations of targeted species in particular areas. The depletion in stocks of commercially targeted fish, as well as the depletion of marine species that are accidently caught with targeted species, has changed and disturbed the food web of the world's ocean resources, resulting in a less yield of fish.

There are also other issues and problems which are associated with fishing methods, such as cyanide fishing. In this fishing technique, fisheries squirt sodium cyanide to stun fish without killing them, making them easy to catch. Cyanide fishing on coral reefs began in the 1960's to supply the international aquarium trade. Since the early 1980's, a much profitable business had emerged, supplying live reef fish for the hotels of Hong Kong, Singapore and mainland China. Some 20,000 tonnes of live fish are eaten annually in the restaurants of Hong Kong, for every live fish caught using cyanide, a square meter of the coral reef home is killed.

What is dynamite fishing?

In this fishing technique, dynamite or other explosives are set off under water. The dead fish floating to the surface are then simply scooped up. The explosives completely destroy the underwater environment, leaving it as rubble. Dynamite fishing has massively contributed to the destruction of the South East Asian coral reefs over the past 20 years.

The impact of this issue on PNG

The problem of overfishing and damaging coral reef has been caused by the usage of the most modern commercial fishing methods. They have been recognised both locally and globally. This is so because fishing is carried out in almost all the countries of the world, except those located inland.

The issue of overfishing and damaging of coral reefs can also be found in the waters of PNG. This is evident in Pere village, Titan tribe of Manus province where grouper species of fish found are increasingly rare because of high demand from mainland Asia.

Research done by environmental organisation called Nature Conservancy showed the depleting of fish in PNG waters, Manus Province. Another province facing the same problem is Madang province. Dynamite fishing is illegal but people continue to use this method to fish in the Madang lagoon, a 49 square kilometre body of water averaging 30-40 metres deep and spotted on them were numerous holes which were caused by the usage of dynamite.

Despite the effects these fishing methods have on the environment, there are ways in which we can conserve and sustain them. Sustainable fishery can now, produce consistent output over an indefinite period without damaging the surrounding environment. There are certain institutions, organisations and individuals who work to make sure the fisheries is sustainable for our future generation. Institutions include Department of Environment and Conservation, organisations like Greenpeace, Nature Conservancy, and individual scientists

such as a conservancy scientist Richard Hamilton. There are many organisations and individual environmentalists and conservationists that work for the sustainability of fisheries. These are some of the steps and measures taken by these institutions and individuals to sustain the fisheries in Pere Village in the Manus Province of PNG:

- With the help of Nature Conservancy, Pere Village recently created a marine protected area to prevent overfishing on reefs, where groupers spawn. This is a move that will stabilize fish populations that villagers depend on for their survival. Knowing that their abundance of groupers would eventually catch the attention of commercial fishing operations, they also warned villagers of the dangers posed by live reef fish.
- Nature Conservancy also advised the Pere villagers to take pressure off reef fish which grow slowly and increase the catch of tuna, a fast growing species, giving time for other species to fully yield.
- There is a similar Community Coastal and Marine Conservation Project in Milne Bay Province. It is supported by the global environment facility executed by UNDP and implemented by Conservation International. It aims to promote conservation of marine biodiversity mainly through developing community based management of marine resources.

Whaling and problems associated with whaling

Whaling is cruel, the demand for whale meat is falling and we can't be certain that whale populations can survive large scale hunting as well as the other daily threats they face. Despite bans on commercial whaling and the trade in whale products, Japan, Norway and Iceland still kill 2000 whales between them each year and also continue trade in whale products.

Fig: 16: Whaling

Once it became clear that the numbers of whales being killed were putting whale populations under threat, a ban on commercial whaling (hunting for commercial profit) was introduced in 1986 by the International Whaling Commission.

However, over 30,000 whales have been killed since the ban came into effect because of loopholes that have allowed some countries to carry on whaling. The Whaling Commission currently allows Norway to hunt under an 'objection' to the ban, and Japan uses a loophole which allows countries to hunt whales for 'research' purposes. Iceland claims it is allowed to break the ban also because it left the Commission in 1992 but was 'allowed' to re-join 10 years later under a 'reservation'. Iceland's reservation is contested by many other Commission member states. Between them, these countries kill around 2,000 whales a year, mainly, fin, minke, bryde's, sei, humpback, and sperm whales. There is also the issue of whale product use in cosmetics and health supplements, and whale meal feed.

The Commission also allows Aboriginal Subsistence Whaling (ASW) in some countries. The International Whaling Commission last met in Slovenia in September, 2014.

Table 2: Most endangered marine species in PNG and the World

Species Name	Scientific Name	Group	Range
Adamson's Grunter	Hephaestus adamsoni	Fishes	Papua New Guinea
Australogyra Zelli	Australogyra zelli	Corals, Jellyfish, Sea Anemones	PNG, Australia, Cambodia, China, Indonesia, Malaysia, Philippines, Singapore, Solomon Islands, Taiwan, Thailand, Vietnam
Australomussa Rowleyensis	Australomussa rowleyensis	Corals, Jellyfish, Sea Anemones	PNG, Australia, Cambodia, China, Federated States of Micronesia, India, Indonesia, Japan, Malaysia, Myanmar, Palau, Philippines, Singapore, Solomon Islands, Sri Lanka, Taiwan, Thailand, Vietnam
Black Mogurnda	Mogurnda furva	Fishes	Papua New Guinea
Blackspot Shark	Carcharhinus sealei	Fishes	PNG, Australia, India, Indian Ocean (Seychelles), Indonesia, Kenya, Madagascar, Mauritius, Philippines, South Africa.

Brown-reticulate Stingray	Dasyatis leylandi	Fishes	Australia, Indonesia, Papua New Guinea
Brown-spotted Catshark	Chiloscyllium punctatum	Fishes	PNG, Australia, Cambodia, China, India, Indonesia, Japan, Malaysia, Philippines, Singapore, Taiwan, Thailand, Vietnam
Cantharellus noumeae	Cantharellus noumeae	Corals, Jellyfish, Sea Anemones	Australia, Indonesia, New Caledonia, Papua New Guinea
Coral Catshark	Atelomycterus marmoratus	Fishes	PNG, Bangladesh, Cambodia, China, India, Indonesia, Japan, Malaysia, Pakistan, Philippines, Singapore, Taiwan, Thailand, Vietnam
Coral Trout	Plectropomus leopardus	Fishes	PNG, Australia, Brunei Darussalam, China, Fiji, Hong Kong, Indonesia, Japan, Malaysia, Marshall Islands, New Caledonia, Palau, Philippines, Solomon Islands, Taiwan, Thailand, Tonga, Vanuatu, Vietnam, Wallis and Futuna
Dasyatis fluviorum	Dasyatis fluviorum	Fishes	Australia, Indonesia, Papua New Guinea
Euphyllia paraglabrescens	Euphyllia paraglabrescens	Corals, Jellyfish, Sea Anemones	Indonesia, Japan, Malaysia, Papua New Guinea, Philippines
Glass Blue-eye	Kiunga ballochi	Fishes	Papua New Guinea
Grey Bamboo Shark	Chiloscyllium griseum	Fishes	China, India, Indonesia, Japan, Malaysia, Pakistan, Papua New Guinea, Philippines, Sri Lanka, Thailand

Hooded Carpet Shark	Hemiscyllium strahani	Fishes	Papua New Guinea
Knifetooth Sawfish	Anoxypristis cuspidata	Fishes	Australia, Bangladesh, China, India (Andaman Is), Indonesia, Japan, Korea, Malaysia, Myanmar, Oman, Pakistan, PNG, Philippines, Singapore, Somalia, Sri Lanka, Taiwan, Thailand, Vietnam
Kutubu Tandan	Oloplotosus torobo	Fishes	Papua New Guinea
Lake Wanam Rainbow-fish	Glossolepis wanamensis	Fishes	Papua New Guinea
Oktedi Rainbow fish	Melanotaenia oktediensis	Fishes	Papua New Guinea
Palauastrea ramose	Palauastrea ramosa	Corals, Jellyfish, Sea Anemones	Australia, Cambodia, China, India, Indonesia, Japan, Malaysia, Myanmar, Palau, Papua New Guinea, Philippines, Singapore, Solomon Islands, Sri Lanka, Taiwan, Thailand, Vanuatu, Vietnam
Papuan Epaulette Shark	Hemiscyllium hallstromi	Fishes	Papua New Guinea

Table 2: Most endangered marine species in PNG and the World

Activity 9

1. Complete the table below. You will also need an atlas to do this exercise.

Country	Capital city	Continent	Developed/Developing
Australia	Canberra		
Cambodia			
Madagascar			
Kenya		Africa	
Palau			
Norway			Developed
Iceland			

2. What are the conditions for fish breeding?

_____

_____

_____

_____

3. Name two unsustainable methods of fishing?
   1) _____
   2) _____

4. What is whaling?

_____

_____

_____

CHECK YOUR ANSWERS AT THE END OF THE UNIT SUMMARY

11.3.3.2 Impact of Waste Disposal on Oceans

Marine pollution occurs when harmful chemicals, particles, industrial, agricultural and residential waste, noise or the spread of invasive organisms enter into the ocean. A recent survey of global ocean health concluded that all parts of the ocean have been impacted by human development and that 41 per cent has been fouled with human polluted runoff, overfishing and other abuses.

Pollution is not easy to fix because pollution sources are so dispersed, and are built into the economic systems we depend on. The United Nations Environment Programme (UNEP) mapped the impact of marine pollution over the oceans. The report shows at least 75% of the worlds' key fishing grounds may be affected.

Pollution is often classed as point source or nonpoint source pollution:

- **Point source pollution** occurs when there is a single, identifiable, and localized source of pollution. An example is directly discharging sewage and industrial waste into oceans. Pollution such as this occurs particularly in developing nations.
- **Nonpoint source pollution** occurs when the pollution comes from ill-defined and diffuse sources. This may be difficult to regulate. Agricultural runoff and wind- blown debris are primary examples

There are many different ways to categorise, and examine the inputs of pollution into our marine ecosystems. Generally there are three main types of pollution into the ocean: direct discharge of waste into the oceans, runoff into the waters due to rain, and pollutants that are released from the atmosphere.

Direct Discharge

Pollutants enter rivers and the sea directly from urban sewage and industrial waste discharges, sometimes in the form of hazardous and toxic wastes. Mining for gold, or copper is another source of marine pollution. Most of the pollution is simply soil, which ends up in rivers flowing into the seas. However, copper is a common industrial pollutant that can cause problems with the life history and development of coral polyps, when discharged in rivers.

Land Runoff

Surface runoff from farming, as well as urban runoff from the construction of roads, buildings, ports, channels, and harbours, can carry soil and particles laden with carbon, nitrogen, phosphorus, and minerals. This nutrient rich water can cause fleshy algae and phytoplankton to thrive in coastal areas, known as algae blooms. Algae blooms have the potential to create hypoxic conditions by using all available resources. Polluted runoff from roads and highways can be a significant source of water pollution in coastal areas.

Atmospheric pollution

Another pollution occurs through the atmosphere. Wind- blown dust and debris, including plastic bags, are blown seaward from landfills and other areas.
Two major factors that contribute to the problem of marine pollution:

1) **Plastic Debris** – marine debris is mainly discarded human rubbish which floats on or is suspended in the ocean. Eighty per cent of marine debris is plastic. Discarded plastic bags, six pack rings and other forms of plastic waste which end up in the ocean present dangers to marine lives.

   Many animals that live on or in the sea consume flotsam by mistake, as it often looks similar to their natural prey. Blocking the passage of food and causing death through starvation or infection.

   Toxic additives used in the manufacturing of plastic materials can leach out to the surroundings when exposed to water. Thus, making plastic far more dangerous when in the ocean then it would be on land.

2) **Ship pollution** – ships can pollute waterways and oceans in many ways. Oil spills can have devastating effects. While being toxic to marine life, polycyclic aromatic hydrocarbons (PAHs), the components in crude oil, are very difficult to clean up, and last for years in the sediment and marine environment.

   Discharge of cargo residues from bulk carriers can pollute ports, waterways and oceans. In many instances vessels intentionally discharge illegal wastes despite foreign and domestic regulation prohibiting such actions. Ships also create noise pollution that disturbs natural wildlife.

Impact of pollution on the Marine Ecosystem

- Affects the formation of coral polyps, which in turn affects the formation of most marine organisms
- Algae blooms – the expansion and spread in the volume of algae, bacteria or phytoplankton in coastal areas causing the spread of water borne diseases in coastal communities. For example, cholera, typhoid or diahorrea.
- Increase in chemical composition of the sea water affect the reproduction of fish population.

Impact of pollution on Coastal inhabitants and Island Communities

- Affect their source of protein supply, for instance, decrease in fish population and other sources of food.
- Develop respiratory and intestinal diseases through chemical poisoning, by consuming fish or other sea food that contains the poison toxin in in its system.

Learning Activity 10

1. Write down four possible solutions that can help reduce the impact of waste disposal on oceans.

a. _____
_____
_____

b. _____
_____
_____

c. _____
_____
_____

d. _____
_____
_____

2. Complete the table below.

Solid Waste	Liquid Waste
Pesticides	Oil spills

CHECK YOUR ANSWERS AT THE END OF THE UNIT SUMMARY

11.3.3.3 Impact of Oil and Mineral Exploration of the Ocean Floor

In this case study we will focus on the effects of deep sea mining and how it affects both, the land and sea environments.

Deep sea mining is a relatively new mineral retrieval process that takes place on the ocean floor. Ocean mining sites are usually around large areas of poly-metallic nodules or active and extinct hydrothermal vents at about 1,400 – 3,700 meters below the ocean surface. The vents create sulphide deposits, which contain precious metals such as silver, gold, copper, manganese, cobalt, and zinc. The deposits are mined using either hydraulic pumps or bucket systems that take ore to the surface to be processed. As with all mining operations, deep sea mining raises questions about environmental damages to the surrounding area.

Ever since methods have been developed it has grown to be an essential and important way to obtain valuable underground resources. Oil is the main resource that is extracted from deep sea mining. At most times during the process of extraction, there are complications which lead to pollution. These pollutions at most times lead to the destruction of marine life and pollution of coastlines.

Brief History of Deep Sea Mining

In the mid-1960s the prospect of deep sea mining was brought up by the publication of the Meros' Mineral Resources of the Sea. The book claimed that nearly limitless supplies of cobalt, nickel, and other metals could be found throughout the planet's oceans. Mero stated that these metals occurred in deposits of **manganese nodules**, which appeared as lumps of compressed sediment on the sea floor at deposits of about 5,000 metres. Some nations including France, Germany, and the United States sent out research vessels in search of nodule deposits.

Initial estimates of deep sea mining viability turned out to be exaggerated. This overestimation, coupled with depressed metal prices, led to the near abandonment of nodule mining by 1982. From the 1960s to 1984 an estimated US$650 million had been spent on the venture, with little to no return.

Over the past decade a new phase of deep-sea mining has begun. Rising demand for precious metals in Japan, China, Korea and India has pushed these countries in search of new sources. Interest has recently shifted toward hydrothermal vents as the source of metals instead of scattered nodules.

Environmental Impacts

Because deep sea mining is relatively a new field, the complete consequences of full scale mining operations are unknown. However, experts are certain that the removal of parts of the sea floor will result in disturbances to the **benthic layer**. In addition there will be an increase in **toxicity** of the water column and sediment plumes from tailings.

Removing parts of the sea floor disturbs the habitat of **benthic organisms**, possibly, depending on the type of mining and location, causing permanent disturbances. Apart from direct impact of mining the area, leakage, spills and **corrosion** would alter the mining area's chemical makeup.

Among the impacts of deep sea mining, sediment plumes could have the greatest impact. Plumes are caused when the tailings from mining (usually fine particles) are dumped back into the ocean, creating a cloud of particles floating in the water. **Two types of plumes occur**:

1) **Near bottom plumes** – occur when the tailings are pumped back down the mining site. The floating particles increase the **turbidity** or cloudiness of the water, clogging **filter-feeding** apparatuses used by benthic organisms.

2) **Surface plumes** – cause a more serious problem. Depending on the size of the particles and water current, the plumes could spread over vast areas. The plumes could impact zooplankton and light penetration, in turn affecting the **food web** of the area. As long as miners continue to mine, there will be an increase in pollution over time.

The degree to which humans have contributed to this issue is very high. In fact we humans are the sole cause of such pollutions. Our growing technology and knowledge of the earth, and the drive and curiosity to discover new things often causes or leads to such destructive events. Apart from accidental oil spills the marine ecosystem is also affected by the noise, heat and motion caused by machinery such as drills, and diggers.

This issue is actually accounted for on a global scale. Although accidental oil spills occur away from the shore, the impact of its destructive nature can cause serious complications for both land and marine ecosystems. Therefore, organisations such as Greenpeace have been established to fight exploitation of the marine resources and the destructive processes that are involved.

Impact of this issue on PNG

Currently, the best potential deep sea site, the Solwara 1 Project, has been found in the waters of Papua New Guinea, a high grade copper-gold resource and the world's first Seafloor Massive Sulphide (SMS) resource.

The Solwara 1 Project is located at 1600 metres water depth in the Bismarck Sea, New Ireland Province. Using the latest ROV (remotely operated underwater vehicles) technology, Nautilus Minerals Inc. is the first company of its kind to begin full-scale undersea excavation of mineral deposits. The production began in 2015.

Papua New Guinea's Solwara 1 Project is still in its exploration and early stages of development, it does not have much impact on the ecosystem. However, as time goes and the project develops and grows, it will eventually have an impact on the people and the environment.

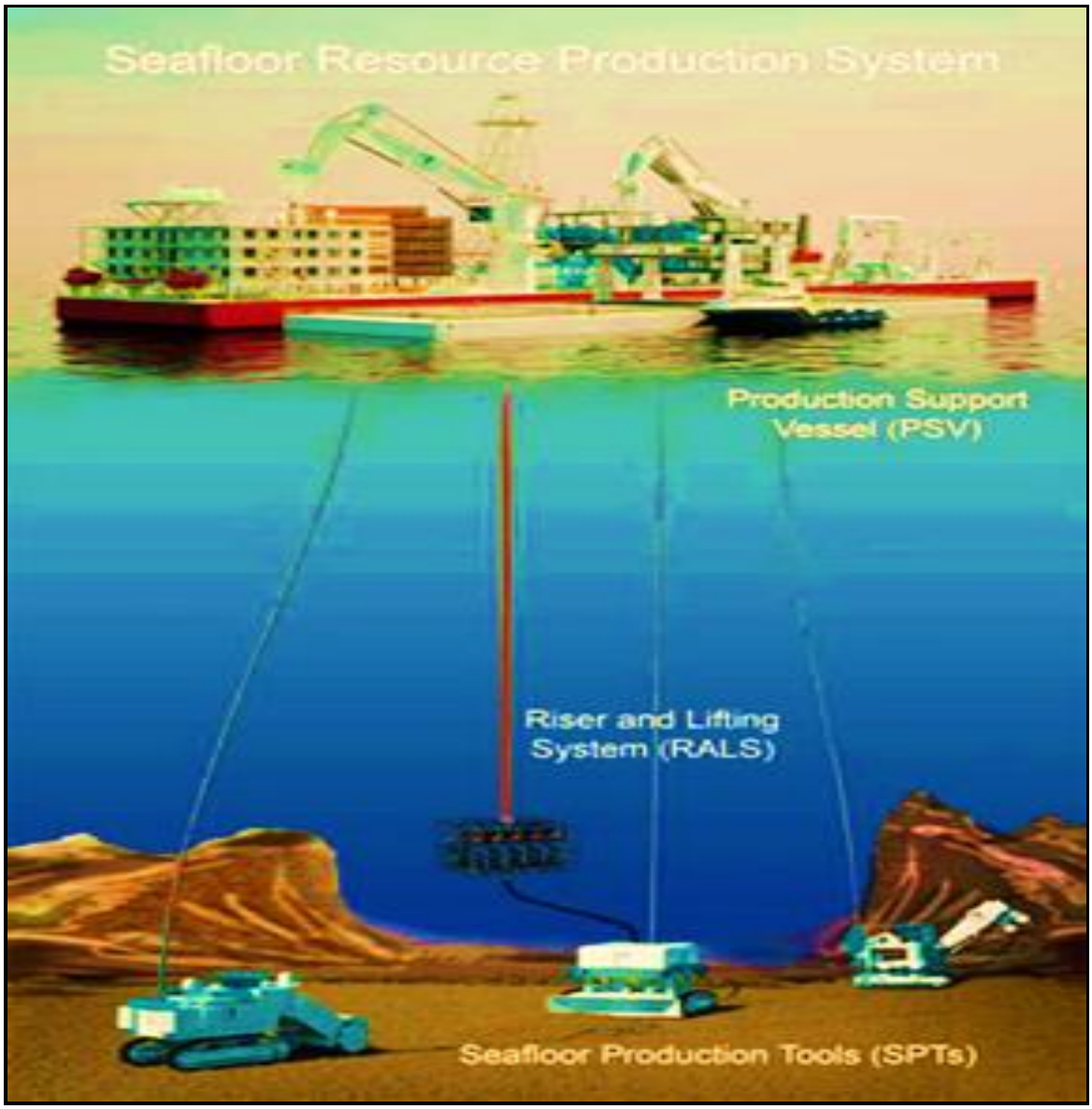


Fig: 17: Diagram showing sea floor mining tool

Learning Activity 11

Define these terms. You can also use a dictionary.

1. Corrosion

   _____

2. Exploitation

   _____

3. Extraction

   _____

4. Filter-feeding

   _____

5. Food web

   _____

6. Mineral

   _____

7. Ocean floor

   _____

8. Oil rig

   _____

9. Pollution

   _____

10. Toxicity

    _____

11. Turbidity

    _____

CHECK YOUR ANSWERS AT THE END OF THE UNIT SUMMARY

11.3.3.4 Effects of Shipping on the Oceans

For many centuries ships have been used to move goods, or **cargo**, across the ocean from one country or port to another. Just as highways link cities on the land, **shipping lanes** are used by ships to transport a wide variety of cargoes across the oceans.

Oceans and the ships that sail on them are the links which allow countries to **trade** with one another. This is particularly important for island countries like Papua New Guinea and Australia.

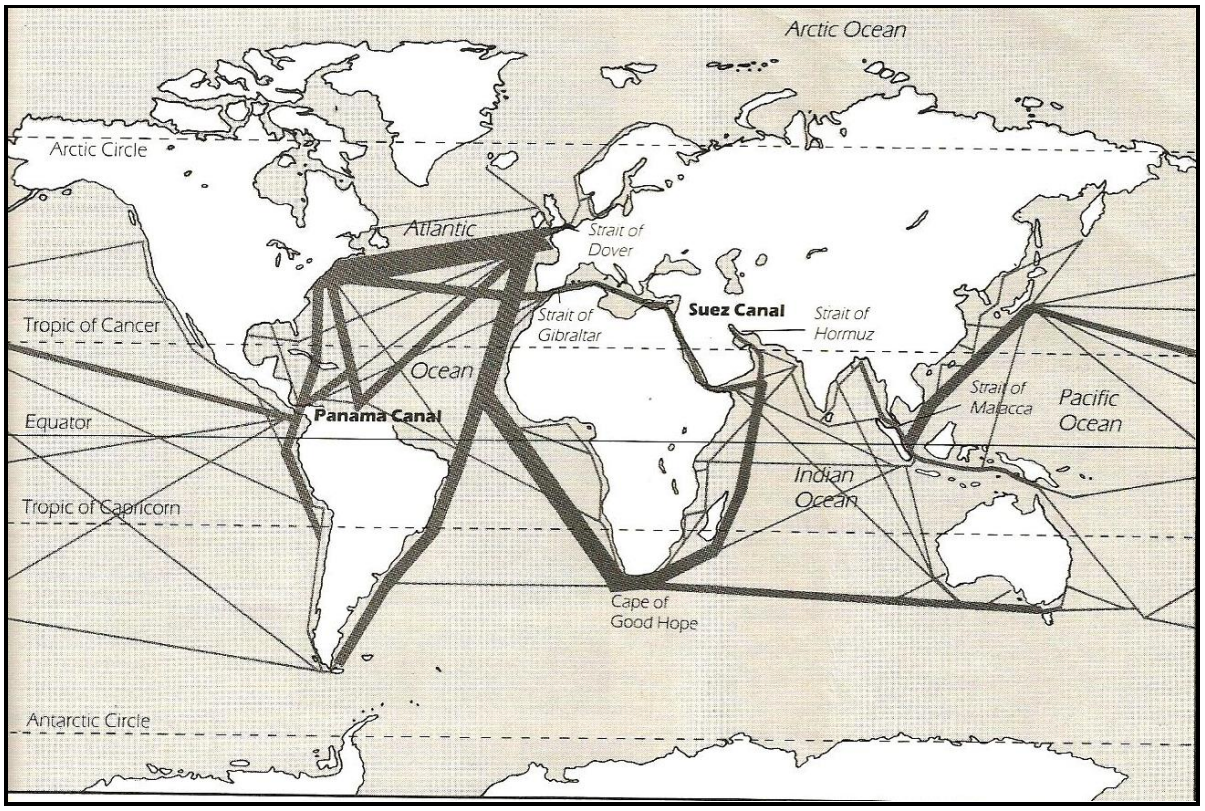


Fig: 18: The world's shipping lanes. The thicker the line the busier the shipping lane.

How do ships carry cargo?

Cargo ships are the most important group of ships today. They carry the fuels, primary products and manufactured goods that people need. The movement of cargo across the ocean from one country to another is very competitive and costly. There are many costs involved:

- **Bunkering**, the fuel needed to drive the ship
- Paying the wages of the crew
- Insurance on the ship (ships are very costly)
- Loading and discharging (unloading) at ports
- Port costs which include pilot fees, tugs and the use of a wharf.
- Administration

To reduce these costs as much as possible, ship builders and shipping companies have:

- Developed larger and more specialized ships to handle different cargoes
- Developed diesel engines capable of using the cheaper oils and at the same time consuming less fuel
- Developed faster methods of loading and discharging cargoes at modern terminals
- Formed **shipping conferences** in which a number of shipping companies join together and use space on one another's ships. This ensures that ships have a full cargo loading and that it is delivered promptly.

Fig: 19: The carriers of the ocean highways

The sea plays a major role in a country's economy through trade. The importance of shipping is not the same as the importance of the ocean. The ocean provide large amount of resources for both maritime places and the marine at large. If the ocean was contaminated through the act of shipping, marine life would decrease or have abnormal reproduction.

Though shipping plays a major role in providing goods and services (employment), it still does not help in the production of resources from the ocean for use. Shipping causes pollution such as oil spill.

Some effects of shipping on the ocean and how it can be resolved:

Source	Cause	solution
Oil spill from chemical and default in ships (polycyclic and aromatic hydrocarbons contained in crude oil)	Pollute the ocean and marine wildlife that are exposed to this source, have development problems, disease and abnormal reproduction cycles	Cannot be cleaned up and damages last for years in sediments and marine environment
Ballast water comes from ships which take in water for the balance of the ship, and given off or disposed in bays or during any stop in the ocean	Causes sicknesses such as cholera through contaminated water being swallowed by people living along the coast	Being watchful of waters taken in and given off. Authorities should be watchful of illegal ships that give off ballast water on the ocean.

Table: 3: Effects of Shipping

Ten Worst Oil Spills by Volume, 1967 – 2002

Name	Location	Quantity (in millions of gallons)	Date
Arabian Gulf/Kuwait	Persian Gulf	380 – 520	1967
IXTOC 1	Mexico	140	1979
Atlantic Express	Tobago	90	1977
Kolva River, Russia	Russia	84	1991
Nowtuz Oil Field	Persian Gulf, Iran	80	1983
Castillo de Bellver	South Africa	79	1983
Amoco Cadiz	Portsall, France	69	1978
ABT Summer	Angola	51 – 81	1991
Haven	Genoa, Italy	45	1991
Odyssey	Nova Scotia, Canada	41	1998
Prestige	Spain	20	2002

Fig: 20: Ten worst oil spills by volume, 1967-2002

When it comes to mixing oil and water, oceans suffer far more than an occasional devastating spill. Disasters make headlines, but hundreds of millions of gallons of oil quietly end up in the seas every year, mostly from non-accidental sources.

Large spills, even though a relatively minor source of ocean oil pollution can be devastating. The same amount of oil can do more damage in some areas than others. Coral Reefs and mangroves are more sensitive to oil than sandy beaches or sea-grass beds. Intertidal zones are the most sensitive. Crude oil cause more problems than others.

Appropriate waste management policies and operational procedures taken by Ports PNG to maintain standards in the handling and storage of toxic chemicals and fluids transported by shipping vessels:

Waste Categories	Ownership of Waste	Steps or Measures taken	Penalties
Chemicals, Toxic & Hazardous Materials	Waste handling, removal and its disposal shall be the responsibility of ship owners, agents and port operators who generate the waste.	PNGPCL shall be pre-notified of any movement of hazardous substances through the port and port facility. Appropriate safety clothing, equipment and apparatus that are consistent with the nature of waste shall be made available and used in handling such waste. Disposal of such waste shall be at the approved designated places in consultation with local waste management authorities.	A fee shall be charged for the management of all ships and port waste by PNG Port Corporation Limited at a rate determined and approved by its management.
Fuels and Oils	Handling, removal and its disposal is the responsibility of ship owners, agents and port operators that generate the waste, includes	When transferring oils or fuels ensure adequate spill containers under the hose connections with earth bonding hat area bunds or wires (to prevent electricity build up), ensure scrubbers are in place or absorbents	Port user employees who put at risk the health and safety of others and the environment by littering or disposed of waste in any manner contrary to his policy and procedures are subject to legal action or disciplinary action with penalties up to and including banning of entry into

	ships bilge discharge in ports.	made available to absorb spills and to avoid risk of contamination to the environment. Disposal of such waste shall be put into designated places in consultation with local management authorities using approved methods.	the company.
Metals and Plastics	Waste handling, removal and disposal shall be the responsibility of PNG Ports Corporation Limited and its agents.	Handling, storage and removal of waste metals and plastics from port facilities, from vessels or generated in ports and disposed at approved disposed sites or recycled.	PNG Ports Corporation Limited Employees who put at risk the health of others and the environment by littering or dispose of waste in any manner contrary to his policy and procedures are subject to PNG Ports Corporation Limited Disciplinary proceedings.
Quarantine Inspections & Certifications	Inspections and decontamination of issues of ships organic waste, duunage and combustions are the responsibility of National Agriculture and Quarantine and Inspection Authority (NAQIA).	Adequate bunds or absorbents must be available to absorb spills and to avoid risk of contamination to persons handling waste and the environment. Disposal of such waste shall be at designated places using approved methods consistent with waste management regulations and standards.	Port user companies who operate without regards to health and safety of people and the environment or dispose waste in any manner contrary to this waste management policy and procedures are subject to penalties specified in appropriate National and International Conventions and Regulations.

Table: 4: Ports PNG waste management policies and procedures

Activity 12

1. What are two negative effects of shipping on the oceans?
   1) _____
   _____

   2) _____
   _____

2. What is a shipping lane?
   _____
   _____

Refer to the map on page 65 to answer questions 3 to 5.

3. Which ocean has the most shipping lanes?
   _____

4. Which two areas of the world are linked by the busiest shipping lanes?
   _____
   _____

5. Which two oceans does the Suez Canal link?
   _____ and _____

6. What is bunkering?
   _____
   _____

7. What does the word trade mean?
   _____
   _____

CHECK YOUR ANSWERS AT THE END OF THE UNIT SUMMARY

11.3.3.5 Impact of Tourism on Coastal Regions and Islands

Tourism is defined as the business activity connected with providing accommodation and entertainment for people who are visiting a particular place for pleasure, business or research and education.

Pacific Islanders have adopted many elements of Western lifestyles however, a few rural isolated places still have minimal western influences. For example, interior of islands such as Papua New Guinea and Fijis' Viti Levu and tiny remote islands. In recent years, rural residents, especially those in coastal villages have been influenced by a growing number of tourists. Western efforts include improved programmes in health and education – the introduction of agriculture and fishing techniques and better transportation and telecommunication networks.

Tourism has become one of the major income earners and employers of local workers in the Pacific. Fiji attracts more tourists than any other Pacific island nations, with 34,000 visitors in 1996. In 1989 tourism surpassed sugar as Fiji's prime source of foreign income and French Polynesia was the second most popular tourist destination. As with trade goods, tourists visit the Pacific islands from former colonial powers and nearby large countries.

In Papua New Guinea, more than 50,000 foreigners visit the country each year. In 2002, 62% of them came to conduct business, 29% for holidays, and 9% to visit friends and family. (PNG Fact Book, 3th Edition; Rannells and Matatier)

Positive impacts of tourism

- Cultural ties and mutual understanding is strengthened
- Provide foreign currency to boost trade
- More jobs or employment
- Provision of more services
- Stimulates economic development
- Preservation of historical sites.
- Ecotourism provides more awareness on the need to use resources sustainably

Negative impacts of tourism

- Loss of cultural identity
- Pressure on resources such as water
- Traffic congestion and overcrowding
- Increased waste disposal
- Disruption of lifestyle of local people
- Benefits of tourism not always evenly shared among people.

Most tourist facilities are owned by foreigners and much of the profit from tourism leaves the Pacific. Furthermore, many products used for tourism such as food, drinks, are often imported and further drain already poor economies.

Tourist Destinations

Some of the scenic features and sites that tourists visit as they travel from country to country:

- Important historical, art and cultural preservation areas such as the Great Wall of China
- Very spectacular and attractive places such as the Ayers Rock in Australia or the Grant Canyon in USA
- Coral reefs and lagoons for fun and recreational purposes
- Experiencing the Art, Culture and Tradition of people such as European tourists attending the Independence shows in parts of PNG
- Important historical cities such as Paris, London, Rome, Jerusalem
- Places and remains of war and war relics such as Rabaul, Wewak and the Kokoda trail in Papua New Guinea
- Important national heritage and preservation sites such as the Great Barrier Reef in Queensland

11.3.3.6 Causes and Effects of Depleting Ocean Resources

What is depletion?

Depletion basically means that when something is reduced by a large amount so that there is not enough left for later use. For example, ozone depletion or the depletion of fish stocks which can lead to a shortage of certain species of fish.

Ocean Resources

The resources of the ocean can be divided into:

- Food Resources – For example, fish, prawns, lobsters, crabs, shrimp, octopus, all those edible marine life that is harvested from the oceans
- Mineral and Energy Resources – For example, manganese nodules, oil and gas, those energy and minerals that are mined off-shore
- Recreational resources – For example, tools and equipment needed for fishing, diving, skiing and so forth.

Causes of depleting ocean resources

The two major causes of the depletion of ocean resources are natural causes and manmade causes. An example of a natural cause is the issue of climate change and global warming. Examples of manmade causes are

- Pollution
- Overpopulation
- Unsustainable fishing practices such as dynamite fishing

This further results in habitat destruction and loss of marine biodiversity. This eventually leads to implications such as migration of fish species or decrease in number of fish species, which in turn is a threat to food security. In addition, some species eventually become extinct.

Causes of Ocean Pollution

Some of the major causes of pollution in the oceans are activities such as:

- Overfishing and the use of explosives, chemicals and dynamites for fast catches of fish
- Dumping of mine waste and mine tailings into the continental shelves
- Accumulated untreated sewage disposals
- Deep sea mineral exploration and mining

Most of these activities have severe impacts on the marine ecosystems and wildlife and depletes ocean resources.

Impact on the Marine Ecosystem

- Affects the formation of coral polyps, which in turn affects the formation of most marine organisms
- Algae blooms, the expansion and spread in the volume of algae, bacteria, phytoplankton in coastal areas, causing the spread of water borne diseases such as cholera, typhoid, and diahorrea in coastal communities.
- Increase in chemical composition of the sea water affect the reproduction of fish populations

Impact on coastal inhabitants and island communities

- Affect their source of protein supply as a result of a decrease in fish population and other sources of sea food.
- Develop respiratory and intestinal diseases through chemical poisoning by consuming fish that contains the poison or toxin in its system.

UNIT SUMMARY

In this unit of work you have learned about the importance of the oceans, and the marine ecosystems and habitats and most importantly the ocean as a resource. You have also learned to:

- Know about the impact of marine pollution
- Know about possible effects of the exploitation of marine resources
- Know about fisheries and conservation
- Know about the exploration and exploitation of underwater oil and gas reserves
- Know about coastal protection policies
- Know the role of ocean in possible global warming and climate change
- Understand past and present global environment changes as well as possible future changes.

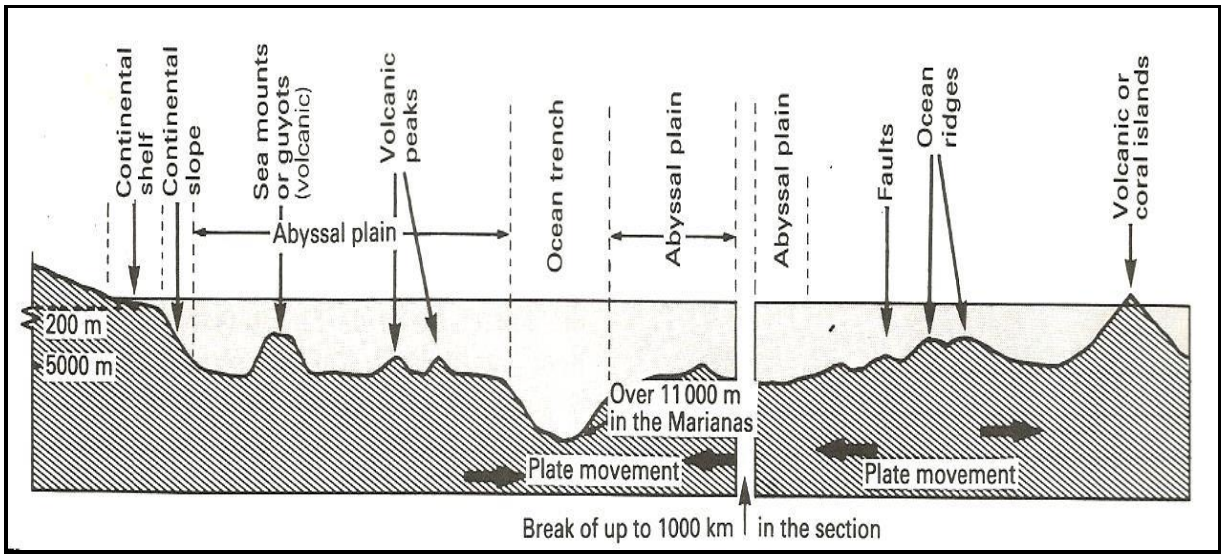
ANSWERS TO LEARNING ACTIVITIES 1-12

Activity 1

1. Continents:
    a. Europe
    b. Asia
    c. North America
    d. South America
    e. Africa
    f. Antarctica
2. Oceans:
    A. Pacific Ocean
    B. Atlantic Ocean
    C. Indian Ocean
    D. Arctic Ocean
3. Seas:
    E. Mediterranean Sea
    F. Red Sea
    G. Arabian Sea
    H. Sea of Japan
    I. Caribbean Sea
    J. South China Sea
    K. Tasman Sea
    L. Coral Sea
    M. Timor Sea
    N. North Sea
    O. Baltic Sea
4. Bays:
    P. Bay of Biscay
    Q. Hudson Bay
    R. Bay of Bengal
5. Gulfs:
    S. Gulf of Guinea
    T. The Persian Gulf
    U. Gulf of Carpentaria
    V. Gulf of Mexico
6. Straits:
    W. Bering Strait
    X. Torres Strait
    Y. Bass Strait
    Z. Strait of Gibraltar
7. The Oceans of the World. Students to label the map.

Activity 2

1. The ocean is a difficult place to explore because at the bottom of the ocean floor, it is so dark and deep and the water hardly moves. Light cannot penetrate beyond 200 meters and the water pressure increases with depth.
2. Oceanographers are scientists who study about oceans.
3. The Pacific Ocean
4. Mariana Trench – 11034M
5. North America, South America, Africa, Europe
6. Mt Everest – 8848M – Nepal in the Asian Continent
7. It provides an abundance of both food as well as mineral and energy resources that is of great economic value.
8. Continental shelf, continental slope, continental rise, abyssal plain, sea mounts or guyots, oceanic ridge, oceanic trench, and oceanic arc.
9. They were formed through plate tectonics by the forces of tension and compression and by Sea Floor Spreading.
10. Cross section of Seabed Landforms



Activity 3

1. Australian plate
2. Centrally located
3. Pacific plate, Antarctic plate, Eurasian plate, African plate

4.

Continental Plates	Oceanic Plates
North American	Pacific
South American	Nazca
Eurasian	Antarctic
Australasian	Philippine
African	Caribbean

5.

Constructive	Destructive
South American and African	Nazca and South American
Caribbean and African	Australian and Pacific
North American and Eurasian	Eurasian and Pacific
Antarctic and African	Australian and Eurasian
Antarctic and Australian	Pacific and Caribbean

6.

Type of Plate Boundary	Description of Change
Constructive	Two plates move away from each other. New oceanic crust is formed, forming mid-ocean ridges.
Collision	Two continental crusts collide and as neither can sink, they are forced up to form fold mountains.
Destructive	Oceanic crust moves towards continental crust, but being heavier, sinks, and is destroyed forming deep ocean trenches.
Conservative /Passive	Two plates move sideways past each other or rub against each other, causing the earth to shake.

Activity 4

1. Horizontal movements are called currents and vertical movements are called tides. Currents are caused by prevailing winds while tides are caused by the rotational effect of the earth and the gravitational pull of the sun, moon and the earth on each other.
2. Sea water is less dense when its level of salinity is high, and the upwelling of bottom water and the lowering of surface water is made easier. The prevailing wind systems help to power the flow of surface currents from areas of high temperature to areas of low temperature and vice versa.
3. Warm currents flow on the western side of continents. They flow from a south westerly direction towards a north easterly direction in the northern hemisphere.
4. West Wind Drift (Peruvian current), Cold Current – Somewhere towards the Polynesian Islands in the Pacific Ocean.
5. Tide is the vertical movement of ocean water. Tides are caused by the gravitational pull of the moon on the earth's ocean surface.
6. A Spring Tide usually has a high tidal range. High tides are usually higher and low tides are usually lower during new moon and full moon, when the gravitational pull of the moon, earth and sun are stronger, because they are all in a straight line and are pulling at each other.
7.
    a. Gyres – giant paths in which ocean water circulate
    b. Spring Tide – high tides are very high and low tides are very low at new moon and full moon.
    c. Neap Tide – high tides are not very high and low tides are not very low during half moon
    d. Tidal Range – difference between high tide and low tide
    e. Inter-tidal Zone – a part of the shore line which is covered by sea at high tide and not covered by sea at low tide
    f. Estuary – a wide part of a river where it flows into the sea

Activity 5

1. Word Definitions:
    a. Marine ecosystem – community of living things found in the oceans
    b. Benthic life – life forms attached to the sea floor
    c. Pelagic life – life forms that are free swimming and flows with the current

d. Photic zone – the upper level of the ocean where sunlight can penetrate below the surface
e. Plankton – microscopic plant and animal life in the ocean
f. Phytoplankton – microscopic plant life
g. Zooplankton –microscopic animal life
h. Nektonic – free swimming pelagic life
i. Food chain – a series of living creatures in which each type of creature feeds on the one below it in the series
j. Food web – a combination of more than one food chains

2. A fishing method where fishermen use explosives and chemicals to harvest fish.
3. Sample Answers: prawns, squid, crabs, lobsters
4. Sustainable use of the ocean resources means ecofriendly ways by which the marine ecosystem is not harmed or damaged by man's activities. Unsustainable use of the ocean resources means ways and methods that harms and damages the marine environment.

Activity 6

1. The oceans are such a vast environment that many people have looked upon them as a dumping ground.
2. We can be affected when we eat fish and other sea food that contains the toxins and poison from the waste that has been dumped into the oceans.
3. An oil slick occurs when the spilt oil drifts and spreads across the ocean surface.
4. From:
   - Tankers colliding and running aground at sea
   - Oil spills which occur when oil is being discharged into storage areas near refineries located in ports or bays
5. Damages such as:
   - The oil sticks on surface feeding birds and stops them from flying and they eventually die of hunger and cold
   - All life forms on the surface are either killed or severely damaged by the toxic effects of oil
   - Affects the tourism industry-especially beach resorts
6. Eutrophication is the depletion of oxygen in sea water. It is the process by which the ocean becomes rich in dissolved nutrients from fertilizers or sewage. This encourages

the growth and decomposition of plant life such as algae which reduces the oxygen level in sea water. This results in harm to some species of fish in particular which needs oxygen for breeding.

7. An algal bloom is a rapid increase or accumulation in the population of algae in an aquatic system.

Activity 7

1. 'Common Heritage of Mankind' means whatever it is, it benefits the entire human race.
2. The Exclusive Economic Zone is very important particularly for the coastal nations because it creates an opportunity for some of them who don't have land resources, especially small island nations to develop their economies through their marine resources.
3. This is the zone where any coastal nation has territorial rights and ownership. Whatever development plans it may have over the marine resources in this zone is entirely up to its development policies and priority areas.
4. United Nations Convention on the Law of the Sea.
5. Word Definitions:

a. Exploit – to treat a person or situation as an opportunity to gain an advantage for yourself

b. Heritage – the history, traditions and qualities that a country or society has had for many years and that are considered an important part of its character.

c. Off-shore – any exploration or mining activities that take place in the sea

d. On-shore – any exploration or mining activities that take place on the land

Activity 8

1.

Papua New Guinea Fishing Methods	
Traditional	**Modern**
Selective Fishing	Using fishing nets
Traditional nature friendly techniques such as diving, use of fishing nets, guns, harpoons, baskets.	Dynamite fishing
Reserved specific areas for specific purposes such as initiation and	Diving

ceremonies.	

2. Word Definitions
    a. Deep Sea Mine tailings – the dumping of mine waste, particularly the soft mine waste which is highly toxic and liquid in nature, into the deeper parts of the ocean, especially into the continental slopes and continental rises.

    b. Deep Sea Mining – the exploration and extraction of oil and gas and other important minerals such as manganese nodules in the deeper oceans below the continental shelves, and around the continental slopes and rises.

Activity 9

1. Complete table

Country	Capital city	Continent	Developed/Developing
Australia	Canberra	Australia	Developed
Cambodia	Hoh Chi Minh City	Asia	Developing
Madagascar	Antananarivo	Africa	Developing
Kenya	Nairobi	Africa	Developing
Palau		Australia	developing
Norway	Oslo	Europe	Developed
Iceland	Reykjavik	Europe	developed

2. The water temperature should not be too hot or too cold. The shallow waters of the continental shelves are ideal for fish breeding.
3. Unsustainable methods of fishing

a. Dynamite fishing

b. Trawling

4. The hunting of whale for commercial purposes.

Activity 10

1. Solutions
    a. Sort out all household and other domestic waste before disposal
    b. Learn to pollute less
    c. Apply the 3Rs – reduce, reuse, recycle
    d. Peer education and awareness on proper waste management behavior and attitude.
2.

Solid Waste	Liquid Waste
Pesticides	Oil spills
Fertilizer residue	Oil tankers' pollution
Sewage	Mine tailings

Activity 11

1. Corrosion - the process by which something especially metal is eaten away or destroyed by chemical actions or rusting.
2. Exploitation - to take advantage of a person or situation for ones' own ends and to make the best use
3. Extraction - the act of removing or uprooting something.
4. Filter-feeding - a way of feeding in which filters are used to catch little organisms, like jellyfish.
5. Food web - a series of organisms in a community, which depend on each other to survive. Also referred to as an ecosystem.
6. Mineral any substance obtained by mining.
7. Ocean floor the bottom of the ocean
8. Oil rig a structure used as a base when drilling an oil well
9. Pollution contamination with poisonous or harmful substances
10. Toxicity poisonous toxic fumes caused by poison
11. Turbidity full of mud and dirt and usually swirling around

Activity 12

1. Negative effects of shipping
    1) Oil spill
    2) Illegal dumping of poisonous and toxic waste
2. Navigation routes followed by ships around the world.
3. Atlantic
4. Europe and North America
5. Atlantic and Indian
6. Fuel needed to drive ships
7. Movement of goods from producers to consumers between countries.

END OF UNIT MODULE 1

NOW YOU MUST COMPLETE ALL THE ASSESSMENT TASKS IN ASSESSMENT BOOK 3 OF THIS UNIT. WHEN YOU FINISH, CROSS CHECK YOUR ANSWERS AND THEN SEND IT TO THE PROVINCIAL COORDINATOR FOR MARKING.

Bibliography or References

1. P.C.H. RANASINGHE (2005) An Introduction to Geography. UPNG Printing, Papua New Guinea.
2. R.B. BUNNET (1965) Physical Geography in Diagrams. Longman ,Pte Ltd, Singapore
3. STAN SQUIRE (1988) Interactions in Physical Geography Today. Oxford University Press, Melbourne, Australia

FODE PROVINCIAL CENTRES CONTACTS

PC NO.	FODE PROVINCIAL CENTRE	ADDRESS	PHONE/FAX	CUG PHONES	CONTACT PERSON		CUG PHONE
1	DARU	P. O. Box 68, Daru	6459033	72228146	The Coordinator	Senior Clerk	72229047
2	KEREMA	P. O. Box 86, Kerema	6481303	72228124	The Coordinator	Senior Clerk	72229049
3	CENTRAL	C/- FODE HQ	3419228	72228110	The Coordinator	Senior Clerk	72229050
4	ALOTAU	P. O. Box 822, Alotau	6411343 / 6419195	72228130	The Coordinator	Senior Clerk	72229051
5	POPONDETTA	P. O. Box 71, Popondetta	6297160 / 6297678	72228138	The Coordinator	Senior Clerk	72229052
6	MENDI	P. O. Box 237, Mendi	5491264 / 72895095	72228142	The Coordinator	Senior Clerk	72229053
7	GOROKA	P. O. Box 990, Goroka	5322085 / 5322321	72228116	The Coordinator	Senior Clerk	72229054
8	KUNDIAWA	P. O. Box 95, Kundiawa	5351612	72228144	The Coordinator	Senior Clerk	72229056
9	MT HAGEN	P. O. Box 418, Mt. Hagen	5421194 / 5423332	72228148	The Coordinator	Senior Clerk	72229057
10	VANIMO	P. O. Box 38, Vanimo	4571175 / 4571438	72228140	The Coordinator	Senior Clerk	72229060
11	WEWAK	P. O. Box 583, Wewak	4562231/ 4561114	72228122	The Coordinator	Senior Clerk	72229062
12	MADANG	P. O. Box 2071, Madang	4222418	72228126	The Coordinator	Senior Clerk	72229063
13	LAE	P. O. Box 4969, Lae	4725508 / 4721162	72228132	The Coordinator	Senior Clerk	72229064
14	KIMBE	P. O. Box 328, Kimbe	9835110	72228150	The Coordinator	Senior Clerk	72229065
15	RABAUL	P. O. Box 83, Kokopo	9400314	72228118	The Coordinator	Senior Clerk	72229067
16	KAVIENG	P. O. Box 284, Kavieng	9842183	72228136	The Coordinator	Senior Clerk	72229069
17	BUKA	P. O. Box 154, Buka	9739838	72228108	The Coordinator	Senior Clerk	72229073
18	MANUS	P. O. Box 41, Lorengau	9709251	72228128	The Coordinator	Senior Clerk	72229080
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21	HELA	P. O. Box 63, Tari	73197115	72228141	The Coordinator	Senior Clerk	72229083
22	JIWAKA	c/- FODE Hagen		72228143	The Coordinator	Senior Clerk	72229085

SUBJECT AND GRADE TO STUDY

GRADE LEVELS	SUBJECTS/COURSES
Grades 7 and 8	1. English
	2. Mathematics
	3. Personal Development
	4. Social Science
	5. Science
	6. Making a Living
Grades 9 and 10	1. English
	2. Mathematics
	3. Personal Development
	4. Science
	5. Social Science
	6. Business Studies
	7. Design and Technology- Computing
Grades 11 and 12	1. English – Applied English/Language& Literature
	2. Mathematics - Mathematics A / Mathematics B
	3. Science – Biology/Chemistry/Physics
	4. Social Science – History/Geography/Economics
	5. Personal Development
	6. Business Studies
	7. Information & Communication Technology

REMEMBER:

- For Grades 7 and 8, you are required to do all six (6) courses.
- For Grades 9 and 10, you must study English, Mathematics, Science, Personal Development, Social Science and Commerce. Design and Technology-Computing is optional.
- For Grades 11 and 12, you are required to complete seven (7) out of thirteen (13) courses to be certified.

Your Provincial Coordinator or Supervisor will give you more information regarding each subject.

GRADES 11 & 12 COURSE PROGRAMMES

No	Science	Humanities	Business
1	Applied English	Language & Literature	Language & Literature/Applied English
2	Mathematics A/B	Mathematics A/B	Mathematics A/B
3	Personal Development	Personal Development	Personal Development
4	Biology	Biology/Physics/Chemistry	Biology/Physics/Chemistry
5	Chemistry/ Physics	Geography	Economics/Geography/History
6	Geography/History/Economics	History / Economics	Business Studies
7	ICT	ICT	ICT

Notes: You must seek advice from your Provincial Coordinator regarding the recommended courses in each stream. Options should be discussed carefully before choosing the stream when enrolling into Grade 11. FODE will certify for the successful completion of seven subjects in Grade 12.

CERTIFICATE IN MATRICULATION STUDIES		
No	**Compulsory Courses**	**Optional Courses**
1	English 1	**Science Stream:** Biology, Chemistry, Physics
2	English 2	**Social Science Stream:** Geography, Intro to Economics and Asia and the Modern World
3	Mathematics 1	
4	Mathematics 2	
5	History of Science & Technology	

REMEMBER:
You must successfully complete 8 courses: 5 compulsory and 3 optional.