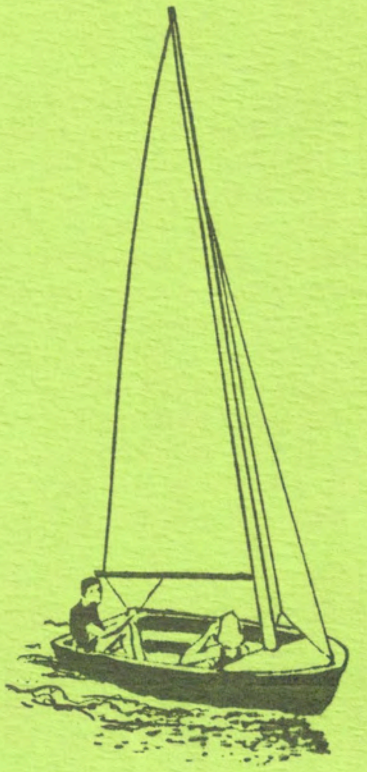
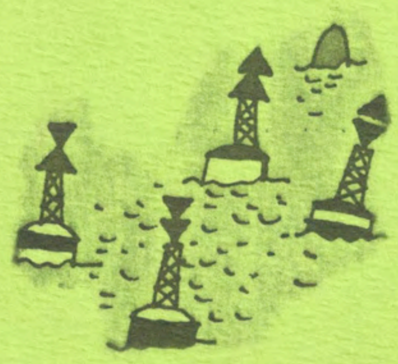
SCIENCE TEACHERS ASSOCIATION OF QUEENSLAND



COASTAL AND ESTUARINE OCEANOGRAPHY



UNIT I

GEOLOGY AND NAVIGATION

written by

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B.Sc. Dip Ed.

TRIAL UNIT

"TO GREAT DAYS AT THE ALEX"

Australia's coastline forms a special place in our environment because over 90% of us live there. Due to different Ecological, Economic, Social and Recreational interests many conflicts arise over the use of our Estuaries, Beaches and Barrier Reefs. Sand Mining, High Rise development, Longline Fishing, Low water Land sales, Resort development and oil Pollution are but a few of the real issues that face us now. There is an urgent need for all Australians to develop an attitude towards sensible resolution of these conflicts. This set of notes is one in a series that hopefully will give students the skills necessary to become involved in these issues and make sensible contributions to coastal environmental decision making. In doing so I hope that the coastline may be managed in such a way that future Australians will derive as much pleasure out of it as I have.

My thanks must go to S.T.A.Q. for providing the financial backing and support for this project. Thanks also to my Mother and Father who deciphered and typed my bad writing; and to Len Zell of the Great Barrier Reef Marine Park Authority who read and critised the draft and for making many useful contributions. As this is a first draft any comments would be gratefully acknowledged.

ACKNOWLEDGEMENTS :

Allistair Martin (M.S.C. Tas.) ; David Kopelke (B.I.F.S.C. Qld) ; Jim Redfield (C.S.I.R.O.) ; Roy Jenkins (F.U.S.E.) ; Dennis Bridger ; Ann Kenny ; Graham Mitchell ; Greg Martin ; Steve Hall (G.S.H.S.) ; Sue Oates ; Merrin Kilgour (B.S.H.S.) ; and the Departments of Harbours and Marine, Fisheries, Oceanography, Great Barrier Reef Marine Park Authority, The Beach Protection Authority and The Brisbane Education Centre for all their help.

UNIT I.

GEOLOGICAL OCEANOGRAPHY

CHAPTER 1.

COASTAL GEOMORPHOLOGY

CHAPTER 2.

COASTAL AND ESTUARINE NAVIGATION

CHAPTER 1.

COASTAL GEMORPHOLOGY

1.1 *Characteristics of the Coastal Zone*

Estuaries are places where the fresh water of the land mixes with the salt water of the sea. They form part of the earth's feature called the *COASTAL ZONE*. This coastal zone is situated at the boundary of the two major environments of the earth - land and ocean.

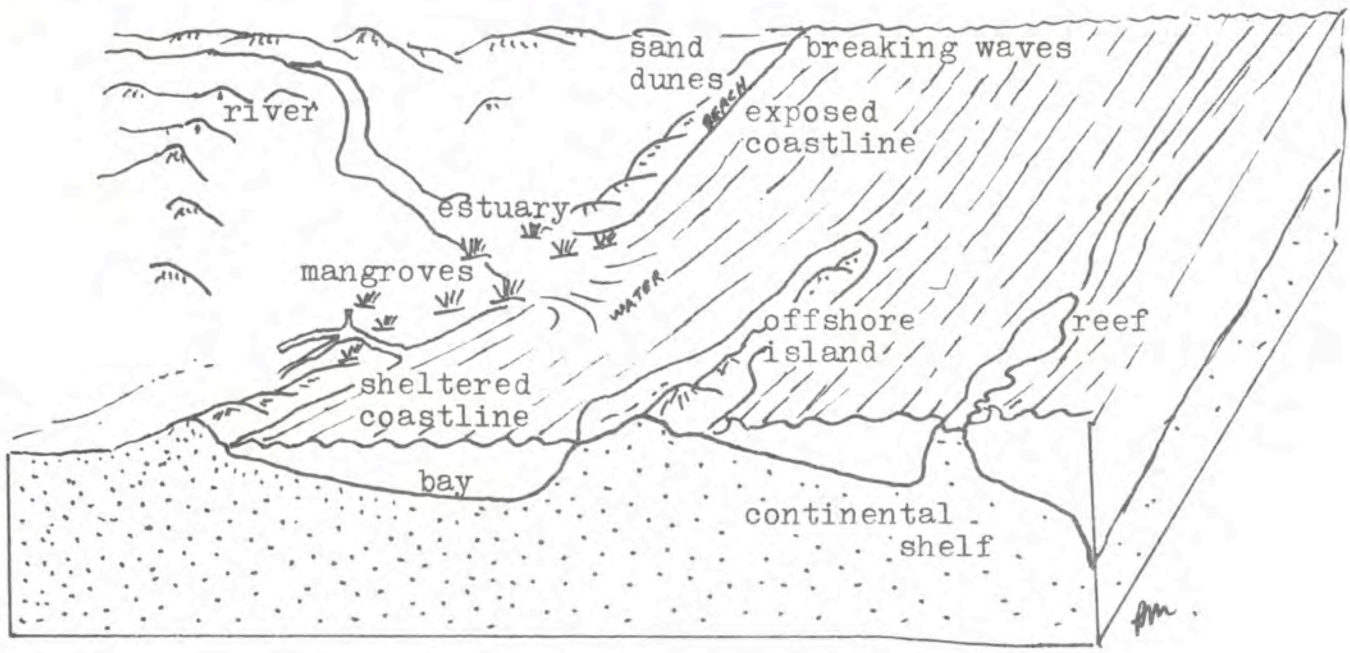


Fig. 1-1: A diagramatic view of some common features of Queenslands Coastal Zone.

This zone is an area of numerous biological, chemical, physical, geological, and meterological interactions. <u>The coastal zone may be defined as that part of the ocean affected by the land, and that part of the land affected by the ocean.</u> The boundary of the two environments is the shoreline, which is constantly changing. In the seaward direction part, if not all, of the continental shelf (including the Great Barrier Reef) may be included within the coastal zone. In the landward direction, estuaries, mangroves, seacliffs, the coastal plains, and other similar environment, may be included.

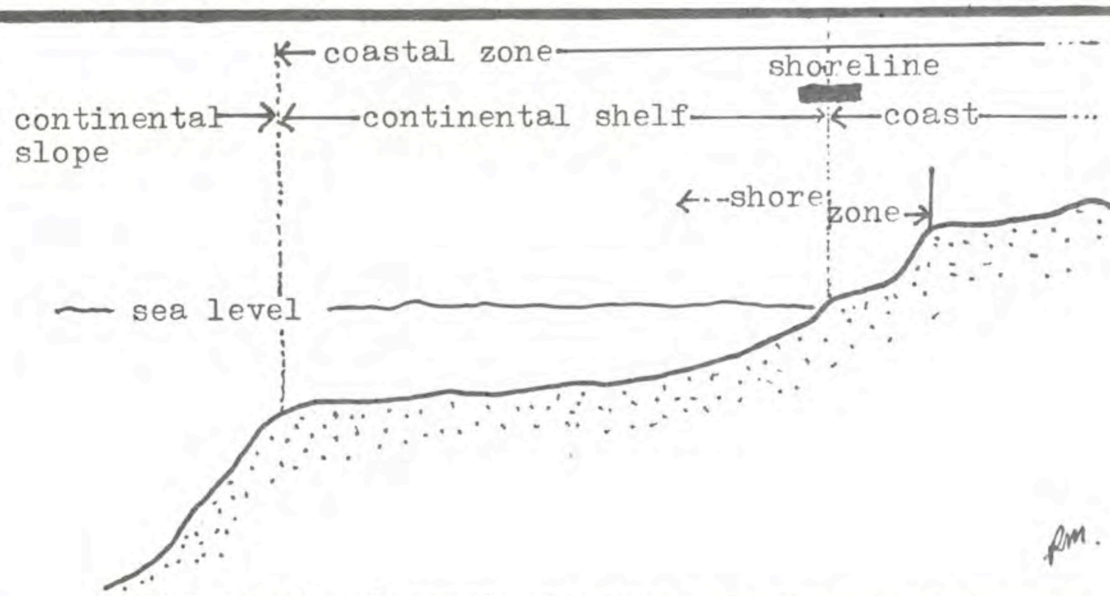


Fig. 1-2: General features of the coastal zone.

There is much agrument about definitions of coastal zone features. Some definitions are shown in Fig. 1-2. A shore zone and shore line can also be defined within the coastal zone; the shore zone covers the area where water and land come into contact, and includes the beach and surf zone. The shore line marks the point where land and water meet; the near shore region is that area seaward of the shore line. Most shore line features are temporary since their position is affected by the height of the sea level which is, in turn, influenced by tides, direction of wind, and strength and height of breaking waves. The shore line is constantly changing and may extend over a large area in a very short time.

1.2 Geological History

In the geological past, the sea has often covered part of Australia. For example, about 500 million years ago, the sea covered the area shown in Fig. 1-3

Fig. 1-3: 500 million years ago

Fig 1-4: 20 million years ago (ice age)

During the ice ages, the sea level fell due to the ocean waters being trapped in the ice. The coastal zone of Australia was then on the edge of the continental shelf. The continental shelf was then exposed to the air. New river valleys formed and the surf broke almost 200 miles further out to sea than it does today. (see Fig: 1-4)

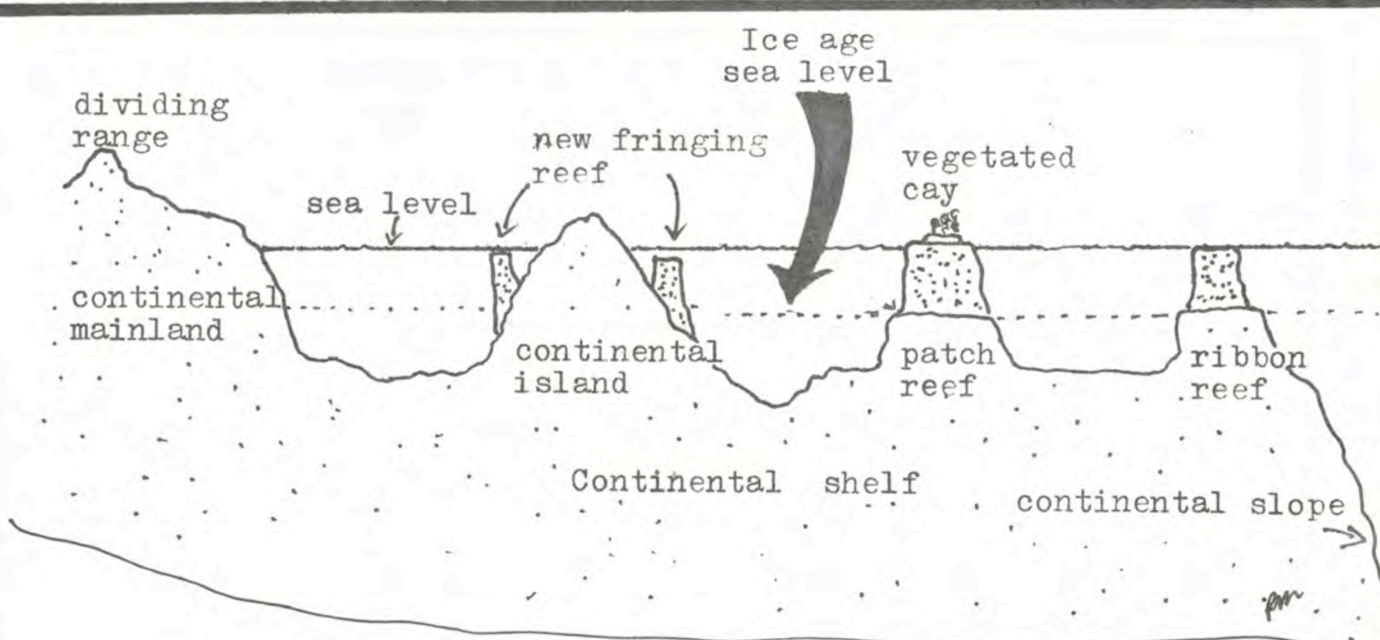


Fig. 1-5 General Bathymetric View

The foundations for the Great Barrier Reef were first made available for reef growth about 20 million years ago when the continental shelf was first formed and subsided below sea level. Two million years later the first corals began to grow forming coral reefs which grew steadily upwards until they reached their present height about 150,000 years ago.

An ice age began then, lowering the sea level until it reached its lowest point (130m below present sea level) about 18 - 20,000 years ago. The ice melted over a period of 10 - 12,000 years reaching present sea level about 6 - 8,000 years ago.

The new submergence of these old fossil reefs allowed new coral growth which is the reefs we see today. Veneers of new growth reach 15m in thickness overlying the old reefs.

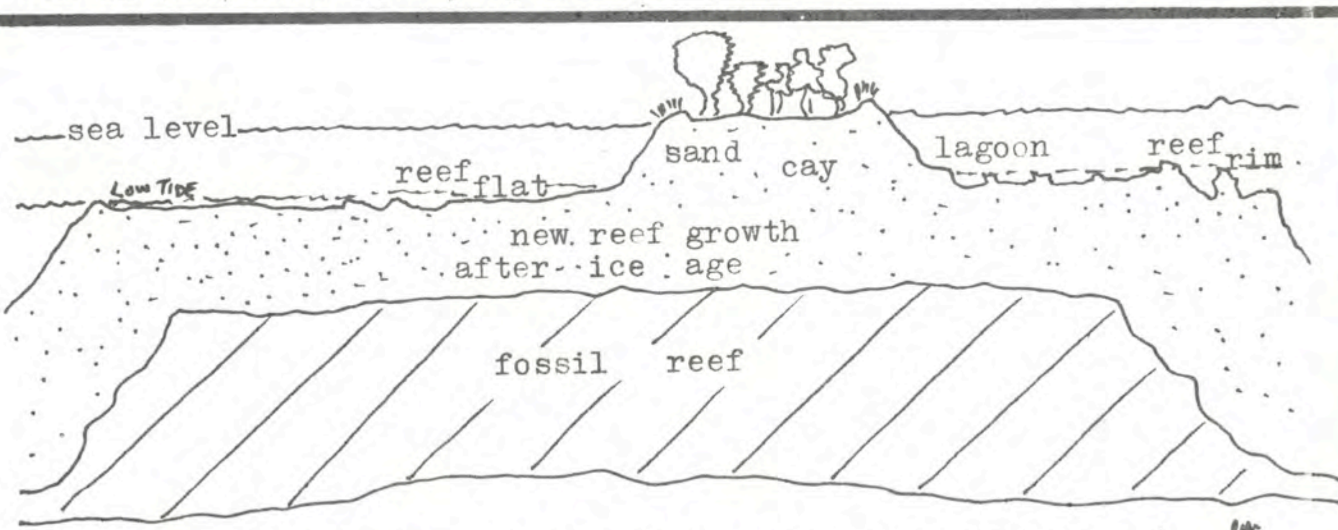
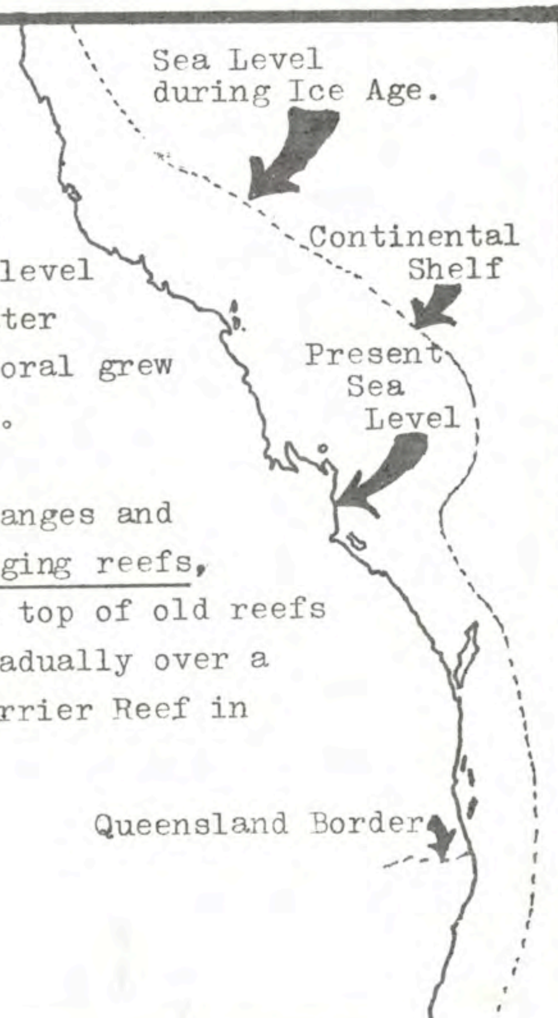


Fig. 1-6: Diagramatic Reef Profile (after Zell, 1980)

The Continental Shelf gradually filled with water as the ice melted.

The warmer waters allowed the tiny coral polyps to grow. As the water level rose gradually with more and more water being freed from the ice caps, the coral grew upwards keeping with the water level.

Reefs grew around old mountain ranges and continental islands formed with fringing reefs, (see figure 1-5). New reefs grew on top of old reefs to form ribbon and patch reefs. Gradually over a period 20 million years the Great Barrier Reef in Queensland formed.



1.3 Types of Shores

Some shore lines jut out into the ocean in a zig-zag fashion. These are called headlands. Other shores push inward to form bays. When waves strike directly against a rocky shore line, the *"bite"* and shape the land. As a result of this action, a wave-cut cliff may form. Erosion causes the rocks at the base of the cliff to break away. The rocks then accumulate near the base of the cliff causing a wave-cut platform.

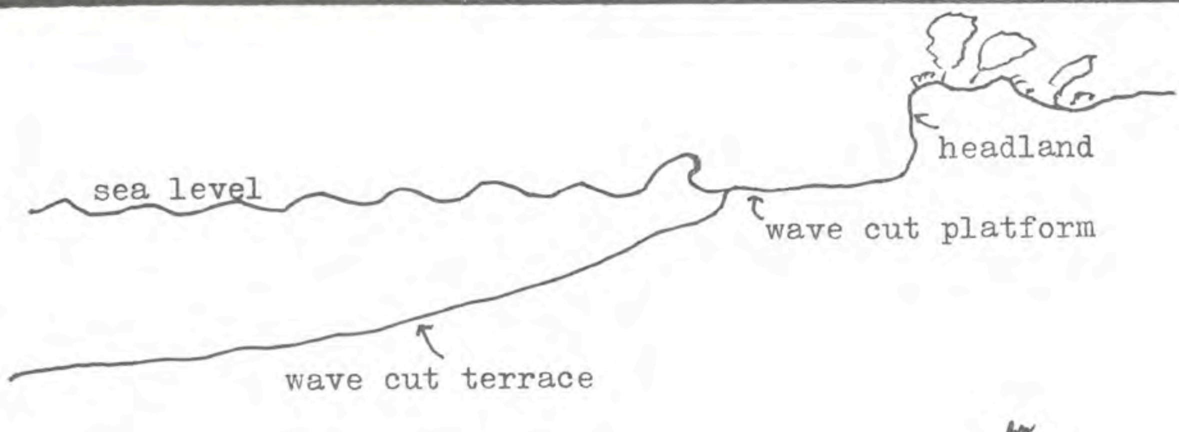


Fig. 1-7: Wave cut coastline. General View.

Over the years, these platforms may get very large and extend many metres into the sea. A shore line that has many of these sea cliffs is called an *EMERGENT SHORELINE*. When the sea level fell during the Ice ages these were exposed. New rivers cut valleys in these, and when the water levels rose they were filled with water. Many coastal features are drowned river valleys - The Capricorn Channel is an example of this for you can actually see this on Chart AUS.819 : Bustard Head to North Reef.

Off the Queensland coast are many drowned river valleys. Moreton Bay, off Brisbane, is another good example. These estuaries have offshore islands which protect the mainland. Other rivers that enter the sea are not so protected. The Tweed River, for example, on the border of Queensland and New South Wales, is completely exposed and rock walls have had to be built in order to allow boats to enter and leave the river.

Fig. 1-8:
Sheltered Coast

Fig 1-9:
Exposed Coast

A third type of coastline occurs in Queensland. In between the ice ages, tine animals called coral polyps, master-minded one of the world's greatest wonders, viz. the Great Barrier Reef. Some reefs formed before the ice ages, but when the ice melted and the sea levels rose, the warm shallow waters formed ideal places for coral communities. The new corals grew over the old reefs like the icing on a cake. Three types of coastal reefs can occur.

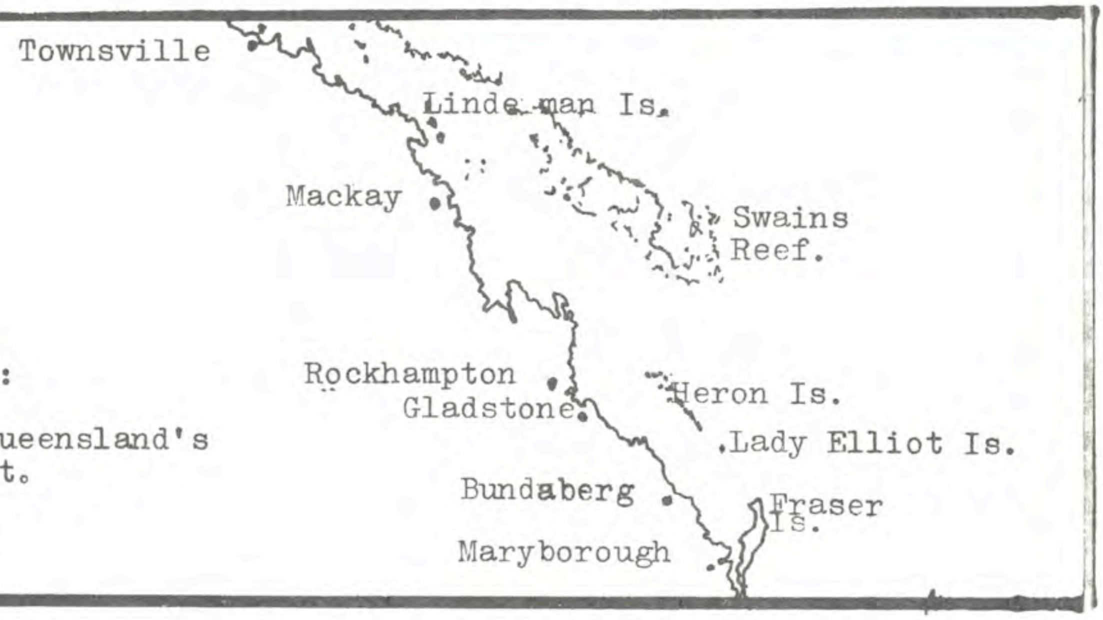


Fig. 1-10: Part of Queensland's Reef Coast.

1.4 Sediments

Sediments consist mostly of grains of various size made from a variety of rocks. The coastal zone may get sediment from a number of sources.

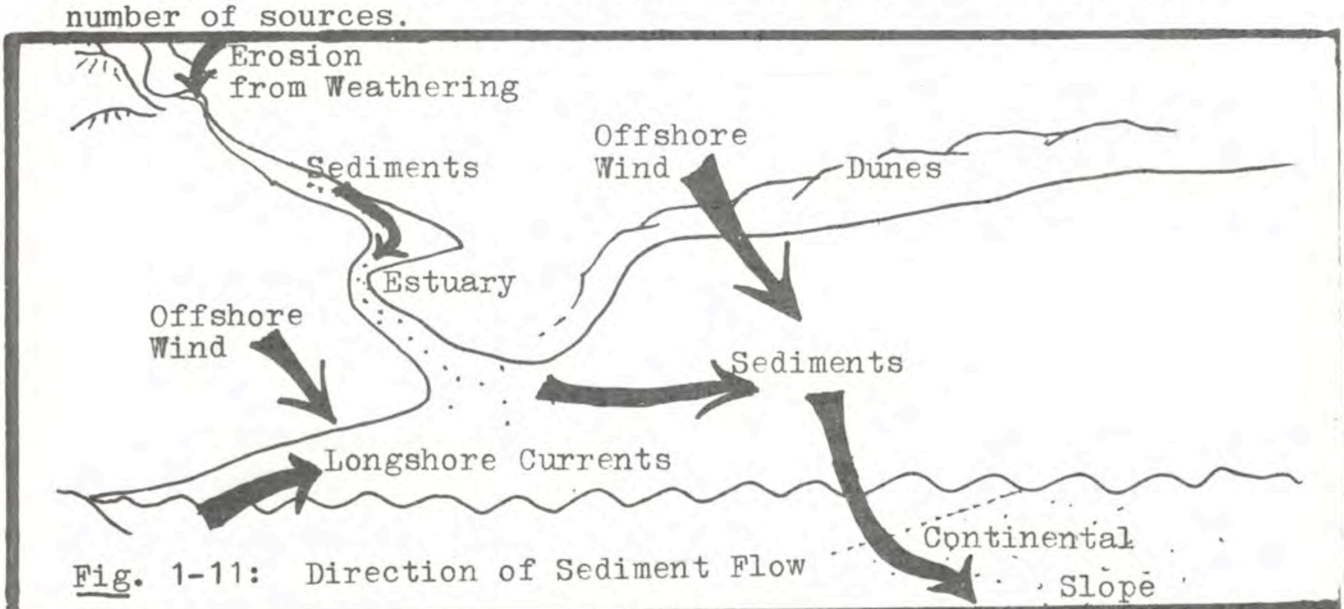


Fig. 1-11: Direction of Sediment Flow

Winds blowing sand and soil from the land, longshore currents causing beach erosion, and rivers, all contribute to sediments being deposited on the continental shelf.

Sediments are important because they can silt up coastal waterways or change the composition of prawning grounds.

1.5 The Importance of the Queensland Coastline

The economic importance of its coastline to Queensland is immense. The tourist industry is worth millions of dollars annually in areas such as the Gold and Sunshine coasts and the Barrier Reef resorts. Also, the fishing industry is a large employer and supplies us with a wide variety of fish products; while controlled sand mining of islands such as Stradbroke Island, provides jobs and capital inflow.

Apart from these facts, 85% of all Queenslanders live on the coastal strip, which would make it an important place to study.

Because such a vast majority of interests are staked in our coastline, management of this valuable resource is vital. Governments have set up groups of specially trained people to make sure that our coasts are not polluted or destroyed. Some of these authorities are listed in the Table below.

TABLE 1 : SOME MANAGEMENT AUTHORITIES OF OUR COAST

AUTHORITY	AREA OF COAST MANAGED
Great Barrier Reef Marine Park Authority	The Great Barrier Reef
National Parks and Wildlife Service	The National Parks of our Coastline (as well as others)
The Beach Protection Authority	Our beaches
The Waterways Authority	Estuarine Development

MAIN IDEAS

1. Our coastal zone can be divided into The Continental Shelf, Shore Zone, Coast and Coastal Plain.
2. Australia's coastline varied over the earth's geological history due to the Ice ages.
3. Three types of shore exists in Queensland. *EXPOSED, ESTUARINE, AND REEF.*
4. Estuaries are very valuable to our economy and are managed by Government authorities.

REVIEW QUESTIONS

1. What is the Continental Shelf, and how does it differ from the Continental Slope?
2. How can we explain the formation of sea cliffs?
3. How are estuaries formed?
4. What is a longshore current, and what affect does it have on sediments?
5. What is beach *EROSION*, and list some of the ways it is controlled.
6. Why do estuaries have to be dredged?
7. Why is it necessary to manage our beaches?
8. What roles do each of the following people play in the study of a shore?

   An ENGINEER, a MARINE BIOLOGIST, a NAVIGATOR, a GEOLOGIST, a GEOGRAPHER?

ASSIGNMENTS

1. Write to one of the Authorities mentioned in this Chapter and ask about the role that particular authority plays in managing our coastline.
2. Find a Geological Time Scale chart in the library and copy it out. Try to figure out where the water levels were on Queensland's coastline over the past 500 million years.

CHAPTER 2

COASTAL AND ESTUARINE NAVIGATION

2.1 *Where Estuaries are found*

An estuary can be many things to many people. To the fisherman it could be an abundant fishing ground; to the small boat operator a place for a great day out; to industry a dumping place for chemicals and sewage; or to the land developer a place to make canals and a fortune in real estate. At high tide, an estuary can be a place of beauty with its beach to walk along with waves gently lapping against the shore. At low tide when the water goes out and the mudflat are exposed, the estuary may look like a garbage heap decorated with tin cans, broken glass, and old tyres protruding from the mud.

An estuary is any place where the fresh water of the river and the salt water of the ocean mix together.

To find our way around estuaries we need to know something about inshore navigation. Also, when sampling data or collecting is done, it is necessary to record the location where the data was collected.

2.2 *Charts and Navigation*

The word navigate is taken from Latin *"navigere"* meaning navis (ship) agere (move or to direct). Marine navigation may be defined as "process of directing the movement of a craft from one point to another on or in a body of water". According to our best estimates man has been navigating the ocean for at least 6000 years - some say perhaps 8000 years or more. Most impressive were the Polynesians, who traversed thousands of miles of open ocean in the Pacific using charts of reeds as early as 1500 B.C.

Among the most important instruments developed to aid navigation of the sea are the compass, chronometer and the sextant. Date and origin of the magnetic compass are unknown. It is one of the oldest instruments and it is thought that the compass originated in China with the discovery of the naturally occurring magnetic material lodestone. The chronometer, an extremely accurate clock is used to determine longitude. Remember, if the earth is viewed from the pole, it rotates through 15 each hour (24 x 15 $= 260^\circ$). Then each 15° of east or west travel on earth represents one hour's difference, (Refer to Time Zones such as Eastern, Central and Pacific). The sextant was invented about the 17th or 18th century. This instrument enables a mariner to determine location at sea with excellent accuracy. The electronic age has added radar, loran and sounding equipment (sonar).

A *map* is a representation of the earth's surface on a plane surface - a *chart* is a map used primarily for navigation.

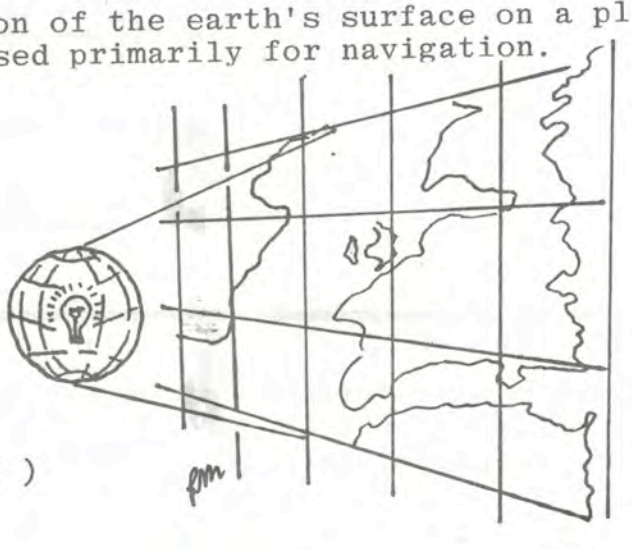


Fig. 2-1:
The principle of chart making could be thought of by the image that would form on a wall from a bulb shining inside a globe. (after Togill, 1979)

A chart is a curved section of the earth's surface reproduced on a flat piece of paper. Since there are obvious difficulties in making a curved surface flat - try flattening half a tennis ball without splitting it - it follows that a number of problems arise in making a chart. There must be some form of distortion somewhere and yet if a chart is to be of any use for navigation, it must have a high degree of accuracy.

In the case of Mercator charts, the charts most commonly used for ships of all kinds, the major distortion is kept to the extremities of the world - near the poles - and since few ships navigate in these areas the problem is not a severe one. In the more temperate and tropical zones, where most navigation is carried out, the distortion is relatively slight, and at the equator it hardly exists.

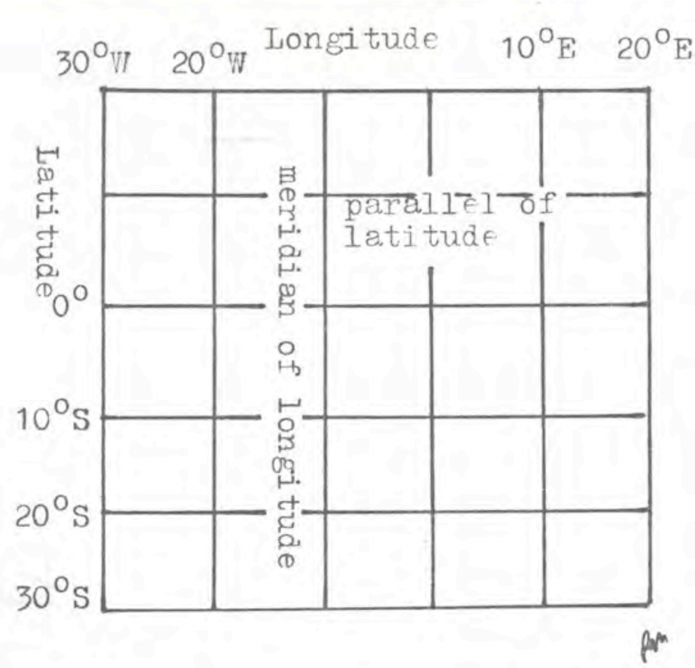
The Mercator projection system by which naval charts are made is best understood by imagining the world as a plastic globe with a light in the centre and a flat wall adjacent to one side. When the light is switched on, the contours of the land massess will be thrown onto the wall in the form of a flat plan. At the equator there will be little distortion, but towards the ceiling the projected contours will be elongated and considerable distortion will occur.

Because only a very small part of the earth's surface is reproduced on most charts, the distortion is reduced considerably and in fact is hardly noticeable except when using charts of higher latitudes. For this reason straight lines can mostly be used as courses between two points. Although in fact the ship steering along this straight line will follow a curved course across the face of the earth, the distortion is so small as to be of little consequence other than when long ocean passages are undertaken, or the passages are in high latitudes.

The great advantage in the Mercator system of constructing charts is that everything is neat and *"squared off"*. The meridians of longitude run north/south squarely from top to bottom and the parallels of latitude run squarely east/west from side to side. This makes life very easy for the navigator who can use straight lines for all his plotting instead of complex curves.

Fig 2-2:

On Mercator Charts Longitude and Latitude are drawn to square.



A nautical chart intended primarily for marine navigation shows land outline, prominent land features (natural and man-made), depth of water, channels, navigation markers and a Compass Rose.

Investigation 2-1

CHARTING YOUR CLASSROOM

You will need

A room plan

A Student Kent Set OR a protractor and 2 set squares 95mm x 95mm

Plotting Compass (orienteering type)

What to do

PART A. The Compass Rose

1. Place the compass in the bottom half of the room plan and mark *NORTH*. Draw a line about 10cm long and mark it so as to point *NORTH* (N, 0°).
2. Place the protractor on this line so that the 0 matches up, and draw a half circle around to the 180°, 180°, and call these *EAST* and *SOUTH*.
3. Now reverse the protractor and complete the semi-circle, carefully marking in the 270°*E*.
4. Join up *E*. and *W*. and put a small circle in the middle of the circle. This will be your *Compass Rose*.
5. Now carefully mark off each 10°so that you have a circle marked in 10°. Your teacher will have a Nautical Chart of the area on display. Check this to see how a Compass Rose is drawn.

PART B. Taking a bearing

1. Take the compass and line up an object in the room to the *EAST* of you. Take a bearing on this position.

RULE OF SQUARES : BASE TO BASE; SIDE TO SIDE; HYPOTENUSE TO HYPOTENUSE.

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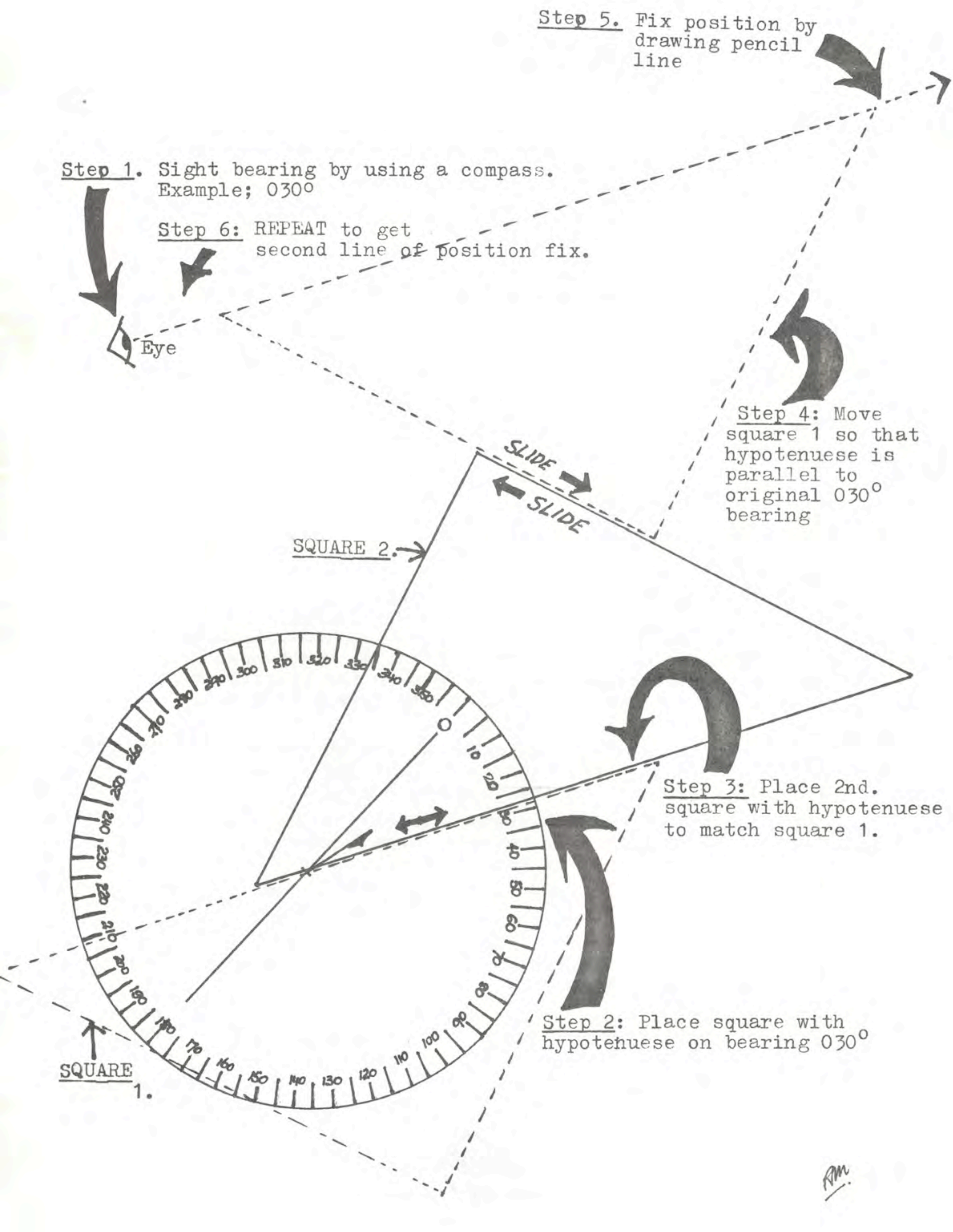
2. Place one of the squares so that an hypotenuse goes from the centre of the compass rose to the bearing you just took. Mark this bearing 1. and draw a line between the two.
3. Place the base of the other square on the corresponding base and walk the squares so that the hypotenuse side stays parallel to the original bearing.
4. When the hypotenuse passes directly over the point from which you took your bearing, draw a line. Write the words Bearing 1. on this line.
5. No take another bearing further *EAST*, a gas tap will do, and repeat the procedure. Call your second line Bearing Line 2.
6. Take a third bearing *WEST* and *"fix"* your position again, draw Bearing Line 3.
7. Shade in the little triangle that forms from the intersection of these 3 lines. Congratulations, you have fixed your position.
8. Now move to another position and fix your position again. Make up a data table.

Walking The Squares

Fig. 2-3: By using two set squares, a compass bearing can be transferred to a chart to fix a position.



Analysing your Results - Questions :

1. What do you notice about the bearing lines drawn on your Compass Rose and your position Fix?
2. How big is your shaded triangle?
3. How good are you at taking a bearing if this triangle is - *LARGE, SMALL.*

Investigation 2-1 introduced you to the basis of navigation.

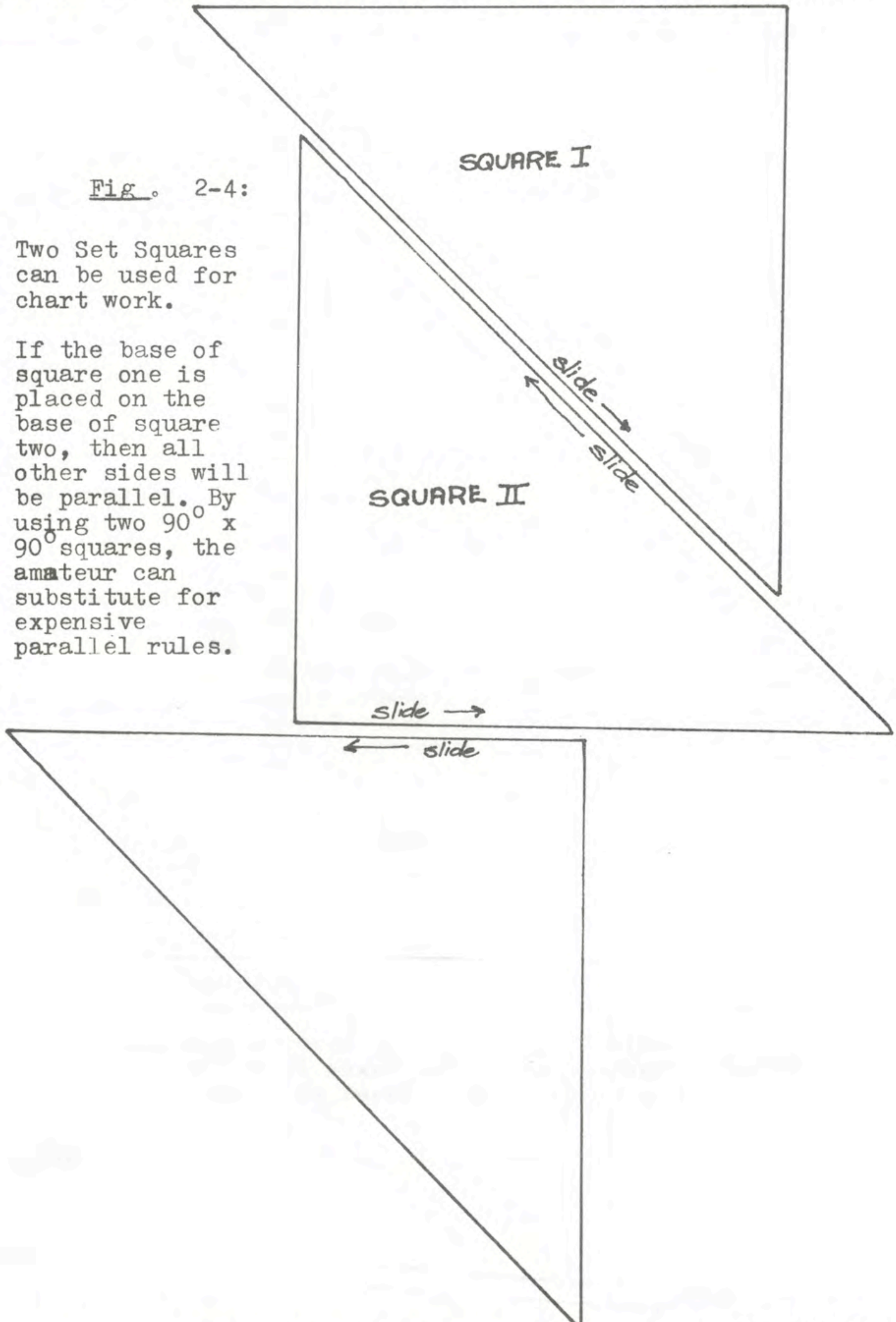


Fig. 2-4:

Two Set Squares can be used for chart work.

If the base of square one is placed on the base of square two, then all other sides will be parallel. By using two 90^{o} x 90^{o} squares, the amateur can substitute for expensive parallel rules.

Small set square can be used to plot positions if the Rule of Side is applied :

1. Use the hypotenuse to read from Rose to Bearing, or Vice Versa.
2. When moving about, always use corresponding sides.

If you have troubles, write the words BASE, SIDE, AND HYOPTENUSE on the SQUARES.

2.3 Latitude and Longitude

In order to create a measurement scale for navigational purposes, the world is divided into a grid of latitude and longitude. Because each is in the form of a circle, the scale of latitude and longitude is in degrees and minutes of an arc (1° = 60 minutes).

LATITUDE is the measurement scale which begins at the equator (0) and runs *NORTH* and *SOUTH* (90°S. or N.).

LONGITUDE begins at the Greenwich Meridian (180° *WEST* or *EAST*).

THE GREENWICH MERIDIAN is the traditional starting place of all longitudinal measurements and is so named because it is the meridian of longitude that runs *NORTH* and *SOUTH* through GREENWICH in London.

On a chart, the latitude scale is marked in degrees and minutes on either side, while the longitudinal scale is similarly marked on the top and bottom of the chart.

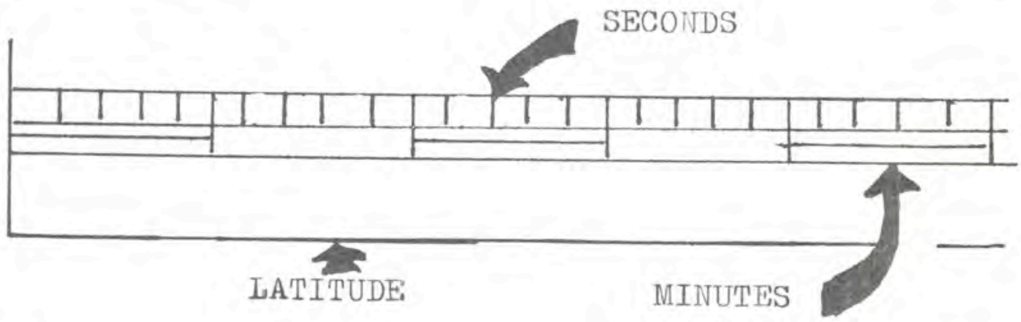


Fig: 2-5. The top and bottom of the chart shows LATITUDE.

2.4 The Nautical Mile

Because the earth's surface is divided up in degrees and minutes, normal kilometres and metres are not used. The scale of measurement is a *nautical mile*, which is represented by one minute of LATITUDE (NEVER LONGITUDE). Thus few charts carry separate distance scales, the scale on the left or right side of the chart being used to measure nautical miles in any direction, ACROSS, AS WELL AS UP AND DOWN the chart.

Distance is measured by dividers. The spread of the divider's points are used to carry the measurement to the LATITUDE scale, where it can be read off in minutes.

1 Nautical Mile = 1 Minute of Longitude

Because of variations due to the Chart's distortation, distance readings should be taken from the LATITUDE scale at a point roughly level with the boat's position.

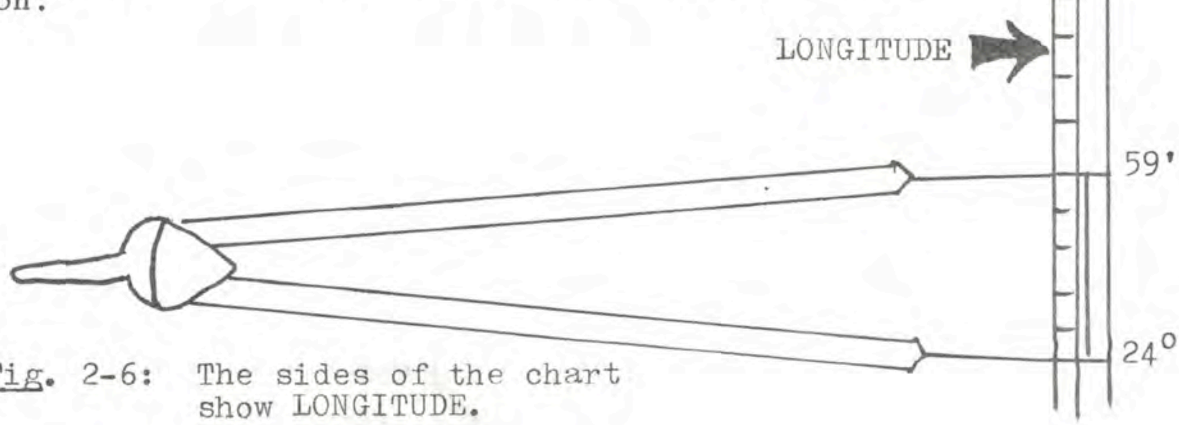


Fig. 2-6: The sides of the chart show LONGITUDE.

2.5 The Compass Rose

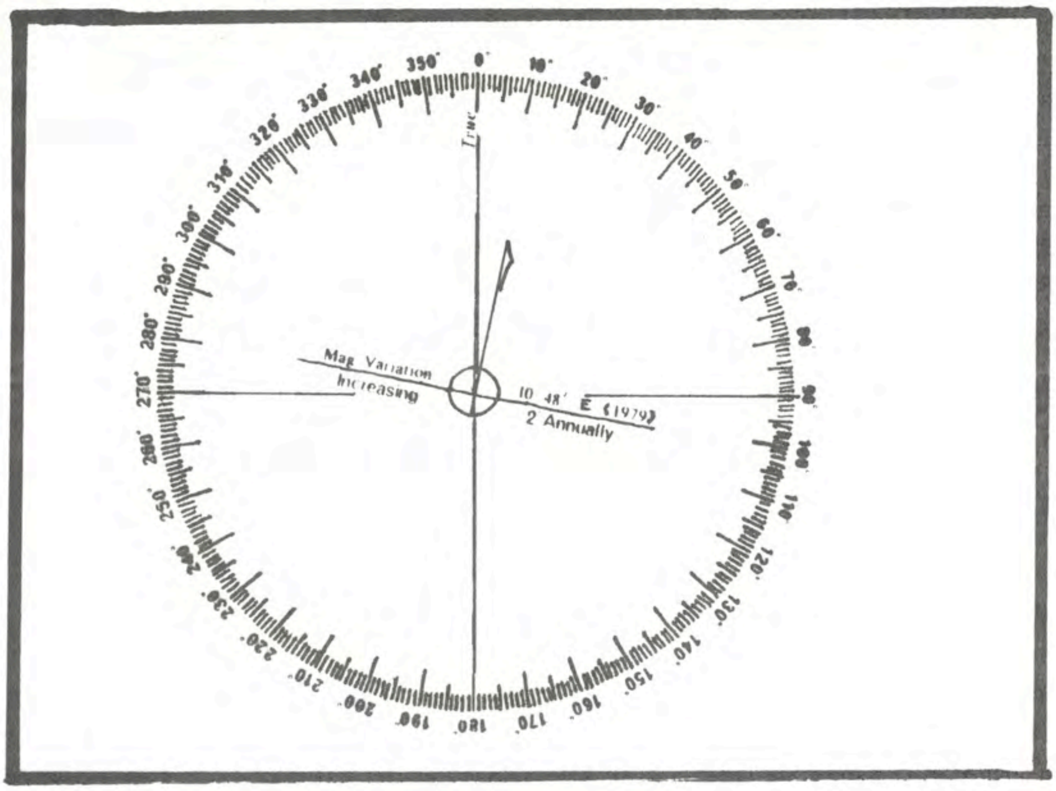


Fig. 2-7: The Compass Rose showing the Magnetic Variation.

Now we will look at a simulated chart. We call it Hypothetical Bay. This bay is a large estuary with a point where surf breaks. Turtle Island is located off a breakwater for trawlers to enter and leave.

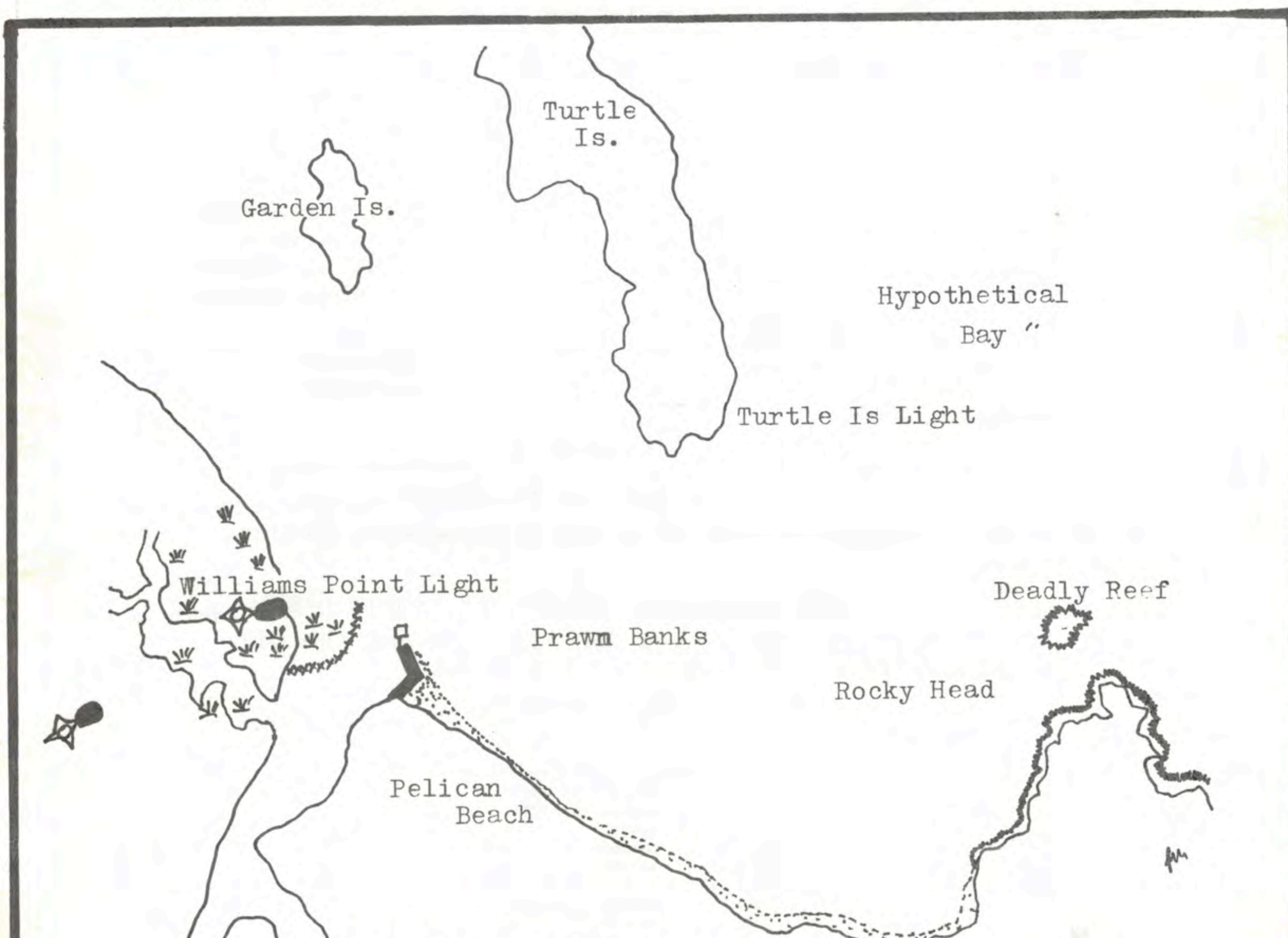


Fig: 2-8: Hypothetical Bay

Investigation 2-2: Basic Estuarine Navigation

You will need

* Hypothetical Bay Worksheet *(Copies can be made from page 10)*
* Access to a chart of a local estuarine system *(photocopy of portion)*
* Chart may be locally purchased or obtained from Department of Harbours and Marine, or selected newsagents
* Pencil
* Plotting Devise, 2 set squares
* Protractor
* Dividers

What to do

PART A: Chart Work:

List five features shown on the Hypothetical Bay chart which do not occur on a map.
Look at the meridians of longitude (down the chart) and latitude (across the chart).
Locate places on the chart - the lights at Big Head, Williams Point and Turtle Island, and describe their longitude and latitude.

PART B: Distance Work:

Using the scale of 1 minute of Latitude = 1 nautical mile (M), figure out the distances between the three places you located in PART A.
By avoiding all water below 5M, figure out the shortest distance between Potts Point and Turtle Island Light House.

PART C: Speed Distance Work: *(1M/hr = 1 knot* $S = \frac{D}{T}$*)*

1. If a vessel travels at 10 knots, how long would it take to travel between Turtle Island Light House and Big Head?
2. If you were a canoeist paddling at 2 knots, how long would it take?

PART D: Plotting a position on your chart:

Suppose you were to sample water temperatures at three station sites - 1, 2, and 3 *(Refer to Hypothetical Bay Chart)*. You are told that Station 1. is located at Latitude 23° 58' South, and at Longitude 151° 51' East. You need to fix your position and know at what bearing to stop and anchor your boat.

1. Place the hypotenuse on a line between Station 1. and Williams Point Light. *"Walk"* your set squares to the Compass Rose.

   RECORD your bearing as ______________

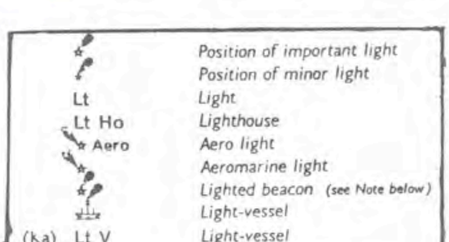
   Bearing to William Pt. Light ____________

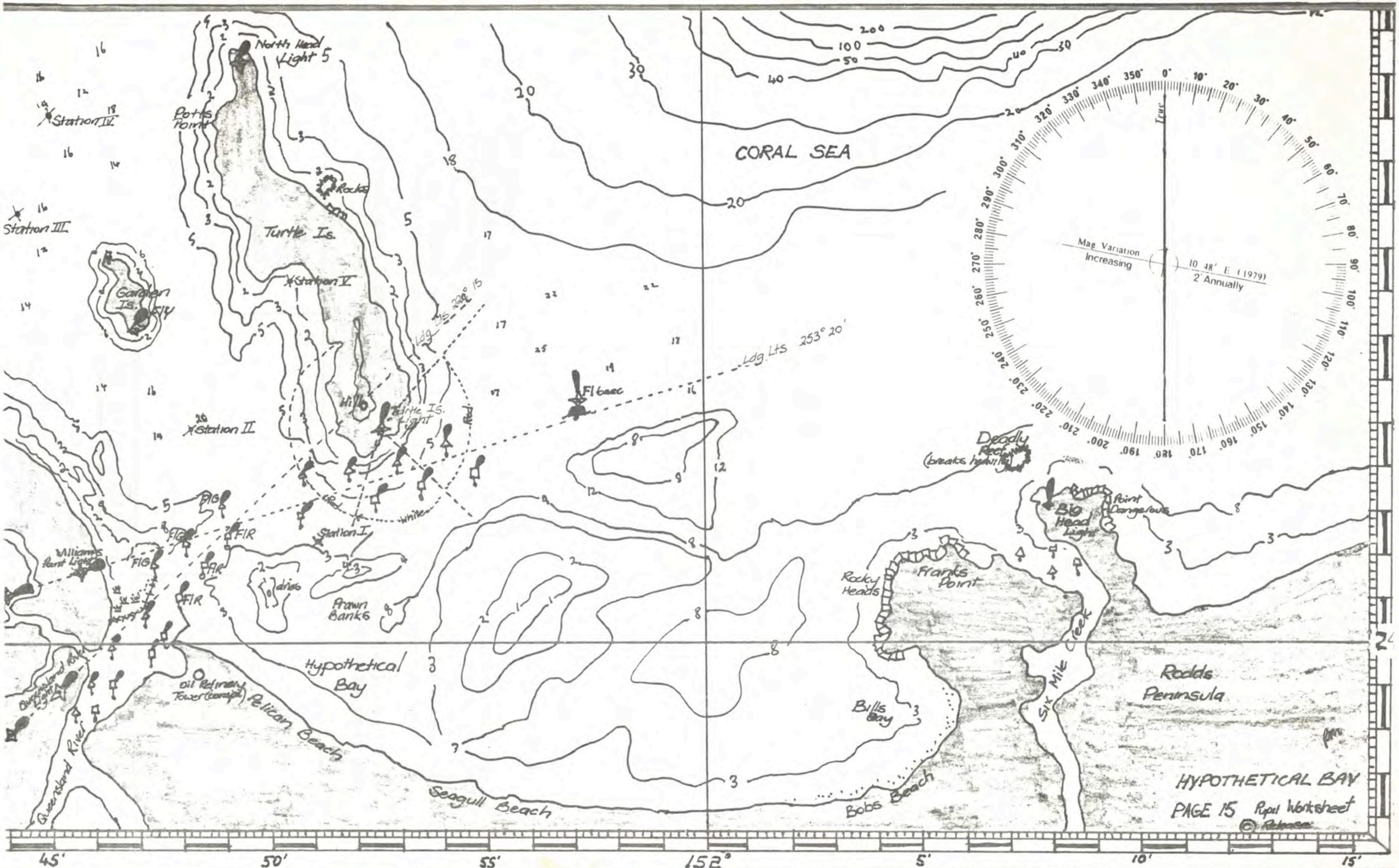
2. Place the hypothenuse on a 2nd line between Garden Island and Station 2.

   RECORD bearing to Garden Island Light ____

3. Place the hypotenuse on a 3rd line between the Oil Refinery Tower *(conspicuous)* and Station 1.

   RECORD bearing to oil Tower ______________




North Head Light
Potts Point
Station IV
Station III
Turtle Is.
Rocks
Station V
Garden Is.
CORAL SEA
Ldg Lts 253° 20'
Mag Variation
Increasing
10° 48' E (1979)
2' Annually
True
Turtle Is. Light
Red
White
Fl 6sec
Station II
Station I
Deadly Reef (breaks heavily)
Big Head Light
Point Dangerous
Williams Point Light
F1G
F1R
dries
Prawn Banks
Rocky Heads
Franks Point
Six Mile Creek
Rodds Peninsula
Hypothetical Bay
Oil Refinery Tower (conspic)
Pelican Beach
Queensland River Light
Queensland River
Seagull Beach
Bills Bay
Bobs Beach
HYPOTHETICAL BAY
PAGE 15 Pupil Worksheet
45'
50'
55'
152°
5'
10'
15'

PART E: *Distance and Bearings:*

Use squares and dividers to find:

a. The distance and bearing from Station 1 to Station 2.
b. From Station 2. to Station 3.
c. From Station 3. to Garden Island anchorage.

PART F: *On Patrol:*

You are on board a fisheries patrol vessel at 24° 50' South and 151° 45' East, and have just been told by radio that the fishing vessel *"Sea Plunderer"* is unlawfully fishing at 24° 55' South and 152° 10' East. Instructions are to notify the master of the patrol vessel the following information immediately.

1. Distance to *"Sea Plunderer"* from your position.
2. Bearing of *"Sea Plunderer"* from your position.
3. Time taken to intercept *"Sea Plunderer"* at its present position if the speed of the patrol vessel is 1645 hrs. and the *"Sea Plunderer"* is stopped.

2.6 Geographical (true) North and Magnetic North

The geographic and magnetic north poles occur in different positions, i.e. a compass needle points to the magnetic North Pole, and not to the true North Pole. The difference is called *VARIATION*.

Look at the Compass Rose. → What is the value of the variation at Hypothetical Bay for this year?

So, in 1982 Mg Var = 9° 40' East or about 10°

Variation is the most important compass error with which a helmsman must cope. That means that a navigator cannot lay off (work out) a course straight from a chart, but must make allowance for the variation. To allow for this error we must remember the jingle

"*ERROR EAST, COMPASS LEAST*
ERROR WEST, COMPASS BEST"

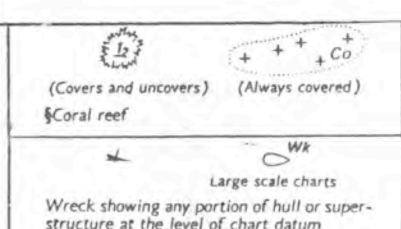
For example :

The true bearing from Williams Point Light to Turtle Island Light is 068 . By our Compass Rose our variation is 10 East. The error is *EAST*, so we *SUBSTRACT*. So by compass the bearing is 068° - 10°, OR 058°. Therefore, if we wanted to travel from Williams Point to Turtle Island in the fog, we would follow a 058° compass course, or travel almost Northeast by compass.

Calculate the compass course from Station 1. to Station 2, and from Station 2. to Station 3.

DATA TABLE

True Course	Error	Compass Course
________	________	________
________	________	________



2.7 Laying off a Course

You are now ready to go to sea. Let us suppose that you wished to go on a water sampling expedition and during the day wanted to navigate around 6 stations. You would make up a Table similar to that below.

Investigation 2-3: Laying off a Course

Problem:

A scientist wishes to leave port at 0700 hrs. and do a day's sampling at the 6 stations indicated. He will need 30 minutes to take water samples at each site.

You will need:

* Hypothetical Bay chart
* 2 plotting squares
* Rule and dividers

What to do

1. Draw up a Log with the headings

Course	ETD	True	Error	Compass	Distance	Speed	Time	ETA

2. Write the Course as follows :

   Marker at end of
   Williams Point Breakwater
   to Station 1.

3. Enter the time 0700 hrs.
4. With plotting squares, take the bearing (039°) and write down
5. Take off the error (10°) and write the compass course 029°.
6. From the side of the chart and with dividers, step off the distance in nautical miles (3M).
7. Compute the time $(T = \frac{D}{S})$ if you plan to speed at 6 knots $T = \frac{3}{6} =$ 30 mins.
8. Calculate ETA at Station 1. 0700 + 0030 = 0730 hrs.
9. Now complete the table for the trip, remembering that it takes ½ hr. for each sample site.

Analysing the results

Q 1 What time would you arrive at port?
Q 2 What happened between Station 4 and Station 5?
Q 3 When would you suggest that the scientist stop for lunch?

2.8 Soundings

On nautical charts, water depths are an aid to navigation Reefs, submerged pilings, and other obstructions, are also noted. In Investigation 3, when Garden Island had to be rounded, the depths of water had to be considered.

Suppose you wanted to chart a body of water and include depths and obstructions on your chart. First, you would need a map showing the outline of the body of water. Then you would need to go out on the water to measure the depth at various locations, being sure to record your exact location on the water. Now, by recording these depths at the right location on your map, you will have constructed your chart. This type of chart is called a *BATHYMETRIC CHART* or a chart of depths.

Investigation 4: Bathymetric Analysis

You will need:

1. A black box prepared in ADVANCE

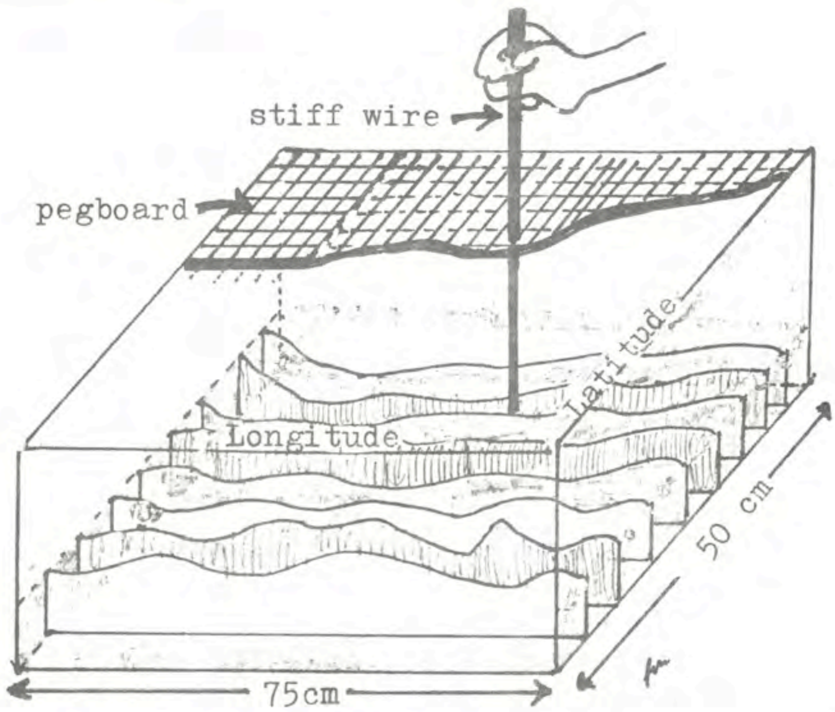


Fig. 2-9: A "Black Bathymetric Box."

The black box is prepared in advance. The box is constructed from one half sheet of 3/4" chip board and 16 boards. Make the box up to 50 X 75 and fill the bottom with bricks, broken blocks and wood scraps. Fill with clean builders sand. Cover the top of the box with peg board and rule lines of longitude and latitude.

2. Stiff wire - welding rod or coat hanger wire to fit through peg board
3. Metre rule
4. Line to mark track

What to do:

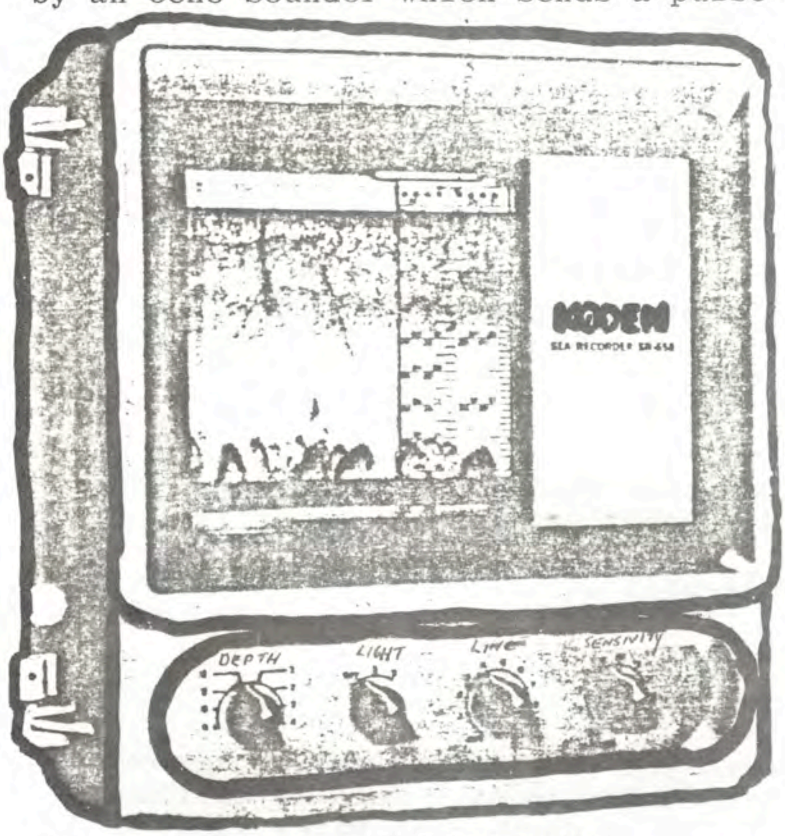
1. Use the wire to poke holes through the peg board until it touches the sand.
2. Note the length of the wire and graph the profile of the unseen floor. You may wish to use a toy ship to simulate the exercise.

Questions: Invesitgation 4

Q 1 How does the size of the interval between readings affect accuracy?
Q 2 How can inconsistent features, ie.e. isolated peaks, one great depth, be explained?
Q 3 Does one of a few tracks really show the general topography?
Q 4 How important is accurage navigation in sailing the seas? How can Bathymetric Charts be used for navigation?
Q 5 Are accurage charts important in deep ocean water? Explain your answer.

NOTES : This investigation similates the techniques used by oceanographers. It will give you the idea of the difficulty in mapping the unseen ocean bottom accurately.

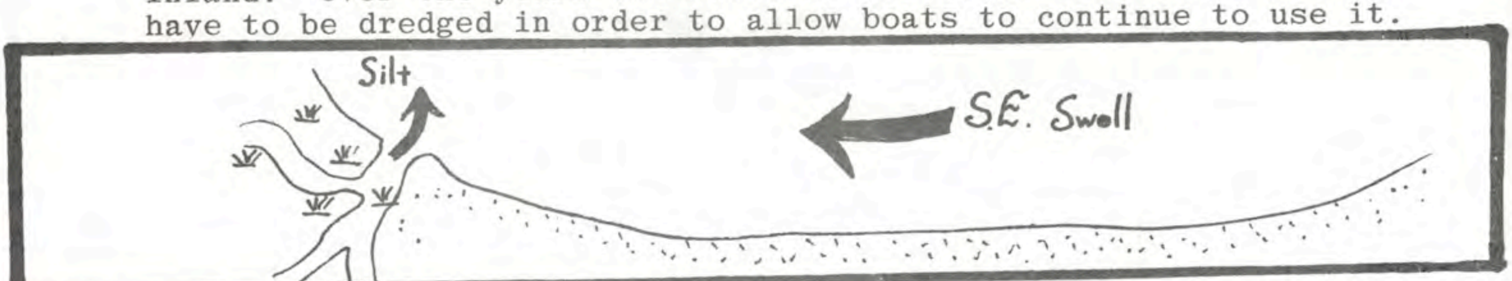
Bathymetric Charts are the results of many soundings and are as accurate as the data collected permits. Soundings are taken by an echo sounder which sends a pulse to the ocean floor and back again. The pulse is sent from a transducer fitted to the bottom of the boat, and the echo is analysed by a small receiver under the keel. By measuring the time interval, the depth of water is computed by the sounder.



2.9 *Estuarine Bathymetric Profiles*

Because estuaries are associated with rivers and creeks they will have water from the land mixing with ocean water. Water from the land carries with it soil, sand, and rocks and deposits this material in estuaries. Consider one example :

Queensland River is a major river system running many miles inland. Over the years the mouth of the river will silt up and have to be dredged in order to allow boats to continue to use it.



The S.E. swell will tend to push the silt N.W. into Hypothetical Bay. The silt is rich with fertilisers from the run off of home gardens and can cause algal growths around Garden Island.

Investigation 2-5: Estuarine Profiles

You will need:

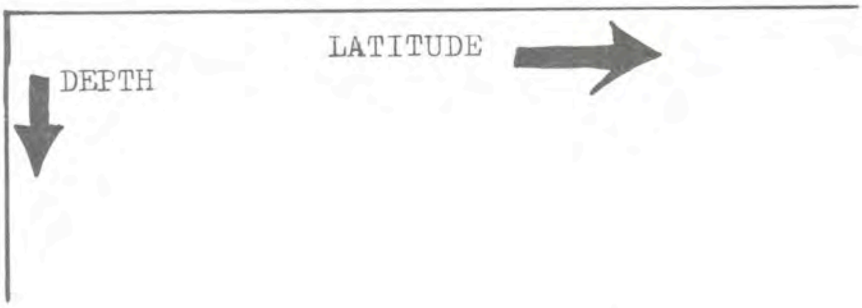
* Bathymetric Chart of Hypothetical Bay (see p.15)
* Student work sheet, Bathymetric Analysis Hypothetical Bay.
* Dividers and clear plastic ruler

What to do:

PART A: Profile 050°N.

1. From the compass rose walk a 050° N bearing from Queensland River Light.
2. Draw a line from here to Latitude 23° 47'.
3. Complete the work sheet provided. Make sure your line goes through the hill on Turtle Island.

NOTE : You can make up your work sheet like this.



PART B:

Draw an estuarine bathymetric profile from Queensland River Light. Latitude 24° 6' at a bearing of 065° to Latitude 23° 47'.

Analysing the results:

Q 1 Compare the bathymetric profiles of PART A and PART B.
Q 2 At Latitude 23° 47' Longitude 152° 01', what is the depth of the water?
Q 3 What is the Continental Shelf? Label it on your profiles.

2.10 The Continental Shelf

Investigation 2-5 showed you that as you go further out to sea, you come to the edge of the Continent. This is called the Continental Shelf. From here on is deep ocean water which does not worry the estuarine oceanographer.

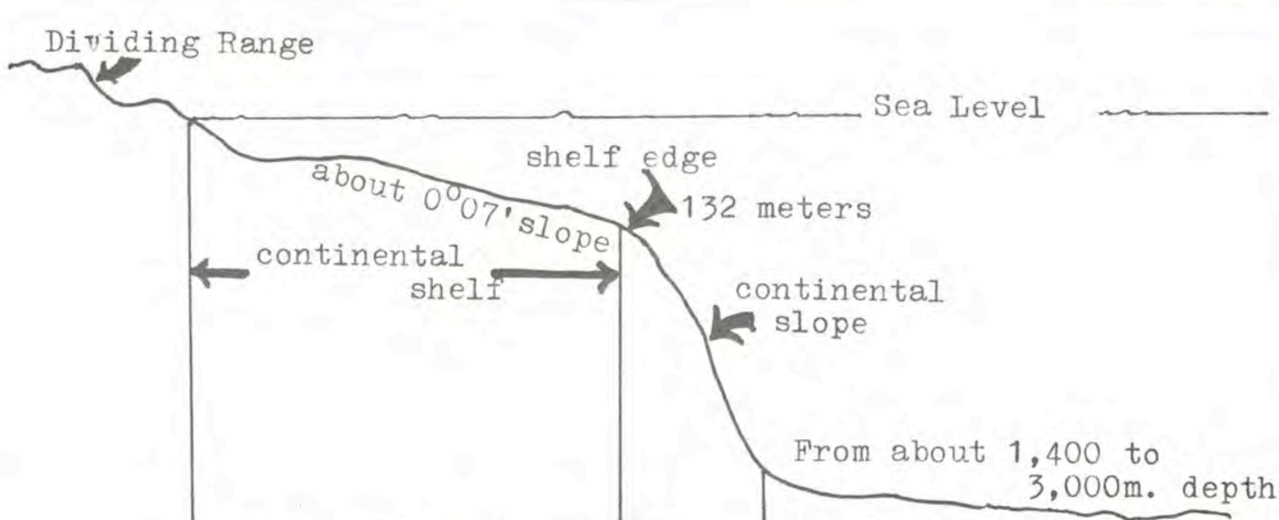


Fig. 2-11: Generalized view of coast

2.11 *Buoys, Beacons and Marks*

Just like a highway has road signs, so does an estuary, especially if it is a major port. Buoys, floats, beacons and marks are driven into the ocean bed or positioned on rocks. On sighting a navigational mark, the mariner's reaction must be *instinctive, positive,* and *correct.* Lack of this knowledge usually ends up in diaster with wrecks and groundings.

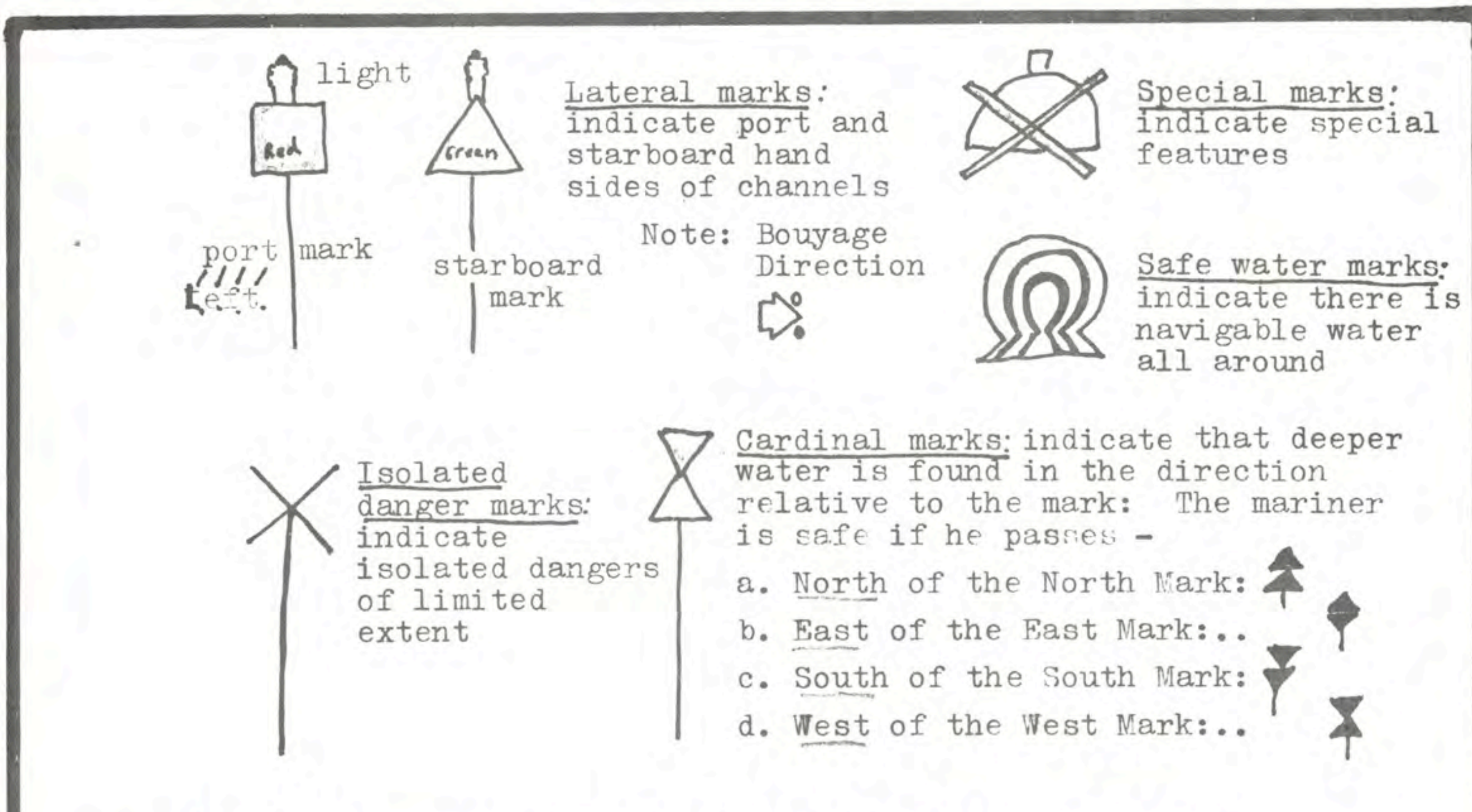


Fig. 2 -12 The Bouyage System of Inshore Navigation.

Upon entering a port, the port hand mark (RED) should be passed on the vessel's PORT side. Remember when coming home there is always a little bit of PORT left in PORT. Alternatively, when departing a port, the port hand buoy (RED) should be passed on the vessel's starboard side.

Look at the Chart below and follow the directions.

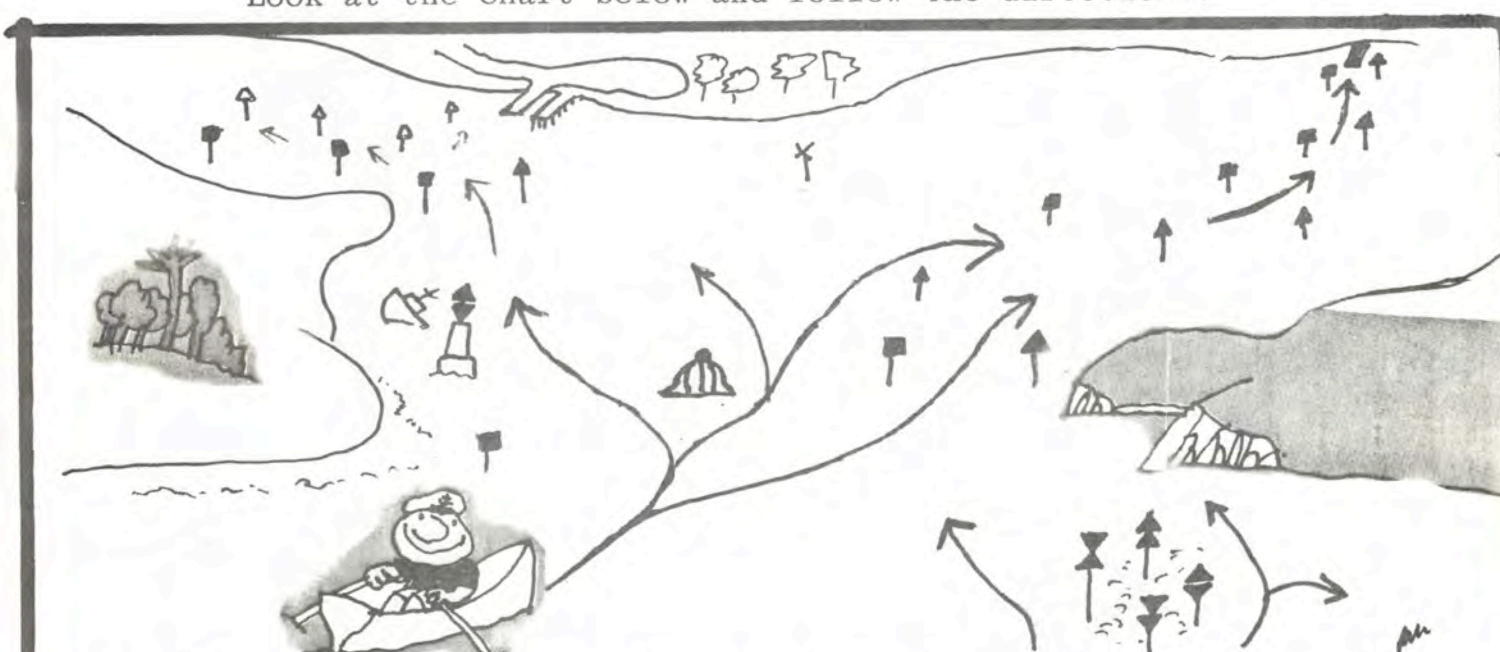
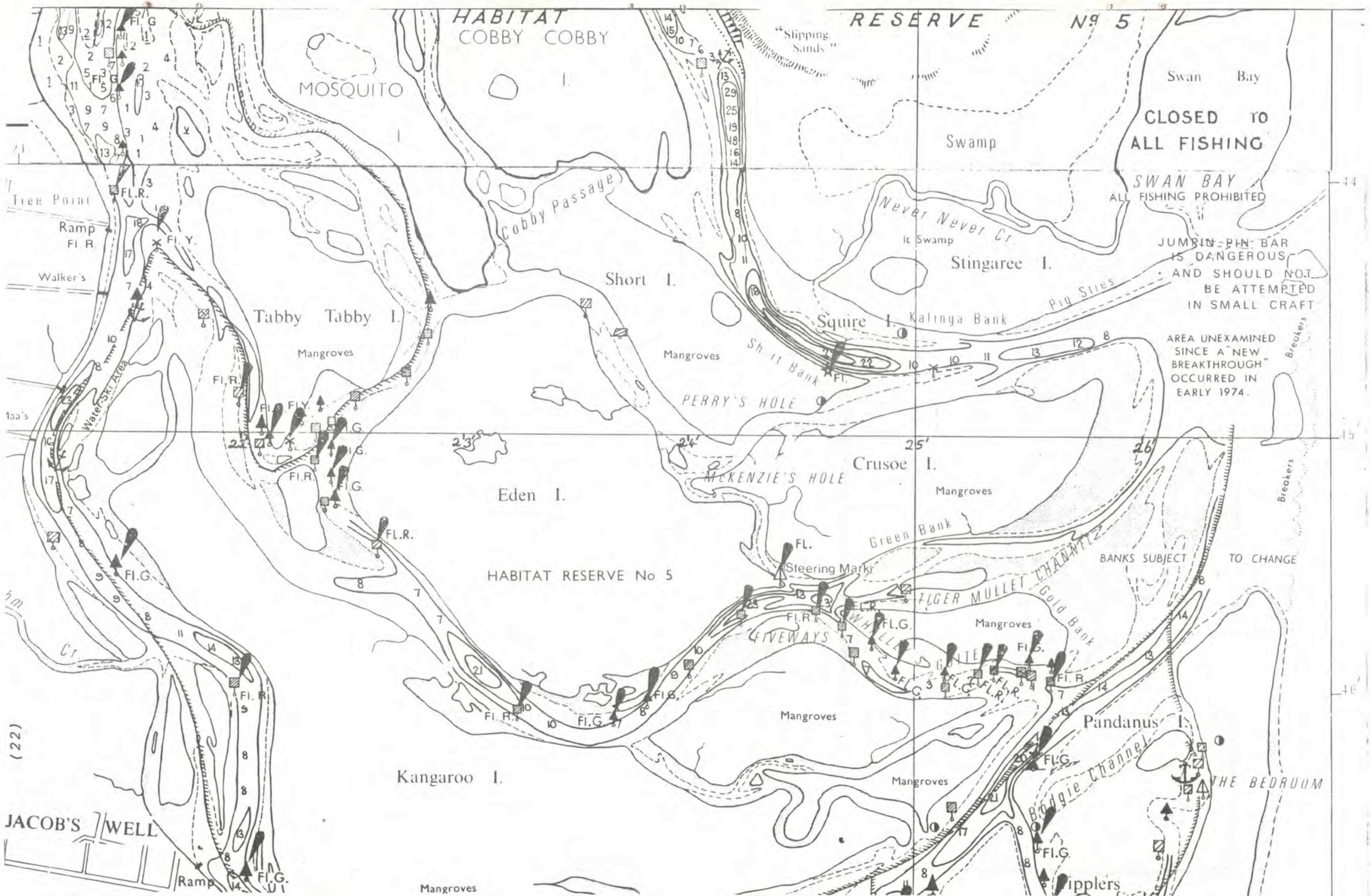


Fig. 2 -13: Possible directions into port using the Bouyage System

Other marks and descriptions can be found in the Department of Harbours and Marine Publication on " Buoys, Beacons and Marks "


HABITAT RESERVE Nº 5
COBBY COBBY I.
MOSQUITO I.
Swan Bay
CLOSED TO ALL FISHING
Swamp
"Slipping Sands"
SWAN BAY
ALL FISHING PROHIBITED
JUMPIN PIN BAR IS DANGEROUS AND SHOULD NOT BE ATTEMPTED IN SMALL CRAFT
AREA UNEXAMINED SINCE A "NEW BREAKTHROUGH" OCCURRED IN EARLY 1974.
Breakers
Tree Point
Ramp
Walker's
Water-Ski Area
Cobby Passage
Never Never Cr.
Stingaree I.
Short I.
Tabby Tabby I.
Mangroves
Squire I.
Kalinga Bank
Pig Sties
Short Bank
PERRY'S HOLE
McKENZIE'S HOLE
Crusoe I.
Eden I.
Green Bank
Steering Mark
HABITAT RESERVE No 5
TIGER MULLET CHANNEL
BANKS SUBJECT TO CHANGE
Gold Bank
FIVEWAYS
WHITE'S GUTTER
Pandanus I.
Bodgie Channel
THE BEDROOM
Kangaroo I.
JACOB'S WELL
Ramp
Pipplers
Fl. R.
Fl. G.
Fl. Y.
Fl.

MAIN IDEAS

1. *Navigation* is the process of directing a craft safely from one point to another over water.

2. *Charts* have special markings to guide mariners.

3. *Navigators* have special instruments which guide them up and down the coastline.

4. The *Compass Rose* is used to lay off a course.

5. When travelling on a *Compass Course*, the earths magnetic *error* must be either added (WEST) or subtracted (EAST).

6. *Distance* is measured in nautical miles and computed from the degree of longitude (never latitude).

7. *Speed* is measured in KNOTS, ONE KNOT = 1 NAUTICAL MILE PER HOUR.

8. *Charts* also show soundings. Areas of equal depth are joined by *Sounding Lines*.

9. An *International System of Bouyage* is used to guide mariners in estuaries.

10. There are rules of the sea to protect ships and crew.

REVIEW QUESTIONS

1. Define a CHART and give a brief account of the first persons to use them.

2. What are lines of latitude and longitude? Which is used for distance measurement and explain how the scale works.

3. Where is the Compass Rose situated on a chart? How are squares used to draw parallel lines?

4. What is laying off a course? Plotting a position.

5. What is the difference between geographic and magnetic course?

6. Draw a Port and Starboard marker.

7. Why is a uniform system of bouyage necessary?

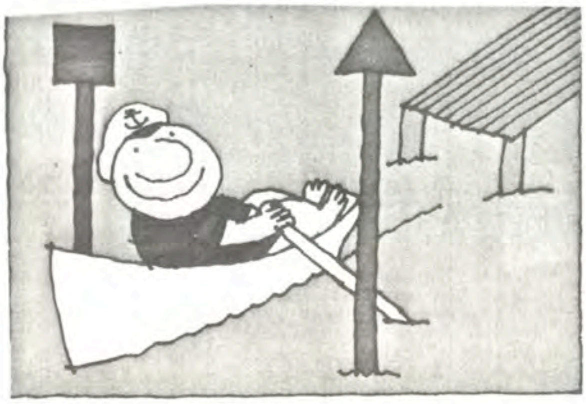
8. Name 2 rules for small ship operators.

STUDY ASSIGNMENTS

1. Research Matthew Flinders and Captain Cooks contribution to world navigation and chart making (Cartography).

2. What are notice to mariners?

3. Make a model Harbour and put in its markers.



MARINE SCIENCE SERIES

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UNIT 1 : Coastal and Estuarine Navigation

UNIT 2 : Coastal Physics

UNIT 3 : Coastal and Estuarine Biology

UNIT 4 : Estuarine Chemistry

UNIT 5 : Oceanographic Field Methods

IN PREPARATION

UNIT 6 : Mangrove and Reef Ecology

UNIT 7 : Snorkeling

UNIT 8 : Operation of Recreational Marine Craft

UNIT 9 : Sun Cancer

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UNIT 12 : Social Issues Involved in Coastal Management

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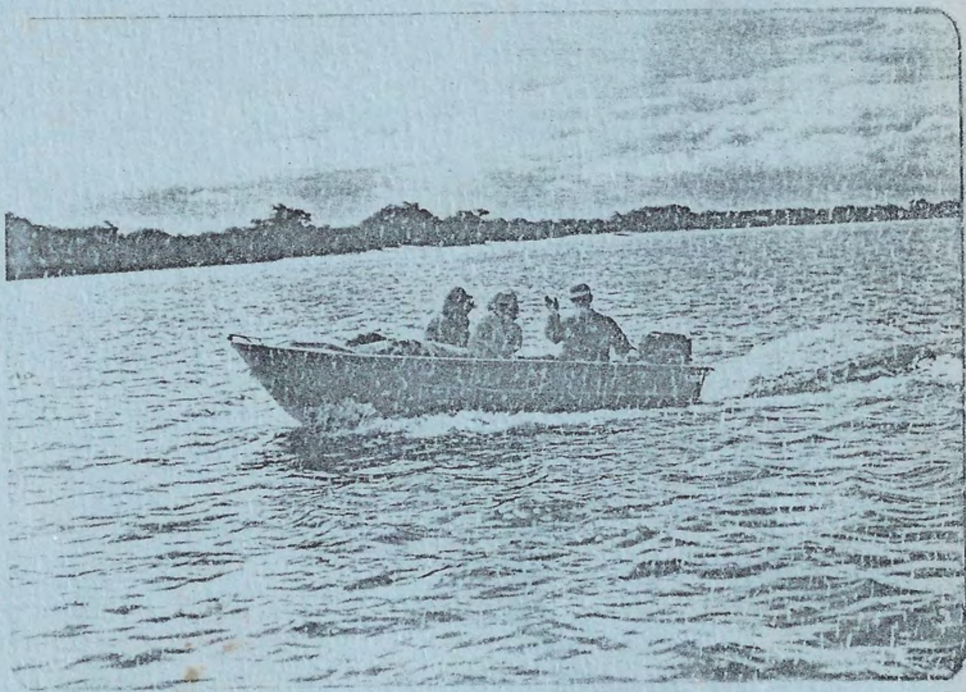

UNIT I

NAVIGATION

written by

R. Moffatt
B.Sc. Dip Ed.

"TO GREAT DAYS AT THE ALEX"

Australia's coastline forms a special place in our environment because over 90% of us live there. Due to different Ecological, Economic, Social and Recreational interests many conflicts arise over the use of our Estuaries, Beaches and Barrier Reefs. Sand Mining, High Rise development, Longline Fishing, Low water Land sales, Resort development and oil Pollution are but a few of the real issues that face us now. There is an urgent need for all Australians to develop an attitude towards sensible resolution of these conflicts. This set of notes is one in a series that hopefully will give students the skills necessary to become involved in these issues and make sensible contributions to coastal environmental decision making. In doing so I hope that the coastline may be managed in such a way that future Australians will derive as much pleasure out of it as I have.

My thanks must go to S.T.A.Q. for providing the financial backing and support for this project. Thanks also to my Mother and Father who deciphered and typed my bad writing; and to Len Zell of the Great Barrier Reef Marine Park Authority who read and critised the draft and for making many useful contributions. As this is a first draft any comments would be gratefully acknowledged.

First Published 1983 by S.T.A.Q. Publications c/- Brisbane Education Centre, PO Box 84, Spring Hill, 4000

The National Library of Australia
Cataloguing-in-Publication data:

ISBN 0 9598303 7 5

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NAVIGATION

An S.T.A.Q. MARINE SCIENCE MODULE

written by

R.D. MOFFATT

This module has 5 sections :

This module is compatible with the Syllabus Topics :

* Science for Recreation
* The Atmospheric Environment

Students, Teachers and Parents are referred to the Multi-strand Science Syllabus (Qld) Board of Secondary School Studies, Spring Hill, Brisbane.

ACKNOWLEDGEMENTS :

The author wishes to thank :
Allistair Martin (M.S.C. Tasmania); David Kopelke (B.I.F.S.C. Qld); Jim Redfield (C.S.I.R.O.); Roy Jenkins (F.U.S.E.); Dennis Bridger; Ann Kenny; Graham Mitchell; Greg Martin; Steve Hall (G.S.H.S.); Sue Oates; Meran Kilgour (B.S.H.S.); K. Enchelmair (F.V.F.S.C.); and the Departments of Harbours and Marine, Fisheries, Oceanography, Great Barrier Reef Marine Park Authority, The Courier Mail and The Brisbane Education Centre for all their help.

WHY STUDY THIS UNIT :

A. *SCIENCE FOR RECREATION*

One consequence of the rapid growth in the use of technology in our society is the increase of leisure time available. The demand for education in the sensible use of this leisure time provides a challenge to schools. Schools have the opportunity, indeed the responsibility, to provide a balanced curriculum which pays due attention to the development of potential recreational activities. The concept of this core topic is to encourage an appreciation of the role of science and scientific methods in recreational pursuits.

Survival Techniques

This topic is concerned with providing the student with skills associated with his well being in outdoor studies which may be extended to adult life. *Possible* areas of study include navigation (e.g. celestial, orienteering), first aid, bushcraft (e.g. locating food and water, finding protection from the elements).

B. *THE ATMOSPHERIC ENVIRONMENT*

Man lives on the surface of the earth on which he is dependent for food, clothing, shelter and movement. But he also lives at the bottom of an ocean of air. His survival is dependent on the existence of favourable conditions of temperature, pressure and chemical composition of this surrounding atmosphere. The state of the atmosphere is a major determinant of weather and hence influences our everyday existency. To understand, to appreciate and to survive in his immediate everyday environment, it is essential that man develops an understanding of the many factors, and their complex interrelationships, which influence the weather and the related atmospheric environment.

From the Multistrand Science Syllabus,
Board of Secondary School Studies (Qld).

SECTION 1 : CHARACTERISTICS OF THE COASTAL ZONE

PRACTICAL EXERCISES

1. Model Coastline
2. Examine Aerial Photographs of Local Area/Whole State

STUDY ASSIGNMENTS

1. Essay on the importance of our Coastline
2. Geological History

COASTAL GEOMORPHOLOGY

1. *OBJECTIVES*
2. *CHARACTERISTICS OF THE COASTAL ZONE*
3. *GEOLOGICAL HISTORY*
4. *TYPES OF SHORES* *(a) Exposed* *(b) Sheltered* *(c) Barrier Reef*
5. *SEDIMENTS*
6. *THE IMPORTANCE OF OUR COASTLINE*

DIRECTED TOPICS

1. Reading of Notes
2. Class discussion

AUDIO VISUAL

1. Charts of Local Coastline
2. Aerial photographs
3. Encounters with the Barrier Reef Slide Set. Part 2

   Evolution of the Reef

(Available from Great Barrier Reef Marine Park Authority)

OBJECTIVES :

CONTENT OBJECTIVES

You should be able to :

1. Recall the characteristics of the Coastal Zone nearest your school.

2. Recall other general features of the Coastal Zone.

3. Define Continental Shelf, Slope, Fringing Reef, Patch Reef, Ribbon Reef, Fossil Reef, Wave cut Platform.

PROCESS OBJECTIVES

You should be able to :

1. Identify features of the Coastal Zone from a local chart of your area (e.g. Townsville, Mackay, Schute, Gladstone Harbours - Moreton Bay, Hervey Bay).

2. Describe how the ice ages contributed to the formation of the Great Barrier Reef.

3. Distinguish between Fringing, Patch and Ribbon Reefs.

4. Distinguish between Coastal and Exposed Coastline and comment on differences in Coastal Landforms.

5. Describe the direction of sediment flow in an Estuary.

6. Discuss the importance of our Coastline and the need for it to be managed wisely.

DIRECTED TOPICS

This section serves to introduce the area to be navigated. Make sure that charts are available to identify the whole State Coastline and also local charts for students to relate to. *PLAN YOUR NAVIGATION EXCURSION NOW.*

AUDIO VISUAL

The Great Barrier Reef Marine Park Authority in association with the Townsville College of Advanced Education have produced a slide/audio/overhead/worksheet presentation called *"ENCOUNTERS WITH THE REEF"* Part 2 *"EVOLUTION OF THE REEF"* would fit in well here. Write to G.B.R.M.P.A. P.O. Box 1379, Townsville, Q. 4810.

SECTION 1 : CHARACTERISTICS OF THE COASTAL ZONE

1. *The Coastal Zone*

Estuaries are places where the fresh water of the land mixes with the salt water of the sea. They form part of the earth's feature called the *COASTAL ZONE*. This coastal zone is situated at the boundary of the two major environments of the earth - land and ocean.

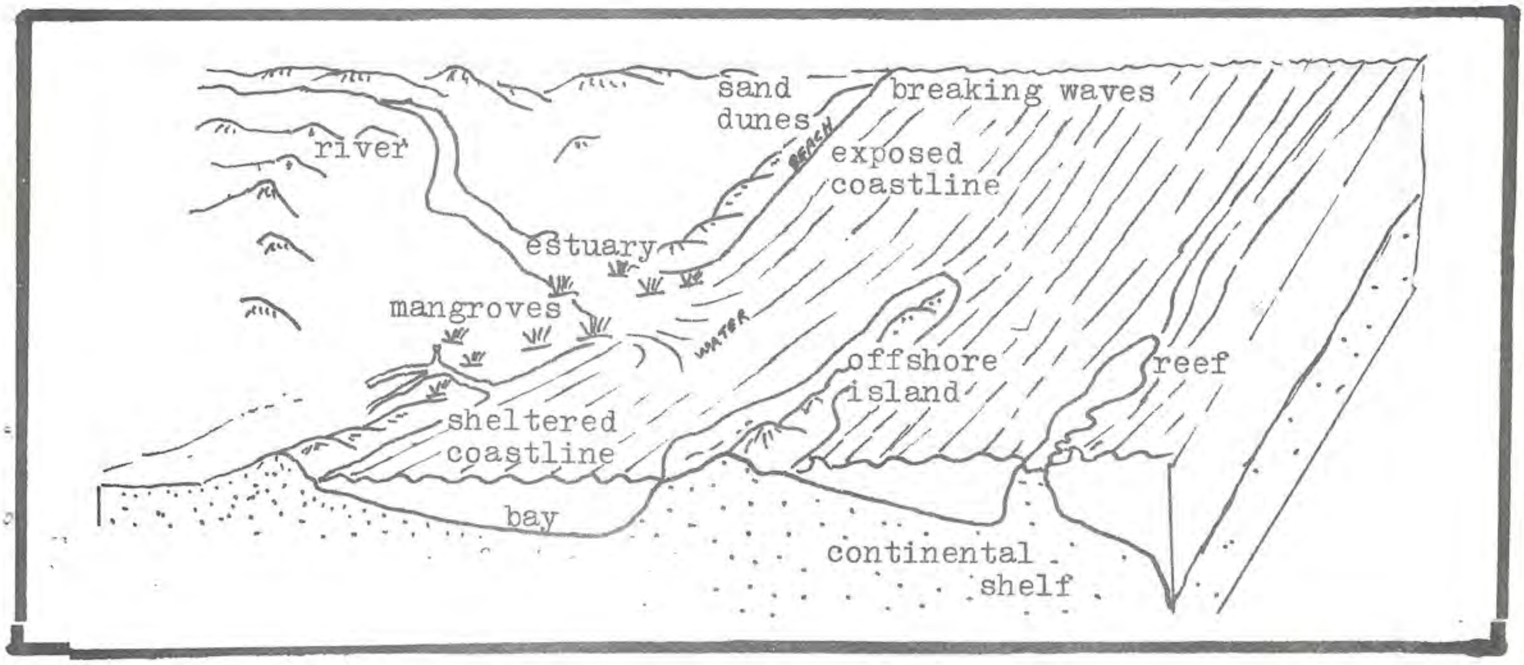


FIG 1 : Some common features of our coastline.

This zone is an area of numerous biological, chemical, physical, geological, and meterological interactions. The coastal zone may be defined as that part of the ocean affected by the land, and that part of the land affected by the ocean. The boundary of the two environments is the shoreline, which is constantly changing. In the seaward direction part, if not all, of the continental shelf (including the Great Barrier Reef) may be included within the coastal zone. In the landward direction, estuaries, mangroves, seacliffs, the coastal plains, and other similar environment, may be included.

There is much argument about definitions of coastal zone features. Some definitions are shown in Fig. 1-2. A shore zone and shore line can also be defined within the coastal zone; the shore zone covers the area where water and land come into contact, and includes the beach and surf zone. The shore line marks the point where land and water meet; the near shore region is that area seaward of the shore line. Most shore line features are temporary since their position is affected by the height of the sea level which is, in turn, influenced by tides, direction of wind, and strength and height of breaking waves. The shore line is constantly changing and may extend over a large area in a very short time.

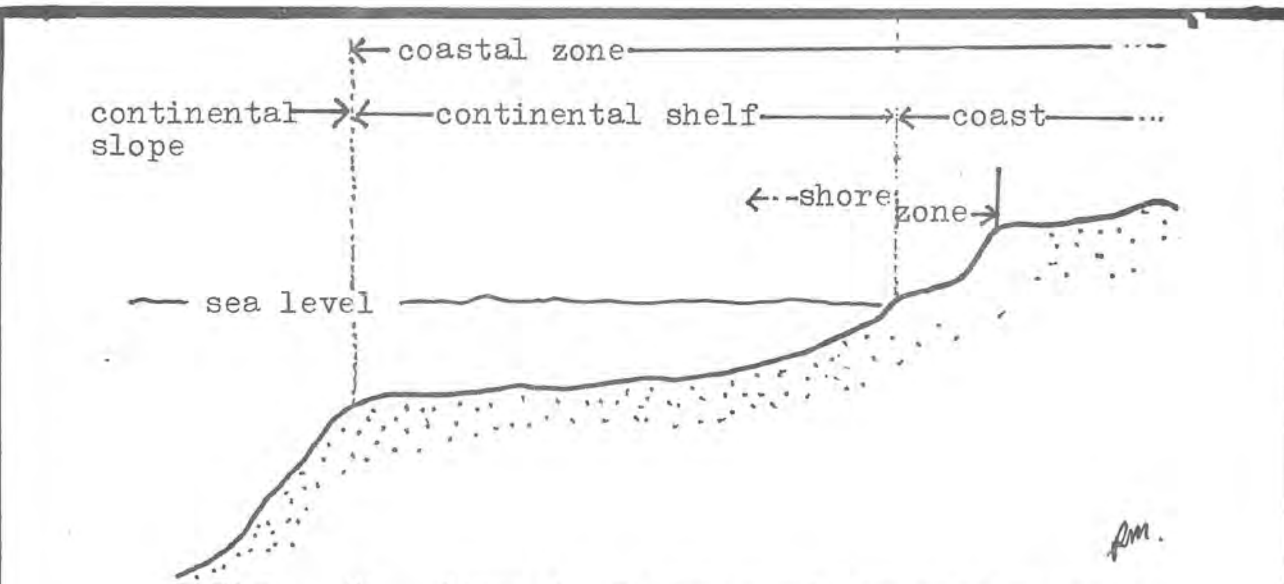


Fig. 2: General features of the coastal zone.

1.2 *Geological History*

In the geological past, the sea has often covered part of Australia. For example, about 500 million years ago, the sea covered the area shown in Fig. 3

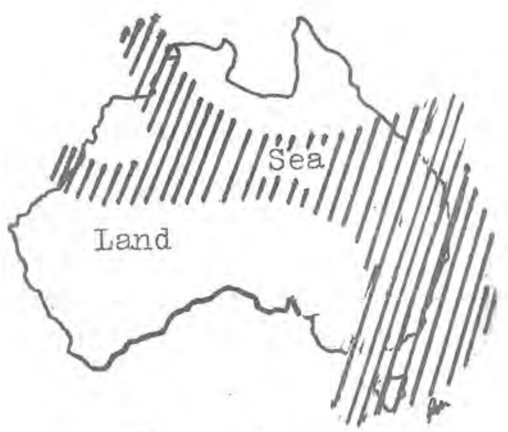
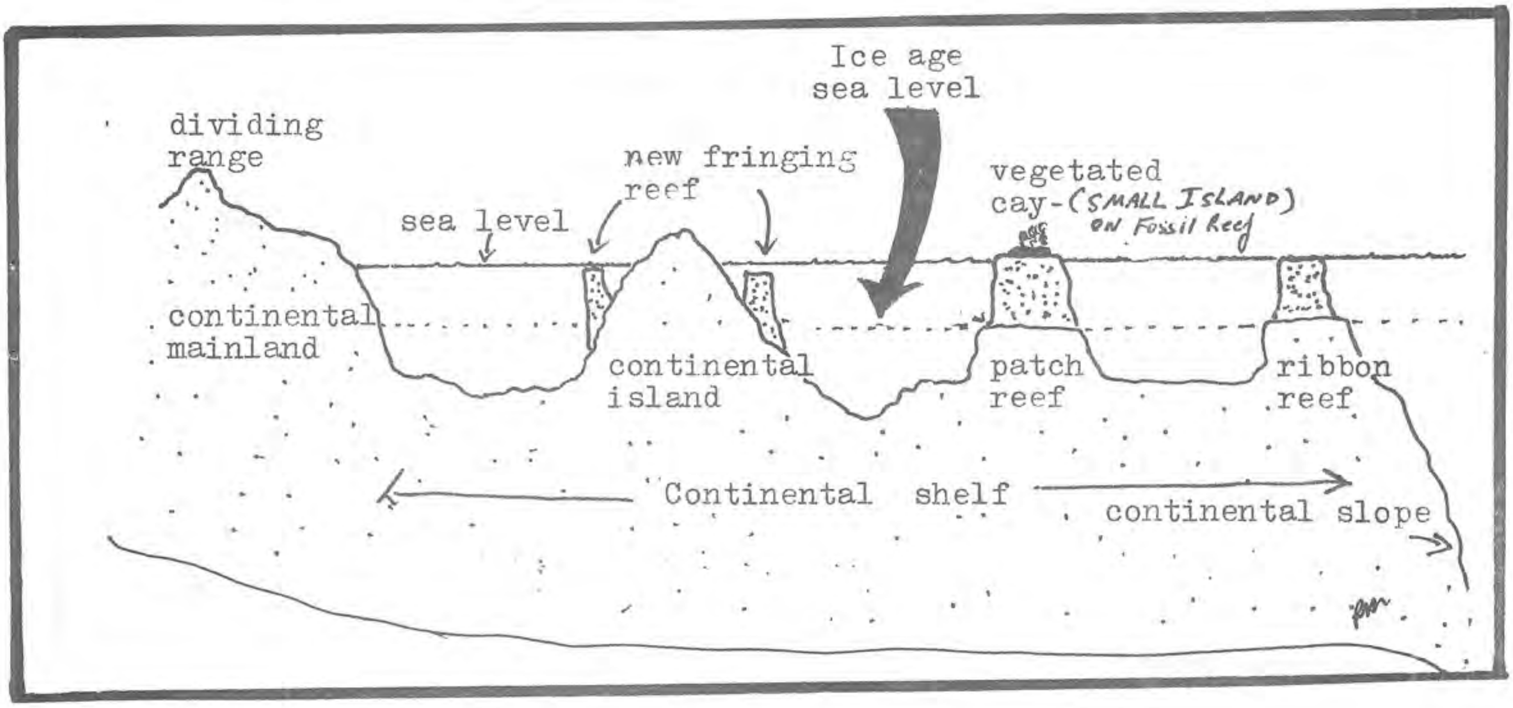


Fig. 3:
500 million years ago

During the ice ages, the sea level fell due to the ocean waters being trapped in the ice. The coastal zone of Australia was then on the edge of the continental shelf. The continental shelf was then exposed to the air. New river valleys formed and the surf broke almost 200 miles further out to sea than it does today. (see Fig: 4)

Fig 4:
20 million years ago (ice age)

The foundations for the Great Barrier Reef were first made available for reef growth about 20 million years ago when the continental shelf was first formed and subsided below sea level. Two million years later the first corals began to grow forming coral reefs which grew steadily upwards until they reached their present height about 150,000 years ago.



An ice age began then, lowering the sea level until it reached its lowest point (130m below present sea level) about 18 - 20,000 years ago. The ice melted over a period of 10 - 12,000 years reaching present sea level about 6 - 8,000 years ago.

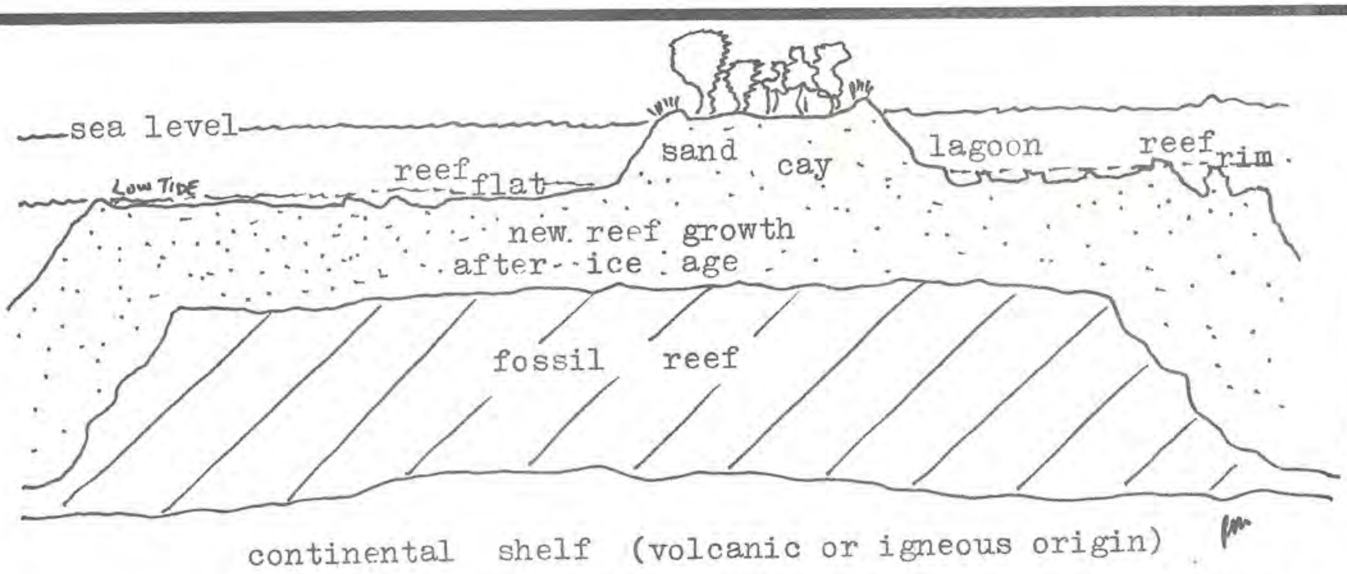


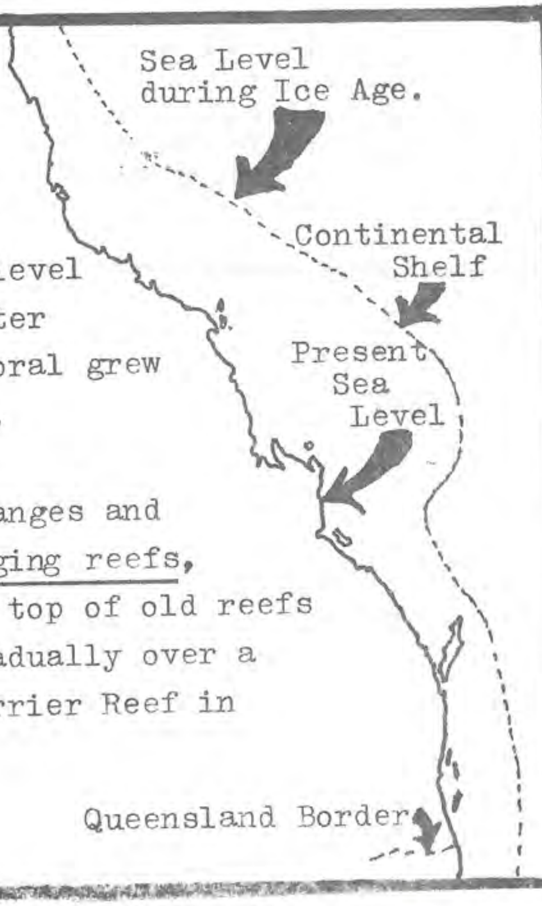
Fig. 6: Diagramatic Reef Profile (after Zell, 1980)

The new submergence of these old fossil reefs allowed new coral growth which is the reefs we see today. Veneers of new growth reach 15m in thickness overlying the old reefs.

The Continental Shelf gradually filled with water as the ice melted.

The warmer waters allowed the tiny coral polyps to grow. As the water level rose gradually with more and more water being freed from the ice caps, the coral grew upwards keeping with the water level.

Reefs grew around old mountain ranges and continental islands formed with fringing reefs, (see figure 1-5). New reefs grew on top of old reefs to form ribbon and patch reefs. Gradually over a period 20 million years the Great Barrier Reef in Queensland formed.



1.3 Types of Shores .

There are 3 main types : * *Sheltered (Estuarine)*
* *Exposed*
* *Reef*

Off the Queensland coast are many drowned river valleys. Moreton Bay, off Brisbane, is another good example. These estuaries have offshore islands which protect the mainland. Other rivers that enter the sea are not so protected. The Tweed River, for example, on the border of Queensland and New South Wales, is completely exposed and rock walls have had to be built in order to allow boats to enter and leave the river.

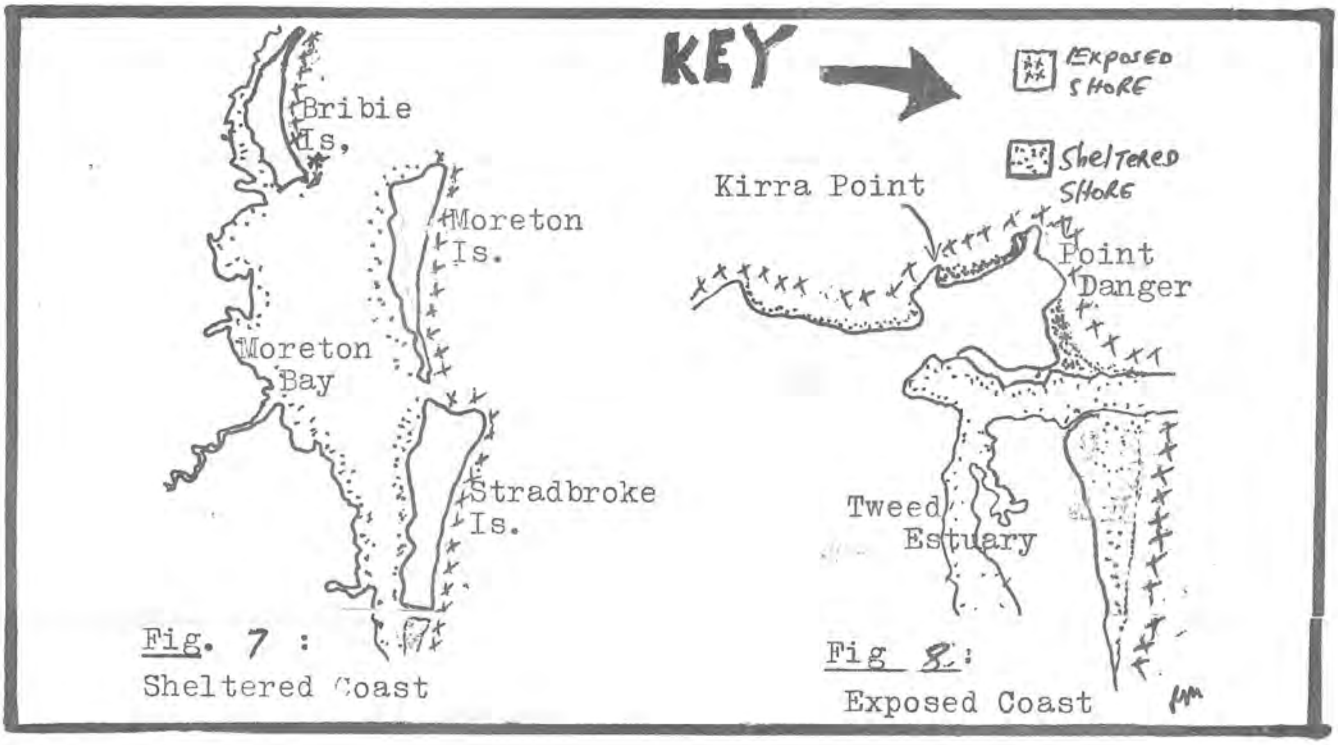


Fig. 7 : Sheltered Coast

Fig 8 : Exposed Coast

Some shore lines jut out into the ocean in a zig-zag fashion. These are called headlands. Other shores push inward to form bays. When waves strike directly against a rocky shore line, the *"bite"* and shape the land. As a result of this action, a wave-cut cliff may form. Erosion causes the rocks at the base of the cliff to break away. The rocks then accumulate near the base of the cliff causing a wave-cut platform.

Over the years, these platforms may get very large and extend many metres into the sea. A shore line that has many of these sea cliffs is called an *EMERGENT SHORELINE*. When the sea level fell during the Ice ages these were exposed. New rivers cut valleys in these, and when the water levels rose they were filled with water. Many coastal features are drowned river valleys - The Capricorn Channel is an example of this for you can actually see this on Chart AUS.819 : Bustard Head to North Reef.

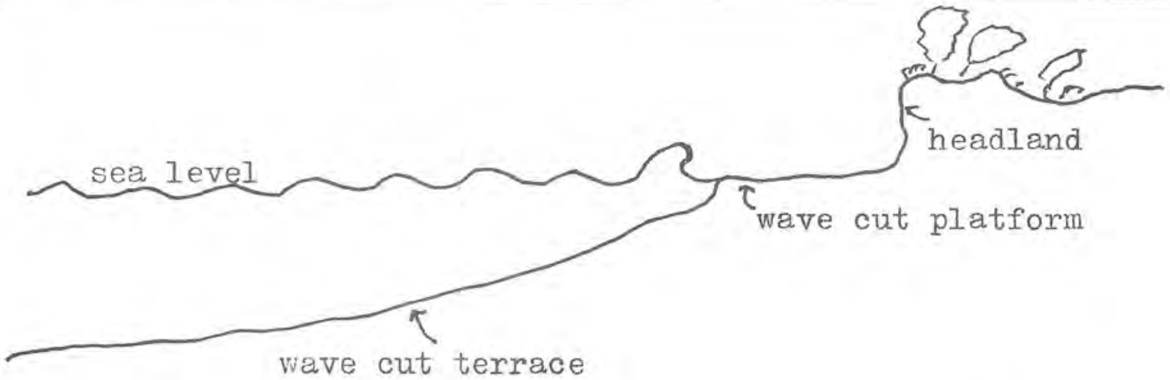


Fig. 9- : Wave cut coastline. General View.

A third type of coastline occurs in Queensland. In between the ice ages, tine animals called coral polyps, master-minded one of the world's greatest wonders, viz. the Great Barrier Reef. Some reefs formed before the ice ages, but when the ice melted and the sea levels rose, the warm shallow waters formed ideal places for coral communities. The new corals grew over the old reefs like the icing on a cake. Three types of coastal reefs can occur.

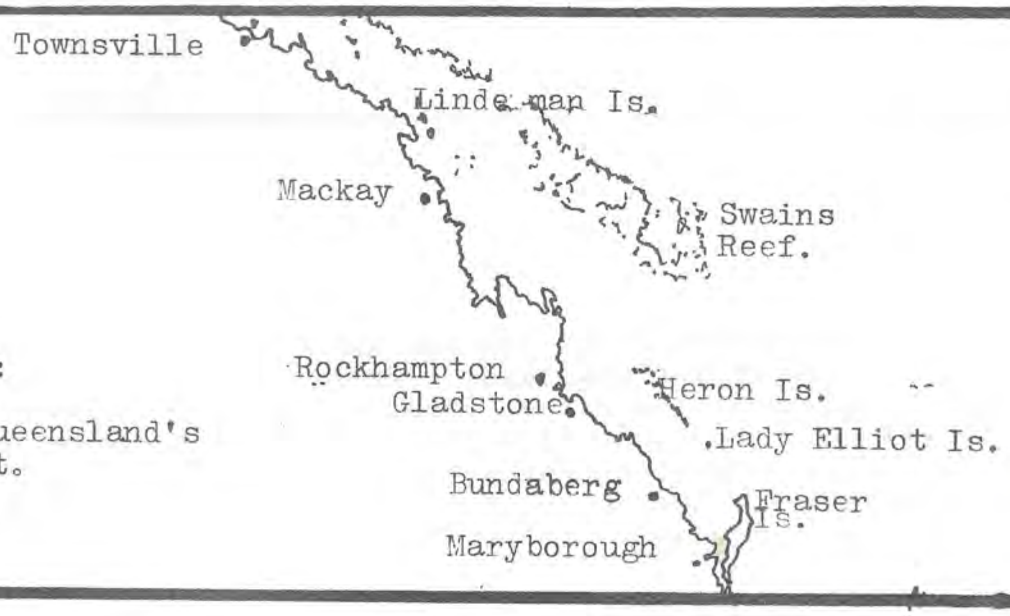


Fig. -10:

Part of Queensland's Reef Coast.

1.4 Sediments

Sediments consist mostly of grains of various size made from a variety of rocks. The coastal zone may get sediment from a number of sources.

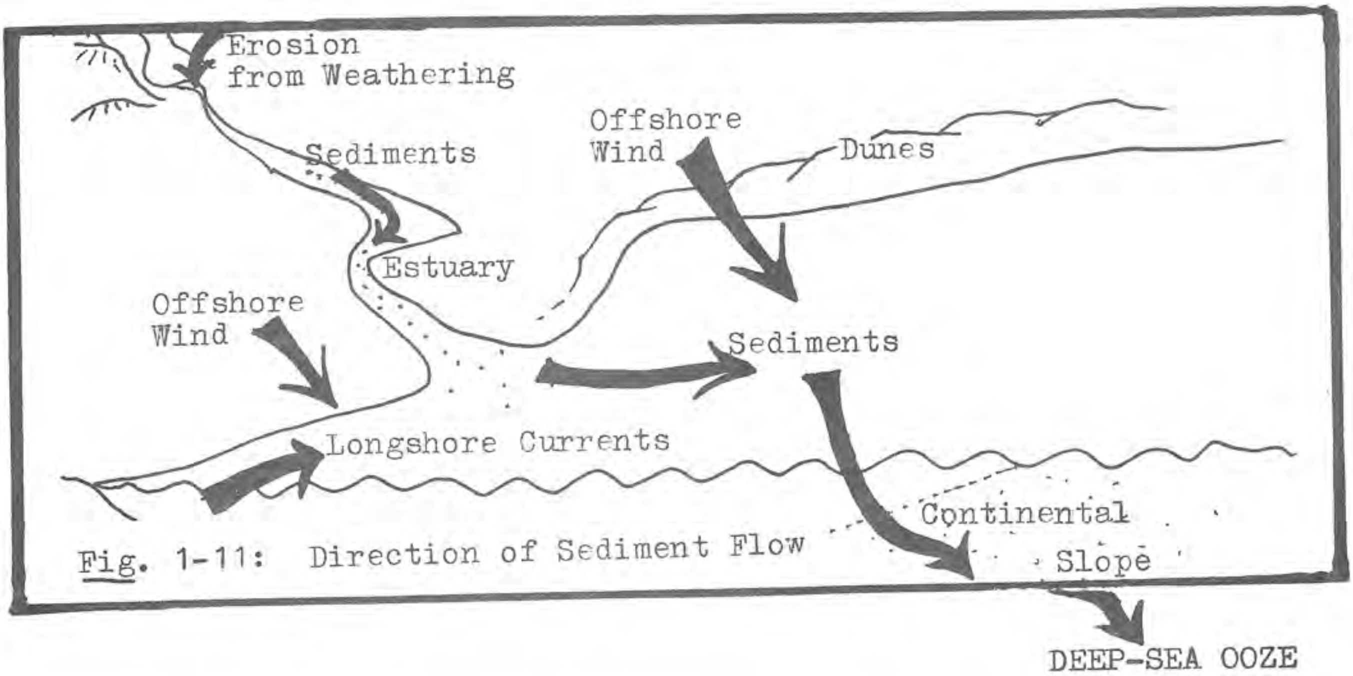


Fig. 1-11: Direction of Sediment Flow

Winds blowing sand and soil from the land, longshore currents causing beach erosion, and rivers, all contribute to sediments being deposited on the continental shelf.

Sediments are important because they can silt up coastal waterways or change the composition of prawning grounds.

WHERE DO SEDIMENTS COME FROM?

Place Found	Type	Origin	Approximate Thickness
Continental shelf	Sands, muds, pebbles	From land	12,000 feet
Shallow abyss	Lime	Skeletons of animals and plants	1,200 feet
Deep abyss	Red clay	Dust, volcanic dust, meteorite dust	300 to 600 feet

Data Table of Deep Sea Ooze indicating where sediments have come from.

1.5 *The Importance of the Queensland Coastline*

The economic importance of its coastline to Queensland is immense.

1. *The Tourist Industry* is worth millions of dollars annually in areas such as the Gold and Sunshine Coasts and the Barrier Reef resorts.
2. *The Fishing Industry* is a large employer and supplies us with a wide variety of fish products.
3. *The Sand Mining Industry*
4. *85% of all* Queenslanders live on the coastal strip, which serves as a major recreational area for their large population.
5. *The Transport Industry* uses its waterways for import and export of goods.
6. *The Armed Forces* need to protect it as it is the first vulnerable point
7. *As an Educational Area* its Resources are just being tapped.

Because such a vast majority of interests are staked in our coastline, management of this valuable resource is vital. Governments have set up groups of specially trained people to make sure that our coasts are not polluted or destroyed. Some of these authorities are listed in the Table below.

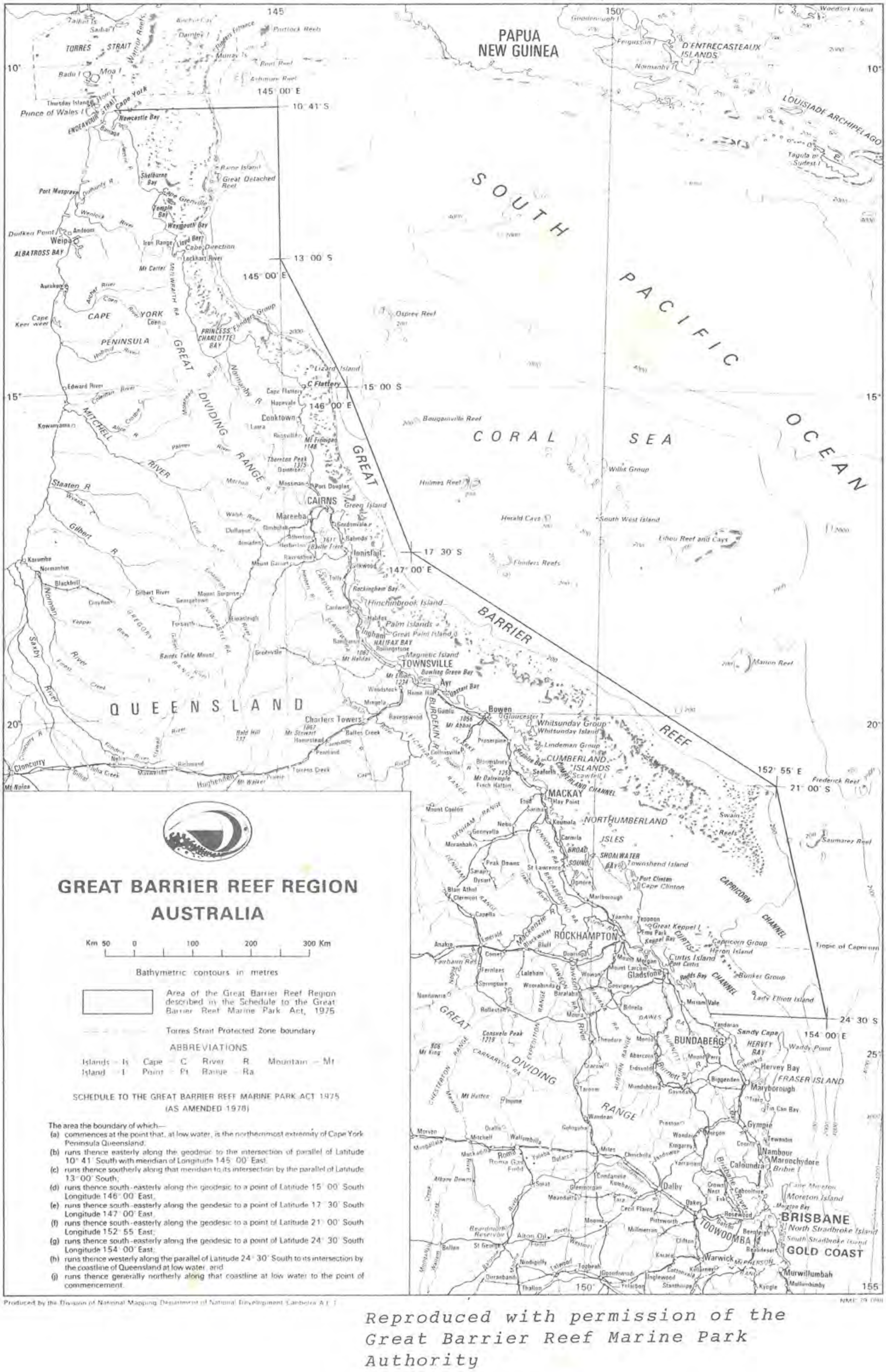
TABLE 1 : SOME MANAGEMENT AUTHORITIES OF OUR COAST

AUTHORITY	AREA OF COAST MANAGED
Great Barrier Reef Marine Park Authority	The Great Barrier Reef
National Parks and Wildlife Service	The National Parks of our Coastline (as well as others)
The Beach Protection Authority	Our beaches
Department of Harbours and Marine	Waterways and general Coastlines
The Waterways Authority	Estuarine Development

From time to time the Great Barrier Reef Marine Park Authority will insert notices in the Newspapers

Eg: *(a) Seasonal closure areas*
(b) Declaration of new areas of park

A possible project might be to cut these out for a scrapbook.



Produced by the Division of National Mapping Department of National Development Canberra A.C.T.

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MAIN IDEAS

1. Our coastal zone can be divided into The Continental Shelf, Shore Zone, Coast and Coastal Plain.
2. Australia's coastline varied over the earth's geological history due to the Ice ages.
3. Three types of shore exists in Queensland. *EXPOSED, ESTUARINE, AND REEF.*
4. Estuaries are very valuable to our economy and are managed by Government authorities.

REVIEW QUESTIONS

1. What is the Continental Shelf, and how does it differ from the Continental Slope?
2. How can we explain the formation of sea cliffs?
3. How are estuaries formed?
4. What is a longshore current, and what affect does it have on sediments?
5. What is beach *EROSION*, and list some of the ways it is controlled.
6. Why do estuaries have to be dredged?
7. Why is it necessary to manage our beaches?
8. What roles do each of the following people play in the study of a shore?

   An ENGINEER, a MARINE BIOLOGIST, a NAVIGATOR, a GEOLOGIST, a GEOGRAPHER?

ASSIGNMENTS

1. Write to one of the Authorities mentioned in this Chapter and ask about the role that particular authority plays in managing our coastline.
2. Find a Geological Time Scale chart in the library and copy it out. Try to figure out where the water levels were on Queensland's coastline over the past 500 million years.
3. Obtain a chart of your local coastline and make a rough copy of the shore outline. Now identify the main features as listed in figure 1-1 Page 1.

SECTION 2 : COASTAL NAVIGATION

PRACTICAL EXERCISES

1. Charting your classroom
2. Hypothetical Bay
3. Laying off a Course
4. Bathymetric Profiles

STUDY ASSIGNMENTS

1. Famous Australian Navigators
2. Plimpsoll Line
3. Types of Ships Hulls

SCIENCE FOR RECREATION

1. *OBJECTIVES*
2. *WHERE ESTUARIES ARE FOUND*
3. *CHARTS AND NAVIGATION*
4. *LATITUDE AND LONGTITUDE*
5. *THE NAUTICAL MILE*
6. *THE COMPASS ROSE*
7. *LAYING OFF A COURSE*
8. *SOUNDINGS*
9. *BATHYMETRIC PROFILES*
10. *THE CONTINENTAL SHELF*

DIRECTED TOPICS

1. Class discussions
2. Practical exercises
3. Plan navigation excursion

AUDIO VISUAL

1. Local Admiralty Chart
2. Local Harbours and Marine Charts
3. Harbours and Marine Pamphlets, Films - Nautical Norm

OBJECTIVES :

CONTENT OBJECTIVES

Define Estuary, Longitude, Latitude, Compass Rose, Geographical North, Magnetic North, Sounding, Laying Off, Bathymetric Profile, Bouy, Beacon, Marker, Bouyage System, Port, Starboard, Bow, Stern. Nautical mile, safety rules for mariners.

PROCESS OBJECTIVES

You should be able to :

1. Distinguish between a map and a chart.
2. Draw a chart of a classroom using a compass.
3. Interpret that chart so as to fix a position in the classroom.
4. Distinguish between features on a chart.
5. Locate positions on a chart.
6. Calculate distance, on a chart from a scale and from longitude.
7. Use set squares or parallel rules to read bearings from a chart.
8. Calculate simple distance time speed problems from a chart.
9. Calculate magnetic error for a given year.
10. Lay off a course along a given distance of coastline indicating where relevant corrections need to be made for a safe trip.
11. Distinguish between the cardinal and lateral system of bouyage so that you know how to enter or leave a harbour on the coast.

SKILL OBJECTIVES

You should be able to :

1. Walk a pair of set squares, to and from a compass rose.
2. Use a set of parelle rules.
3. Use a hand bearing compass to read a bearing to 2° accuracy.
4. Use dividers to locate and measure distance.
5. Perform 1 - 4 at sea.
6. Steer a compass course reasonably accurately in up to 10 knott winds.
7. Recognise land and sea conspicuous marks with binoculas.
8. Direct a ships master to pass harbour navigational markers on the correct side. (Both systems of bouyage).
9. Read a echo sounder, a ships log, and identify other safety and navigational equipment.

AFFECTIVE OBJECTIVES

You should :

1. Develop a respect for the sea.
2. Realize that more effort is required to live and work at sea than land.
3. Develop a tolerance for those individuals who cannot work as fast as you at sea.

SECTION 2 : COASTAL NAVIGATION

2.1 *Where Estuaries are found*

An estuary can be many things to many people. To the fisherman it could be an abundant fishing ground; to the small boat operator a place for a great day out; to industry a dumping place for chemicals and sewage; or to the land developer a place to make canals and a fortune in real estate. At high tide, an estuary can be a place of beauty with its beach to walk along with waves gently lapping against the shore. At low tide when the water goes out and the mudflat are exposed, the estuary may look like a garbage heap decorated with tin cans, broken glass, and old tyres protruding from the mud.

An estuary is any place where the fresh water of the river and the salt water of the ocean mix together.

To find our way around estuaries we need to know something about inshore navigation. Also, when sampling data or collecting is done, it is necessary to record the location where the data was collected.

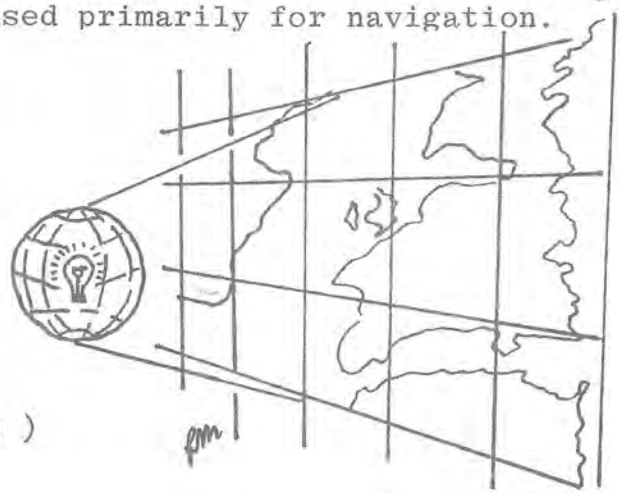
2.2 *Charts and Navigation*

The word navigate is taken from Latin *"navigere"* meaning navis (ship) agere (move or to direct). Marine navigation may be defined as "process of directing the movement of a craft from one point to another on or in a body of water". According to our best estimates man has been navigating the ocean for at least 6000 years - some say perhaps 8000 years or more. Most impressive were the Polynesians, who traversed thousands of miles of open ocean in the Pacific using charts of reeds as early as 1500 B.C.

Among the most important instruments developed to aid navigation of the sea are the compass, chronometer and the sextant. Date and origin of the magnetic compass are unknown. It is one of the oldest instruments and it is thought that the compass originated in China with the discovery of the naturally occurring magnetic material lodestone. The chronometer, an extremely accurate clock is used to determine longitude. Remember, if the earth is viewed from the pole, it rotates through 15° each hour ($24 \times 15 = 360^\circ$). Then each 15° of east or west travel on earth represents one hour's difference, (Refer to Time Zones such as Eastern, Central and Pacific). The sextant was invented about the 17th or 18th century. This instrument enables a mariner to determine location at sea with excellent accuracy. The electronic age has added radar, loran and sounding equipment (sonar).

A *map* is a representation of the earth's surface on a plane surface - a *chart* is a map used primarily for navigation.

Fig. 2-1:
The principle of chart making could be thought of by the image that would form on a wall from a bulb shining inside a globe. (after Togill, 1979)



A chart is a curved section of the earth's surface reproduced on a flat piece of paper. Since there are obvious difficulties in making a curved surface flat - try flattening half a tennis ball without splitting it - it follows that a number of problems arise in making a chart. There must be some form of distortion somewhere and yet if a chart is to be of any use for navigation, it must have a high degree of accuracy.

In the case of Mercator charts, the charts most commonly used for ships of all kinds, the major distortion is kept to the extremities of the world - near the poles - and since few ships navigate in these areas the problem is not a severe one. In the more temperate and tropical zones, where most navigation is carried out, the distortion is relatively slight, and at the equator it hardly exists.

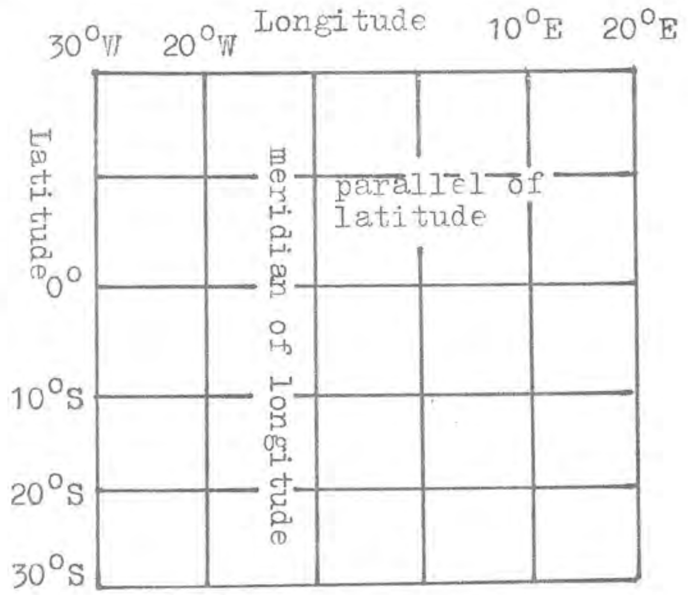
The Mercator projection system by which naval charts are made is best understood by imagining the world as a plastic globe with a light in the centre and a flat wall adjacent to one side. When the light is switched on, the contours of the land massess will be thrown onto the wall in the form of a flat plan. At the equator there will be little distortion, but towards the ceiling the projected contours will be elongated and considerable distortion will occur.

Because only a very small part of the earth's surface is reproduced on most charts, the distortion is reduced considerably and in fact is hardly noticeable except when using charts of higher latitudes. For this reason straight lines can mostly be used as courses between two points. Although in fact the ship steering along this straight line will follow a curved course across the face of the earth, the distortion is so small as to be of little consequence other than when long ocean passages are undertaken, or the passages are in high latitudes.

The great advantage in the Mercator system of constructing charts is that everything is neat and *"squared off"*. The meridians of longitude run north/south squarely from top to bottom and the parallels of latitude run squarely east/west from side to side. This makes life very easy for the navigator who can use straight lines for all his plotting instead of complex curves.

Fig 2-2:

On Mercator Charts Longitude and Latitude are drawn to square.



A nautical chart intended primarily for marine navigation shows land outline, prominent land features (natural and man-made), depth of water, channels, navigation markers and a Compass Rose.

Investigation 1

CHARTING YOUR CLASSROOM

You will need

A room plan (make one up before you start)

A Student Kent Set OR a protractor and 2 set squares 95mm x 95mm

Plotting Compass (orienteering type)

TAKE CARE

(1) Metal affects a Compass so try to keep your compass as far away from Metal as possible.

(2) Always sit the same way in the room.

What to do

PART A. The Compass Rose (*ALTERNATIVE : Cut the Compass Rose at the back of these notes and line it up with your Compass).*

1. Place the compass in the bottom half of the room plan and mark *NORTH*. Draw a line about 10cm long and mark it so as to point *NORTH* (N, 0°). (or place the protractor over the Compass).

2. Place the protractor on this line so that the 0° matches up, and draw a half circle around to the 180 , and call these *NORTH* and *SOUTH*.

3. Now reverse the protractor and complete the semi-circle, carefully marking in the 90°E. and 270°W.

4. Join up *EAST* and *WEST* and put a small circle in the middle of the circle. This will be your *Compass Rose*.

5. Now carefully mark off each 10 so that you have a circle marked in 10 . Your teacher will have a Nautical Chart of the area on display. Check this to see how a Compass Rose is drawn. (or look at the back of these Notes).

PART B. Taking bearings

1. Take the compass and line up a corner in the room to the *EAST* of you. Take a bearing on this position. (Your teacher will show you how to use the Compass).

2. Record the bearing as *"from desk to east corner"*.

3. Now take new bearings from 2 other corners.

PART C. Finding your Position

1. Start with your first bearing, your teacher will show you how to walk your squares.

2. Place one of the squares so that the hypotenuse goes from the centre of the compass rose to the equivalent number of degrees you took. Mark this bearing 1 and draw a line between the two.

3. Place the base of the other square on the corresponding base of the first square and walk the squares so that some points on the hypotenuse end up on a corner of the room that you took your bearing on.

4. When the hypotenuse passes directly over this point, draw a line. Write the words Bearing 1 on this line. (This line must be parallel with the line you frew in the Compass Rose).

5. Now repeat the procedure for your second bearing. Call your second line bearing line 2.

6. Now draw bearing line 3 use by walking your squares.

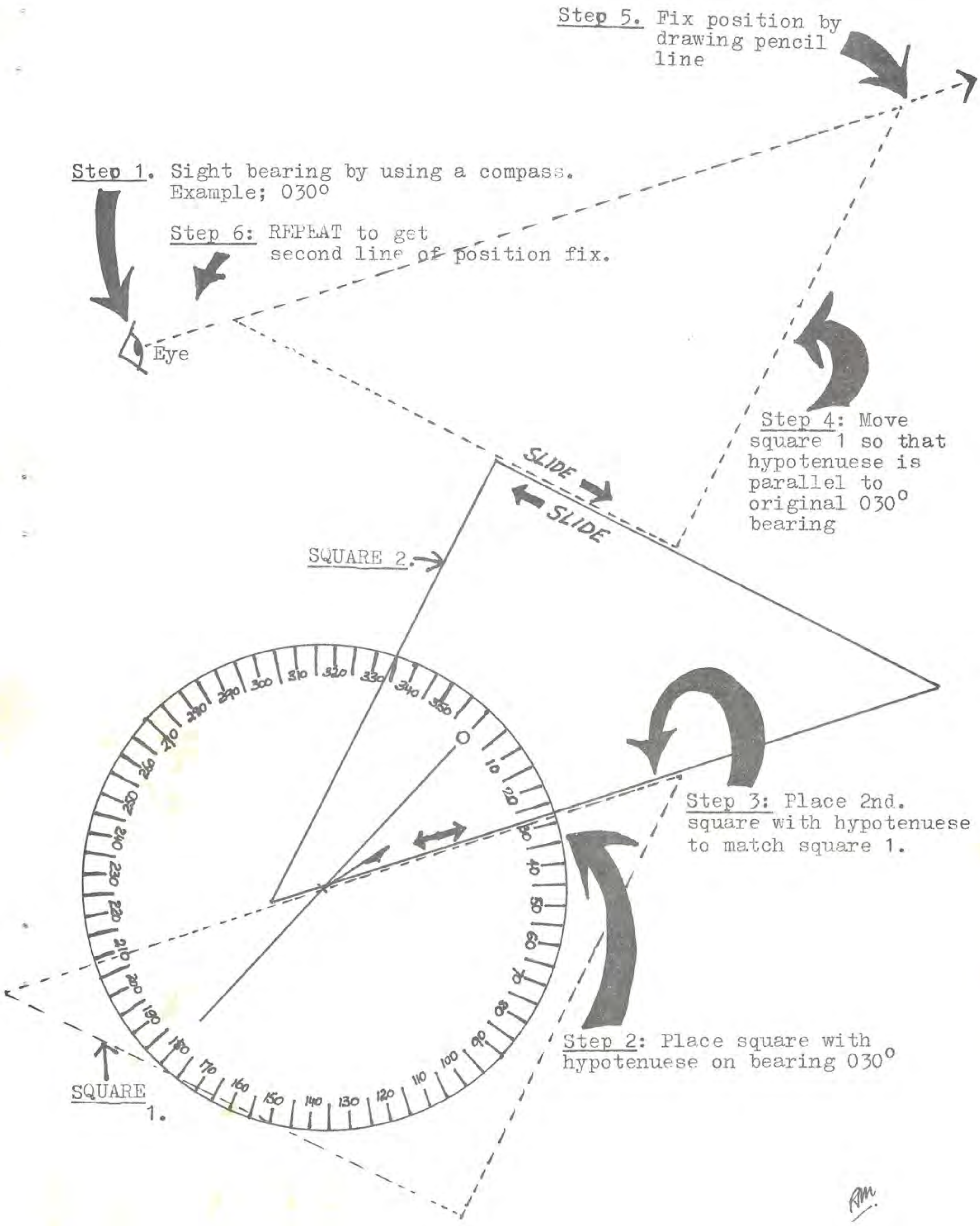
7. Shade in the little triangle that forms from the intersection of these 3 lines. Congratulations, you have fixed your position.

8. Now move to another position and fix your position again.

RULE OF SQUARES : BASE TO BASE; SIDE TO SIDE;
HYPOTENUSE TO HYPOTENUSE.

Walking The Squares

Fig. 2-3: By using two set squares, a compass bearing can be transferred to a chart to fix a position.



Analysing your Results - Questions :

1. What do you notice about the bearing lines drawn on your Compass Rose and your position Fix?
2. How big is your shaded triangle?
3. How good are you at taking a bearing if this triangle is - *LARGE, SMALL.*

Investigation 2-1 introduced you to the basis of navigation.

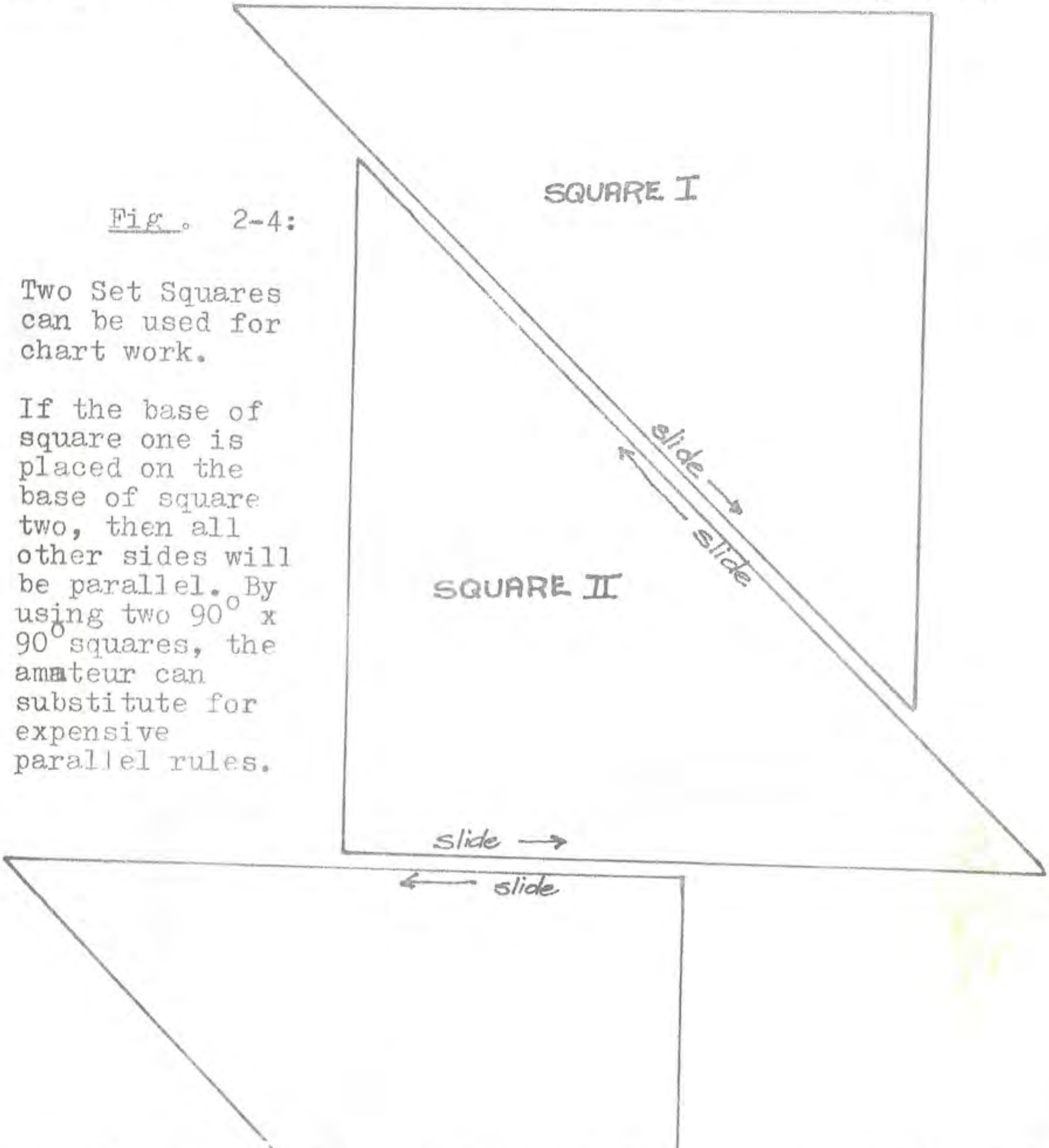


Fig. 2-4:

Two Set Squares can be used for chart work.

If the base of square one is placed on the base of square two, then all other sides will be parallel. By using two 90° x 90° squares, the amateur can substitute for expensive parallel rules.

Small set square can be used to plot positions if the Rule of Side is applied :

1. Use the hypotenuse to read from Rose to Bearing, or Vice Versa.
2. When moving about, always use corresponding sides.

If you have troubles, write the words BASE, SIDE, AND HYOPTENUSE on the SQUARES.

2.3 *Latitude and Longitude*

In order to create a measurement scale for navigational purposes, the world is divided into a grid of latitude and longitude. Because each is in the form of a circle, the scale of latitude and longitude is in degrees and minutes of an arc (1^{o} = 60 minutes).

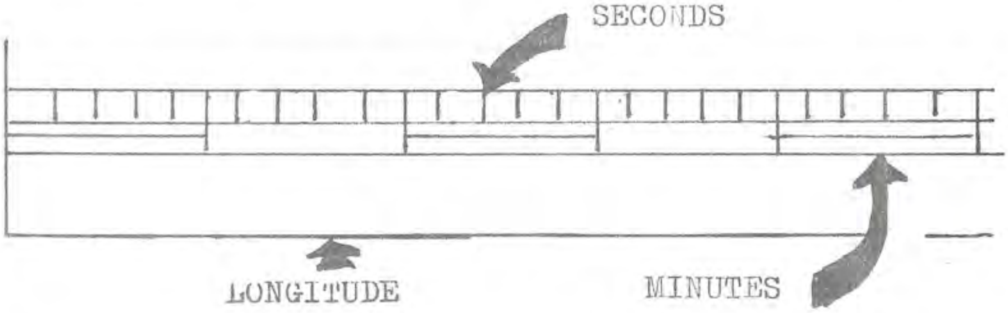
LATITUDE is the measurement scale which begins at the equator (0^{o}) and runs *NORTH* and *SOUTH* (90^{o} S. or N.).

LONGITUDE begins at the Greenwich Meridian (180^{o} *WEST* or *EAST*).

THE GREENWICH MERIDIAN is the traditional starting place of all longitudinal measurements and is so named because it is the meridian of longitude that runs *NORTH* and *SOUTH* through GREENWICH in London.

On a chart, the LATITUDE scale is marked in degrees and minutes on either side, while the LONGITUDE scale is similarly marked on the top and bottom of the chart.

Fig: 2-5.
The top and bottom of the chart shows
LONGITUDE



2.4 *The Nautical Mile*

Because the earth's surface is divided up in degrees and minutes, normal kilometres and metres are not used. The scale of measurement is a *nautical mile*, which is represented by one minute of **LATITUDE**.
Thus few charts carry separate distance scales, the scale on the left or right side of the chart being used to measure nautical miles in any direction, ACROSS, AS WELL AS UP AND DOWN the chart.

Distance is measured by dividers. The spread of the divider's points are used to carry the measurement to the Latitude scale, where it can be read off in minutes.

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1 Nautical Mile = 1 Minute of LATITUDE

Because of variations due to the Chart's distortation, distance readings should be taken from the LATITUDE scale at a point roughly level with the boat's position.

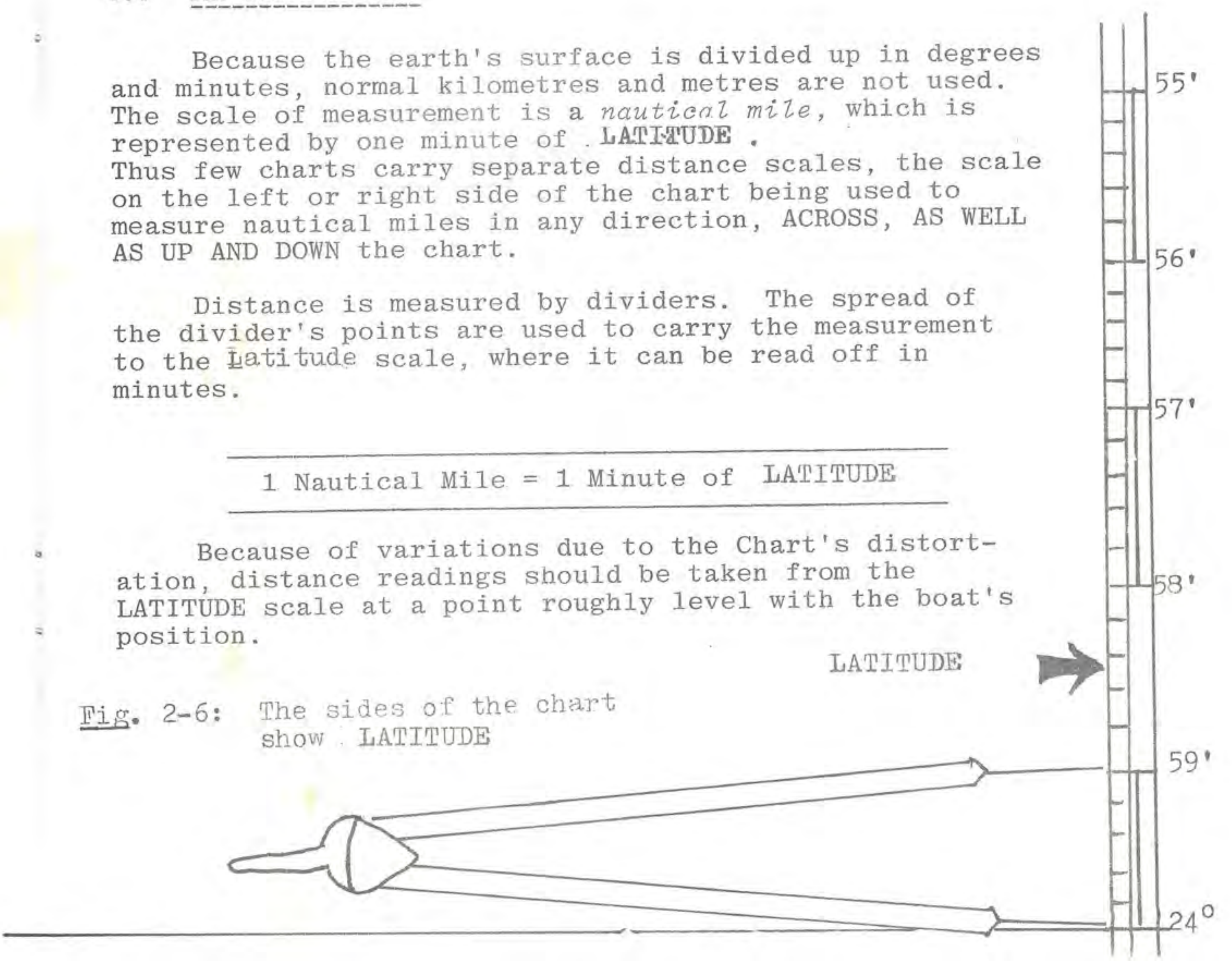


Fig. 2-6: The sides of the chart show LATITUDE

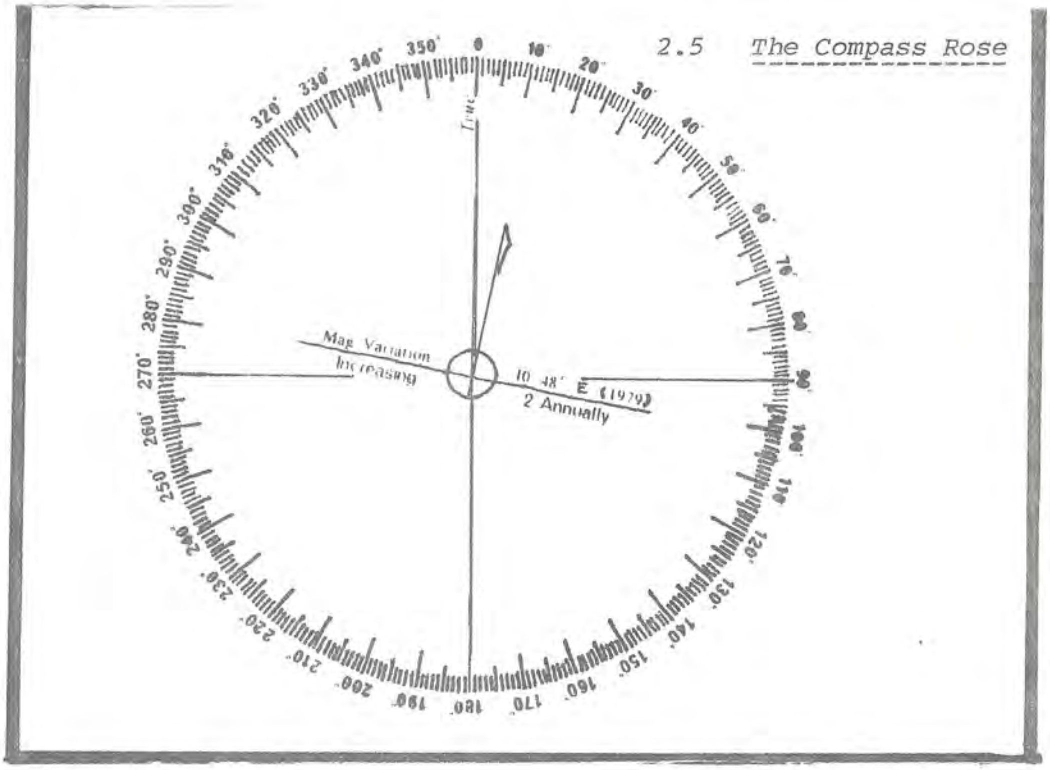


Fig. 2-7: The Compass Rose showing the Magnetic Variation.

Now we will look at a simulated chart. We call it Hypothetical Bay. This bay is a large estuary with a point where surf breaks. Turtle Island is located off a breakwater for trawlers to enter and leave. HYPOTHETICAL BAY is LOCATED APPROX 24°S ; 152°E.

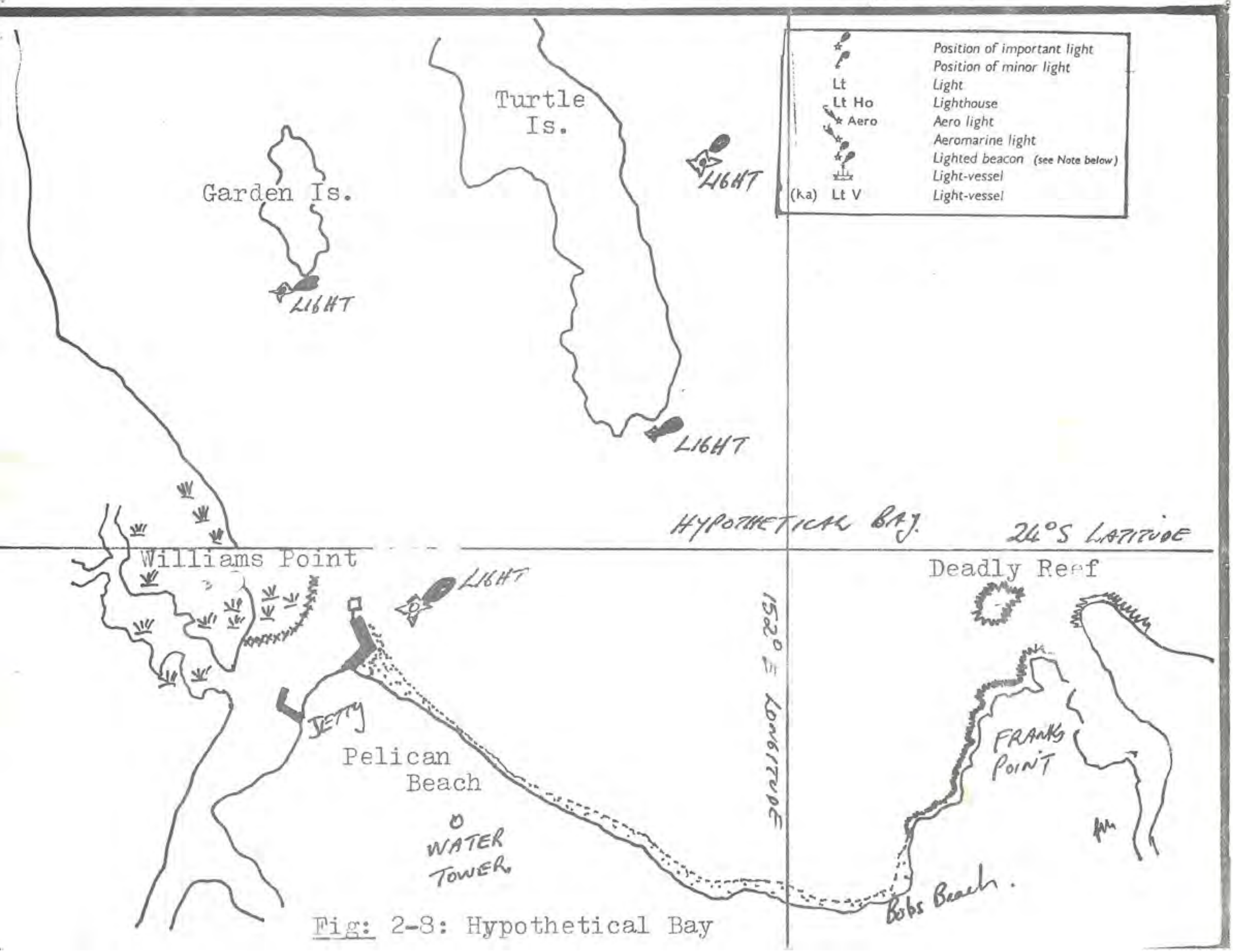
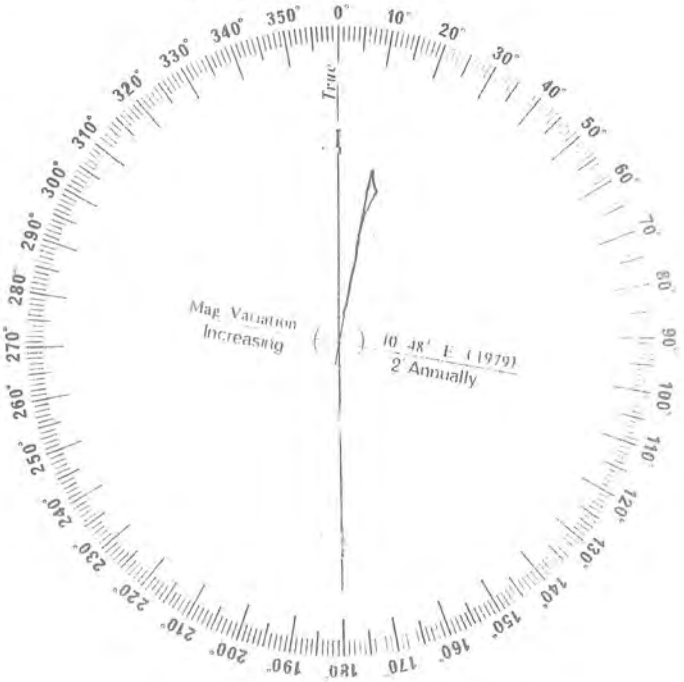


Fig: 2-8: Hypothetical Bay

2.6 Geographical (true) North and Magnetic North



The geographic and magnetic north poles occur in different positions, i.e. a compass needle points to the magnetic North Pole, and not to the true North Pole. The difference is called *VARIATION*.

Look at the Compass Rose. ⇨ What is the value of the variation at Hypothetical Bay for this year?

So, in 1980 Mg Var = $10^{\circ}48'$ East or about 11°

Variation is the most important compass error with which a helmsman must cope. That means that a navigator cannot lay off (work out) a course straight from a chart, but must make allowance for the variation. To allow for this error we must remember the jingle

> "*ERROR EAST, COMPASS LEAST*
> *ERROR WEST, COMPASS BEST*"

For example :

The true bearing from Williams Point Light to Turtle Island Light is 50°. By our Compass Rose our variation is 11° East. The error is *EAST*, so we *SUBSTRACT*. So by compass the bearing is $50^{\circ} - 11^{\circ}$, OR 39°. Therefore, if we wanted to travel from Williams Point to Turtle Island in the fog, we would follow a compass course, or travel almost Northeast by compass.

Calculate the compass course from North Head Light to Deadly Reef Light and from Garden Island Light to Queensland River Light.

DATA TABLE

True Course	Error	Compass Course

Investigation 2 : Hypothetical Bay NOTE : SPEED = $\frac{distance}{time}$

You will need

* Hypothetical Bay Worksheet *(Copies can be made from page 26)*

What to do

(a) List five features shown on the Hypothetical Bay chart which do not occur on a map.
(b) What is the latitude and longitude of the following : North Reef Light; Potts Point Jetty; Garden Island Light; Big Head Light; Queensland River Light; South Head Light; North Head Light.

PART B : DISTANCE WORK :

What is the shortest distance between the following Points : Turtle Island Light and North Reef; Big Head and Queensland River Light; Garden Island Light and The Clubhouse on Bobs Beach; Turtle Island Light and Potts Point Jetty; Garden Island Light and Turtle Island Light.

PART C : SPEED DISTANCE WORK : NOTE : 1 knott = 1 nautical mile per hour

1. If a vessel travels at 10 knots, how long would it take to travel between Turtle Island Light and North Head Light?
2. If you were a canoeist paddling at 2 knots, how long would it take?
3. How long would it take if you had a boat travelling at 6 knots?

PART D : PLOTTING A POSITION ON YOUR CHART :

What are the following positions on the chart? 23°48'S; 152°03'E; 23°49'S; 151°50'E; 24°04'S; 152°04'E.

The following true bearings are relayed to you. Where are you at sea?

1. To water tower Pelican Beach ; 198°; To Mountain Peak Turtle Island 274°.
2. To North Reef Light 44°; To Garden Island Light 350°.

PART E : DISTANCE AND BEARINGS :

What is the distance and bearing from :

(a) South Head Light to Big Head Light?
(b) Turtle Island Light to Deadly Reef Light?
(c) Queensland River Light to Garden Island Light?

PART F : COURSE ALTERATIONS :

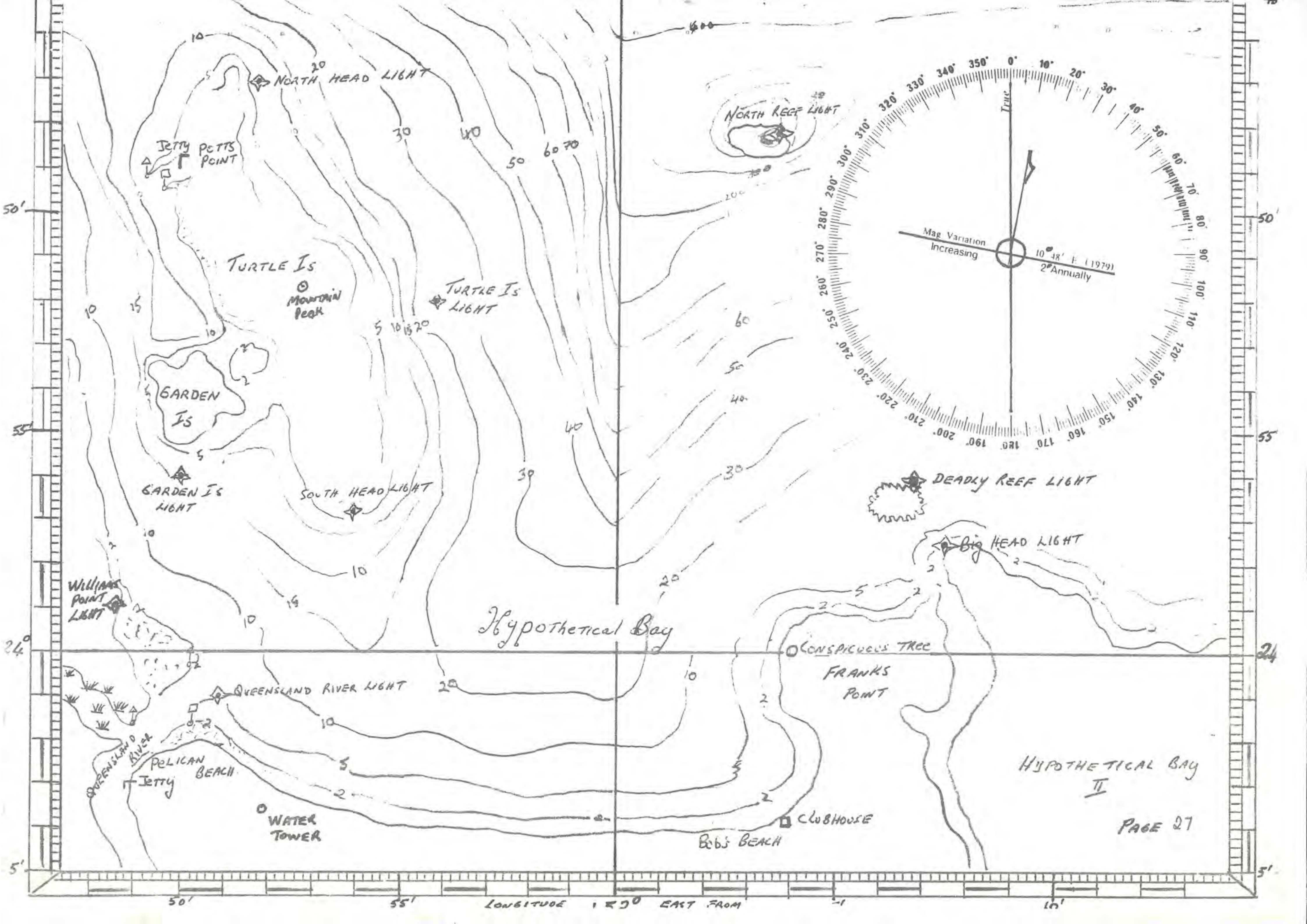
Avoiding all water below 5 meters, how long would it take a vessel travelling at 5 knots to travel around Turtle Island?

PART G : ON PATROL :

You are on board a fisheries patrol vessel sea protector at 23°50' South and 151°49' East, and have just been told by radio that the fishing vessel *"Sea Raper"* is unlawfully fishing at 23°55' South and 152°03' East. Instructions are to notify the master of the patrol vessel the following information immediately.

1. Shortest distance to *"Sea Raper"* from your position.
2. Bearings of *"Sea Raper"* from your position and course corrections.
3. Time taken to intercept *"Sea Raper"* at its present position if the speed of the patrol vessel is 15 knots and the *"Sea Raper"* is stopped.

EXTRA FOR EXPERTS : After 10 minutes, *"Sea Raper"* gets wise and sets off at 5 knots at 350°. Recalculate the intercept time.



NORTH HEAD LIGHT
JETTY
PETTS POINT
TURTLE Is
MOUNTAIN PEAK
TURTLE Is LIGHT
GARDEN Is
GARDEN Is LIGHT
SOUTH HEAD LIGHT
WILLIAMS POINT LIGHT
QUEENSLAND RIVER LIGHT
QUEENSLAND RIVER
PELICAN BEACH
JETTY
WATER TOWER
Hypothetical Bay
NORTH REEF LIGHT
Mag Variation Increasing
True
10°48' E (1979)
2' Annually
DEADLY REEF LIGHT
BIG HEAD LIGHT
CONSPICUOUS TREE
FRANKS POINT
CLUBHOUSE
BOB'S BEACH
HYPOTHETICAL BAY II
PAGE 27
LONGITUDE 153° EAST FROM

2.7 *Laying off a Course*

You are now ready to go to sea. Let us suppose that you wished to go on a water sampling expedition and during the day wanted to navigate around 6 stations. You would make up a Table similar to that below.

Investigation 2-3: *Laying off a Course*

Problem:

A scientist wishes to leave port at 0700 hrs. and do a day's sampling at 6 stations. He will need 30 minutes to take water samples at each site. (Decide the latitude and longitude of the 6 stations first).
(NOTE: Your research vessel travels at 5 knotts).

You will need:

* Hypothetical Bay chart
* 2 plotting squares
* Rule and dividers

What to do

1. Draw up a Log with the headings

Course	ETD	True	Error	Compass	Distance	Speed	Time	ETA

2. Write the Sample Course as follows :

   Marker at end of
   Queensland River
   to Station 1.

3. Enter the time 0700 hours.
4. With plotting squares, take the bearing (true) and write down .....
5. Take off the error (11) and write the compass course.
6. From the side of the chart and with dividers, step off the distance in nautical miles (D).
7. Compute the time $\left\{T = \frac{D}{S}\right\}$ if you plan to speed at knots $T = \frac{D}{S} = X$ mins.
8. Calculate ETA at Station 1. 0700 + X = Y hrs.
9. Now complete the table for the trip, remembering that it takes Y hrs. for each sample site.
   Complete your exercise with a course plotted on Hypothetical Bay.

Analysing the results

Q 1 What time would you arrive at port?
Q 2 What happened between Stations?
Q 3 When would you suggest that the scientist stop for lunch?

2.8 *Soundings*

On nautical charts, water depths are an aid to navigation Reefs, submerged pilings, and other obstructions, are also noted. In Investigation 3, when Garden Island had to be rounded, the depths of water had to be considered.

Suppose you wanted to chart a body of water and include depths and obstructions on your chart. First, you would need a map showing the outline of the body of water. Then you would need to go out on the water to measure the depth at various locations, being sure to record your exact location on the water. Now, by recording these depths at the right location on your map, you will have constructed your chart. This type of chart is called a *BATHYMETRIC CHART* or a chart of depths.

Investigation 4: Bathymetric Analysis

You will need:

1. A black box prepared in ADVANCE

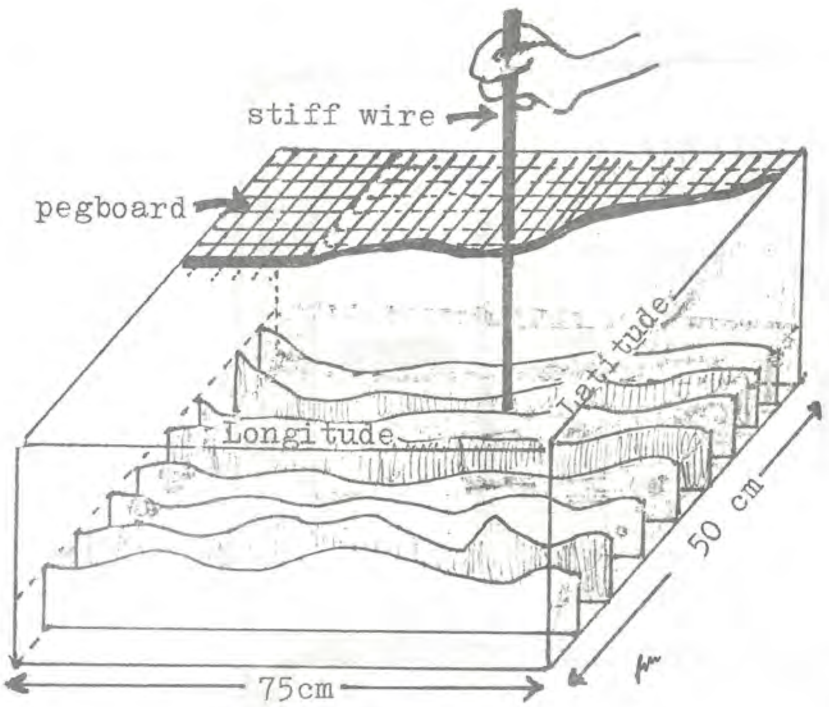


Fig. 2-9: A 'Black Bathymetric Box!'

The black box is prepared in advance. The box is constructed from one half sheet of 3/4" chip board and 16 boards. Make the box up to 50 X 75 and fill the bottom with bricks, broken blocks and wood scraps. Fill with clean builders sand. Cover the top of the box with peg board and rule lines of longitude and latitude.

2. Stiff wire - welding rod or coat hanger wire to fit through peg board
3. Metre rule
4. Line to mark track

What to do:

1. Use the wire to poke holes through the peg board until it touches the sand.
2. Note the length of the wire and graph the profile of the unseen floor. You may wish to use a toy ship to simulate the exercise.

Questions: *Invesitgation 4*

Q 1 How does the size of the interval between readings affect accuracy?

Q 2 How can inconsistent features, ie.e. isolated peaks, one great depth, be explained?

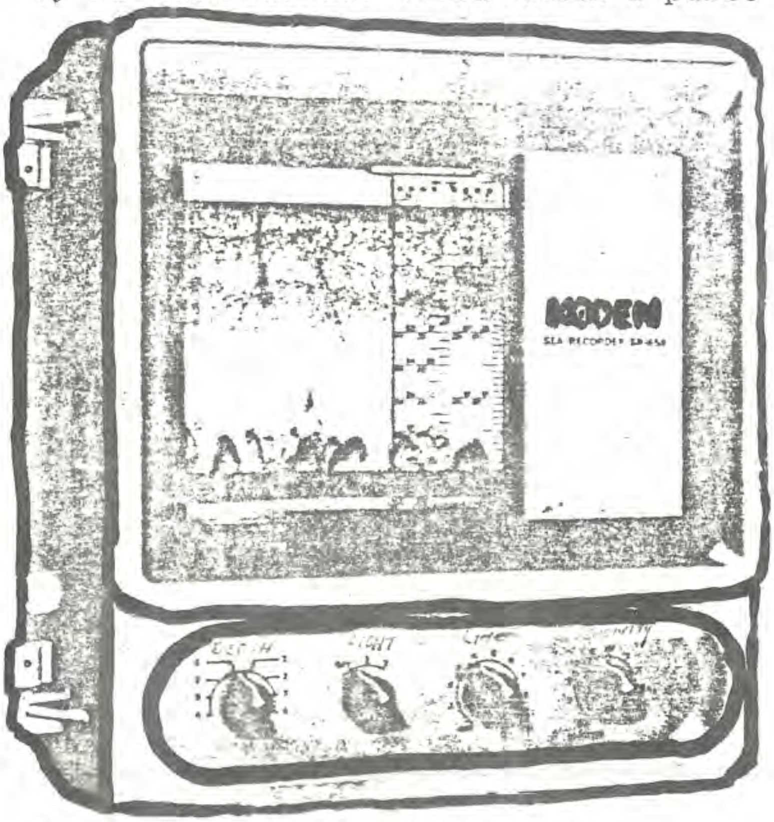
Q 3 Does one of a few tracks really show the general topography?

Q 4 How important is accurage navigation in sailing the seas? How can Bathymetric Charts be used for navigation?

Q 5 Are accurage charts important in deep ocean water? Explain your answer.

NOTES : This investigation similates the techniques used by oceanographers. It will give you the idea of the difficulty in mapping the unseen ocean bottom accurately.

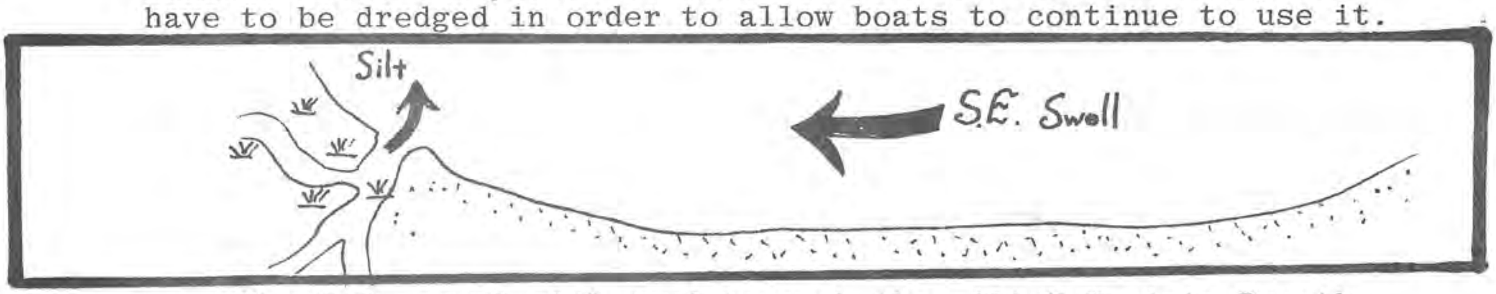
Bathymetric Charts are the results of many soundings and are as accurate as the data collected permits. Soundings are taken by an echo sounder which sends a pulse to the ocean floor and back again. The pulse is sent from a transducer fitted to the bottom of the boat, and the echo is analysed by a small receiver under the keel. By measuring the time interval, the depth of water is computed by the sounder.



2.9 *Estuarine Bathymetric Profiles*

Because estuaries are associated with rivers and creeks they will have water from the land mixing with ocean water. Water from the land carries with it soil, sand, and rocks and deposits this material in estuaries. Consider one example :

Queensland River is a major river system running many miles inland. Over the years the mouth of the river will silt up and have to be dredged in order to allow boats to continue to use it.



The S.E. swell will tend to push the silt N.W. into Hypothetical Bay. The silt is rich with fertilisers from the run off of home gardens and can cause algal growths around Garden Island.

Investigation 2-5: Estuarine Profiles

You will need:

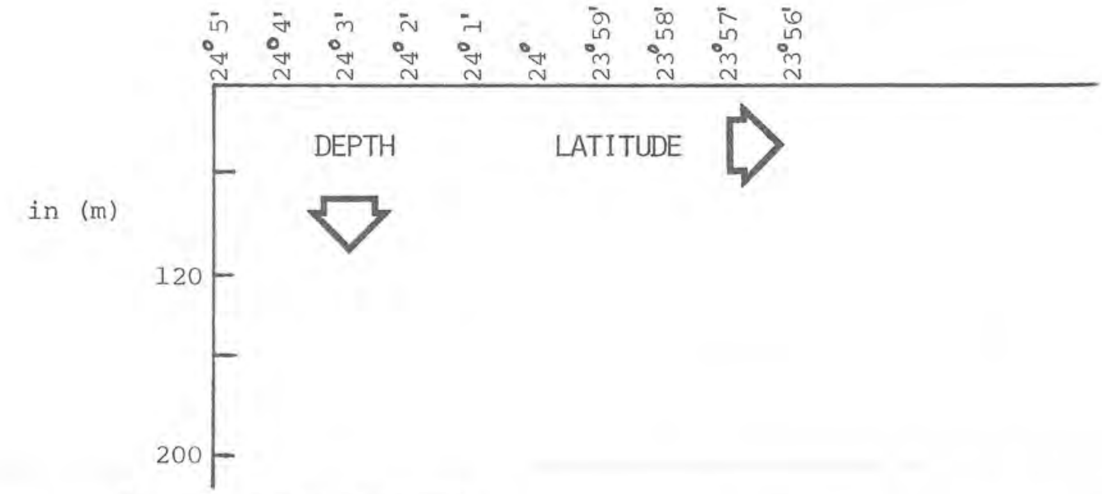
* Bathymetric Chart of Hypothetical Bay (see p. 26)
* Student work sheet, Bathymetric Analysis Hypothetical Bay
* Dividers and clear plastic ruler

What to do:

PART A: Profile 152° EAST

1. Find the 152° East line of longitude.
2. Draw lines on it for every minute of latitude.
3. Complete the work sheet provided. Make sure your line goes through the hill on Turtle Island.

NOTE : You can make up your work sheet like this.



Analysing the results:

Q 1 Compare the bathymetric profiles of PART A and PART B.
Q 2 At Latitude 23° 47' Longitude 152° 01', what is the depth of the water?
Q 3 What is the Continental Shelf? Label it on your profiles.

2.10 The Continental Shelf

Investigation 2-5 showed you that as you go further out to sea, you come to the edge of the Continent. This is called the Continental Shelf. From here on is deep ocean water which does not worry the estuarine oceanographer.

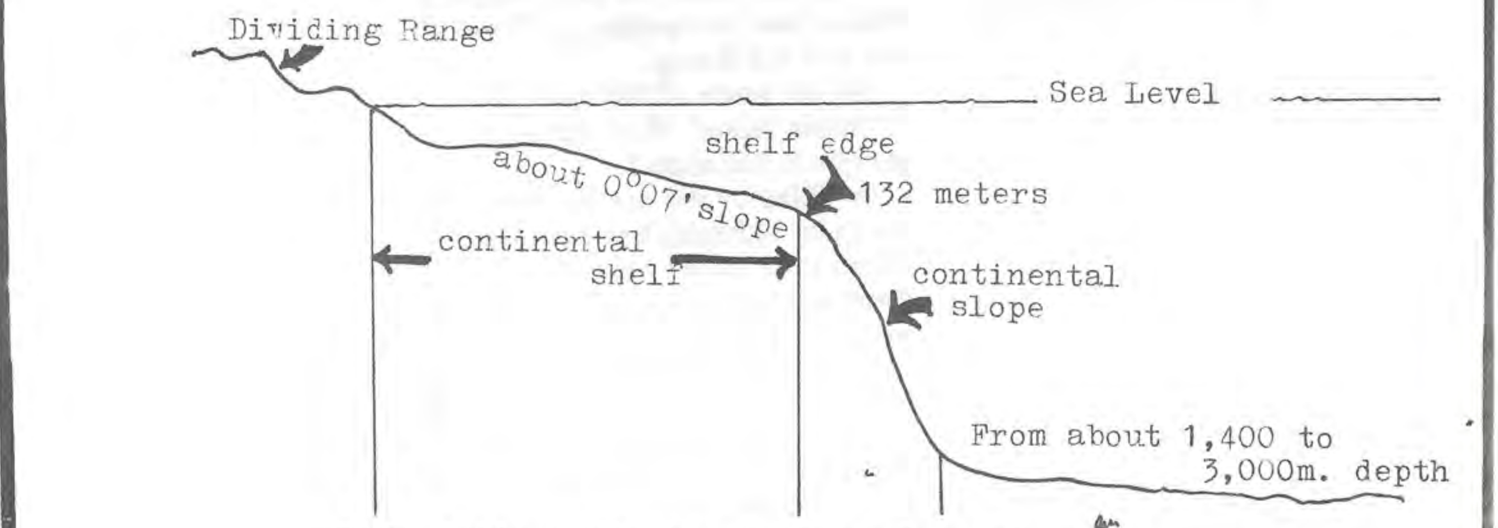
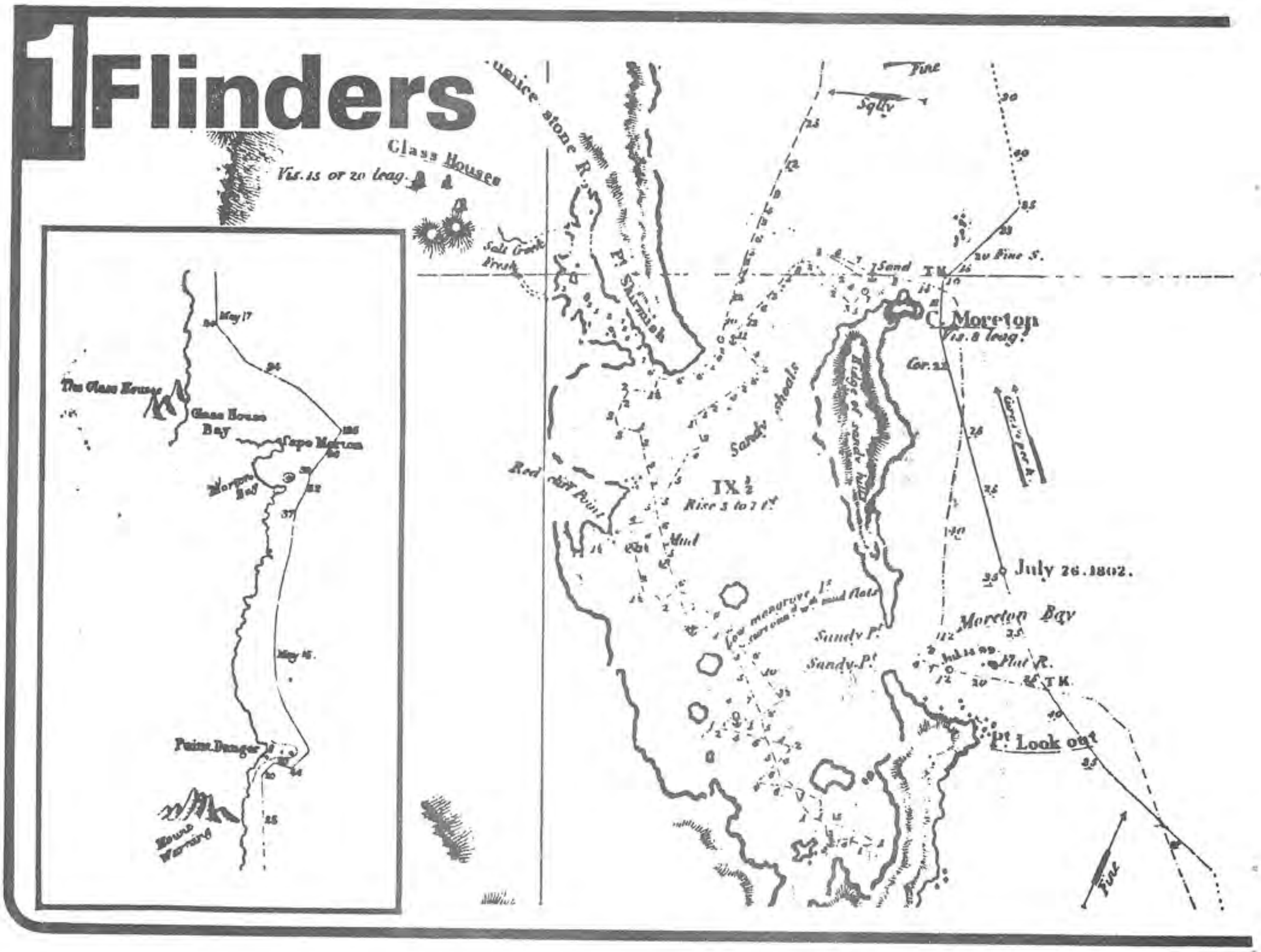


Fig. 2-11: Generalized view of coast

1 Flinders



Flinders was the first explorer to enter what we know as Moreton Bay in 1799. The map shows he plotted Moreton Island and parts of Stradbroke and Bribie Islands. Notice:

(i) the way "Red Cliff" is written.

(ii) the location of Moreton Bay. What we know as Moreton Bay was called Glasshouse Bay by Captain Cook (see inset map). Notice also the spelling of Moreton on Cook's map.

(iii) the name of the lower part of Bribie Island. Why did Flinders give it this name?

(iv) Flinders did not know that his Point Skirmish was part of an island so he called the passage of water a river and not a channel as we know it today.

(v) the absence of the Brisbane River.

There is a memorial to Flinders and another explorer near the Bay at Redcliffe.

18 — THE COURIER-MAIL

TUESDAY, MARCH 1, 1983

2 Three convicts

Using the story by Thomas Pamphlet, mark onto the map of the Moreton Bay area the, journey they took. The bridge near the spot where they crossed Oxley Creek has been called the Pamphlet Bridge.

This page was prepared by KEITH ENCHELMAIER, Officer in Charge of Fortitude Valley Field Study Centre.

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Why not contact the
Local Field Study Centre
in your area and find out
a bit about Local History.
Or write an article for
your local paper similar
to this one.
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The discovery of the Brisbane River is usually credited to John Oxley but he was not the first European to see the river. This honour goes to three shipwrecked sailors Pamphlet, Finnegan and Parsons.

Pamphlet, Finnegan and Parsons were ticket-of-leave convicts who, on 21 March 1823, set out in a boat from Sydney to buy cedar at Illawarra. They were blown out to sea by a gale. After more than three weeks they landed on the east coast of Moreton Island, and their boat was broken up by the surf. They believed they were to the south of Sydney, and attempted to reach it by walking north along the beach. Passing Cape Moreton, they followed the shore until they reached the South Passage, where they realized that they were on an island. They crossed the passage in a native canoe and were cared for by the natives at Amity Point. There they built a canoe of their own and paddled to Peel Island and finally to the mainland near Cleveland, where they abandoned their canoe. They continued walking northward.

Thomas Pamphlet's story:

7th June 1823: *We arrived at a large river at a place where the natives used to cross, but it was too wide for us to attempt to swim and we could not find a canoe.*

We decided to go up the river until we could find some way to cross, but we went on travelling for nearly a month, our way being blocked by many salt creeks which we walked around, neither of my companions being able to swim well enough to cross them.

At last we reached the bank of a creek (Oxley Creek; approximately 23rd June, 1823) on the opposite side of which we saw two canoes; one of these I decided to get.

I swam across with difficulty because I was weak from only eating fern roots during our walk along the river. I loosened the canoe and brought it back to my companions. It was so small it would not carry more than two, so I took Parsons across the river first and then returned for Finnegan, but we found the bush so thick it was impossible for us to travel, so we returned to the bank from which we had come.

We then commenced our return down the river but we had not the difficulties we had in coming up for when we came to a river or creek we were able to cross it in the canoe. We continued like this for three days, Parsons and Finnegan walking and I paddling down in the canoe until we found another canoe. We were able to all travel by canoe down the river to the mouth.

Pamphlet, Parsons and Finnegan reached the mouth of the river around the 27th June, 1823. They continued north along the shores of Moreton Bay to Bribie Island. They started to continue north again, but returned to Bribie Island to live with the Aboriginals where they were rescued by John Oxley at the end of November.

MAIN IDEAS

1. *Navigation* is the process of directing a craft safely from one point to another over water.

2. *Charts* have special markings to guide mariners.

3. *Navigators* have special instruments which guide them up and down the coastline.

4. The *Compass Rose* is used to lay off a course.

5. When travelling on a *Compass Course*, the earths magnetic *error* must be either added (WEST) or subtracted (EAST).

6. *Distance* is measured in nautical miles and computed from the degree of longitude (never latitude).

7. *Speed* is measured in KNOTS, ONE KNOT = 1 NAUTICAL MILE PER HOUR.

8. *Charts* also show soundings. Areas of equal depth are joined by *Sounding Lines*.

9. An *International System of Bouyage* is used to guide mariners in estuaries.

10. There are rules of the sea to protect ships and crew.

REVIEW QUESTIONS

1. Define a CHART and give a brief account of the first persons to use them.

2. What are lines of latitude and longitude? Which is used for distance measurement and explain how the scale works.

3. Where is the Compass Rose situated on a chart? How are squares used to draw parallel lines?

4. What is laying off a course? Plotting a position.

5. What is the difference between geographic and magnetic course?

6. Draw a Port and Starboard marker.

7. Why is a uniform system of bouyage necessary?

8. Name 2 rules for small ship operators.

STUDY ASSIGNMENTS

1. Research Matthew Flinders and Captain Cooks contribution to world navigation and chart making (Cartography).

2. What are notice to mariners?

3. Make a model Harbour and put in its markers.

SECTION 3 : NAVIGATION EXCURSION

PRACTICAL EXERCISES

1. Taking a bearing
2. Walking dividers
3. Calculation of distance, time
4. Plotting, position fix

STUDY ASSIGNMENTS

1. Repeat of Excursion
2. Local historical navigational notes

PRACTICAL NAVIGATION

Objectives

Navigation field trip

Boats and safety

Material required

Buoys, Beacons and Markers

Position fixing

Plotting your course at Sea

Worksheet

DIRECTED TOPICS

Dead Reaconing

AUDIO VISUAL

Local chart of area to be navigated. Slide set of local navigational marks

OBJECTIVES :

CONTENT OBJECTIVES

You should be able to :

1. Name areas on a local navigational chart.

2. Recall or recognise from photographs local navigational marks and/or hazzards.

PROCESS OBJECTIVES

You should be able to :

1. Plot a position on a chart using information from 3 bearings.

2. Lay off a course of no less than 3 legs.

SKILL OBJECTIVES

You should be able to :

1. Perform 1 and 2 above at sea.

2. Use a Compass, Chart, Dividers and Parallel Rules.

ATTITUDE

You should realize that working at Sea is slow and difficult.

DIRECTED TOPICS

The excursion described is one for Moreton Bay, however the general principles can be transferred to any local area. By photocopying a local chart and putting on a Compass Rose for your area, you can design your own worksheets.

NOTE WELL : Moreton Bay is one of the few Bays to have GRID references and a scale marked in the chart.

1. *NAVIGATION FIELD TRIP :*

Prerequisite skills :

You should be able to :

1. Read a compass and take a bearing of a distant point.
2. Recognise significant features on a chart.
3. Use a set of parallel rules or set squares to work from and to a compass rose.
4. Correct for magnetic declination.
5. Work simple distance/time/speed calculations.
6. Lay off a course so as to compute distance/time/speed.

Purpose :

To enable students to go to sea so as to practice those above skills that they have learnt in the classroom.

Time required :

One day, (depending on class size and distance from the sea).

2. *BOATS AND SAFETY :*

A local ferry boat chartered for the day proves ideal because it gives the whole class a chance to get aboard. Also there is plenty of room for charts and plotting at sea. Check to see if the launch hired has a current certificate of survey and that the launch master has the required launch masters certificates.

For South East Queensland students the Education Department has approved the Darling Point Special School's vessel, "*M.V. Heritage*" for navigation exercises. The operators of this vessel both hold launch masters certificates and the vessel will accomodate 20 students comfortably. For further information see the information in appendix 1.

3. *GENERAL NOTE :*

Life at sea is different from life on land. It takes more effort and more time to work. A lot of time is spent in preparation and cleaning up. People can be effected in many different ways by it and you will have to learn to help and/or tollerate these individual differences.

4. *MATERIALS REQUIRED :*

* Worksheets (see samples attached)
* Local Chart with compass rose
* Hand bearing compass
* Parallel rules (or set squares)
* Dividers
* Binoculars

5. *PART A : BUOYS, BEACONS AND MARKS :*

As the vessel leaves the harbour/jetty, there will be a set of lateral marks that will guide her out of the harbour. Make a drawing of each one you pass, and note which side (port or starboard) the vessel passed it on. The cardinal system of marks is just starting to be introduced in Australia and you may or may not see cardinal marks.

6. *PART B : POSITION FIXING* :

One of the first things to do is to find out where you are. Ask the skipper to anchor the vessel a short distance outside from the harbour. Then take 3 bearings on points that you can locate on your chart. Using your parallel rules or squares, work from your bearing on the compass rose to the point on land/sea that you took the bearing off. You will need to think back to the time you navigated your classroom and how you found your position there.

If there is more than one mark near each other then use binoculars to check accurately that you have taken the right one.

Now record your latitude and longitude (or Grid reference).

7. *PART C : PLOTTING A COURSE AT SEA* :

In this part of the exercise you will work out three legs of a course, their distances and the times each will take to complete.

FOR THE FIRST LEG :

Decide on a short leg, say 1 nautical mile. Work out a safe course avoiding all shallow water, and try to end up at a marker buoy or island. Fill out the table below on your worksheet :

COMPASS COURSE	DISTANCE	SPEED	ETA	ETA

Make the necessary magnetic corrections to get to the compass course then ask the skipper to steam at a set speed. At the end of the time you should end up where you want.

Now take 3 bearings and check your position and mark your chart.

FOR THE SECOND LEG :

Decide on a longer course at a different speed. The aim of this part is for you to learn to take *running fixes* so as to locate your position along the way. Also work out the bearing at the end of your course so that you know when you have finished. At three times on the leg have someone ask you to show them where they are and fill out the table below :

COMPASS COURSE :		RUNNING FIXES :			
DISTANCE :		TIME OF LEG :	BEARING TO LANDMARK	LATITUDE	LONGITUDE
TIME :		START :			
SPEED :					
TIME DEPART :					
TIME ARRIVE :		FINISH :			

FOR THE LAST LEG :

Here is a chance for you to see how good you are. When you are about to start the last leg of your course, find somewhere in the vessel where you cannot see where you are going. Imagine that its pitch black and you have to navigate with only a compass. To do this you will have to work well as a group as well as with the skipper.

Lay off your course, work out the speed/distance/time sums and set off. Now with your chart, compass and dividers ask for running fixes so as to plot your position. Ask for checks to be done along the way of landmarks that you should pass and when you come to the end of your calculated time ask the skipper to stop and see how good you were. This is what the job of a navigator is like with skipper and crew working together to get about the ocean.

Now as you come into port record the buoys, beacons and marks and on which side (Port or starboard) that the vessel passes.

YOUR REPORT :

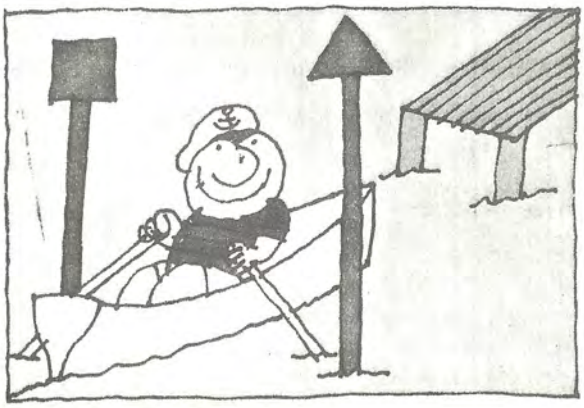
Write this up as your teacher directs you to, however you should show that you should be able to :

(a) Plot a position Fix (Part A)

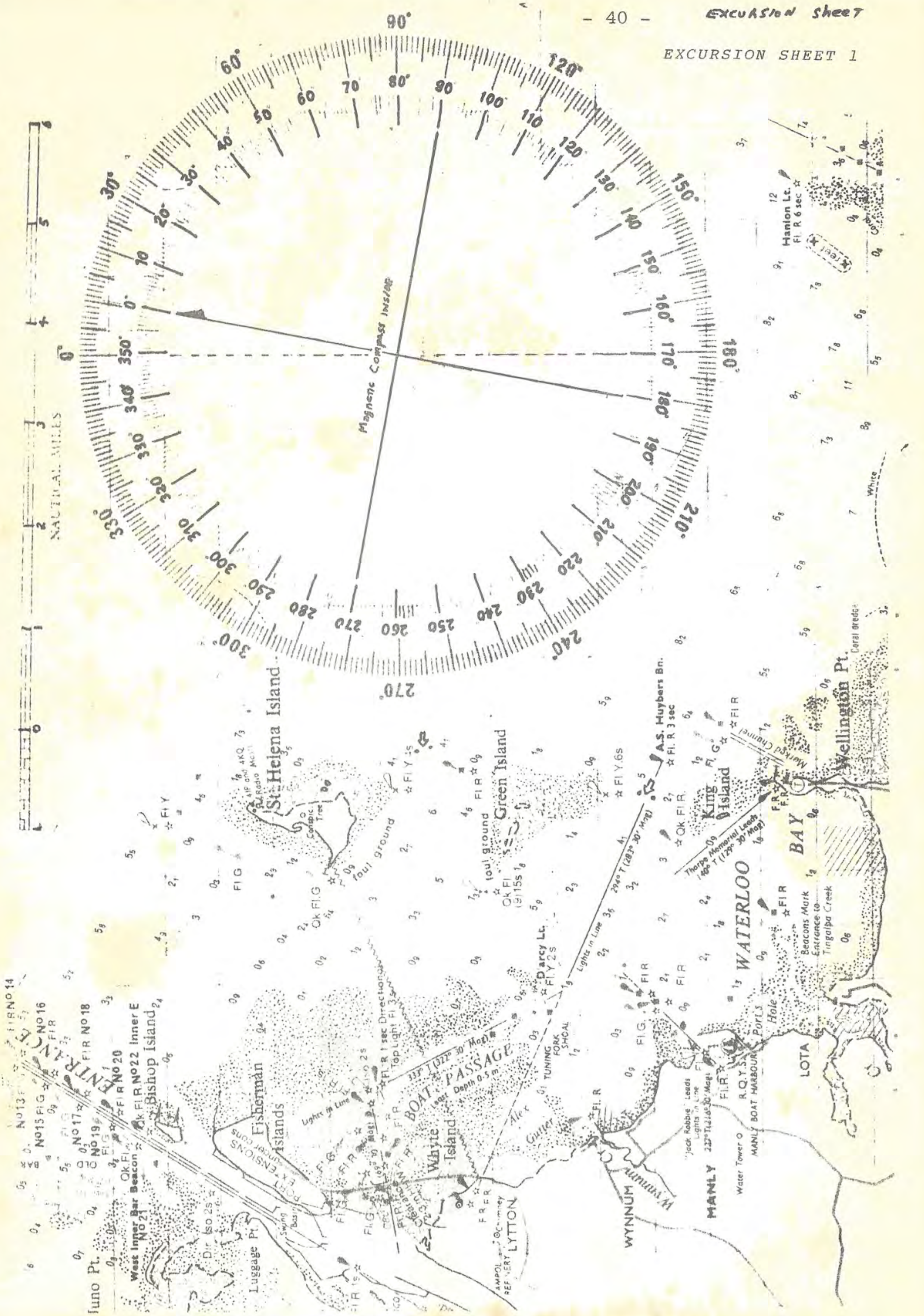
(b) Plot a course and calculate speed/distance time sums

(c) Lay off a course so as to estimate time of arrivals

(d) Compute latitude and longitude and do a running fix so as to locate position at sea for any given point in time



EXCURSION SHEET 1



EXCURSION SHEET 2

BOUYS, BEACONS AND MARKS

In the space below draw any 3 Lateral Marks you see and one Cardinal Mark. For each say what they mean.

Cardinal Mark	Lateral Mark
Lateral Mark	Lateral Mark

POSITION FIXING

From where you are anchored take 3 bearings to points that you can locate on the chart and write them in the space below.

BEARING	FROM	TO	BEARING
1	Boat		
2	Boat		
3	Boat		

Now using Squares and the compass Rose DRAW lines to locate our position.

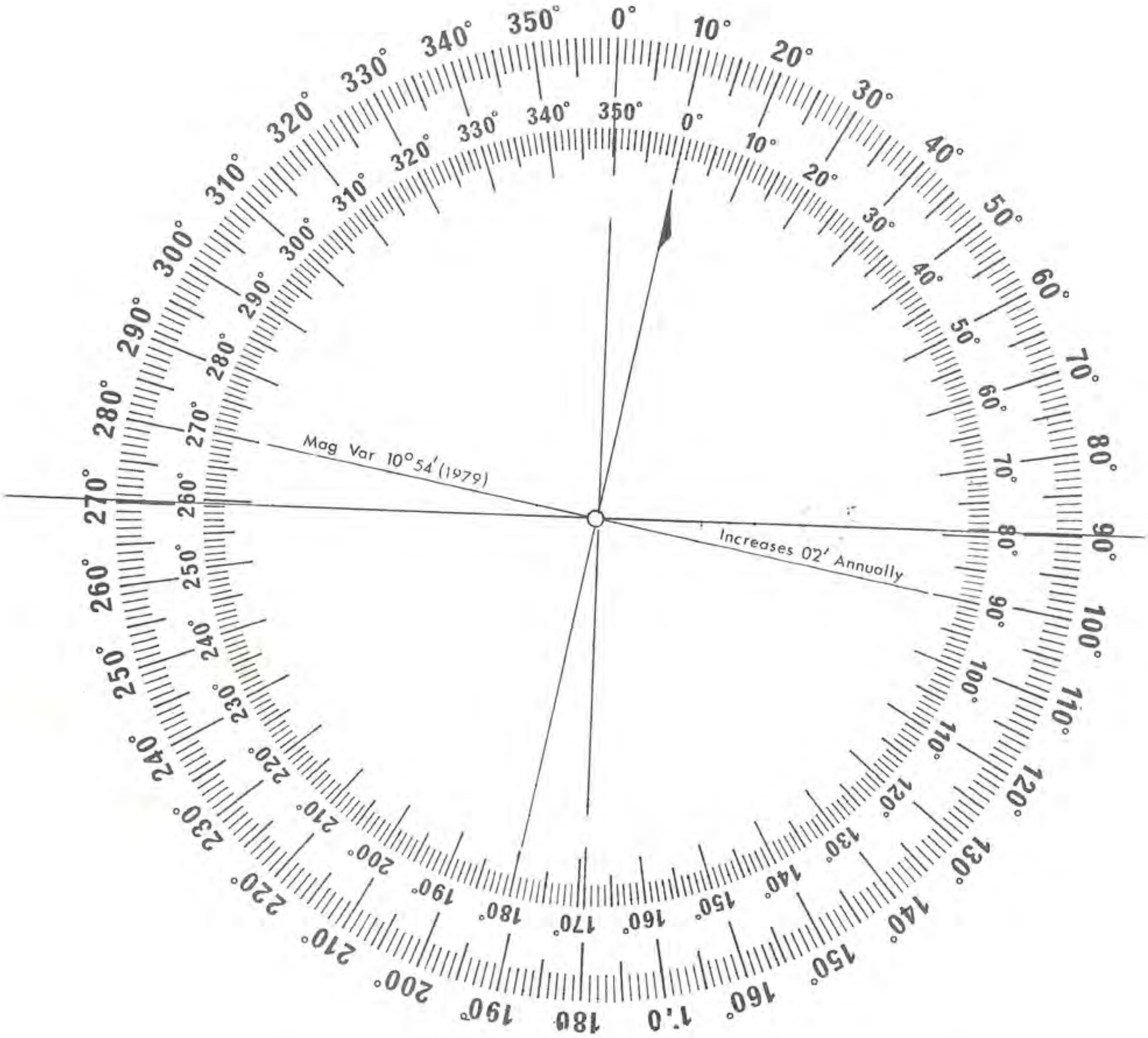
LAYING OFF A COURSE

Lay off a course involving 3 or 4 changes of course and fill in the table below. Then set off on that course.

COURSE	ETD	COMPASS	DISTANCE	SPEED	TIME	ETA
1						
2						
3						
4						

RUNNING FIX

Bearing at end of course to Visible Point	
Bearing at end of Course	



COMPASS ROSE FOR :

(1) Charting your classroom

OR (2) For your Local Chart

OR (3) Your Overhead Transparency

SECTION 4 : ESTUARINE NAVIGATION

PRACTICAL EXERCISES

1. Boating safety
2. Boating equipment

STUDY ASSIGNMENTS

1. Photograph local navigational marks and say what they mean
2. Safety afloat

THE BUOYAGE SYSTEM

1. *Buoys, Beacons and Marks*
2. *Note from Department of Harbours and Marine*
3. *Safety afloat*
4. *The boating rules*
5. *Standard signs*
6. *List of official publications*

DIRECTED TOPICS

1. Class discussions
2. Visit to/by local boating officers

AUDIO VISUAL

Photographs/slides of local area

OBJECTIVES :

CONTENT OBJECTIVES

You should be able to :

1. Recall the Symbols for the Cardinal and Latical Systems of Buoyage.
2. Recognise them in the tide book.
3. Recall the safety rules for boating.
4. Recall important international Code Flag Signals.

PROCESS OBJECTIVES

You should be able to :

1. Interpret the rules and regulations as set out in the tide book.
2. Plot a safe course into/out of a harbour.

DIRECTED TOPICS

For the teacher : Much of this section assumes a competance in boating generally. However, the local boating patrol officers of the Department of Harbours and Marine are willing to give class talks and show their films if given notice. Parents also have boats and usually are willing to bring them in. There is almost a complete course in interpreting all the information in the tide book. This section only serves to introduce it to the student, however, it shall serve to introduce the importance of another Management Authority.

1. *Buoys, Beacons and Marks*

Just like a highway has road signs, so does an estuary, especially if it is a major port. Buoys, floats, beacons and marks are driven into the ocean bed or positioned on rocks. On sighting a navigational mark, the mariner's reaction must be *instinctive, positive,* and *correct.* Lack of this knowledge usually ends up in diaster with wrecks and groundings.

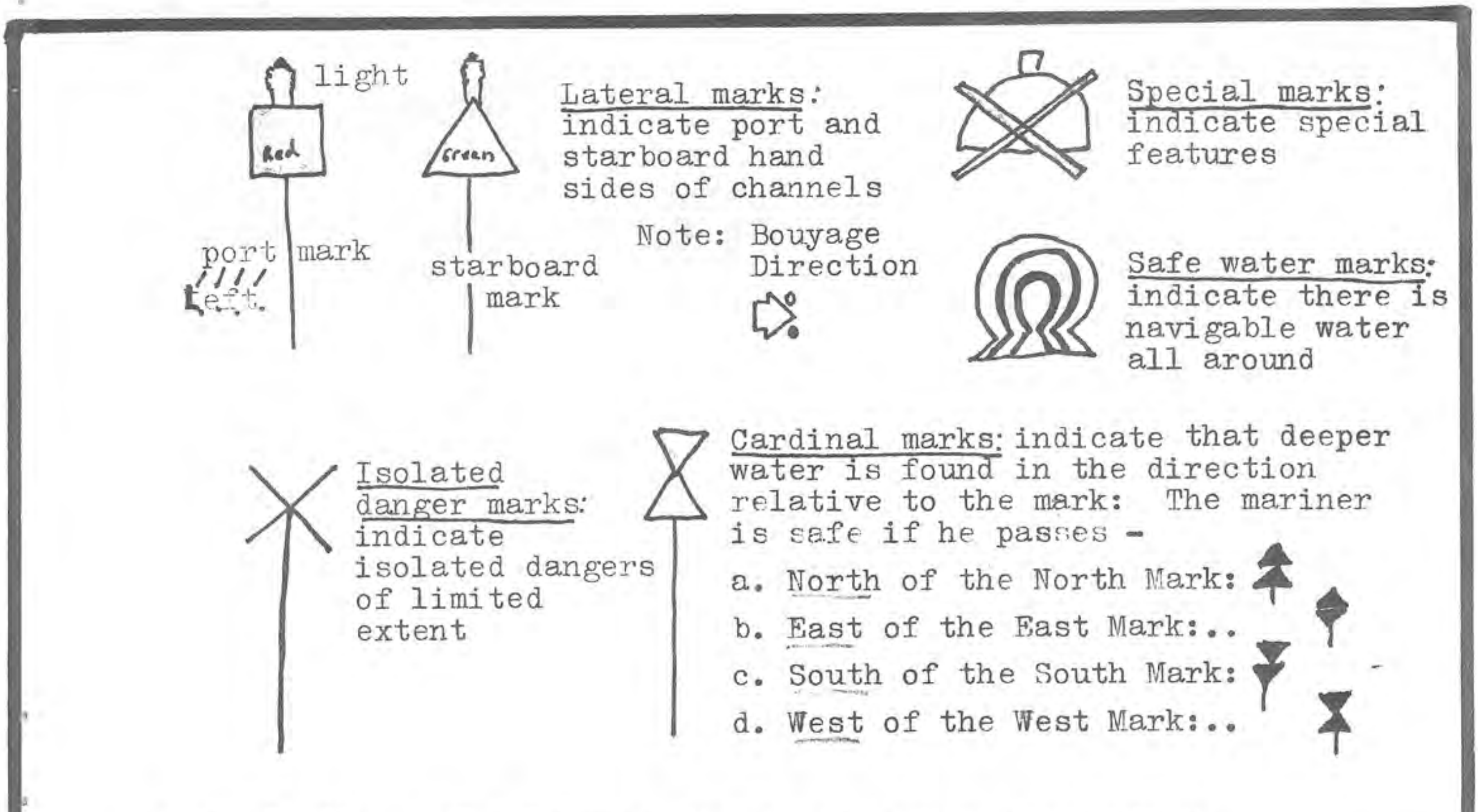


Fig. 2 -12 The Bouyage System of Inshore Navigation.

Upon entering a port, the port hand mark (RED) should be passed on the vessel's PORT side. Remember when coming home there is always a little bit of PORT left in PORT. Alternatively, when departing a port, the port hand buoy (RED) should be passed on the vessel's starboard side.

Look at the Chart below and follow the directions.

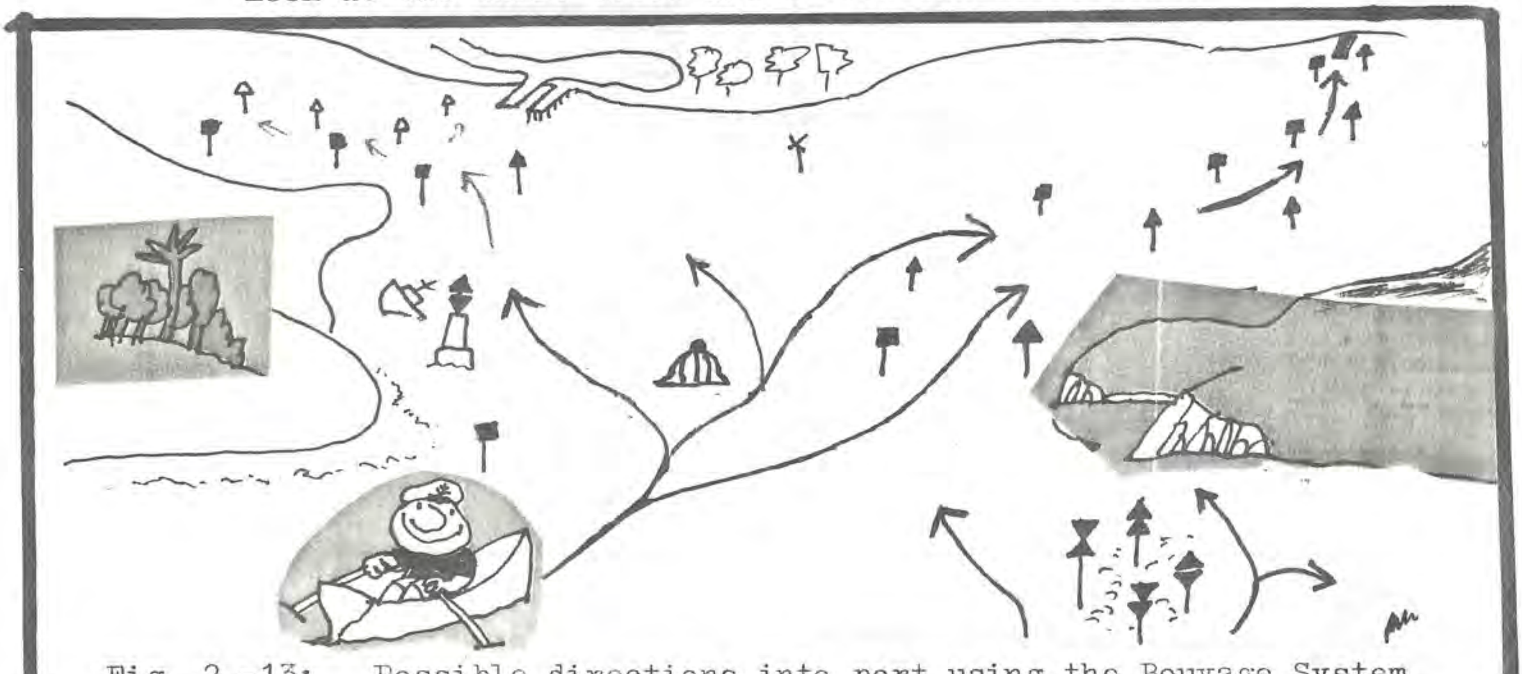
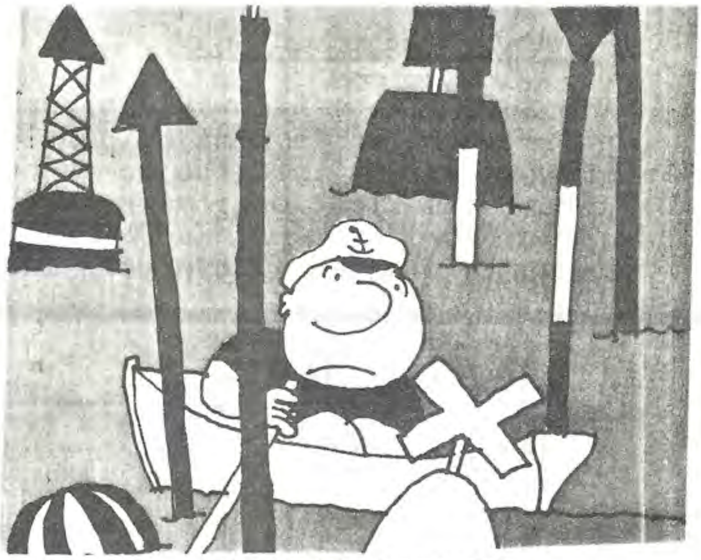


Fig. 2 -13: Possible directions into port using the Bouyage System

Buoys, Beacons & Marks

THE IALA MARITIME BUOYAGE SYSTEM "A"



Buoys and Beacons of the IALA Buoyage System "A" are shown on maritime charts in the following manner:—

UNLIT MARKS	LIGHTED MARKS

Lateral, generally marking the limits of well-defined channels.

Port Hand

All red
Topmark (if any): can — R R R R | *Fl.R* R, *Occ.R* R etc — *Red light (any rhythm)*

Symbol used to indicate buoyage direction where not obvious; size and orientation varied to suit its situation.

Starboard Hand

All green or black
Topmark (if any): cone — G B G B | *Fl.G* G, *Occ.G* B etc — *Green light (any rhythm)*

Cardinal, indicating navigable water to the named side of the mark.

Topmarks: 2 black cones

NW — NE — SW — SE — Point of interest

North Mark
Black above yellow — BY BY

West Mark — YBY YBY
Yellow with black band

East Mark — BYB BYB
Black with yellow band

South Mark
Yellow above black — YB YB

White light

North Mark	BY	*V Qk Fl or Qk Fl*
East Mark	BYB	*V Qk Fl(3)5s or Qk Fl(3)10s*
South Mark	YB	*V Qk Fl(6)+L Fl.10s or Qk Fl(6)+L Fl.15s*
West Mark	YBY	*V Qk Fl(9)10s or Qk Fl(9)15s*

The same abbreviations are used for lights on spar buoys.
The periods, 5s, 10s and 15s, may not always be charted.

Isolated danger, stationed over a danger with navigable water around it.

Body: black with red horizontal band(s)
Topmarks: 2 black spheres — BRB BRB | *Gp Fl(2)* BRB, *Gp Fl(2)* BRB — *White light*

Safe water, such as mid-channel and landfall marks.

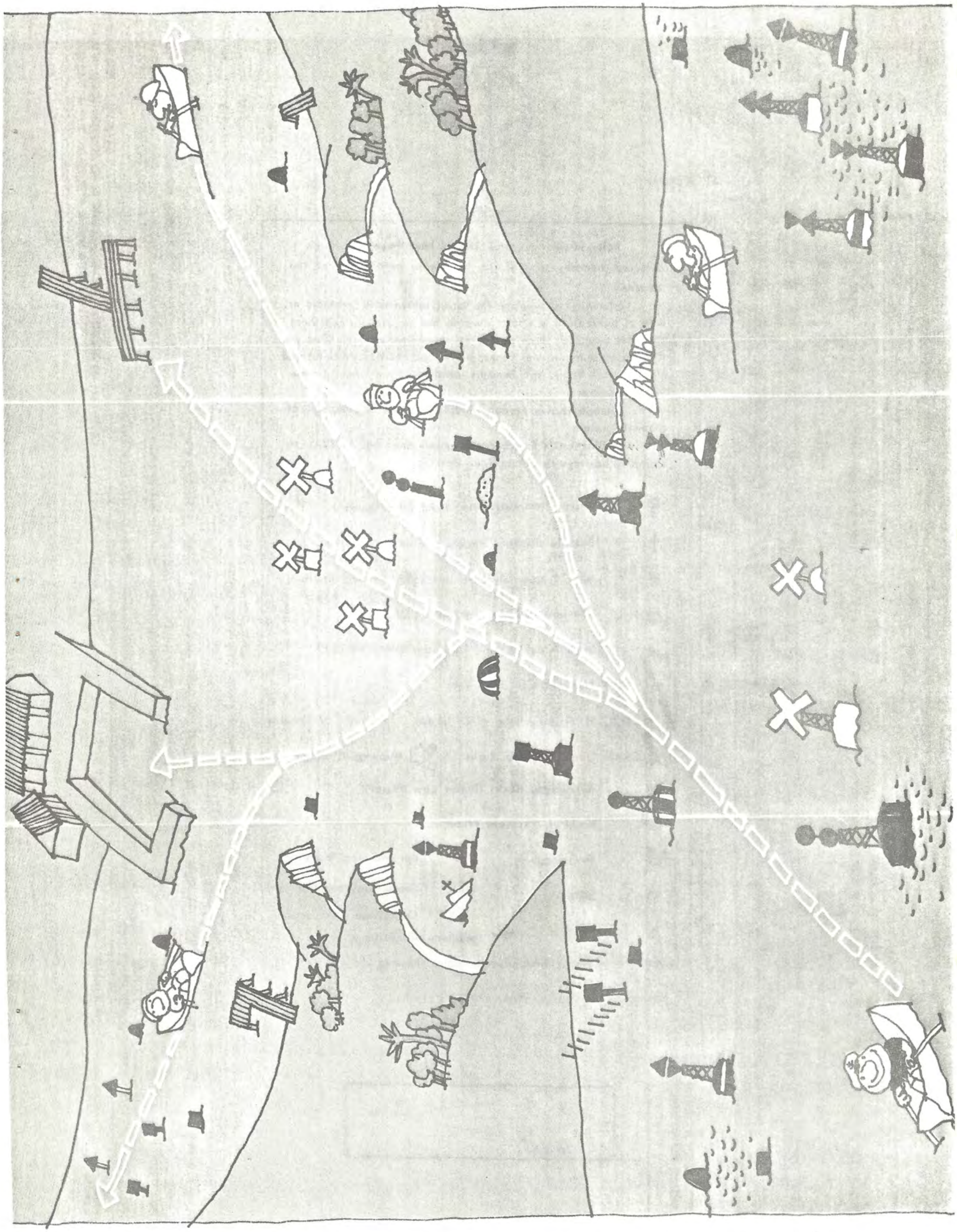
Body: red and white vertical stripes
Topmark (if any): red sphere — RW RW RW | *Iso,Occ or L Fl* RW, *Iso,Occ or L Fl* RW, *Iso,Occ or L Fl* RW — *White light*

Special, not primarily to assist navigation but to indicate special features.

Body (shape optional): yellow
Topmark (if any): yellow X — Y Y Y etc | *Fl.Y* Y, *Fl.Y* Y, *Fl.Y* Y etc — *Yellow light*

QUEENSLAND BOATING AND FISHERIES PATROL

DEPARTMENT OF HARBOURS AND MARINE QUEENSLAND



2. Notes from Department of Harbours and Marine

NOTES

Reflectorised indicator arrows have been placed on selected beacons to indicate the deep water sides of the beacons.

Soundings shown are the latest information available at date of publication of chart; they do not necessarily represent the best available water or the recommended course. Due to changes in channels and banks, buoys and beacons are re-located or additional buoys and beacons installed, from time to time, without notice.

Symbols shown hereon should be taken as indicative of channel location.

Declination is East and correction must be ADDED to Compass bearings to obtain True Bearings.

Beacons marking Port hand from Seaward

Beacons marking Starboard hand from Seaward

Yellow Special Mark (Marking Channel Junction)

Red buoy marking Port hand

Black buoy marking Starboard hand

Navigation aid with light

Qk.Fl.G. Fl. Flashing light G. Green R. Red Y. Yellow

Qk.Fl. Quick Flashing Light

Buoyage Direction

Submerged Rocks (Below Low Water)

Rocks dry at Low Water

Anchorage

Bar Warning Signs

Jetty

Green Buoy (obstruction)

Underwater Obstruction

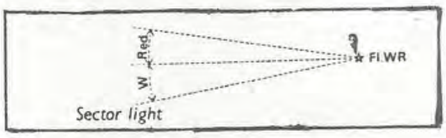
Ramp

Seaplane Alighting Area

Wreck with superstructure showing above L.W.

Submarine Cable (KEEP CLEAR)

Sand or Mud dry at Low Water



STUDY ASSIGNMENTS

Obtain a copy of the official Tide Table (Qld)

1. Find out about Annual registration fees, Boat Identification, Licences to drive a speed boat.
2. Why do boating and ski-ing accidents occur?
3. What is the Queensland boating fisheries patrol?
4. What are the safety rules for boats?
5. What are the standard things a boater does before going to sea?
6. List the rules of the road.
7. What safety rules are required for water ski-
8. Make a table of a safety equipment schedule for a 12' 1 (4m) boat. You could make a poster to display in the class.
9. What is a DAN BUOY?
10. Make a flag of the International Code Signals.
11. Ask your librarian to purchase the official list of publications/charts/sets from the Department of Harbours and Marine.
12. Discuss the importance of navigational lights on a boat.

PRACTICAL EXERCISES

1. Design boating safety posters for the classroom.
2. Arrange for a display of safety equipment :

   - FLARES
   - V SHEETS
   - SURVIVAL KITS

3 Is Oxley's plaque in the right spot?

John Oxley first sailed into the Brisbane River on 2nd December 1923, and charted the river as far as Goodna, or Termination Hill as shown on the map.

He returned the following year with Alan Cunningham and explored further upstream. It was during the second trip that the diary extracts below were written.

Thursday Sept. 16th: *Fine, pleasant weather. Left the brig, accompanied by Lieut. Butler and Mr Cunningham, with two boats, to complete the survey of the river. At four arrived at the head of Sea Reach, when we stopped for the night.*

(Location 1, near the mouth of Breakfast Creek).

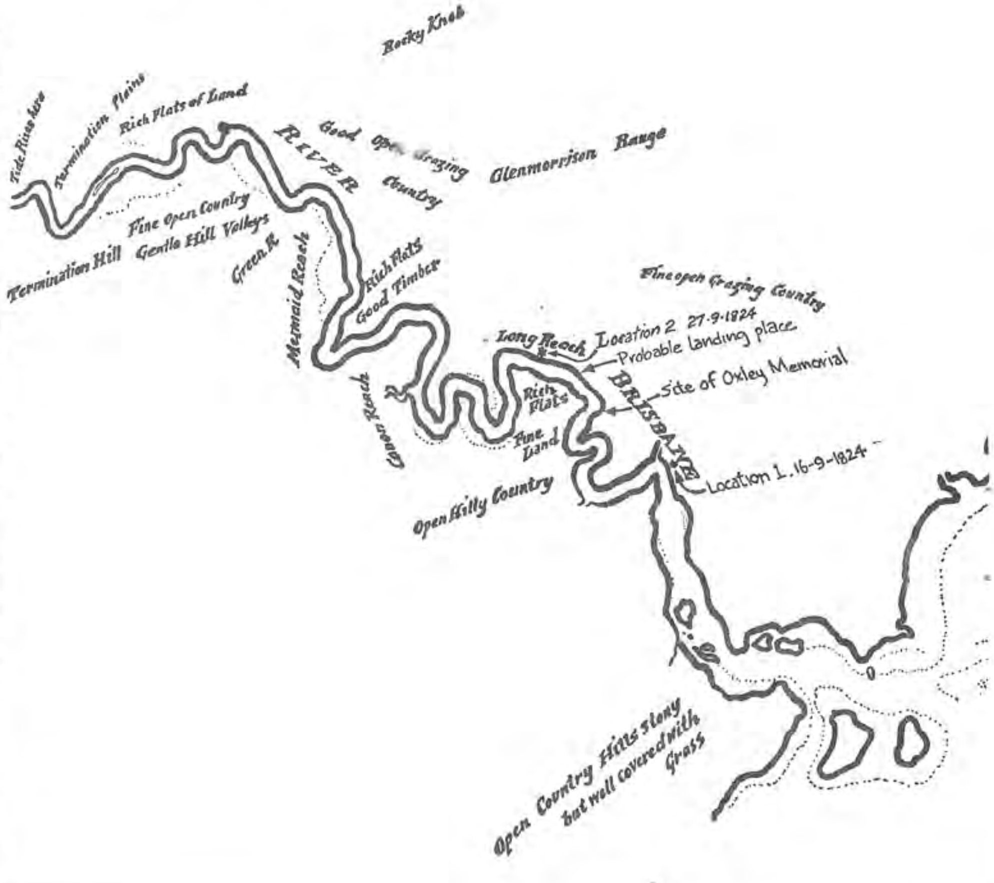
THE RETURN TRIP

Monday Sept 27th: *The tide having been against us the greater part of the day, we did not get lower down the river than Crescent Reach (shown as Long Reach on the map), where we intended stopping for the night, as I expected to find fresh water. We saw at commencement of the reach on the left bank a very large assemblage of natives in the same spot we saw them last year. It was evidently a favorite place for them, most probably on account of water being convenient, as among the company was a full proportion of women and children. We landed about half-mile below this encampment on the same side of the river, there being a small creek between us, which I hoped would prevent them visiting us.*

(Location 2, probably at Moorlands Park, Toowong).

Tuesday Sept. 28th: *...we proceeded down the river, landed about three-quarters of a mile from our sleeping place, to look for water, which we found in abundance and of excellent quality, being at this season a chain of ponds watering a fine valley. The soil good, with timber and a few pines, by no means an ineligible station for a first settlement up the river.*

(It is conjectured that the water holes described by Oxley were at Frew Park, near the Milton tennis courts.)



Some things to do

Try to find sketches, maps and diaries of the explorers of your area. It they were well known people these records could be in a State historical library. Local historical groups and older residents may also be able to help.

From these sources try to locate features named, landmarks mentioned, and sites of camps etc in the local area. You may also be able to discover the appearance of the landscape and the location and activities of the inhabitants of the area.

Prepare a report on the significance of these sites for your school library. Design a plaque or monument which could be located on a site. Approach the local council to see if your plaque could be erected.

If a special feature, for example a tree with survey markings, is present in the locality, investigate ways of preserving that feature for all times.

SECTION 5 : WEATHER AND THE SMALL SHIPS FORECAST

PRACTICAL EXERCISES

1. Study of weather patterns
2. Visit to local weather stations
3. Weather instruments

STUDY ASSIGNMENTS

1. Small ships forecast charts
2. Isobars
3. Line squalls
4. Trade winds

THE ATMOSPHERIC ENVIRONMENT

1. *Objectives*
2. *Structure of atmosphere*
3. *Solar Radiation and its transmission*
4. *Patterns of air movements*
5. *The water cycle*
6. *Basic termonology and conventions used in weather maps*
7. *Violent forms of weather*
8. *Instrumentation*

DIRECTED TOPICS

1. Reading of exploring Science
2. Reports from T.V., Radio

AUDIO VISUAL

1. Satellite weather photographs
2. Films on weather

OBJECTIVES :

CONTENT OBJECTIVES

The student should have a knowledge of :

(a) the structure of the atmosphere;
(b) solar radiation and its transmission;
(c) patterns of air movements;
(d) the water cycle;
(e) basic terminology and conventions used in weather maps;
(f) violent forms of weather;
(g) some man-made changes to the atmosphere, and their consequences;
(h) the operation of some instruments used to monitor factors which influence the weather; and
(i) some work undertaken by the Australian Bureau of Meteorology.

PROCESS OBJECTIVES

The student should be able to :

(a) demonstrate the role of the glasshouse effect in maintaining stable earth conditions;
(b) identify characteristics and causes of air movements;
(c) interpret weather maps; and
(d) predict short term weather conditions.

SKILL OBJECTIVES

The student should be able to :

(a) use instruments to measure factors which influence the weather and atmospheric conditions.

AFFECTIVE OBJECTIVES

Students should have the opportunity to :

(a) appreciate the importance of weather in influencing the economy and our behaviour;
(b) appreciate the difficulty of accurate weather prediction;
(c) value local knowledge and experience in predicting short term local weather;
(d) value the potential of man to deliverately or inadvertently change the weather and the atmospheric environment;
(e) value the gains of technology (e.g. use of satellites) in weather prediction.

From Multistrand Science
Syllabus B.O.S.S.S. (1982)

DIRECTED TOPICS

Text Readings from - *Exploring Science, Book 2*
Stannard and Williamson
McMillian 1982.

1. Read chapter 10 : The Earths Air.
2. Do investigations 1 and 2 - pages 187, 188 and 196.
3. Answer Research Question 1 and 2 on page 190.
4. Answer the Question 5 on page 197.
5. Read chapter 11 : Weather
6. Do investigations 1 and 2 - pages 203 and 215.
7. Answer Questions 5 and 6 on page 218.
8. Answer the For Research Questions 2, 3 and 4 on page 219.

PRACTICAL EXERCISES

1. Make a Wind Vane or model barometer as shown on page 220 *Exploring Science, Book 2*.
2. Study the wind speed over a year (data can be obtained from the Bureau of Meteorology.

DIRECTED TOPIC

FORECASTING THE WEATHER

Weather systems generally move in a west - to - east direction which makes forecasting relatively easy provided good information is available.

Consider yourself at Sea with a small ship, forecast the following :

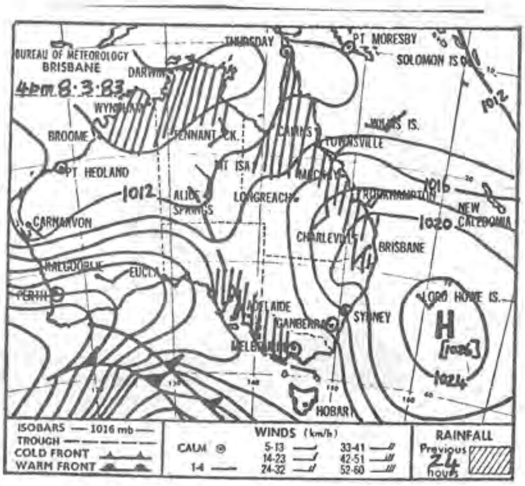
Weather

THE Brisbane Weather Bureau reported on its chart last night:

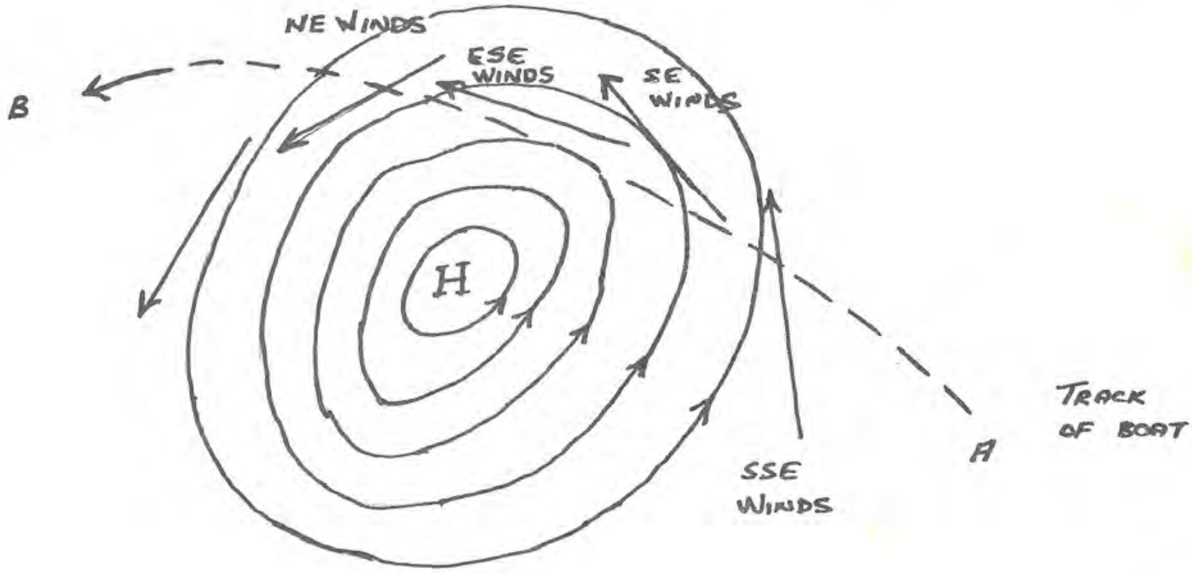
The monsoon trough extends across the far northern parts of Australia and crosses Cape York Peninsula near Weipa. This together with an upper low centred west of Cairns has caused widespread rain and scattered thunderstorms over the north-east tropics and to lesser extent over other northern tropical parts. A high centred over the Tasman Sea extended a firm though gradually weakening ridge along the Queensland coast south of Cooktown. The moist east to south-east airstream being directed over Queensland from this high has produced isolated showers on the central and south coasts. Mostly fine conditions have prevailed over the rest of the state under the influence of a strong upper ridge.

FUTURE DEVELOPMENTS. — Further rain or thunderstorms will continue over north Queensland near the monsoon trough and the low. This cloud, with some rain and thunderstorms, is likely to extend south into the central interior in the next day or two. Onshore winds should maintain showers on the central coast, more widespread in northern parts initially due to the upper low. Southern districts should continue fine due to a stable upper atmosphere, although a few thunderstorms may develop in western parts late in the week.

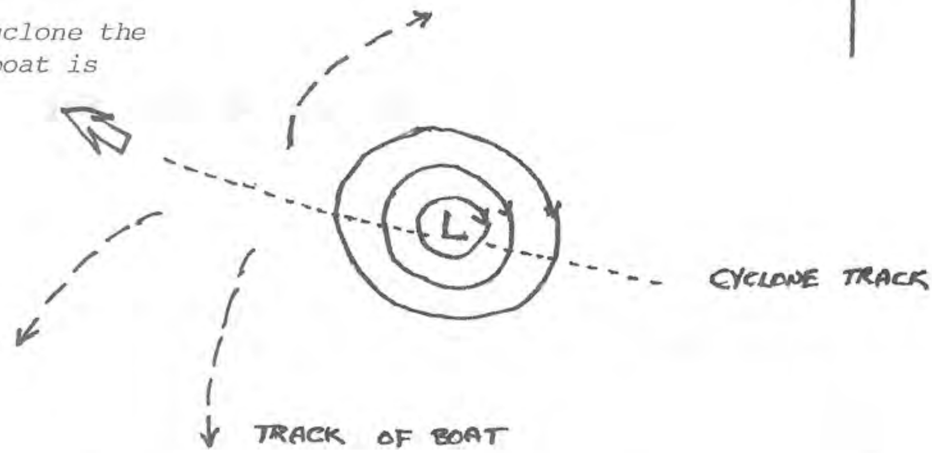
From this a weather map can be drawn



Consider now a boat travelling through the pressure system from A   B.



If sailing into a cyclone the following track of boat is recommended.



CYCLONE WARNING SIGNALS ARE :

(1) Barometer falling fast, to an exceptionally low reading.
(2) A marked heavy ground swell. This is quite different from normal swell conditions.
(3) A distinctly lurid appearance about the sky in the direction of the storm.
(4) As the storm approaches, a marked shift in the direction of the winds as well as increasing wind force.
(5) A distinctly howling wind - cyclone winds are quite distinctive.

AFTER TOGILL 1975.

Small Ships Forecasting and Boat Safety

Each day the weather bureau produces a weather chart and issues a forecast.

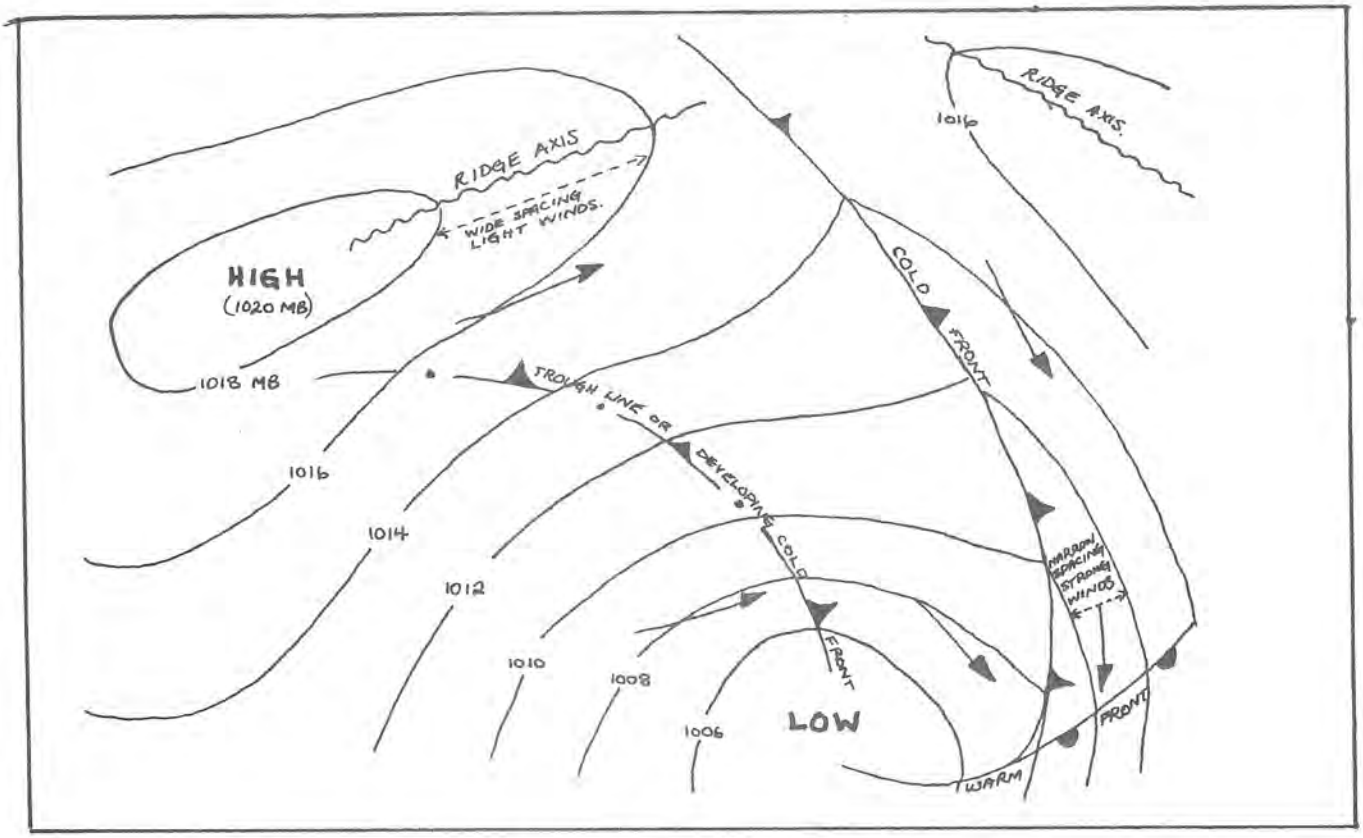


Fig. 2: A Typical Weather Map

Winds also play a vital role in small ships forecasting as can be seen by the table below:

Wind Speed (Knots)	*Sea Condition*	*Av Wave Hgt.*	*General Effect Observed*
0	calm	0	No waves break on beach
0-5	calm	0.5M	No waves break on beach
5-10	slight	1 M	Slight breaking on beach
10-15	moderate	1.5M	Waves break on beach
15-20	moderate - rough	2 M	Seas furrowed
20-25	rough	2.5M	Seas deeply furrowed
25-30	rough - very rough	3 M	Strong wind warning
30-35	very rough	4 M	Gale warning
735	extreme	4 M	Cyclone warning

Table 1: Forecast Table (modified after Beaufort)

Sample Forecast: "Double Island Point to Coolangatta" seas slight, 5-10 knot SE winds freshing to late afternoon waves to 1m in exposed waters."

THE WEATHER

CLOUD COVER

The general classifications into ten main types is as follows:—

(1) CIRRUS (Ci)—Very high thin clouds called Mares Tails; they are composed of ice particles, cast no shadow, and are uniformly white.

(2) CIRRO STRATUS (Ci-St)—A high thin white cloud sometimes like a tangled web; it often produces haloes around the Sun and Moon.

(3) CIRRO-CUMULUS (Ci-Cu)—High, small, white flakes, arranged in groups or in lines; a "mackerel sky".

(4) ALTO-CUMULUS (A-Cu)—Larger rounded white masses, partially shaded, and arranged in groups or lines.

(5) ALTO-STRATUS (A-st)—A fairly high, dense sheet of a bluish-grey colour.

(6) STRATA-CUMULUS (St-Cu)—Large lumpy masses of dull grey cloud, frequently covering the whole sky, especially in winter.

(7) CUMULUS (Cu)—Woolpack or Cauliflower cloud. A lumpy piled up cloud, formed at the top of ascending air currents.

(8) NIMBUS (Nb)—A dense layer of dark shapeless cloud with ragged edges from which steady rain falls. If a layer of nimbus is separated into a small detached cloud, it is called "scud".

(9) STRATUS (St)—A uniform layer of cloud, like fog, but not lying on the ground.

(10) CUMULO-NIMBUS (Cu-Nb)—The thunder cloud, shower cloud. Great masses of clouds rising in the form of mountains or towers.

STATE OF SEA

Despite popular theory, sheer experience has shown that the Weather Bureau is correct in by far the greatest number of its predictions. Come to rely on these as an ever-available source of help in the enjoyment of your boating.

The Weather Bureau uses certain descriptive terms which indicate windspeed and the probable maximum height of waves. In this phraseology, wave heights are those applicable to the ocean.

It is not possible to apply them to inshore water where the waves are affected by the sloping seabed as well as by offshore and onshore winds. Shallow water increases the steepness of the sea and seaswell and this should be borne in mind in interpreting the Bureau's forecasts as defined in table on the following page.

The Bureau also uses the following descriptive phrases in its broadcast to describe the height and length of swell waves.

Descriptive Term	**Height of swell** in Metres
Low	0- 2 metres
Moderate	2- 4 metres
Heavy	Over 4 metres

Descriptive Term	**Length of Swell** in Metres
Short	0- 90 metres
Average	90-180 metres
Long	Over 180 metres

In other words, when the forecast is for slight seas and a moderate swell, you can expect winds between 11-16 knots with waves averaging 0·6-1·0 metres maximum height, with swell waves between 2-4 metres.

Reprinted courtesy
Department of Harbours and Marine

BEAUFORT WIND SCALE AND SEA DISTURBANCE TABLE

Wind Force (Beaufort)*	Limits of Speed in knots†	Descriptive Terms (Sea)	Descriptive Terms (Wind)	Sea Criterion	Probable Mean Height of waves‡ (metres)	
0	Less than 1	Calm (glassy)	Calm	Sea like a mirror		
1	1– 3	Calm (glassy)	Light air	Ripples with the appearance of scales are formed but without foam crests	0·1	(0·1)
2	4– 6	Calm (rippled)	Light breeze	Small wavelets, still short but more pronounced; crests have a glassy appearance and do not break	0·2	(0·3)
3	7–10	Smooth (wavelets)	Gentle breeze	Large wavelets. Crests begin to break. Foam of glassy appearance. Perhaps scattered white horses	0·6	(0·9)
4	11–16	Slight	Moderate breeze	Small waves, becoming longer; fairly frequent white horses	1·1	(1·5)
5	17–21	Moderate	Fresh breeze	Moderate waves, taking a more pronounced long form; many white horses are formed. (Chance of some spray)	1·8	(2·6)
6	22–27	Rough	Strong breeze	Large waves begin to form; the white foam crests are more extensive everywhere. (Probably some spray)	2·9	(4·0)
7	28–33	Very rough	Near gale	Sea heaps up and white foam from breaking waves begins to be blown in streaks along the direction of the wind	4·1	(5·8)
8	34–40	High	Gale	Moderately high waves of greater length; edges of crests begin to break into spin-drift. The foam is blown in well-marked streaks along the direction of the wind.	5·5	(7·6)
9	41–47	Very high	Strong gale	High waves. Dense streaks of foam along the direction of the wind. Crests of waves begin to topple, tumble and roll over. Spray may affect visibility.	7·0	(9·8)
10	48–55	Phenomenal sea	Storm	Very high waves with long overhanging crests. The resulting foam in great patches is blown in dense white streaks along the direction of the wind. On the whole the surface of the sea takes a white appearance. The tumbling of the sea becomes heavy and shocklike. Visibility is affected	8·8	(12·5)
11	56–63	Phenomenal sea	Violent storm	Exceptionally high waves. (Small and medium-sized ships might for a time be lost to view behind the waves). The sea is completely covered with long white patches of foam lying along the direction of the wind. Everywhere the edges of the wave crests are blown into froth. Visibility is affected	11·3	(15·8)
12	64–71	Phenomenal sea	Hurricane	The air is filled with foam and spray. Sea completely white with driving spray; visibility is very seriously affected	13·7	over

* The Beaufort wind force scale extends to Force 17 (up to 118 knots), but Force 12 is the highest which can be identified from the appearance of the sea.

† Determined at coast stations for a height of 10 m above sea level.

‡ In enclosed waters, or when near land with an off-shore wind, wave heights will be smaller and the waves steeper. Figures in brackets indicate the probable approximate maximum height of waves.

Reprinted courtesy
Department of Harbours and Marine

STUDY ASSIGNMENTS

1. Why are the Trade Winds important?

2. Of what significance are the DOLDRUMS, WESTERLIES to Mariners?

3. Make a poster of the various cloud types.

4. What is the Marine Operations Centre in Canberra? What role does it play in Maratime EM urgencies? Write to them and see what publications they have.

5. Distinguish between Cyclones, Hurricanes and Typhoons.

6. Distinguish between Tornadoes, Willy-Willies and Water-spouts.

7. Distinguish between Troughs and Ridges.

8. What is a Line Squall?

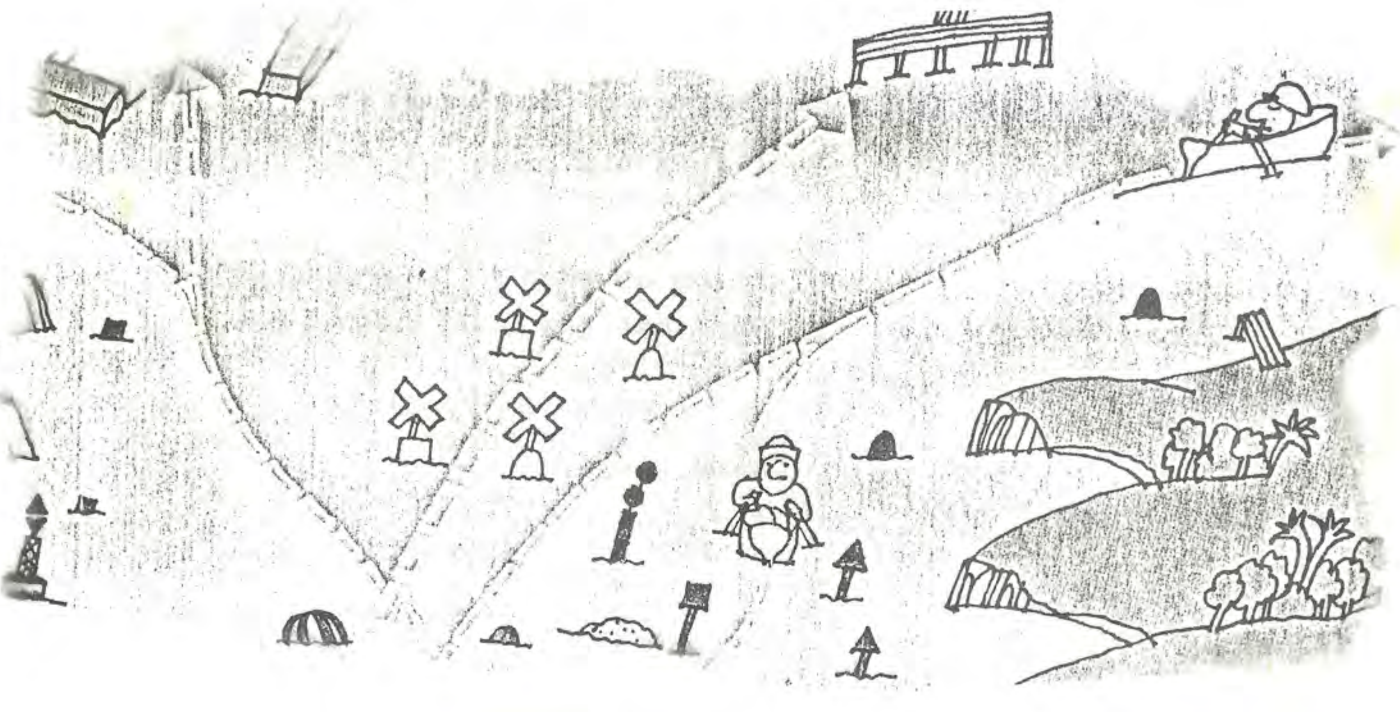
PRACTICAL EXERCISES

1. Obtain a Thermometer, Barometer, Weather Vane, Psychrometer, (wet and dry Bulb Hydrometer), and learn how to take measurements.

2. Set up a weather station and prepare a talk on the weeks weather.

3. Make up a small ships forecast.

4. Go to a Radio Station and see how forecasts come in from the Weather Bureau and are broadcast.



GLOSSARY :

BASIN	:	Bottom of the ocean floor.
BREAKERS	:	Large waves that release their energy at the shore.
CONTINENTAL SHELF	:	Part of ocean floor extending from the shore for 200m.
CONTINENTAL SLOPE	:	Part of ocean floor which extends from shelf to ocean depths.
CONTINENTS	:	Large masses of land on earth.
CAY	:	Sand mass sometimes with vegetation extending up from Continental Shelf and built on Fossil Reef.
CORAL	:	Skeleton remains left by Reef building animals.
CURRENTS	:	Moving bodies of water.
CREST	:	Top of a wave.
ECHO SOUNDING	:	A method of finding the oceans depths by sounding out waves.
ESTUARY	:	Brackish body of water formed from a
FRINGING REEF	:	A reef that develops off a continental Island or Coastline.
FOSSIL REEF	:	Dead reef that was alive before or during Ice Ages.
HYDROSPHERE	:	Part of the earth covered by water.
LATITUDE	:	Lines which run up and down the Earths surface.
LONGITUDE	:	Lines which run across the Earth surface.
NAVIGATION	:	The art of finding the position and direction of ships at sea.
NAUTICAL MILE	:	One degree of latitude.
PATCH REEF	:	Reef that has grown up from Continental Shelf since Ice Age.
RIBBON REEF	:	Similar to Patch Reef but forms long chains at edge of Continental Shelf.
SEDIMENT	:	Matter that has been washed down rivers by erosion.
TRADE WINDS	:	Powerful winds in Tropical Regions, the major driving forces of currents in these areas.
WAVE CUT CLIFF	:	Cliffs resulting from action of waves against rocky shoreline.
WAVE CUT TERRACE	:	Results from rocks accumulating at the base of a cliff.

SCIENCE TEACHERS ASSOCIATION OF QUEENSLAND

(Incorporated in Queensland)

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Mr Bob Moffatt
c/- Benowa Marine
Benowa S H S

14 June 1984

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