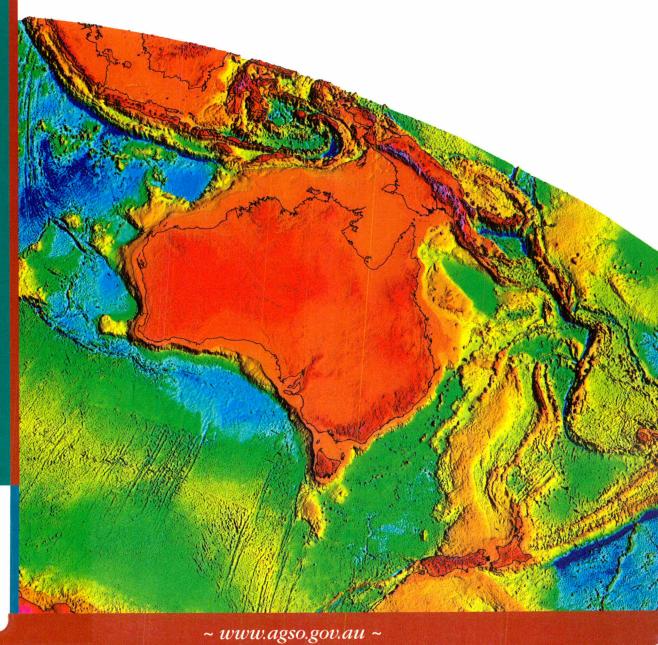
Teacher Notes & Student Activities on Australia's Offshore Territory

Cindy M. Hann





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Record 2001/38

#### DEPARTMENT OF INDUSTRY, SCIENCE AND RESOURCES

#### GEOSCIENCE AUSTRALIA

Chief Executive Officer: Dr Neil Williams

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## 1. BOOKLET OVERVIEW

Australia is a vast continent, often recognised by its very familiar outline. Geologically, however, the real 'Australia' is very different and actually extends far offshore, well beyond the current coastline.

The offshore areas of all continents have been dynamic over time. Throughout Earth's history the processes of climate change, erosion and tectonics have altered the amount of land above sea level around the world. These processes certainly affected the size of the Australian continent and its surrounding islands. These same processes are still in action today.

The political definition of 'Australia' has also changed during human history. The area under Australian jurisdiction has altered due to political decisions, international treaties and conventions that were established during the last two hundred and fifty years since European settlement. 'Australia' does not just consist of the mainland, Tasmania and some offshore islands. Six remote islands and two large segments of Antarctica are now external territories under Australian jurisdiction.

In recent times, by far the greatest influence on areas under Australian jurisdiction was the 1982 United Nations Convention on the Law of the Sea (UNCLOS). Under this Convention Australia was able to declare a 200 nm Exclusive Economic Zone (EEZ) that gave jurisdiction over some 11 million km<sup>2</sup> of water, seabed and what lies beneath.

Under Article 76 of UNCLOS Australia will define the outer limits of its 'legal' extended continental shelf by November 2004, giving possible jurisdiction over an additional area of seabed beyond the 200 nm EEZ. This size of this area is at least 4 million km<sup>2</sup>, equivalent to more than half of the Australian landmass. UNCLOS has altered, forever, our view of what 'Australia' actually is.

This education resource outlines the main provisions of UNCLOS and focuses specifically on the impact of UNCLOS on Australia. This resource also outlines the different research methods carried out to support the submission to the United Nations on the outer limit of Australia's Continental Shelf. Rules governing access to the living and non-living resources within Australia's marine jurisdiction are also discussed.

Three case studies on orange roughy, Antarctica and the north west margin of Australia, are included to outline the main elements of Australia's submission and to discuss key aspects of its importance to the nation. Many facts and statistics have been included to enrich the understanding of teachers and students alike. In addition, student activities will help to further develop an understanding of certain aspects of the United Nations Law of the Sea and its implications. A glossary of relevant terms used in the text is provided to assist in clarifying concepts and content.

### 2. INTRODUCTION



## Activity: How well do you know Australia?

Quick! Draw a sketch map of 'Australia' on a piece of paper. Include all the parts of Australia that you want to, or that you can remember (you don't need to worry about showing any detail such as rivers; just include the outline).

What did you include in your sketch of Australia? No doubt you drew the outline of the mainland and Tasmania to the south. Perhaps you remembered the interesting shape of these landmasses. Did you include any other large islands around the coast, such as Kangaroo Island off South Australia or Fraser Island off Queensland? Your sketch probably represents what the majority of us would call 'Australia'. In fact, what really constitutes Australia is far larger and more complex than most of us realise.

What land comes under Australia's jurisdiction? Over what parts of the ocean does Australia also have jurisdiction? How far from the coast do Australian waters extend? Did you know that more of Australia lies offshore than onshore? What offshore resources does Australia have legal access to, and for what distance from the coast? How far can Australia's fishing fleets travel before they are in international waters, and can they fish in those waters? How are such jurisdictional decisions made and by whom?

Some of these questions are currently the subject of detailed scientific work at Geoscience Australia. By 16 November 2004 Australia will submit to the United Nations, details of the outer limit of its seabed jurisdiction where it extends beyond 200 nm. Using rules and guidelines within Article 76 of the United Nations Convention on the Law of the Sea (UNCLOS), Geoscience Australia is playing a major role in defining the area of seabed over which Australia has legal control, or sovereign rights.

## 3. AUSTRALIA THROUGH TIME

#### a. Ice Age Australia

The shallow continental shelves that surround most continents formed when the sea flooded the edges of landmasses. Therefore the continental shelf is nothing more than the extension of the continent underwater.

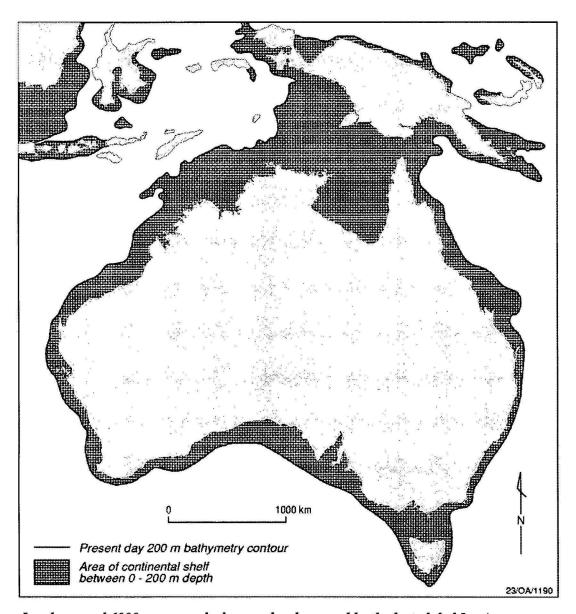
As a continent, Australia has a unique and very familiar shape that is formed by the area of land that is currently exposed above sea level. But Australia has only held this shape for the last 6 000 years or so. Prior to that, the world was experiencing its most recent Ice Age. So much water was trapped in vast areas of continental ice that global sea levels were much lower than today. Lower sea levels exposed areas of the continental shelf around all of Earth's continents.

Global sea levels were so low that the Australian mainland, islands such as Tasmania and the islands of New Guinea formed a single huge continent that stretched from the equator to latitude 45°S. At the current location of the Great Barrier Reef, sea levels 10,500 years ago were 45 metres lower than at present!



## see Activity: Fire and Ice

With the end of the Ice Age, global temperatures increased and most of the continental ice melted. This fed large volumes of water into rivers that entered the sea - global sea levels rose again and flooded the exposed continental shelves.



Land exposed 6000 years ago by low sea levels caused by the last global Ice Age

Land bridges between Tasmania and the Australian mainland started to flood 9,000 years ago, and between Australia and New Guinea about 8,000 years ago. This inundated about 2.5 million km<sup>2</sup> of this huge continent, flooding one seventh of its area. This flooding also resulted in Tasmania, the Australian mainland and New Guinea being isolated from each other. In addition, many new islands appeared as rising sea level isolated high areas of land eg. King Island between Victoria and Tasmania. New islands were also created as reefbuilding organisms constructed atolls and cays in shallow waters such as Ashmore Reef on the North West Shelf.

The edge of the continental shelf for most continents is approximately 200 metres below sea level. This is because the edges of many continents are a similar thickness so this makes their continental margin sit a similar depth below the current sea level.

Therefore the size of the current continental shelf depends on the current sea level. When sea levels are lower, more continental shelf is exposed and the shelf area below sea level is much narrower. With higher sea levels, continental shelves are much wider because more of the continent is under water.



## Activity: Sea Level Change

If sea levels rose in the future, what would happen to the size of Australia's onshore area compared to the size of its continental shelf?

If sea levels fell in the future, what would happen to the size of Australia's onshore area compared to the size of its continental shelf?

### b. Legal Australia

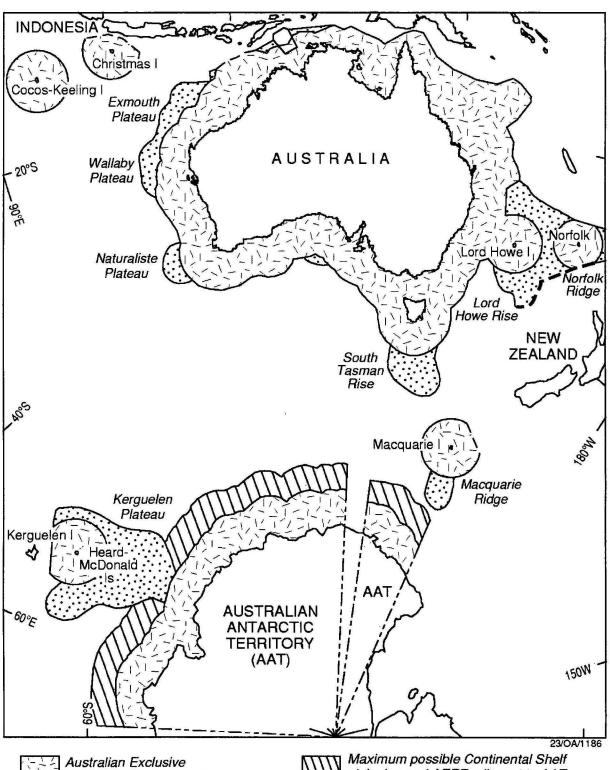
Even though the shape of the Australian continent has remained relatively constant for the last 6,000 years, the shape and size of the area legally under Australian jurisdiction has changed markedly during human history due to non-climatic and non-geologic reasons. The area under Australian jurisdiction has altered due to political decisions, international treaties and conventions that were established during the last two hundred and fifty years of European settlement.

In August 1770 Captain James Cook claimed the eastern part of the Australian mainland, plus Tasmania, for the British Government. This introduced the first formal government controlling Australia. Later the entire continent came under British rule until Federation in 1901 when the first Australian government was established. All Australian territories then came under the control of the state or federal governments.

At various times, Australia's territory included two areas that are no longer under Australian jurisdiction. New Zealand was actually part of New South Wales between 1839 and 1841. New Guinea was also part of Australian jurisdiction until Indonesian rule in western New Guinea in 1962 and Papua New Guinea's independence in 1975.

Today Australia's jurisdiction includes territories that are scattered over a vast area, including a number of islands and two segments of Antarctica. The Australian continent is very large, covering about 7.7 million km<sup>2</sup>. Australia's coastline is approximately 69,630 km in length and this includes the coastlines of some 12,000 islands. Although the majority of these islands are small in area, under UNCLOS these territories allow Australia to proclaim marine jurisdiction over large tracts of the ocean and seafloor that surround them.

As large as the continent is, Australia is dwarfed by the area of its surrounding Exclusive Economic Zone (EEZ) of 11 million km<sup>2</sup>. This may increase by an additional 5 million km<sup>2</sup> with Australia's 2004 submission for extended Continental Shelf under UNCLOS. Therefore, UNCLOS has altered forever, our view of what 'Australia' actually is.



Economic Zone (AEEZ)

Preliminary area of Continental

Shelf extending beyond AEEZ

Maximum possible Continental Shelf claim beyond AEEZ adjacent to AAT (based on 350 nmile cut-off)

- - Boundary to be negotiated/ratified

Proposed marine jurisdiction zones around Australia and its territories. EEZ and areas of extended continental shelf are based on UNCLOS definitions. Extended continental shelf areas are yet to be finalised with the UN's International Sea-Bed Authority.

8

#### **Australian Territories**

Australia's external territories, and islands under the control of individual Australian states, comprise the following seven land areas.

#### a. Australian Antarctic Territory

Australia lays claim to two large segments of Antarctica, forming the largest Antarctic claim by any one country. Areas of Antarctica originally claimed by Britain in 1909 became Australian territory in 1933. Australia has maintained a continuous scientific presence in Antarctica since 1954.

#### b. Christmas Island

Located 1,410 km north west of Australia, Christmas Island covers an area about 135 km<sup>2</sup>. Britain annexed this island in 1888 and it is now Australian territory.

#### c. Cocos (Keeling) Islands

Covering only 14 km<sup>2</sup>, the Cocos Islands comprise 27 islands located 3,685 km west of Darwin. The islands were purchased from the Clunies Ross family by the Australian government in 1978.

#### d. Heard and McDonald Islands

Heard Island and the three nearby McDonald Islands are 4,110 km south west of Perth and cover a total of 412 km<sup>2</sup>. These islands came under Australian jurisdiction in 1947. Heard Island is home to the volcano Big Ben. At 2,745 m, this volcano is the highest point on any Australian territory and Australia's only active volcano. An interesting point - Heard Island is actually closer to Madagascar off the coast of Africa than it is to Perth!

#### e. Norfolk Island

1,676 km north east of Sydney, Norfolk Island was a British colony from the late eighteenth century when it provided materials such as masts and flax for the British Royal Navy. It is now Australian territory.

#### f. Coral Sea Islands

These include a number of islands and cays lying several hundred kilometres east of the Queensland coast between Townsville and Cairns. The islands are an important habitat for many species of seabirds and turtles. As a consequence, Coringa-Herald Cays and Lihou Reef are National Nature Reserves.

#### g. Territory of Ashmore and Cartier Islands

These islands lie in the Timor Sea about 750 km west of Darwin and have a total land area of only 2 km<sup>2</sup>. The islands are associated with large reef complexes; Cartier Island is a sand cay and Ashmore consisting of three vegetated islands. The islands exhibit high biodiversity, and Cartier has been proclaimed a marine reserve and Ashmore a National Nature Reserve.

Two other state-controlled island territories also contribute significantly to the size of Australia's marine jurisdiction:

#### h. Macquarie Island

Located 1,500 km to the south east of Tasmania, the Tasmanian Government administers this small sub-antarctic island of 128 km<sup>2</sup>. In 1998, Macquarie Island was granted World Heritage status for its geological and aesthetic values. It is also an important habitat reserve.

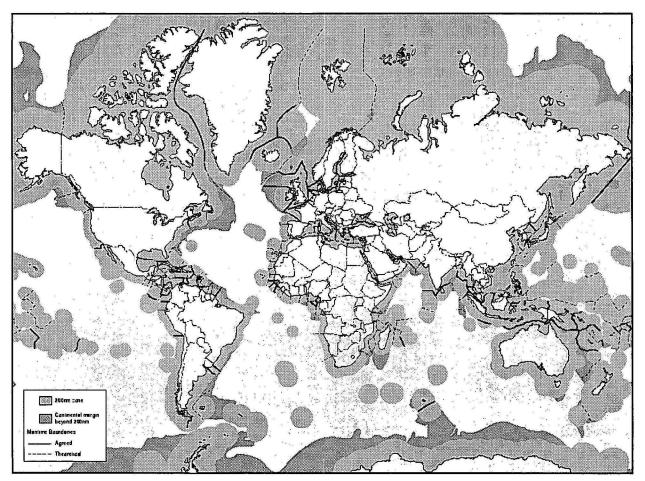
#### i. Lord Howe Island

Located 592 km east of Sydney, Lord Howe Island is administered as part of NSW. It was granted World Heritage status in 1982 for its unique flora and fauna.

#### 4. THE OCEANS

Earth is often referred to as the Blue Planet because oceans cover so much of its surface. Some 149,450,000 km<sup>2</sup> of the Earth's surface is land whilst a huge 360,000,000 km<sup>2</sup> is water. This contrast between land and sea is visible in images of Earth from space.

Every land border of Earth's oceans is controlled by a coastal country and currently, 151 countries borders oceans. In 1982 the United Nations introduced 200 nm Exclusive Economic Zones (EEZs) as part of the United Nations Convention on the Law of the Sea (UNCLOS). This allowed individual coastal countries to claim an EEZ out to a distance of 200 nm from their territorial baseline (usually taken as low water mark). Subsequently, about one third of Earth's oceans came under the jurisdiction of coastal countries.



Agreed and theoretical international maritime boundaries. 200 nautical mile Exclusive Economic Zones (EEZs) and theoretical areas of extended continental shelf (reproduced with permission of the International Boundaries Research Unit, University of Durham)

Some small seas are completely under the control of coastal countries and do not comprise any international waters. Both the 2.76 million km<sup>2</sup> of the Caribbean Sea and 2.52 million km<sup>2</sup> of the Mediterranean Sea are completely contained within the EEZs of the countries that border them – these seas contain no international waters.

The remaining two thirds of the Earth's ocean areas are international waters, not under any country's control.

Australia's vast marine areas form part of three large oceans - the Pacific, Indian and Southern Oceans - and part of the Coral, Arafura and Timor Seas. The oceans within Australia's marine jurisdiction cover all five of the world's ocean temperature zones - tropical, sub-tropical, temperate, subpolar and polar. Australia's marine environment has a wide biodiversity due to the broad range of habitats created by latitude, the characteristics throughout the water column (such as nutrients, temperature and light) and the changing characteristics of the sea floor.

Therefore Australia is responsible for managing huge marine areas across a diverse range of ecosystems. As part of the country's role to manage the marine and coastal environments within its EEZ, Australia also accepts responsibility for a search and rescue area equivalent to one-ninth of the Earth's surface.

#### 5. LAW OF THE SEA HISTORY

The 1982 United Nations Convention on the Law of the Sea (UNCLOS) is an international convention that includes over 300 separate articles (or points). These are the governing rules that all countries party to UNCLOS must follow concerning the sea, its legal boundaries, the use and management of its resources and the activities that can occur within it. There were many developments, over a very long period of time, that led to the eventual creation of UNCLOS. The main developments are briefly summarised here.

Far back in time before maritime laws were first introduced, individual groups and countries decided on their own use of the seas. For instance, in the Northern Territory and Queensland, traditional Aboriginal estates extended from the coastline into the sea. The boundaries of these areas were recorded in stories, artwork and ceremonies that were passed down through generations.

During Roman times, countries were known to make some claims to the seas next to their land. This included fishing rights in certain bays and on coastal land that was used for producing salt.

Territorial claims by coastal countries to their adjacent waters were common throughout Europe in the sixteenth century. However, these claims excluded most of the world's seas. The first reference to the concept of international marine law was in 1609 when Hugo Grotius published a treatise, 'On the Law of Prize and Booty'. Grotius made reference to the concept of international waters. He also stated that the resources of the sea were inexhaustible and available for the unrestricted use of all nations, as long as this did not interfere with other nations' use of the sea. Grotius also realised that a territorial marine zone needed to be established to give each coastal nation some control over their adjacent seas. The width of the territorial sea was generally accepted as 3 nm (~5.6 km), or the distance that cannons of the day could fire! (compare this to the width of each Australian State's current territorial limits).

Apart from some isolated nineteenth century claims to resources beyond this 3 nm territorial limit such as pearl beds far off the coasts of Australia and Ceylon (now Sri Lanka) and Mediterranean sponge beds in Europe, this 3 nm limit remained virtually unchallenged until the 1940's.

The aftermath of the Second World War saw new nations formed and the widespread development of more advanced technology. Governments realised the wealth of resources that were available in the sea, especially fisheries and mineral resources, and began to access them. Unlike 400 years ago, however, modern nations realised that marine resources were not endless and needed effective, sustainable management. To achieve this, international laws concerning the seas were required.

The main event that led to the introduction of modern laws of the sea was one country's policy on marine jurisdiction. In 1945 President Harry S. Truman of the United States of America released his country's policies on seabed resources that came to be known as the Truman Proclamations. Rather than limiting his country's claim to the territorial waters within 3 nm, Truman included the resources of the surrounding offshore continental shelf. Truman stated that the continental shelf was a natural extension of the USA's landmass and was therefore part of his nation's maritime claim. This would mean that the USA could police and protect the resources of its continental shelf, both on and beneath the seafloor.

Truman's announcement led to many other countries making similar claims. In 1952 the South American countries of Peru, Chile and Ecuador each extended their sovereign claim out to 2,000 nm (3,700 km) from their coasts, but unlike the Truman Proclamations, these claims were well beyond the limits of the continental shelf. Such actions clearly demonstrated to the world that an international agreement was needed to clarify jurisdiction over the seas.

12

In 1958 the United Nations held its first conference on the Law of the Sea. A total of 86 countries met in Geneva and adopted four basic international conventions concerning fishing and living resources, the territorial sea, high seas and the continental shelf.

The continental shelf was defined as the seabed and subsoil beyond the territorial sea that extended to a water depth of 200 metres, or beyond that point to the depth to which exploitation of natural resources could occur. Therefore this convention did not actually define the outer limit of the continental shelf but made it subject to the so-called 'exploitability clause' that allowed a coastal state to claim as much of the seabed and subsoils as it was capable of accessing with available technology. This was ambiguous and difficult to define due to relatively rapid advances in technology. This 1958 conference also developed definitions for the baselines on which much of the Law of the Sea debate would focus in later years.

In 1960, the second UN Conference on the Law of the Sea failed to reach significant agreement on fishing rights and the width of a territorial zone. The conferences discussed the need to establish baselines from which to measure the width of the territorial sea but did not set any distance. There was also ambiguity when combining the arbitrary 200 metre depth contour and the "exploitability clause" to define the outer limit of the continental shelf and this caused much controversy. The definition did not match up with the known topography of continental shelves that often extended well beyond the 200 nm depth contour, and it left the outer limit of the continental shelf open to interpretation.

In 1963 such issues were becoming of increasing importance in the international forum when Australia officially joined in the United Nations Conferences on the Law of the Sea. Advances such as deep sea drilling allowed technologically advanced countries to exploit the resources of neighbouring areas that were outside their own jurisdiction. This created further pressure to resolve such controversies.

Additional complexities were added to discussions about areas beyond the limits of continental shelves. At the United Nation's General Assembly in 1967, Ambassador Arvid Pardo from Malta suggested a new treaty to make the deep ocean floor "the common heritage of all mankind". Pardo believed the international community needed to address the introduction of laws to govern the seas beyond national jurisdictions. His idea met with wide support from other countries.

At the United Nation's Law of the Sea sessions in 1974 and 1975, many requests were made about specific requirements of a Law of the Sea document, such as taking into account the needs of land-locked countries. There was general agreement on a 12 nm (~22.2 km) territorial sea and a 200 nm (~370 km) 'economic resource zone'.

Later, the 1978 conference modified the 200 nm zone to an Exclusive Economic Zone (EEZ). Many countries wanted the legal continental shelf limit to coincide with the 200 nm EEZ. However, a small number of influential countries with continental shelves wider than 200 nm pushed for a definition that could extend beyond the EEZ. Most importantly, formulas were

also developed to define features of the continental margin beyond 200 nm, ie. how to recognise the continental shelf, slope and rise that were the vital components of most continental shelves.

It was not until 1981, after nine further conference sessions, that the first Draft of the Law of the Sea Convention was produced. Even after exhaustive discussions, agreement could not be reached on some text and this was subsequently excluded. Some of the original baseline definitions that were suggested during the first law of the Sea conference in 1958 were adopted in this draft.

The final United Nations Law of the Sea document was 'opened for signing' to countries on 10 December 1982. All member countries of the United Nations are eligible signatories to UNCLOS, whether or not they have a coast. Australia signed the UNCLOS document on 16 November 1994.

By 31 March 2000, 158 Member States (countries) were signatories to UNCLOS, expressing agreement with the text. Of those 158 countries, 132 were 'Parties' to UNCLOS, meaning that they agreed to be bound by the Convention.

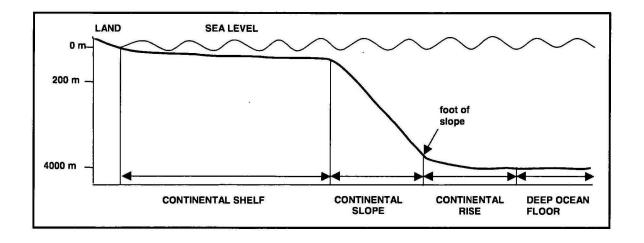


## Activity: Time for UNCLOS

Read the history of events that led to the development of UNCLOS. Identify eight key events that you consider were the most important in creating UNCLOS. Construct a timeline summary using these eight points.

## 6. CONTINENTAL SHELF ADVENTURE

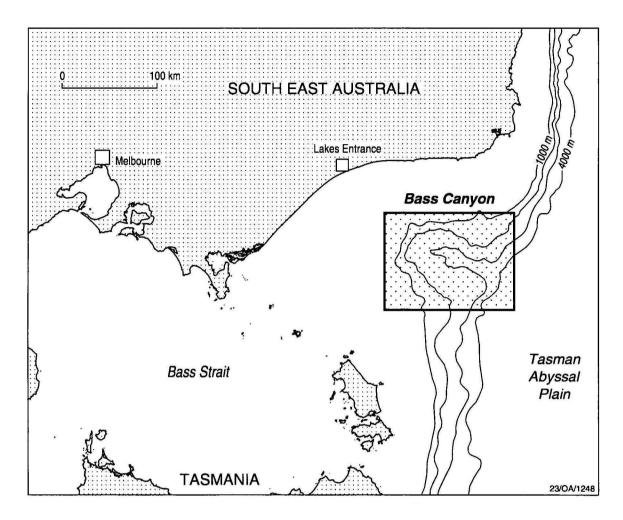
Most people have little inkling of what lies beneath the sea, beyond the familiar coastlines and shallow ocean waters where we sail, fish, snorkel or scuba dive. Far from shore lies an unfamiliar marine environment of changing topography and geology, home to a wide variety of organisms.



Imagine you are about to undertake a fascinating journey to discover Australia's offshore areas first-hand. You struggle into old-fashioned deep sea diving gear, complete with diving helmet and a powerful underwater lamp. Fresh air rushes into the helmet pumped through a very long hose from a boat that will follow wherever you go. You start this journey on the beach at Lakes Entrance, about 250 km east of Melbourne; it is time for your undersea adventure to begin!

You begin walking, straight out into the sea, heading east-south-east. You are jostled by the breaking waves as you gradually get deeper and deeper, until the water rises over your head. Waves keep buffeting you until you are beyond the surf zone. Diving weights keep you submerged so you walk instead of swim and the air hose keeps you breathing normally. Welcome to the marine world!

As you turn on the lamp, a powerful shaft of light penetrates the greenish gloom. Looking ahead through turbid water you can just make out the sea floor sloping gently downwards, far into the distance. This is the continental shelf, an area of very gently sloping land with a width of about 15 to 500 kilometres that encircles the continent. Your walk will take a long time because this relatively flat continental shelf extends for about 100 kilometres from the coast near Lakes Entrance.



Location of Bass Canyon on the edge of the continental margin, south eastern Australia

For most of this distance the shelf is about 100 to 200 metres below sea level. Looking above your head, you see the glow of daylight receding as you go beyond the reach of sunlight. Soft sand and mud beneath your boots are stirred up with each step and add to the deepening gloom. Now it is dark. The torch is your only source of light and it does not penetrate far. Occasionally you disturb a fish resting place on the seafloor and it darts away from you. These fish and the few other sea creatures of the continental shelf are your only companions.

The walk continues across the increasingly sandy floor of Bass Strait, with a 200 meters column of water rising above your head. The seafloor hardly changes, except for an occasional outcrop of rocks or groups of bottom dwelling fish that flash into view.

One hundred kilometres from your starting point the journey changes. The gentle slope on which you have walked since leaving Lakes Entrance begins to steepen quite quickly. You approach the edge of the continental shelf and begin to descend the continental slope.

Take great care! One slip and you could end up in the vast Bass Canyon, a submarine canyon that cuts deeply into the seabed between Victoria and Flinders Island in Bass Strait. This canyon runs south eastward and is about 3000 metres deep and 10 kilometres wide at its base. You avoid the small canyons that feed into Bass Canyon like tributaries into a river. Such canyons are either deep, relict river valleys carved when sea levels were lower, or valleys cut

by recent streams of erosive, shelly sand carried offshore by rivers that cascades down the continental shelf. As these sediments reach the bottom of the canyons they spread out to form large, fan-shaped layers that extend far beyond the continental margin and out over the deep abyssal plain.

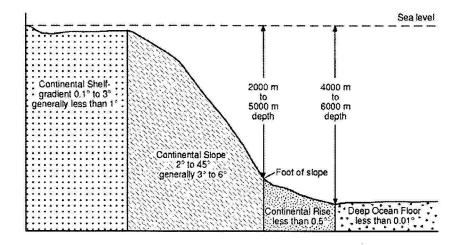
You are struggling against gravity and breathing heavily. It is cold inside your diving suit but you still sweat profusely due to the exertion of your descent. You scramble almost 4000 metres down the continental slope, safely beside Bass Canyon. Now your descent becomes easier. The slope quickly decreases as you approach the continental rise. Sand and mud cascade off the edge of the continental shelf, career down the continental slope and was dumped abruptly at the bottom of the slope. Over time, these sediments build up to form a wedge shaped pile called the continental rise.

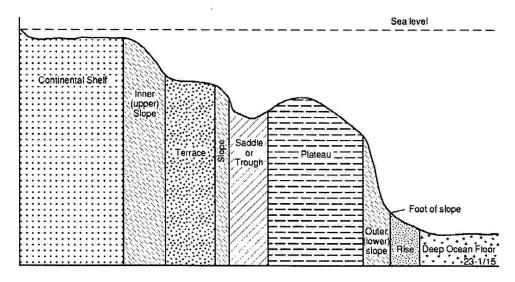
You stagger down the gentle slope, through the surface layer of soft sediment. The slope becomes more and more gentle until finally, after 200 kilometres of walking, you have reached the vast flat plains of the deep ocean floor beyond the edge of Australia's continental margin. You are no longer on the Australian continent and no longer in Australian waters.

## 7. DEFINING THE CONTINENTAL MARGIN

As we have learned, each continent is surrounded by a continental margin. This area beneath the ocean is the extension of a landmass such as a continent or island. Under UNCLOS the continental margin includes the continental shelf, slope and rise. It does not include any of the deep sea floor beyond the continental rise.

Australia's continental shelf covers an area of about 2 million km<sup>2</sup>. The continental shelf is continuous under the water with Papua New Guinea to the north and the island of Tasmania to the south. The width of the continental shelf around Australia ranges from approximately 15 to 500 km and is less than 200 metres deep. However, the average depth of the continental shelf is only 100 metres. The continental shelf is very wide around parts of Australia such as east of Mackay in Queensland, in Bass Strait where the remnants of a land bridge between Victoria and Tasmania lie beneath the water, in the Great Australian Bight, along the north western coast north of Barrow Island and in the Gulf of Carpentaria. The east coast between Brisbane and Mallacoota, the South Australian coast east of Kingston and the Western Australian coast south of Geraldton has a much narrower continental shelf.





Generalised cross-section from the coastline to the deep ocean floor, showing the topography of simple and complex continental margins.

At the edge of the continental shelf the slope of the seabed increases rapidly and this is known as the continental slope. At the base of the continental slope the gradient changes again and becomes more gentle. This is the continental rise and it is usually formed by a wedge-shaped pile of sediments that collects at the base of the slope. The rise ends where it meets the flatlying deep ocean floor. This is the simple topography of a continental margin

However, many continental margins are more complex than this simple example. In some offshore areas, Australia's geologic continental margin extends beyond the continental shelf, slope and rise. It includes a complexity of various plateaus, terraces, rises, saddles and troughs within the continental slope around Australia and its island territories. This more complex topography has created the need for detailed studies of Australia's offshore areas to ascertain the nature of the transition from continental margin to ocean floor. One example of this type of complex offshore margin is the North West Shelf in Western Australia (see case study).

### 8. EARTH'S OUTER SKIN

The application of the United Nations Convention on the Law of the Sea (UNCLOS) depends on many factors, one of which is the shape and composition of the seafloor and subsurface. Countries are only allowed to make submissions under UNCLOS based on areas of extended continental shelf that comprise extensions of their landmass ie. their continental crust. Countries are unable to make submissions based on areas of oceanic crust that make up most of the deep sea floor and mid ocean ridges.

Deep ocean floor composed of ocean crust cannot be part of a submission on areas of extended continental shelf, even if it falls within the 350 nm limit from the territorial baseline or the boundary that is 100 nm from the 2500 metre isobath (depth contour). Therefore defining the boundary between continental and ocean crust is very important as it contributes to identifying the outer limit of the continental margin under Article 76 of UNCLOS.

To understand the continental margin we need to review the characteristics of Earth's outer skin, the crust, and the processes that create and shape it. In particular, we need to know what the crust is like beneath the sea compared to the crust beneath continents.

#### a. Dry Earth?

Imagine we could temporarily remove the oceans and seas from Earth. If we could dig beneath the loose sands and muds that blanket the dry seafloor, we would reach the crust, the first of Earth's internal layers. The crust comprises the 'land', made up of seven large continents and many smaller islands, and the now-dry ocean floor.

An Earth with no oceans would be dominated by a vast, flat area called the abyssal plain that normally underlies the deep ocean, between 3-6 kilometres below sea level. Elsewhere the exposed seafloor would consist of long mountain ranges (mid ocean ridges), deep, long slashes in the seafloor (trenches) and huge underwater volcanoes (seamounts).

Most people know that, at 8,848 metres above sea level, Mt Everest is the highest point on Earth. But did you know that Earth's tallest mountains are partly hidden beneath the sea? Mauna Kea is a dormant volcano that forms part of the largest of the islands in the Hawaiian Islands chain. Its summit is only 4205 metres above sea level but its base is actually located on the abyssal plain, some 5,493 metres below sea level. Therefore Mauna Kea's true height is 9,698 metres, making it the world's tallest mountain!

#### b. Earth's Layers

The Earth's radius is approximately 6378 km, measured at the Equator. Earth's internal structure of the Earth is made up of three main layers; the crust, mantle and core. Each layer or sub-layer has different characteristics.

```
crust - between ~ 5 and 80 km thick
- solid.

mantle - upper mantle ~ 590 km thick
- partly plastic, partly molten, mostly solid.
- lower mantle ~ 2230 km thick.
- solid.

core - outer core ~ 2250 km thick
- liquid.
- inner core ~ 1228 km thick.
- solid.
```

#### c. Tectonic Plates

Compared to Earth's deeper layers, the crust is very thin. The crust is not one unbroken layer over the Earth's surface but is actually divided up into a number of pieces called 'tectonic plates' that are about 60 to 200 km thick. In cross section each plate comprises all of the crust and the brittle part of the mantle that sits just below the crust.

#### i) slipping and sliding

Each plate can move relative to its neighbours at a rate between 2 and 15 cm each per year. The Australian Plate is moving northward at about 7 cm per year, the rate at which your fingernails grow. Plates can move in one of three ways; side by side, towards each other and away from each other. Where two plates move apart, molten rock (magma) from the upper mantle is able to rise up and fill the space created. Under the sea, magma rising through this gap cools rapidly in contact with seawater and forms pillow-shaped blobs of a dark igneous rock called basalt. As the separating plates continue to move, they pull this new rock apart and more magma rises. The process repeats to create new ocean crust.

Because new ocean crust is still hot it is less dense than the surrounding cooler rock and it rides higher to form elevated, long mid ocean ridges. Away from the ridges the older rock is cooler and more dense. Therefore this older rock sits lower and forms the extensive deep abyssal plains that form most of the seafloor. Occasional volcanoes are created where the crust sits over a localised area of rising magma that has broken through the ocean crust (a 'hot spot'). If they rise above sea level these volcanoes form islands such as the chain of Hawaiian Islands. If the volcanoes are not high enough to reach sea level, or have been worn down by erosion, they form undersea volcanoes called seamounts, such as those located off the south east coast of Tasmania.

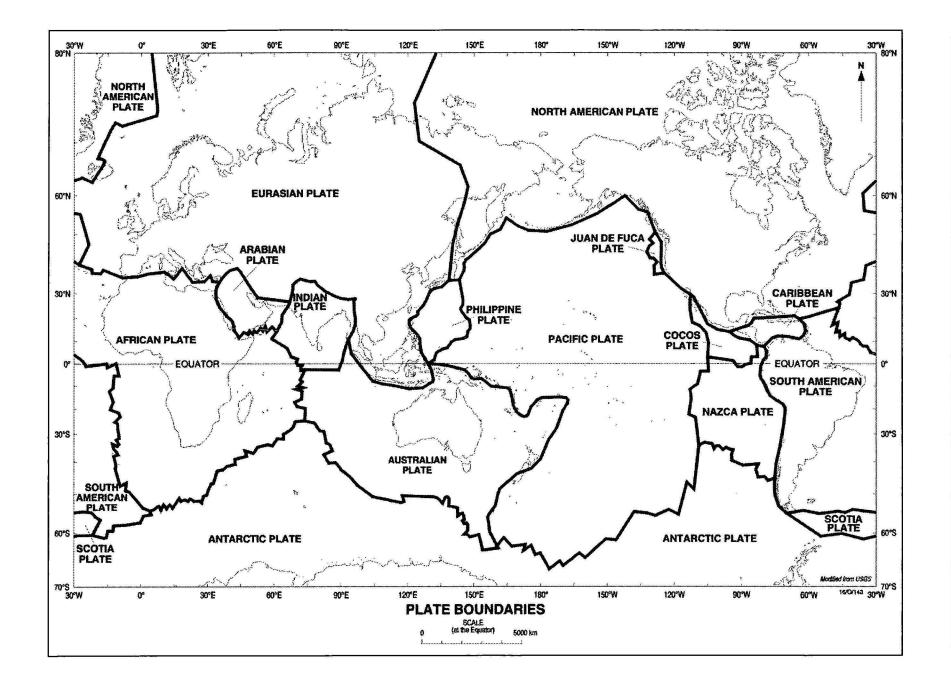
#### ii) pushing or pulling?

Because the Earth is not constantly growing in size, tectonic plates must also be destroyed somewhere. A recently held theory was that large convection currents circulated in a molten upper mantle. Where the convection currents rose at mid-ocean ridges they forced plates apart and carried the plates like a raft being carried along by a river. Where two plates were pushed together, one would be forced beneath the other in a process called subduction.

However, that theory is no longer supported. Now it is believed that gravity is a major force that drives plate movement and leads to the destruction of plates. Although mostly solid, Earth's upper mantle is plastic, behaving a bit like a thick mixture of cornflour and water – brittle if moved suddenly but able to flow slowly over time. The old oceanic crust at the leading edge of a tectonic plate is cold and dense. Under gravity the edge sinks below its neighbouring plate, descending into the less- dense plastic upper mantle. This sinking plate edge slowly pulls the rest of the plate with it. The trailing edge of the plate is therefore pulled away from its neighbouring plate to form a mid ocean ridge, along which molten material reaches the surface to form new crust. Therefore convection currents in the upper mantle assist the motion of plates but the majority of the force that drives plates comes from the sinking of dense plate edges beneath other plates.

#### iii) trenches

When the leading edge of a plate descends under its neighbour it forms a trench on the sea floor. These trenches are often thousands of kilometres long, between 50 and 100 km wide and very deep. In fact, the lowest point on Earth is the 11 km deep Mariana Trench off Guam in the Pacific Ocean. Here the Pacific Plate is forced under the Philippine Plate.



#### d. Two Types of Crust

The crust that makes up continents has a very different thickness and composition compared to the crust beneath oceans. This reflects their different methods of formation. Newly formed ocean crust is only about 5 to 8 kilometres thick, compared to the 30 to 80 kilometres thickness of continental crust. This difference in thickness also affects how plate edges can interact.

Approximately 65% of the Earth's crust is made up of ocean crust and 35% is continental crust. A single tectonic plate can be made up of ocean crust, continental crust or a mixture of both. The large South American plate is approximately 60% oceanic crust and the remaining 40% comprises the South American continent.

#### i) ocean versus ocean crust

Thin ocean crust can sink below other ocean crust. The islands of Japan were created when the oceanic crust of the Pacific Plate was subducted beneath oceanic crust of the Eurasian plate. When molten material from the leading edge of the subducting Pacific Plate melts it is less dense and rises up through the Eurasian Plate to erupt as Japan's volcanoes eg. Mt Fuji.

#### ii) ocean versus continental crust

Because ocean crust is much thinner, it can sink below thicker continental crust. An example is where the west coast of South America meets the eastward moving Nazca Plate. The continental crust of South America is forcing the ocean crust of the Nazca Plate to subduct beneath it to form the deep Peru-Chile Trench.

#### iii) continental versus continental crust

What happens when two plates consisting of continental crust collide? Neither plate can sink below the other because they are both too thick. Instead, they continue to be forced together and crumple up like cars in a traffic accident, folding and fracturing (faulting) the rocks. Approximately 50 million years ago the part of the Indo-Australian plate that included India separated from the part including Australia. India moved to the north west until it collided with the Eurasian continent. As the two continents met and were pushed together they crumpled up to form the Himalayas. This continued plate movement and crumpling is causing Mt Everest to slowly increase in height each year.

Where two plates with continental crust slide past one another, neither plate is subducted. An excellent example is the San Andreas Fault along the west coast of the USA where the Juan de Fuca Plate is grinding past the North American Plate. The San Andreas Fault cuts through the cities of Los Angeles and San Francisco and the stress caused as the plates slide past each other is the cause of powerful earthquakes in this region.

#### e. Crust and UNCLOS

We know that the type of crust that makes up tectonic plates affects the surface features of the Earth's surface and how they interact. The seafloor is composed almost entirely of oceanic crust formed from new material created at mid ocean ridges. Deep sea trenches indicate where one plate is descending beneath another. Earthquakes are common in such locations. Colliding continents form crumpled mountain ranges. Other plate movements create major fault lines and mid ocean ridges. Abyssal plains represent cool, old oceanic crust away from mid ocean ridges. Seamounts rise up where molten magma breaks through the oceanic crust creating underwater volcanoes.

The legal definition of the continental margin under UNCLOS requires that coastal countries define the outer edge of their landmass under the sea based on the geomorphologic margin ie. characteristics of foot of slope, continental shelf and rise.

However, Article 76.3 of UNCLOS states that

'the continental margin comprises the submerged prolongation of the land mass of the coastal State, and consists of the sea-bed and subsoil of the shelf the slope and the rise.

It does not include the deep ocean floor with its oceanic ridges or the subsoil thereof'.

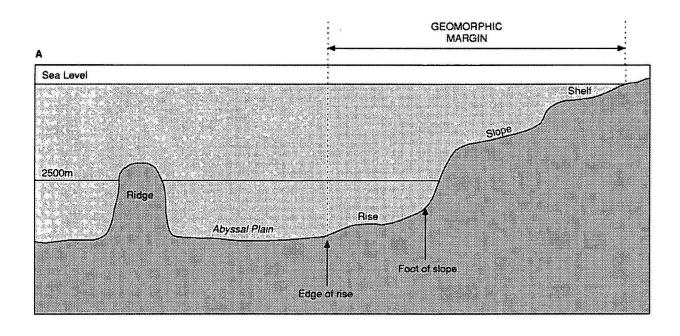
Because this definition of the continental margin under UNCLOS includes the sea-bed and subsoil, but precludes ocean ridges and areas of deep ocean floor (primarily formed from basalt at ocean ridges), there is an implied geological aspect to the definition of the continental margin. However the boundary where the continental crust of the landmass becomes the ocean crust of the deep sea floor is not always distinct.

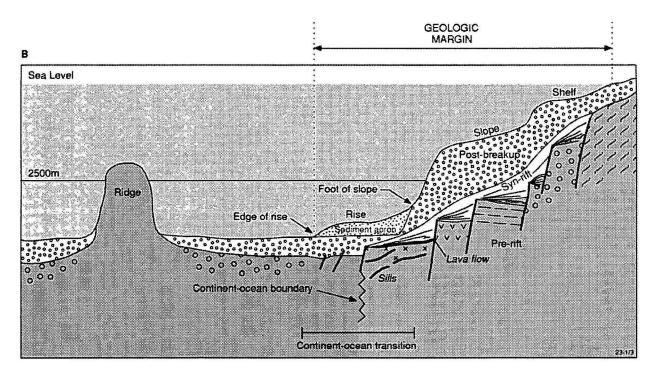
Continental margins are complex areas and can include a variety of different rock types due to the different geological processes that have occurred over extended periods of time. Continental margins such as the North West Shelf of Australia have evolved as a direct result of the break-up of the Gondwana supercontinent when India rifted away from north west Australia. This resulted in stretching and thinning of the continental crust in that region and extensive volcanism around the newly formed margin of Australia. Volcanism such as lava flows associated with the rifting is often basaltic and this can be difficult to distinguish from pre-existing ocean crust.

Also, sediment aprons formed before the rifting (pre-rift), during the rifting (syn-rift) and after the rifting (post break-up or post-rift). Only a thin veneer of the sediment may be derived from normal deposition that would create a sediment apron at the base of the continental slope. This combination of factors complicate the transition from continental to oceanic crust and make it difficult to identify the continental margin for which the provisions of Article 76 of UNCLOS can be applied.

To further complicate matters, in some parts of the world oceanic rocks that formed on the ocean floor can later be joined onto 'normal' continental crust. This makes the oceanic crust into part of the landmass. Tectonic forces can also uplift ocean crust so that it becomes part of a country's continental margin.

On the margin of Papua New Guinea there are sequences of rocks that were once ocean crust eg. basalts and associated deep-sea sediments but these have now become part of the Papua New Guinea landmass. UNCLOS excludes deep ocean floor but some countries may make submissions based on continental margins that include rocks that used to be deep ocean floor prior to plate tectonics!





Effect of complex sub surface geology on application of UNCLOS in areas of extended continental shelf.

- a) Top diagram shows an apparent simple cross section with clear continental shelf, slope and rise.
- b) Complications of simple cross section due to sub surface geology. This is a margin created by plate tectonics when two continents rifted apart. The continental crust was thinned and stretched. Magma created underground sills, or lava flows where it reached the ancient surface. Most sediments are not modern sediments draping the shelf they are ancient sediments derived from pre, syn and postrift episodes. in addition the transition between continental and oceanic crust is spread over a wide area, making the identification of the outer limit of the continental margin problematic.

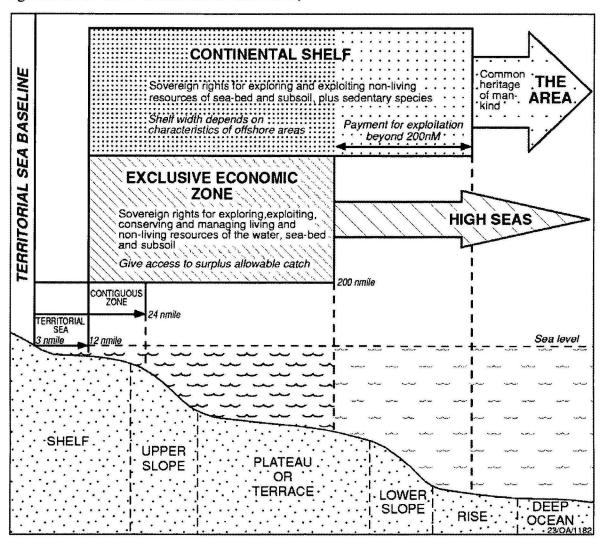
#### f. The Oldest Crust on Earth

Why is continental crust so much thicker than oceanic crust? Continental rocks are subjected to constant cycles of weathering, erosion, tectonics, intrusions of molten rock and metamorphism. Continental rocks are broken down into small pieces, cemented together to form new rocks, melted to erupt as lava or metamorphosed into new crystal arrangements. These extended periods of reworking and recycling have allowed very complex rock sequences to build up and form continental crust between 30 and 80 kilometres thick.

These continents and are too thick to be subducted so they can exist for billions of years. In fact Earth formed about 4.6 billion years ago. The oldest evidence of continental crust on Earth comes from zircon crystals dated at approximately 4.4 billion years old in rocks from Jack Hills in north west Western Australia. The Western Australian zircon crystals formed in continental crust very early in Earth's history. Because the continental crust that is now part of Western Australia was not destroyed at any plate margins, the zircons in the crust were recycled from the original rocks in which they formed. They were eventually preserved as fragments within a conglomerate (a type of sedimentary rock formed from an assortment of large and small rocks and crystal fragments). In contrast, the oldest ocean crust known on Earth is only 250 million years. Any older oceanic crust on the seafloor was destroyed during earlier subduction of tectonic plates.

## 9. MARINE ZONES DEFINED UNDER UNCLOS

Under UNCLOS each coastal country can claim a range of zones that are defined by maritime jurisdictional limits out from their coastline. Each zone has different sovereign rights. All limits are defined within UNCLOS, except that of State Waters, which is an Australian government term. Beyond the maritime limits, international jurisdiction prevails. There are eight zones or limits defined under UNCLOS;



Maritime jurisdictional zones based on the United Nations Convention on the Law of the Sea 1982 (UNCLOS), linked to seafloor topography.

#### a. Territorial Sea Baseline

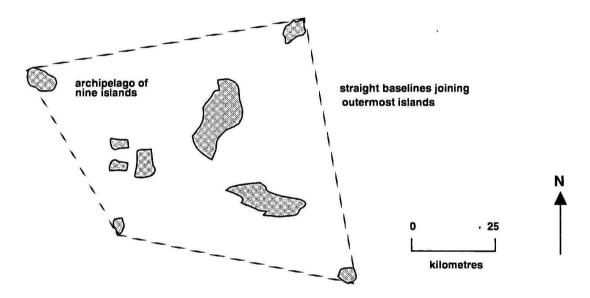
The territorial sea baseline (TSB) is usually the low water mark around a landmass such as an island or continent. It does not necessarily equate to the coast or shoreline. Australia uses the Lowest Astronomical Tide mark (LAT) as its baseline. The TSB is the starting point from which the important 200 nm (~370 km) EEZ and 350 nm (~648 km) cut-offs are both measured under UNCLOS

Fringing reefs such as the Great Barrier Reef, and near-shore islands such as Fraser Island, affect the location of a coastal country's TSB. The TSB is the low water mark on the outer edge of reefs or islands. On very gently sloping coastlines the LAT line is located far out into the water.

UNCLOS makes allowance for heavily indented coastlines that include features such as bays, wide-mouthed rivers and broad estuaries. Rather than the TSB extending up into bays and wide rivers, a straight-line boundary can be drawn across the mouth of these features to form the TSB. The water inside the boundary on the landward side is termed 'internal waters'.

For some coastal countries defining the TSB can be difficult. Archipelagic States are countries that are formed entirely from one or more groups of islands (archipelagos). Because the islands in an archipelago may be small and widely spaced, such as those of the Seychelles in the Indian Ocean east of Tanzania, the normal baselines used to define the limits for coastal countries can be difficult to apply.

In determining their marine zones under Article 47 of UNCLOS, Archipelagic States can draw straight archipelagic baselines that join the outermost points of their outermost islands (see diagram). The straight baselines cannot exceed 100 nm in length (except that up to 3% of the straight segments can be up to 125 nm in length).



Some landmasses such as Antarctica, Iceland and Norway are covered in permanent or semi-permanent ice where there is no 'land' exposed at the coast. Therefore there is no low water mark along the landmass itself, just along the ice covering it.

This issue directly affects areas of Australia's Antarctic Territory. Within the provisions of UNCLOS, Australia has proclaimed a 200 nm EEZ off the coast of the Australian Antarctic Territory (AAT). AUSLIG, Australia's national mapping agency, has the complex task of identifying and mapping the TSB along Australia's Antarctic Territory for use in defining the limits of our EEZ and for a potential UNCLOS submission on the outer limit of the Continental Shelf off the AAT.

#### **b. State Waters**

Since the Offshore Constitutional Settlement in 1979 between Australian States and the Commonwealth, the 3 nm zone measured from the territorial sea baseline is controlled by individual Australian States. In this zone, State laws apply concerning matters such as navigation, commercial development and policing. Beyond 3 nm, the Commonwealth controls all waters out to the limit of Australia's jurisdiction.

#### c. Territorial Sea

The territorial sea acts as an extension of a country's land territory and was designed for the protection of each coastal country. The territorial sea is the sea along a country's coastline up to 12 nm from the territorial sea baseline. A coastal country has sovereignty over the airspace above the territorial sea, the water column, the seabed and subsoil below it.

#### d. Contiguous Zone

This zone starts at the outer limit of the territorial sea and can extend up to 24 nm from the baseline. A coastal country is able to control customs matters, immigration, sanitation and revenue within this zone. A coastal country can prevent and punish infringement of its customs, immigration and sanitary laws and regulations within its land territory or territorial sea. Prior to UNCLOS one of the original purposes of the contiguous zone was to allow the pursuit of a vessel outside the territorial sea before it entered international waters. Therefore, this zone acts as a buffer for a coastal county's territorial sea.

#### e. Exclusive Economic Zone (EEZ)

The EEZ begins at the outer limit of the territorial sea 12 nm from the territorial sea baseline. The EEZ then extends out to a maximum distance of 200 nm from the territorial sea baseline. It does NOT overlap the territorial sea, therefore its maximum possible internal width is 188 nautical miles. In the EEZ a coastal country has;

- sovereign rights to explore and use, conserve and manage all natural living and non-living resources of the water column, the seabed, and the subsoil beneath the seabed.
- jurisdiction to protect and preserve the marine environment, regulate, authorise and conduct marine scientific research, and construct installations such as offshore oil production platforms. In the EEZ a coastal country must also allow other countries freedom of navigation and freedom to lay pipelines and cables. They must allow air traffic from other countries to overfly the EEZ.



Activity: EEZy as Pi!

#### f. Continental Shelf

A geologic definition of the continental shelf is a gently sloping submarine extension of a landmass at about 200 metres water depth. The continental shelf ends where it drops steeply to become the continental slope, leading to the continental rise and the deep ocean floor.

The legal continental shelf is quite different to the geologic shelf. Article 76 of UNCLOS defines the legal continental shelf as the prolongation of the land out to the edge of the geologic continental margin ie. where the continental crust becomes oceanic crust. Therefore the legal continental shelf includes the seabed and subsoil of the geomorphologic continental shelf, slope and rise.

Within the continental shelf, a coastal country has;

- sovereign rights to explore and use the natural resources of the seabed, and the subsoil beneath the seabed. These resources include non-living resources on or under the seafloor, as well as living organisms on the seafloor (sedentary species). They do not include resources in the water column above the seabed eg. fish stocks and tidal energy and resources above the water column eg. wind energy.
- jurisdiction to protect and preserve the marine environment, and to regulate, authorise and conduct marine scientific research.
- a requirement to pay the International Sea-Bed Authority for the use of any non-living resources in, or under, the seafloor beyond the 200 nm EEZ. Payment is to be made after the fifth year of production, although some exemptions apply for developing countries.

#### g. High Seas

All parts of the sea that are not included in the EEZ, in the territorial sea or the internal waters of any country are called the High Seas. The High Seas begin and end at the outer edge of the Exclusive Economic Zone, 200 nm from the territorial sea baseline of coastal countries.

The High Seas are open to ALL countries for freedom of navigation, overflying, laying of seafloor cables and pipelines, fishing and scientific research, subject to certain UNCLOS provisions. All countries have the right to engage in fishing on the High Seas as long as they honour any existing treaty obligations and support the conservation and management all living resources in the High Seas. Countries are to cooperate in the conservation and management of fish stocks and where necessary, establish fisheries organisations to carry out this obligation.

#### h. 'The Area' of International Seabed

The non-living resources of the seabed and subsoil, beyond the limits of any nation's jurisdiction, lie within the zone called 'the Area'. It is considered the "common heritage of mankind", meaning these resources are to be available for all people.

The Area begins at the outer edge of a country's legal continental shelf. In some cases where a landmass is not surrounded by a continental shelf eg. Hawaii, The Area will begin at the edge of the country's EEZ. In other cases, such as around parts of Australia with a broad continental shelf, the Area will begin near the outer edge of the continental margin, beyond the EEZ.

## 10. How UNCLOS defines the limit of marine jurisdiction

Article 76 of UNCLOS contains a series of rules and procedures for defining the outer edge of the continental margin, and ultimately, for establishing the outer limit of the continental shelf jurisdiction of a coastal country.

#### i) INITIAL CONSIDERATIONS

There are two possibilities for any coastal country assessing the limits of its extended continental shelf under UNCLOS; these are summarised as Case A and Case B.

#### Case A: No Extended Continental Shelf

A coastal country finds that the outer edge continental margin, as defined by the rules in Article 76 of UNCLOS, does not reach as far as its 200 nm EEZ. Therefore there is no region of extended continental shelf under UNCLOS. This coastal country already has sovereign rights to the resources of its 200 nm EEZ and this is the maximum area over which it has jurisdiction.

The country needs to deposit copies of the charts or lists of coordinates that define the limits of its EEZ with the Secretary-General of the United Nations. There is no recourse for making a future claim to an extended continental shelf, once the ten year deadline from the time UNCLOS was in force for the country has passed.

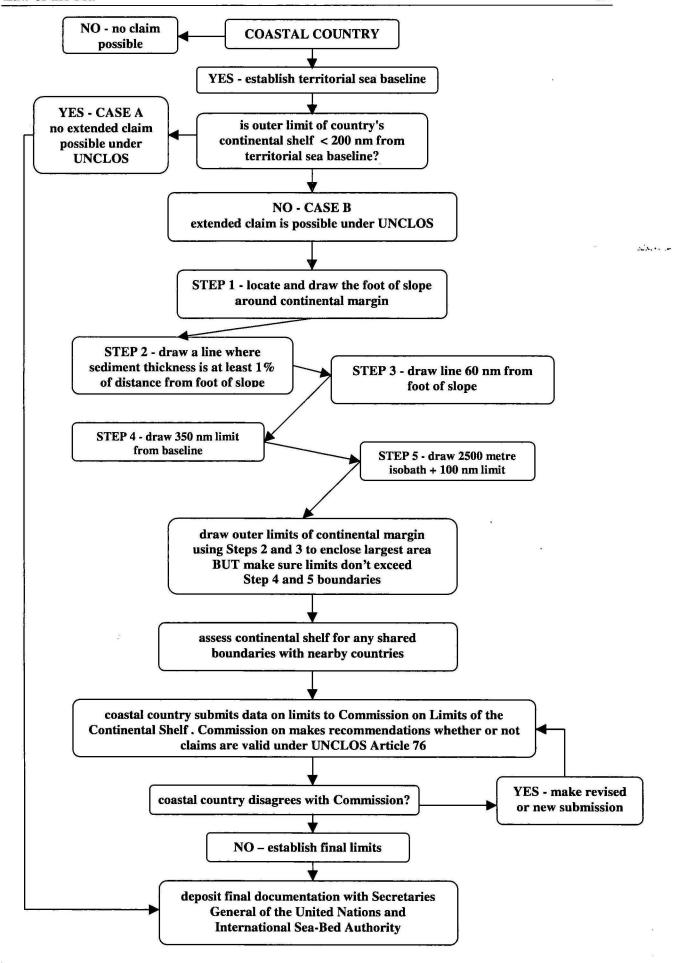
#### Case B: Extended Continental Shelf

A coastal country finds that the outer edge of its continental margin, as defined by the rules in Article 76 of UNCLOS, <u>does</u> extend beyond its 200 nm EEZ. In this situation there is a case for an extended Continental Shelf submission.

The country must apply the rules of UNCLOS to firstly determine the edge of its continental margin (ie. shelf, slope and rise), then the outer limit of its extended continental shelf. The coastal country can then make a submission to the United Nations Commission on the Limits of the Continental Shelf (CLCS). The submission must be supported by relevant scientific information and this typically requires detailed mapping of the outer edge of the continental margin, identifying up to five different parameters (steps 1 to 5). This submission should be made within the ten year deadline from the time UNCLOS was in force for that country.

If the recommendations of the United Nation's CLCS on the initial submission are not accepted by the country, then the country can make a revised or new submission within an unspecified time frame. Once the country accepts the CLCS's recommendations on the limits of its shelf then those limits become final and binding and these charts permanently describe the outer limits of that country's continental shelf. Charts or list of geographic coordinates defining the outer limit of the Continental Shelf must be lodged with the Secretary-General of the United Nations, and the Secretary-General of the International Sea-bed Authority.

In Australia's case, its submission on the extended continental margin will be made by 16 November 2004, exactly ten years since Australia ratified UNCLOS on 16 November 1994. This is the earliest date at which UNCLOS came into force for any country. Other countries have later dates depending on when they officially accepted, or ratified, the Convention.



#### ii) IDENTIFYING OUTER EDGE OF CONTINENTAL MARGIN

To define the outer edge of its 'legal' continental margin prior to making a submission under Article 76 of UNCLOS, a Case B country must carry out the six main steps summarised in the flow chart and also in the following notes.

#### Step 1. Locate Foot of Slope points

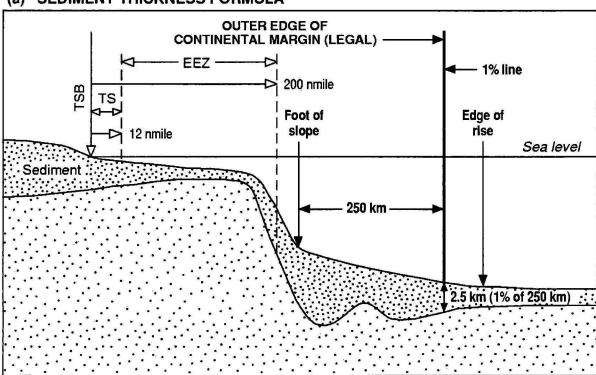
The foot of slope at the base of the continental slope is defined as the point of maximum change in gradient. The shape of the seafloor must be known to locate the foot of slope.

Once located and mapped, the foot of slope is the starting point from which the outer edge of the continental margin is measured. Two steps are used to determine this location, Step 2 the sediment thickness rule, and Step 3 the 60 nautical mile boundary rule or Hedberg formula (named after USA geologist Hollis Hedberg who proposed the use of the foot of slope in UNCLOS). A country may use either rule, or a combination of rules, to maximise the extent of its 'legal' continental margin, to give it the greatest jurisdictional limit.

#### **Step 2. Determine Sediment Thickness**

Sediment thickness was made part of UNCLOS because it allows many coastal countries to claim sovereign rights over areas of thick sediments on their continental margins where offshore hydrocarbon deposits such as oil and gas are most likely to be found.

#### (a) SEDIMENT THICKNESS FORMULA



By carrying out seismic investigations, scientists can determine the thickness of sediments that have settled across the continental margin. Most of this sediment has been moved off the continental shelf via ocean currents, or by gravity causing the collapse of shelf and slope sediments. For UNCLOS, scientists need to calculate the point where the sediment thickness on the outer continental margin is equal to a particular ratio. The ratio chosen by UNCLOS was 1% of the distance from the foot of slope.

Scientists start measuring the thickness of sediments at the foot of slope (Step 1) and work seaward, comparing sediment thickness with the distance from the foot of slope.

Close to the foot of slope, sediments should be thick where most of the sediment that slumped off the continental shelf comes to rest. Here, sediment thickness should be more than 1% of the distance back to the foot of slope, e.g., the sediment might be 10 km thick at a distance of 20 km from the foot of slope. The ratio here between sediment thickness and distance is therefore 10:20 or 1:2. The sediment thickness is therefore 50% of the distance back to the foot of slope. This ratio is too high for use under UNCLOS.

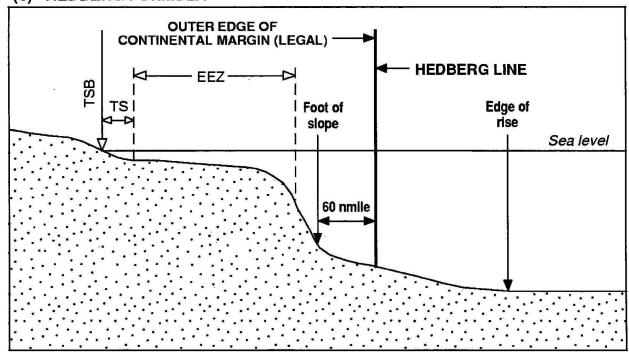
Further from the foot of slope, the sediment gets thinner because less sediment travels this far from the continental slope. As the sediment gets thinner, the ratio between the sediment thickness and the distance back to the foot of slope decreases. Eventually there will come a point where the sediment thickness is 1:100 or 1% of the distance back to the foot of the slope. For example, the sediment may be 2.5 km thick at a point 250 km from the foot of slope. The ratio of 2.5:250 is the same as 1:100. This sediment thickness represents 1% of the distance back to the foot of slope.

Further out to sea the sediment thins out into the deep ocean basin. At 500 km from the foot of slope the sediment thickness might only be 0.5 km thick which is a ratio of 0.5:500 or 1:1000. This represents 0.1% of the distance back to the foot of slope.

#### Step 3. 60 nautical miles from foot of slope; Hedberg arcs

In addition to the sediment thickness formula, a country can define the outer edge of its continental margin by drawing connecting arcs of 60 nm radius that start at the foot of slope, as defined in Step 1. These arcs are often known as 'Hedberg arcs'.

#### (b) HEDBERG FORMULA



## iii) DETERMINING OUTER LIMITS OF EXTENDED CONTINENTAL SHELF

Steps 2 and 3 above define the edge of the 'legal' continental margin, and determine the maximum possible limit of the extended continental shelf for any country. There are 29 known areas of continental margins that extend beyond 200 nm EEZs.

Steps 4 and 5 impose constraints beyond which the outer limit of the continental shelf cannot extend. Step 4 and 5 are only used as the outermost cut-off if the edge of the continental margin extends beyond the limits determined by Steps 1, 2 and 3. As with Steps 2 and 3, a country may use either of these cut-offs, or a combination, in order to maximise the extent of its extended continental shelf.

## Step 4. 350 nautical mile limit

This limit is defined by a line that is 350 nm from the territorial sea baseline (usually low water mark).

## Step 5. 2500 metre + 100 nautical mile limit

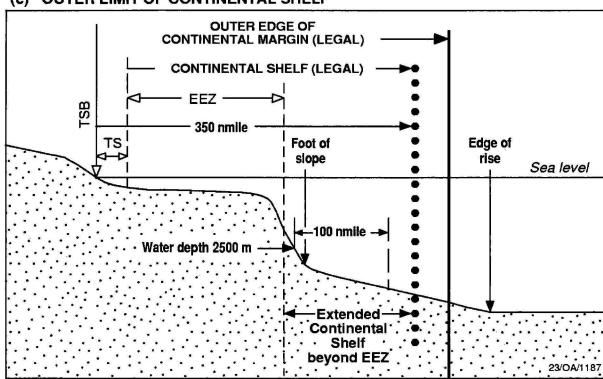
This is defined by a line that is 100 nm from the 2500 metre isobath (contour line).

## Step 6. Drawing the line

Using all of the five steps, the outer limit of a country's marine jurisdiction comprises a line made up of straight segments not more then 60 nm in length, that can be defined by any or all of the following:

- 200 nm Exclusive Economic Zone
- 1% sediment thickness points
- 60 nm Hedberg arcs
- 350 nm limit
- 2500 metre plus 100 nm limit

## (c) OUTER LIMIT OF CONTINENTAL SHELF



## Example 1

The outer edge of the continental margin of a coastal country is best defined by Step 3 using 60 nm arcs measured from the foot of slope. These arcs lie inside the cut-offs of both of Steps 4 and 5 therefore the outer edge of the continental margin is 60 nm from the foot of slope. Therefore it is the 60 nm arcs that determine the outer limit of the continental shelf and not Step 4 or 5.

## Example 2

A country uses all three steps to assess the outer edge of its continental margin. Using the best method of Step 2, the 1% sediment thickness rule, the outer edge of its continental margin is 375 nm from the territorial sea baseline. Because the sediment thickness rule gives the greatest area of extended continental margin of all three steps, it is the one used by this country to determine the outer most edge of its continental margin.

However, Step 4 and 5 must then be applied. Of the Step 4 and 5, the 350 nm arcs of Step 5 forms the furthest cut-off line. Because the outer limit of any country's continental shelf cannot extend beyond the 350 nm cut-off this country can only have jurisdiction of an area out to 350 nm from the territorial baseline.



see Activity: Drawing the Line

## iv) MAKING AN UNCLOS SUBMISSION

Once all of the relevant research and data gathering has taken place, a coastal country that choses to make a submission that defines the outer limit of its extended continental shelf, must deposit all relevant information supporting its submission with the Commission on the Limits of the Continental Shelf (CLCS). As noted previously, each country has a deadline of 10 years from the date they become party to UNCLOS to make their submission. Australia's submission date is 16 November 2004.

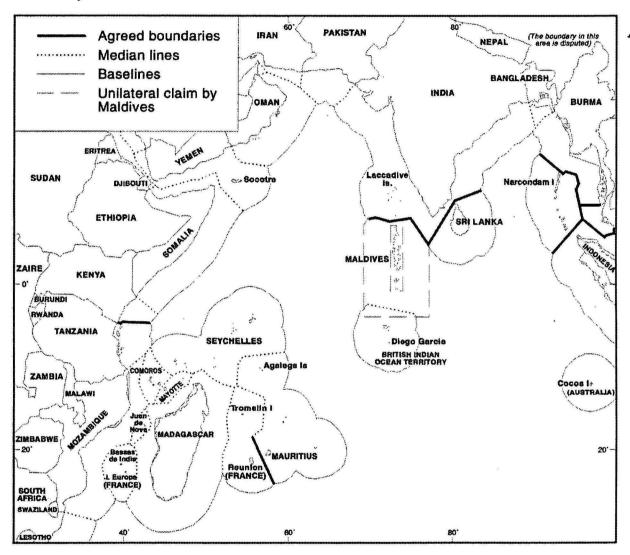
The CLCS will assess each country's submission and make recommendations on the outer limit of its continental shelf. The CLCS may request more supporting information during its assessment of the submission, and may recommend that a country makes revisions to its proposed outer limit or refuse its submission. If the country does not accept the recommendations of the CLCS it will need to make a revised or new submission within a reasonable period of time.

If the country accepts the recommendations of the CLCS and establishes the outer limits of its continental margin on that basis then those limits become final and binding. Finally, charts or coordinates describing this outer limit need to be deposited with the Secretaries General of the United Nations and the Secretary-General of the International Sea-Bed Authority.

Scientific and geographic information in support of a submission should include all charts and coordinates indicating the outer limit of the continental shelf and the relevant territorial sea baselines, the rules and approaches of UNCLOS that have been used in the submission as well as all supporting scientific and technical data such as bathymetric, seismic and other geophysical and geological information.

## v) SHARED BOUNDARIES

When coastal countries share maritime boundaries, UNCLOS allows for agreed boundaries to be negotiated. For example, where two or more countries are closer than 400 nm and their EEZ claims overlap, they must agree on a common EEZ boundary. This is to be established by bilateral or multilateral agreement on the basis of international law in order to achieve an equitable solution for all parties. A possible solution would be to divide the EEZ equally so that each country has an equal radius of EEZ from their baseline, however this solution is not mandatory.



The spatial distribution of Exclusive Economic Zones (EEZs) in the northern Indian Ocean. The effects of concave and convex coastlines on the size of EEZs is clear. Also note the shared EEZ boundaries between countries such as Kenya and Tanzania.

Compare the uninterrupted shape of Australia's EEZ around the Cocos Islands with that of its EEZ around the Christmas Islands. No neighbouring country is closer than 200 nm to the Cocos Islands but Christmas Island shares a common EEZ boundary with Indonesia. Therefore, although only 14 km² in land area, the Cocos Islands under Australian jurisdiction has an uninterrupted EEZ totalling 466,000 km² whereas Christmas Island with a land area of 135 km², has a smaller truncated EEZ of only 277,000 km².

Many of Australia's shared boundaries are associated with its island territories. Australia shares maritime boundaries with countries such as New Zealand, Papua New Guinea, the Solomon Islands, Indonesia and East Timor. We share boundaries with France because of the proximity of Australian territory to French territory in New Caledonia and the Kerguelen Islands in the sub-Antarctic south west of Perth. Australia also shares boundaries with Norway, France and New Zealand in Antarctica. The map of Australia's proposed marine jurisdiction shows many of these shared boundaries as areas where an EEZ is truncated.

In some regions, many coastal countries have relatively short lengths of coastline eg. Jordan 28 km, Gambia 38 km and Zaire 40 km. This creates very small EEZs. In addition, in the northern Indian Ocean several countries have overlapping EEZs around continental and island coastlines. The juxtaposition of neighbouring countries can affect the size of a country's EEZ. Compare the large size of the EEZs around the archipelagos of Mauritius and the Seychelles, compared to that of the Comoros and Mayotte to the north west. The EEZs of Sri Lanka and India are juxtaposed along an agreed boundary between the two countries. Such areas of overlap must be negotiated to produce bilateral or multilateral agreements between the countries involved.

The shape of the coastline is influential in determining the size of the offshore EEZ. Concave coastlines have smaller EEZs than similar sized countries with convex coastlines. Kenya's concave coastline of 457 km creates a tapered, small EEZ of 118 000 km<sup>2</sup> whilst Bangladesh with a longer coastline of 574 km has a more concave coastline and therefore an EEZ of only 76 800 km<sup>2</sup>. Compare these countries to those with convex coastlines such as Somalia and Oman.



see Activity: Stuck in the Middle Again!

## vi) SCENARIOS FOR THE FUTURE

In some situations here is potential for disagreement about the application of the UNCLOS definition of the 'legal' continental shelf. This could arise in a variety of ways such as through ambiguities in UNCLOS itself, through changing ideas on the nature and characteristics of continental margins, and because many continental margins do not exhibit the simple morphology referred to in UNCLOS.

In terms of geomorphology, the continental shelf is the part of the continental margin that is closest to the coast, and is usually followed by the slope and then the rise, leading to the deep ocean floor. However, all elements of a classic margin are not always present, and in some locations, one element is missing or a complicating element may be present, such as a deep trench offshore from the Philippines or areas of complex geology. In other cases, the elements and their boundaries may be difficult to locate, such as on the margin of the Exmouth Plateau off the North West Shelf.

## a. Unusual Continental Margin Geology

Mid ocean ridges are a controversial aspect of UNCLOS and are handled in special ways under Article 76. UNCLOS states that continental shelf jurisdiction does not cover the deep ocean floor with its ocean ridges. However, Iceland is an island formed on an active mid ocean ridge that rises from the deep ocean floor. It is interesting to think how its potential marine jurisdiction beyond 200 nm will be interpreted under UNCLOS.

## b. Missing Continental Margin Elements

The outer limit of the 'legal' continental shelf around some islands is not easily assessed in terms of UNCLOS. Hot spot islands, islands along deep-sea trenches and those islands that straddle mid-ocean ridges are problematic. Around island nations such as Japan and the Philippines there is no simple continental rise and the continental slope on one side of the islands plunges straight into a deep ocean trench. Rarely does much sediment accumulate at the base of such a steep slope and those sediments that do, form a short continental rise with a foot of slope located close to the landmass. In this situation it may be difficult to identify the edge of the continental margin as anything other than the foot of slope that occurs in the trench. This limits the area of extended continental margin available for a submission under UNCLOS.

The islands of Hawaii are under USA jurisdiction. They formed when the Pacific Ocean's crust moved over a hot spot causing molten material to rise up through the crust from the underlying mantle to create a chain of volcanic islands. Each volcano became extinct as it moved to the northwest, away from the hot spot, and this created the linear chain of Hawaiian Islands. The USA can claim an EEZ of 200 nm around the island group. However, these islands rise steeply from the seafloor. The highest point is the volcano, Mauna Kea, 4205 metres above sea level. Given that the surrounding seafloor is over 5,400 metres deep, this volcano is 9,698 metres high. The Hawaiian Islands have a very narrow geological continental shelf surrounding them and a very steep continental slope. Aprons of material from large slumping events that have collapsed part of the islands e.g. Oahu, have been noted off Hawaii but the matter of whether they have a 'legal' continental shelf has yet to be resolved. Given the steepness of the slopes and the poorly developed continental rise, it seems unlikely that there will be any substantial extension of continental shelf beyond the EEZ for the Hawaiian Islands.

## c. Unclear Identification of Continental Margin Elements

Identifying the base of the continental slope is a key factor in determining the outer edge of the continental margin under UNCLOS. It is more difficult to apply UNCLOS where there are deep, thick aprons of sediment that make up the continental rise. These can blur the boundary between the slope and rise and makes it difficult to locate the geological boundary between the continental crust of the shelf and slope, and the ocean crust of the deep ocean floor.

Off Australia's north west coast it is very difficult to determine the location of the foot of slope due to the complex morphology of the continental margin in this region. The foot of slope will be used in this area to determine some of the outermost margins of the continental shelf. For some areas of the North West Shelf there are multiple foots of slope possible and each affects the possible extent of the continental margin allowable under UNCLOS (see North West Shelf case study).

## d. Sea level change

The United Nations Convention on the Law of the Sea makes no mention of falling or rising sea levels and the impacts these could have on the location of the maritime limits that UNCLOS defines, such as the territorial sea baseline. This may be because the issue of sea level change was not of such concern in 1982 when the wording of the document was finalised.

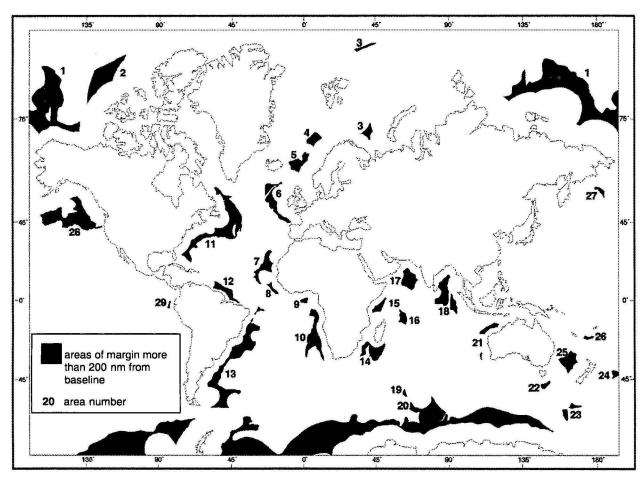
Once a coastal country submits its charts and other data to the Secretary-General of the United Nations with reference to areas of extended continental shelf, the outer limits of its

continental shelf are permanent, i.e. they are final and binding. However, the situation is less clear regarding the 200 nm Exclusive Economic Zone of a coastal country that is measured from the territorial sea baseline. The location of this baseline may be affected by rising or falling sea levels.

Therefore changing sea level could have an effect on the claims and submissions by countries under UNCLOS. What effect this will have has yet to be determined but it is the subject of continued international debate.

## vii) EQUITY OF ACCESS TO CONTINENTAL SHELF RESOURCES

All of the above factors influence the spatial distribution of countries that are able to claim areas of extended continental margin beyond their 200 nm EEZs.



The global distribution of major areas of extended continental margin that extend beyond the 200 nautical mile Exclusive Economic Zone of coastal countries. Used with permission of Victor Prescott, University of Melbourne.

The total area of extended continental margins that are beyond EEZs (shown in the accompanying map) is about 74 million km<sup>2</sup>. Of these, 15 million km<sup>2</sup> comprises continental margins around Antarctica where the seabed and subsoil resources are unable to be exploited under the Antarctic Treaty. This leaves an area of 59 million km<sup>2</sup> of extended continental margins available to 151 coastal countries, an average of about 390 700 km<sup>2</sup> per country.

But averages do not come into play when working out the areas of extended continental margins that countries can use to make submissions under UNCLOS. Most continental shelves wider than 200 nm are associated with continental margins of continents that border

the Atlantic, Arctic and Indian Oceans. Some countries have large areas available on which to base a submission under UNCLOS. Russia, the United States and Canada have potential access to an area of extended continental margin of 294 000 km² in the Arctic Ocean. However continents such as Africa are divided into many countries and many of these share small areas of extended continental margin. One small area of continental margin off the central west coast of Africa (Area 9 on accompanying map) is only 36 900 km² and could be shared by as many as 7 different neighbouring countries, therefore providing little access to resources.

There is already scope under Articles 69 and 70 of UNCLOS for equitable access of land-locked and geographically disadvantaged countries to the living resources of the EEZ. Land-locked countries and those that are geographically disadvantaged due to small EEZs or other factors, have the right to part of surplus stocks of living resources such as fish, in EEZs of coastal countries in the same region. This access must take into account the needs of other countries in that region and the sustainable management of those resources. However, the same provision does not exist under UNCLOS regarding equitable access to the non-living resources of extended continental margins such as oil.

It has been suggested that the spatial distribution of the world's continental margins could be taken into account when assessing the access of countries to the resources of the extended continental shelf. In future, land-locked countries without a continental shelf, or countries with a small continental shelf, might be able to claim access to continental shelf resources of other countries. As Australia has a very large extended continental shelf of 5.6 million km<sup>2</sup>, this could become an important issue for future management of Australia's offshore resources. This issue is not, however, a part of UNCLOS and therefore yet to be resolved.

## viii) SCIENTIFIC METHODS TO DEFINE MARINE JURISDICTION

To support the outer limit of its marine jurisdiction under UNCLOS, Australia has to accurately define the outer limit of its extended continental shelf (Steps 1 - 5). UNCLOS describes methods for defining the outer edge of the continental margin, and ultimately the outer limit of the continental shelf, using scientific data such as the seafloor's topography and sediment thickness.

#### a. Assessment

Prior to 1996 a preliminary study of existing scientific data by AGSO – GEOSCIENCE identified at least nine areas of continental shelf that extended beyond Australia's EEZ, totalling just under 3.8 million km<sup>2</sup>.

REGION	AREA KM <sup>2</sup>
Kerguelen Plateau	1 240 000
<b>Lord Howe Rise</b>	870 000
Exmouth/Wallaby Plateaus	600 000
Macquarie Ridge	540 000
Naturaliste Plateau	190 000
South Tasman Rise	110 000
east of Norfolk Ridge	100 000
<b>Great Australian Bight</b>	90 000
Argo Abyssal Plain	20 000

If the 1 800 000 km<sup>2</sup> area of continental shelf beyond the EEZ off Australia's Antarctic Territory is also included, the total area of extended continental shelf in the UNCLOS claim increases to about 5.6 million km<sup>2</sup>. By adding the 11.1 million km<sup>2</sup> area within the existing EEZs of Australia and its territories, Australia's total marine jurisdiction may increase to 16.7 million km<sup>2</sup>, more than twice the area of Australia's landmass at 7.7 million km<sup>2</sup>.

Because there was insufficient scientific information over much of its continental margin, Australia needed to collect further information on seafloor topography and sediment thickness to allow the identification and measurement of critical UNCLOS parameters; ie. the location of the foot of the continental slope, the 2500 metre isobath + 100 nm and sediment thickness.

The data for Australia should be collected, interpreted and presented to the UN Commission on the Limits of the Continental Shelf within ten years of Australia ratifying UNCLOS, that is by 16 November, 2004. Thus, in 1996, the Australian Federal Government made the gathering of this scientific data a priority by funding *Geoscience Australia* 's marine program (then called the Australian Ocean Territory Mapping Program).

Geoscience Australia, AUSLIG, the Department of Foreign Affairs and Trade and the Attorney-General's Department are working closely together to prepare Australia's submission on the outer limits of its continental shelf beyond 200 nm for presentation to the UN Commission on the Limits of the Continental Shelf by November 2004.

## b. Data required

The planning of the surveys involved compiling and integrating all existing geological and geophysical data over many remote and poorly surveyed parts of Australia's continental margins. Areas were then identified for which insufficient data existed. In early 2001 Geoscience Australia completed the collection of bathymetric, seismic and other geophysical data (such as magnetic and gravity data) covering the relevant parts of the margins of Australia and its island territories. The data collection was achieved using ship-mounted equipment to make measurements along survey tracks at a spacing of 30-50 nm over the relevant parts of the margins of Australia and its island territories.

These surveys provide regional information on the seafloor topography, water depth, sediment thickness and other geological characteristics of the regions. This research has the added benefit of providing significant new data to aid resource assessment and management of Australia's offshore areas.

## **Bathymetry**

Bathymetric data on the depth of the ocean is critical data for defining the outer limit of the continental shelf under UNCLOS as it helps to locate the foot of the slope and the 2500 metre isobath.

To collect such data a survey ship sails over an area of seafloor and from transmitters on the hull of the ship a burst of sound energy into the water sends out high frequency sound waves. Each sound wave is reflected off the sea floor then travels back to the ship where it is collected by a receiver, converted into an electrical signal, amplified and interpreted. By analysing the time taken for the sound wave to travel from the ship's transmitter to the sea floor and back to the receiver, scientists calculate the accurate depth to the sea floor.

One sound wave frequency generates one type of information. By combining different frequencies ie. generating sound waves of more than one frequency each time, a more detailed set of sea floor information can be obtained. Higher frequencies reflect off smaller objects so the use of higher frequencies gives more detailed topography information of the seafloor. However, lower frequencies give better penetration of the sea floor for detailed mapping of structures just below the sea floor.

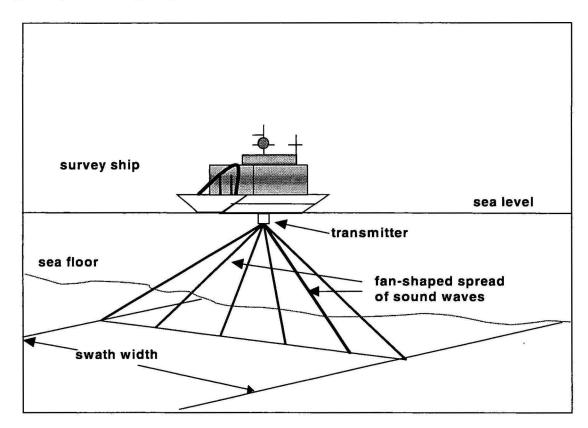
The speed of the sound wave must be known in order to calculate the depth to the seafloor but the speed varies with the temperature of the water. During mapping surveys Geoscience Australia scientists measured the water's change in temperature with depth using a bathythermograph. This is a torpedo-shaped device approximately 20 cm in length, attached to two very fine wires, completing a circuit back to the ship. When released from the ship the bathythermograph sinks and sends a temperature signal back to the ship via one wire. High frequency sound waves used for making bathymetric measurements travel at approximately 1520 metres per second in sea water.



# see Activity: Margin Matters

Sea water quickly weakens higher frequency sound waves so less information returns when compared to lower frequency waves. Therefore, the deeper the water, the lower the sound wave frequencies used. In deep ocean surveys, sound wave frequencies of 3.5 kHz-13 kHz are used so that the acoustic signal is not too weak by the time it reaches the sea floor.

In the early 1990's a sophisticated technique called swath or multibeam mapping became available that allowed much more efficient mapping of the seafloor. In simple terms, multibeam systems generate sound waves in a wide fan at right angles to the direction in which the ship is sailing. This technique receives reflected sound from a strip or swath beneath the ship that can range in width from a few tens of metres to as much as 20 km depending on the frequency of sound used and the water depth.



Sound waves are produced in a fan shape from a transmitter on the hull of a survey ship. They travel downward at 1520 metres per second and reflect off the sea floor, back to receivers on the ship. By analysing the speed of return of sound waves, scientists determine the depth to the sea floor and therefore produce detailed maps of sea floor topography.

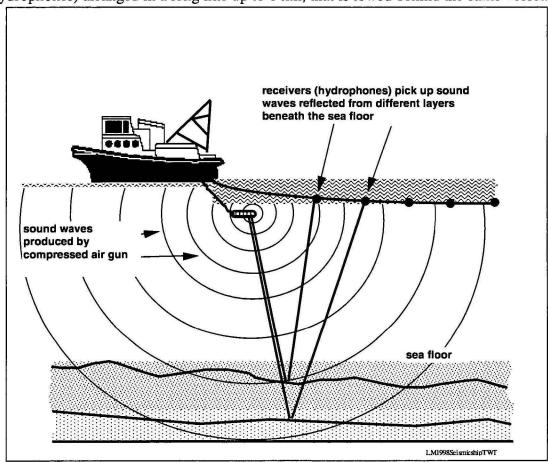
Since 1994 Geoscience Australia has used the French research vessel L'Atalante to conduct a series of multibeam swath mapping surveys around Australia in water depths from 300 to 4 500 metres. This vessel enabled fast mapping of the morphology of the continental margin, and at the same time carried out important seismic surveys to study the subsurface up to 1 000m beneath the sea floor.

The swath beam width on the L'Atalante can be varied electronically by turning off some beams that point in specific directions. The deeper the water, the narrower the beam used to achieve better penetration of the sound wave. In shallower water a wider angle is used. Variations in penetration and resolution can also be achieved by altering the sound frequency used. Lower frequency systems using a 12 kHz sound signal are commonly used in deep water and give greater penetration and wide swath widths up to about 20 km or so in 4 km of water. Higher frequency systems using a 100 kHz frequency sound signal are used to give greater detail in shallow water but these have much narrower swath widths and less area is covered in each sweep.

#### i) Seismic

Over vast lengths of geologic time, mud and sand washed in from the land settled to the seafloor, along with the bodies of marine organisms. These sediments formed thick deposits, many of which were layered and represent the materials that settled at different times.

Seismic investigations are surveys that also use sound waves – but unlike bathymetry surveys, marine seismic surveys use sub-audio frequencies (less than 250 Hz) to penetrate deep below the seabed and reflect off these different layers. In marine seismic surveys a compressed air gun is towed behind the survey ship. When the gun is fired, sound waves spread out through the water. Some sound waves penetrate the sea floor and bounces back from the various layers beneath. The reflected signal is received by a series of microphone-like instruments (hydrophones) arranged in a long line up to 6 km, that is towed behind the same vessel.



Sound waves from a compressed air gun travel down through the sea floor. The sound waves reflect off sub surface layers of sediment or rock and return to surface at different times. They are collected by hydrophones towed behind the ship. By analysing the sound waves, scientists can determine the geological characteristics beneath the sea floor.

The seismic signals are recorded and processed to generate an image of the sea floor in cross section. The seismic image provides an enormous amount of information on subsurface geology - the sediments and rock types present, their thickness, how the original sediments were deposited and structures such as folds and faults. This type of seismic investigation has been essential for determining the sediment thickness over the continental margin, required to define Australia's extended continental shelf under UNCLOS.



see Activity: Carnarvon Capers

## 11. MARINE RESOURCES

#### a. Overview

Under UNCLOS, a coastal country is able to explore and utilise, conserve and manage all the resources over which it has sovereign rights. These include;

- all living and non-living resources within the water column, and on and beneath the seabed within its 200 nm EEZ
- all living and non-living resources on, and beneath, the seabed of the 'legal' continental shelf but not in the water column above the continental shelf.

The provisions of UNCLOS carry with them important implications for sustainable development covering the conservation and management of both living and non-living resources, and the protection and preservation of the marine environment.

#### b. Continental Shelf Resources

A country is more restricted in terms of the resources available to it within its extended continental shelf compared to its EEZ. On the extended continental shelf a country only has sovereign rights to the living and non-living resources that are located on, or below, the seafloor. Examples are bottom-dwelling species such as scallops, mineral deposits such as manganese nodules that also occur on the seafloor and petroleum found below the seafloor. However, they do not have access to resources in the water column, nor the airspace above the water column. This means that coastal countries do not have sovereign rights to use resources of the water or air of their extended continental shelf eg. for activities such as the production of electricity using tidal and wind-powered turbines.

## c. Conservation of Living Resources

Under UNCLOS coastal countries are expected to use the best scientific information available to ensure that the living resources of their EEZ and the extended continental margin are properly conserved and managed and not endangered by over-exploitation. Species must be harvested at or below, sustainable rates to maintain populations. If populations are depleted steps must be taken to allow them to regenerate. Coastal countries must also take into account the interdependence of species so as not to adversely affect populations on which other species depend. If sufficient numbers of a species exist above the country's harvest levels, that country is required under UNCLOS, to give other countries access to these surplus resources.

Some species migrate large distances through the EEZ of more than one coastal country, and into international waters. Article 64 of UNCLOS requires that all countries directly involved must cooperate using bilateral or multilateral agreements, or through suitable international organisations, to ensure these species are effectively managed and conserved.

#### d. International Sea-bed Authority

Based in Jamaica, the International Sea-Bed Authority was established under UNCLOS to organise and control activities within the International Sea-bed Area and to grant opportunities for use of its seafloor and subsoil resources. The Authority is composed of representatives from all countries that are signatories to UNCLOS.

Even though the living resources of the extended continental shelf are freely available to be used, a coastal country must pay to use the non-living resources within this jurisdiction. After the fifth year of production at a site within the extended continental shelf, payments must be made to the International Sea-Bed Authority based on the value or volume of production.

Where do these payments go? The International Sea-Bed Authority distributes payments equitably to countries that signed UNCLOS. However, this does not mean that each country receives equal payment. UNCLOS takes into account the needs of countries that are land-locked without access to marine resources, as well as the needs of developing countries, especially those that are least developed countries.

## i) Developing Countries

Compared to developed coastal countries, developing coastal countries stand to gain additional benefits when accessing non-living resources within their extended continental shelf. If a developing country is a net importer of a mineral resource that is also produces from its extended shelf, it does not need to make payments to the International Sea-Bed Authority for that resource.

Consider a developing country that produces crude oil from its extended continental shelf. If that country also imports crude oil it does not need to make payments for the production of the crude oil to the Authority. If the same country mines manganese nodules on its continental shelf and exports the majority of the manganese without importing any, payments must be made to the International Sea-Bed Authority after the fifth year of production.

## ii) Geographically Disadvantaged Countries

Land locked countries such as Chad and Uganda in central Africa, and Austria and Belarus in Europe have the right to use a proportion of surplus living resources within the EEZs of coastal countries in the same region or subregion. Again, this must be achieved via bilateral, regional or subregional agreements, taking into account that the species population must be conserved and sustainably managed. In addition, UNCLOS requires that these agreements must not burden one coastal country more than others.

Similar allowances exist for coastal countries if they are disadvantaged by having a small EEZ because they;

- have a short coastline (eg. Iraq)
- have a concave coastline (eg. Germany)
- border an enclosed or semi-enclosed sea (eg. countries surrounding the Mediterranean Sea)

#### iii) Example

UNCLOS also takes into account the needs of developing versus developed countries. Consider a hypothetical developed coastal country with a successful, well-managed fishing industry. With successful management of the tuna stocks and with the use of advanced technology and processing techniques, the developed county is approaching the maximum allowable catch size for tuna in its EEZ. However, this developed country is located next to a developing coastal country that is geographically disadvantaged because of a very short coastline. There are insufficient stocks of tuna within this developing country's own small EEZ. UNCLOS requires that both countries cooperate and reach a mutually acceptable agreement on how the tuna in the developed country's EEZ can be used fairly by both countries.

#### e. Resources within Australia's Marine Jurisdictions

Australia manages its EEZ and the living and non-living resources it contains; for example, fish stocks within EEZ fisheries are assessed and fishing rates are managed to allow for sustainable use of these living resources. The seabed mineral resources of the EEZ such as manganese nodules, oil and other hydrocarbon deposits are also available for exploration, assessment and recovery. Australia has numerous offshore hydrocarbon fields that are economically viable. In addition, *Geoscience Australia* is carrying out extensive research on the future hydrocarbon potential of Australia's offshore areas within this country's EEZs and beyond in areas of extended continental shelf (see North West Shelf case study).

In 1984, Australia's marine industries were worth an estimated \$16 billion annually. This figure jumped to \$52 billion in 1998 and estimates for 2020 are over \$120 billion. Therefore, marine resources are of great importance to Australia's economy and are a growth area for new industries and jobs. An approximate breakdown of the main marine resource sector values for 1998 follows.

SECTOR	VALUE (\$ billion)
Tourism	36.0
Oil & Gas	10.0
Shipping	2.2
Fisheries & aquaculture	1.8
Ship/boat building	1.5
Other	0.5
Total	<b>52.0</b>

A wide variety of living and non-living resources are available within Australia's marine jurisdiction that contribute towards this country's strong marine industries. These include;

#### i) Non Living Resources

- petroleum products including oil and gas
- minerals including manganese nodules on the seafloor and diamonds washed onto the continental shelf by rivers
- renewable energy including tidal and wind power

## ii) Living Resources

- fisheries including fish, crustaceans and other marine species
- aquaculture including oyster and prawn farming
- biotechnology including new pharmaceuticals eg. from coneshell venom (conotoxin) for pain and the treatment of disease

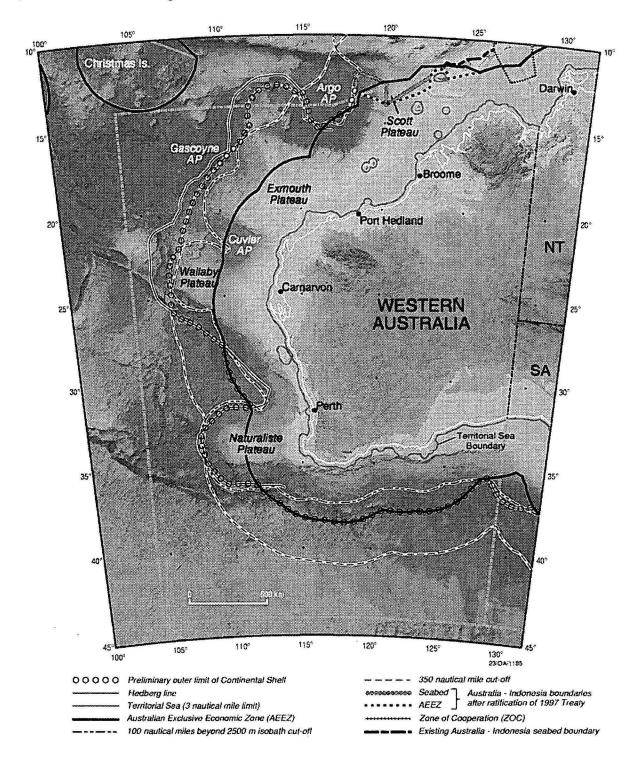
#### iii) Other

- tourism; a huge growth area in Australia worth \$36 billion in 1998. In 1989 it was estimated that 50% of international visits and 42% of domestic visits are related to coastal and marine tourism
- recreation. 80% of Australians live within 50 km of the coast and many use Australia's marine jurisdiction for boating, scuba diving and other recreational pursuits
- transport. 97% of the volume of our domestic and foreign trade is moved by sea
- ship building and coastal/ocean engineering

# **CASE STUDY - NORTH WEST SHELF**

## INTRODUCTION

The North West Shelf is a vital area of Australia because of its unique environment and for its important resources. Large areas of continental margin extend beyond the Australian Exclusive Economic Zone (EEZ) and could become part of Australia's United Nations Convention on the Law of the Sea (UNCLOS) submission in 2004. The North West Shelf also provides an interesting case study in the application of the different methods used to define the outer limits of the 'legal' continental shelf.



#### LOCATION

The North West Shelf covers an area of about 720,000 km<sup>2</sup>. It lies mainly in Western Australia but the northern end extends a short way into Northern Territory waters. The North West Shelf extends for 2,400 kilometres along the north west margin of Australia, from the Exmouth Gulf near Onslow in the south, to Melville Island north of Darwin. Many offshore islands and reefs occur along this continental shelf, in waters between 1000 and 2000 metres deep.

Australia's continental shelf off Western Australia is huge, covering a total area of about 1.4 million km<sup>2</sup>. It extends for a total of 4,700 km and is divided into three distinct regions;

- North West Shelf (Scott, Exmouth and Wallaby Plateaus and Argo Abyssal Plain)
- Naturaliste Plateau
- Great Australian Bite

#### PHYSICAL CHARACTERISTICS

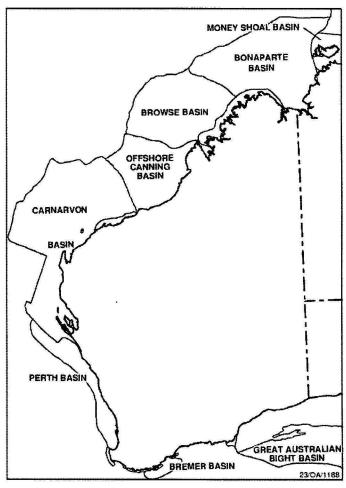
The climate of the North West Shelf is tropical, dominated by the effects of waves, winds and cyclones. In this region, cyclone frequency is moderate to high. The effects of tsunamis are also felt, especially those from the volcanic and seismically active South East Asia to the north. In the past, tsunamis generated near Java are thought to have caused 5 metre tidal waves on Barrow Island, off Dampier.

Seas of the North West Shelf are relatively low in nutrients and subsequently low in vital components of the food chain such as phytoplankton. This means that marine life is not as abundant or diverse as expected.

#### **GEOLOGY**

The North West Shelf is composed of four separate sedimentary basins, the Northern Carnarvon Basin, Offshore Canning Basin (the majority of the Canning Basin is onshore), Browse Basin and Bonaparte Basin. These four basins of the North West Shelf developed over the last four hundred million years. Their development intensified when Australia rifted away from India during the break-up of Gondwana over the last one hundred and fifty million years. This occurred when plate tectonics pulled Gondwana apart and India and Australia were moved away from each another. This created stretching of the continental crust along the north west margin of Australia and a series of faults developed that broke up the crust into separate blocks.

Boundaries of large offshore sedimentary basins in Western Australia, including the North West Shelf. Reproduced with permission of P and R Purcell.



The four very large depressions located offshore gradually filled in with layers of sediment such as mud and sand. These sediments were washed off the continent and into the ancient seas by rivers, or were derived from the remains of dead organisms such as algae and plankton. Over a long geological history, these basins accumulated sediments up to 17 kilometres thick. Although the current supply of sediment to the North West Shelf is very restricted, the ancient sediments contain significant hydrocarbon deposits (mainly oil & gas).

This developmental history has complicated the geology of the North West Shelf. This, in

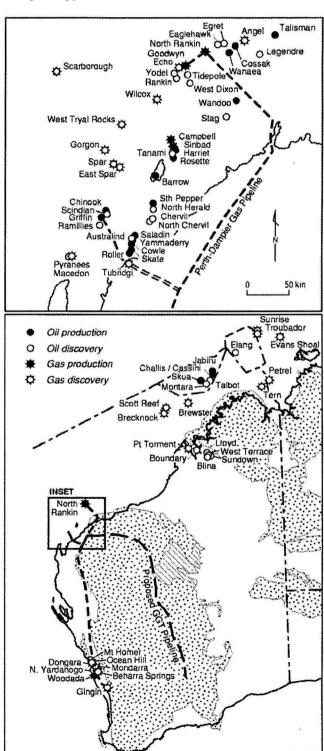
turn, complicates the application of UNCLOS when defining the outer limits of Australia's continental margin in this region.

#### HYDROCARBON RESOURCES

Much of Australia's hydrocarbon production comes from the Gippsland Basin, the Timor and Arafura Seas and the North West Shelf, where offshore platforms access petroleum deposits beneath the seafloor. In 1996 offshore petroleum production in Australia was valued at \$8 billion, of which \$5 billion was exports.

Although the Gippsland Basin off Victoria has led in terms of the production and reserves of oil, Western Australia is increasing in national significance. In 1994 it was estimated that Western Australian sedimentary basins, both on and offshore, contained approximately 45% of Australia's known oil, 78% of the condensate reserves and 80% of gas reserves. Western Australian basins produce a quarter of the nation's crude oil at around 150,000 barrels per day. Most oil produced in Western Australia is from the North West Shelf, although there have been oil discoveries in the Perth Basin to the south. The North West Shelf is one of Australia's richest and most complex natural resources, generating more than \$6 billion for this country's economy.

Oil and gas producing fields and discoveries in Western Australia. Note the large number of sites in the North West Shelf region. Maps reproduced with permission of P and R Purcell.



Western Australia's first commercial oil production was in 1967 from the Barrow Island Oil Field located in the Northern Carnarvon Basin. Barrow Island remains the largest Western Australian oil field, although production levels are now decreasing. Between 1967 and 1993 this field produced a total of 256 million barrels of crude oil and 1994 production was approximately 15,000 barrels per day. There are another 17 oil-producing fields in the Northern Carnarvon Basin.

50% of Australia's current gas production, one billion cubic feet per day, comes from Western Australian basins. The majority of this gas comes from the offshore North Rankin Field in the Northern Carnarvon Basin. Some of this gas is for Western Australia's domestic market but the majority is exported as Liquefied Natural Gas.

The Western Australian basins contain about 50% of undiscovered oil resources and over two thirds of predicted undiscovered gas resources in Australia. A total of 48 offshore exploration wells were drilled in Australia in 1996. This increased to 62 in 1997 and 75 in 1998 as the search for new petroleum discoveries intensified. On the North West Shelf, new oil fields were discovered in the Bonaparte, Browse and Carnarvon Basins during 1998. In that same year, new gas fields were also discovered in all three basins.

#### OFFSHORE EXPLORATION

Australia produces a substantial amount of offshore crude oil and natural gas. However, there are many existing Australian basins that have yet to be explored for hydrocarbons such as petroleum. Currently Australia's petroleum production comes from only 1% of Australia's EEZ. It is estimated that a further 45% of the EEZ contains sedimentary basins that may have commercial petroleum deposits. Of this area, 38% have insufficient scientific information to assess their commercial potential. Exploration companies are unlikely to take up such areas until sufficient knowledge is obtained about their geology and structural characteristics.

To determine the potential petroleum reserves in an area such as the North West Shelf an exploration company needs regional geological and geophysical data to target areas likely to contain hydrocarbons. However, the cost of undertaking regional surveys can be prohibitive. In Australia each state and the Northern Territory has their own geological survey. These organisations work together with *Geoscience Australia*, Australia's national geological survey, on programs such as the National Geoscience Mapping Accord to provide regional geoscientific data that is used by the exploration industry.

By completing geological surveys governments can provide exploration companies with scientific data to help pinpoint prospective petroleum deposits in a timely and cost-effective manner. As well as producing regional maps and seismic sections, research is also carried out to better understand the processes that determine the formation and distribution of petroleum. *Geoscience Australia* plays an important role in gathering and interpreting this information. This includes:

- the nature of the basement rocks that underlie the seafloor
- the influence of the basement rocks on the development of the overlying basin
- processes that control the distribution of basins, how they began and their evolution
- the material deposited in the basins, the processes that led to the sediments building up and later folding and faulting
- controls on the development of petroleum within the sediments and the factors affecting the movement of the petroleum throughout the basins

Bathymetry and seismic data enable exploration companies to better interpret the underlying geological structures on the North West Shelf. These structures control the possible location of petroleum deposits such as oil and gas beneath the seafloor by creating traps for migrating liquid and gaseous hydrocarbons.

In addition magnetic and gravity data assists in identifying areas containing potential hydrocarbon resources.

- Gravity data shows variations in the density of sub-surface rocks. Different rock types
  have a different gravity signature: for example, rocks with a high iron content have a high
  gravity signature. Gravity data for offshore areas of Australia is gathered during ocean
  surveys and from satellite imagery.
- High-resolution data magnetic anomaly data details the strength of the Earth's magnetic field. This assists in identifying areas containing specific target minerals. Magnetic minerals such as iron have a strong magnetic signature. Also, certain geologic structures can be identified by their magnetic profile.

Scientific data such as seismic records collected by *Geoscience Australia* are available commercially using information technology and the World Wide Web. Researchers can access information on a relatively small area or one encompassing hundreds of kilometres and order all associated data over the *Geoscience Australia* website. Offshore exploration in Australia has reached record levels, in part due to reliable access to detailed survey data housed in *Geoscience Australia* 's collection. This increased exploration has occurred even with the unstable price of oil since the early 1980s.

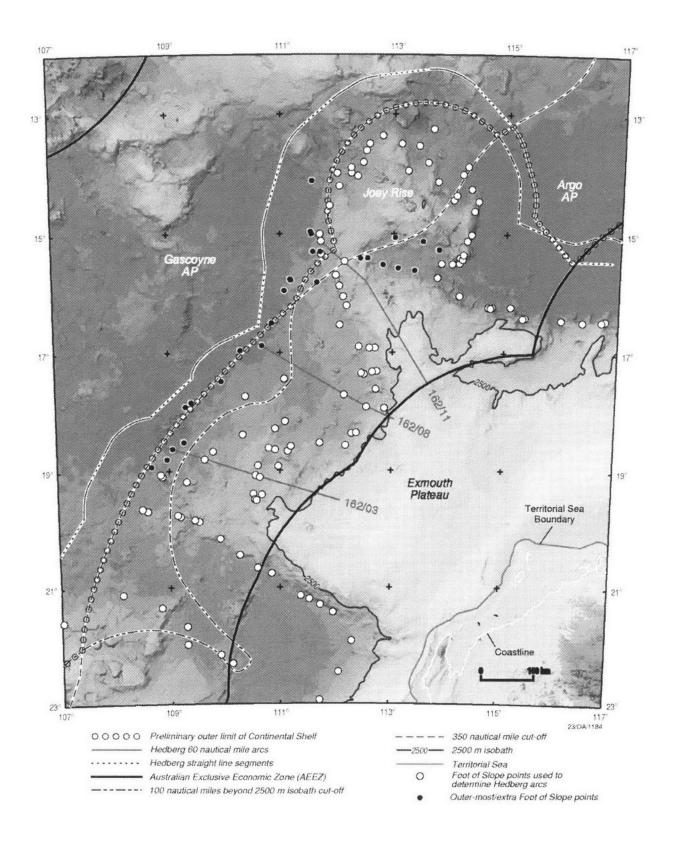
#### **Applying UNCLOS to the North West Shelf**

In twenty nine regions of the world offshore continental margins extend beyond established EEZs (page 39). These regions could be included in the UNCLOS submissions of individual countries in the future. Five of these regions of extended continental margin, Numbers 20-23 and 25, are part of Australia's proposed marine jurisdiction under UNCLOS. One of these regions, Number 21, is Australia's North West Shelf. Therefore, an important adjunct to Geoscience Australia 's scientific research on the North West Shelf is defining the outer limits of Australia's continental margin in this region and supporting Australia's 2004 submission to the UN on these areas.

Although the Scott Plateau on the North West Shelf is within Australia's EEZ, both the Exmouth and Wallaby Plateaus straddle the EEZ and extend beyond it to the edge of the continental margin. Some 20% of the Exmouth Plateau lies beyond Australia's EEZ. Together, the Wallaby and Exmouth Plateaus cover a combined area of 600,000 km² beyond the EEZ.

A country has sovereignty over resources on and below the seafloor on the continental shelf and *Geoscience Australia* scientists consider that there may well be commercially viable petroleum deposits on these two plateaus beyond the 200 nm EEZ. An important consideration for exploration companies is that their petroleum fields are legally and physically secure. Therefore it is vital that the outer limits of Australia's continental margin are accurately defined under UNCLOS so that the resources of the seabed and those beneath can be assessed and sustainably managed.

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#### **UNCLOS** data

For Australia to claim beyond the existing EEZ the following information is required;

- bathymetry (topography) of the seafloor
- sediment thickness
- sediment distribution

This scientific data has been acquired by *Geoscience Australia* and is being used to determine the extended outer limits of Australia's continental margin. The North West Shelf is an ideal case study to highlight some of the problems associated with applying UNCLOS to an area of continental margin. Its complex geologic history and its physical characteristics make it difficult to determine the location of UNCLOS limits. This process is further complicated by indiscrete and complex boundaries between the continental margin and the deep ocean floor in this region, because the change from continental to oceanic crust occurs over a broad transitional zone.

There are five main aspects that cause difficulty when determining where the edge of the continental margin is located. Each of the aspects refers to features shown on the Exmouth Plateau map page 49.

## i) Deep Ocean Floor

About 20% of Australia's continental margin is continental shelf (less than 200 m water depth), about 30% is deep continental margin (plateaus and slopes) and the remaining 50% is deep-ocean floor. UNCLOS states that deep ocean floor cannot be included in a country's continental margin.

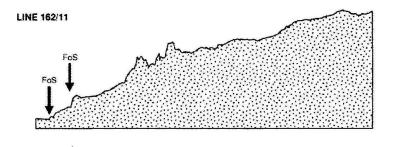
However, on the North West Shelf of Australia, the continental margin extends around, and encompasses, some areas of deep ocean floor that are still within the allowable outer limits under UNCLOS. An example of this is the Argo Abyssal Plain. Its southern region is within the Australian EEZ, within 60 nm from the foot of slope points, and within the 100 nm beyond the 2500 metre isobath limits. Yet this part of the Argo Abyssal Plain includes areas of deep ocean floor.

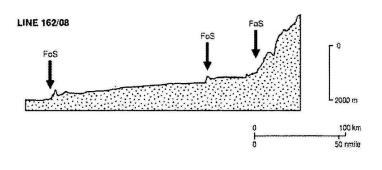
## ii) Continental Slope

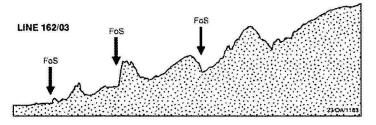
On the Exmouth Plateau beyond 200 nm from the coast, the continental slope is complex and variable because of its geological history. The variability of the Exmouth Plateau's continental margin is shown in the following bathymetric profiles, taken on three separate tracks by survey ship.

Although a simple continental margin has a clear continental slope, the slope on the Exmouth Plateau forms a zone extending over an area of 135 nm that includes many significant slope changes. This makes it difficult to defining the foot of slope (page 32) upon which other boundary limits are based.

An example is shown along the profile line 162/08. The location of the possible foot of slope points varies from just west of the 2500 metre isobath to the beginning of the Gascoyne Abyssal Plain.







Bathymetry across the region north west of the Exmouth plateau (see map page that shows location of each profile). The various potential foot of slope locations are shown by arrows.

## iii) Continental Rise and the Foot of Slope

Identifying the continental rise on the Exmouth Plateau is also a problem. Although profile 162/08 appears to include a continental rise that formed by an apron of sediment at the base of the continental slope, seismic research shows otherwise. It is actually a very complex terrane, affected by a long history of deformation due to tectonism and actually has a very thin veneer of sediment.

The crust was stretched and thinned over a long period of time and broken into blocks that moved relative to one another. Then the region was affected by volcanic events. This created a complicated offshore topography that mimics a normal continental rise (page 24). Applying the normal definition of the foot of slope based on apparent physical characteristics of the continental margin would support the foot of slope being close to the 2 500 m isobath. However, *Geoscience Australia* 's research suggests that the correct location for the foot of slope is actually at the very western end of this profile, at the beginning of the Gascoyne Abyssal Plain (see page 49).

## iv) Sediment Thickness

Over recent geological history, the North West Shelf has had very little new sediment deposited on it. Seismic data acquired on this continental margin suggests that there are insufficient areas where the sediment is thick enough to use in assessing the edge of the continental margin (page 32).

## v) 2,500 metre isobath + 100 nautical miles

On complex margins such as the North West Shelf, the continuous 2,500 metre isobath usually lies near the top of the outer continental slope. This isobath can be seen in the map of north western Western Australia (page 39). The isobath actually defines features such as narrow extensions of the shelf, shown along profile line 162/11, and a small marginal plateau with a narrow neck, just east of the same profile line. However, there are other small, isolated closures of the 2,500 metre isobath further away from the coast. An example is on Joey Rise, north east of the Argo Abyssal Plain and just west of the 350 nm outer limit. These closures represent higher areas, often associated with events such as volcanism or blocks of crust that have been moved upwards. Although an isolated rise, Joey Rise is connected to the remainder of the Exmouth plateau by a saddle, making it part of Australia's continental margin.

## vi) Conclusion

Once all of these factors have been applied, the outer limits of the continental margin on the Exmouth Plateau is mainly defined by the 350 nm and 2,500 metre isobath + 100 nm cut-offs. The 60 nm line beyond the foot of slope is only of relevance in determining the outer limit of the continental margin near Joey Rise. Individual foot of slope points have been drawn at the base of Joey Rise. The 60 nm line has been drawn, based these points (page 39). It encloses both the Exmouth Plateau and Joey Rise, including them in Australia's proposed extended continental margin.

By analysing these areas of extended continental margin, Australia can add about 600 000 km<sup>2</sup> of the Exmouth and Wallaby Plateaus and 20 000 km<sup>2</sup> of the Argo Abyssal Plain to its UNCLOS submission.

However if Australia cannot use the 2,500 isolated metre isobath and the resulting 100 nm cut-off beyond it, the 350 nm cut-off must be used. This will exclude a considerable part of the continental margin from Australia's 'legal' continental margin.

# Sustainable Management of North West Shelf

#### i) UNCLOS requirements

It is a fundamental legal requirement of UNCLOS that countries protect and preserve the marine environment as well as sustainably manage and conserve its living resources. This applies to the resources within a country's own marine jurisdictions and also in areas of extended continental margin.

#### ii) Future Management

Alternative energy sources are being actively researched and developed at present and may compete with petroleum as an energy source in the future. An example is tidal power being research in north west Australia. Here tidal ranges between high and low tide of 10 m have been recorded. A commercial venture has been proposed to create a 48 million-Watt tidal power plant in King Sound near the town of Derby, being driven by the outflow of water at high tide through turbines. As these alternative energy sources are made available to the

general public, there may be changing demands for petroleum. Until that time, the world's population as a whole depends heavily on this resource.

The petroleum exploration and production industries are very aware of the need to manage and conserve the ecosystems in which they explore, produce and transport petroleum products. This applies to areas within an EEZ and beyond to the edge of the continental margin.

Australia's North West Shelf is managed effectively to minimise disturbances to the environment. Within the Marine and Technology Plan, part of the 1999 Australian government's Oceans Policy, a priority was to manage marine industries to prevent accidents such as oil spills. In response, engineering guidelines for shipping, offshore and coastal constructions are being revisited to ensure they are appropriate for the normal conditions that exist in Australia's offshore and coastal regions and for infrequent events such as cyclones.

Detailed mapping of the continental shelf by *Geoscience Australia* has provided a wealth of scientific information about its physical characteristics. Bathymetry information identifies the shape and the depth of the ocean floor. Such data provides more accurate information about the physical characteristics of the North West Shelf; for example, the depth of the water column and the distribution of canyons, plateaus and basins.

Because each species has specific habitat requirements, the geoscience data assists in determining the region's biodiversity. More effective conservation and management of the living resources on the North West Shelf are then possible by understanding the seabed topography and its spatial association with ecosystems. Resource managers can better understand the environments and management needs of areas they are managing with access to this data. *Geoscience Australia* is making this data available to organisations involved primarily in the sustainable management of the living and non-living resources on the shelf and those involved in commercially developing some of these resources.

# **CASE STUDY - ANTARCTICA**

#### **Antarctica and UNCLOS**

Antarctica is a huge continent that is almost completely covered in permanent ice. It is also surrounded by a continental shelf that extends for 40-200 km from the 'coast'.

Australia lays claim to two large segments of the Antarctic continent (the Australian Antarctic Territory or AAT), comprises 42% of the landmass and has a combined coastline just over 5,000 km in length. These two segments extend from 45° - 136°E and 142° - 160°E and are separated by the French claim of Terre Adélie. The western and eastern boundaries of the Australian claim abut the Norwegian and New Zealand claims respectively. Australia has already declared a 200 nm EEZ off its AAT of about 2.5 million km² (page 7).

On December 2, 1999 the Commonwealth Ministers for Foreign Affairs and Environment & Heritage announced that Australia would carry out the necessary work to prepare a submission delineating the extended continental shelf off the AAT, in accordance with UNCLOS. The area of extended continental shelf beyond the EEZ off the AAT is about 1.8 million km² (similar to the area of Queensland), with the likely actual area that Australia could include in a submission under UNCLOS being closer to 1 million km².

The Australian Antarctic Southern Ocean Profiling Project was subsequently established to acquire and interpret the large quantity of geoscience data from offshore Antarctica that would be required to support an UNCLOS submission on areas of extended continental margins. By defining the morphology (shape) of the seabed off the AAT and providing information about the underlying geology, *Geoscience Australia* will be able to define size of the extended continental shelf. The Australian Surveying and Land Information Group (AUSLIG) is playing a vital role in determining the UNCLOS baselines from which the outer limits are measured.

With the collection of detailed geoscientific information, Australia is now in a position to prepare a 2004 submission for the AAT under UNCLOS, if it so chooses.

## **Governing Treaties**

In all activities in Antarctica, Australia is bound by the provisions of the Antarctic Treaty to which it is a signatory. This treaty is a multilateral agreement between 42 countries, all members of the United Nations. *Geoscience Australia's* scientific surveys are being undertaken in accordance with the Antarctic Treaty and with environmental permit guidelines issued by Environment Australia and the Australian Antarctic Division.

## **Antarctic Resources**

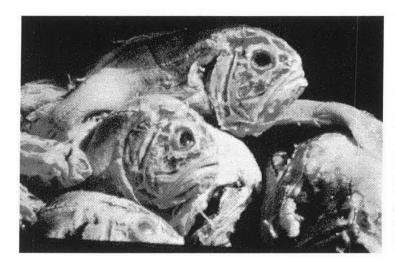
Although the provisions of UNCLOS suggest that the resources of any marine EEZ or extended continental margin areas could become available for use, this is not the case in Antarctica. Special restrictions apply on the activities that can occur, both on and offshore, based on the provisions of the Antarctic Treaty. Irrespective of UNCLOS, the Treaty designates Antarctica as a 'natural reserve, devoted to peace and science'. Strict environmental principles have been established that encompass all activities within the AAT and prohibit certain activities such as mining and the disposal of waste.

An additional convention within the Treaty is the Conservation of Antarctic Marine Living Resources. Its purpose includes establishing protected species, identifying fishing regions and regulating fishing such as catch sizes.

Therefore the living resources of Antarctica are subject to use under strict rules and the non-living resources are unavailable for use.

The Southern Ocean surrounding Antarctica is probably the most poorly understood area on the planet. The *Geoscience Australia* surveys are the most wide-ranging geoscience surveys ever completed off Antarctica. After Australian scientists have interpreted the data it will be made available to the international scientific community under the terms of the Antarctic Treaty and through the Scientific Committee on Antarctic Research. This wealth of scientific information obtained by the Australian Antarctic – Southern Ocean Profiling Project will increase international scientific understanding of Antarctica and its role in the global climate system, as well as provide vital information to support future conservation and management of the Antarctic environment.

# **CASE STUDY - ORANGE ROUGHY**



Orange roughy are a bottom-dwelling deepwater fish.
Considered good eating, they are important to Australia's deepwater fishing industry. Orange roughy fisheries are distributed from Western Australia through to New South Wales. Large stocks of the fish have been located in the South Tasman Fishery, associated with seamounts (extinct volcanoes) on the South Tasman Rise off Tasmania.

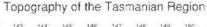
#### Habitat

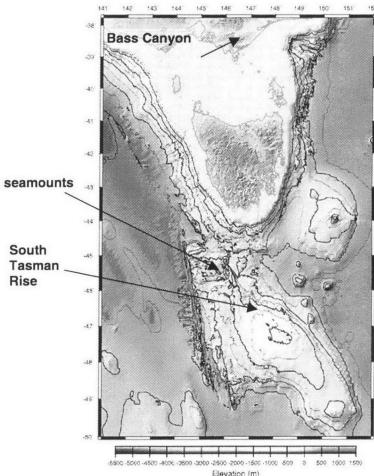
Living at depths of about 800 - 1000 metres, orange roughy feed on prey swept passed the seamounts by ocean currents. In this deep-water environment the fish must cope with high water pressures, low light levels and very low water temperatures.

# Sustainability Of Orange Roughy Stocks

After the initial discovery in the late 1980s that large numbers of these fish aggregated around seamounts in the South Tasman Rise, the species was heavily fished by deepwater bottom-trawling vessels. Huge single catches up to 100 tonnes were taken. A total of 46 000 tonnes of orange roughy was caught in 1990, compared to only 1 000 tonnes in 1986.

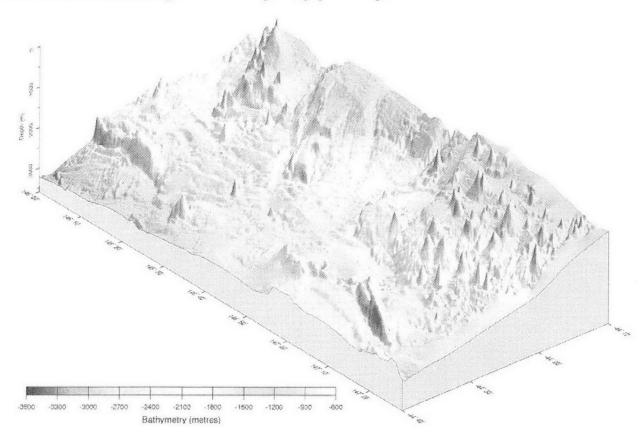
Recent investigations into the habitat requirements and reproduction of orange roughy indicate that commercial vessels were catching large numbers of fish when they gathered to feed and reproduce.





South Tasman Rise off the south east coast of Tasmania. Note the location of the seamounts at the northern end of the Rise where large populations of orange roughy are found.

Orange roughy are slow growing fish and may live as long as 150 years. The fish have low reproductive rates and require a long time for populations to regenerate. This meant that orange roughy were in danger of being overfished. Such large catch sizes were unsustainable and more effective management of orange roughy was required.



Oblique bathymetry view of the seamounts (extinct undersea volcanoes) discovered recently off south east Tasmania. Orange roughy feed and breed around these sea mounts - the individual peaks can be seen, especially to the lower right (please note – strong vertical exaggeration).

## **Australian Fisheries Industry**

There are more than 4000 different fish species in Australian waters, of which commercial quantities of 200 marine species are caught. In addition, the fishing industry also catches 60 crustacean species, 30 mollusc species and a few echinoderm species such as sea urchins.

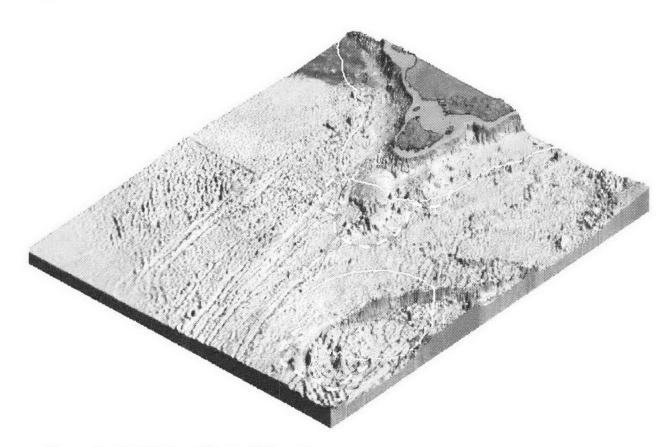
Together, fishing and aquaculture make up Australia's fifth-largest primary industry and are worth about \$1.6 billion annually. Although Australia's EEZ is very large, the fish catch is proportionally small due to relatively low nutrient levels in Australian waters. Total annual catches are about 200,000 tonnes, with foreign boats licensed to catch an additional 15,000 tonnes in Australia's EEZ.

With respect to the current management of the orange roughy in the South Tasman Rise Fishery, the Australian Fisheries Management Authority (AFMA) determines total catch sizes and establishes management arrangements in consultation with the commercial South Tasman Rise Australian Trawl Association. As a consequence only 14 fishing permits were issued for orange roughy in the South Tasman Rise Fishery in April 1999 and a total catch limit was set. The estimated 1998-99 South Tasman Rise catch was 2,146 tonnes, worth approximately \$7,511,000.

## **UNCLOS** and Orange Roughy

Between 1974 and 1978 the United Nations held conferences on the Law of the Sea. These covered the possible introduction of an economic resource zone and a 200 nautical mile (nm) Exclusive Economic Zone (EEZ) around each coastal country. In 1979, Australia responded to the conferences by establishing its own fishing zone that extended from the coast to a distance of 200 nm.

It was not until 1994 that Australia ratified the UN Convention on the Law of the Sea (UNCLOS). Under this convention, Australia gained sovereign rights over all living and non-living resources within its 200 nm EEZ, part of which is shown by solid white line on the following map. The boundaries of this new EEZ overlapped most of the original 1979 fishing zone. Australia now had marine jurisdiction over a 9 million km² fishing zone, the third largest in the world.



The marine jurisdiction of Australia's south east.

The solid white lines indicate the outer edge of EEZs. The dashed white lines show the proposed limit of Australia's continental margin under UNCLOS and the basis of Australia's 2004 submission to the UN.

The separate white line far to the south indicates the EEZ circling Australia's Macquarie Island. The associated area of extended continental shelf extends beyond the EEZ further to the south.

The EEZ off southern Tasmania excludes half of the South Tasman Rise which is orange roughy habitat. The extended continental margin would encompass all of the South Tasman Rise. However, the management of this region would still exclude the living resources of the water column and therefore orange roughy from Australia's jurisdiction.

Under UNCLOS coastal countries must properly conserve and manage the living resources within their EEZs. They are required to determine the allowable catch of commercial marine species. UNCLOS recommends that coastal countries base catch limits on the best scientific evidence available to ensure that commercial species in EEZs are not endangered by over-exploitation.

Coastal country can set requirements that all vessels fishing in their EEZ must comply with such as:

- determining the species that can be caught, fixing catch quotas for particular species or groups of species, or the allowable catch per vessel over a period of time
- regulating seasons and areas of fishing, the types, sizes and amount of gear, and the types,
   sizes and number of fishing vessels that may be used;
- fixing the age and size of fish and other species that can be caught;
- specifying information recorded during fishing activities is required back from fishing vessels, including catch statistics and vessel position reports
- regulated fisheries research programs that include the sampling of catches and reporting of scientific data

Therefore under UNCLOS Australia is obliged to conserve and sustainably manage all of the living resources of its EEZ, including fish such as orange roughy. The activities of foreign fishing vessels can be controlled within the EEZ and catch sizes limited.

Seafloor mapping by *Geoscience Australia* revealed that the South Tasman Rise extends beyond the limit of Australia's 200 nautical mile EEZ. This sea floor area therefore is part of Australia's extended continental margin and will be included in the 2004 submission to the United Nations.

Groups of orange roughy were found both within and beyond Australia's EEZ in the region of the South Tasman Rise. Recent research has shown that these fish represent one population, not separate populations. Juveniles congregate inside the EEZ but adult fish move outside the EEZ to reproduce. Adult fish are sought commercially. Outside the EEZ these adult orange roughy are no longer under Australian management and are vulnerable to unregulated fishing by vessels operating in international waters.

Would this situation be resolved by Australia's 2004 submission on areas of extended continental shelf under UNCLOS? Under the provisions of Article 76 of UNCLOS Australia can extend its marine jurisdiction beyond the EEZ to the edge of the continental shelf; this would include the entire South Tasman Rise (see map). However, Australia would only be able to manage the resources on, or under, the sea floor. All resources in the water column above the sea floor would not be included.

Orange roughy are not a sedentary species; that is, they do not spend the majority of their life in contact with the sea floor. Therefore orange roughy outside the EEZ, but within the limits of the extended continental margin, would not come under Australian jurisdiction and therefore would not be managed by this country.

## **International Agreements**

Article 63 of UNCLOS makes provisions where a marine species lives inside an EEZ as well as beyond that EEZ. Therefore Australia and the countries wishing to catch species that live across the EEZ boundary are expected to reach agreement on sustainable catch sizes and measures to conserve stocks.

Such discussions have already occurred with respect to orange roughy. In 1997 Australian and New Zealand boats caught large quantities of orange roughy in the South Tasman Rise Fishery in international waters outside the EEZ. Australian fishing operators, concerned at the impact on future orange roughy catches of such unsustainable fishing, approached the Australian Government and requested regulation of this Fishery. A bilateral agreement was negotiated between Australia and New Zealand to limit fishing and introduce cooperative sustainable management practices.

A Memorandum of Understanding (MOU) between Australia and New Zealand came into effect on 1 March 1998. The March 1998 - February 1999 orange roughly catch in the South Tasman Rise Fishery outside Australia's EEZ was therefore restricted to 2 100 tonnes. This was to be reassessed once scientific information indicated whether or not larger catches were sustainable.

"Both Australia and New Zealand have clear responsibilities under the Law of the Sea and the United Nations Agreement on Straddling Fish Stocks..... to cooperate to the maximum extent possible in taking action to conserve and manage this resource"

Senator Parer, Minister for Resources and Energy DPIE Press Release, 13 November 1997

When the MOU was due for renewal in early 1999 further negotiations between Australia and New Zealand did not reach agreement about future management of the South Tasman Rise Fishery. Therefore, Australia now requires all Australian vessels fishing in the South Tasman Rise beyond Australia's EEZ to follow the provisions of existing Australian Fisheries regulations. Catch limits apply to the Australian fishing industry based on the 1998 MOU levels. Bilateral negotiations with New Zealand are continuing.

## Future Management of Australia's Marine Jurisdiction

The Australian government released its Oceans Policy in 1999. As an adjunct to the Oceans Policy, the Australian Marine Science and Technology Plan outlined the scientific goals necessary to achieve the aims of the Oceans Policy. These documents emphasised ecosystem-based planning and management of all Australia's ocean territories in keeping with the requirements of UNCLOS. In order to carry out this policy effectively the Australian Government introduced the concept of Regional Marine Plans based on different marine ecosystems. These plans are to be developed progressively and will eventually encompass all areas of Australia's marine jurisdiction.

The first plan to be initiated was the Southeast Regional Marine Plan (SERMP) on April 14, 2000. and it is expected to take three years to be completed. The SERMP includes all of the waters and seabed within the 200 nautical mile limit of Australia's EEZ, stretching from the western most point on Kangaroo Island in South Australia, the waters off Tasmania and Victoria, through to latitude 36°S off New South Wales. The region also includes the extended continental shelf beyond the EEZ, which Australia will be claiming under the

United Nations Convention on the Law of the Sea. The SERMP will include orange roughy habitat in the South Tasman Rise Fishery.

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Effective management such as the establishment of Regional Marine Plans requires detailed scientific information on which to base decisions. Because each marine species has specific habitat requirements, more effective conservation and management of these species in Australia's marine jurisdiction are possible by understanding the seabed topography (shape) and its spatial association with ecosystems.

This information was lacking for vast areas of Australia's marine jurisdiction. *Geoscience Australia* was therefore given the task of mapping in detail the seafloor topography of Australia's continental shelf (including the habitat of orange roughy off southern Tasmania). This information will be used to define the physical characteristics of the areas to be covered in each Regional Marine Plan.

In addition, *Geoscience Australia* is defining the outer limits of Australia's continental shelf under UNCLOS. This information will be the basis for future use and management of Australia's marine jurisdiction.

# **USEFUL WEB SITES**

## GEOSCIENCE AUSTRALIA www.agso.gov.au

United Nations homepage www.un.org

United Nations Law of the Sea homepage, including a searchable website www.un.org/depts/los/index.htm

United Nations Law of the Sea - documents outlining articles www.un.org/depts/los/losconv1.htm

Australia's Oceans Policy www.environment.gov.au/marine/ocepoly/

National Oceans Office website www.oceans.gov.au

AUSLIG web site on determining maritime boundaries www.auslig.gov.au/marbound/ambis.htm

Australian Fisheries Management Authority www.afma.gov.au/

South Tasman Rise Fishery information www.afma.gov.au/fisheries/

Australian Antarctic Division - Antarctic treaty webpage www.antdiv.gov.au/information/treaty/

International Boundaries Research Unit, University of Durham, UK www-ibru.dur.ac.uk/

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# **GLOSSARY**

## abyssal plain

A smooth flat area of the deep ocean floor that begins at the base of the continental rise.

## agreement

International agreements are binding documents under international law. These agreements may take a variety of forms and titles, for example, "convention", "protocol", "treaty", "executive agreement", "exchange of notes", "exchange of letters" or simply "agreement". They can be bilateral (between two parties) or multilateral (among more than two parties). A particular agreement is binding under international law if the parties to it intend it to be so.

#### annex

To add territory to existing territories over which a nation has control eg. Britain annexing the Christmas Islands in 1888.

## aquaculture

The commercial farming of marine or freshwater species.

## archipelagic State

A country formed completely from one or more groups of islands (archipelagos).

## archipelago

A group of islands that are in close spatial association, share interconnecting waters and other natural features, and can be considered a single political and geographical entity under UNCLOS

## Area, the

Under UNCLOS, "the Area" is defined as the seabed, ocean floor and subsoil beyond the limits of national jurisdiction ie. beyond the limits of any country's EEZ or the 'legal' continental shelf (whichever is greater). No country can claim sovereignty over any part of the Area or its resources. All rights rest with Mankind (all people), not individuals or groups. The International Sea-Bed Authority can manage the use of resources within the Area for the benefit of all people, taking into account the needs of developing countries and other disadvantaged countries.

#### atoll

A circular island reef that encloses, partly or completely, a lagoon.

#### baseline

See territorial sea baseline.

## bathymetry

The depth of the ocean floor from the ocean surface. The seafloor topography.

#### bilateral

Involving two groups only eg. organisations or countries. The MOU between Australia and New Zealand over the orange roughy fishery in the South Tasman Rise was a bilateral agreement.

#### coastal country

For ease of reference in this document only, a coastal country replaces the concept of a coastal State as defined by UNCLOS. In this document, a coastal country has at least one border along one of the world's seas.

#### contiguous zone

A country's jurisdictional zone which is adjacent to its territorial sea and may extend from 12 nm up to 24 nm from the territorial sea baseline.

#### continent

A large landmass. Today there are seven separate continents on Earth (either joined or isolated) consisting of Australia, Antarctica, South America, North America, Africa, Europe and Asia. In the past, these continents were once joined together to form supercontinents eg. Gondwana in the Southern Hemisphere once comprised Australia, South America, Antarctica, Africa, plus current islands or what are now parts of other modern continents ie. New Zealand, India, Sri Lanka, and Madagascar).

#### continental margin

The submerged extension of a landmass into the sea. Consists of the continental shelf, slope and rise.

#### continental rise

A subsurface feature representing the part of the continental margin in between the continental slope and the deep ocean floor. It often consists of an apron of sediment built up against it from sediment descending from the continental slope.

#### continental shelf

The Legal Continental Shelf (LCS) is the area of land that slopes gently towards the sea and extends from the coast to the beginning of the continental slope.

#### continental slope

The part of the continental margin in between the shelf and the rise.

#### convention

This term is frequently employed for multilateral agreements to which a large number of countries are party. The Law of the Sea Convention is available to all member countries of the United Nations. Currently 151 countries have signed UNCLOS.

#### country

Used to describe areas under the control of a single national government. In this resource, the term country has been used in preference to the more ambiguous to the term, State.

#### deep ocean floor

The surface of the seafloor beyond the edge of the continental margin.

#### **EEZ**

Exclusive Economic Zone. Area within a distance of 200 nm (370 km) from the territorial baseline (usually low water mark) of a coastal country. All living and non-living resources of the EEZ are the within the sovereign claim of the coastal country.

#### foot of slope

The point of maximum gradient change at the base of the continental slope.

#### high seas

All parts of the oceans or a smaller sea that are not included in the EEZ, in the territorial sea or the internal waters of a country or archipelagic waters.

#### hot spot

An area of the Earth's continental or ocean crust where molten rock (magma) is able to rise through the crust and break through to the surface, sometimes creating a volcano. Many of Australia's volcanoes such as the Glasshouse Mountains in Queensland, are hot spot volcanoes.

#### igneous rock

Rock formed from the cooling of molten rock. Two examples are basalt (fine grained, dark coloured rock) and granite (coarse grained, paler coloured rock).

#### internal waters

The water on the landward side (inside) of a coastal baseline when drawn across the mouth of wide rivers and bays.

#### **International Seabed Authority**

The Authority came into existence on 16 November 1994 as it is an organisation brought into existence by UNCLOS. Its headquarters are in Kingston, Jamaica. All member countries of the UN are members of the Authority. Through the Authority, UN member countries organise and control seabed activities in the Area on behalf of all people. Particular emphasis is given to administering the resources of the Area (eg. polymetallic nodules found on the seabed). Special consideration can be given to developing countries, including land-locked countries and geographically disadvantaged coastal countries.

#### isobath

A contour line drawn on a map that connects points that are at the same depth below the water surface.

#### jurisdiction

Having legal authority over an area.

#### land-locked country

Is one that has no sea coast. It may have an inland lake coast.

#### lowest astronomical tide

The low water line used to determine the territorial sea baseline. It is the lowest level to which sea level can be predicted to fall under normal meteorological conditions.

#### low water mark

Usually indicates the lowest astronomical tide line.

#### magma

Molten material from the upper mantle or crust.

#### mantle

The zone of the Earth's crust in between the outer crust and inner core. The upper mantle is partially molten and can extrude through weaknesses in the crust.

#### maritime jurisdiction

The area of the sea that is under the control of a country. This may include its territorial waters, contiguous zone, exclusive economic zone or continental margin.

#### member countries

Countries (States) that are members of the United Nations General Assembly.

#### MOU

Memorandum of Understanding. An MOU is an arrangement between organisations, governments states etc. that has less status than a treaty. There are usually no legal rights or obligations between the parties in an MOU.

#### multilateral

Involving more than two groups eg. organisations or countries. UNCLOS is a multilateral agreement because it involves many countries.

#### nautical mile

A term used in ocean navigation and is equivalent to the distance of one minute of latitude, measured at 45 degrees latitude. This equates to 1852 metres (1.852 km). 100 nm converts to approximately 115 land miles or 185 kilometres. Conversely, 1 km is approximately 0.54 nm. The nautical mile was adopted by the International Hydrographic Organisation as the standard for measuring distances at sea.

#### party

A party to an international agreement means a country that has consented to be bound by a treaty that is in force.

#### petroleum

Naturally occurring liquid hydrocarbons (such as crude oil) formed by the decay of organic material underground. It often migrates through porous rocks and can collect in natural traps to form drillable commercial petroleum deposits. Petroleum deposits are often found in association with gaseous hydrocarbons eg. natural gas.

#### plastic

Does not refer to the composition of rock (ie. the rock is not made of petroleum-derived plastic) but refers to the way in which the rock behaves. Plastic rocks are those that deform slowly under heat and/or pressure. They are pliable and can bend and move slowly over time. Rocks that are folded have been deformed when plastic. The rocks of the upper mantle are plastic and help to move the Earth's tectonic plates.

#### ratify

To ratify a document is the next step after signing the document. To ratify signifies the intention of the country to be bound by the provisions of a treaty.

#### seabed

Found at the bottom of the sea, the seabed is the top of the surface layer of sand, mud, rock or other material (or a combination of these materials). Also called the seafloor.

#### sedentary species

Under Article 77 of UNCLOS, these are defined as living organisms that, at the stage when they are able to be harvested, are either immobile when living on or under the seabed, or they are organisms that move while maintaining contact with the seabed or the subsoil.

#### sedimentary rock

Rock formed from layers of sediment such as mud, or sand or that accumulate and are compressed or cemented together to form rock. Sedimentary rocks are often formed in marine or freshwater environments where water carries sediment then deposits it in layers.

#### signatory

A signatory is a country (specifically, its representative) that has signed an agreement.

#### sign

To sign an agreement. By signing a document, a country expresses its consent to the text of a treaty, but not necessarily its consent to be bound by its provisions. Once a country has signed a treaty it is not obliged to ratify it. However, the Australian government's policy is not to sign a treaty without the intention to ratify it at a later date. The Australian government signed UNCLOS on 16 November 1994.

#### State

The people and territory under one sovereign government eg. Australia under the Australian Federal government. In this document the term 'country' has been substituted for the term 'State' in UNCLOS for ease of explanation and to avoid confusion with a country's internal states eg. New South Wales and Queensland.

#### storm surge

When sea level rises rapidly due to winds associated with storms. These winds tend to 'push' the sea water ahead of them and onto the coast. The sea levels can rise much higher than at normal high tides and this can inundate low-lying coastal areas, causing severe flooding.

#### subduction

Where the leading edge of one tectonic plate is forced beneath another plate. These boundaries are marked by deep sea trenches and are the site of frequent earthquakes.

#### submerged prolongation of the land mass of a coastal state

Is the terminology used in Article 76 of UNCLOS for the continental margin (shelf, slope and rise) in the offshore region of a coastal country.

#### subsoil

The natural materials directly underlying the seabed/seafloor. The subsoil may be unconsolidated sediment such as mud, or rock.

#### sustainable development

Sustainable development was defined by the 1987 World Commission on Environment and Development as "development which meets the needs of the present without compromising the ability of future generations to meet their needs".

#### tectonic plate

A piece of the Earth's crust and upper mantle that moves relative to its neighbouring plates. The curst is divided into six large and numerous small plates.

#### tectonism

Long term deformation of the Earth's crust and the structural features that this forms. Tectonism is associated with the movement of pieces of the Earth's crust and mantle called plates.

#### territorial sea baseline

Usually the low water mark on the coastline of a coastal country. On an indented coastlines the baseline may be a straight line across a bay or river mouth. It may also be straight lines joining the outermost points of the outermost islands of islands in an archipelago. It can also join the outermost fringing islands and reefs to neighbouring outer islands and join to the coast where the islands or reef cease.

#### territorial waters

The sea next to the coast. It extends from the coastal country's baseline up to 12 nm.

#### topography

Shape of the Earth's surface, either on land or on the seafloor, measured in metres above or below sea level. Seafloor topography is usually referred to as bathymetry.

#### treaty

An international written agreement between two or more countries (or other entities such as international organisations) and governed by international law. A treaty may be in the form of a convention or an agreement.

#### **UNCLOS**

United Nations Convention on the Law of the Sea, opened for signing in 1982.

#### water column

A vertical column of water from the sea surface to the seabed.

# student activities

& suggested answers

# Fire and Ice

You are a trained archaeologist. You have been asked to gather evidence for aboriginal occupation of three islands off the coast of Australia. The occupation by the Baringa people dates back to the time of the last Ice Age, a global climatic event.

In conjunction with members of the local Aboriginal community, you visited the region and mapped all known aboriginal occupation sites (see map). At each site charcoal samples were carefully collected. The charcoal is burnt wood from ancient fireplaces.

The samples were sent to a university research laboratory for dating using radioactive Carbon-14 in the charcoal. The results are listed in the table below.

Samples and their approximate age (years)

<u>Mai</u>	nland	Rich	ı İsland	Flan	nery Island	<b>Kool Island</b>
S1	19000	<b>S5</b>	13500	<b>S7</b>	3000	no samples
<b>S2</b>	7500	<b>S6</b>	8000	<b>S8</b>	4000	_
<b>S3</b>	22000			<b>S9</b>	15000	
<b>S4</b>	2500			<b>S10</b>	14000	

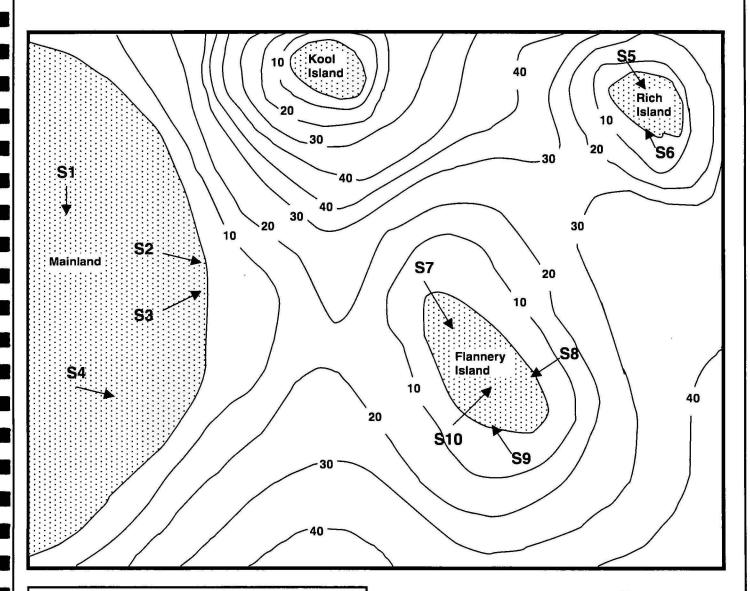
- 1. When did Baringa people first leave evidence of living in this region?
- 2. Colour or shade in all areas that are between 0 and 20 metres below current sea level. Using a different colour or pattern, colour in all offshore areas that are between 20 30 metres below current sea level. Add this new information to your legend.

How low was the sea level when Baringa people walked to Rich Isle?

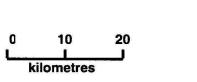
3. When do you think Baringa people first walked to Flannery Island?

4.	There is no evidence that the Baringa people used boats to travel between islands and the ocean currents in the area are very dangerous. What probably happened t enable the Baringa people to reach the islands?
 5.	Despite thorough searching, why were there no signs of aboriginal occupation or Kool Island?
6.	What clues do you have that might suggest when the land bridge between Rich Isle and Flannery Island flooded?
7. —	Why aren't the same occupation dates found on Flannery and Rich Islands?
8.	What caused the land bridges between the islands and the mainland to be floode again?

# Fire and Ice



# S10 sample site 10 offshore contour lines (metres below sea level)

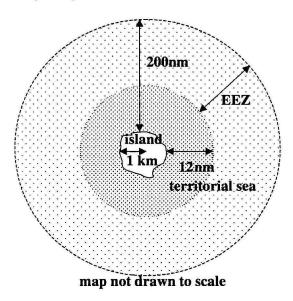


# EEZy as Pi!

The United Nations Convention on the Law of the Sea (UNCLOS) allows any coastal country to have sovereign rights over its 200 nautical mile Exclusive Economic Zone (EEZ). This gives the coastal country access to all living and non-living resources on the sea floor (eg. scallops and mineral deposits), under the sea floor (eg. oil and gas) and in the water column above the sea floor (eg. fish).

But how large is the area of sea within the EEZ of a coastal country? Does a country have to be large to have a large EEZ surrounding it? You might be surprised!

Let's use an example of a small, circular island nation only 1 km in radius. Under UNCLOS the island is surrounded by an EEZ of 200 nm (remember that the total width of an EEZ is actually only 188 nm because the first 12 nm is the territorial sea).



useful conversions:

1 nautical mile is equal to 1.85 kilometres 1 kilometre is equal to 0.54 nautical miles So a distance of 188 nm is equal to about 347.8 km

Using the following formula to calculate the circle's area (assume the value of  $\pi$  is about 3.14) we'll calculate the area of the circular island of 1 km in radius.

area of a circle = 
$$\pi$$
 x radius<sup>2</sup>

area = 
$$3.14 \times (1)^2$$
  
=  $3.14 \times 1$   
=  $3.14 \text{ km}^2$ 

Now, to calculate the area of the EEZ around the island we need to look at three areas, the island, the territorial sea (from 0 to 12 nm) and the EEZ (from 12 nm to 200 nm).

So to calculate the total size of the EEZ we calculate;

i) the total area of the island + territorial sea + EEZ

Then subtract;

- ii) the area of the island and
- iii) the area of the territorial sea

This leaves

iv) a doughnut-shaped EEZ that starts at 12 nm from the territorial sea baseline and extends to 200 nm.

Start by converting all distances in nautical miles to kilometre!

1 nautical mile ~ 1.85 kilometres

EEZ = 188 x 1.85 km = 347.8 km kilometres for radius of EEZ

12 nm = 12 x 1.85 km = 22.2 km for radius of territorial sea

Area of EEZ =  $\pi$  x (EEZ + territorial sea + island)<sup>2</sup> -  $\pi$  x (territorial sea + island)<sup>2</sup>

=  $\pi$  x (347.8 km + 22.2 km + 1 km)<sup>2</sup> -  $\pi$  x (22.2 km + 1 km)<sup>2</sup>

 $= 3.14 \text{ x } (371 \text{ km})^2 - 3.14 \text{ x } (23.2 \text{ km})^2$ 

 $= 3.14 \times 137 641 \text{ km}^2 - 3.14 \times 538.24 \text{ km}^2$ 

= 432 192.74 - 1690.07

 $= 430 502.67 \text{ km}^2$ 

Therefore the total area of the EEZ around a tiny island of only 1 km radius is almost half a million square kilometres! The Australian continent and its offshore territories cover 7.7 million km<sup>2</sup> and have an EEZ of 11 million km<sup>2</sup>, one of the world's largest.

You are a member of the United Nations committee accepting claims from countries wishing to establish their marine jurisdictions under UNCLOS. Compare the two countries of Staggia and Lewisonia. Both are circular.

#### Staggia

- an island country, sharing no borders with any other country
- has a radius of 80 km

#### Lewisonia

- a land-locked country, surrounded on all sides by coastal countries
- has no coastline of its own
- has a radius of 400 km

The area of a circle =  $\pi$  x radius<sup>2</sup> (assume  $\pi$  is 3.14) Therefore the area of an EEZ can be worked out using this formula;

$EEZ = \pi x$ (radius of $EEZ + territorial sea + island)$	$^2 - \pi$ x (radius of territorial sea + island) $^2$

a)	What is the total land area of each country in km <sup>2</sup> ? Use the working out space here then fill in the summary table below
_	· · · · · · · · · · · · · · · · · · ·

country	country country radius km <sup>2</sup>		EEZ area km²
Staggia	80		
Lewisonia	200		

	First work out the area of FEZ I territorial see I island
	First, work out the <u>area of EEZ + territorial sea + island</u>
	Now subtract the area of territorial sea + island to leave the doughnut-shaped I (work this all out in square kilometres, not square nautical miles so make sure you convert nautical miles to kilometres first!)
	Fill out the summary table.
*****	
<del></del>	
,	
c)	In the summary table add the area of the EEZ around Lewisonia in km <sup>2</sup> .
:)	In the summary table add the area of the EEZ around Lewisonia in km <sup>2</sup> .

land resources	
marine resources	
overall resources	
overam resources	
	hat are some considerations when comparing the be available to each country?
What can the land-locked Le resources?	ewisonia do under UNCLOS to gain access to marine
	ewisonia do under UNCLOS to gain access to marine
	ewisonia do under UNCLOS to gain access to marine
	ewisonia do under UNCLOS to gain access to marine
	ewisonia do under UNCLOS to gain access to marine
what characteristic/s would	Lewisonia need to have for the United Nations to give g this country with access to other marine resources?
what characteristic/s would	Lewisonia need to have for the United Nations to give
what characteristic/s would	Lewisonia need to have for the United Nations to give
what characteristic/s would	Lewisonia need to have for the United Nations to give

# **Drawing the Line**

The United Nations Convention on the Law of the Sea (UNCLOS) allows each of the world's 151 coastal countries to claim sovereign rights over a 200 nautical mile Exclusive Economic Zone (EEZ). Together, all EEZs cover 60 million km<sup>2</sup> of the world's oceans.

Some coastal countries such as Australia also have an offshore continental margin that extends beyond the limit of their EEZ. A total of 54 coastal countries may be able to make submissions to the United Nations on continental margins beyond their EEZ. They would gain access to the seafloor and subsoil resources of those continental margins. Together, the areas of extended continental margins and EEZ areas would include 75 million km<sup>2</sup> of the world's oceans.

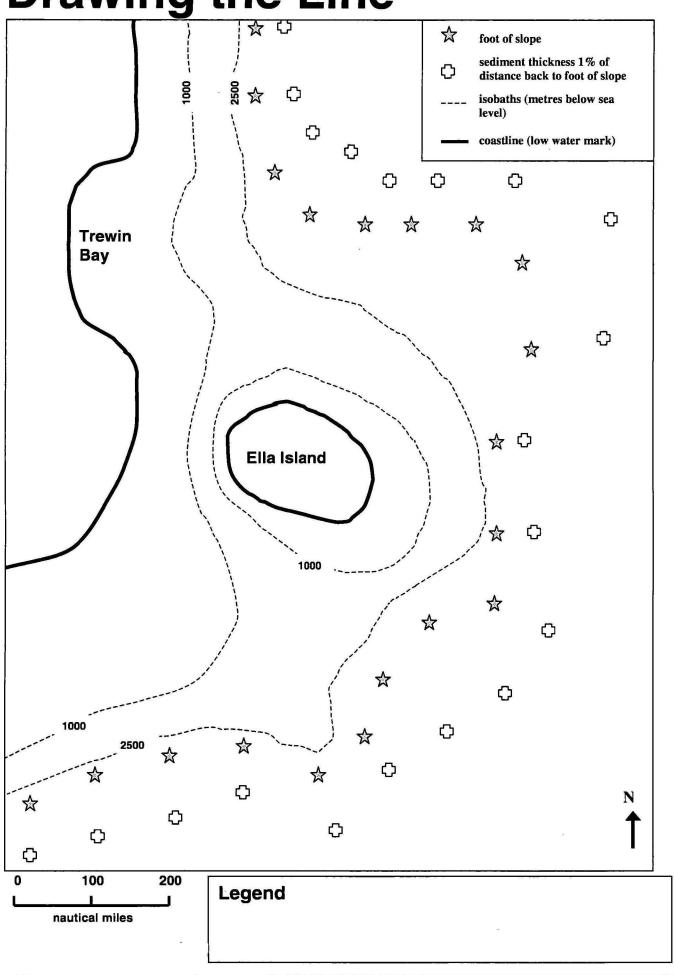
You are the Chief MapMaker for the country of Hann, part of which is shown in the accompanying map. Trewin Bay indents the coastline of Hann, and Ella Island is located offshore.

Your country's mining industry has identified rich mineral deposits on the seafloor beyond your EEZ. Your country wishes to define the outer limits of its continental margin under UNCLOS. Your vital task is to locate the outer limit of your country's continental margin using the following steps.

- 1. Draw in the outer limit of Hann's Exclusive Economic Zone on the map (mark points 200 nautical miles from the low water mark and connect them with a smooth line). Think what happens to the EEZ across the mouth of Trewin Bay and near Ella Island.
- 2. On the map locate the two types of features that a coastal country can use to define the outer limit of its continental margin. It helps if you use different colours or symbols for each boundary. These are the maximum limits for the continental margin of Hann.
  - measure 60 nautical miles from each foot of slope point and connect them
  - locate the 1 percent sediment thickness points and connect them
- 3. Remember UNCLOS states that the edge of a country's continental margin cannot extend more than 100 nautical miles beyond the 2500 metre isobath, or beyond the 350 nautical mile limit (which ever is furthest). Draw in these limits too.
- 4. Now, mark in the location of the absolute outer limit of marine jurisdiction. Use a separate colour or symbol. Make sure you follow the rules above!
- 5. Add a legend to your map to identify each of the different boundaries. Submit your map to the United Nations for approval.

**Drawing the Line** 

3.2



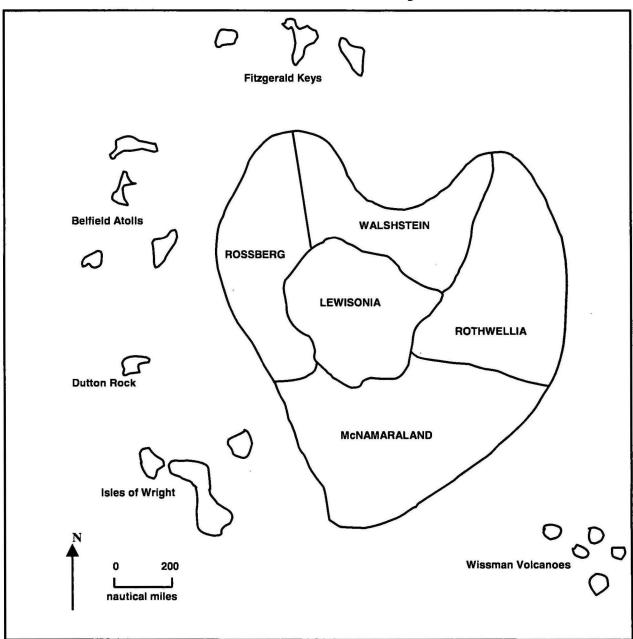
# Stuck in the Middle Again

The small continent of Kay is made up of five countries, each of which is shown on the accompanying map.

Lewisonia is land-locked and shares borders with four coastal countries; McNamaraland, Rothwellia, Walshstein and Rossberg. Twelve offshore islands are located to the west, including the three Isles of Wright. The five Wissman undersea volcanoes (seamounts) are located to the south east.

Each country is deciding the location of their marine jurisdiction using the United Nations Convention on the Law of the Sea (UNCLOS).

# **Continent of Kay**



a)	Quickly! Look at the map and guess which of the five countries would have the largest offshore area claimable under UNCLOS.				
b)	What is the area called that is within 200 nautical miles of a coastal country?				
c)	So how can we find out where the offshore areas are that each country can claim under UNCLOS? It's easy!				
	Measure 200 nautical miles from the coastline of each coastal country. Mark in this 200 nautical mile distance as a series of dots. Then join the dots to show a line around each country that is 200 nautical miles from the coast (using a pencil helps in case you change your mind). Remember that the shared marine border between two coastal countries is usually at right angles to the coastline.				
COI	eck the islands offshore. Decide if any of them within 200 nautical miles of a antry's coastline. If so, these islands can be part of that coastal country's claim I the new boundary extends another 200 nautical miles beyond them.				
d)	Check your map and see if any of the five countries claim islands around the continent of Kay, based on UNCLOS? If so, which countries and which islands? Give reason/s for your answer.				
e)	What change/s did you have to make to the shared border between Rossberg and McNamaraland due to offshore islands?				

	to shade in each country's offshore area with a different colour to sh between them.
	pastal country has the largest claimable area offshore? Which coastal has the smallest claimable area? Does Lewisonia have a claim to any areas?
•	d to a straight coastline, does a convex or a concave coastline affect of the offshore area that a country can claim? Explain how.
c)	You are an entrepreneur about to start exploring for oil in offshore areas around the continent of Kay.
both have of	evidence suggests that the countries of Walshstein and Rossberg may fishore oil deposits because the same sequences of rocks occur m both countries.
within their	paying the government of either country the same fee for exploring jurisdiction. Therefore, in which of these two countries would you your exploration business for offshore oil? Give reasons why.

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#### **Extension Activities**

#### **Activity A**

The country of Rothwellia was first settled in 956 AD. The Rothwellian Archaeological Institute claims that there are archaeological remains on the largest of the three Isles of Wright. These remains are believed to match those found in a cave located 15 km from the south east coast of Rothwellia. The two sets of remains are both dated at about 1100 AD.

Based on the archaeological remains, Rothwellia now claims the Isles of Wright as their territory. They also claim the 200 nautical mile Exclusive Economic Zone (EEZ) around that island group.

You represent either the government of Rothwellia or the government of McNamaraland. Put forward your case for, or against, the Isles of Wright being within the marine jurisdiction of Rothwellia.

#### **Activity B**

A large breeding and feeding ground for the Blue Smoothy fish has just been located around the Wissman undersea volcanoes, south east of McNamaraland. The Blue Smoothy is a commercial fish that is popular in the restaurant markets of all countries on the continent of Kay.

- a) Can any country currently claim the Blue Smoothy breeding and feeding grounds within their Exclusive Economic Zone (EEZ)?
- b) What problems currently face these fish in their habitat under UNCLOS?
- c) You represent the multilateral environment group called Friends of Imperilled Saltwater Habitats. Write a press release to explain what steps could be taken, and by whom, to sustainably manage these Blue Smoothy fish in the future.

#### **Activity C**

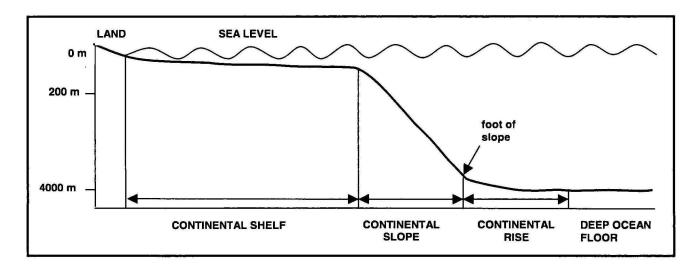
An application has been made to the United Nations by the country of Lewisonia, requesting fair access to a share of the seabed and water column marine resources that are within the Exclusive Economic Zones (EEZs) of its neighbouring coastal countries.

Students form into six separate groups. Five student groups each represent one of the five countries indicated on the accompanying map. The sixth group represents the United Nations and is to organise, and host, the discussions regarding Lewisonia's application.

The six groups discuss the issues associated with Lewisonia's request until a suitable bilateral or multilateral agreement is reached that resolves any issues that are raised.

# **Margin Matters**

You are a geologist employed by the Symondsland government. You must locate continental margin for use in a submission to the UN on areas of extended continental margin. You must decide if these features lie beyond Symondsland's 200 nm EEZ.



#### **Part A: BATHYMETRY**

To locate these features you need to analyse the results of a bathymetry survey completed off the coast of Symondsland. The survey ship 'Excelsior' carried out a swath mapping survey at right angles to the coastline, out to a distance of 480 km (approximately 238 nm).

During the survey, sound waves were made that spread downwards from transmitters on the ship's hull to form a wide strip of sound waves. Each wave bounced off the sea floor and returned to the ship where its total travel time was recorded.

The time taken for the sound wave to return is twice the time to reach the sea floor. To work out the distance to the sea floor let's use the velocity of a sound wave in seawater as approximate 1520 metres/second (m/s). How deep is the sea floor?

**Example** - Time for one sound wave to travel from ship to sea floor and return is 0.40 seconds.

time to travel to sea floor 
$$= \underbrace{0.4 \text{ s}}_{2}$$

$$= 0.2 \text{ s}$$

$$= 0.2 \text{ s}$$

$$= velocity \text{ x time}$$

$$= 1520 \text{ m/s } \text{ x } 0.2 \text{ s}$$

$$= 304 \text{ m}$$

Therefore, the distance from the sea surface to the sea floor was 304 metres (we assume that the transmitter was on the sea surface).

\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*

Fill out the last two columns in the following table, using the formula for distance given above and the figures in the third column (assume speed of sound is 1520 m/s).

**TABLE 1: SWATH SURVEY RESULTS** 

location	distance from coastline (kilometres)	time for return trip of wave (seconds)	time for single trip of wave (seconds)	distance to sea floor (metres)
Α	40	0.25		
В	80	0.30		
C	120	0.30	3/17/11 88 1	A 3 45 450 AU 102 AU
D	160	1.30		
E	200	2.30		
F	240	3.30		
G	280	4.30		
Н	320	4.60		
I	360	4.80		
J	400	4.80		
K	440	4.80		
L	480	4.85		

- 1. For each of these twelve points, plot the distance from the coastline against the depth of water across the continental margin on the following page.
- 2. Connect the twelve points with straight lines this represents a graph of the sea floor topography along this bathymetry survey line.
- 3. Mark in the main physical features of the continental margin ie.
  - continental shelf
  - continental rise
  - foot of slope
  - deep ocean floor
- 4. Using the vertical scale, mark in the location of the 2,500 metre isobath. On which part of the continental margin does the 2,500 metre isobath occur?
- 5. Mark in the location of the other features that define the edge of the continental margin under UNCLOS using different coloured lines. These include;
  - EEZ between 22 km (12 nm) and 200 nautical miles (371 km) from the coast
  - the point 60 nautical miles (~ 111km) from the foot of slope
  - the point 100 nautical miles (~ 185 km) beyond the 2500 m isobath (the 350 nm (~ 648 km) outer limit probably will not fit on your graph)

#### **Part B: SEDIMENT THICKNESS**

The last method of determining the outer limit of the continental margin is to work out the depth of sediment beyond the foot of slope. Few need to find the point where the sediment thickness is 1% percent of the distance back to the foot of slope.

**Example -** sediment is 10 km thick a distance of 20 km from the foot of slope

Therefore the sediment thickness is 50% of the 20 km distance back to foot of slope.

\*\*\*\*\*\*\*\*\*\*\*\*\*

Seismic data was obtained for the same strip of sea floor used in the bathymetry survey and used to work out the depth of the sediment beneath the sea floor. The thickness of the sediment is recorded in the following table.

On the same graph, mark in the approximate thickness of the sediment layer beneath the sea floor at the following four points that are beyond the foot of slope.

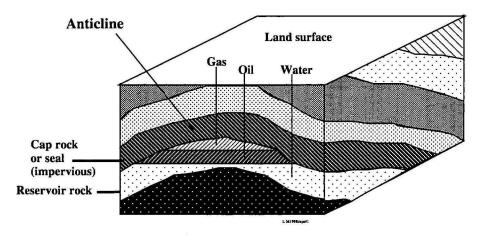
TABLE 2: SEDIMENT THICKNESS CALCULATION

location	distance from foot of slope (km)	sediment thickness (km)	% sediment thickness
I	40	15	"
J	80	0.8	
K	120	0.5	
L	160	0.4	-

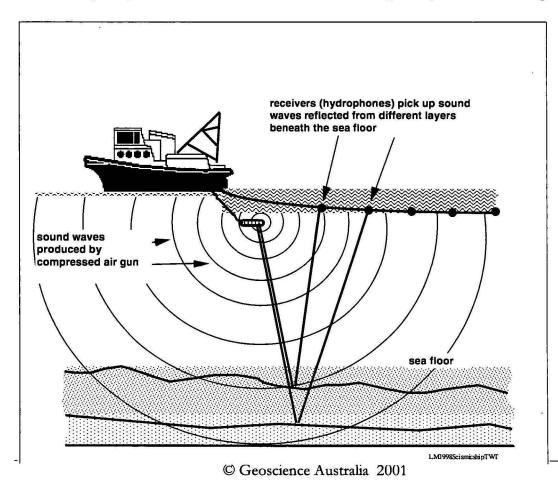
- 6. Fill in the last column in Table 2 using the formula above.
- 7. On your graph mark in and clearly label, the point where the sediment thickness is 1% of the distance back to the foot of slope.
- 8. Compare all of the limit lines marked on your graph.
  - Decide where the legal outer limit of the continental margin under UNCLOS should be located and clearly mark it on your graph.
  - Give reasons why you chose this limit line (answer on paper for more space).

# **Carnarvon Capers**

Companies exploring for petroleum use seismic surveys to check subsurface geology as they try to locate petroleum deposits. Once a company finds on a likely area, it purchases an exploration permit. Detailed seismic investigations then help geologists to map the detailed structure of rocks under the Earth and predict where oil might be.



During marine seismic exploration, an air gun at the surface of the sea is towed behind a survey ship. It produces a blast of sound waves that travel out from the air gun, through the water and deep into layers beneath the sea floor. Sound waves bounce off individual layers under the sea floor at different times and then return to the sea surface. Returning waves are picked up by hydrophones towed in a long line behind the survey ship. Sound waves that reflect off deeper layers take a longer time



to return to the ship. By analysing the return time for sound waves, we can find out how deep the layers are beneath the sea floor.

A seismic survey has just been completed off the coast of Carnarvon in the North West Shelf off Western Australian. The raw data has been handed to you, the petroleum geologist. Your task is to accurately work out the depths of the different layers beneath the sea floor so that drilling costs can be estimated. Be careful or you could cost your company millions of wasted dollars!

Can you work out how the time relates to the depth of each of the layers? Let's use the approximate velocity of sound as 1500 metres per second. How deep is the sea floor? To work this out we use the formula;

#### distance = velocity x time

1. Check out the raw survey data in Table 1 and the seismic diagram. Use the graph paper provided to draw two labelled axes in pencil. Show *depth below sea level* on the vertical axis and *time* on the horizontal axis.

On the graph, plot depth versus two way time for the Carnarvon seismic data.

- 2. Draw the line of best fit through these points.
- 3. Fill in the one way travel time in the table. Draw in the line of best fit for the time taken for one way travel of each signal onto the same graph. Label each line.
- 4. Reading from the graph, answer these questions.
  - a) How long would it take for a sound wave to travel from the survey ship's air gun, down to a layer that is 1750 metres deep and back to the hydrophone receivers?
  - b) How long would it take for a sound wave to travel down to a layer 2750 metres below sea level?
  - b) How deep is a layer of sediment that has a one way signal time of 0.6 seconds?

Table One – raw data from Carnarvon survey on North West Shelf.
At this location the sea depth is 473 metres.
The sound waves bounce off the boundary between layers.

boundary	depth below sea level (metres)	two way travel time (seconds)	one way travel time (seconds)
A	473	0.450	
В	785	0.708	
С	825	0.745	
D	922	0.822	
Е	1013	0.893	
F	1060	0.930	
G	1100	0.960	
Н	1147	0.995	
I	1550	1.289	
J	1948	1.613	
K	2379	1.924	
L	2572	2.044	
M	2827	2.169	
N	3238	2.375	
О	3390	2.454	
P	3459	2.484	10 to
Q	3592	2.542	
R	3915	2.681	
S	4010	2.720	

#### Fire and Ice

You are a trained archaeologist. You have been asked to gather evidence for aboriginal occupation of three islands off the coast of Australia. The occupation by the Baringa people dates back to the time of the last Ice Age, a global climatic event.

In conjunction with members of the local Aboriginal community, you visited the region and mapped all known aboriginal occupation sites (see map). At each site charcoal samples were carefully collected. The charcoal is burnt wood from ancient fireplaces.

The samples were sent to a university research laboratory for dating using radioactive Carbon-14 in the charcoal. The results are listed in the table below.

#### Samples and their approximate age (years)

M	lainland	Rich	ı İsland	Flan	nery Island	Kool Island
S		S5	13500	S7	3000	no samples
S	Pc (0.00 (0.	S6	8000	<b>S8</b>	4000	
S				<b>S9</b>	15000	
S				S10	14000	

1. When did Baringa people first leave evidence of living in this region? 22,000

years ago

 Colour or shade in all areas that are between 0 and 20 metres below current sea level. Using a different colour or pattern, colour in all offshore areas that are between 20 - 30 metres below current sea level. Add this new information to your legend.

How low was the sea level when Baringa people walked to Rich Isle?

must have been at least 30m lower

3. When do you think Baringa people first walked to Flannery Island?

least 15,000 years ago.

4. There is no evidence that the Baringa people used boats to travel between islands and the ocean currents in the area are very dangerous. What probably happened to enable the Baringa people to reach the islands?

Too dangerous to swim. Most likely sea levels usere lower due to le Age at that time.

5. Despite thorough searching, why were there no signs of aboriginal occupation on Kool Island?

Sea levels probably did not drop enough to allow people to walk to Kool Island. Sea level would need to be lower than 30 metres

6. What clues do you have that might suggest when the land bridge between Rich Isle and Flannery Island flooded?

Youngest archaeological evidence on Rich Island is 8000 years old. May have left around that time.

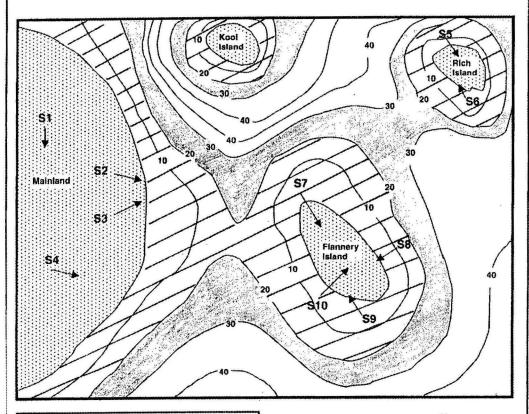
7. Why aren't the same occupation dates found on Flannery and Rich Islands?

Oldest are on Flannery Island-first to have a land bridge? Also, people on Flannery Island couldn't reach Rich Island after sea levels rose.

8. What caused the land bridges between the islands and the mainland to be flooded again?

Warmer global climate melted ice caps at end of Ice Age. More water entered ocans + sea levels rose worldwide.

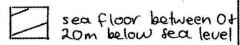
# Fire and Ice

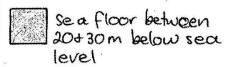


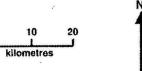
#### Legend

\$10 sample site

\_\_10 \_\_ contour line (offshore)







#### EZZy as Pi!

You are a member of the United Nations committee accepting claims from countries wishing to establish their marine jurisdictions under UNCLOS. Compare the two countries of Staggia and Lewisonia. Both are circular.

#### Staggia

- an island country, sharing no borders with any other country
- has a radius of 80 km

#### Lewisonia

- a land-locked country, surrounded on all sides by coastal countries
- has no coastline of its own
- has a radius of 400 km

The area of a circle =  $\pi$  x radius<sup>2</sup> (assume  $\pi$  is 3.14)

Therefore the area of an EEZ can be worked out using this formula;

EEZ =  $\pi \times (\text{radius of EEZ} + \text{territorial sea} + \text{island})^2 - \pi \times (\text{radius of territorial sea} + \text{island})^2$ 

a) What is the total land area of each country in km<sup>2</sup>? Use the working out space here then fill in the summary table below

Staggia land area = 
$$7.0 \times (80)^2$$
  
= 3.14 x 6,400  
= 20,096 km<sup>2</sup>  
Lewisonia land area =  $7.0 \times (400)^2$   
= 3.14 x 160,000

country	country radius km²	land area km²	EEZ area km²
Staggia	80	20, 096	603,053
Lewisonia	200	502,400	0

 $=502,400 \, \mathrm{km}^2$ 

b) What is the area of the EEZ around Staggia in km<sup>2</sup>?

First, work out the area of EEZ + territorial sea + island

Now subtract the area of territorial sea + island to leave the doughnut-shaped EEZ (work this all out in square kilometres, not square nautical miles so make sure that you convert nautical miles to kilometres first!)

Fill out the summary table.

*all nautical	mile	distances	converted	to kilometre
		·····		

$$= 3.14 \times (450)^{2}$$

$$= 3.14 \times 202,500$$

$$= 635,850 - 32,797$$

$$=603,053 \text{ km}^2$$

c) In the summary table add the area of the EEZ around Lewisonia in km².

d)	Think about the area containing resources to which each country has access
	Which country has the greatest potential access to the following resources?

land resources	Lewisonia
marine resources	Staggia
overall resources	Staggia

e) Other than size, however, what are some considerations when comparing the actual resources that would be available to each country?

Its geology (+: mineral deposits) its climate, populations of living resources, the technology available to the country to exploit its resources.

f) What can the land-locked Lewisonia do under UNCLOS to gain access to marine resources?

Hold bilateral or multilateral negotiations with neighbouring countries to gain access to excess living resources within their EEZs.

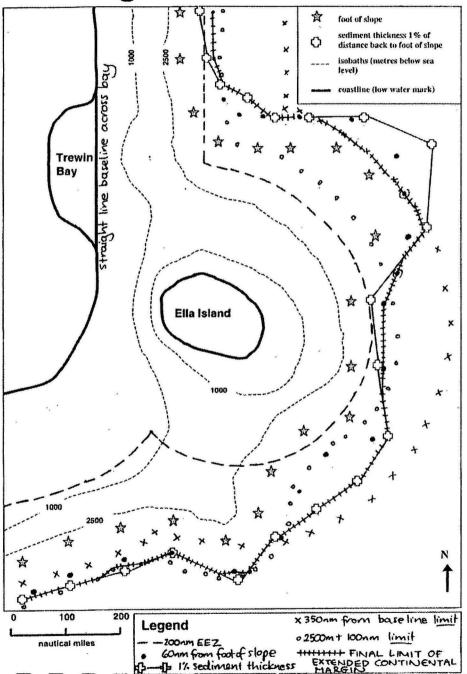
f) What characteristic/s would Lewisonia need to have for the United Nations to give it a high priority in providing this country with access to other marine resources?

To access non-living resources of

EEZ (and extended continental shelf) Lewisonia usuld need to be a

developing country to have a high

# **Drawing the Line**



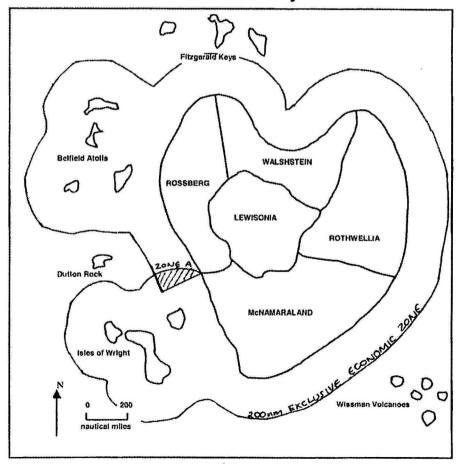
# Stuck in the Middle Again

The small continent of Kay is made up of five countries, each of which is shown on the accompanying map.

Lewisonia is land-locked and shares borders with four coastal countries; McNamaraland, Rothwellia, Walshstein and Rossberg. Twelve offshore islands are located to the west, including the three Isles of Wright. The five Wissman undersea volcanoes (seamounts) are located to the south east.

Each country is deciding the location of their marine jurisdiction using the United Nations Convention on the Law of the Sea (UNCLOS).

#### **Continent of Kay**



a) Quickly! Look at the map and guess which of the five countries would have the largest offshore area claimable under UNCLOS.

Many may choose Mc Namaraland because of very long coastline.

b) What is the area called that is within 200 nautical miles of a coastal country?

#### Exclusive Economic Zone

c) So how can we find out where the offshore areas are that each country can claim under UNCLOS? It's easy!

Measure 200 nautical miles from the coastline of each coastal country. Mark in this 200 nautical mile distance as a series of dots. Then join the dots to show a line around each country that is 200 nautical miles from the coast (using a pencil helps in case you change your mind). Remember that the shared marine border between two coastal countries is usually at right angles to the coastline.

Check the islands offshore. Decide if any of them within 200 nautical miles of a country's coastline. If so, these islands can be part of that coastal country's claim and the new boundary extends another 200 nautical miles beyond them.

d) Check your map and see if any of the five countries claim islands around the continent of Kay, based on UNCLOS? If so, which countries and which islands? Give reason/s for your answer.

Rossberg-can claim Belfield Atolls

McNamaraland - can claim Isles of Wright:

Both groups of islands start inside the

200nm EEZ of the countries. Dutton Rock,

Fitzgerald Keys + the Wissman Volcances

are outside any country's EEZ limit.

e) What change/s did you have to make to the shared border between Rossberg

and McNamaraland due to offshore islands?

Rossberg and McNamaraland due to possible EEZ overlap due to offshore island.

You might like to shade in each country's offshore area with a different colour to easily distinguish between them.

f) Which coastal country has the largest claimable area offshore? Which coastal country has the smallest claimable area? Does Lewisonia have a claim to any offshore areas?

i)Mc Namaraland - largest ii)Walshtein - smallest iii) Lewisonia - no EEZ

g) Compared to a straight coastline, does a convex or a concave coastline affect the size of the offshore area that a country can claim? Explain how.

A convex coastline provides a larger EEZ. In contrast, a concave coastline provides a smaller EEZ because the EEZ is folded in on itself, not stretched out along astraight or convex coastline about to start exploring for oil in offshore areas around the continent of Kay.

Geological evidence suggests that the countries of Walshstein and Rossberg may both have offshore oil deposits because the same sequences of rocks occur offshore from both countries.

You will be paying the government of either country the same fee for exploring within their jurisdiction. Therefore, in which of these two countries would you want to start your exploration business for offshore oil? Give reasons why.

Would want to start exploration business in EE2 of Rossborg because it has a larger EE2 compared to Walshtein. There may be more chance of finding oil in Rossberg's EE2, and or more oil available to find.

#### **Margin Matters**

Fill out the last two columns in the following table, using the formula for distance given above and the figures in the third column (assume speed of sound is 1520 m/s).

TABLE 1: SWATH SURVEY RESULTS

location	distance from coastline (kilometres)	time for return trip of wave (seconds)	time for single trip of wave (seconds)	distance to sea floor (metres)
A	40	0.25	0-125	190
В	80	0.30	O·15	228
C	120	0.30	0.15	228
D	160	1.30	0-65	988
E	200	2.30	1.15	1748
F	240	3.30	1.65	2508
G	280	4.30	2.15	3268
Н	320	4.60	2.3	3496
ī	360	4.80	2.4	3648
J	400	4.80	2.4	3648
K	440	4.80	2.4	3648
L	480	4.85	2 · 425	3686

- 1. For each of these twelve points, plot the distance from the coastline against the depth of water across the continental margin on the following page.
- 2. Connect the twelve points with straight lines this represents a graph of the sea floor topography along this bathymetry survey line.
- 3. Mark in the main physical features of the continental margin ie.
  - continental shelf
  - continental rise
  - foot of slope
  - deep ocean floor
- 4. Using the vertical scale, mark in the location of the 2,500 metre isobath. On which part of the continental margin does the 2,500 metre isobath occur?

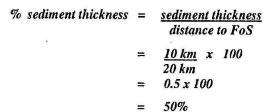
### on the continental slope

- Mark in the location of the other features that define the edge of the continental margin under UNCLOS using different coloured lines. These include;
  - EEZ between 22 km (12 nm) and 200 nautical miles (371 km) from the coast
  - the point 60 nautical miles (~ 111km) from the foot of slope
  - the point 100 nautical miles (~ 185 km) beyond the 2500 m isobath (the 350 nm (~ 648 km) outer limit probably will not fit on your graph)

#### Part B: SEDIMENT THICKNESS

The last method of determining the outer limit of the continental margin is to work out the depth of sediment beyond the foot of slope. Few need to find the point where the sediment thickness is 1% percent of the distance back to the foot of slope.

Example - sediment is 10 km thick a distance of 20 km from the foot of slope



Therefore the sediment thickness is 50% of the 20 km distance back to foot of slope.

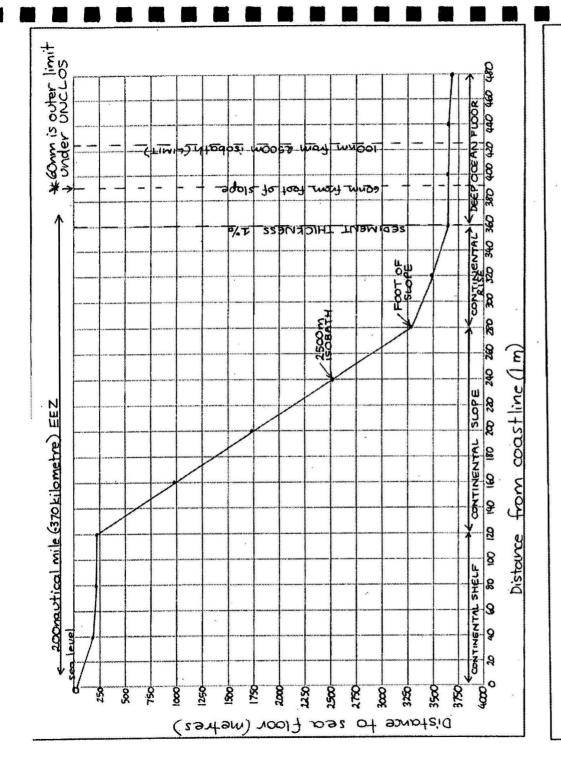
Seismic data was obtained for the same strip of sea floor used in the bathymetry survey and used to work out the depth of the sediment beneath the sea floor. The thickness of the sediment is recorded in the following table.

On the same graph, mark in the approximate thickness of the sediment layer beneath the sea floor at the following four points that are beyond the foot of slope.

**TABLE 2: SEDIMENT THICKNESS CALCULATION** 

location	distance from foot of slope (km)	sediment thickness (km)	% sediment thickness
I	40	15	37-5
J	80	0.8	1.0
K	120	0.5	0.42
L	160	0.4	0.25

- 6. Fill in the last column in Table 2 using the formula above.
- 7. On your graph mark in and clearly label, the point where the sediment thickness is 1% of the distance back to the foot of slope.
- 8. Compare all of the limit lines marked on your graph.
  - Decide where the legal outer limit of the continental margin under UNCLOS should be located and clearly mark it on your graph.
  - Give reasons why you chose this limit line (answer on paper for more space).



#### **Carnarvon Capers**

to return to the ship. By analysing the return time for sound waves, we can find out how deep the layers are beneath the sea floor.

A seismic survey has just been completed off the coast of Carnarvon in the North West Shelf off Western Australian. The raw data has been handed to you, the petroleum geologist. Your task is to accurately work out the depths of the different layers beneath the sea floor so that drilling costs can be estimated. Be careful or you could cost your company millions of wasted dollars!

Can you work out how the time relates to the depth of each of the layers? Let's use the approximate velocity of sound as 1500 metres per second. How deep is the sea floor? To work this out we use the formula;

#### distance = velocity x time

1. Check out the raw survey data in Table 1 and the seismic diagram. Use the graph paper provided to draw two labelled axes in pencil. Show depth below sea level on the vertical axis and time on the horizontal axis.

On the graph, plot depth versus two way time for the Carnarvon seismic data.

- 2. Draw the line of best fit through these points.
- 3. Fill in the one way travel time in the table. Draw in the line of best fit for the time taken for one way travel of each signal onto the same graph. Label each line.
- 4. Reading from the graph, answer these questions.
- a) How long would it take for a sound wave to travel from the survey ship's air gun, down to a layer that is 1750 metres deep and back to the hydrophone receivers?

The sound wave would take ~ 1.4 seconds

b) How long would it take for a sound wave to travel down to a layer 2750 metres below sea level?

The sound wave would take ~ 1.0 seconds

b) How deep is a layer of sediment that has a signal one way time of 0.6 seconds?

The layer is 1500m below sea level

Table One – raw data from Carnaryon survey on North West Shelf.

At this location the sea depth is 473 metres.

The sound waves bounce off the boundary between layers.

boundary	depth below sea level (metres)	two way travel time (seconds)	one way travel time (seconds)
A	473	0.450	0.225
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G	1100	0,960	0.480
Н	1147	0.995	~0.498
1	1550	1.289	~0.645
J	1948	1.613	~0.807
K	2379	1.924	0.962
L	2572	2.044	1.082
М	2827	2.169	~ 1.085
· N	3238	2.375	~1.188
0	3390	2.454	1.227
Р	3459	2.484	1.242
Q	3592	2.542	1.271
R	3915	2.681	~ 1.341
S	4010	2.720	1.360

