Section 6: Coastal Navigation

Section Contents Page

Section learning outcome

Learning outcome 6

Apply navigation techniques to ensure the safe navigation of a small vessel in sheltered and inshore waters.

Assessment Criteria:

Interpret the information displayed on a large scale hydrographic chart of the local area to identify:

- Title, number scale and other information provided in the title block and margins
- prominent features
- dangers including isolated dangers
- tidal data
- tidal streams and currents
- navigational aids
- depth contours and nature of bottom

Interpret the information contained in other types of charts that may be available of the local area and understand the limitations of the information.

Use a large scale chart to lay off a bearing, plot a safe course and measure distance

Solve simple speed/time /distance problems

Use transits, beam marks and leading lights to establish position lines

Use various techniques to estimate distances off

Identify the times and heights of high and low water from local tide tables

Use the vessel's compass to steer a course and take bearings

Apply the IALA Buoyage System A to the safe navigation of the vessel

Conditions

The learner will be provided with: charts of the local area plotting instruments, tide tables, access to a vessel with appropriate navigational equipment for practical assessment, models to assist with oral explanations and/or diagrams to assist with written explanations access to approved safety equipment for use during practical exercises.

The learner will provide:

- work clothes including safety footwear and weather protection gear
- notebook and pen

This learning outcome may be assessed through practical exercises onboard a vessel of appropriate size and power, supported by oral questioning technique, written tests and plotting exercises.

Section introduction

In this section we will examine the basic principles of coastal navigation. These concepts will be essential in navigating around the 15 nautical mile limit of operation.

Section learning sequence

- Information on Charts
- Position and Measurement
- Using the Chart
- Speed, Time and Distance
- Transit Bearings
- Tides
- Steering by Compass
- Buoyage

The Chart

The chart is essential for the safe navigation of a vessel. The chart is a scaled representation of the area used by vessels either operating off the coast, on ocean passages or even inland waters.

6.1 Information On A Chart

There is a great deal of information presented on a nautical chart, and you need to be able to interpret it correctly. Much of the information is in symbol or abbreviated form and coloured for easier identification. These are all listed in the publication NP 5011 Chart Symbols and Abbreviations.

Practical Activity

Obtain a chart, preferably one from your local area. Examine it closely and observe as many different features as possible.

6.1.1 Main Features

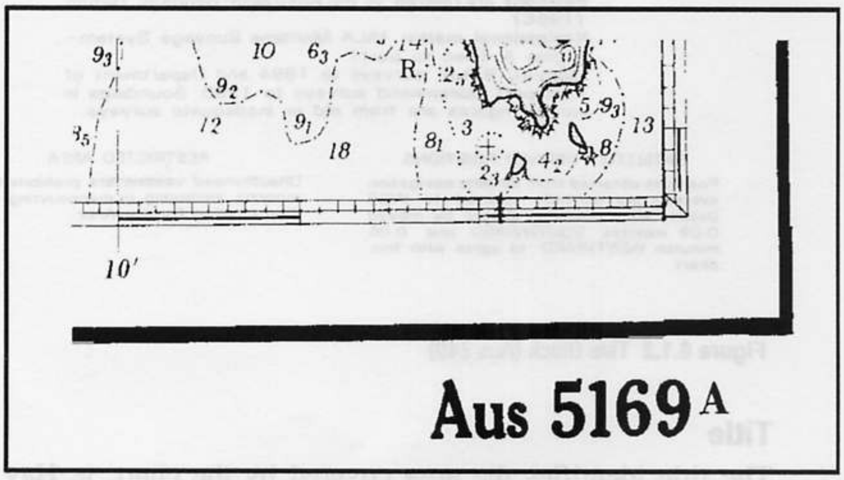


Figure 6.1.1

Chart Number

The number of the chart is printed boldly outside the margin at the top left and bottom right. The chart number is used to identify the chart.

Latitude and Longitude Scale

The latitude scale is found on the sides of the chart. The longitude scale is at the top and bottom of the chart. Latitude and longitude is used to identify a position.

AUSTRALIA - EAST COAST

QUEENSLAND

HAY POINT

TO

PENRITH ISLAND

SCALE 1:75 000 at Lat 27°15'

Depths are in metres and are reduced to Chart Datum, which is approximately the level of Lowest Astronomical Tide.
Heights are in metres. Underlined figures are drying heights, in metres and decimetres, above Chart Datum, all other heights are above Mean High Water Springs.
Projection: Mercator
Positions are related to the Australian Geodetic Datum (1966).
Navigational marks: IALA Maritime Buoyage System - Region A (Red to port).
Sources: R.A.N. surveys to 1984 and Department of Transport Queensland surveys to 1990. Soundings in upright figures are from old or inadequate surveys.

SATELLITE - DERIVED POSITIONS

Positions obtained from satellite navigation systems are normally referred to WGS Datum; such positions should be moved 0.09 minutes SOUTHWARD and 0.06 minutes WESTWARD to agree with this chart.

RESTRICTED AREA

Unauthorised vessels are prohibited from mooring, anchoring or manoeuvring in the Ship Loading Facility Area.

Figure 6.1.2 Title Block (Aus 249)

Title

The title identifies the area covered by the chart, ie Hay Point to Penrith Island.

Scale

The scale of a chart is a ratio, ie 1:75000, it represents a given distance on the chart to the real distance.

Depths

Depths are either in metres or fathoms. It is very *important to know the units of depth* that you are currently using. Metric charts have the land coloured yellow, and also display the legend 'depths in metres' outside the border of the chart next to the chart number. On Imperial charts, the land is a light grey colour.

Aus 831 DEPTHS IN METRES

Soundings or depths are always measured below the chart datum. Chart datum is a fancy name for a level which is round about the lowest low tide level. This means that the height of tide is almost always added to the sounding on the chart.

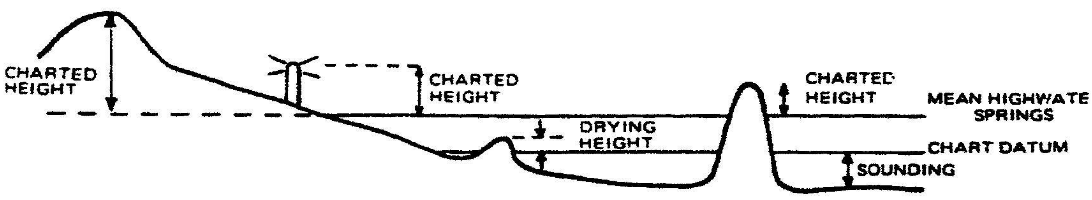


Figure 6.1.3 Depths and Heights

Rocks and beaches that cover and uncover with the tide may have a drying height marked on or alongside them. This drying height is measured (in feet or metres) above chart datum. Thus a rock with a drying height marked will not always be visible. You will only be able to see it when the tide has fallen below the height of the rock.

Heights

Heights ashore are measured in feet or metres above mean high water springs, which is the highest normal high water. This is so that the height shown on the chart will be the minimum height of the object above water level. When the tide is below high water the actual height of an object above water level will be increased by the amount of fall of tide.

Sources or Authorities

This will indicate how recently the survey was conducted, in this case, 1990. Modern electronic equipment, ie echo sounder and sonar, were used to survey the area. Newer charts will have Reliability Diagrams or Zones of Confidence (ZOC) diagrams to enable the user to assess the accuracy of the chart.

Notes and Cautions

There may be other information below the title:

- Navigational marks
- Restricted areas
- Satellite – Derived Positions
- Tidal streams
- Magnetic Anomalies etc

For example,

FORMER MINED AREAS

Trinity Opening, Papuan, Cruiser and Lark Passages have been swept and are open to surface navigation only. They are not safe for anchoring, trawling or bottoming by submarines owing to mines.

CAUTION – INCOMPLETELY SURVEYED

Owing to the incomplete nature of surveys in the areas indicated, shoaler water than charted may exist.

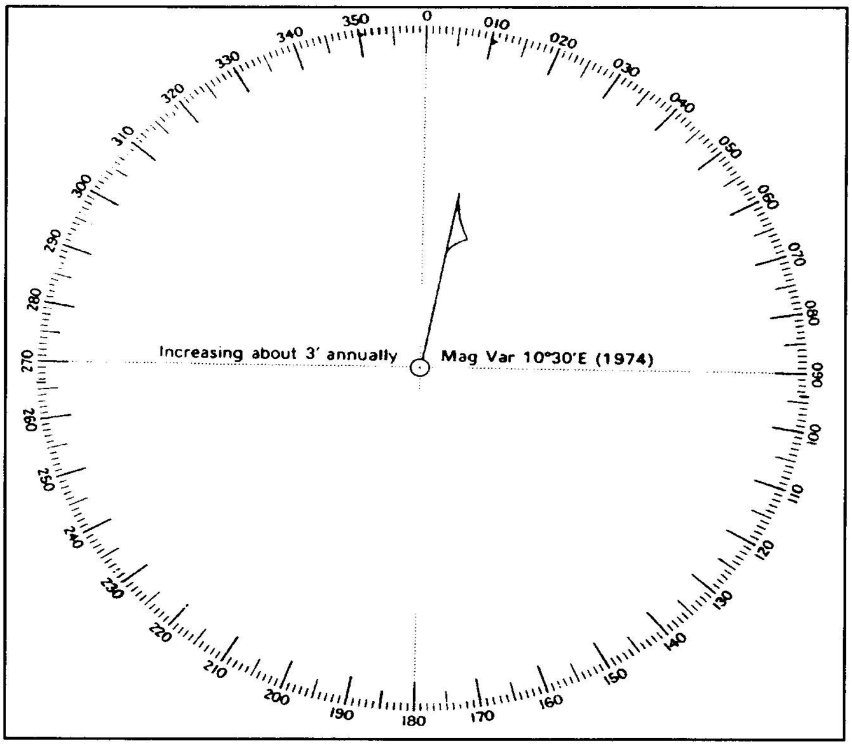


Figure 6.1.4

Compass Rose

The compass rose indicates direction on the chart, true north, magnetic north and magnetic variation for a given year.

Depth Contours

A depth contour is a line joining soundings of equal depth, ie 10 metres. On the example, Cape Bedford. Look closely and identify the 2, 5, 10, 15 and 20 metre depth contours. Note, on a photocopy how hard it is to distinguish between the shore, 2 and 5 metre depth contours without colour.

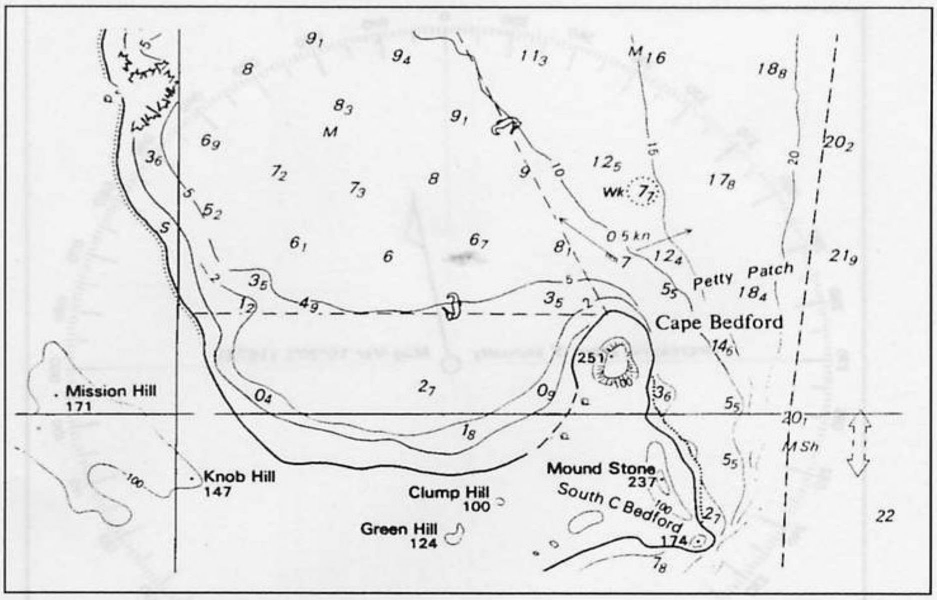


Figure 6.1.5 Cape Bedford (Aus 831)

Nature Of Bottom

This is the type of bottom, ie mud, sand, shells etc. On a chart mud is abbreviated as M, sand as S and shells as Sh. There are many variations of bottom types and colour. Look at the example, Cape Bedford and identify the bottom type. All of the abbreviations are found in NP 5011.

Buying a Chart

When you purchase a chart from a Chart Agency you must ensure the chart is the latest edition and is corrected up to date. The corrections and edition will be printed on the bottom margin of the chart.

Practical Activity

Now compare and identify the main features between a metric and Imperial (fathom) chart. Note well the units of depth.

6.2 Position And Measurement

6.2.1 Position

Latitude and longitude is one method of identifying a vessel's position at sea. This position is expressed in degrees, minutes and decimal of a minute, ie 27° 30´.5 (meaning 27 degrees, 30.5 minutes). 60 minutes equals one degree.

Small Ships Manual or Australian Boating Manual. Chapter on Chartwork. Read the definitions on latitude, longitude and for general reference.

Simply, latitude is expressed in degrees between 0-90° North (N) or South (S) of the equator. Latitude is also referred to as parallels of latitude.

Longitude is expressed in degrees between 0-180° East (E) or West (W) of Greenwich, the prime meridian. Longitude is also referred to as 'a meridian of longitude'.

When a position is given latitude is always given first,
ie 27° 30´.5 S 153° 45´.5 E

6.2.2 Measurement

The nautical mile is always used to measure distance on a chart. One nautical mile (nm) is equal to 2000 yards (1852 metres).

The latitude scale on the chart is used to measure distance. One degree of latitude equals 60 nm. Since one degree equals 60 minutes therefore, one minute of latitude equals one nautical mile.

one minute or 1´	= 2000 yards
0´.1	= 200 yards or 1 cable

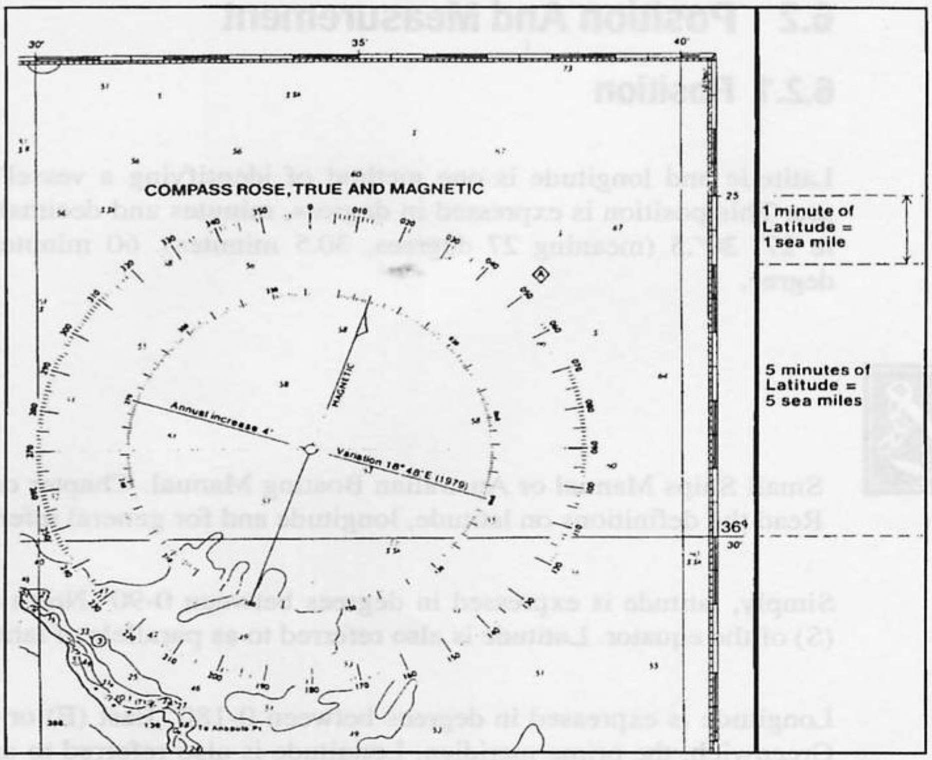


Figure 6.2.1 Reading Chart Distance (Drawing by courtesy of Coastal Yacht Navigation)

NOTE: Longitude is never used to measure distance.

Practical Activity

Using various local charts, identify a distance of one nautical mile. Ask your master/facilitator to assess you with the following:

1. identify a distance of one nautical mile, ie minute of latitude.
2. compare one minute of latitude to one minute of longitude.
3. discuss why longitude is not used to measure distance.

Measurement of direction

True direction is measured from true north. Direction is defined as the point on the horizon towards which a vessel is heading.

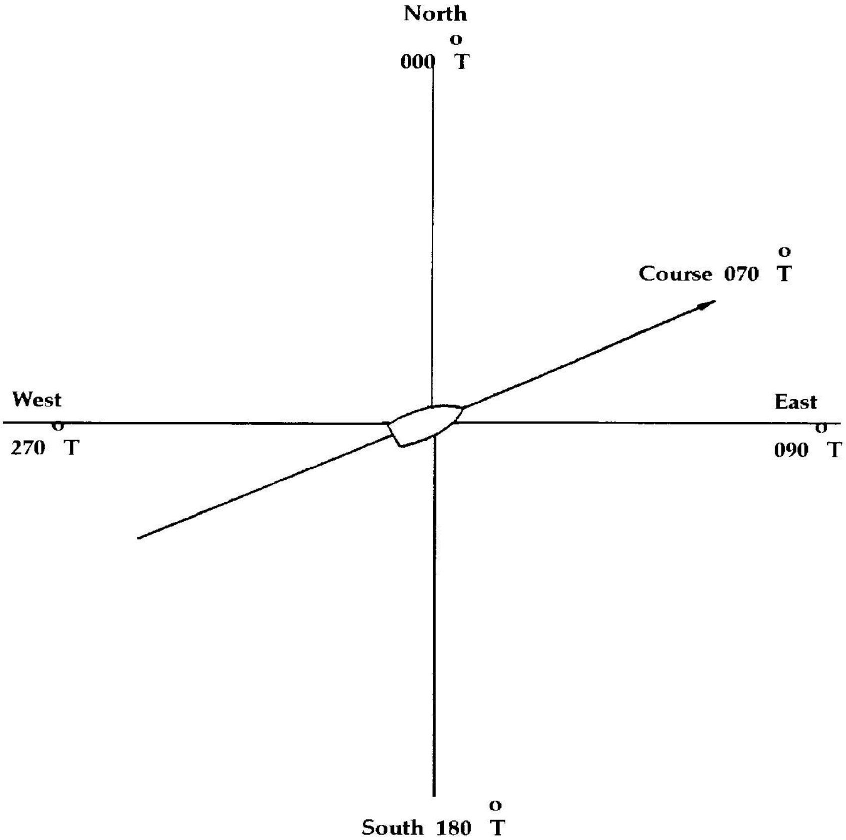


Figure 6.2.2 The cardinal points

NOTE: The direction the vessel is heading, 070° T (True). All courses and bearings should be given in a three digit format to avoid confusion.

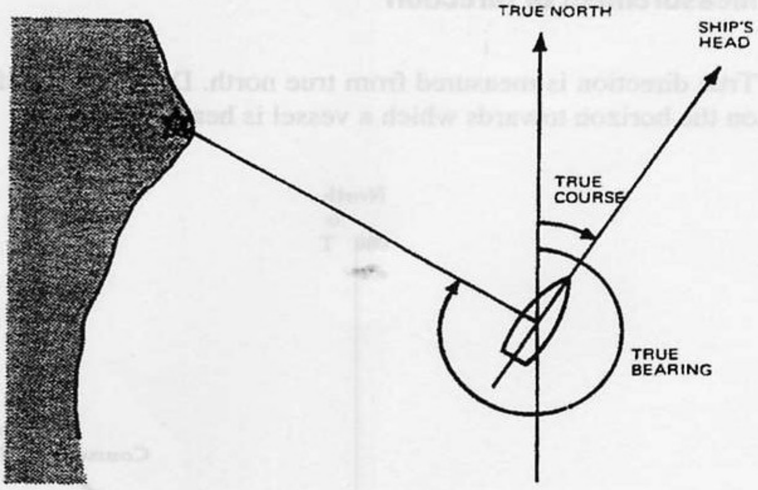


Figure 6.2.3 True course and true bearing

The *true course* the vessel is steering is the angle between true north and the vessel's head. The *true bearing* of any object from the vessel, is the angle between true north and the line joining the vessel to the object. The compass rose is used to measure true courses and bearings on a chart.

6.3 Using The Chart

6.3.1 The navigator's instruments

Data for use in coastal navigation is obtained from the compass and electronic aids such as radar, echo sounder and GPS. To work on the chart, the coxswain needs

- a soft (2B) pencil
- a soft eraser
- a pair of dividers
- a large compass
- parallel ruler, either roller, Capt Fields type or navigational triangles

What type of instruments you use is entirely a matter of choice. The only criterion is that you are able to measure, and transfer, distances and directions accurately and correctly from one part of the chart to another. This course describes the use of parallel rulers and dividers. If you are using different instruments, you need to perfect a slightly different technique.

Using the instruments

Practical Activity

On your vessel check the equipment available and ask the master/facilitator to show you how to use them effectively, especially drawing and transferring a line.

6.3.2 Position Lines

When you obtain a bearing of a lighthouse or other terrestrial object, and convert it to a true bearing, it can now be plotted on a chart. As this is a true bearing, the vessel must lie somewhere on this line. This line of bearing is called a *position line* and is the basis of position fixing.

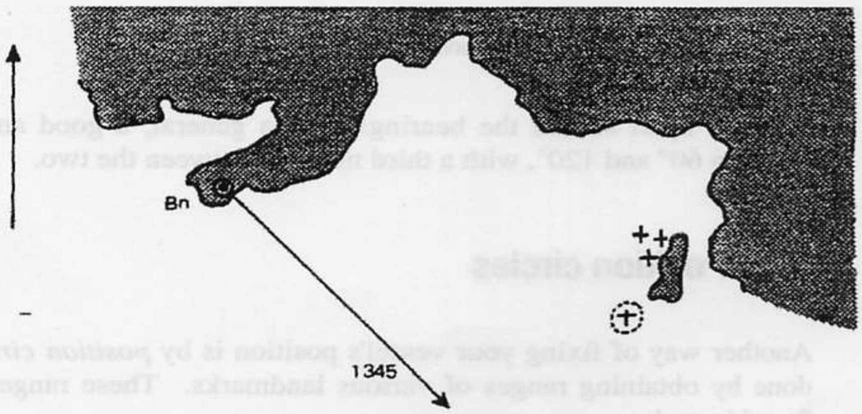


Figure 6.3.1

To obtain a fix, we could take a bearing of a second object and obtain another position line. We have already stated that the vessel must lie on a position line, so if we have two position lines then we must be at their point of intersection.

For better accuracy it is better to fix your vessel's position using *three* position lines if possible. See Fig 6.3.2.

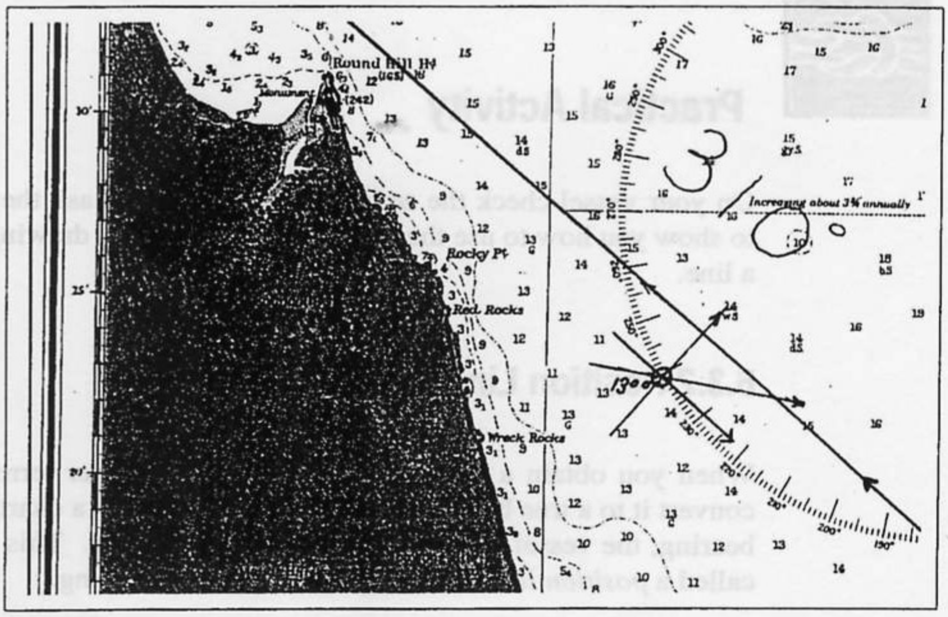


Figure 6.3.2: Fix by three cross bearings

How far apart should the bearings be? In general, a good angle of cut is between 60° and 120°, with a third midway between the two.

6.3.3 Position circles

Another way of fixing your vessel's position is by *position circles*. This is done by obtaining ranges of various landmarks. These ranges are usually found by radar.

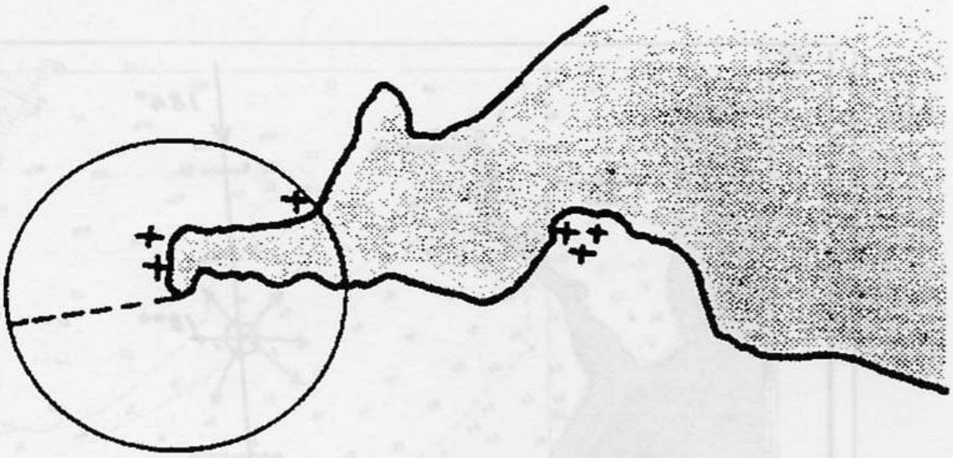


Figure 6.3.3

For example, if you obtain a radar range of a headland of four miles, you must be somewhere on a circle with a radius of 4 miles from that headland.

If at the same time a second range circle can be obtained, your vessel must lie at the point of intersection of the two range circles. (See Figure 6.3.4).

Again, it would be more accurate to fix the vessel's position with three ranges. See Fig 6.3.4.

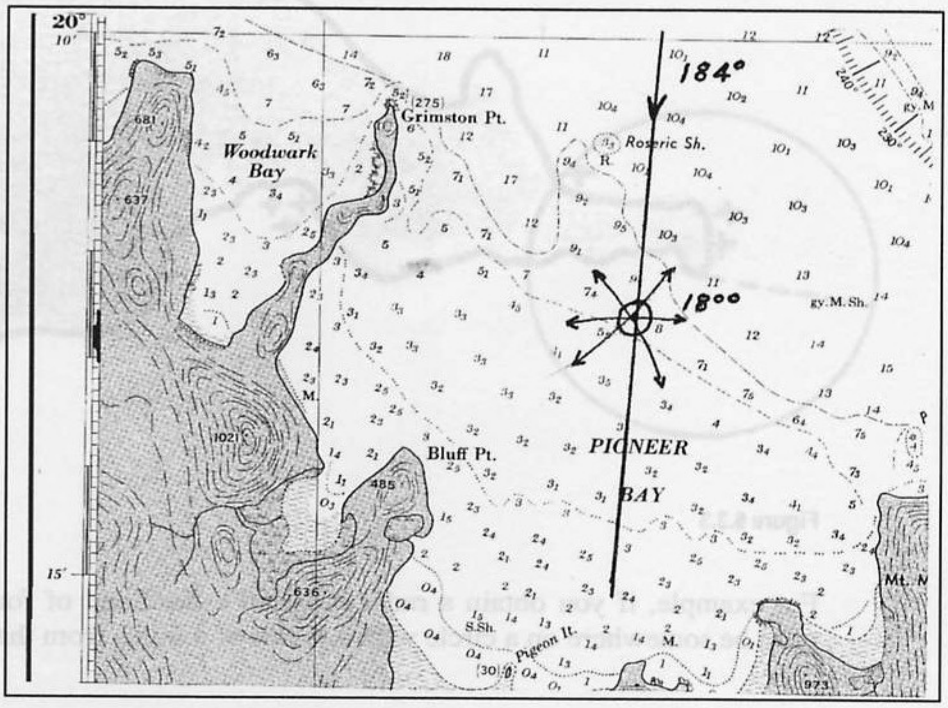


Figure 6.3.4 Fix by three radar ranges

Ranges must be taken off the adjacent latitude scale and the relevant arc plotted on the chart using compasses. Both ends of the arcs should be marked with a single arrow, the point of intersection circled, and the time of the fix written alongside.

Selection of objects for ranges is as important as it is with bearings.

Practical Activity

If your vessel is fitted with a radar, with the permission of the master, take two or three ranges simultaneously and plot your position on the chart. Note the exact time that you observed the radar ranges.

If you can taken bearings with a compass or even a hand held compass repeat the above exercise using two or three usual bearings.

Have the master/facilitator check this position.

Please note at this point that you are not limited to using one method or the other; the two methods are often mixed.

You must be aware that even if you obtain an apparently perfect fix using two bearings or two ranges it could be wrong. Hence, it is necessary to cross-check with a third bearing and/or range. Also check that you have correctly identified the object(s) that you are taking for a fix.

6.3.4 Plotting Position by Latitude and Longitude

We will consider plotting our position on the chart from a given latitude and longitude. There are two methods of carrying this out.

You will be able to follow the process by looking at Fig 6.3.5.

Place one edge of the parallel ruler along one of the parallels of latitude printed on the side of the chart and walk the ruler until one edge passes through the given latitude.

Pencil in the latitude line.

Now line up the ruler with a longitude meridian and walk the ruler across the chart until one edge is through the correct longitude. Pencil in the line and where it crosses the latitude line is your position.

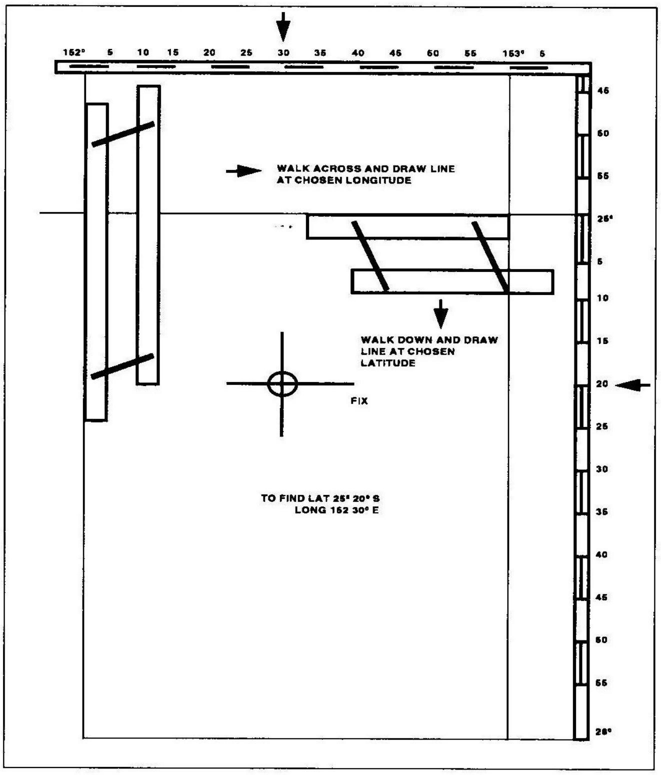


Figure 6.3.5: Plotting Lat. and Long. Using Parallel Rules

An alternative method is shown in Fig 6.3.6.

Line the ruler up on the correct latitude and then with a pair of dividers measure to the required mark on the longitude.

This method can be worked with the ruler on the longitude and the dividers on the latitude.

Remember to express Latitude and Longitude in degrees, minutes and tenths of a minute.

e.g.	Latitude	25° 15´.2 S
	Longitude	150° 25´.9 E

6.3.5 Satellite-Derived Positions

The United States Navstar Global Positioning System (GPS) is a satellite navigation system widely used by mariners. Positions from GPS receivers should be corrected before plotting on a chart. Many groundings have resulted because of incorrect interpretation of GPS position.

SATELLITE-DERIVED POSITIONS

Positions obtained from satellite navigation systems are normally referred to WGS72 Datum; such positions should be moved 0.09 minutes SOUTHWARD and 0.06 minutes WESTWARD to agree with this chart.

This note may be found under the title block on your chart. Basically, GPS uses a different datum to refer positions. Therefore, you should apply the adjustments as stated in the note.

An example of how the adjustment should be made using the above note. The shift is 0.09 minutes SOUTHWARD and 0.06 minutes WESTWARD.

Satellite-Derived Position (WGS84)	34° 02´.00 S	151° 30´.00 E
Lat/long adjustments	0.09 S	0.06 W
Adjusted position (compatible with chart datum)	34° 02´.09 S	151° 29´.94 W

Practically the shift is to the south west by approximately 200 yards.

Practical Activity

When alongside, plot the vessel's uncorrected GPS position and discuss with your master/facilitator the degree of reliance that can be placed on the system.

Further information on GPS Derived Positions is available in the Annual Australian Notices to Mariners.

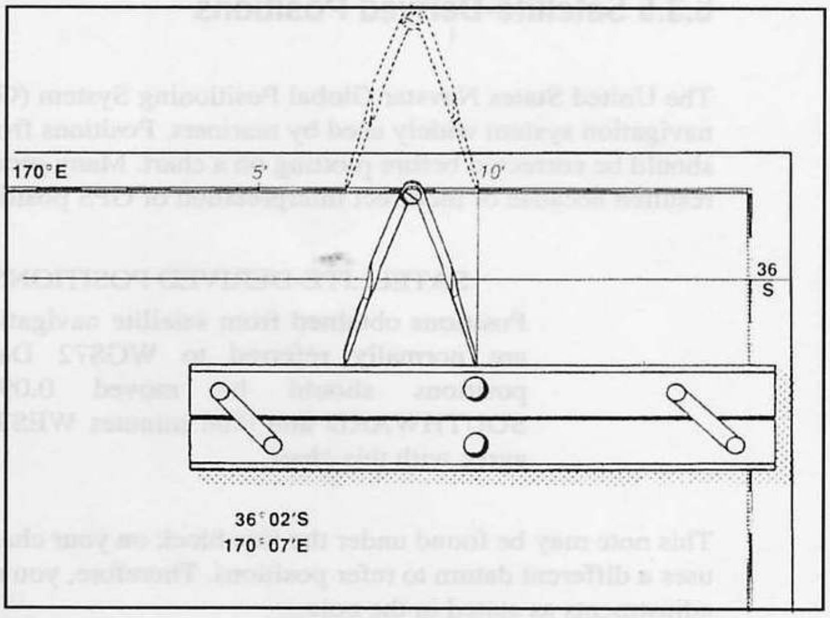


Figure 6.3.6: Plotting Lat. and Long. using Parallel Rules and Dividers

Practical Activity

Select a chart, ask your master/facilitator to demonstrate plotting a position, then complete the following tasks:

- Plot two other positions on the chart.
- Find the latitude and longitude of two given positions.
- Have your work checked.

6.3.6 Laying off courses on a chart

Use the largest scale chart available and study it carefully. When laying off a course bear in mind the following:

(a) Keep well clear of hazards and dangers near the coast.

(b) It is preferable to keep close to the coast by day so that identification of terrestrial objects is facilitated and constant fixing made possible.

(c) By night, the distance from the coast should be increased keeping within visible range of lights.

(d) If weather and visibility deteriorate, avoid a course that converges with the land.

(e) Allow for effects of wind, current and tidal streams. Beware a "lee shore", where you may be blown or set into danger.

(f) Bear in mind the traffic density.

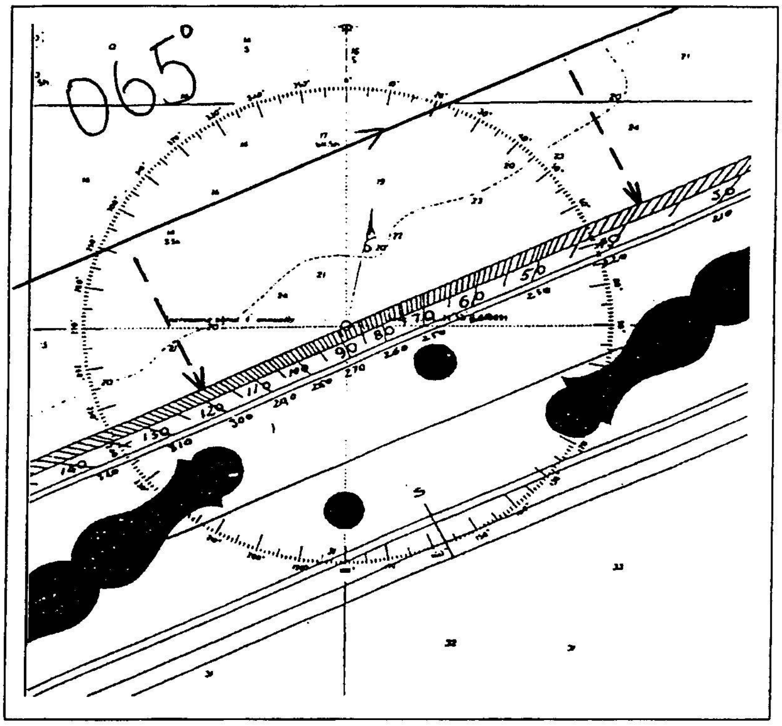


Figure 6.3.7: Reading a Bearing or Course from the Compass Rose

Put your parallel rules on the course line diagram (Fig 6.3.7) and then manoeuvre the parallel rules to the nearest compass rose. Put the edge of the parallel rules through the centre of the rose and look at the edge of the compass rose. Where the parallel rules cuts the edge, you can now read off the course to steer. It should be 065° T.

6.3.7 Measuring Distance

Take the dividers and open them until the points are on the two places in question. The dividers are moved to the side of the chart adjacent to the middle of the course and the distance is read.

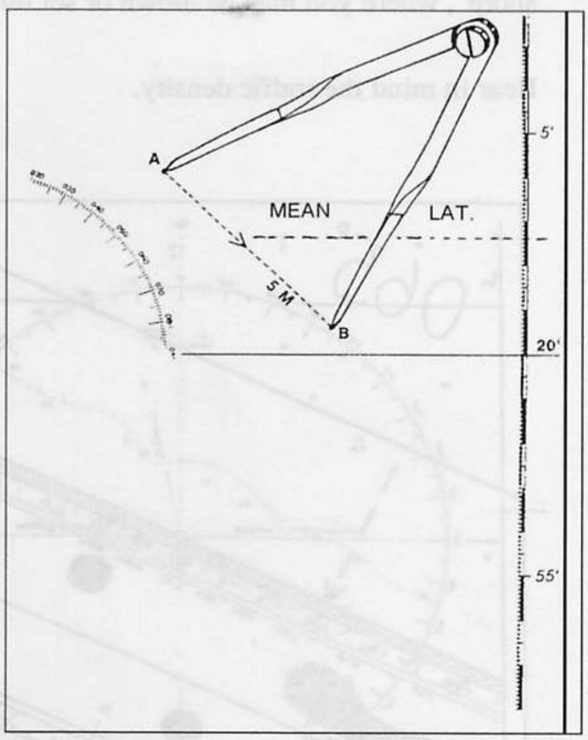


Figure 6.3.8: Measuring Chart Distance Using Dividers

On most coastal charts the minutes of latitude are subdivided into tenths and it is usual to express distance in miles and decimals of a mile e.g. 5.8 mile.

Practical Activity

Ask you master/facilitator to select two positions, A and B on your chart.

Find the true course to steer from A to B and measure the distance. Have the answer checked.

Practice laying off safe courses, use your parallel ruler to find the course to steer and measure the distance to run.

6.4 Speed, Time & Distance

The *day* is a unit of time of twenty-four hours. The start of the day is 0001, or midnight.

The first two figures represent the hours and the second two figures represent the minutes of the hour. Thus, looking at the clock as you know it, we have the following:

The 24-Hour Clock

Midnight - 0001	12 noon - 1200
1 am. - 0100	1 pm. - 1300
2 am. - 0200	2 pm. - 1400
3 am. - 0300	3 pm. - 1500
4 am. - 0400	4 pm. - 1600
5 am. - 0500	5 pm. - 1700
6 am. - 0600	6 pm. - 1800
7 am. - 0700	7 pm. - 1900
8 am. - 0800	8 pm. - 2000
9 am. - 0900	9 pm. - 2100
10 am. - 1000	10 pm. - 2200
11 am. - 1100	11 pm. - 2300
	Midnight - 2359

The minutes are added as follows:

5.10 am. = 0510
1.45 pm. = 1345

EXAMPLE 1

What is the time interval between 0915 and 1733?

  1733
- 0915
  0818 or 8 hours 18 minutes

EXAMPLE 2

What is the time interval between 0312 6th June and 1839 6th June?

```
  1839  6th June
- 0312  6th June
  1527
```

or 15 hours 27 minutes.

Speed and distance

If you were in a car travelling at 60 kilometres per hour and your passenger asked you how far you would travel in 3 hours, you would quickly give the answer "180 kilometres". If the time were 3 1/2 hours you would quickly reply "210 kilometres". But what about 3 hours 42 minutes?

To decimalise minutes, divide the number of minutes by 60.

EXAMPLE 1

$$\frac{42}{60} = 0.7 \text{ hours}$$

42 minutes = 0.7 hours

Well, we can do exactly the same with time, so in the problem above, 3 hours 42 minutes becomes 3.7 hours, and at 60 kilometres per hour we would cover 3.7 x 60 = 222 kilometres.

EXAMPLE 2

What is 12 hours and 54 minutes expressed in hours?

$$\frac{54}{60} = 0.9$$

12 hours 54 minutes = 12 + 0.9 = 12.9

6.4.1 Distance Calculations

As mentioned in the introduction to this section, the units used in navigation to express speed, distance and time are knots, nautical miles, and the 24-hour clock.

The *knot* (kn) is the nautical term for expressing speed and is defined as one nautical mile per hour.

If any two of time, speed and distance are known, the third can be found.
If we require the *distance* (D), we multiply S by T (Speed x Time).

If we require the speed we divide D by T $\frac{\text{Distance}}{\text{Time}}$,

and if we require the time we divide D by S $\frac{\text{Distance}}{\text{Speed}}$

To summarise:
distance = speed x time

$$\text{time} = \frac{\text{distance}}{\text{speed}}$$

$$\text{speed} = \frac{\text{distance}}{\text{time}}$$

EXAMPLE 1

Your vessel has been steaming for 7 hours 36 mins at 12 kn. What distance have you covered?

distance	=	speed x time
	=	12 x 7.6
	=	91.2 nm

EXAMPLE 2

Your vessel has 38 nm to go to reach port and your speed is 6.7 kn. How long will it be before you reach port?

$$\text{time} = \frac{\text{distance}}{\text{speed}}$$

$$= \frac{38}{6.7}$$

$$= 5.67 \text{ hours}$$

$$= 5 \text{ hours } 40 \text{ mins.}$$

EXAMPLE 3

Your vessel has travelled 48 nm at 10.2 knots. What has been the speed made good?

$$\text{speed} = \frac{\text{distance}}{\text{time}}$$

$$= \frac{48}{10.2} = 4.7 \text{ kn}$$

6.5 Transit bearings

When two charted objects come into line they are said to be in transit. One of the easiest ways of obtaining a position line is by using a transit. A transit can be used with a radar range or a sounding to obtain a fix without using a compass. Transit bearings are also an instant way of checking compass error.

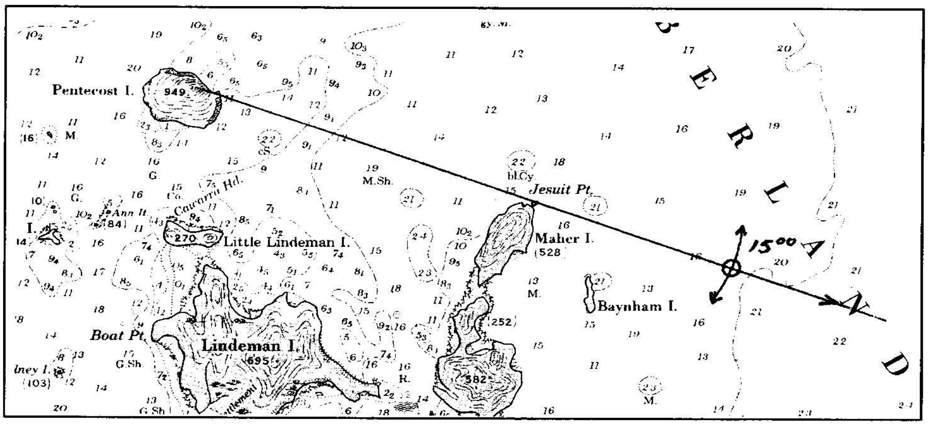


Figure 6.5.1 Transit with Radar Range

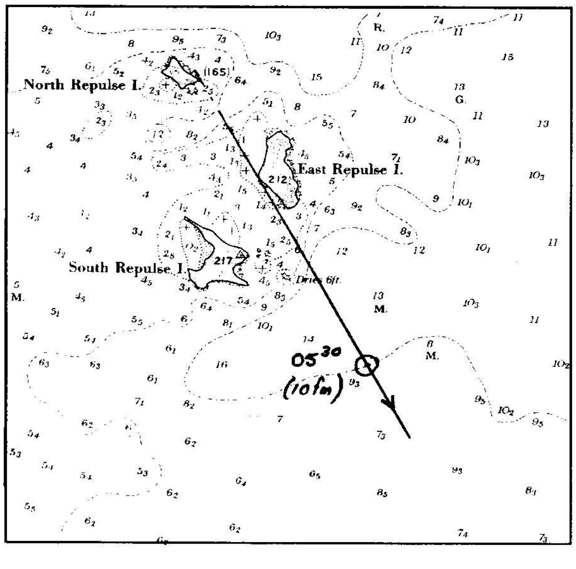


Figure 6.5.2 Transit with Sounding

Leading Lights

Leading lights and beacons are established to indicate the centre of a channel. Leading lights are also transits, so they are position lines and can be used to check compass error.

When entering or leaving a harbour you would be using leading lights to keep within the channel and also monitor the effects of wind and tidal stream on your vessel.

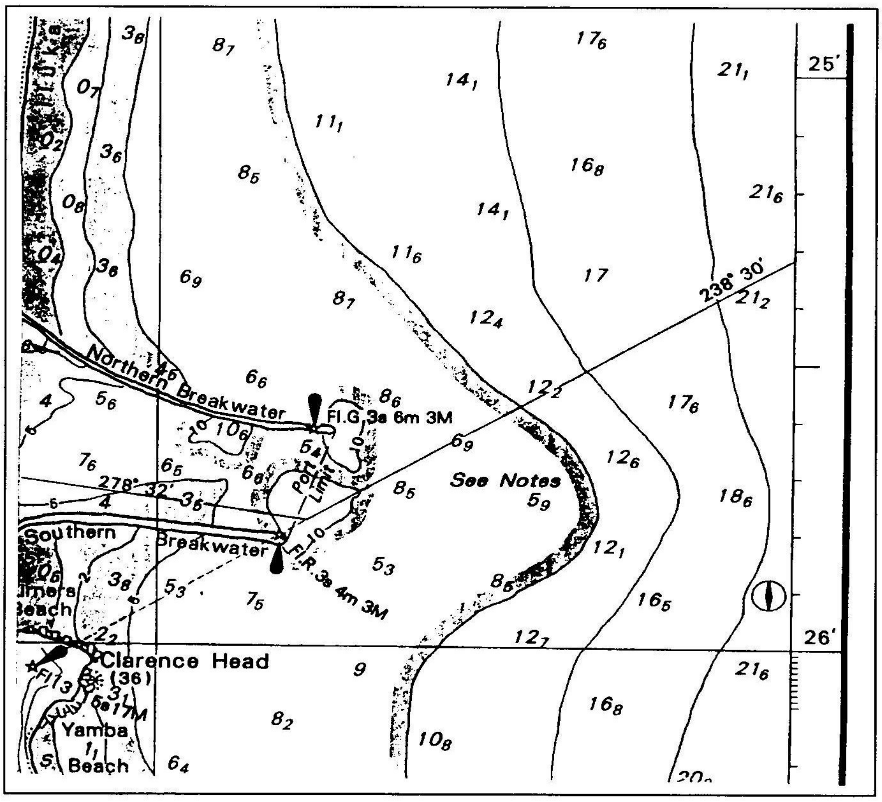


Figure 6.5.3 Leading Lights (AUS 220)

Beam Marks

Beam marks are charted objects, ie beacons, edges of land etc, which will pass on a vessel's beam. You can use a beam mark to visually estimate your position when running on a transit.

Since, a transit is a position line and beam marks have a high rate of change it is a very practical way to estimate a vessel's position.

6.5.1 Estimating Distance Off

There are many ways of estimating a distance off. The four-point bearing and doubling the angle on the bow are two useful examples. Your master/facilitator would be able to identify other methods.

The Four-Point Bearing

This is a type of running fix in which the first bearing is taken when the object is at four points (45°) on the bow. When the object is on the beam the range will be the same as the distance run since the first bearing was taken. The disadvantage of the four point bearing is that the range of the single object is not known until it is abeam. This is of little help in passing at a safe distance.

The four point bearing is illustrated below:

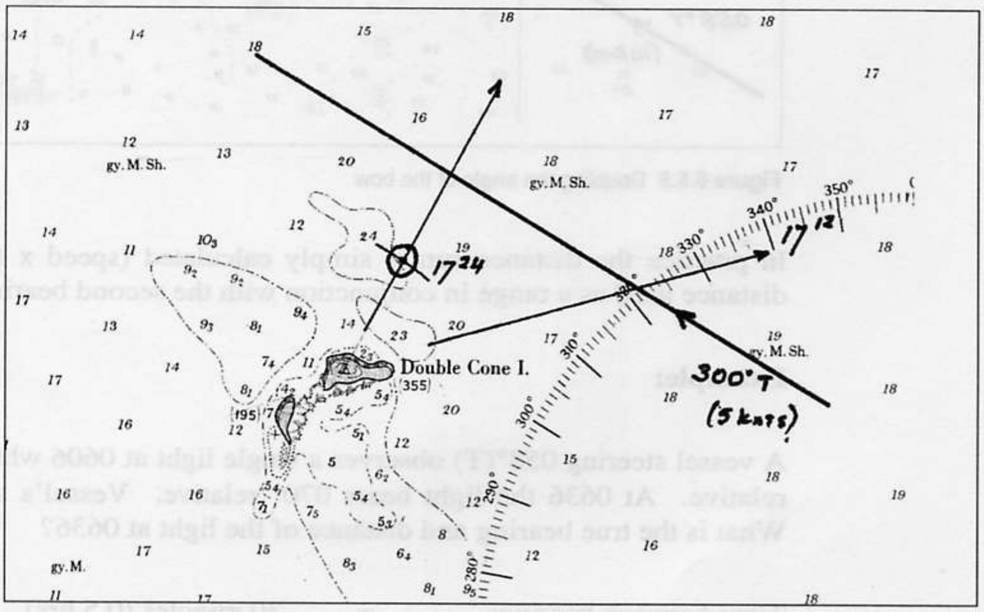


Figure 6.5.4 Four Point Bearing

With all types of running fix the accuracy of the final position depends on the accuracy of the prediction of the course and distance made good between bearings, ie effect of tidal stream.

Doubling the Angle on the Bow

This is a type of running fix which takes advantage of the properties of isosceles triangles.

As illustrated the angle on the bow when the first bearing is taken is 35°. The time of this bearing is noted and the bearing then carefully watched until the angle on the bow doubles to 70°. The triangle formed by the two position lines and the course line is isosceles, therefore the range at the time of the second bearing is equal to the distance run between bearings.

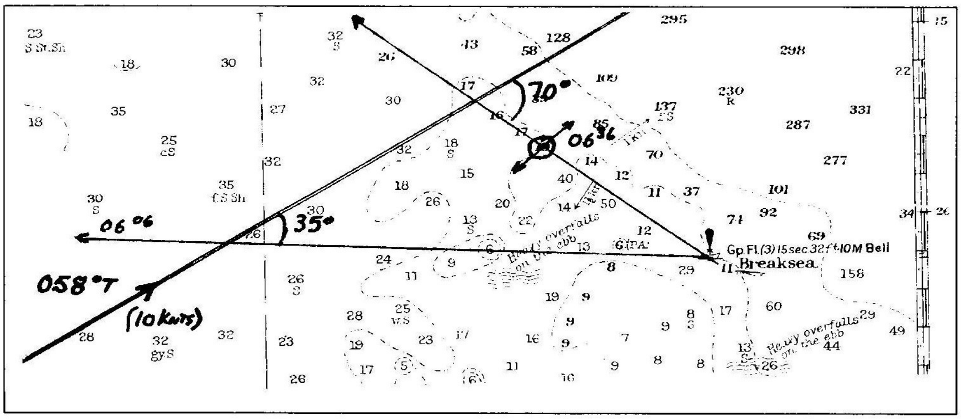


Figure 6.5.5 Doubling the angle of the bow

In practice the distance run is simply calculated (speed x time) and this distance used as a range in conjunction with the second bearing.

Example:

A vessel steering 058°(T) observes a single light at 0606 which bears 035° relative. At 0636 the light bears 070° relative. Vessel's speed 8 knots. What is the true bearing and distance of the light at 0636?

Time between bearings	=	30 minutes (0.5 hrs)
So distance run	=	8 x 0.5 miles
	=	4.0 n. miles
True course	=	058°(T)
Relative bearing	=	070°(R)
So true bearing	=	128°(T)

Answer: At 0630 the light bears 128°(T) at distance 5.0 n.miles.

6.6 Tides

Tides are vertical movements of water, causing high tides and low tides.

Causes of tides

Tides are caused by the gravitational effect of the moon, and to a lesser extent the sun, on the oceans and seas. Basically, the tide-raising force exists because of the difference between the gravitational forces exerted by the moon and the sun.

Spring tides and neap tides

When moon and sun work together, at new moon and full moon, high tides are higher, and low tides lower, than average. There is a larger tidal range. These are spring tides. At first and third quarters the sun and moon work against each other. High tides are lower, and low tides higher, than average. There is a small tidal range. These are neap tides. Note - the range is the difference in metres between high and low water.

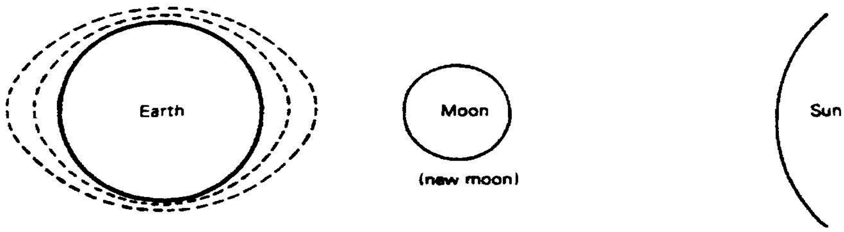


Figure 6.6.1 Spring tides

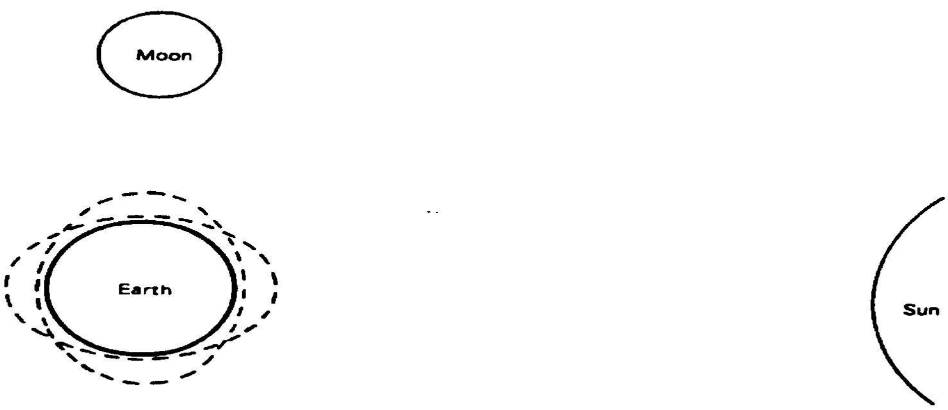


Figure 6.6.2 Neap tides

Tides on the real Earth

Even on the ideal earth, completely covered with water, tides are thus a continually changing cycle of different highs and lows. On the real earth, this is modified by land masses getting in the way of the tides.

Each ocean (Pacific, Atlantic, and Indian) acts as a large basin, and the tides therein are modified by the characteristics of the basin. The Pacific Ocean is responsive to diurnal forces, so the tides there tend to be more diurnal (one high and one low tide per day) in character. The Indian Ocean is more semi-diurnal (two high and two low waters per day).

Small Ships Manual or Australian Boating Manual. Tides and Tidal Streams. Read this chapter for general reference.

Use of tide tables

Make sure you are using the current year's tide tables:

Check the
- Port
- month
- date

Note the time zone, if your state or territory is using daylight saving you must add one hour to these times.

If a * symbol is next to the day's tidal information this refers to extra tides for that day. The extra tides will normally be found at the back of the tables (refer Cairns sample, 9 August 1997).

Once you have extracted the data go back into the tables and check – mistakes do happen.

Practical Activity

Look at the local tide tables for your port and determine the heights and times of high and low water. Local tide tables may be set out in a different format but most are set out in the same format as the example, Cairns.

Compare your tide tables to the example and note the phases of the moon and the different ranges in tide, ie springs and neaps.

AUSTRALIA, EAST COAST – CAIRNS

1997

LAT 16° 55' S LONG 145° 47' E

TIME ZONE – 1000

TIMES AND HEIGHTS OF HIGH AND LOW WATERS

MAY

Day	Moon	Time	m	Time	m	Time	m	Time	m
1 TH		0501	2.72	1130	0.97	1729	2.26	2322	1.00
2 FR		0551	2.84	1211	0.75	1821	2.50		
3 SA		0015	0.85	0638	2.92	1249	0.57	1911	2.73
4 SU		0101	0.75	0720	2.93	1328	0.43	1956	2.90
5 MO		0145	0.72	0759	2.87	1406	0.35	2037	3.01
6 TU		0228	0.76	0833	2.75	1444	0.35	2116	3.03
7 WE	●	0311	0.87	0909	2.58	1522	0.44	2157	2.98
8 TH		0355	1.04	0945	2.36	1601	0.59	2239	2.85
9 FR		0442	1.24	1026	2.12	1641	0.80	2326	2.67
10 SA		0539	1.44	1109	1.87	1721	1.04		
11 SU		0023	2.48	0755	1.55	1204	1.66	1805	1.26
12 MO		0157	2.34	1024	1.46	1517	1.59	1938	1.44
13 TU		0334	2.33	1105	1.34	1644	1.73	2143	1.48
14 WE	◐	0432	2.37	1128	1.23	1730	1.88	2250	1.43
15 TH		0515	2.40	1151	1.13	1803	2.03	2337	1.36
16 FR		0548	2.44	1215	1.04	1832	2.17		
17 SA		0015	1.30	0619	2.46	1238	0.95	1900	2.31
18 SU		0047	1.24	0645	2.46	1300	0.87	1927	2.43
19 MO		0117	1.20	0711	2.46	1324	0.77	1953	2.56
20 TU		0146	1.17	0736	2.46	1350	0.68	2021	2.67
21 WE		0217	1.14	0804	2.43	1418	0.60	2052	2.77
22 TH	○	0251	1.12	0833	2.39	1451	0.55	2126	2.82
23 FR		0328	1.14	0906	2.31	1526	0.56	2202	2.83
24 SA		0409	1.19	0943	2.21	1604	0.62	2245	2.78
25 SU		0457	1.27	1028	2.07	1647	0.73	2336	2.70
26 MO		0558	1.36	1127	1.92	1738	0.90		
27 TU		0043	2.60	0754	1.36	1258	1.81	1844	1.07
28 WE		0209	2.55	0921	1.22	1447	1.85	2018	1.18
29 TH	◑	0326	2.57	1017	1.04	1608	2.02	2153	1.18
30 FR		0429	2.61	1105	0.86	1715	2.24	2304	1.12
31 SA		0526	2.63	1149	0.68	1815	2.47		

JUNE

Day	Moon	Time	m	Time	m	Time	m	Time	m
1 SU		0002	1.03	0616	2.63	1231	0.53	1906	2.68
2 MO		0053	0.97	0702	2.59	1312	0.43	1952	2.84
3 TU		0138	0.94	0743	2.52	1350	0.38	2034	2.94
4 WE		0222	0.96	0819	2.42	1429	0.38	2113	2.96
5 TH	●	0304	1.01	0854	2.29	1506	0.45	2150	2.92
6 FR		0346	1.10	0930	2.15	1545	0.58	2228	2.82
7 SA		0431	1.22	1009	1.99	1622	0.75	2307	2.67
8 SU		0521	1.35	1047	1.83	1658	0.94	2349	2.51
9 MO		0626	1.45	1129	1.68	1732	1.14		
10 TU		0038	2.35	0844	1.46	1224	1.57	1811	1.32
11 WE		0156	2.22	1002	1.38	1551	1.59	1912	1.49
12 TH		0329	2.18	1045	1.28	1657	1.74	2147	1.55
13 FR	◐	0423	2.19	1114	1.18	1737	1.90	2258	1.51
14 SA		0502	2.21	1138	1.07	1807	2.05	2343	1.44
15 SU		0535	2.23	1200	0.96	1835	2.21		
16 MO		0018	1.37	0605	2.25	1224	0.84	1901	2.37
17 TU		0051	1.29	0635	2.27	1251	0.71	1930	2.53
18 WE		0124	1.21	0707	2.30	1322	0.58	2003	2.69
19 TH		0200	1.12	0743	2.31	1357	0.46	2039	2.83
20 FR		0237	1.05	0819	2.31	1434	0.38	2117	2.93
21 SA	○	0318	1.01	0859	2.29	1515	0.36	2158	2.97
22 SU		0402	1.01	0942	2.23	1557	0.40	2241	2.94
23 MO		0451	1.04	1031	2.13	1644	0.52	2330	2.86
24 TU		0547	1.09	1131	2.02	1734	0.70		
25 WE		0025	2.73	0659	1.12	1246	1.93	1833	0.93
26 TH		0132	2.58	0830	1.08	1416	1.92	1952	1.14
27 FR	◑	0248	2.47	0944	0.96	1546	2.03	2133	1.24
28 SA		0401	2.40	1042	0.81	1707	2.23	2257	1.23
29 SU		0508	2.36	1132	0.67	1812	2.45		
30 MO		0000	1.16	0606	2.34	1218	0.55	1904	2.65

JULY

Day	Moon	Time	m	Time	m	Time	m	Time	m
1 TU		0054	1.08	0656	2.30	1301	0.46	1950	2.80
2 WE		0140	1.03	0739	2.26	1342	0.42	2030	2.88
3 TH		0221	1.01	0815	2.20	1419	0.42	2107	2.89
4 FR		0300	1.02	0848	2.14	1456	0.47	2140	2.85
5 SA	●	0338	1.07	0920	2.06	1531	0.56	2212	2.77
6 SU		0415	1.14	0952	1.97	1604	0.70	2243	2.64
7 MO		0451	1.23	1023	1.87	1634	0.86	2312	2.50
8 TU		0527	1.32	1052	1.77	1701	1.03	2340	2.35
9 WE		0606	1.40	1126	1.67	1731	1.21		
10 TH		0011	2.21	0703	1.44	1216	1.59	1806	1.39
11 FR		0051	2.08	0955	1.37	1629	1.63	1856	1.55
12 SA		0200	1.98	1030	1.26	1713	1.79	2215	1.61
13 SU	◐	0415	1.97	1055	1.14	1744	1.96	2315	1.54
14 MO		0455	2.00	1120	1.00	1809	2.14	2354	1.44
15 TU		0530	2.05	1149	0.85	1836	2.33		
16 WE		0029	1.31	0607	2.11	1222	0.68	1908	2.53
17 TH		0105	1.17	0646	2.19	1300	0.50	1945	2.73
18 FR		0144	1.03	0728	2.27	1339	0.34	2024	2.91
19 SA		0224	0.90	0810	2.33	1420	0.23	2105	3.04
20 SU	○	0306	0.80	0853	2.36	1503	0.18	2145	3.10
21 MO		0349	0.76	0938	2.36	1547	0.22	2228	3.07
22 TU		0434	0.77	1026	2.30	1633	0.35	2311	2.95
23 WE		0524	0.83	1121	2.20	1722	0.58		
24 TH		0000	2.75	0620	0.91	1227	2.08	1817	0.88
25 FR		0058	2.51	0735	0.98	1349	2.00	1930	1.18
26 SA		0213	2.28	0911	0.95	1532	2.06	2130	1.33
27 SU	◑	0343	2.14	1023	0.83	1708	2.26	2302	1.29
28 MO		0503	2.11	1121	0.70	1811	2.48		
29 TU		0010	1.17	0604	2.12	1210	0.59	1900	2.66
30 WE		0100	1.07	0654	2.14	1254	0.50	1942	2.77
31 TH		0140	0.99	0734	2.14	1333	0.46	2019	2.83

AUGUST

Day	Moon	Time	m	Time	m	Time	m	Time	m
1 FR		0215	0.95	0809	2.14	1410	0.45	2052	2.83
2 SA		0248	0.95	0839	2.12	1443	0.49	2121	2.78
3 SU	●	0319	0.98	0906	2.09	1514	0.57	2147	2.70
4 MO		0348	1.04	0931	2.04	1542	0.69	2211	2.60
5 TU		0415	1.11	0955	1.98	1607	0.83	2232	2.47
6 WE		0441	1.17	1019	1.91	1631	0.98	2253	2.34
7 TH		0508	1.23	1049	1.83	1659	1.15	2318	2.20
8 FR		0542	1.29	1130	1.74	1730	1.33	2348	2.06
9 SA	*	0622	1.33	1227	1.66	1810	1.51		
10 SU		0028	1.91	0721	1.34	1648	1.75	* 2158	1.67
11 MO	◐	0141	1.78	1004	1.23	1717	1.93	2303	1.56
12 TU		0422	1.80	1042	1.07	1741	2.12	2340	1.42
13 WE		0506	1.90	1118	0.88	1809	2.34		
14 TH		0013	1.26	0547	2.02	1158	0.68	1845	2.57
15 FR		0048	1.07	0630	2.16	1240	0.46	1924	2.80
16 SA		0127	0.88	0715	2.30	1323	0.27	2005	3.00
17 SU		0207	0.70	0759	2.43	1406	0.14	2046	3.13
18 MO	○	0247	0.57	0842	2.52	1449	0.08	2126	3.18
19 TU		0329	0.51	0927	2.55	1533	0.14	2205	3.11
20 WE		0412	0.52	1014	2.50	1618	0.32	2245	2.93
21 TH		0456	0.61	1105	2.39	1705	0.60	2330	2.66
22 FR		0545	0.75	1205	2.23	1759	0.95		
23 SA		0022	2.33	0647	0.91	1325	2.10	1915	1.28
24 SU		0138	2.03	0835	0.99	1531	2.13	2146	1.38
25 MO	◑	0339	1.88	1006	0.91	1706	2.33	2330	1.24
26 TU		0507	1.92	1109	0.78	1801	2.52		
27 WE		0022	1.09	0602	2.01	1159	0.67	1845	2.66
28 TH		0057	0.97	0646	2.08	1242	0.58	1924	2.74
29 FR		0128	0.90	0723	2.14	1318	0.53	1958	2.77
30 SA		0157	0.86	0755	2.17	1352	0.53	2028	2.75
31 SU		0225	0.86	0822	2.18	1423	0.57	2053	2.70

THE NATIONAL TIDAL FACILITY THE FLINDERS UNIVERSITY OF SOUTH AUSTRALIA

Datum of Predictions is Lowest Astronomical Tide

***Contained in Tables Denotes Extra Tides**

Guide to Moon Symbols

● New Moon ◐ 1st Quarter ○ Full Moon ◑ 3rd Quarter

Figure 6.6.3 1997 Qld Tide Table

Written Activity 1

1. What are the times and heights of high and low waters at Cairns on 21 June 1997?

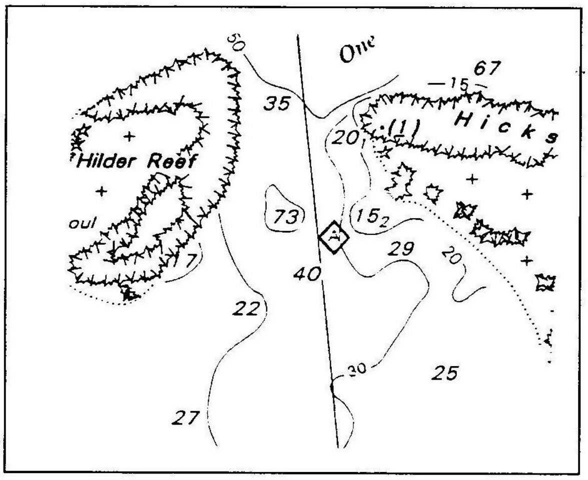
2. What are the times and heights of afternoon high and low water at Cairns on 11 August 1997? What is the phase of the moon?

3. What are the times and heights of low water at Cairns on 27 July 1997?

4. What is the earliest time and height of high water at Cairns on 24 May 1997?

Tidal Streams

Tidal streams are horizontal movements of water which result from tides (for example flowing in and out of rivers). Tidal stream information is shown on the chart either as a diamond shape or with arrows.



Tidal Streams referred to HW at CAIRNS

Hours		A 14°27·6'S 145°26·4'E Dir	Rate (kn) Sp	Np	B 14°32·4'S 145°33·3'E Dir	Rate (kn) Sp	Np
Before HW	6	027°	0·5	0·1	026°	0·2	0·1
	5	163	0·4	0·1	228	0·4	0·1
	4	177	1·1	0·3	223	1·3	0·4
	3	182	1·6	0·4	215	1·8	0·5
	2	191	1·7	0·5	205	1·4	0·4
	1	200	1·2	0·3	195	0·7	0·2
HW		211	0·6	0·2	071	0·4	0·1
After HW	1	335	0·3	0·1	039	1·0	0·3
	2	003	1·0	0·3	028	1·1	0·3
	3	008	1·6	0·4	028	1·2	0·3
	4	009	2·0	0·6	028	1·1	0·3
	5	009	1·6	0·4	028	0·8	0·2
	6	018	0·8	0·2	028	0·4	0·1

Figure 6.6.4 (AUS 832)

In this example (Fig 6.6.4) you must refer to the tides at Cairns for the nearest time of high water (HW) to use the table. The figure in the Dir column indicates the direction the tidal stream is going. The Sp refers to the spring tide and Np refers to the neap tide – notice the different rates.

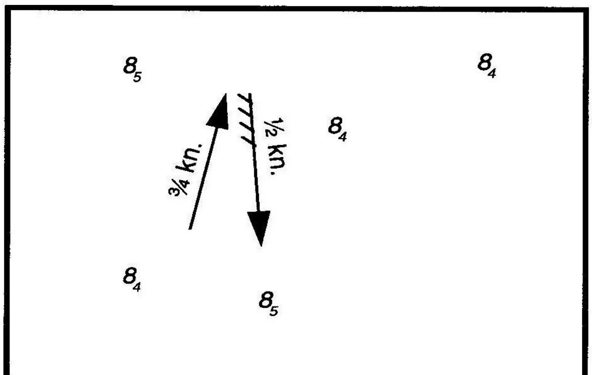


Figure 6.6.5 Tidal Stream Chart Symbols (Chart 5011 – Symbols)

The arrows indicate the direction the tidal stream is going and the rate in knots (kn). The arrow with 'feather' indicates the flood stream, ie when the tide is coming in, and the other arrow indicates the ebb stream, ie when the tide is going out.

Practical Activity

Discuss with your master/facilitator any special tidal features which may occur in your area.

Currents

A current is a non tidal movement of water caused by weather and oceanographic conditions.

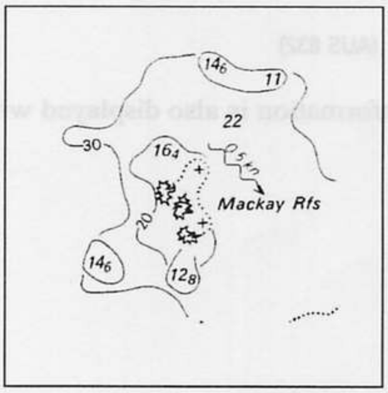


Figure 6.6.6 (AUS 831)

The arrow indicates the direction the current is going and the rate is indicated, ie 0.5 knots.

CURRENTS

Within the Great Barrier Reefs the currents produced by the prevailing winds set fairly through the channels. From April to November the predominant set is northerly with rates up to about 1·25 knots. From December to March the currents are irregular, but southerly sets may predominate with rates up to about 0·75 knots Seaward of the Great Barrier Reefs the currents are variable, but within 60 miles of it the set is mainly north westward increasing in strength closer to the reefs. A southerly set with rates up to about 1·5 knots predominates close to the reefs between May and November.
For further information see Sailing Directions and Current Atlases.

CAUTION – INCOMPLETELY SURVEYED

Owing to the incomplete nature of surveys in the areas indicated, shoaler water than charted may exist.

Figure 6.6.7 (AUS 832)

Current information is also displayed within the title block.

6.7 Steering by Compass

In the section on navigation one of the tasks you performed was to lay off a course between two places on a chart and find the true course. In this section we take the next step and calculate the compass course to steer on the boat to make good the true course laid off on the chart.

6.7.1 Magnetic variation

Courses and bearing laid off on a chart are true bearings but we steer and take bearings from a magnetic compass. The magnetic compass follows magnetic lines of force, the magnetic poles of which are in a different place to the true poles. Therefore, in all but a few places around the world the true and magnetic bearings of an object will be different. This difference is called **'magnetic variation'** and changes from place to place. The value of the magnetic variation is always given in the compass rose on the chart.

The North magnetic pole is located north of Canada and wanders about in the general area. For someone on the cast coast of Australia the North magnetic pole is slightly to the east of true North and the magnetic variation is correspondingly named EAST on charts of that area.

For much of the west coast of Australia, magnetic north lies to the west of true North and the variation is correspondingly named west.

Practical Activity

Obtain a chart of your local area and have your master/facilitator assist you to find the following:

i. the value of the magnetic variation and its name (east or west)

ii. the year to which that amount of variation refers

iii. any annual change (increasing or decreasing) in **'minutes'**

Practical Activity

Obtain a small scale chart of the east or west coast of Australia and note the changing values for magnetic variation across the chart.

Calculating the magnetic variation

The value of the magnetic variation is given in degrees and minutes on the chart. For practical purposes mariners work in whole degrees and ½ degrees (not minutes).

Calculation of the magnetic variation for the current year involves two steps:

<u>Step 1</u>: Add or subtract the change in variation between the chart and the current year.

For example, from Fig 6.7.1.

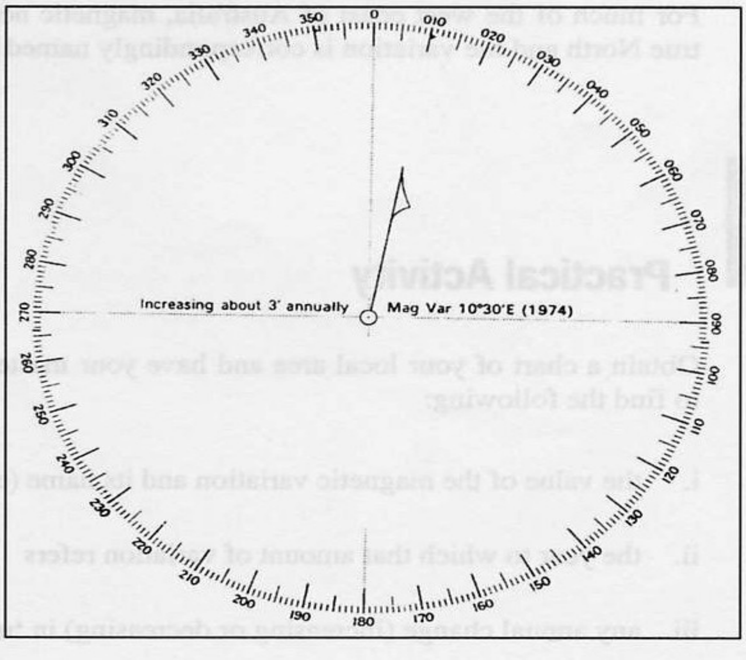


Figure 6.7.1

Number of years: 1997 – 1974 = 23 years
Increase: 3′ x 23 years = 69′ = 1° 09′

Magnetic Variation for 1997: 10° 30′ E (1974)
+ 1° 09′

11° 39′ E (1997)

Step 2: Round off the updated magnetic variation to the nearest ½°
From step 1, 11° 39′ E rounds to 11½° E

The rules for rounding to the nearest ½° are straight forward.

Use 15′ and 45′ as the cut offs. If the minutes are more than 15 and less than 45 take it the ½°. If they are less than 15 or more than 45 go to the nearest whole degree.

eg 8° 10′ = 8°
8° 20′ = 8½°
8° 40′ = 8½°
8° 50′ = 9°

Application of variation

Changing from true to magnetic courses and vice versa requires a simple addition or subtraction of the variation. The trick is knowing when to add and when to subtract.

In each of the following figures the:
OUTSIDE rose is the TRUE rose and the
INSIDE rose is the MAGNETIC rose

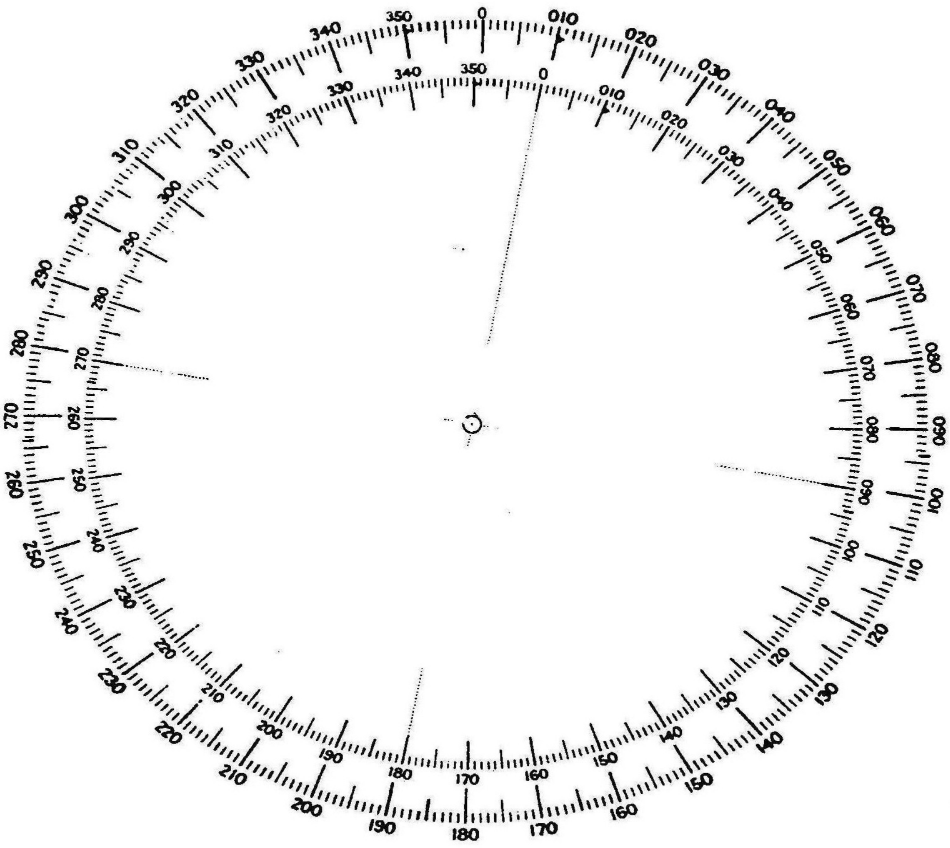


Figure 6.7.2

Note Fig 6.7.2. The variation is 10° E.

See that in any particular direction the magnetic bearing is always 10° less than the true bearing. In other words when the variation is EAST, the magnetic bearing will always read least (or less than the true).

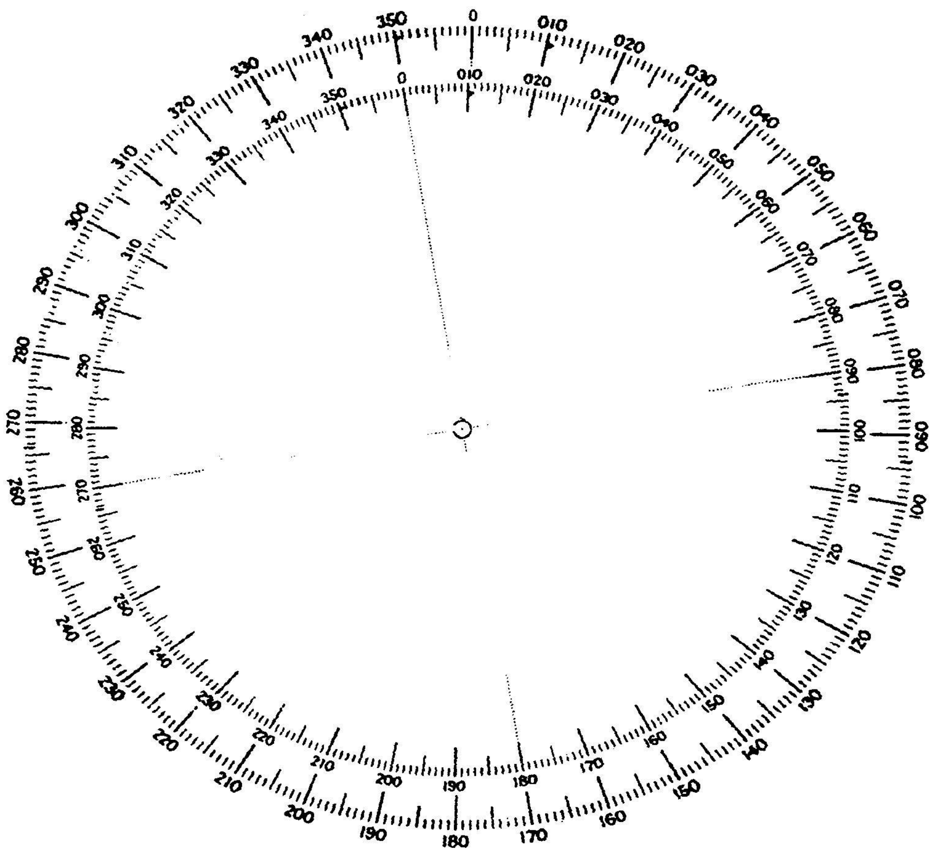


Figure 6.7.3

Conversely, in Fig 6.7.3 where the variation is 10° W the magnetic bearings are always 10° bigger than the corresponding true bearings. That is when the variation is WEST the magnetic bearing will read best (or bigger than the true).

These rules are normally condensed to:

if the VAR is EAST, the MAG will read LEAST

and if the VAR is WEST, the MAG will read BEST

Examples:

	1		2		3
True Co	108°	True Co	240°	True Co	357°
Var	4° W	Var	8° E	Var	6° W
Mag Co	112°	Mag Co	232°	Mag Co	003°

	4		5		6
True Co	270°	True Co	100°	True Co	004°
Var	12° E	Var	10° W	Var	7° E
Mag Co	258°	Mag Co	110°	Mag Co	357°

Small Ships Manual. Chapter on Compass. Read this chapter for general reference.

6.7.2 Transits

In the section on navigation we found that a transit was a bearing through any two points that can be identified on a chart, for example, a set of lead lights.

For any set of lead lights the true bearing is always given on the chart and this allows us to carry out a simple compass check.

Checking your compass by transit

Firstly, the true bearing of the leads is converted to a magnetic bearing by applying the variation.

Then, while steaming your vessel along the leads, the compass bearing of the leads is noted (it is your course steered) and compared to the calculated magnetic bearing of the leads. They should both be the same.

If your compass bearing does not agree with the magnetic bearing of the leads then your compass is carrying another error called compass deviation. Deviation is investigated and resolved in higher level certificates. For the Coxswain it is sufficient to be able to recognise the presence of deviation from a transit.

NOTE: A set of leads on a chart are a convenient transit because they are easily seen and the true bearing is given. However, any transit can be used and the true bearing found by laying parallel rules along the transit and reading the bearing from the rose on the chart.

Because compass deviation changes as your vessel's heading changes your compass needs to be checked from time to time, over a number of different transits. Deviation is cause by something within the boat affecting your compass. Therefore, if a deviation of more than about three degrees is discovered when you check your compass, firstly check to make sure there are no steel or magnetic objects placed around the compass. If no cause can be readily found then your second option is to have a licensed compass adjuster 'swing' your compass.

Practical Activity

Have your master/facilitator steam along a set of leads while you compare the magnetic and compass bearings. Note the degree of precision that is required to keep the vessel exactly on the leads and that the steering compass on most small vessels is graduated in 5° increments making the detection of one or two degrees of deviation guesswork at best.

6.7.3 Steering A Course

In a seaway a small vessel will move about substantially making the compass difficult to read and impossible to hold dead on course.

Where possible, use a landmark to steer to, checking your compass from time to time. Where this is not possible and you are forced to steer by compass alone allow the boat to wander or 'yaw' to the natural rhythm of the sea (within reason). These random errors should be roughly the same to port and to starboard and the average course should be the required course. Being off course 5°, even up to 10° from time to time, is not dangerous if a frequent check is kept on the average compass course and the initial required course was accurate.

If however, there is an error in the required course through incorrect application of magnetic variation or undetected deviation, then the steered course will be biased by that error, be it 5 or 10°, and that is dangerous.

6.7.4 Taking Bearings With A Compass

On larger vessels provision is made for taking bearings off a main compass (azimuth ring) or by a pelorus and applying it to the main compass. On small vessels there is no such provision and the only way to take accurate bearing with the steering compass is to point the vessel straight at the target and read the bearing from the lubbers line. However, it is much more convenient to use a hand bearing compass (either conventional or electronic). Modern hand bearing compasses have precision sights and easy to read cards graduated in 1° increments. The only correction that can be applied to a hand bearing compass is magnetic variation. They can not be compensated or corrected for compass deviation and are therefore of no value on steel boats.

Written Activities 2

Complete the following exercises on magnetic variation by filling in the missing value.

	1		2		3
True Co	095°	True Co	240°	True Co	357°
Var	5° E	Var	8° W	Var	4° W
Mag Co		Mag Co	230°	Mag Co	168°
	4		**5**		**6**
True Co	005°	True Co		True Co	147°
Var	10° E	Var	5° E	Var	½° W
Mag Co		Mag Co	232°	Mag Co	003°
	7		**8**		**9**
True Co	108°	True Co	004°	True Co	358°
Var	4½° W	Var		Var	
Mag Co	032°	Mag Co	002½°	Mag Co	003°

6.8 Buoyage

6.8.1 Description Of Buoyage System "A"

Many countries throughout the world have agreed to the use of a uniform coding system of navigational marks.

The system, developed with the assistance of the International Association of Lighthouse Authorities, has been in wide use within Australia waters since late 1983.

The buoyage system during the day, uses shape, colour and topmarks whilst at night, colour and rhythm to identify the individual mark. Five basic shapes are: cylindrical (can), conical, spherical, pillar and spar.

Australia uses IALA Buoyage System A.

Type Of Marks

1. **Lateral** — indicates port and starboard hand sides of channels.
2. **Cardinal** — indicates that deeper water lies to the direction shown ie to the north, south, east or west.
3. **Isolated Danger** — indicates isolated dangers of limited extent with navigable waters all round them.
4. **Safe Water** — indicates that there is navigable water all round and under the position, eg mid channel buoy.
5. **Special** — indicates special feature eg spoil grounds, or prohibited anchorages.

Small Ships Manual or Australian Boating Manual. Chapter IALA Maritime Buoyage System "A".

Keep this chapter open throughout this section.

Practical Activity

To assist you in learning the buoyage system it is recommended that you make a series of palm cards.

For example,

Front of Card

Draw and colour in one type of mark.

Back of Card

- **type of mark**
- lights, colour and rhythm
- meaning

A completed example.

- **port hand buoy**
- red light, any rhythm except Fl (2+1) R
- port side of channel

Lateral Marks

They are usually positioned to define **well established channels** and indicate port and starboard had sides of the navigation route into a port. Where there may be any doubt, the direction of buoyage may be indicated on charts by the symbol.

Read section on Lateral Marks.

Remember:

- Port hand Mark is coloured red and the basic shape is a can and shows a red light.
- Starboard hand Mark is coloured green and the basic shape is conical and shows a red light at night.

When going into port, leave the port hand mark to port. Hence the term, red to red when entering port. When departing it's the opposite, leave the port mark to starboard.

The Cardinal Marks

There are four cardinal marks:- North, South, East and West. A cardinal mark will indicate where the **best and safest water may be found**.

A cardinal mark may indicate –

- the **deepest** water in an area;
- the **safe side** on which to pass a danger and to draw **attention to a feature** in a channel such as a bend, junction or an end of a shoal.

Read section on Cardinal Marks.

Remember: The mariner is safe if passing –

(a) North of the north mark
(b) East of the east mark
(c) South of the south mark
(d) West of the west mark.

- both the colour pattern and top mark will indicate which side to pass during the day
- at night the cardinal mark exhibits a white light and its quadrant is distinguished by a specific group of quick or very quick flashes
- associate the number of flashes of each group with that of a clock face, three o'clock east, six o'clock south, nine o'clock west and twelve o'clock north.

When making up your palm cards note the apex of the topmark always points to where the black is painted on the marker, ie north marker apex up, black on top of the marker.

Isolated Danger Marks

Indicates an **isolated danger of limited extent** which has navigable water all round it eg an isolated shoal, rock, reef or wreck – but don't pass too close.

Read section on Isolated Danger Marks.

Remember:
- its colour is black with red horizontal bands with two black spheres.
- at night always a white flashing light showing a group of two flashes.
- the characteristics may be best remembered by association of two white flashes with two spheres as the topmarks.

Make up palm cards to help you learn this mark.

Safe Water Marks

Indicates that **there is navigable water** all around the mark, eg mid channel or land falls buoy.

Read section on Safe Water Marks.

Remember:
- always with red and white vertical stripes
- topmark is a single **red sphere**
- at night **a white light**, isophase, occulting, a **single long flash** every 10 seconds, or morse A

Make up palm cards to help you learn this mark.

Special Marks

Indicates a **special area** or feature such as:

Traffic separation marks
Spoil ground marks
Cable or pipe line marks including outfall pipes.

Also to define a **channel within a channel**, eg a channel for deep draught vessels in a wide estuary where the limits of the channel for normal navigation are marked by red and green lateral buoys. Refer to the chart for the exact meaning.

Read section on Special Marks.

Remember:
- it is always yellow in colour
- it may have a **single yellow X** topmark.
- at night a yellow light with any rhythm, other than those used for the white lights or cardinal, isolated danger and safe water marks (at night).

Make up palm cards for this mark.

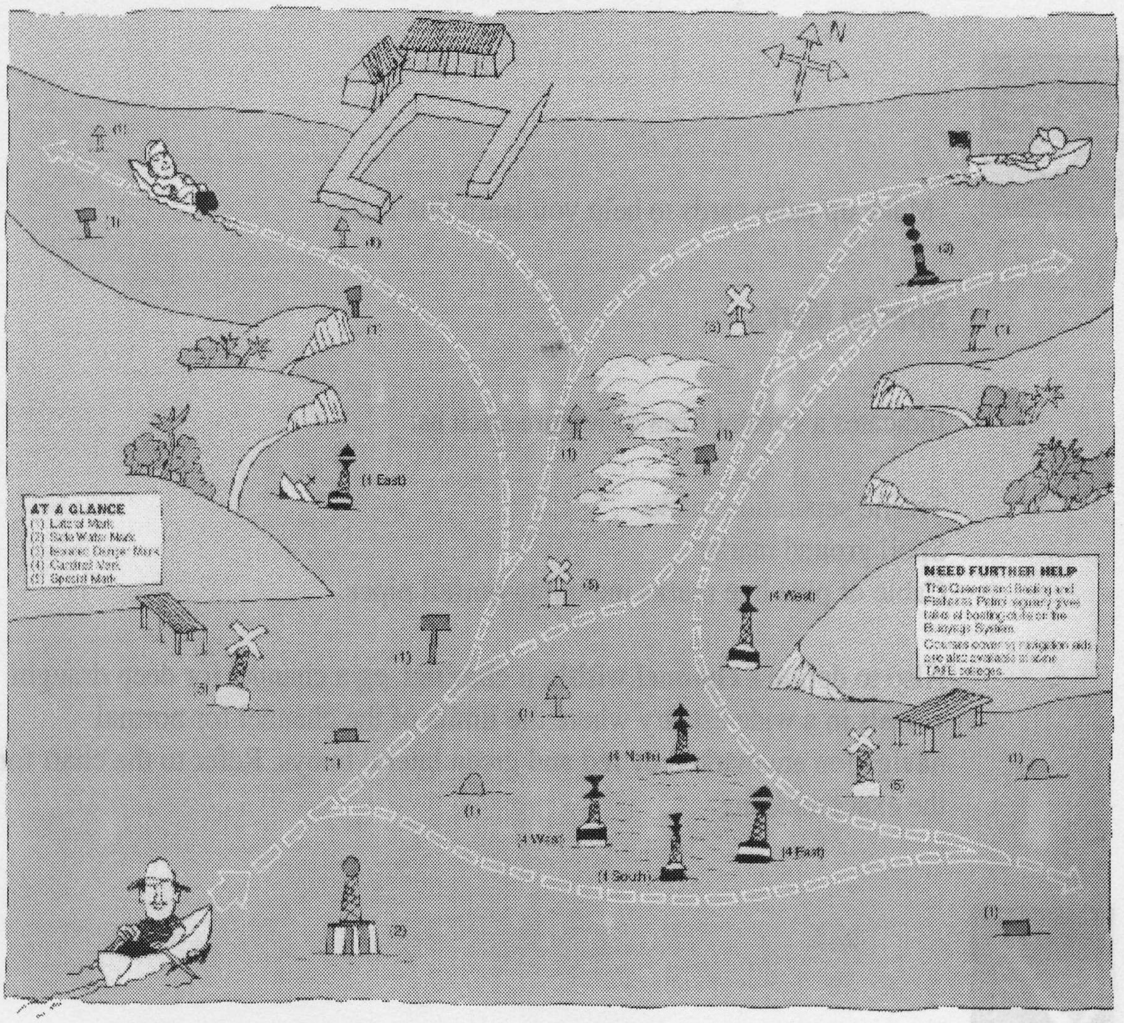


Figure 6.8.2 (Qld Tide Tables QT)

Practical Activity

1. .On the diagram above identify the various types of marks.

2. Check to see if they are the correct marks for each situation.

3. Trace the various routes shown and gain an appreciation of the buoyage system.

Section Summary

In this section we dealt with basic coastal navigation techniques, these techniques are useful to navigate safely around the coast. These skills are essential in your position as a Coxswain to get your passengers, cargo or even catch fish in a particular area, as it allows you to plan your voyage before it starts and also be prepared in emergencies, such as rough weather etc by being able to read a chart for safe havens etc.

Check your progress

1 Which scale would you use to measure distance?

2 Where do you find the units of depth used on a chart?

3 What level are charted soundings measured from?

4 Convert 7 hours 18 minutes to hours and decimals of an hour?

5 One minute of latitude equals how many yards?

6 Your vessel has covered 78 miles in the previous 8 hours. What is the average vessel's speed?

7 Define a transit bearing.

8 Using the Cairns example (Fig 6.6.3).

On the 13 July 1997 when is the next HW after midday? Is the tide phase in springs or neaps at this time?

9 Compass course is 251° Variation 5½° E. Find the true course.

10 Using a local chart, lay off two courses. Calculate the magnetic course for each leg and the total distance to run.

What is the latitude and longitude of the start position?