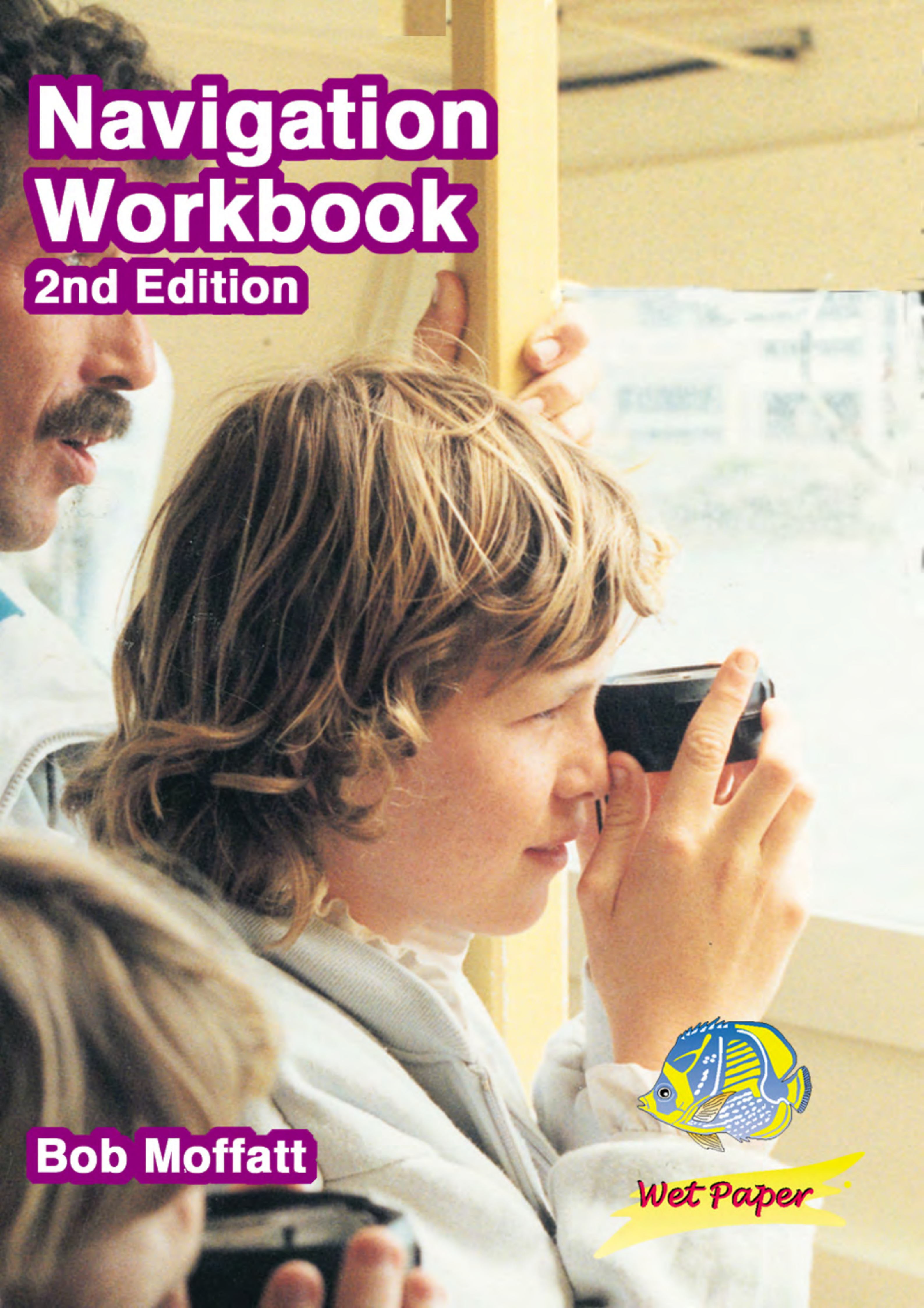
Navigation Workbook

2nd Edition



Bob Moffatt

Wet Paper

ISBN (2025 E Pub)

978-1-86283-143-8

Published by

Wet Paper Publishers and Consultants
A division of the Moffatt Group Australia Pty Ltd
ACN 086 521 084
PO Box 540 COOLANGATTA Q 4225
Telephone (07) 5525 6122
www.wetpaper.com.au

Worksheets developed by

Tim Ryan and Bob Moffatt

Honorary consultants

Mark Collins and Bruce Parmentier

Edited by

Paula Moffatt

Original text and illustrations

Bob Moffatt with suggestions from Bruce Parmentier and Tim Ryan
Navigation exercises on Hillsborough Channel by Bob Critchley

Cover design

Trent Moffatt Designs.

Printed

1st Edition, February 1989
2nd Edition June 2001, Revised March 2004, Reprinted January 2006, Revised 2009
Reprinted February 2011
Flipbook 2014 E Pub 2025 (Includes answers)

Acknowledgements

The publisher would like to thank Tim Ryan, the Hydrographer of the Navy, 1982, Commonwealth of Australia for permission to publish sections of the Cape Hillsborough Channel training chart, John Wiley, Bob Critchley, Len Couzins, Sea World, John Armstrong, AUSAR, Bruce Chapman, GME Electrophone, TAFE NSW, Capt Dick Gandi, Australian Maritime College, students of Maryborough and Benowa High Schools for their assistance in this publication. Thanks also to Bruce Parmenter for his useful suggestions for this 2009 revision and the answer booklet.

Disclaimer

Although all care has been taken to provide safety instructions, and offers of training and advice, Wet Paper or any of its employees, advisors or consultants accept no responsibility for any accident that may occur as a result of students performing any of these activities. If schools are unsure of any method, they are advised first to consult with their own State regulations and then if further assistance is required, contact us here at Wet Paper at the above address.

Contents

Section 1 Introduction

The word navigate is taken from the Latin "navagere" meaning navis (ship) and "agere" (move or to direct).

Navigation is the art of directing a vessel at sea.

It can be as simple as paddling a surf ski through shallow water or as complicated as steering an ocean liner across an ocean.

Knowledge and experience

The sea cannot be taken for granted no matter what size or type of vessel you take to sea because the shoreline is littered with the remains of vessels that could not find their way safely.

These wrecks lie as silent reminders of the need for good navigational skills. Even with all our modern navigational aids, over a hundred larger ships are lost at sea each year.

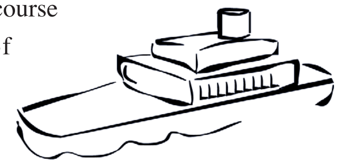
Most of these losses occur through human error, equipment failure, or being caught in natural disasters such as cyclones.

The sea can be a dangerous place, but with basic navigational knowledge it can be a rewarding experience.

It takes many years to train a mariner with many sea time hours logged under the direction of a ship's master to direct the movements of a vessel safely and efficiently from one point to another. Other aspects of navigation such as weather, tides and currents are discussed in other workbooks in this series.

However, having completed the workbook, you should have a basic insight into:

- Some local coastal features shown on a chart
- The use of navigational equipment
- Pilotage and buoyage systems
- Setting and plotting a course
- The importance of modern navigational aids



AMSA

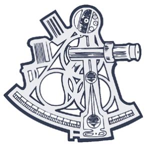
Figure 4.1 Navigation is the art of directing a vessel at sea.

AMSA

Wet Paper

Figure 4.2 The shoreline is littered with the remains of vessels that could not find their way safely.

Fundamentals of navigation



Many first time mariners believe that navigation is shrouded in mystery. How can you find your way at sea when there is no land in sight and everywhere you look is all the same? The novice is concerned that navigation involves complicated mathematics, star sighting, sextants and complex chart work — this is a myth.

It's not rocket science

Basic navigation is quite simple. We do it successfully daily on land when we use signs, road maps, and landmarks to get from point A to point B.

Navigation at sea is very similar and it requires minimal mathematics. You do need to be able to add and subtract, think rationally, process simple information and be practical.

The ability to navigate is extremely important to:

- Travel in strange waters
- Travel at night on water
- Travel in fog or when weather conditions do not allow the use of familiar features
- Find a safe path to your destination.

Most people can use a street directory to find their way around a town or city so if you don't feel confident with this topic, why not practise using a street directory before starting chart work.

History

Early mariners did not venture very far from the land and made sure that the coast was visible allowing them to identify the structures on the land and hence, know the position of their vessel. They usually travelled by day and went into protected coastal areas at night. They did not have charts but simply relied on basic lists of instructions and details of landmarks.

The art of navigation was born out of necessity. Once mariners had vessels that could travel beyond the sight of land, they needed to be able to find their way back to their starting point.

The only method these ancient mariners had to find their way back was to use observation of their ship's direction in relation to the sun, moon and stars or the direction of prevailing winds and currents in the area.

According to our best estimates sailors have been navigating the oceans for at least six thousand years – some say perhaps eight thousand years or more. Most impressive were the Polynesians, who traversed thousands of kilometres of open ocean in the Pacific on rafts made from reeds as early as 1500BC.

History records a number of great voyagers of varying significance to the development of today's knowledge of navigation.

As you progress through this course you may have a chance to go to sea to experience some of the difficulties in working there.

Hopefully you will admire some of the skills and determination of the seafarers who laid the foundations for modern navigation.

Queensland Museum

Figure 5.1 Polynesians, who traversed thousands of kilometres of open ocean in the Pacific on rafts made from reeds as early as 1500BC.

Challenge

- Write a postcard describing living conditions of a convict on board one of the ships of the First Fleet.
- What was a Scurvy Line?
- Some say there is an art to navigation while others suggest it is a science.

  Debate this topic - navigation is an art and not a science.
- Web site for further information:

  http://www.education.qld.gov.au/tal/kla/compass
- Tell a partner 10 facts you know about navigation at sea.
- Design a mind map to illustrate the to the class your prior knowledge of navigation.
- Suggest how migratory birds can follow the same migratory route each year.
- What is the angle of the North Star for Oslo in Norway, Berlin in Germany or Amsterdam in Holland?

The first navigational aids

Among the most important instruments developed to aid navigation of the sea are the compass, sextant, an accurate clock, almanacs and the telescope.

The compass

Date and origin of the magnetic compass are unknown. It is one of the oldest instruments and is thought to have originated in China with the discovery of the magnetic material, loadstone.

European mariners had known the magnetic properties of lodestone for centuries. This knowledge was used to develop the first magnetic compass, which was used by mariners in the twelfth century.

Figure 6.1 shows a photo of a modern magnetic compass that is mounted in a vessel at sea.

GME

Figure 6.1 A magnetic compass

The sextant

Navigators in the northern hemisphere had used the North Star to navigate at night because they realized that it had a fixed position in the sky.

The North Star is almost directly above the North Pole. Not only does it show the position of North, but its angular height above the horizon is roughly equal to latitude.

For example the angle of the north star in London is 51° and the latitude is 51.5°N.

Early navigators believed that by finding the angle between the themselves, the horizon and the star they might be able to relate this to a distance north on the Earth's surface. This was later refined by the use of tables and observations.

The angles were first measured by using a cross-staff. This instrument consisted of a long wooden staff upon which several cross pieces were mounted perpendicular at various lengths. In 1590 John Davis invented the back staff or sea quadrant, which called for the shadow of the instrument to be aligned with the horizon.

In 1730 the Englishmen Hadley developed the sextant as shown in Figure 6.3. The sextant remained practically unchanged since its invention over two hundred years ago.

Unfortunately there is no equivalent of the North Star in the Southern Hemisphere.

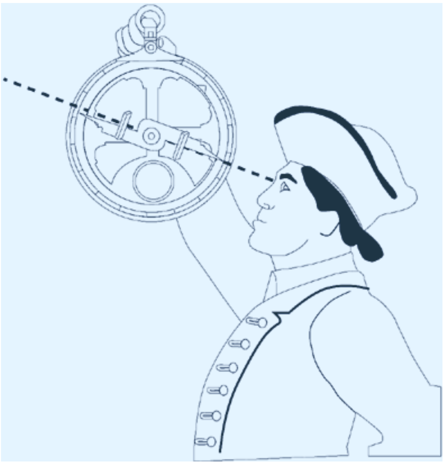


Figure 6.2 This astrolobe was used between the 13-16th century to measure the altitude of the sun and stars
Wet Paper

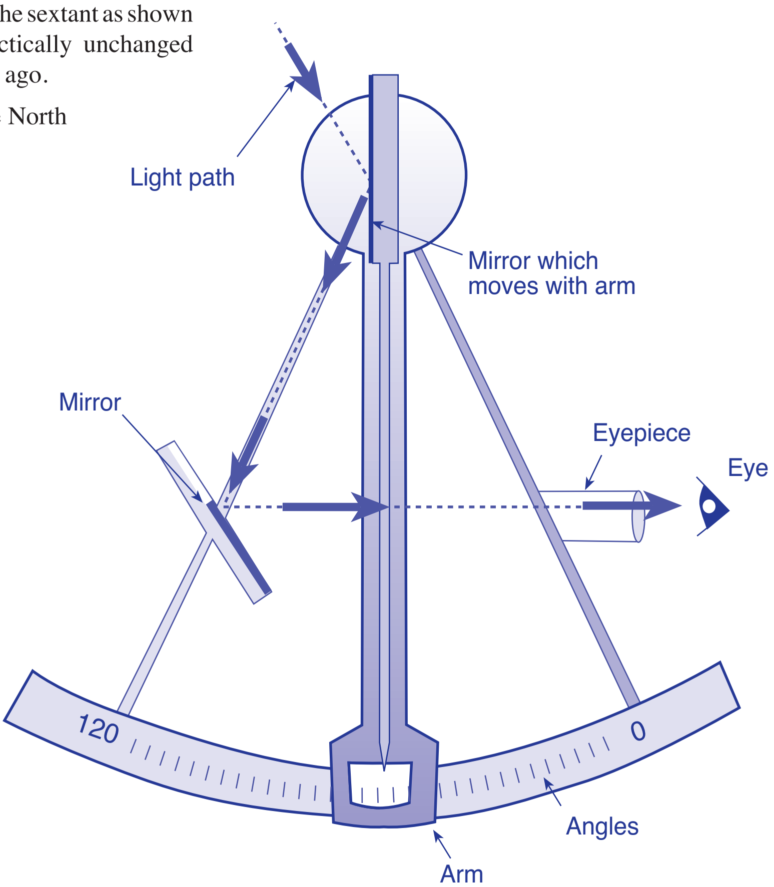


Figure 6.3 Sextant
Wet Paper

An accurate clock

Navigators also needed an accurate clock. The hourglass was the first clock that was used but this was very inaccurate. John Harrison, an English carpenter developed the first accurate clock the chronometer between 1730 and 1763. This clock used a type of pendulum that is still being used by clock makers today. Figure 7.1 shows Harrison's chronometer.

The almanacs

Almanacs were used by early astronomers and contained the recorded observations and tables of the angles and times to celestial bodies (sun, stars and moon).

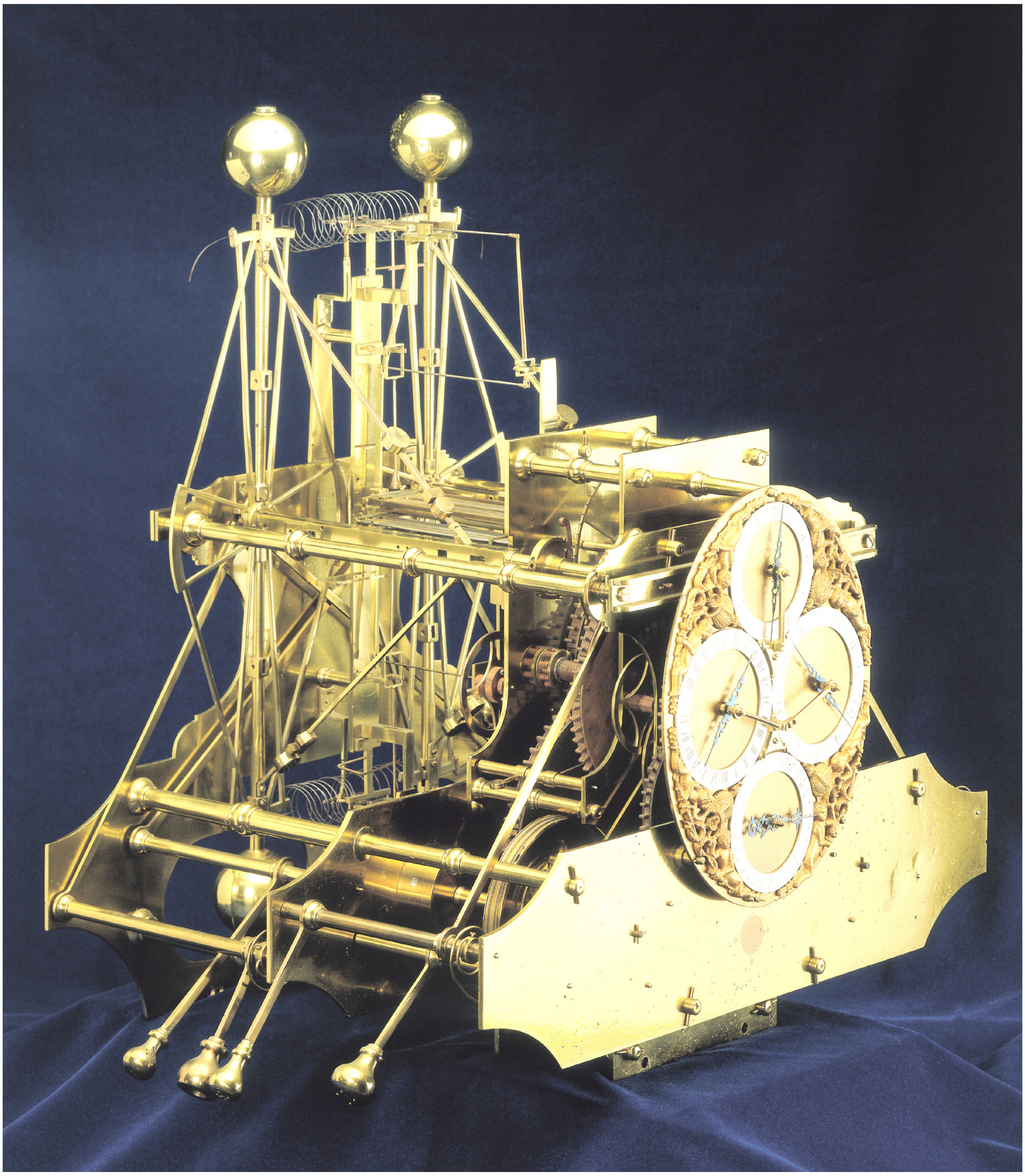
These were forerunners of the nautical almanacs, which are still used today to find one's position by using the sun, star and moons.

These nautical almanacs are produced each year by the Hydrographic Department.

The telescope

The telescope was of great importance to the early explorers as it was used as an early warning system to detect hazards such as reefs, shoals, and rocks early enough to allow the navigator to manoeuvre around the obstruction.

They were also used to identify landmarks, lighthouses and other ships at sea.



National Maritime Museum London

Figure 7.1 Harrison's chronometer

Worksheet 1 Research and review

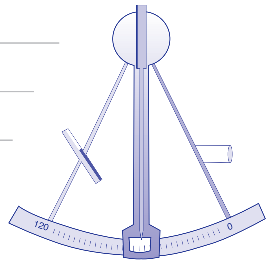
Questions

1. Who was the first person to sail around the world?

   In what century did he complete this feat?

   Why was it such a big deal in those days to accomplish this feat?

2. The figure oppiste shows an early navigation aid. What is it, how was it used and show how it worked.

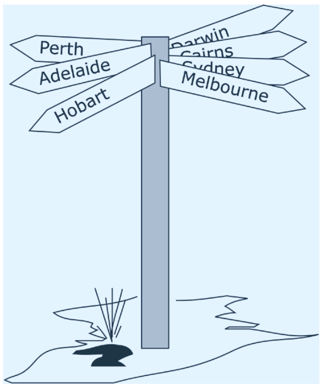


3. Make a list of modern navigation equipment that is available for inshore navigation.

4. Investigate a major maritime disaster that has occurred in the 20th century. From your investigations suggest the cause of this accident and how it might have been prevented.

5. Would you take up the challenge that Jessey Martin did — to sail alone around the world? Why?

6. A signpost, such as the one shown opposite, is rarely found at sea. Why do you believe this is so? Does your group think this type of land/road sign posting should or could be used at sea?



7. What problems would the modern commercial ships incur when navigating their way through the Great Barrier or Ningaloo Reefs? Suggest ways in reducing the potential danger to our reefs from shipping.

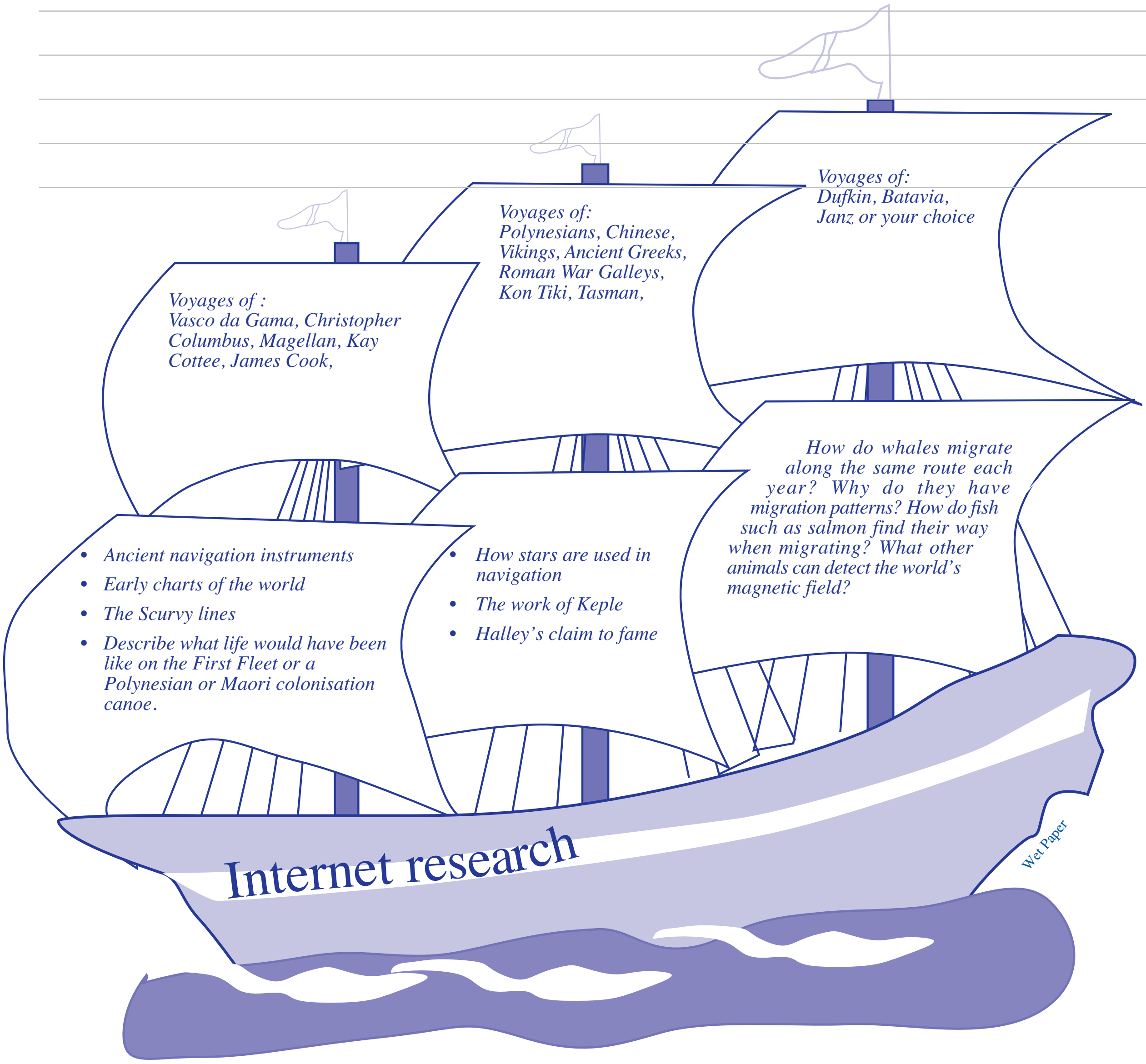
8. Do you think the government should be spending thousands of dollars in upgrading and enhancing the navigational aids along our coastline? List points for and against your view.

WORKSHEET 2 LIBRARY/INTERNET RESEARCH

In small groups investigate the topics in one of the masts of the ship shown below.

- You will need access to research facilities in resource centre and/or computer room.
- Each group is to report their findings to the class at the end of the research time.

Answers



Section 2 Pilotage

IALA buoyage system A

- The buoyage system helps skippers navigate into and out of a port or an anchorage. The system uses five markers, namely - *Lateral, cardinal, isolated danger, safe water and special marks*.
- These marks can be shaped as cans, cones, spheres, pillars or spars.

Lateral marks

- These indicate port and starboard hand sides of the channel and are positioned in well established channels.
  - The port mark is coloured red and has the basic top shape of a can.
  - At night the port buoy may show a red light and flashes to any of the sequences as shown in the figure below.
- The starboard mark is green and has the basic conical top shape.

  At night the starboard buoy may show a green light and flashes to any of the sequences shown in the figure below.

Leaving port

- When departing a port the port hand buoy (red) should be passed on the vessel's starboard side as shown by boat A.

Heading into port

- Upon entering port, the port hand mark (red) should be passed on your vessel's port side as shown by boat B.

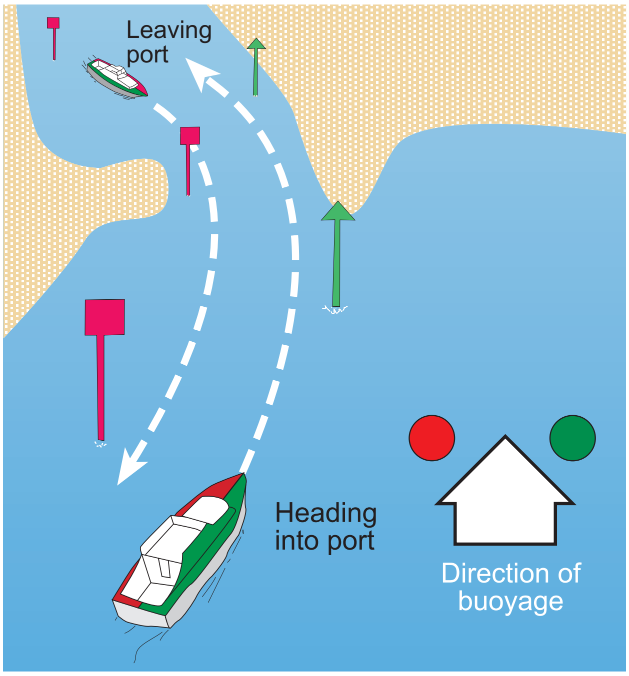


Figure 11.1 Direction of buoyage symbol and rules for entering and leaving port

Direction of buoyage

- Where there may be doubt, the direction of buoyage can be checked on charts as indicated by the symbol as shown in the figure above.

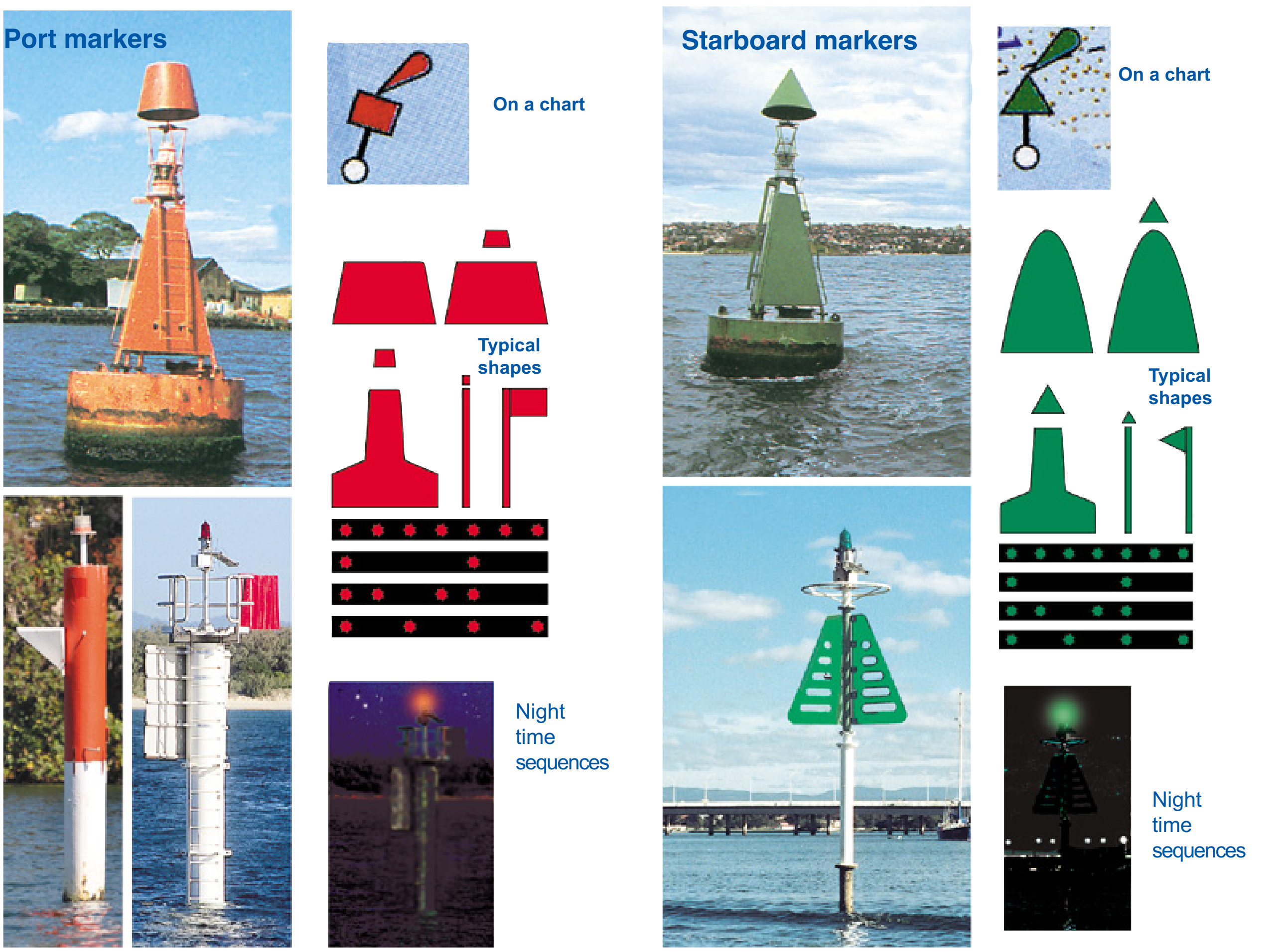


Figure 11.2 Lateral marks

Cardinal marks

A cardinal mark indicates where safest water may be found and is used in conjunction with the compass.

These marks are show in Figures 12.1 and include the following features:

- Two black double cones are clearly separated.
- Black and yellow horizontal bands with the position of the black band (or bands) relative to the respective cardinal points.

Figure 12.1 Cardinal marks (Courtesy TAFE NSW)

Figure 12.2 shows how cardinal marks could be used to navigate around a reef if the skipper passes north of the north mark, east of the east mark, south of the south mark or west of the west mark.

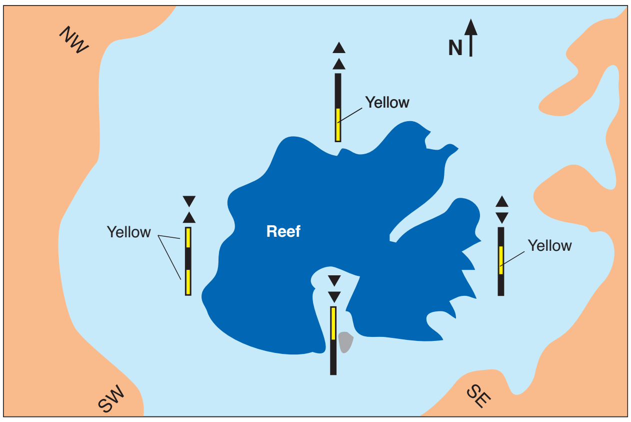


Figure 12.2 Cardinal marks protecting a reef (after TAFE NSW)

At night a white light flashes in a sequence that indicates the type of mark. The flashes are:

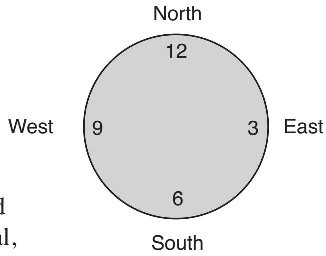
North Uninterrupted continuous flash

East 3 flashes in a group

South 6 flashes in a group plus one long

West 9 flashes in a group

To help you remember this associate the number of flashes of each group with that of a clock face.



Isolated danger marks

These designate an isolated danger of limited extent which has navigable water all around it. For example an isolated shoal, rock or wreck.

These marks are black with one or more horizontal red bands.

The top mark has two black spheres positioned vertically and clearly separated.

The light comprises a white flash showing groups of two flashes.

The best way to remember this is by associating the two flashes with the two spheres.

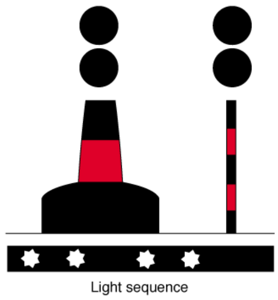


Figure 12.3 Isolated danger mark (Courtesy TAFE NSW)

Buoys, beacons and lighthouses

Buoys are used to delineate channels, indicate shoals, mark obstructions and warn the mariner of dangers. Buoys are floating aids that are anchored into position.

Safe water marks

These are painted with red and white vertical stripes and have one red ball on the top (see Figure 11.1).

They indicate that there is safe water beyond this point and are usually found at the end of a channel or when entering a port.

At night they flash with a white light followed by a period of darkness.

Figure 13.1 Safe water marks

Beacons

Figure 13.2 A beacon

Beacons are fixed aids to navigation that are placed on the shore or in shallow water as shown in Figure 11.2.

Lighthouses

Lighthouses have characteristic flashes which are clearly marked on a chart.

The lighthouse in Figure 13.3 has a light that flashes three times and each separate sector is white, red and green in 10 seconds. The height of the light is 145 metres and the visibility is 22 nautical miles out to sea.

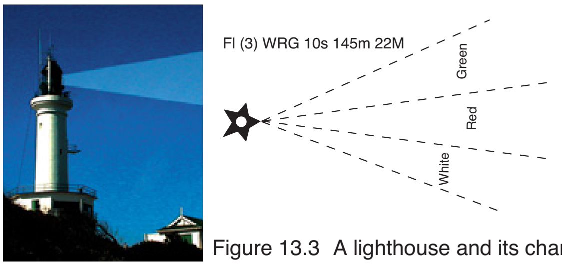


Figure 13.3 A lighthouse and its chart symbol

Special marks

These indicate a special feature such as a cable, outfall pipe, recreational diving area or ground marks. They also define a channel within a channel. For example a channel for deep draught boats in a wide estuary within the limits of the channel for normal navigation. Generally they are used where no other mark can be so the top of the mark carries a single yellow cross.

A diver's flag

At night they show a yellow light with any light sequence (other than that used for the white lights or cardinal, isolated danger and safe water marks).

When you see a special mark – consult your chart.

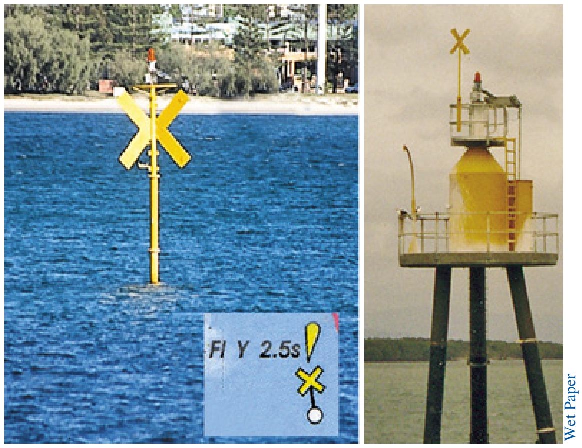


Figure 13.5 Special marks

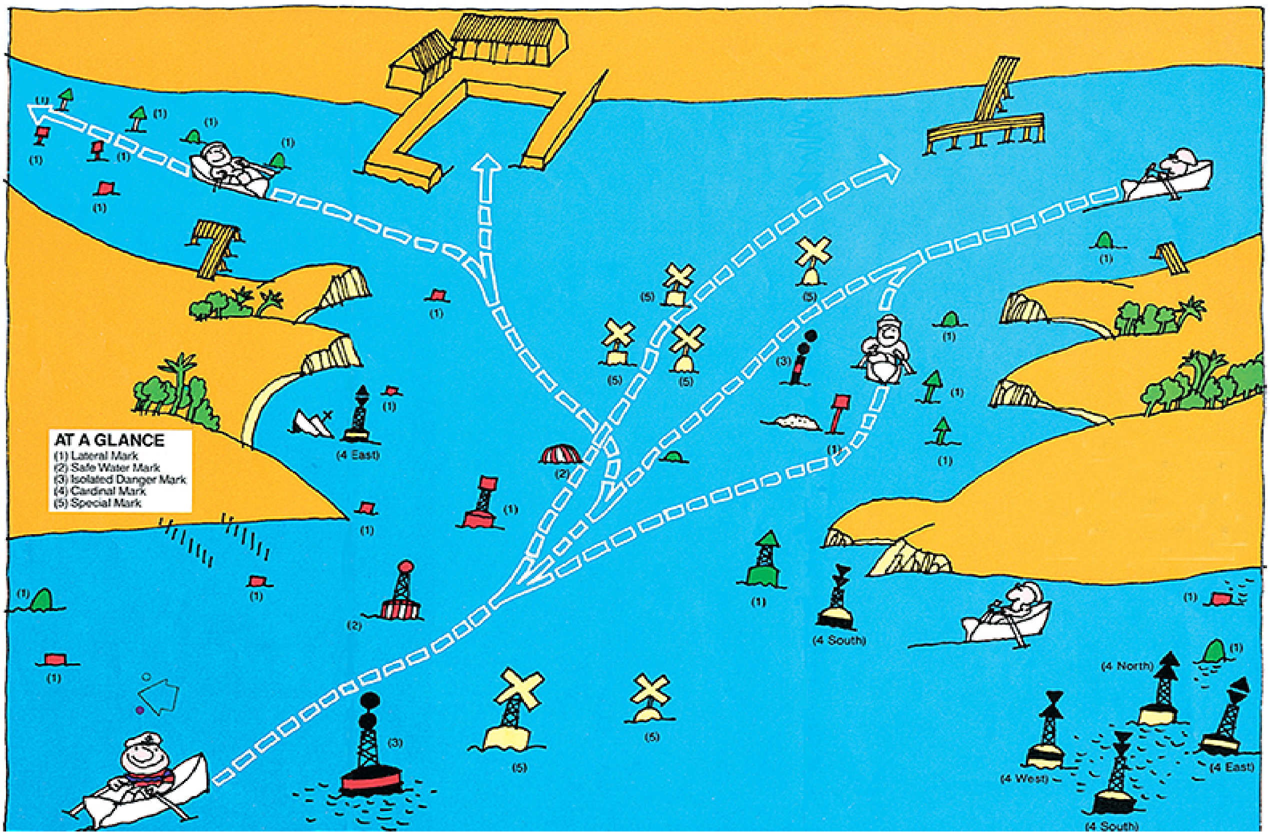
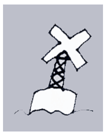


Figure 13.4 Summary of buoyage system (Courtesy Qld Transport)

Worksheet 3 Navigation markers

Name and colour in the following navigation symbols

(a)

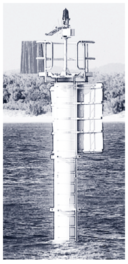


(b)

(c)

(d)

2. The following marks are observed. Indicate the message each conveys.



(a)

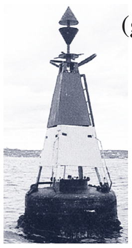
(b)

(c)

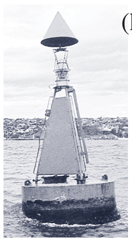
(d)

(e)

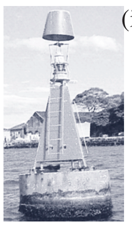
(f)



(g)



(h)



(i)

Section 3 Navigation Equipment

See also pages 65 and 66 for GPS and Radar

The magnetic compass

If a small magnet is pivoted at a point or is free to turn, it will tend to align itself with the magnetic field of Earth and therefore show a direction.

Consequently, one of the most important navigational aids on a vessel is the compass.

There are two main types of compass:

a. magnetic — which points to Magnetic North

b. gyro — which points to True North

If a magnet were simply placed on a float in a bowl of water it would be of very little use in a vessel at sea in rough conditions. Thus the magnetic compass is constructed using a bowl commonly made of brass or non-magnetic metal with a glass top. The bowl is weighted at the bottom and is suspended in gimbals so that it remains fairly horizontal as the vessel is moved by the seas.

Since vessels are in constant motion when at sea, the magnetic needle (which is made of several magnets united parallel to each other) is located in a liquid that reduces or dampens the needle's movement. The liquid that is placed in the bowl is mostly water with some alcohol added to prevent freezing.

Since this compass has a magnetic needle it is important to choose the location of the compass carefully. The position should be-

- As far away from metal objects as possible
- Located well away from electrical wiring and instruments requiring electricity
- Have as stable a location as possible thus preventing vibration
- Be protected from the elements (rain, sun and sea spray)

The compass card

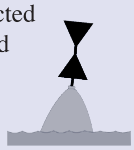
A compass card is a compass rose that is graduated in 360 degrees and is mounted in the bowl.

The compass card within a compass (the compass rose) is a circle marked off in a clockwise direction in 360 equal units (360 degrees). North is marked at 0°, east at 90°, south at 180° and west at 270°.

These are called the cardinal points of the compass. Mid-way between these cardinal points are the inter-cardinal points – north-east (45°), south-east (135°), south-west (225°) and north-west (315°). These can once again be subdivided giving another eight points e.g. north-north-east. The compass card normally has thirty-two points shown in a clockwise order and is known as 'boxing the compass'.

Statement

The marine magnetic compass was perfected in 1862 and was first used by the United States navy.



Wet Paper (Courtesy Sea World)

Figure 15.1 Binnacle mounted compass. Note — A binnacle is the pedestal in which a compass is mounted.

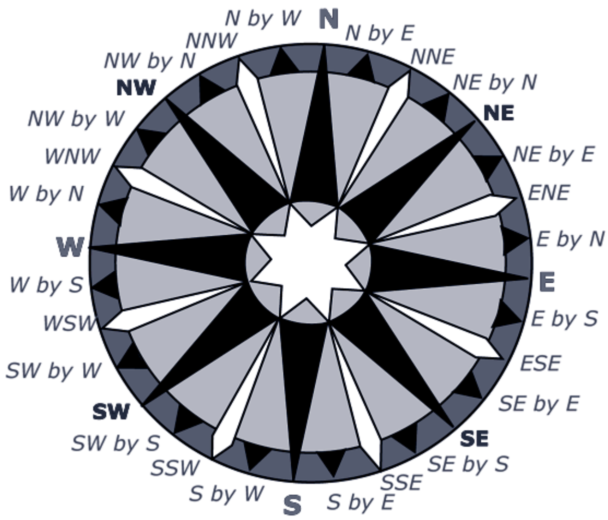


Figure 15.2 A compass card
Wet Paper

The steering compass

This compass is used “to steer” the boat and is usually mounted near the helm in a ‘free swinging’ or flush mounted position so it can easily be read when the ship rocks.

A ‘lubber line’ indicating which way the ship is heading is incorporated into the glass and a light illuminating the card makes the compass easy to read at night.

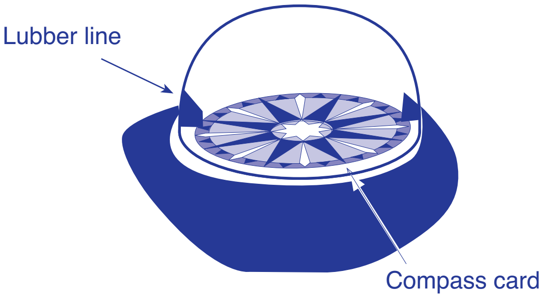


Figure 16.1 Lubber line

The steering compass can be mounted in a number of different ways to suit its location, bearing in mind the effect of outside magnetic fields which may induce errors into the reading. A steering compass is shown in Figure 16.3.

The hand bearing compass

Whereas the steering compass is usually a fixture near the helm, the hand bearing compass is free and can be carried to the most suitable spot on the boat for navigational observations as shown in Figure 16.2.

For this reason, the hand bearing compass is usually much smaller and lighter and incorporates some form of sighting device, the simplest and most common being the ‘V’ sight used on small rifles. Because it is relatively small, this type of compass usually has a magnifying glass to enlarge the figures on the card.

Others like the one shown in Figure 16.2 may have a built-in prism which reflects the bearing back to the eye.

Figure 16.2 Prism mounted handbearing compass

Figure 16.3 Steering compass

Fluxgate compass

The fluxgate compass does not use a magnetic needle to provide direction but consists of two coils carrying electric current. One coil is mounted horizontally and the other vertically. If the vessel changes its heading or position in the Earth’s magnetic field it alters the flow of current in one coil relative to the other.

Being electrical, the information can be displayed digitally. It can be fitted with microprocessors which can automatically compensate for both deviation and variation thus providing a true bearing.

The fluxgate compass does require power from a small battery for it to operate.

This compass must also be held fairly steady for accurate readings.

Two types of fluxgate compasses are shown in Figure 16.4.

Figure 16.4 Two types of fluxgate compasses (compasses courtesy Bruce Chapman Marine)

Gyro compass

The age of the iron ship demanded a compass that could show True North and not be affected by the ship's hull. The magnetic compass was of little use in these steel vessels and a gyro compass was invented to take its place.

The gyro compass points to True North and does not rely on the Earth's magnetic field. It is a non-magnetic compass. It relies on the principle that a fast spinning wheel will maintain its direction. Once this is in motion, it will maintain its orientation and the direction a vessel is heading can be determined. It relies on electricity to spin the wheel.

Since a gyro compass is not affected by the magnetic field it is not subjected to the errors that are inherent in the magnetic compass such as deviation and variation. It can also have repeaters (slaves) in other positions on the vessel run from the main compass so that all vessel's workings are from the one compass.

Use of the sextant

The marine sextant is a hand held instrument used to determine the angle between your eye, the horizon and the distant object. It has been used for centuries to measure the altitude of celestial bodies such as the sun, moon and stars. The altitude of these celestial bodies changes as one moves in a northerly or southerly direction. This altitude can then be used to determine the latitude (position) on the Earth's surface.

The sextant can also be used to measure the difference in bearing between two geographical points on the coastline thus allowing the vessel to fix a position. The sextant is placed on its side to complete this measurement.

Courtesy John Armstrong

Figure 17.1 Using a sextant

Chart room

The chart room on a ship is where most of the navigation equipment is stored. The wheel house is where most of the measurements are taken and the ship is steered. Other navigation instruments and equipment discussed in this workbook include the clock, charts,echo sounders, parallel rules and rulers, radar and GPS . Figure 15.2 shows part of a chart room on a training ship operated by the Australian Maritime College in Tasmania.

Challenge

1. Construct a model to demonstrate how a sextant works
2. In winter - is the sun directly overhead at 12 midday at your school i.e. does it not caste a shadow?

   Will the shadow fall to the north or to the south?

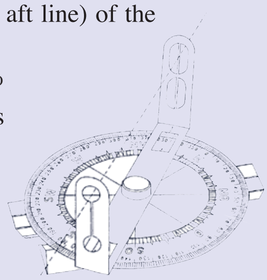
   Will the shadow be greater or shorter in summer or in winter?

   Explain your answers.
3. Why is it easier to maintain balance on a bicycle that is moving than one that is stationary?
4. Suggest some examples where the gyro or spinning effect is used to our advantage
5. Suggest why the gyro compass was not invented until the 20th century.

The pelorus

This is used to take bearings relative to the vessel's heading (the way it is pointing). This bearing can then be added to the vessel's heading to give the compass bearing. The pelorus consists of a set of sighting vanes mounted over a circular card showing 0^{O} – 360^{O} without a magnetic needle and it has no directional properties. It can be located anywhere on the vessel but it must line up on the Lubber Line (fore and aft line) of the vessel.

The pelorus must be set at 00^{O} dead ahead. Relative bearings are then observed. You can read more about the pelorus and the gyro compass in Chapter 8 of *Australian Boating Manual - Available from Sydney Maritime Group Tel: (02) 9907 6744*



Pelorus illustration courtesy Capt Dick Gandi

Wet Paper

Figure 17.2 Navigation equipment in a chart room of a training ship.

Chronometer

An extremely accurate ship's clock is set at Greenwich Mean Time. This allows the navigator to find the time difference between Greenwich time 12 noon and the time the sun is directly overhead at your position (12 noon).

This allows you to calculate how far you are away from Greenwich. GMT (Greenwich Mean Time) is now called UTC (Universal Time Coordinated).

Calculating time by longitude

Your longitude can be calculated by the time difference between you and UTC.

The Earth rotates 360° in 24 hours, so:

1 hour = 15° of arc

4 mins = 1° of arc

1 min = 15' of arc

4 sec = 1' of arc

This means that if a vessel A is located at longitude 100° East and vessel B is located at longitude 160° East the time difference will be equal to (60 / 15) = 4 hours.

The sun will rise 4 hours earlier at position B.

Since the Earth rotates from West to East, places east of Greenwich will have times in advance of Greenwich Mean Time. (GMT)

If Perth and Sydney have 30° difference in longitude, what time difference should there be?

The international date line

The 180° meridian is very important as it is by international agreement, the date line.

A vessel sailing eastward will need to put back the calendar one day when it crosses the date line. A vessel will add a day when going in a westward direction. This is used to many people's advantage when they can celebrate New Year's Eve in two areas.

Note on UTC

UTC — Universal Time Coordinated, previously known as Greenwich Mean Time (GMT;1928 - 1972). UTC was introduced in 1972 and replaces midnight GMT with 0000h (0 hours).

Wet Paper

Figure 18.1 A ship's clock

Challenge

- Some ancient Viking mariners carried ravens with them on their voyages across the oceans.

  These birds were used for navigational purposes.

  Suggest a possible reason as to how they would assist in navigation.

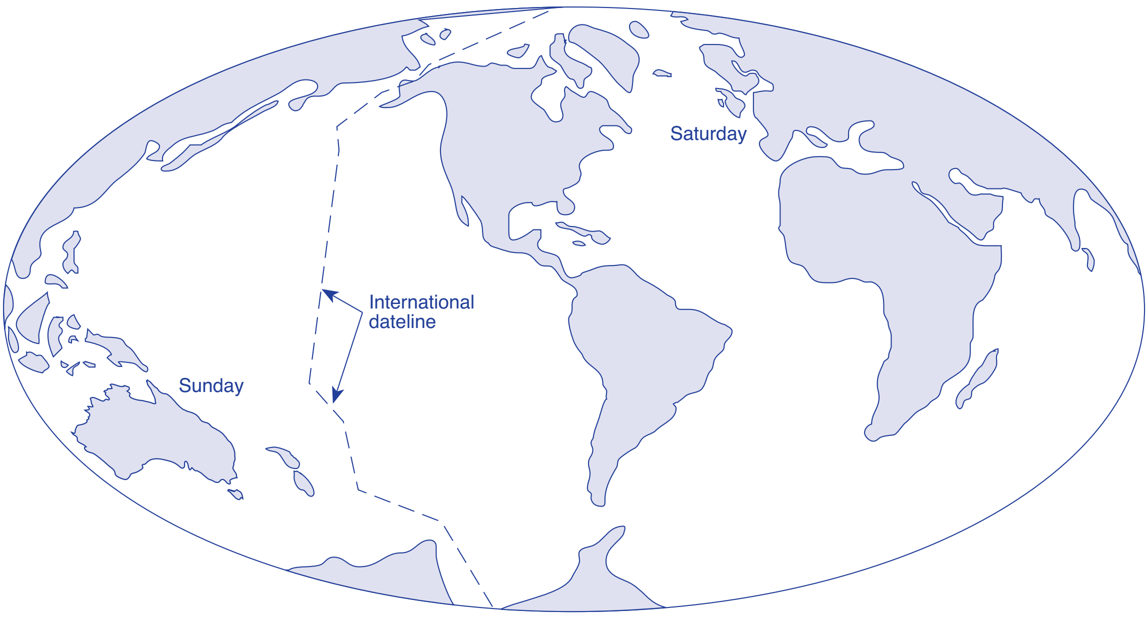


Figure 18.2 The International Dateline

Wet Paper

Worksheet 4 What day is it?

Questions

1. GMT (Greenwich Mean Time) is now called UTC (Universal Time Coordinated). They are in effect the same time standard, but differ in that mid-night GMT is replaced by 0000 h. UTC time is 24 hour time.

   If UTC is 1200 what will be the time at

   a. East coast of Australia

   b. Central Africa

   c. Brazil

   d. India

2. Two vessels are communicating on radio when the person on vessel A stated the sun is just rising at his position. Vessel B states the sun has been up for 2 hours at his position. If the vessels are at the same latitude, what is the difference in longitudinal position of each vessel?

3. Why do you believe the International Date Line does not follow the 180^{O} meridian exactly?

   Where does it deviate from the meridian?

4. Suggest why Australia has at least 3 time zones. What are they and what are the time differences?

5. A cricket fan in Australia wants to listen to a cricket match being played in England near Greenwich. The match is to start at the grounds at 11 am. The cricket fan knows his position is 20^{O} 30S 150^{O} 0' E. At what time will the game broadcast start at his home, if it is a direct telecast?

6. Locate the latitude and longitude of the following cities on an atlas and calculate the time at these cities if the Universal Time Coordinated (UTC) is 1200 hours.

   London

   New York

   Beijing

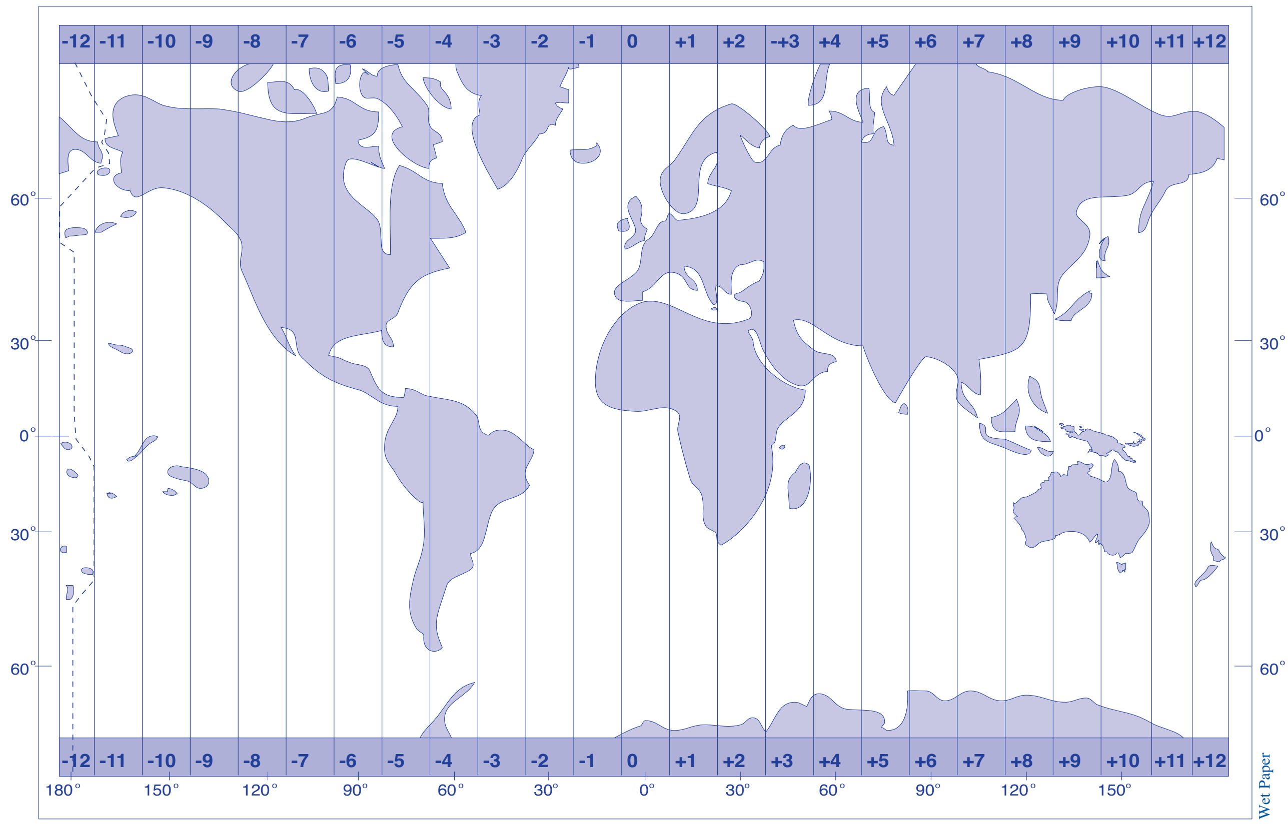
   Paris

   Los Angeles

   Calcutta

   Moscow

Time zone chart of the world



WORKSHEET 5 MAGNETIC FIELDS

Aim

To map a magnetic field.

Materials

- bar magnet
- iron filings
- a small compass
- acetate sheet (overhead transparency)

Method

A magnetic field is the area where the magnetic force acts.

1. Place a bar magnet on a desk and place a piece of A4 paper on top of the magnet. Keep the paper as level as possible by supporting the sides with books, etc.
2. Carefully sprinkle iron filings over the acetate paper so that the iron filings are spread evenly over the sheet. Place the acetate sheet with the iron filings onto the paper that is above the magnet.
3. Draw a sketch of the pattern made by the iron filings. You may need to sprinkle more iron filings to obtain a distinct pattern.
4. Remove the acetate sheet and place a small magnetic compass at a number of different positions on the paper. Record the direction in which the compass needle points at the different locations. Suggest which end of the magnet would be north and which end south.

Questions

1. What happens to the strength of the magnetic field as you move further from the magnet? What evidence do you have to support this conclusion?
2. Why do some of the iron filings stand up on the acetate? What does this tell you about the magnetic field in this area?
3. Do the compass needle directions and the shape the iron filings formed on the acetate have anything in common?
4. Where is the magnetic field the strongest? What evidence do you have to support your answer? Predict what would happen if you were to cut or break the magnet in half.
5. How might you make a simple compass? Endeavour to construct your own compass.
6. When you use a bar magnet to pick up small items such as pins, you use the end of the magnet. Suggest why you do this.
7. Suppose you were given a magnet and you were asked to label the north and south ends, how would you go about deciding which end was which?

Extension exercise

Aim

To discover which materials are magnetic.

Materials

- bar magnet
- iron
- copper
- steel (nails)
- stainless steel (bolt)
- aluminium (rivets)
- plastic
- glass
- silver
- gold (jewellery)
- lead
- brass

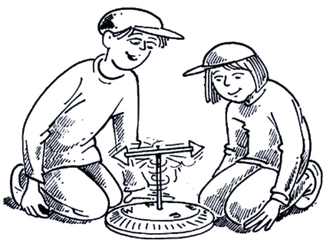
Results

Method

1. Design a table to display the results of this experiment showing which materials are magnetic and which are not.
2. Place a bar magnet on each of the substances and draw the magnet away. Record which materials are held by the magnet as it is drawn away.
3. Place a compass on the table. Place one material at a time near the compass needle and observe which substances have an effect on the needle. Record results.

Questions

1. Which of the materials tested need to be kept well away from the ship's magnetic compass?
2. Do you believe a magnetic compass could be used in a vessel made of steel?
3. Do you believe that a magnetic compass could be affected in any way on an operational aluminium vessel? Explain your answer.
4. Why do you believe modern steel vessels should carry a fluxgate compass?
5. Design an experiment to test if animals could detect magnetic current. What type of animal might you use?



Worksheet 6 Using a hand bearing compass

Wet Paper

Figure 22.1 Handbearing compass

Aim

To learn how to take a compass bearing

Materials

Hand bearing compass

Method

This exercise can be simulated in the classroom but later put into practice on a vessel at sea.

This is an important art to practise.

Step 1 With some chalk mark a spot outside the classroom where there is a clear view of a number of features e.g. building, church steeples, trees, etc.

Step 2 Make a list of six or more features your group must take a bearing to.

Step 3 Record these bearings.

Step 4 Compare the bearing students have taken.

Step 5 Place a desk that has a metal frame on the spot. Repeat the exercise with the compass placed on the desk.

Step 6 Record these results.

Step 7 Go back to the classroom and mark the direction of Magnetic North.

Repeat the exercise marking South, East and West. Mark the positions with wall charts so students become familiar with the magnetic directions.

Results

1. What difficulties did you have in completing this exercise?

2. Compare your results with other students in the class. If there are differences in the bearing results, explain these differences.

3. What effect did the steel frame have on the bearing taken? Explain why this occurred.

4. Suggest a method to reverse the effect of the steel frame.

Extension

Design an experiment to show the effect of electric current on a compass.

Worksheet 7 Making A Compass Rose

Aim

To learn the points of the compass and take bearings in your classroom

Materials

- pencil, ruler and rubber
- orienteering compass
- A4 sheet of paper

Method

1. Use your pencil and ruler to make a map of your room on your A4 sheet of paper.

   Draw in the desks and mark in conspicuous features such as the door, wall clock, blackboard and where you are sitting.
2. Using the circle in Figure 23.1 as a guide, mark in classroom North with a capital N and write 0° beside it.
3. Now mark in 10°, 20°, 30° to 360° around the circles as shown in Figure 23.1. You have now made a compass rose.
4. On the inside of the circle mark off the compass points: NE, E, SE, S, SW, W, NW to match numbers you have just marked.

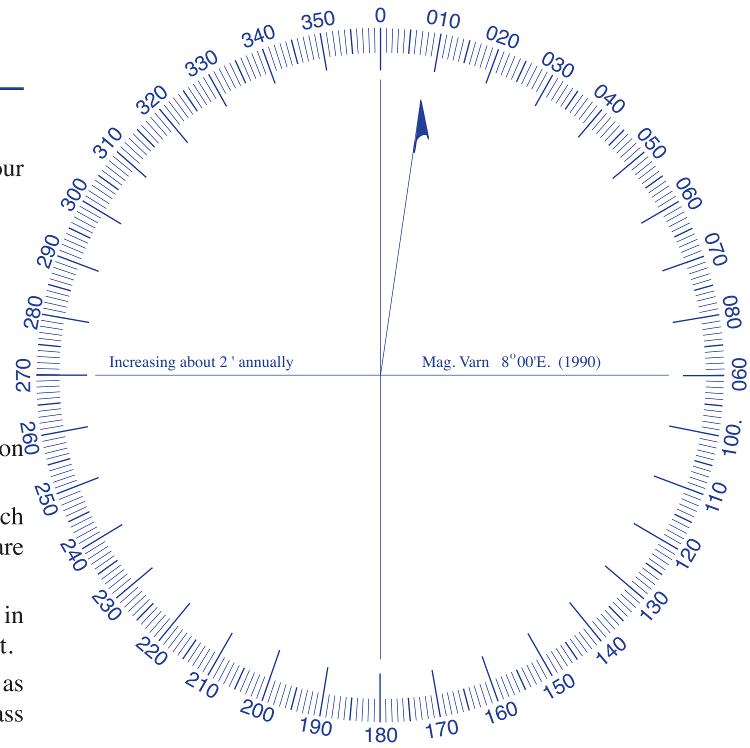


Figure 23.1 A compass rose

5. Take the orienteering compass, place it in front of you away from the metal parts of the desk and find Magnetic North.
6. Now mark this on your compass rose as Magnetic North.

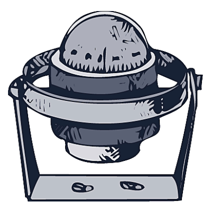
Questions

1. How many degrees difference is there between Classroom North and Magnetic North?

   Give a reason for this difference.

   ____

2. From where you are sitting, what are the approximate compass point positions of the following conspicuous points in the classroom. Give your answer in compass points.
   a. Right hand corner of room
   b. Room entry door
   c. Clock
   d. Teacher's desk.
   e. Nearest student's desk



Section 4 Charts

The Earth

In basic navigation, the Earth is, for all practical purposes, treated as a sphere.

The Earth in actual fact is similar to a sphere flattened at the poles and is termed an oblate spheroid. It rotates on an axis, which is inclined approximately 23.5 degrees to the vertical, and it rotates from West to East (Figure 24.1).

The problem then comes of how to represent this surface of the Earth on a flat chart. If the Earth was divided up with a network of lines running vertically and horizontally, it would form a grid. These imaginary lines would then intersect at right angles. Distances could then be measured and locations determined by means of angles calculated from these lines.

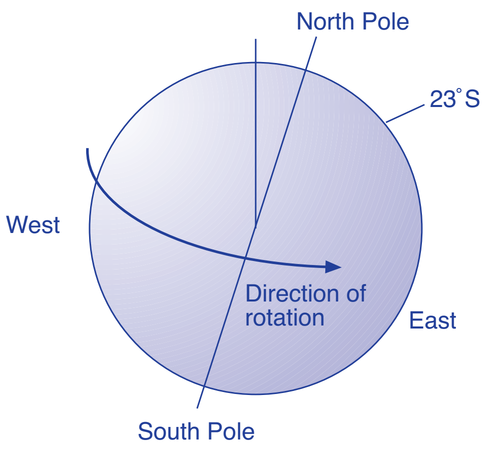


Figure 24.1 Earth's rotation
Wet Paper

A chart

A chart is a curved section of the Earth's surface reproduced on a flat piece of paper.

A map

A map is a representation of the Earth's surface on a plane surface.

Challenge

- Do you believe the Earth is round?
  Give three pieces of evidence to support your belief.

Latitude (Parallels)

The line perpendicular to the Earth's axis that cuts the Earth into two equal hemispheres is known as the Equator and is mid-point between the poles. Lines drawn parallel to the Equator around the Earth are called lines of latitude. The line of latitude at the Equator is said to be 0^{O} latitude (Figure 24.2).

The latitude of a position is given by the angle formed from its position at the surface to the centre of the Earth and to a position on the Equator.

The circles (lines of latitude) get smaller as you go to the poles.

This angle is measured in degrees, minutes and seconds for 0 – 90 degrees, North or South of the Equator.

1 degree (1^{O}) = 60 mins (60)'

1 minute = 60 seconds

In the 13 century the Italians used a chart called a Portolano which showed an outline of the coast.

It was one of the earliest charts and also contained land features and safe anchorages.

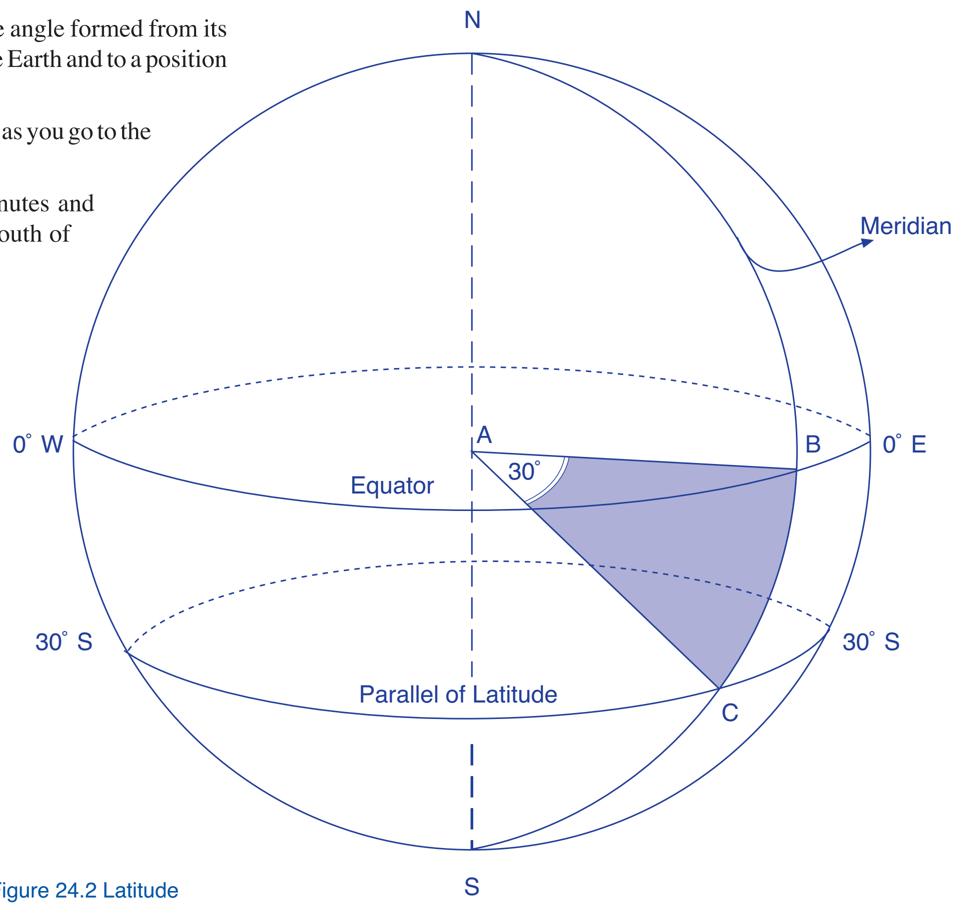


Figure 24.2 Latitude
Wet Paper

Longitude (Meridians)

Meridians are the imaginary great circles drawn on the surface of the Earth passing through both poles. These lines converge at the poles and are perpendicular to the Equator. The meridian or line passing through Greenwich (London) is called the Prime Meridian (Greenwich) and indicates zero degrees.

The longitude of a position is the angle (up to 180°) East or West of Greenwich that is formed when a triangle is drawn from one's position on the surface of the Earth to the centre of the Earth and back to Greenwich.

Lines of longitude are shown east or west of Greenwich and go up and down a chart (Figure 25.1).

If the Earth rotates 360 degrees in 24 hours it will therefore rotate 15 degrees in 1 hour.

Time	=	Arc
24 hours	=	360°
1 hour	=	15°
60 minutes	=	15°
4 minutes	=	1° = 60 '
1 minute	=	15'
4 seconds	=	60"
1 second	=	15"

Message to "light" on the horizon

"This is the HMAS Enterprise to the light on the horizon, please alter course."

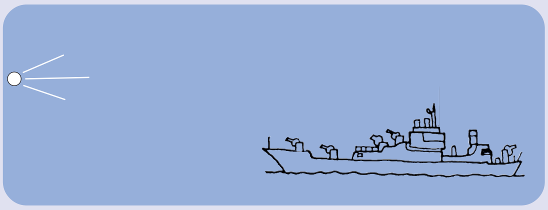
"This is the light on the horizon, please alter your course."

"This is the HMAS Enterprise, we are well armed and dangerous, I suggest you alter course."

"This is the light on the horizon, we don't care, please alter your course."

"This is the HMAS Enterprise, I you don't alter course we will RAM you, IDENTIFY YOURSELF."

"This is the lighthouse keeper of the light on the horizon, RAM at will."



Which is first

Latitude is usually followed by followed by longitude

Eg: 24° 02.5' S, 162° 06.8' E

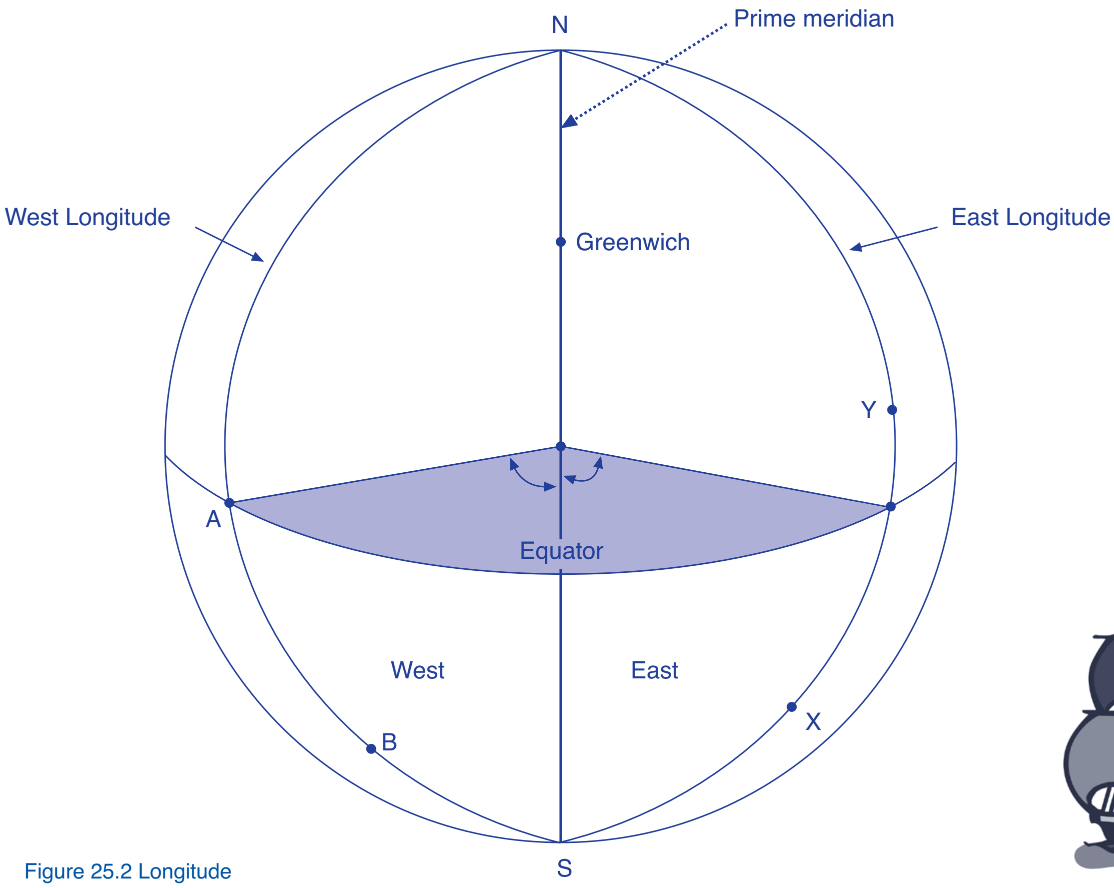


Figure 25.2 Longitude

Wet Paper

The mercator chart

Important features of charts based on the Mercator projection are:

1. Parallels of latitude are all straight lines although the distance between them increases as the latitude increases as shown in Figure 26.1
2. Rhumb lines are curved lines on the surface of the Earth that cut all meridians of longitude at the same angle.

   These are shown in Figure 26.2.

Challenge

- Two penguins are standing at the south pole.

  One walks towards the north the other in the opposite direction. In which direction would the second penguin be walking? Explain your answer.

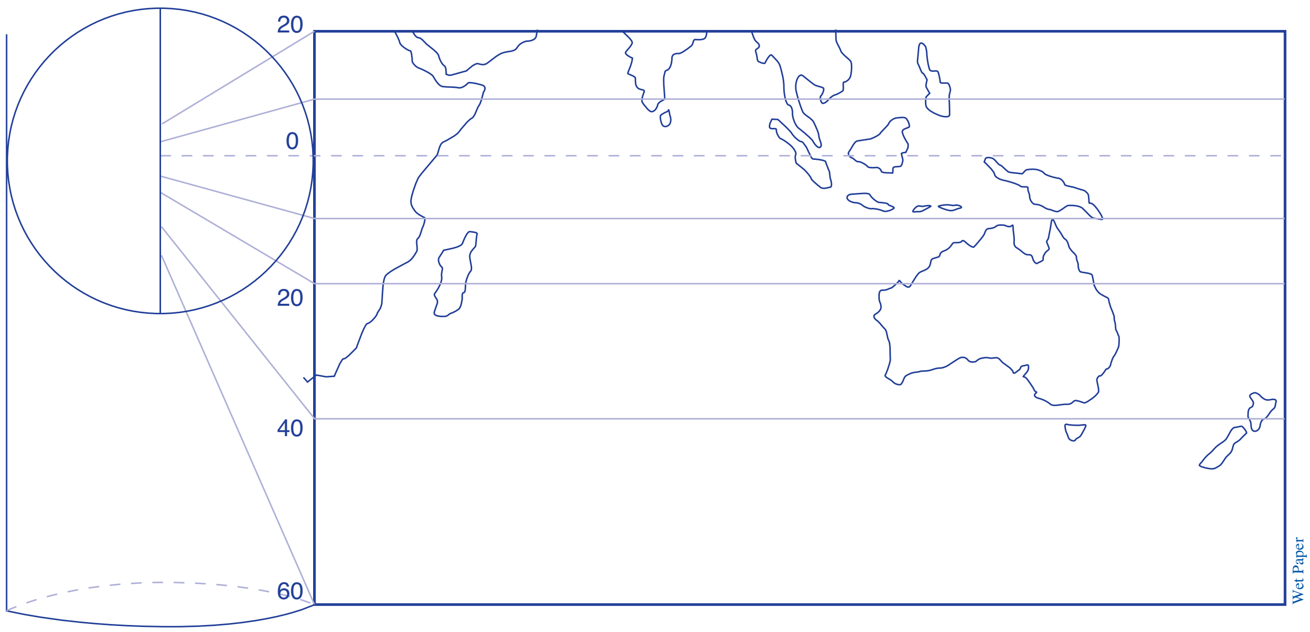


Figure 26.1 Parallels of latitude are all straight lines although the distance between them increases as the latitude increases.

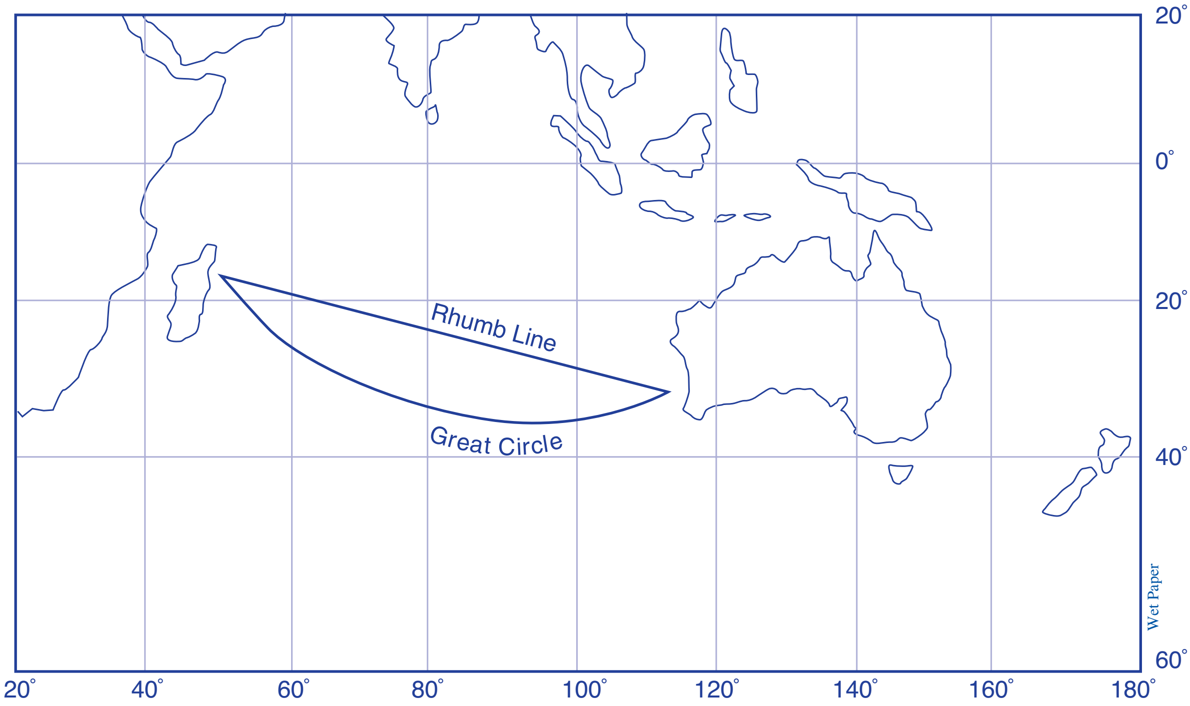
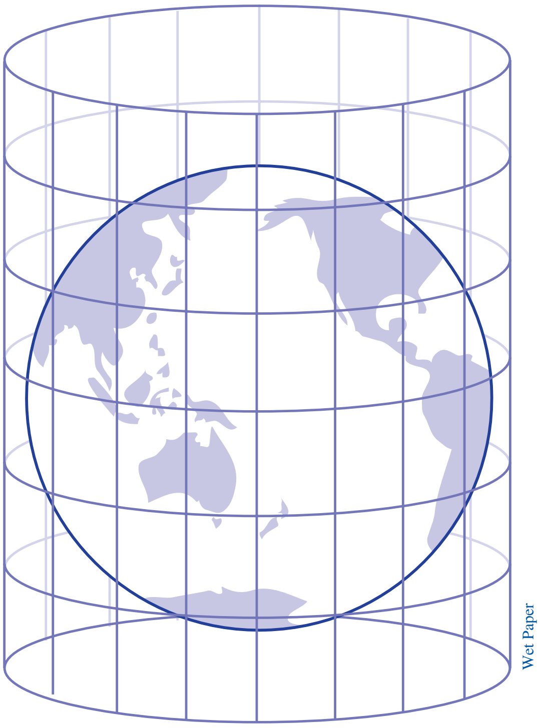


Figure 26.2 Rhumb lines or courses between two positions on the chart appear as straight lines.

3. All the meridians appear as straight lines, which are perpendicular to the Equator. These meridians are equally spaced as shown in Figure 27.1.



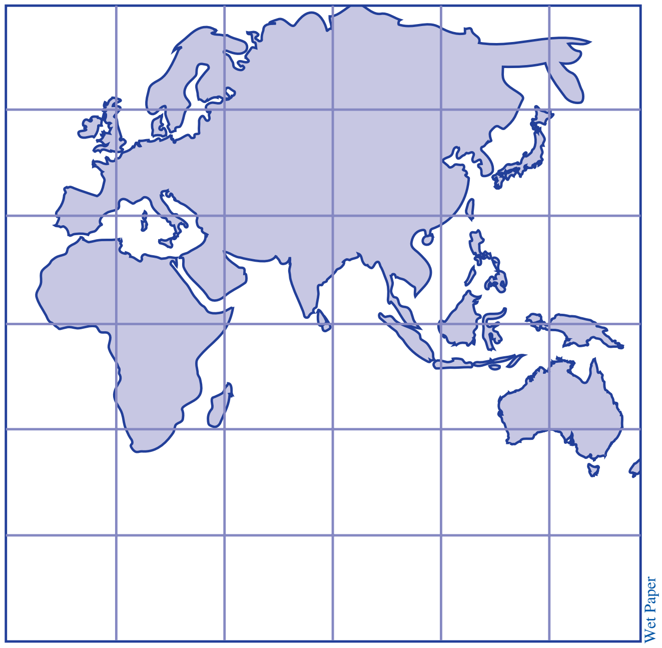


Figure 27.1 All the meridians appear as straight lines, which are perpendicular to the Equator.

Small scaled charts

In this map of Australia, we can see that there are a number of areas marked out. These are the small scaled charts which will show a large area. They are not much good for local conditions and should not be used for Worksheet one. Their main use is in large ocean voyages for calculations of positions.

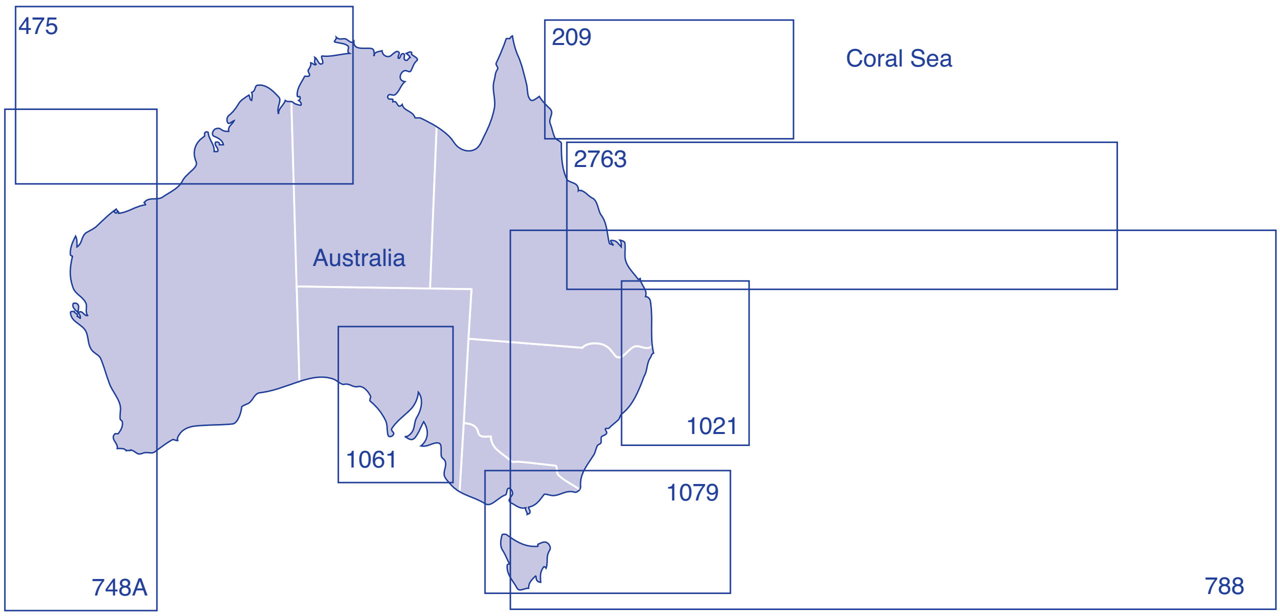


Figure 27.2 Small scaled charts are used for large areas of water

Wet Paper.

An important chart feature — depth

The depth printed on the charts are called soundings, which have been reduced to a common level known as the chart datum point. This datum point is the lowest astronomical tide (LAT) or the lowest low water spring tide in that area. These are therefore close to the minimum depth in the area and the height of the tides must be calculated to predict a real depth. (Tides are discussed in another workbook in this series.)

Most charts are now metric charts and a depth reading of 3_6 is 3.6 metres. If the chart is in fathoms (1 Fathom = 6 feet) a recording of 3_4 is 3 fathoms and 4 feet or 22 feet. 1 metre =3.25 feet.

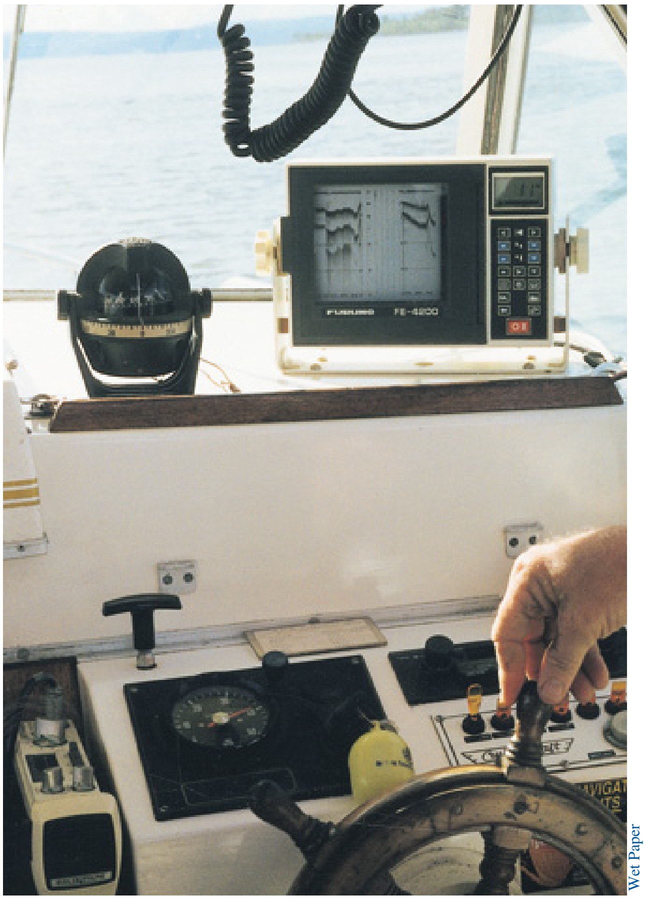


Figure 28.1 Depth sounder mounted in wheelhouse of small boat. (Photo Courtesy Dave Claridge)

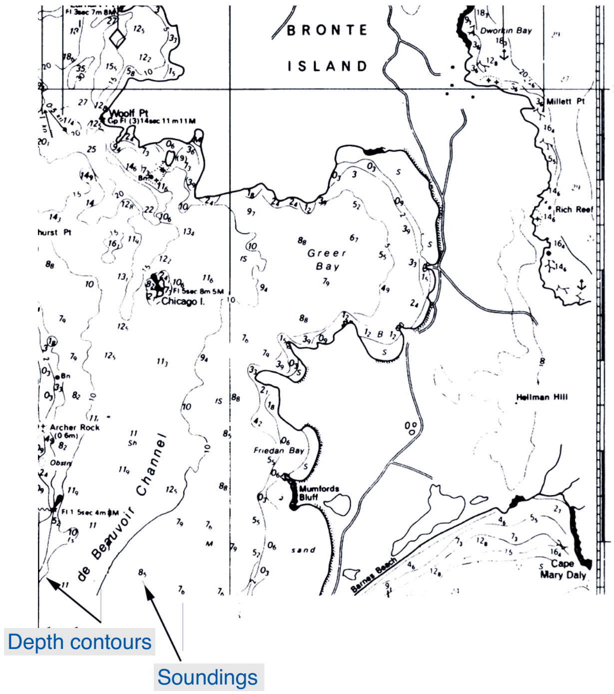


Chart tidal datum

Chart datum is the level of water that charted depths on a nautical chart are measured from.

Figure 283 shows that the datum is derived from the lowest point of mean low waster springs.

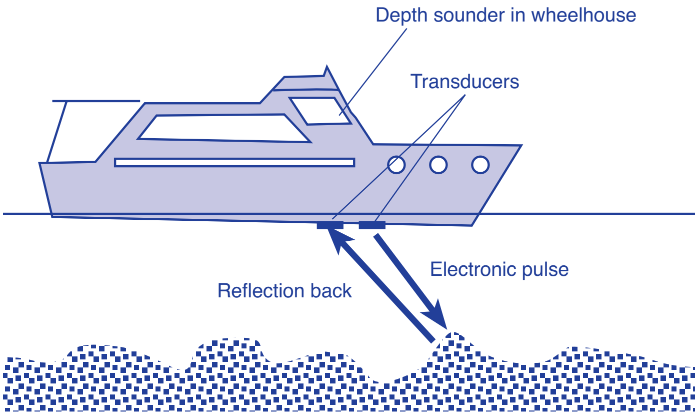


Figure 28.2 How a depth sounder works.
Wet Paper

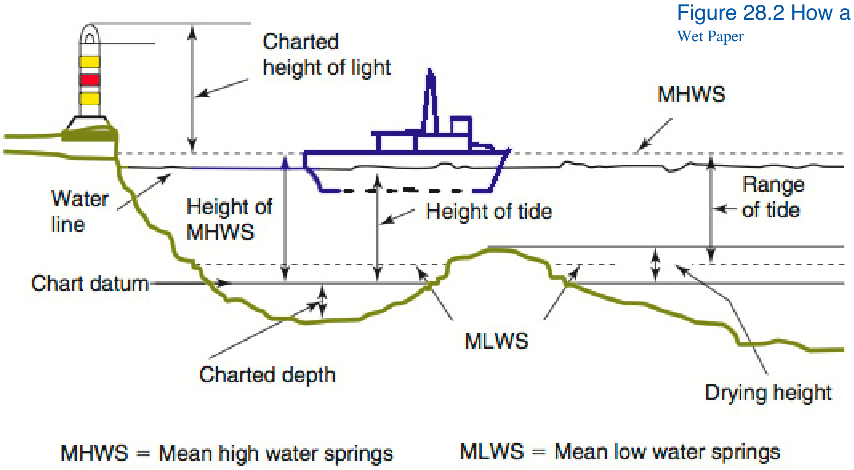


Figure 28.3 Tidal terms of reference

The rule of twelfths

This allows you to calculate the height of a tide below a boat and is discussed later.

Worksheet 8 Your Local Chart

When you look at charts for the very first time they look quite complicated. This Worksheet seeks to introduce you to some chart features that don't occur on a map. Later activities will help you use the chart.

Materials

- chart of the local area
- map of the local area

Method

1. As a class, look carefully at the map and then at the chart and write a list of 10 differences between the chart and the map on the classroom black board, giving your reasons for the differences.
2. Now answer the questions below.

Questions

1. What is the deepest section of water on the chart?

2. What is the most northerly point on the chart?

3. Why does a chart need latitude and longitude?

4. What date was the chart prepared?

5. Is there a scale on the chart and if so what scale is used?

6. What are the main shipping lights nearest the local port?

7. What is the main degree of longitude and latitude?

8. Is the chart in fathoms or metres?

9. If you had to navigate a ship into port, why would you use a chart rather than a map?

10. Locate the photographs of the navigation marks in this workbook and tick off from the list below those you can identify.
    - Starboard lateral mark [ ]
    - Port lateral mark [ ]
    - Port hand floating can [ ]
    - Starboard mark on pole [ ]
    - Port mark on pole [ ]
    - North cardinal mark [ ]
    - South cardinal mark [ ]
    - East cardinal mark [ ]
    - West cardinal mark [ ]

Wet Paper

Figure 29.1 A North cardinal mark

11. Select a venue for an overnight stay on your chart, noting:
    a. What time you should leave to arrive three hours before sunset?
    b. Will tides affect your trip? If so, how?
    c. How far are you going?
    d. What type of boat will you be in?
    e. What types of forecast will cancel your trip ?
    f. How much fuel will you need?
    g. What will be your first compass course?
    h. How many course changes will you be making?
    i. What type of buoyage system (if any) is shown on your chart?

Wet Paper

Figure 29.2 Offshore islands

Worksheet 9
Hypothetical Bay

Based on an original idea by Bob Moffatt

There are many things to learn about navigation. To navigate outside of the classroom requires skills and knowledge that come later in this set of notes. However for the present let us look at how to use a *chart*. The one we will use will be Hypothetical Bay.

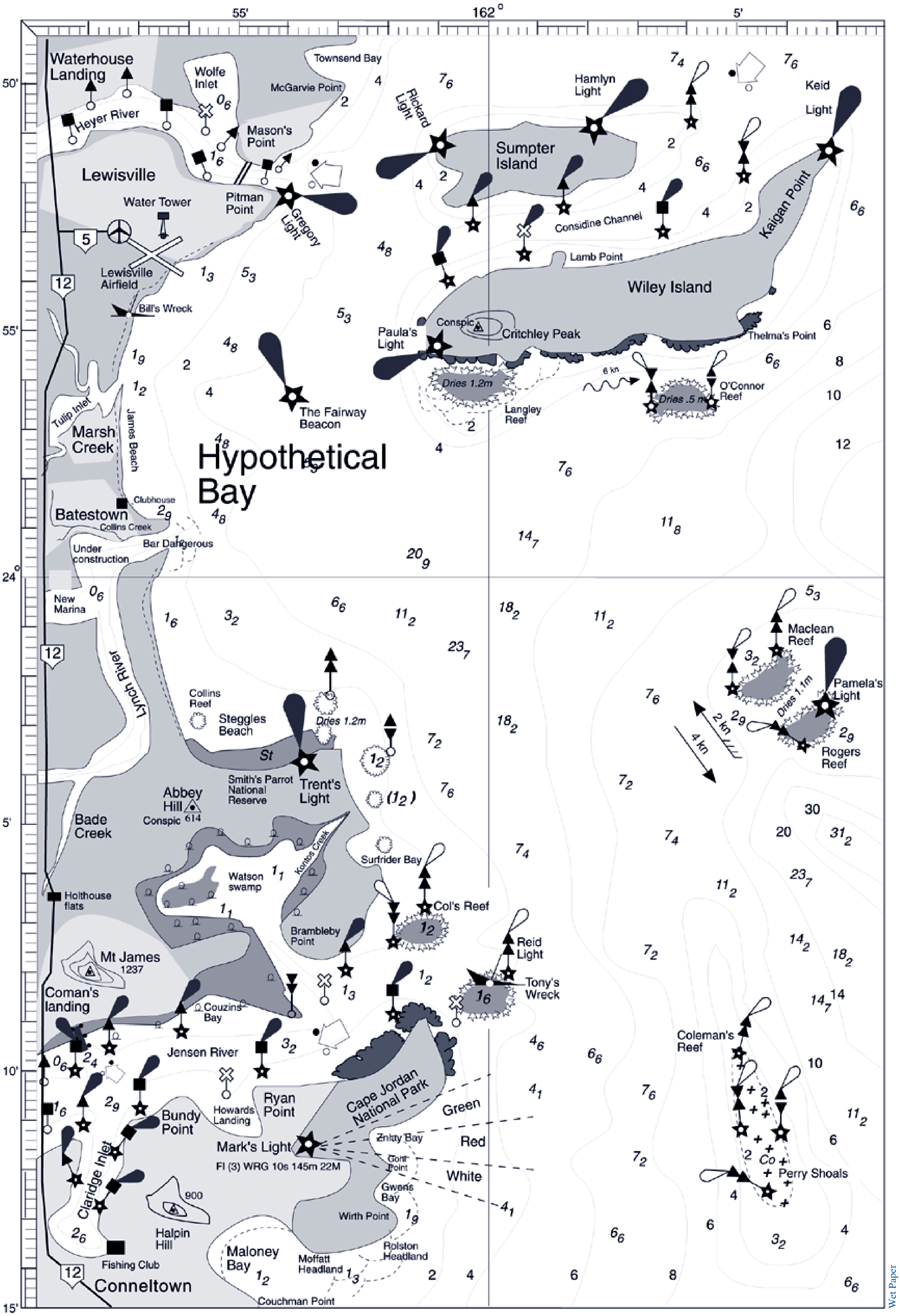
Questions

Use an atlas to find a map of Australia showing a Mercator projection.

1. What are the northern most and southern most latitudes?
2. What are the eastern most and western most longitudes?
3. Where is Greenwich? What line of longitude passes through it?
4. Name one place the Tropic of Capricorn passes through.
5. What is the latitude of your school?
6. Look carefully at the latitudes and longitudes of Hypothetical Bay.
   a. Is the bay in the Northern Hemisphere or Southern Hemisphere?
   b. Off what continental shelf is the bay located?
   c. How big is the bay approximately in kilometres?

Look carefully at Hypothetical Bay opposite and answer the questions below.

7. List any six chart features that are not found on a map.
8. Where are the deepest and the shallowest parts of the chart?
9. Use Worksheet 10 to make drawings of each of the following features:
   - wreck
   - direction of buoyage
   - light
   - water tower
   - sectored light
   - special mark
   - hill
   - rocky headland
   - airport
   - breaking waves
   - coral reef
   - stony beach
   - sounding
   - mangrove area
   - sounding line
   - starboard lateral unlit mark
   - beacon
   - sandy beach
10. What is the depth of water at the entrance to Jensen River?
11. What is the difference between pilotage and buoyage? Use your textbook index to write a definition of each.
12. What is the depth of water in Claridge Inlet?
13. Where is Thelma's Point?
14. What is found in Watson Swamp?
15. Describe the coastline features around the mouth of Lynch River?
16. Name any three hills over 500 m.
17. Name the two islands in the bay.
18. What is the speed of the ebb tide off Maclean Reef?
19. What is the sea floor made of in Perry Shoals?
20. What is the sea floor and surrounding coastline made of around Langley Reef?


55'
162°
5'
50'
55'
24°
5'
10'
15'
Waterhouse Landing
Heyer River
Wolfe Inlet
Townsend Bay
McGarvie Point
Mason's Point
Lewisville
Water Tower
Pitman Point
Gregory Light
Lewisville Airfield
Bill's Wreck
Rickard Light
Hamlyn Light
Sumpter Island
Keid Light
Considine Channel
Kaigan Point
Lamb Point
Wiley Island
Conspic
Critchley Peak
Paula's Light
Thelma's Point
Dries 1.2m
Langley Reef
6 kn
Dries .5 m
O'Connor Reef
The Fairway Beacon
Tulip Inlet
Marsh Creek
James Beach
Hypothetical Bay
Clubhouse
Batestown
Collins Creek
Bar Dangerous
Under construction
New Marina
Lynch River
Collins Reef
Steggles Beach
Dries 1.2m
St
Smith's Parrot National Reserve
Trent's Light
Abbey Hill
Conspic 614
Bade Creek
Maclean Reef
Pamela's Light
Dries 1.1m
Rogers Reef
2 kn
4 kn
Watson swamp
Kontos Creek
Surfrider Bay
Col's Reef
Brambleby Point
Holthouse flats
Mt James 1237
Reid Light
Tony's Wreck
Coman's landing
Couzins Bay
Jensen River
Coleman's Reef
Howards Landing
Ryan Point
Cape Jordan National Park
Green
Red
White
Bundy Point
Mark's Light
Fl (3) WRG 10s 145m 22M
Zinlay Bay
Goff Point
Gwens Bay
Perry Shoals
Claridge Inlet
900
Halpin Hill
Wirth Point
Maloney Bay
Moffatt Headland
Rolston Headland
Fishing Club
Conneltown
Couchman Point
Wet Paper

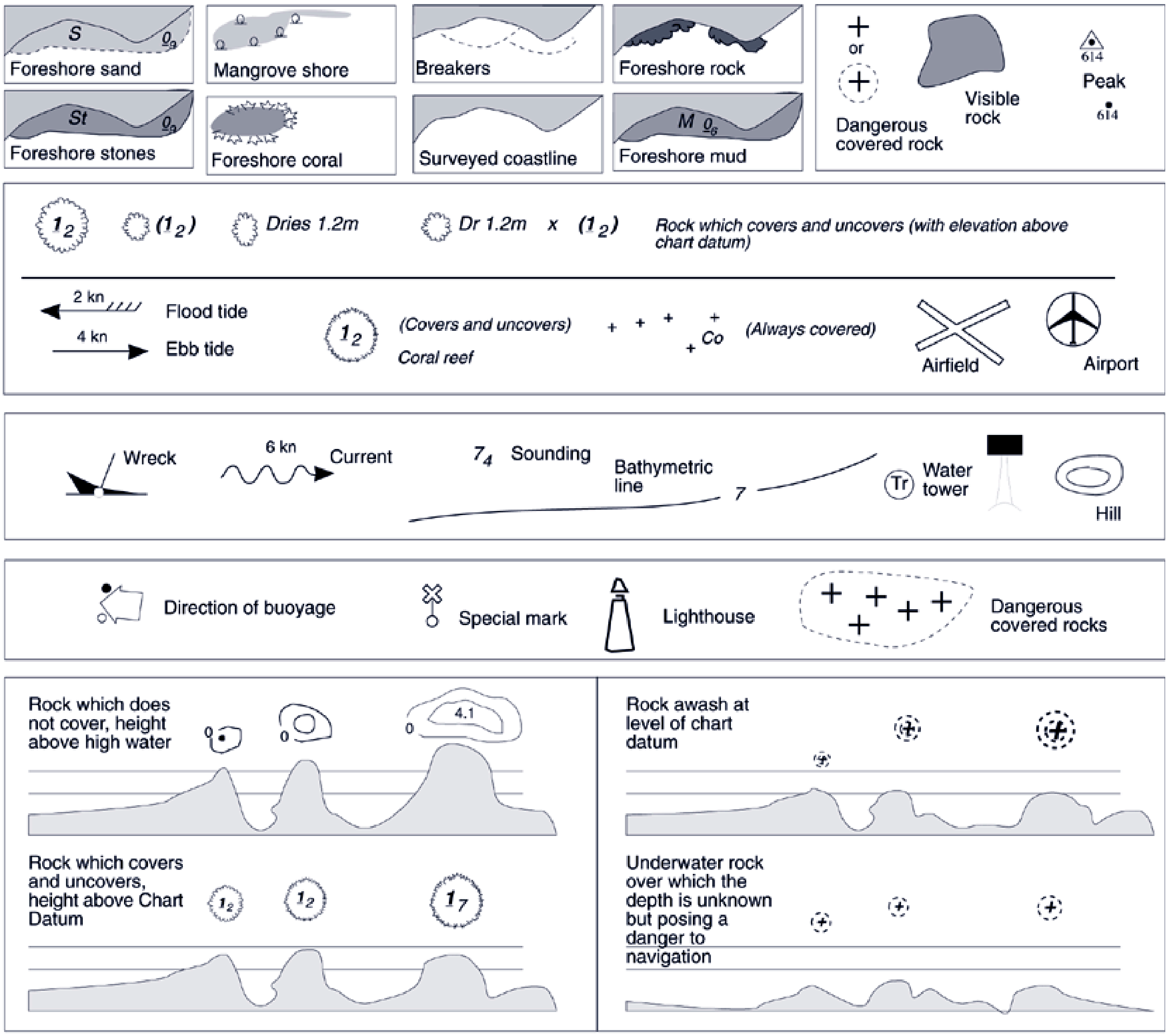
Worksheet 10 Your own chart

Project

Make up a hypothetical bay of your own using the symbols on this page.

Additional references

Charts and chart symbols and maritime buoyage system, published by the Hydrographer of the Navy, 1982, Commonwealth of Australia.



Nature of seabed			
Co	Coral	Sh	Shells
Cy	Clay	Si	Silt
G	Gravel	S/M	Sand over mud
M	Mud	St	Stones
P	Pebbles	Wd	Weed
R	Rock	Wk	Wreck
S	Sand		

Qualifying terms	
c	Coarse
f	Fine
h	Hard
m	Medium
sf	Soft
sy	Sticky

Other terms	
ED	Existence doubtful
PA	Position Approx.
PD	Position Doubtful
Rep	Reported
SD	Sounding doubtful

Fig 13.1 Common chart symbols

Wet Paper

Worksheet 11 Chart Features

1. Lights

   Suggest what you would observe at night if the chart features below were sighted:

   F1 R2s

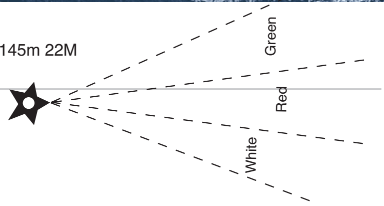
   F1 (3) 10s

   F1 (2) G5s

   F1 (2) 6s 33m 7M

   F1 G 6s

   F1 (2) WRG 10s



2. Nature of Seabed

   Describe the nature of the seabed in areas labelled

Cy	Co
M	Si
Wk	S/M
Wd	St

3. Complete the sentences by drawing the following features:

   a. Coral reef which is always covered

   b. A flood tide of 3 knots

   c. A submerged hazard

   d. A rock which will be uncovered at low tide

   e. A rock which will be 2 metres above at high side

   f. An underwater rock which is considered dangerous

4. Make up a chart below using the correct symbols

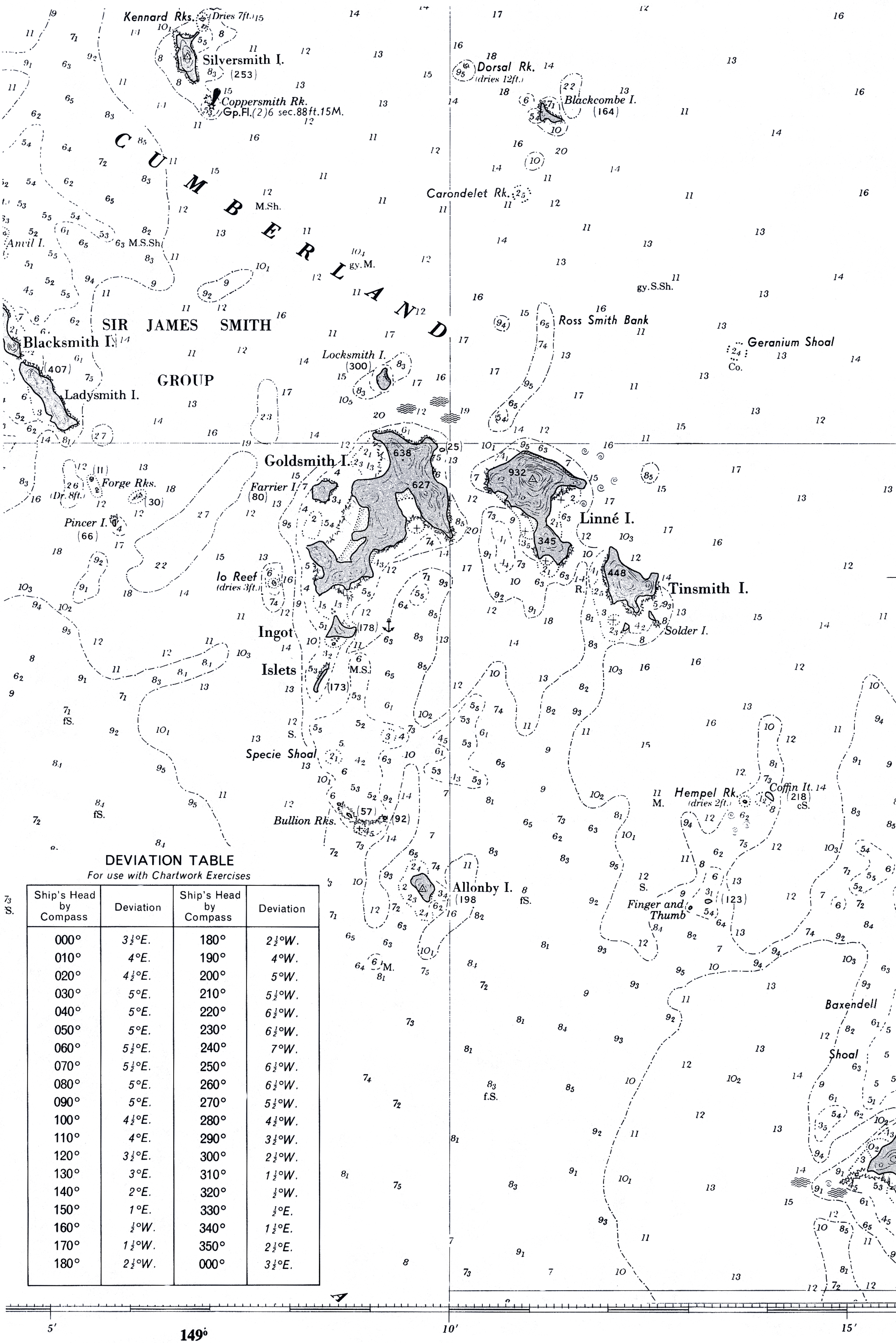
Rocky area

Coral reef

breakers

Submerged hazard

foreshore coral



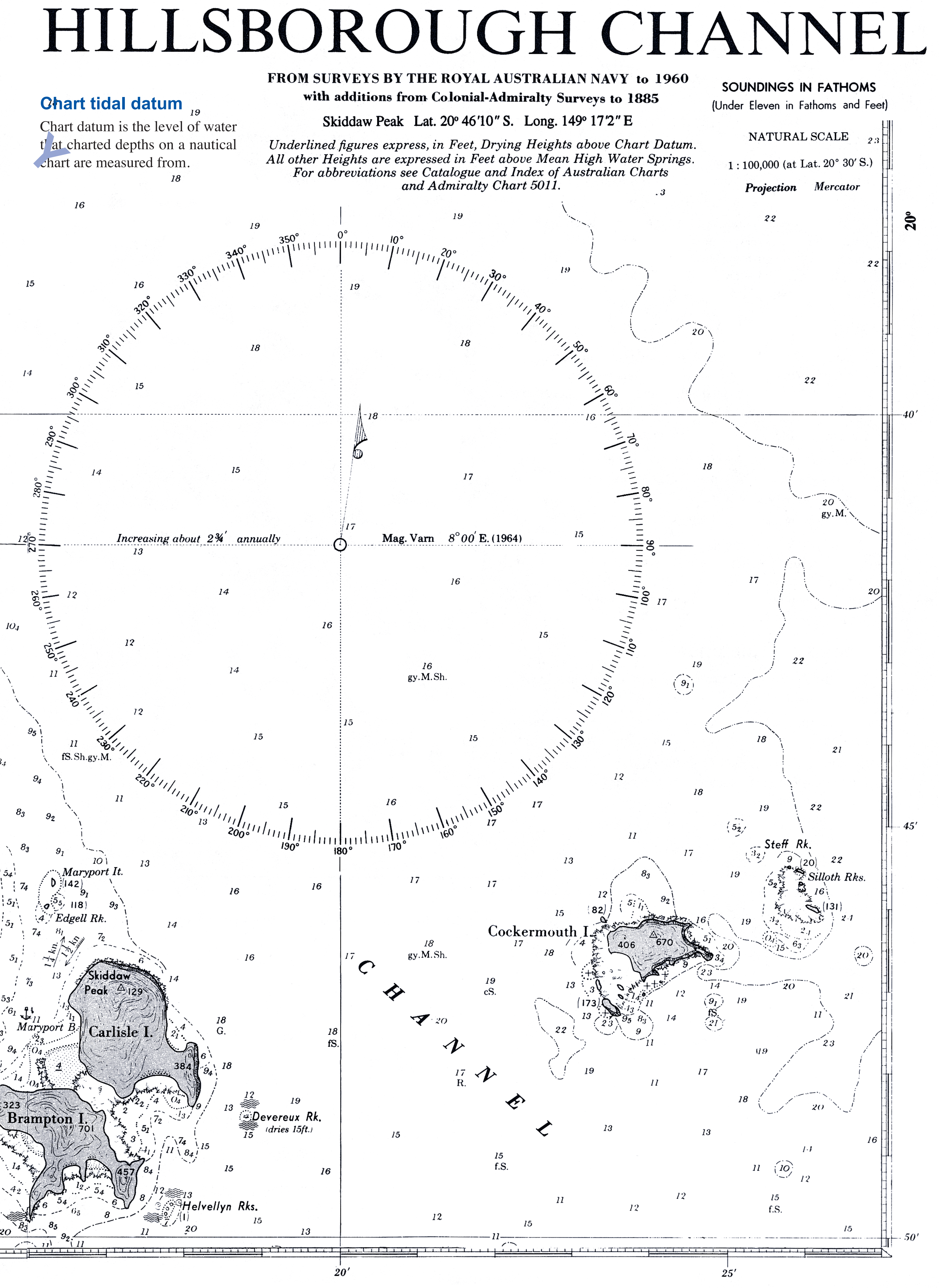
DEVIATION TABLE

For use with Chartwork Exercises

Ship's Head by Compass	Deviation	Ship's Head by Compass	Deviation
000°	3½°E.	180°	2½°W.
010°	4°E.	190°	4°W.
020°	4½°E.	200°	5°W.
030°	5°E.	210°	5½°W.
040°	5°E.	220°	6½°W.
050°	5°E.	230°	6½°W.
060°	5½°E.	240°	7°W.
070°	5½°E.	250°	6½°W.
080°	5°E.	260°	6½°W.
090°	5°E.	270°	5½°W.
100°	4½°E.	280°	4½°W.
110°	4°E.	290°	3½°W.
120°	3½°E.	300°	2½°W.
130°	3°E.	310°	1½°W.
140°	2°E.	320°	½°W.
150°	1°E.	330°	½°E.
160°	½°W.	340°	1½°E.
170°	1½°W.	350°	2½°E.
180°	2½°W.	000°	3½°E.

Chart tidal datum

Chart datum is the level of water that charted depths on a nautical chart are measured from.



Section 5 Chart Work

Chart work involves using a chart and other instruments to navigate a vessel. For example a vessel's position on a chart can be given by finding the latitude and longitude.

The latitude scale is marked on the side of the chart and the latitude increases as one moves further from the Equator. It increases as you go down the chart in the Southern Hemisphere. The longitude scale is marked across the top of the chart and increases eastward in Australia.

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 used is the nautical mile, which is represented by one minute of latitude.

1 Nautical Mile = 1 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.

Distance is measured by dividers.

The spread of the divider's points are used to carry the measurement of the latitude scale, where it can be read off in minutes. Because of variations due to the chart's distortion, distance readings should be taken from the latitude scale at a point approximately level with the boat's position.

Speed and distance

These two factors are related by a formula that involves distance and time.

Think of the speed of a car. It is measured in kilometres per hour.

Speed is the total distance travelled, divided by the total time taken, and can be summarised in the magic triangle as shown in Figure 36.2

The speed of a vessel is measured by a speed log.

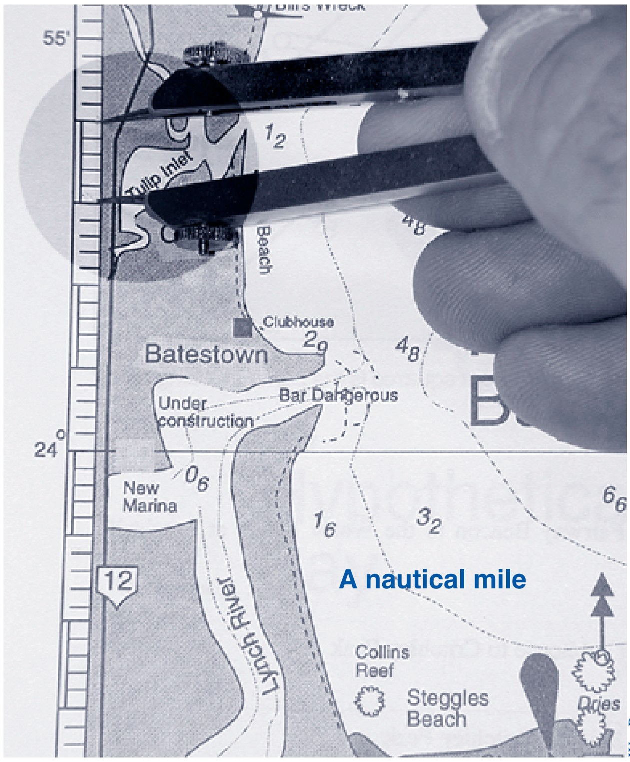
This computes the time it takes to travel a nautical mile.

Speed is measured in knots. The log on a boat shows distance and sometimes speed. Distance logs are more important because they can be combined with travelling time to compute a boat's speed.

The nautical mile is equal to a boat travelling at one knot for one hour or the distance travelled in one hour by a boat travelling at one knot.

A navigator may be called upon to calculate three possible factors:

Boat speed =		distance / time
Distance	=	speed x time
Time	=	distance / speed



Wet Paper

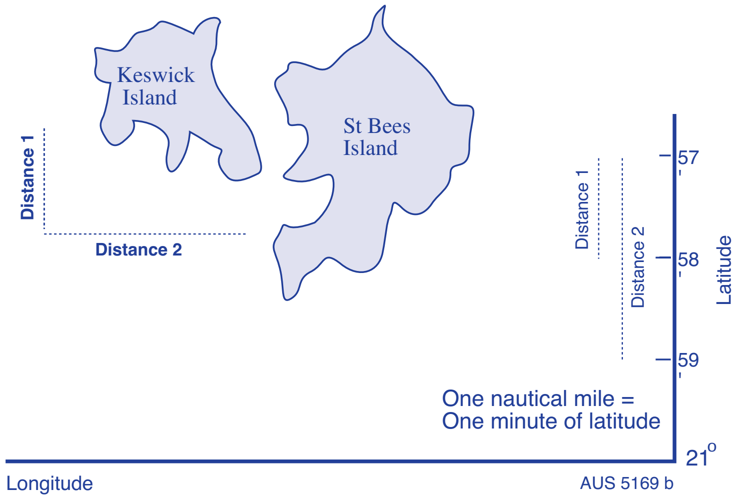
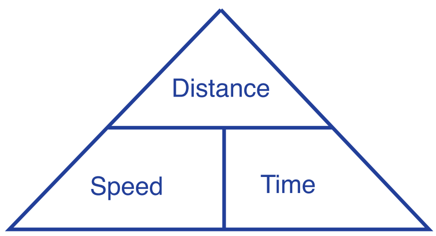


Figure 36.1 The nautical mile: Unit of distance equal to one minute of latitude. 1n.mile = 1.852 km

Wet Paper



The magic triangle. Place finger on what you want to find to obtain formula

Figure 36.2 Formulas for distance, speed and time

Wet Paper

Plotting a course

Plotting a course involves drawing lines on a chart to indicate where you want to go.

The main navigational instruments used for plotting, measuring speed or distance, depth, and direction are:

- dividers
- parallel rulers
- protractors
- plotters

A divider as shown in Figure 37.1, is an instrument that basically consists of two metal arms with pointed ends. These arms can be drawn apart to a fixed distance and it will hold this distance by friction at the hinge. Distances can be accurately transferred from a chart to a grid or ruler. If one of the arms has a pencil for drawing it is called a beam compass.

Parallel rulers basically transfer a line, parallel to the original line. It consists of two rulers hinged together and one ruler is held firm while the other arm is moved (walked) to a parallel position. It is mostly constructed of plastic and metal. A cheap substitute is the use of two triangles to produce a parallel line as shown in Figure 37.2.

A protractor is a device used in the measurement of angles on a chart. It is a graduated arc of usually 180 degrees and is made of plastic or metal.

A plotter is basically a protractor combined with a ruler. Some plotters have moveable parts.

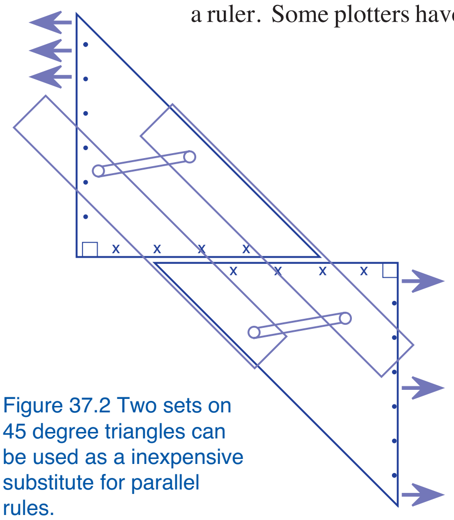
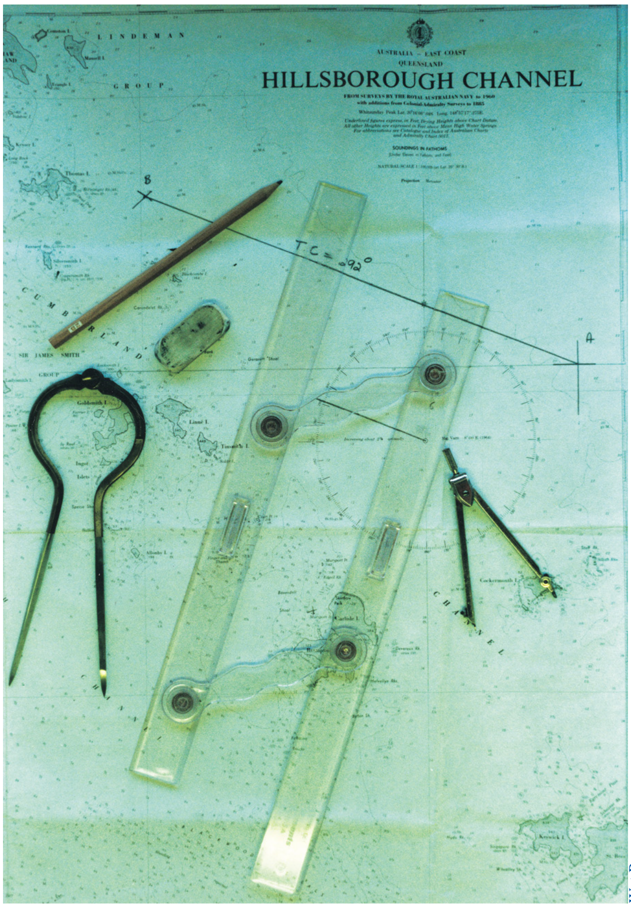


Figure 37.2 Two sets on 45 degree triangles can be used as a inexpensive substitute for parallel rules.

Wet Paper



Wet Paper

Figure 37.1 Some navigation instruments

Challenge

1. Wood fires maintained by Priests along the Mediterranean coast of Egypt were the first forms of lighthouses. Our coastline is dotted with old lighthouses. Why are the number of these lighthouses decreasing and not increasing?
2. Explain why the great exploration voyages of the 16 and 17 centuries were difficult to insure. Also few details of some of these expeditions were recorded. Suggest why.

Using parallel rules

Obtain two 90^0 set squares or parallel rules and complete the following tasks on the Hypothetical Bay chart.

1. 'Walk' the instruments from the top of the chart to the bottom, keeping the sides parallel. Now 'walk' the squares from one corner to the other, keeping the bases parallel.
2. Place one of the squares so that the hypotenuse lies over the Fairway Beacon and Paula's Light. Draw a light line between the two (remember that you will have to rub out all lines at the end of the exercise).
3. Now place the side of the other square opposite the side of the first square. Slide the second set square down the page until the hypotenuse of the second square is over the centre of the compass rose.
4. The bearing from Paula's Light to the Fairway Beacon can now be read from the number of degrees shown on the compass rose. What did you get? Discuss with your teacher the level of accuracy required in this exercise.

Worksheet 12 Latitude and longitude

Notes: In these early exercises the compass rose has been left off the map of Hypothetical Bay. A nautical mile is one minute of latitude.

Figure 38.1 Wiley Island

Questions

Use a ruler to find the latitude and longitude of the following places. Remember lines of latitude run down from the Equator and lines of longitude run east or west of Greenwich as shown in Figure 38.1 below.

1. Find the latitude and longitude of the following points:
   a. Gregory Light
   b. Paula's Light
   c. Pamela's Light
   d. Tony's Wreck
   e. Fishing Club on Claridge Inlet
   f. Airport at Lewisville
   g. Rickard Light
   h. Hamlyn Light
   i. the mouth of Kontos Creek
   j. Ryan Point
   k. the peak of Halpin Hill
2. Name the charted features at the following positions of latitude and longitude.
   a. 23° 54' S, 161° 53' E
   b. 23° 52' S, 161° 56' E
   c. 24° 02' S, 162° 06' E
   d. 24° 11' S, 161° 54' E
   e. 24° 02.5' S, 162° 06.8' E
   f. 24° 11.6' S, 161° 56.2' E
   g. 24° 6.6' S, 161° 51.2' E
3. Find two features at different latitudes but the same longitude.
4. Find two features at different longitudes but the same latitude.
5. What is the safest navigable distance between the following places for a deep draft vessel?
   a. Gregory Light and the Fairway Beacon
   b. the Fairway Beacon and Trent's Light
   c. Gregory Light and Keid Light
   d. Keid Light and Maloney Bay
   e. The north mark on Maclean Reef and Bundy Point in Jensen River.
   f. the Southern Mark on Perry Shoals and Waterhouse Landing
6. Calculate the size of the following places:
   a. Watson Swamp
   b. the new marina in Lynch River
   c. Roger's Reef
   d. Wiley Island

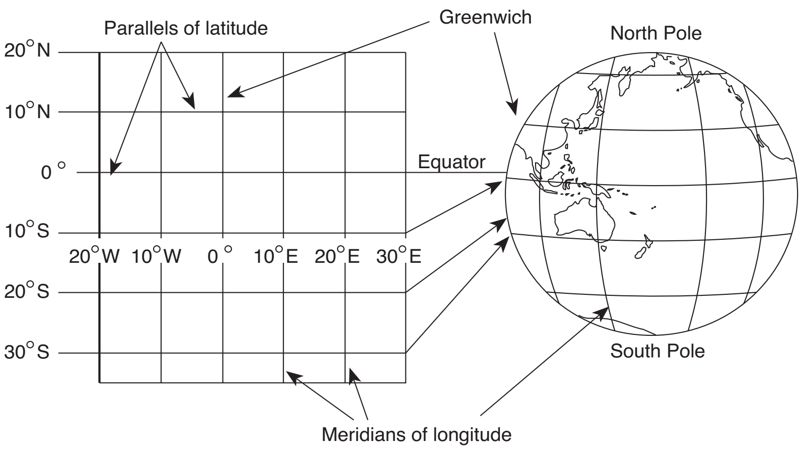
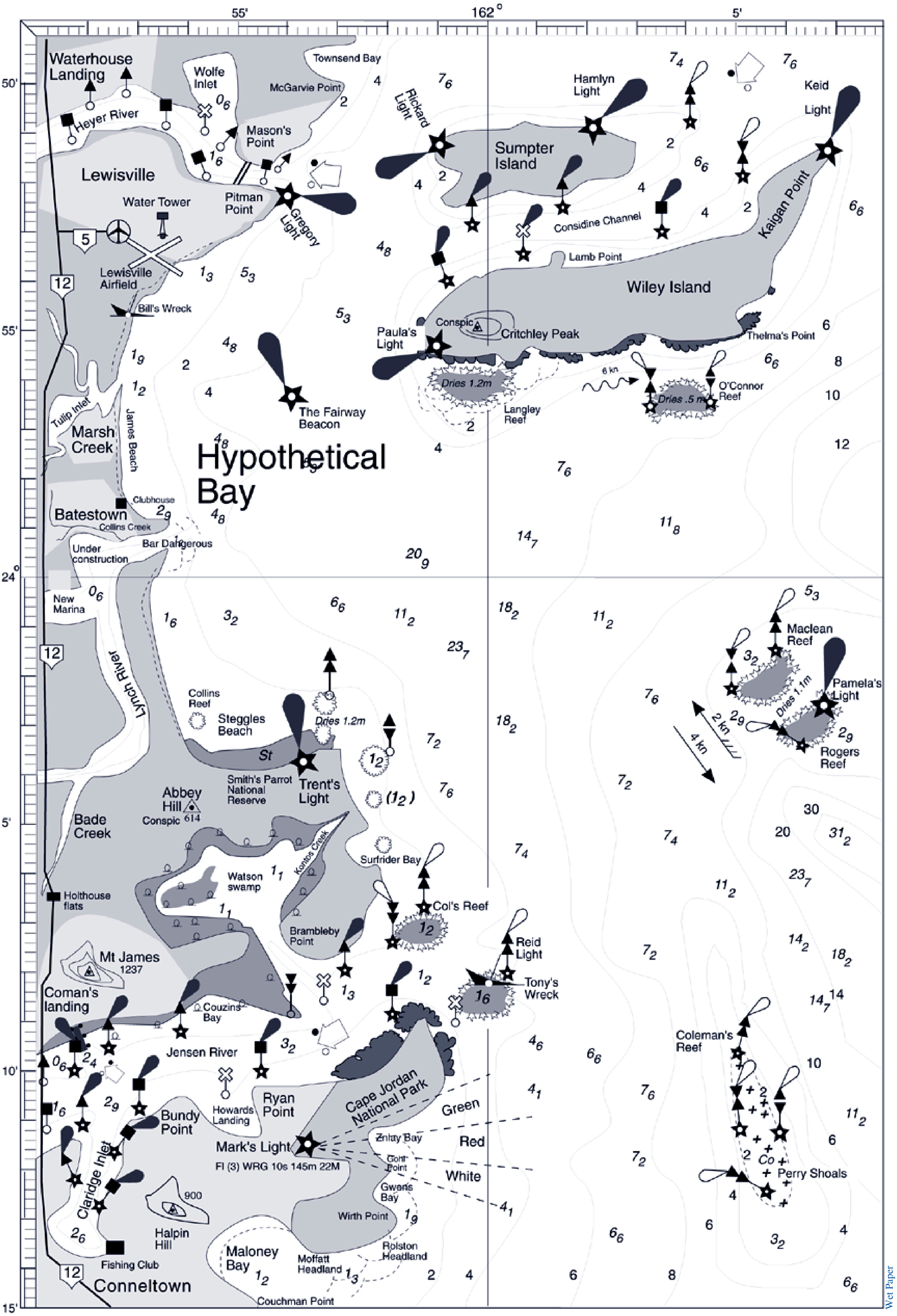


Figure 38.1 Latitude and longitude
Wet Paper


55'
162°
5'
50'
55'
24°
5'
10'
15'
Waterhouse Landing
Heyer River
Wolfe Inlet
Townsend Bay
McGarvie Point
Rickard Light
Hamlyn Light
Keid Light
Mason's Point
Lewisville
Sumpter Island
Water Tower
Pitman Point
Gregory Light
Considine Channel
Kaigan Point
Lamb Point
Lewisville Airfield
Wiley Island
Bill's Wreck
Conspic
Critchley Peak
Paula's Light
Thelma's Point
Dries 1.2m
Langley Reef
6 kn
Dries .5 m
O'Connor Reef
Tulip Inlet
Marsh Creek
James Beach
The Fairway Beacon
Hypothetical Bay
Clubhouse
Batestown
Collins Creek
Under construction
Bar Dangerous
New Marina
Lynch River
Maclean Reef
Pamela's Light
Dries 1.1m
Collins Reef
Steggles Beach
Dries 1.2m
St
Trent's Light
Smith's Parrot National Reserve
Abbey Hill
Conspic 614
2 kn
4 kn
Rogers Reef
Bade Creek
Kontos Creek
Watson swamp
Surfrider Bay
Holthouse flats
Col's Reef
Brambleby Point
Reid Light
Mt James 1237
Tony's Wreck
Coman's landing
Couzins Bay
Coleman's Reef
Jensen River
Ryan Point
Howards Landing
Bundy Point
Cape Jordan National Park
Green
Red
White
Mark's Light
Fl (3) WRG 10s 145m 22M
Zinlay Bay
Goff Point
Gwens Bay
Wirth Point
Claridge Inlet
900
Perry Shoals
Co
Halpin Hill
Maloney Bay
Moffatt Headland
Rolston Headland
Fishing Club
Conneltown
Couchman Point
Wet Paper

Worksheet 13 Distance, speed and time

Method

This exercise allows you to practise using the nautical mile to determine speed and time.

Remember one knot is equal to one nautical mile per hour.

Worked examples

a. How fast am I travelling if I cover 100 Nm in 5 hours?

S = D/T = 100 Nm/5 hrs = 20 Nm/hr or 20 knots

b. How far can I travel in 2 hours and 30 minutes, if I am travelling at 10 knots?

D = S x T = 10 knots x 2.5 hrs = 25 Nm

c. How long is it going to take me to travel 75 Nm if my boat travels at a constant speed of 10 knots?

T = D/S = 75 Nm/10 Nm per hr = 7.5 hrs = 7 hrs and 30 minutes

Questions

1. How far can I travel in 10 hours if I am travelling at 9 knots?

2. How far can I travel in 6 hours at a constant speed of 4 knots?

3. For 2 hours I travel at 10 knots, and for the next 3 hours my boat can only make 5 knots. How far have I travelled?

4. My boat travels 10 Nm in two hours. How fast did she go?

5. I left harbour at 7 a.m. and travelled 5 Nm by 10 a.m. How well did my speed boat perform?

6. If I set out in my sailing boat at 10.30 a.m. and reached my destination at 2 p.m. after travelling 35 Nm, what was my average speed for the trip?

7. How long did it take a mariner to travel 20 Nm at an average speed of 5 knots?

8. Your sailing boat is travelling at 4 knots and your navigator predicts 32 Nm to go. How many hours will it take to reach your destination?

9. How far is it from the fishing club in Conneltown to the 4 m line off Col's reef? My boat can do 6 knots and draws 2.9 m. When can I leave the fishing club on the morning of 4 January and how long will it take to get to Col's reef? Use the tide tables in Figure 40.1 to help you.

10. How far is it from the port mark at the mouth of Heyer River to Lamb Point on Wiley Island?

Wet Paper

Figure 40.1 Jensen River

11. *Wet Paper* I leaves the new marina on Lynch River at 0800 hrs and travels to 24° 01'S, 161° 59'E. She can do 25 knots, but a 15 knot S/E is blowing and she can only make 12.

    a. How long will she take to get there?

    b. Whales have been spotted off Thelma's Point. Can *Wet Paper I* make it in time for lunch? Show all working.

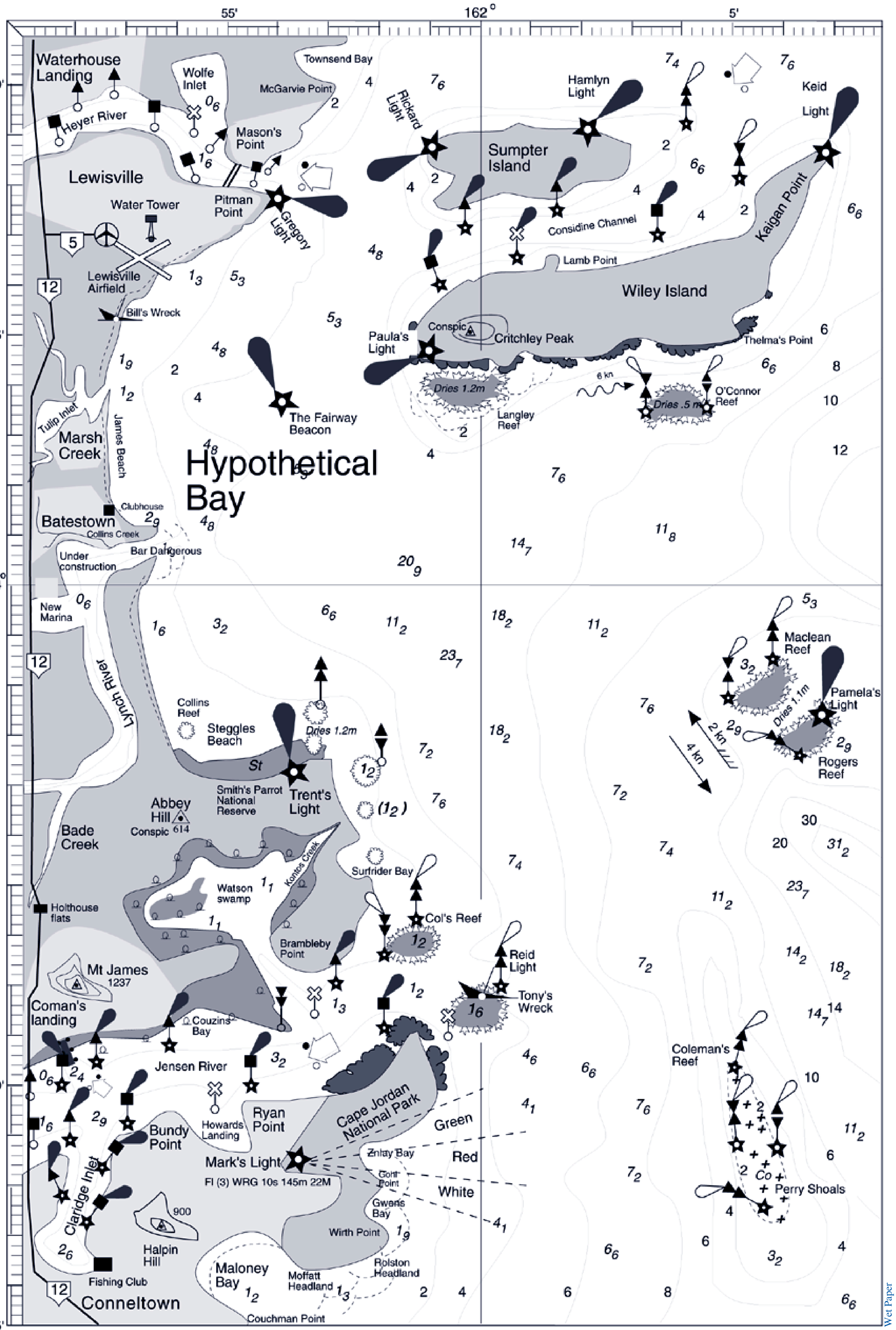
12. Another vessel, *Whyamber*, can make 5 knots and travels from the same marina. How long will she take?

13. If you were running a coach company and wanted to tap into the growing market of whale watching tourists from Hypothetical Bay, and your cousin has a restaurant at Marsh Creek, what bus schedule would you draw up for your operation? Lewisville airport can take direct flights from Tokyo and Sigatoka.

Tide tables for Jensen River

Date	Time	m	Date	Time	m
Jan 1	0221	0.99	Jan 4	0409	1.26
	0815	2.32		0930	1.93
	1424	0.51		1559	0.54
	2101	2.55		2252	2.66
Jan 2	0252	1.06	Jan 5	0502	1.99
	0835	2.22		1007	3.32
	1452	0.49		1642	0.71
	2133	2.58		2301	3.55
Jan 3	0321	1.16			
	0900	2.06			
	1524	0.51			
	2201	2.55			

Figure 40.1 Tides for Jensen River



55'
162°
5'
50'
55'
24°
5'
10'
15'
Waterhouse Landing
Wolfe Inlet
Townsend Bay
McGarvie Point
Heyer River
Mason's Point
Rickard Light
Hamlyn Light
Keid Light
Sumpter Island
Lewisville
Water Tower
Pitman Point
Gregory Light
Considine Channel
Kaigan Point
Lamb Point
Lewisville Airfield
Wiley Island
Bill's Wreck
Conspic
Critchley Peak
Paula's Light
Thelma's Point
Dries 1.2m
6 kn
O'Connor Reef
Dries .5 m
Langley Reef
The Fairway Beacon
Tulip Inlet
Marsh Creek
James Beach
Hypothetical Bay
Clubhouse
Batestown
Collins Creek
Under construction
Bar Dangerous
New Marina
Maclean Reef
Lynch River
Pamela's Light
Dries 1.1m
Collins Reef
Steggles Beach
Dries 1.2m
St
2 kn
4 kn
Rogers Reef
Smith's Parrot National Reserve
Trent's Light
Abbey Hill
Conspic 614
Bade Creek
Kontos Creek
Surfrider Bay
Watson swamp
Holthouse flats
Col's Reef
Brambleby Point
Reid Light
Mt James 1237
Tony's Wreck
Coman's landing
Couzins Bay
Coleman's Reef
Jensen River
Ryan Point
Howards Landing
Cape Jordan National Park
Green
Bundy Point
Mark's Light
Fl (3) WRG 10s 145m 22M
Red
White
Claridge Inlet
Gwens Bay
Perry Shoals
900
Wirth Point
Halpin Hill
Maloney Bay
Moffatt Headland
Rolston Headland
Fishing Club
Conneltown
Couchman Point
Wet Paper

Section 6 Magnetic Effects

All navigators need to understand how a compass guides the ship as well as the errors caused by the Earth's magnetism and the steel in the ship. Figure 42.1 shows the Earth's magnetic field and explains why charts are corrected for east or west variations. The two most significant errors are variation and deviation.

Variation

This is the error caused by the magnetic and true poles being in different places.

Error is defined as the angle between True and Magnetic North caused by the Magnetic North pole moving. It manifests itself in every compass by deflecting the needle away from the true north until it is pointing at Magnetic North.

There may be a difference of up to thirty degrees or more between these poles and this is obviously a factor which must be taken into consideration when steering a course or taking bearings.

The deflection may be to the east or the west of True North, and varies as the boat progresses across the surface of the Earth. However, it is well plotted, and is listed on every chart so that the navigator can be immediately aware of its value.

Once found, the error is constant for that area, and changes only slowly as the boat progresses.

Deviation

This error is due to the effect of each ship's individual magnetic field.

It is found by creating a deviation card as shown in Figure 41.1 by swinging the compass around a known mark as shown in Figure 42.3.

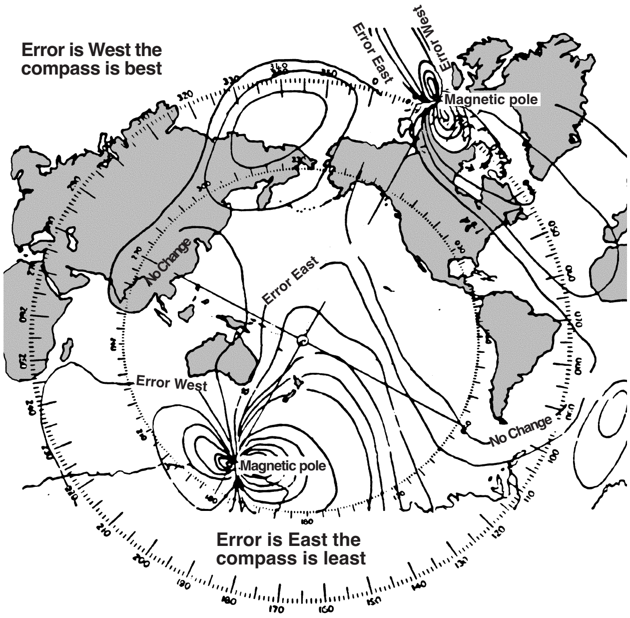


Figure 42.1 Magnetic North is now in Hudson Bay Canada.
Wet Paper

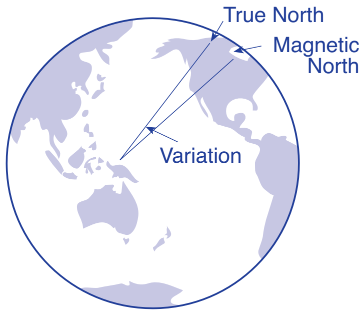


Figure 42.2 Variation
Wet Paper

Wet Paper

Figure 42.3
A fixed mark is used to swing a compass on a small vessel.

Swinging the compass

To find whether or not a deviation exists on your vessel's compass you will have to 'swing the compass'. If the vessel is a large commercial vessel intended for serious coastal and offshore work, the compass should have its deviations chart made up professionally, as well as having the compass adjusted. Fitting a compass binnacle and/or magnets inside the binnacle may reduce the deviation. A deviation chart will be set up for use with that compass.

The deviation of a compass in a smaller vessel may be evaluated by lining up a fixed mark and/or a charted mark with a distant conspicuous mark as shown in Figures 40.3 and 43.1.

Use the chart to find the true bearing and the variation to calculate the magnetic bearing. Compare the magnetic bearing with the compass bearing on the line as shown in A 2^o East (Figure 43.1).

The vessel is then moved through each of the four compass bearings along the transit line and a note is taken between the compass bearing and the known chart bearing and a graph drawn. Note that for more accurate work eight bearings are used making a curved graph as shown in Figure 43.1.

Total error

Variation and deviation together give the compass error (sometimes called the Total Error or just Error).

Magnetic polarity reversals

One of the most remarkable characteristics of the Earth's magnetic field is that studies of the magnetic rocks in the Earth's surface reveal that the magnetic poles have been reversed in the past. It is believed these changes have occurred a number of times with the north pole changing to south and vice-versa. The last reversal occurred 730,000 years ago and the next is predicted for 1,300 years time.

Terms

Variation

is the angle between True and Magnetic North.

Deviation

is the angle between Magnetic and Compass North

Error

is the sum of Variation and Deviation

True North

True North (geographic north) is the basis of the lines of latitude and longitude.

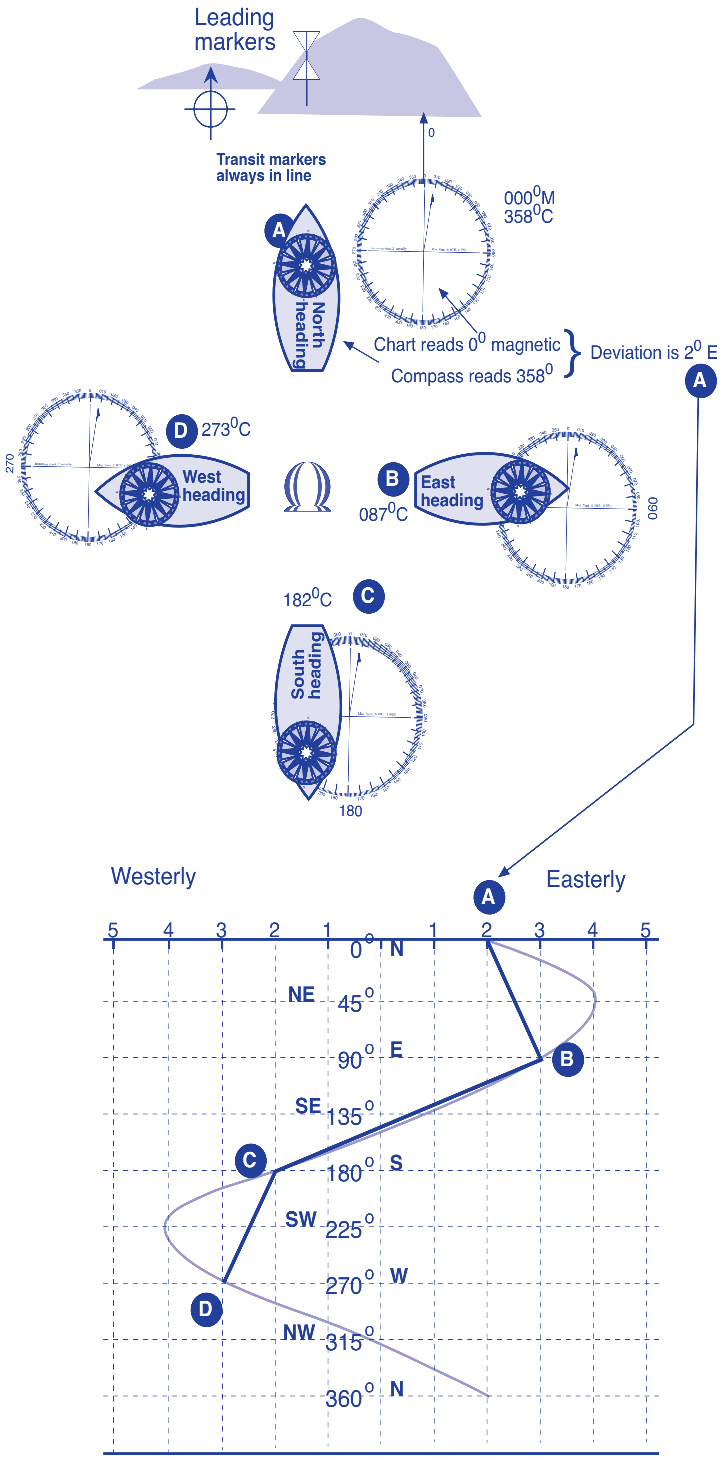
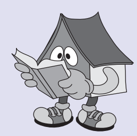


Figure 43.1 Swinging a compass
Wet Paper

Challenge



- Imagine you are a newspaper reporter interviewing a young person who has just sailed around the world alone. Why type of things might you ask this person? Give an account of the interview.

Compass conversions

In any location, the Earth's magnetic field is at an angle to the meridians of longitude, and so your compass (either steering or hand-bearing) does not point to the True North of the longitude lines on the chart.

Because of this we end up with three types of angular bearings which need to be interpreted for navigation.

True bearings

These are relative to True North and are taken off the compass rose on the chart or measured with a protractor against the grid lines of the chart.

- These are usually written with a T after the angle, eg 32ºT means an angle of 32º to the True North of the chart.

Compass bearings

Compass bearings are relative to the Earth's magnetic field lines in the area, and are read off the hand bearing compass or the steering compass.

- Usually written with a C after the angle, eg 165ºC means an angle of 165º to the Earth's magnetic field in that area.
- The bearing (or direction) from one position to another on a chart is found by drawing a line through the compass rose that is parallel to the line joining the position.

Variation

This is the local *variation* (for the particular year). It is taken off the compass rose information on your chart, and is always given in the direction of east or west to indicate which way the magnetic field lines are pointing as well as how far. Figure 43.1 shows the variation.

- Variation in 2002 for the compass rose shown in Figure 43.1 is as follows:

  The variation was measured in 1964 as 8º 00'E

  The number of years between 2002 - 1964 = 38 years

  Therefore variation 2002 = 8º 00'E + (38 x 2.75)

  = 8º 00'E + 104.5'

  = 8º 00'E + 1º 44'

  = 9º 44'E

Conversion rules

Rule 1

To convert between true and compass bearings we use the rule:

Error East - Compass Least

Error West - Compass Best (best means the bigger number)

The table below shows some examples.

Example	a.	b.	c.	d.	e.
True bearing	40ºT	85ºT	243ºT	5ºT	356ºT
Variation (error)	8ºE	5ºW	10ºE	10ºE	12ºW
Compass bearing	32ºC	90ºC	233ºC	355ºC	8ºC

In example d. think of 5ºT as 365ºT before you subtract the 10º.

In example e. 356º + 12º = 368º, which becomes 8ºC.

Rule 2

To find out which course to steer a boat.

This rule indicates the steps to be taken in changing from Compass to True (left column) and True to Compass (right column).

The rule can be remembered by writing the letters CDMVT in either the forward or reverse direction as shown below.

The end result is the ships head or direction in which the ship is steered. Figures 44.1 and 43.2 summarise this process.

Conversions from compass to true		Conversions from true to compass	
C an	**Compass**	**T** ele	**True**
D ead	**Deviation**	**V** ision	**Variation**
M en	**Magnetic**	**M** akes	**Magnetic**
V ote	**Variation**	**D** ull	**Deviation**
T wice	**True**	**C** ompany	**Compass**

Worked example

Which direction do you steer a boat if you want to go 50º True North out of Sydney heads if the deviation is 8ºE?

Because you are working from True to Compass, Rule 2 — CDMVT is written backwards. Total error is 18ºE and because it is east, Rule 1 says to take it away.

So you steer your boat 32º by compass.

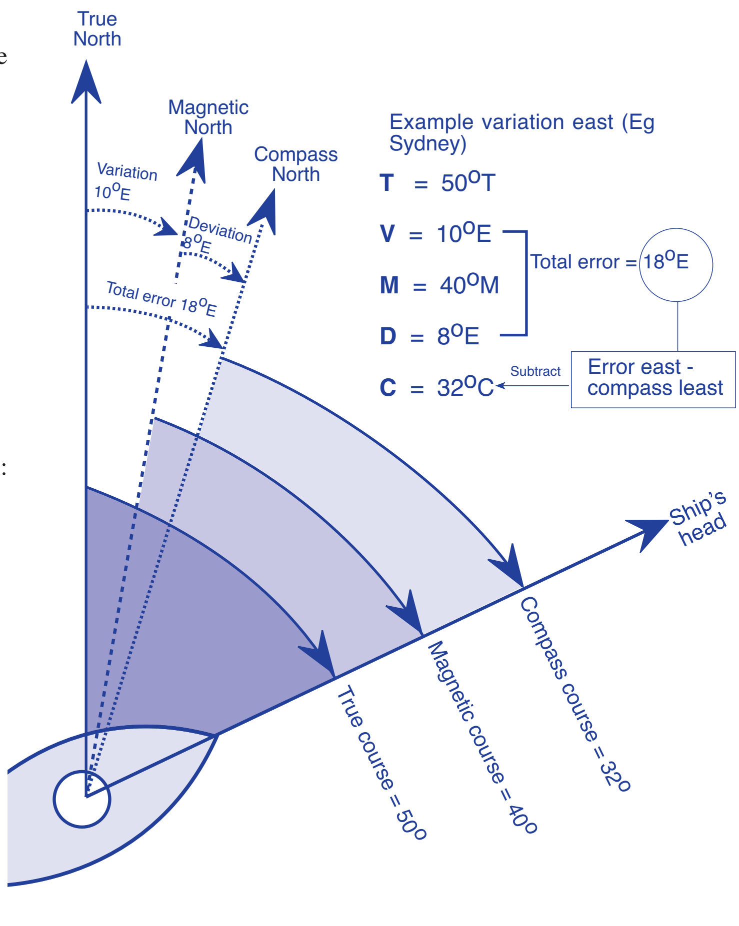


Figure 44.1 Variation east

The compass rose

The compass rose is printed on charts to indicate direction and is aligned with the True or Geographic North.

A small half arrow head is printed inside the rose indicating the direction of the Magnetic North Pole and the angle between True and Magnetic is printed across the centre of the rose with the date of the last determination of the rate of change.

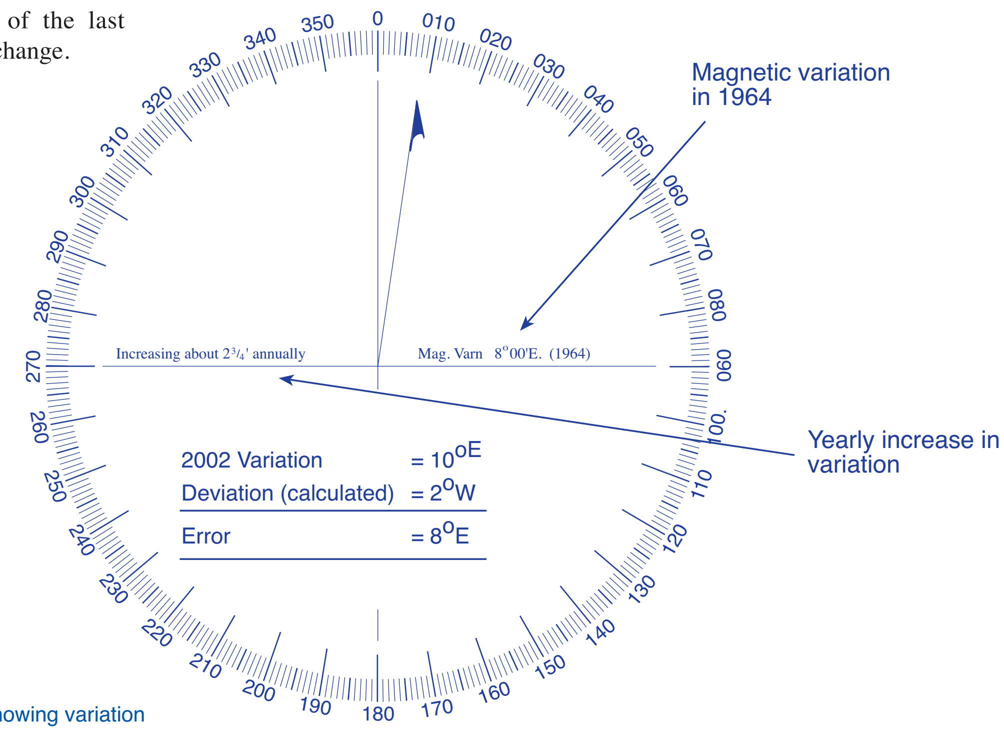


Figure 45.1 A compass rose showing variation

Wet Paper

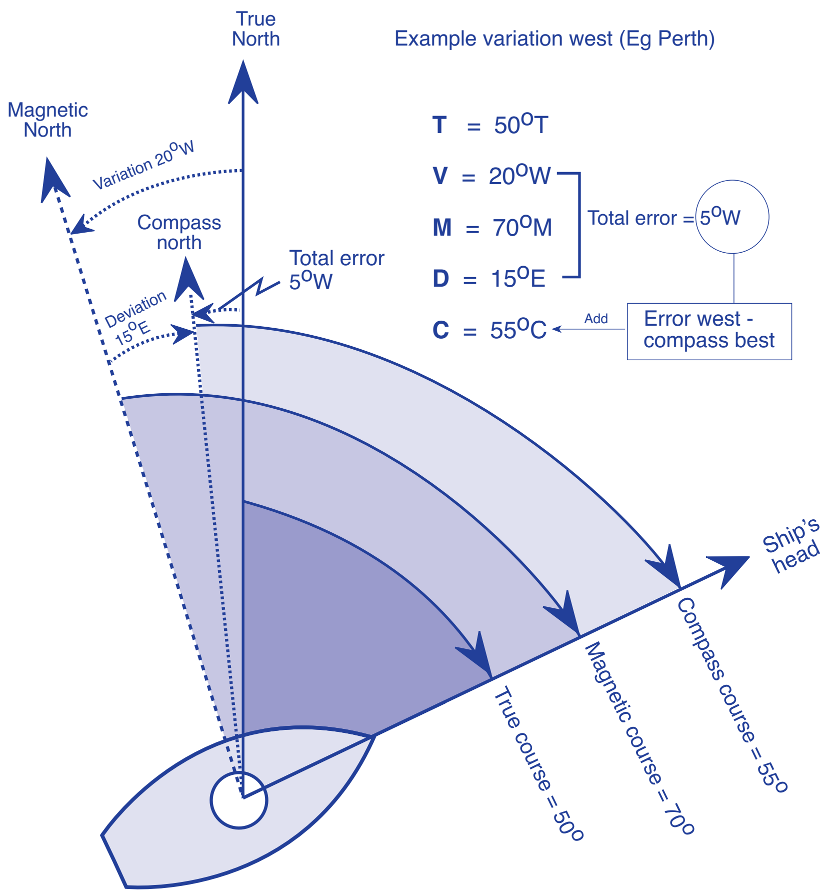


Figure 45.2 Compass error west — for West Australians

Wet Paper

Worksheet 14 Compass conversions

1. Complete the following exercises, using the deviation table in Figure 46.1.

T	300°	T	201°	T	95°
V	10°E	V	10°E	V	
M		M		M	85°
D		D		D	
C		C		C	

Wet Paper

2. On the compass rose the variation is shown as:
In 1970 the variation was 9° 25' E increasing at 2' annually.
What will be the variation on 20.04.2005?

3. On the compass rose the variation is shown as:
In 1972 the variation was 7° 45' E increasing at 4' annually.
What will be the variation today?

4. On the compass rose the variation is shown as:
In 1984 the variation was 9° 55' E increasing at 3' annually.
What will be the variation on the 21.11.2010?

5. The true course from Point A to Point B is 230°T. Using a variation of 11°E and a deviation from the table on the bottom of the page, calculate the compass course from A to B.

6. Use the deviation chart in Figure 46.1, to find the course to steer by compass if the true course is 75° and the variation is 10°E.

7. Brainstorm criteria for a great navigator or make a wall chart for uses for magnets.

8. Apply the following compass errors to complete the following statement:

   a. 132° (C), 16° W = ______ ° T

   b. 357° (T), 7° W =______ ° C

   c. 004° (C), 11° E =______ ° T

   d. 097° (C), 5° E =______ ° T

   e. 196° (T), 7° E =______ ° C

   f. 274° (T), 8° W =______ ° C

   g. 324° (C), 7° W =______ ° T

   h. 339° (T), 6° W =______ ° C

   i. 157° (C), 8° E =______ ° T

Ships head True	Dev	Ships head True	Dev	Ships head True	Dev	Ships head True	Dev
000	2°E	105	2°E	195	3°W	285	8°W
015	3°E	120	1°E	210	5°W	300	5°W
030	4°E	135	1°E	225	7°W	315	2°W
045	5°E	150	Nil	240	9°W	330	1°W
060	4°E	165	1°W	255	12° W	345	Nil
075	3°E	180	2°W	270	9°W	360	2°E
090	3°E						

Figure 46.1 Deviation chart

9. Given the magnetic variation = 5˚ E, find the compass error and deviation from the following sets of transit bearings. [TRUE , COMPASS]

a. 042° T , 036˚ C E _______ D _______

b. 358° T , 010° C E _______ D _______

c. 176° T , 192˚ C E _______ D _______

d. 246° T , 245° C E _______ D _______

e. 263° T , 291° C E _______ D _______

f. 148° T , 142° C E _______ D _______

g. 083° T , 077° C E _______ D _______

h. 039° T , 048° C E _______ D _______

i. 306° T , 291° C E _______ D _______

10. Given variation and deviation, find total error

a. 8.5° E, 3° E

b. 9° E, 4.5° E

c. 10.5° E, 1° E

d. 11° E, 5.5° E

e. 9° E, 1° E

f. 8.5° E, 2.5° E

g. 11° E, 3° E

h. 10.5° E, 6.5° E

i. 11° E, 7° W

j. 8.5° E, 1.5° W

k. 10.5° E, 3° W

l. 9° E, 6° W

m. 8.5° E, 8.5° W

n. 11° E, 4° W

o. 9° E, 1° W

p. 10.5° E, 2.5° W

11. Given Variation and Total Error — find deviation

a. 11° E, 17.5° E

b. 8.5° E, 1.5° E

c. 10.5° E, 13° E

d. 9° E, 15.5° E

e. 8.5° E, 8.5° E

f. 11° E, 9° E

g. 10.5° E, 16° E

h. 9° E, 5.5° E

12. Deviation, Total Error - find Variation

a. 3° E, 12.5° E

b. 6.5° W, 2° E

c. 4° E, 14.5° E

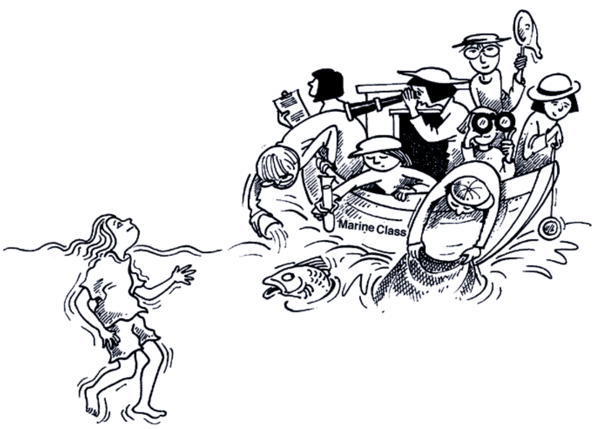
d. 5.5° E, 13.5° E

e. 1.5° W, 9° E

f. 3° W, 8° E

g. 0.5° E, 10.5° E

h. 2.5° W, 6° E



Gee I'm glad to see you people... which way to the coast?

Sharon Madder

Section 7 Charting

YOUR COURSE

When you make an observation with a hand bearing compass to an object such as a hill or a lighthouse, this information can be placed on a chart.

The compass bearing must first be changed into a true bearing as all the chart bearings are set to True North. A line can then be drawn on the chart from the lighthouse or hill at the bearing observed.

This line on the chart is called a line of position or LOP.

Lines of position — LOP's

Conversions of compass bearings to true bearings

When you make an observation with a hand-bearing compass, and transfer it to a chart as an LOP (line of position), you have to convert a compass bearing to a true bearing to be able to plot it off the compass rose on the chart.

Example

Note: The deviation for the vessel has been calculated at zero

1. Suppose you are out on Hypothetical Bay somewhere to the north of Trent's Light and east of Batestown. You are looking through your hand-bearing compass at Critchley Peak .
2. The hand-bearing compass is reading 30°C. Because of the 8°E variation, you need to add 8° to get 38°T before you may plot your line of position on the chart. (Error east, compass 30° is less than 38°T). See Figure 48.1.

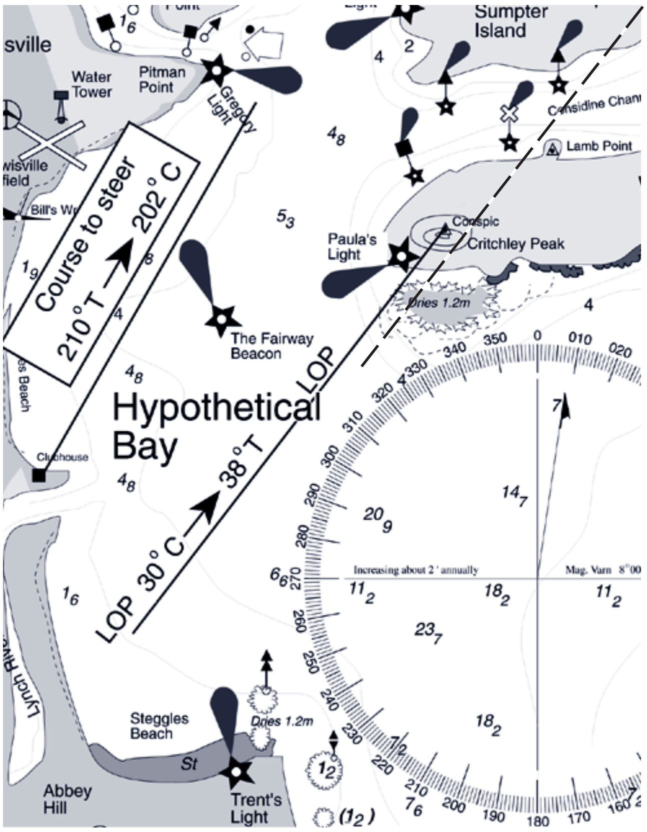


Figure 48.1

Wet Paper

Conversions of true bearings to compass bearings

Note: The deviation for the vessel has been calculated at zero

When you draw a line on a chart to indicate where you want your boat to go (that is a course to steer), you read off the chart the true bearing of the course to steer.

Before the skipper can start moving the boat, this must be converted to a compass course to steer, so you know what numbers to be reading on the steering compass.

Example

1. You have just come out of Heyer River, and want to go straight to the clubhouse at Batestown. The deviation is 0.
2. On the chart you have drawn the course (see Figure below) and with your parallel rule have found from the compass rose that the course is 210°T.

   Now you must subtract the 8°E to get the compass course to steer of 202°C.

   Error east, compass of 202° is least/less than 210°. (You yell to the helmsperson to steer 202° by the compass).

Wet Paper

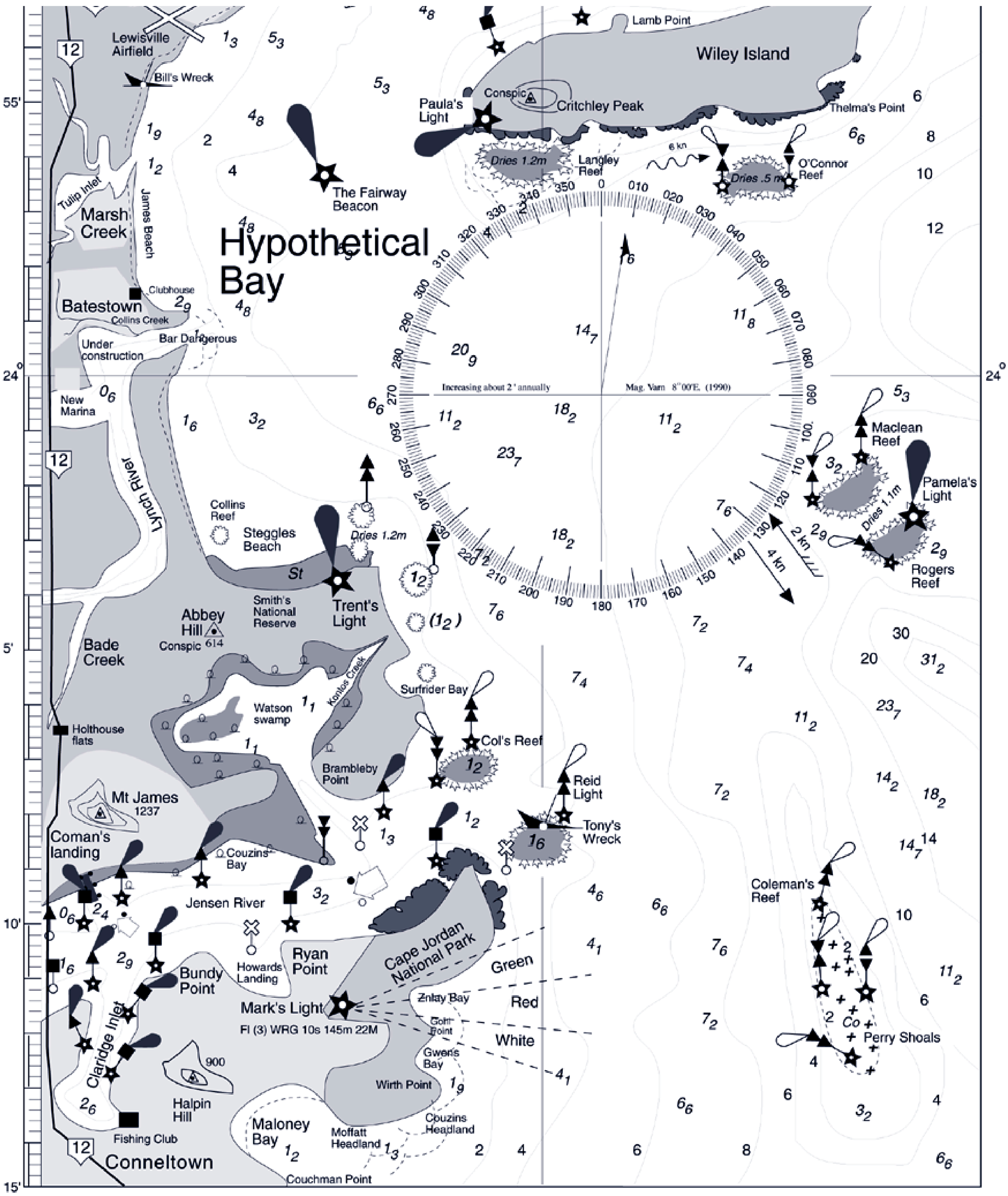
Compass bearing is 30° to Critchley Peek

WORKSHEET 15 LOP's

Draw in LOP's for the following hand bearing-compass observations

Each set of three gives a cocked hat position fix.

1. Mark's Light 258ºC, Trent's Light 294ºC, Pamela's Light 346ºC
2. Trent's Light 216ºC, Paula's Light 325ºC, Pamela's Light 110ºC
3. Critchley Peak 279ºC, Keid Light 13ºC, Pamela's Light 155ºC



Worksheet 16
Compass courses

In a perfect world Geographical North and Magnetic North would be the same.

When you draw a line on your chart to indicate where you want your boat to go - that is the course to steer, you read off the chart the true bearing of the course to steer.

The course the skipper needs to steer is slightly different because the compass points to Magnetic North and not True North.

Worked example

Calculate the compass course to steer between the Fairway beacon to Paula's light.

Answer

By using parallel or roller rulers, draw a line from the Fairway beacon to Paula's light. Now walk the rules so that a parallel line passes through the centre of the compass rose and its outside circle.

The true direction is 70ºT. The deviation is zero.

Since the variation is 8.00 E in 1990 and increasing 2' annually, the variation in 2001 - 11 years later will be 11 x 2' = 22'

The variation in 2001 = 8º22' (For most navigation exercises this is rounded down to Variation of 8º.

Therefore the compass course is: 70º - 8º = 62º (Error East Compass Least)

Questions

The deviation is zero for Questions 1 - 3.

1. Calculate the true course to steer between

   a. Gregory Light and Paula's light

   b. Trent's Light and Roger's Reef Light

   c. Trent's Light and The Fairway Beacon

   d. Batestown Clubhouse and Richard Light

Wet Paper

Figure 50.2 The Fairway Beacon

2. Draw lines of position for the following hand bearing compass observations:

   a. Marks Light 260º
   b. Trent's Light 290º
   c. Fairway Beacon 280º
   d. Pamela's Light 180º
   e. Mouth of Lynch River 270º
   f. Paula's Light 160º

3. Calculate the compass course to steer to go between the following places:

   a. Fairway Beacon to Gregory Light

   b. Gregory Light to Rickard Light

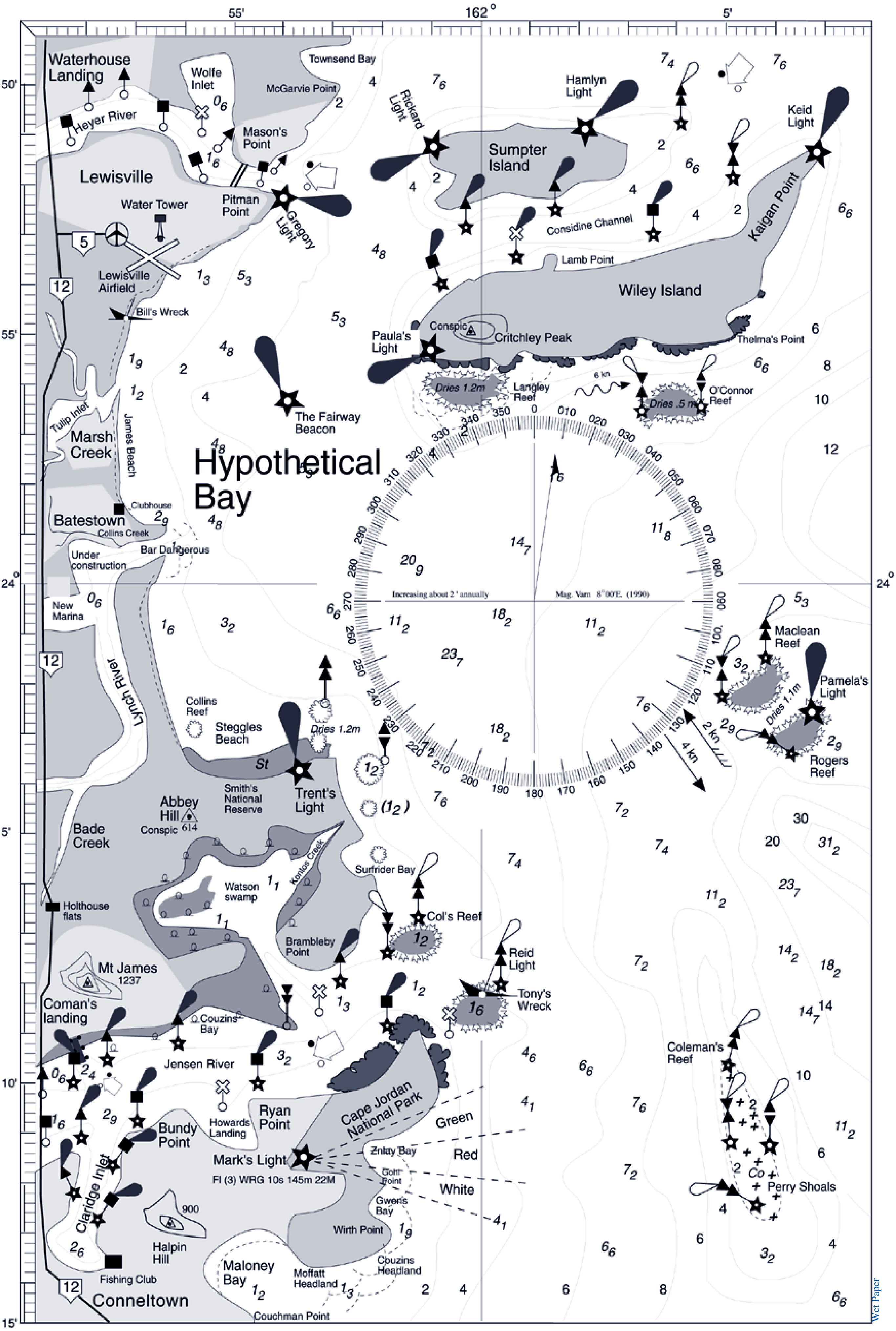
   c. Batestown Clubhouse to northern tip of Maclean Reef

   d. Pamela's Light to Keid Light

   e. Keid Light to Hamlyn Light

Figure 50.1 Paula's Light

Wet Paper


55'
162°
5'
50'
55'
24°
5'
10'
15'
Waterhouse Landing
Wolfe Inlet
Townsend Bay
McGarvie Point
Heyer River
Mason's Point
Rickard Light
Hamlyn Light
Sumpter Island
Keid Light
Lewisville
Water Tower
Pitman Point
Gregory Light
Considine Channel
Kaigan Point
Lewisville Airfield
Bill's Wreck
Lamb Point
Wiley Island
Conspic
Critchley Peak
Paula's Light
Thelma's Point
Dries 1.2m
Langley Reef
6 kn
Dries .5 m
O'Connor Reef
The Fairway Beacon
Tulip Inlet
Marsh Creek
James Beach
Hypothetical Bay
Clubhouse
Batestown
Collins Creek
Bar Dangerous
Under construction
Increasing about 2 ' annually
Mag. Varn 8°00'E. (1990)
New Marina
Maclean Reef
Pamela's Light
Dries 1.1m
Rogers Reef
2 kn
4 kn
Lynch River
Collins Reef
Steggles Beach
Dries 1.2m
St
Trent's Light
Smith's National Reserve
Abbey Hill
Conspic 614
Bade Creek
Kentos Creek
Watson swamp
Surfrider Bay
Col's Reef
Holthouse flats
Brambleby Point
Reid Light
Tony's Wreck
Mt James
1237
Coman's landing
Couzins Bay
Coleman's Reef
Jensen River
Ryan Point
Howards Landing
Cape Jordan National Park
Green
Red
White
Bundy Point
Mark's Light
Fl (3) WRG 10s 145m 22M
Znlay Bay
Golf Point
Gwen's Bay
Wirth Point
Perry Shoals
Co
Claridge Inlet
900
Halpin Hill
Fishing Club
Maloney Bay
Moffatt Headland
Couzins Headland
Conneltown
Couchman Point
Wet Paper

Section 8 Position Fixing

When travelling at sea, it is very important to know where you are. It is essential to the safety of the vessel for the navigator to frequently or as continuously as possible, get positional information. This is essential in areas where there are navigational hazards such as rocks and reef where a small error could cause loss of the vessel. It is therefore very important to know the position of the vessel at all times. The navigator may use a number of methods to find or fix position. Some of these methods are discussed below.

Single bearing fix

A single bearing fix can be used to approximate a vessel's position. For example if the bearing on the water tower in Figure 52.1 is 40 degrees, a line of position drawn on a chart will indicate that the boat is somewhere on that line.

The position line found is known as a line of bearing. It is important that the chart feature, for example a water tower, has been correctly identified and the compass work is accurate.

When drawing the line on the chart the line extends outward from the landmark along the reciprocal of the observed bearing.

Therefore, if the bearing taken to the lighthouse is 40 degrees the line extending from the water tower will equal 180 degrees + 40 degrees = 210 degrees.

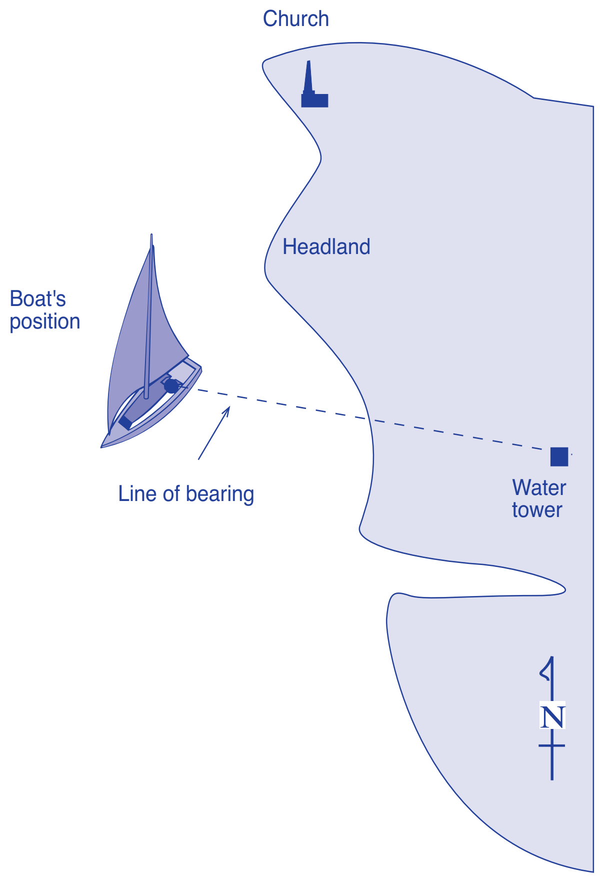


Figure 52.1 The line of bearing

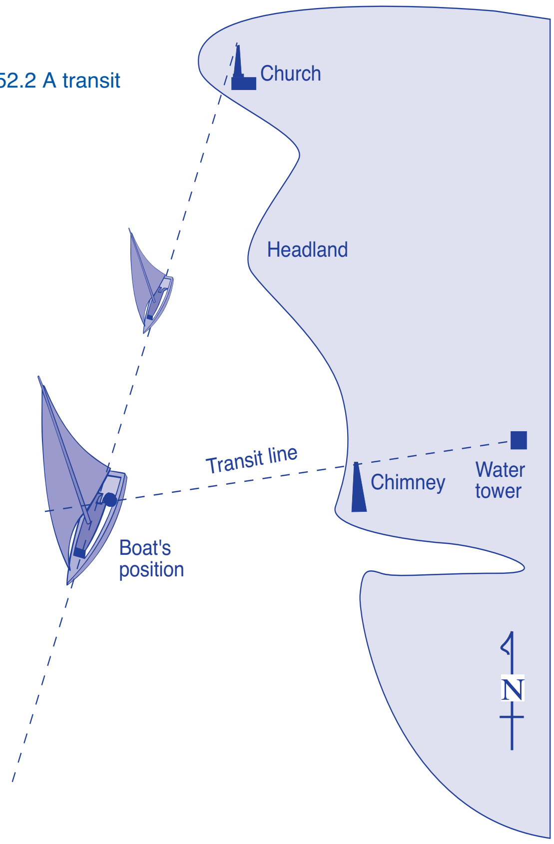
Wet Paper

A transit

If two objects are lined up they are said to be in transit. The vessel must be on the same line extended away from this line. These transits may be used to check compass error or act as leads to steer a course or maintain a heading.

Figure 52.2 A transit

Wet Paper



True bearing fix

When lines of bearing are obtained from two different landmarks at the same time (Figure 52.3), the vessel must be located at the intersection of these lines. This point is one method of position fixing. If you are trying to fix your position the angle formed between the two lines should be more than 30^{o} to give an accurate fix.

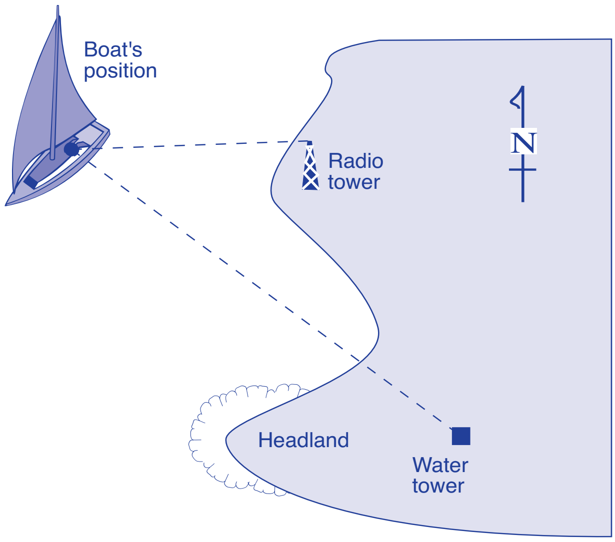


Figure 52.3

Wet Paper

True bearing fix or cocked hat

Most navigators will take a third line of bearing to confirm a position. It is rare to have the three lines meet at one point and then mostly they form a triangular or cocked hat. The vessel's position can be expected to be in the centre of the triangle.

The accuracy of the fix is indicated by the size of the cocked hat. If you are in an area where there is a shipping hazard, your position should be taken as the corner of the triangle nearest the hazard.

The size of the 'cocked hat' depends on:

- The identification of the mark
- Error in the plotting of the lines
- The time taken to obtain the bearing and the speed of the vessel
- Compass error or deviation of the compass not included

Worked example

Find the position of a vessel from three bearings taken off Carline Island in Hillsborough Channel. Assume that there are no other errors than variation.

A: 232°M (Finger and Thumb)

B: 297°M (Solder I.)

C: 151°M (Skiddow Peak, Carlisle I.)

Step 1 The variation from the compass rose is calculated at 8 + 2' annually since 1964 = 9°.

Step 2 Convert the compass bearing A to its true bearing on the chart.

Can	=	**C**ompass	=	232°C
Dead	=	**D**eviation	=	0°
Men	=	**M**agnetic	=	232°
Vote	=	**V**ariation	=	9°
Twice	=	**T**rue bearing	=	232°C + 9° = 241°T

Step 3 Draw the line using your parallel rules

Step 4 Repeat for the other two bearings and your position is where the lines intersect

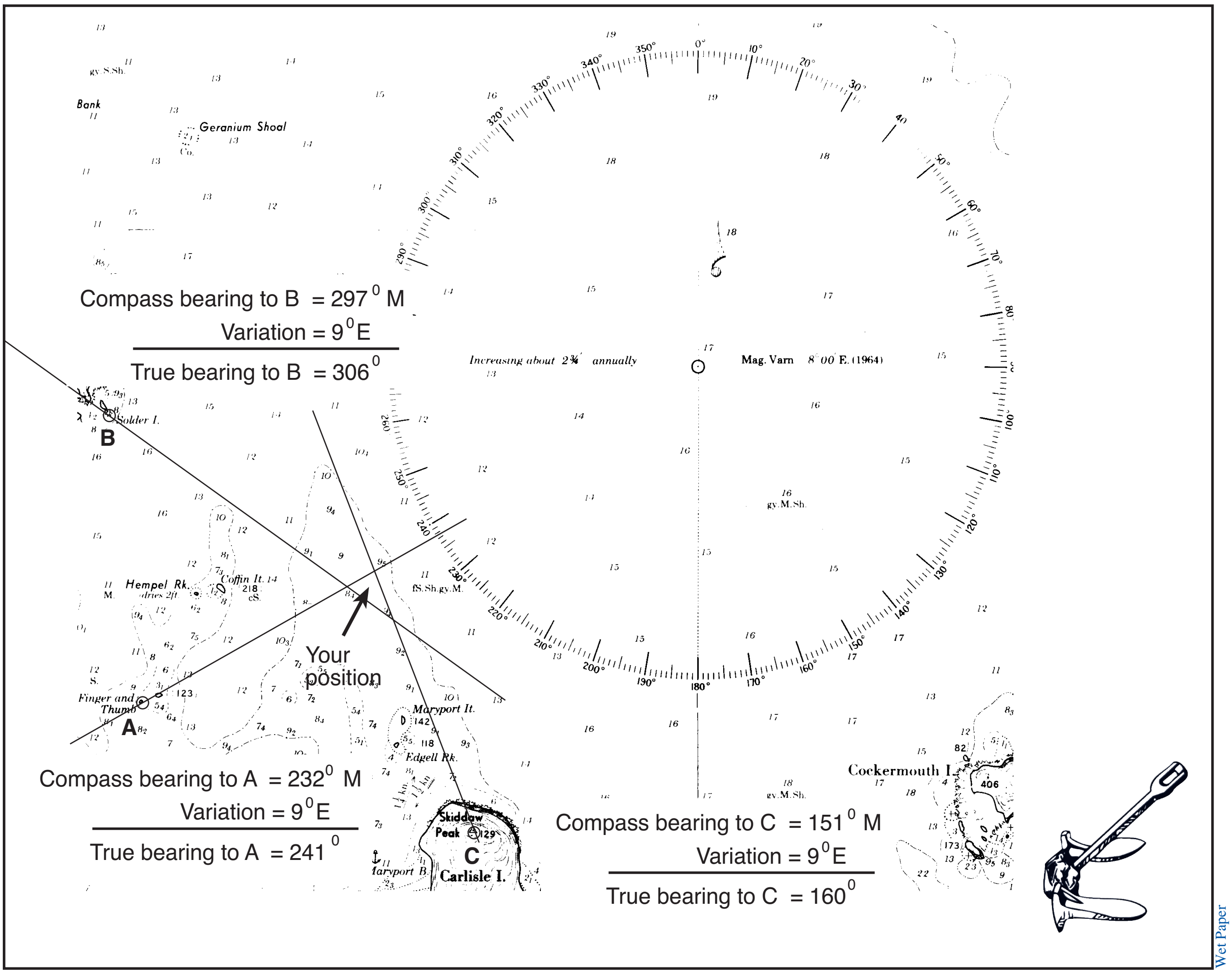


Figure 53.1 The cocked hat - locating your position by three bearings

Other methods of fixing position

Radar and bearings

The position of a vessel may also be found by using information gained from different instruments, eg, a bearing from a compass could be used with the distance calculated from radar.

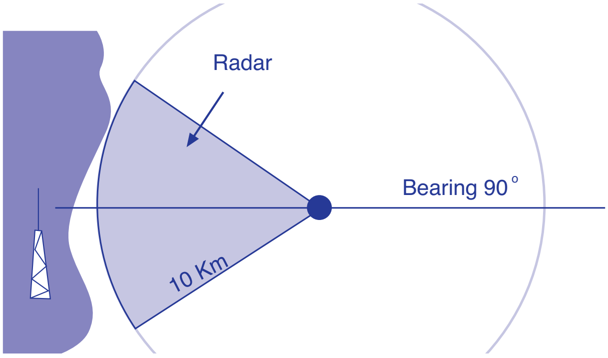


Figure 54.1 Radar

Wet Paper

Depth soundings

An approximate position may also be obtained by using a bearing from a compass and the depth recording from a depth sounder.

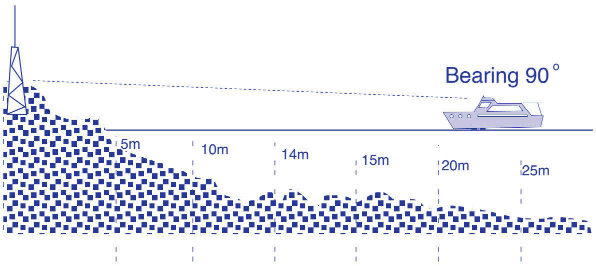


Figure 54.2 Depth soundings

Wet Paper

Distance between two marks

The position may also be found by calculating the distance from two landmarks, by use of radar or sextants and using the depth sounder to confirm the position.

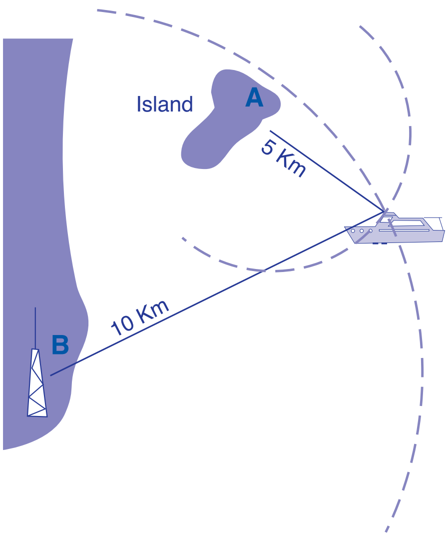


Figure 54.3 A vessel 5 nautical miles from A (an island) and 10 nautical miles from B (a lighthouse)

Wet Paper

The running fix

This fix is taken while the vessel is moving and the bearings are taken to landmarks at different times. It may also be a bearing taken to the same object at different times. The vessel's speed is used in this calculation and this must be known accurately for a definite fix.

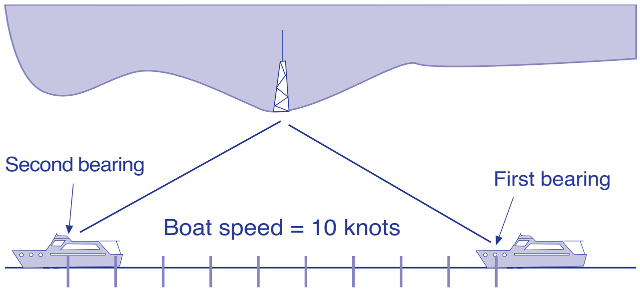


Figure 54.4 Running fix

Wet Paper

Vertical sextant angle

The vertical sextant angle is used to calculate the distance a vessel is from an object located high on the shore.

$$\tan ø = \frac{h}{d} \qquad d = \frac{h}{\tan ø}$$

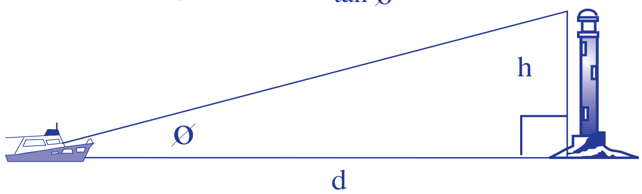


Figure 54.5 Vertical sextant angle

Wet Paper

Ø	$\frac{1}{\tan ø}$	h
1^o	57.30	
2^o	28.64	
3^o	19.08	
4^o	14.30	
5^o	11.43	
10^o	5.67	
20^o	2.75	

Wet Paper

Example

Distance from a lighthouse of 90m seen at 2^0 equals

$$d = \frac{h}{\tan ø}$$

$= 90\text{ m} \times 28.64$

$= 2577\text{ m}$

$= 2.6\text{ km}$ **Ans**

Worksheet 17 Chartwork

Method

Cape Hillsborough Channel courtesy Hydrography Service for the Navy, exercises prepared by Bob Critchely, Bowen SHS. Reproduced with permission. Notes: Variation for 2001. No Deviation. Work in soft lead pencil. Leave all your working on the chart.

Written answers to be done on a separate sheet and attached to chart. All distance to within 0.1 mile, and all angles to 0.5°. Your teacher may have prepared a chart and overlays with all the solutions so you can check your progressive working. The numbers at the bottom of the page are page numbers and are not lines of longitude. The longitude is 149°E. 1 fathom = 1.83 metres.

Questions

This exercise uses the A3 Version 5169 B and variation 2001 - nearest degree.

1. What are the latitude and longitude of the following points?

   a. Hempel Rock

   b. Coppersmith Rock Lighthouse

   c. Hill 670 Cockermouth Island.

2. You are at the anchorage at Maryport Bay, Brampton Island, in position 20°48' S 149°16' E. Mark this on your chart as position A and answer the following questions. Variation for 2001. No deviation.

   a. What is your magnetic variation to the nearest whole degree?

   b. You want to go to Coffin Island. What compass course will you steer?

   c. How far is it from position A to Coffin Island?

   d. How long will it to take to arrive at Coffin Island if you travel at 6 knots?

   e. After you have been travelling for half an hour, what will be your DR position? Mark this on the chart as position B.

   f. You are worried about what you can see and decide to fix your position. You take the following bearings:

Allonby Island Hill 198	273°
Brampton Island Hill 323	131°
Tinsmith Hill 448	340°

   Plot this position and mark it on the chart as position C.

   g. What are the rocks you can see in front of you?

   h. How do you account for the change in position from point B to point C?

3. a. You are anchored near Geranium Shoal.

   Locksmith - S (southern tips of Locksmith Island) is in transit with Ladysmith - S.

   You also have Allonby Island Hill 198 in transit with Tinsmith Island - SE. Mark this position as position D.

   b. What is the latitude and longitude of point D?

   c. How far are you from Geranium Shoal?

   d. What course would you steer to arrive at the shoal?

   e. How long will it take you to get there at 6 knots?

   f. It is now a 3 m tide. What will your Metric Depth sounder read as you find the shoal?

Worksheet 18
Position fixing

Its nice to know where you are and this exercise lets us use our chart to find out where we are.

Worked example

Having travelled out for 45 minutes from the marina in Lynch River, the skipper of *Wet Paper I* wants her first mate to plot their position. She takes three bearings, as follows, using a hand-bearing compass.

Bearing 1 to	Pamela's Light	CB =	88^0C
Bearing 2 to	Trent's Light	CB =	163^0C
Bearing 3 to	Mt James	CB =	202^0C

These convert using error east compass least rule.

Step 1 Do conversion for bearing 1

To Pamela's Light CB =88^0C TB = 96^0T

Step 2 Place rule or square on compass rose from the centre to Pamela's light. (See figure 56.1)

Step 3 Walk rule or square to Pamela's Light and draw a line back towards the mainland.

Step 4 Do conversions for bearings 2 and 3 respectively and repeat as described in steps 2 and 3.

Step 5 Shade in your cocked hat as described in your textbook.

Questions

Find the latitude and longitude of the following positions and mark them on your chart. Check your answer with the suggested answer given. Note all bearings have been made with a hand-bearing compass.

1. Position A.
   Bearing to Pamela's Light 20^0
   Bearing to Mark's Light 257^0
   Bearing to Trent's Light 314^0

   (Suggested answer $24^0$11' S, $162^0$02'E)

2. Position B.
   Bearing to Pamela's Light 20^0
   Bearing to Paula's Light 327^0
   Bearing to Reid Light 244^0

   (Suggested answer $24^0$7'S, $162^0$04.5'E)

3. Position C.
   Bearing to Halpin Hill 178^0
   Bearing to Mt James 306^0
   Bearing to Trent's Light 013^0

   (Suggested answer $24^0$10' S, $161^0$54'E)

4. Position D.
   Bearing to Trent's Light 222^0
   Bearing to Pamela's Light 175^0
   Bearing to Critchley Hill 263^0

   (Suggested answer $23^0$55' S, $162^0$07'E)

5. Position E.
   Bearing to Pamela's Light 357^0
   Bearing to Trent's Light 281^0
   Bearing to Paula's Light 320^0

   (Suggested answer $24^0$07' S, $162^0$06'E - you are on the beach)

6. Position F.
   Bearing to Halpin Hill 302^0
   Bearing to South Cardinal Mark Perry Shoals 74^0
   Bearing to Mark's Light 20^0

   (Suggested answer $24^0$14' S, $161^0$55'E)

7. Position F.
   Bearing to Trent's Light 242^0
   Bearing to Fairway Beacon 310^0
   Bearing to Clubhouse at Batestown 285^0

   (Suggested answer $24^0$02' S, $162^0$01'E)

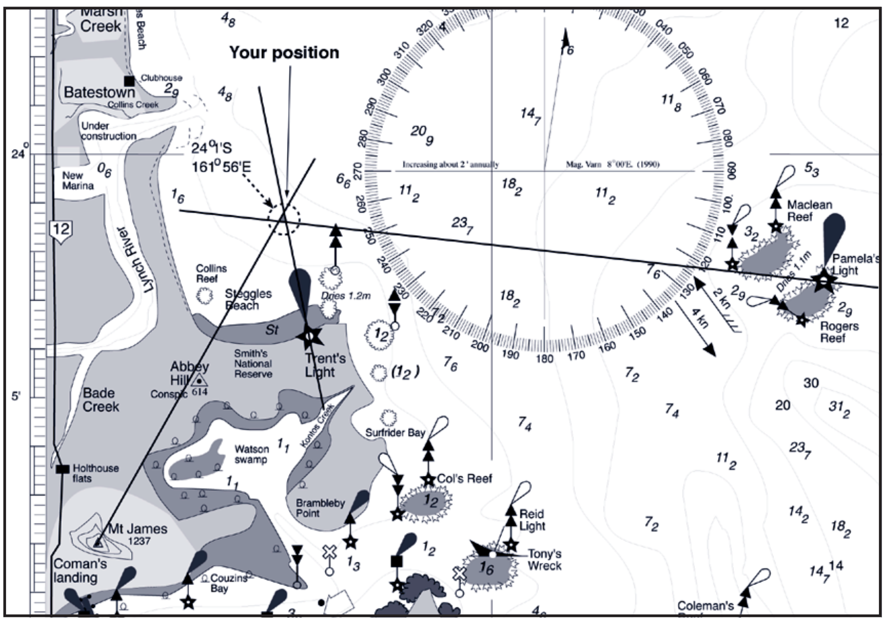
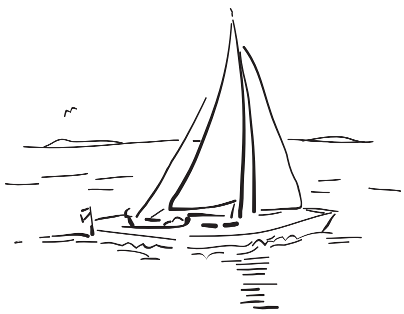
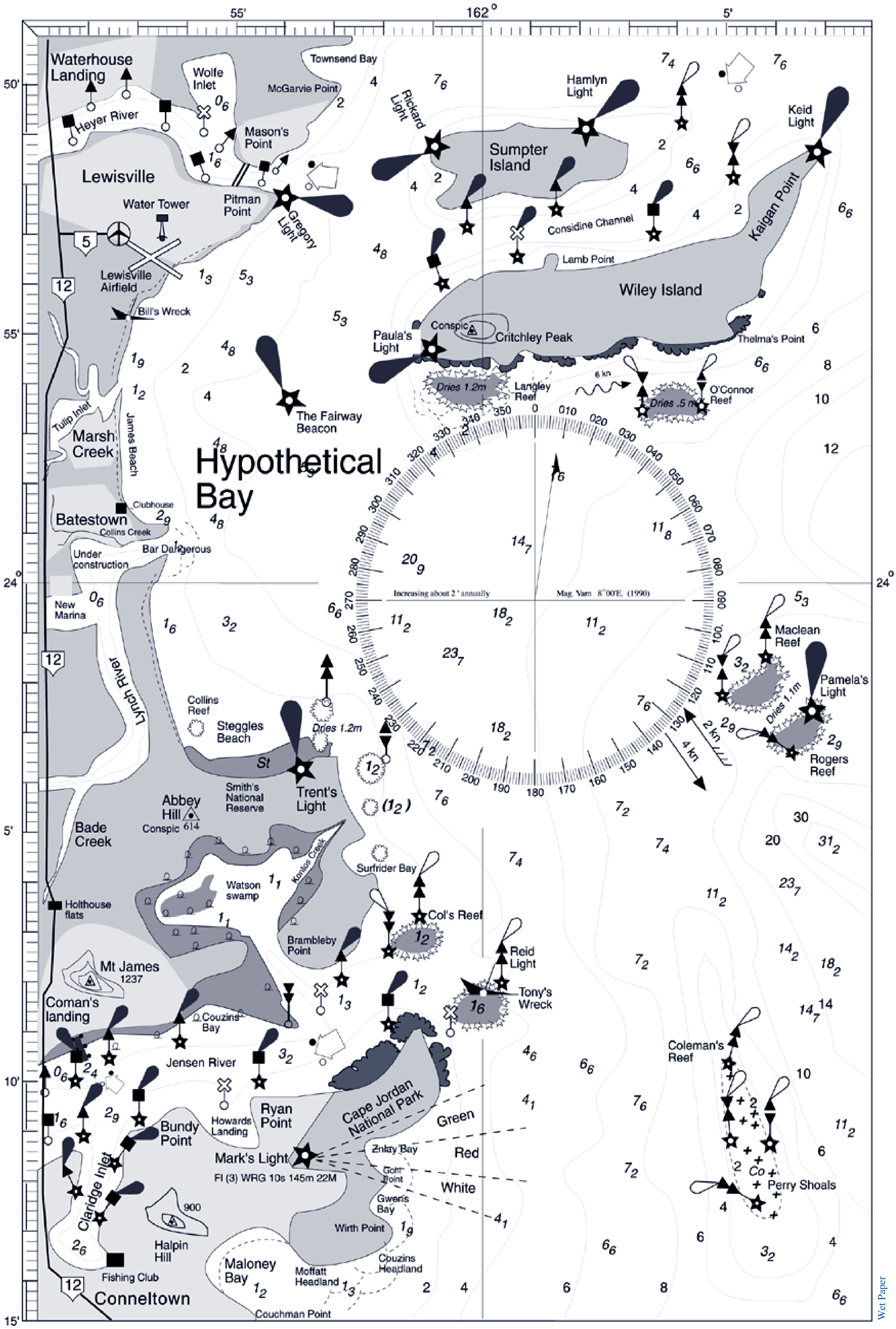


Figure 56.1 Worked example



Note: It is not good practice taking two bearings along the same line


55'
162°
5'
50'
55'
24°
24°
5'
10'
15'
Waterhouse Landing
Wolfe Inlet
Townsend Bay
McGarvie Point
Heyer River
Mason's Point
Rickard Light
Hamlyn Light
Sumpter Island
Keid Light
Lewisville
Water Tower
Pitman Point
Gregory Light
Considine Channel
Kaigan Point
Lamb Point
Wiley Island
Lewisville Airfield
Bill's Wreck
Paula's Light
Conspic
Critchley Peak
Thelma's Point
Dries 1.2m
Langley Reef
6 kn
Dries .5 m
O'Connor Reef
The Fairway Beacon
Tulip Inlet
Marsh Creek
James Beach
Hypothetical Bay
Clubhouse
Batestown
Collins Creek
Bar Dangerous
Under construction
New Marina
Increasing about 2' annually
Mag. Varn 8°00'E. (1990)
Maclean Reef
Pamela's Light
Dries 1.1m
Rogers Reef
2 kn
4 kn
Lynch River
Collins Reef
Steggles Beach
Dries 1.2m
St
Trent's Light
Smith's National Reserve
Abbey Hill
Conspic 614
Bade Creek
Kenlos Creek
Surfrider Bay
Watson swamp
Holthouse flats
Col's Reef
Brambleby Point
Reid Light
Tony's Wreck
Mt James 1237
Coman's landing
Couzins Bay
Jensen River
Coleman's Reef
Bundy Point
Howards Landing
Ryan Point
Cape Jordan National Park
Green
Red
White
Zinlay Bay
Golf Point
Mark's Light
Fl (3) WRG 10s 145m 22M
Gwens Bay
Claridge Inlet
900
Perry Shoals
Co
Wirth Point
Halpin Hill
Fishing Club
Maloney Bay
Moffatt Headland
Couzins Headland
Conneltown
Couchman Point
Wet Paper

Worksheet 19
Laying off and plotting

Which course do you steer, how long will it take to get there and are you on course? This exercise lets you practise the skills in laying off and plotting a course.

Worked example

A day's outing and whale watching is planned off Thelma's Point. You live at Waterhouse Landing and are planning the trip.

From Gregory Light, you decide to go around Paula's Light and Wiley Island Reef as shown in the chart of Hypothetical Bay opposite.

1. You decide to avoid all water below 4 metres and draw four lines with changes in direction at A, B, C and D (as shown).
2. You calculate your distances in nautical miles for each course and the total distance. You figure you can make at least 10 knots and so decide that this is safe for the day.
3. Using your parallel rule and compass rose, you find the true course from Gregory Light to point A is 153°T.

   This converts to 145°C (Error east, compass least)
4. You will need to know when you are at point A. From the chart you find that it is 6 miles from Gregory Light.

   At 10 knots, this will take 0.6 hours, or 36 minutes, give or take a bit depending on currents, etc. and instrument error. (Your speedo might be slightly out).
5. From the chart you can see that Critchley Peak should be on your port beam quarter when you are at A, if you stayed on your intended track.

   It is far more reliable to use a hand-bearing compass reading, so on the chart you find that the bearing of Critchley Peak should be 25°T, which is 17°C when you are at point A.

On the day

1. The day has come and you have your chart ready with the planned course marked in. You pass Gregory Light at 9 a.m. and so immediately mark it on the chart.
2. At 9.30 you are not sure of what you are looking at on your port beam, so calculate your DR position on the chart.

   Since your boat is travelling at 10 knots and it is 30 minutes since you passed Gregory Light, you should be 5 miles along your track.

   You mark this in as your 9.30 DR position, which gives you a better idea of what you should be able to see.

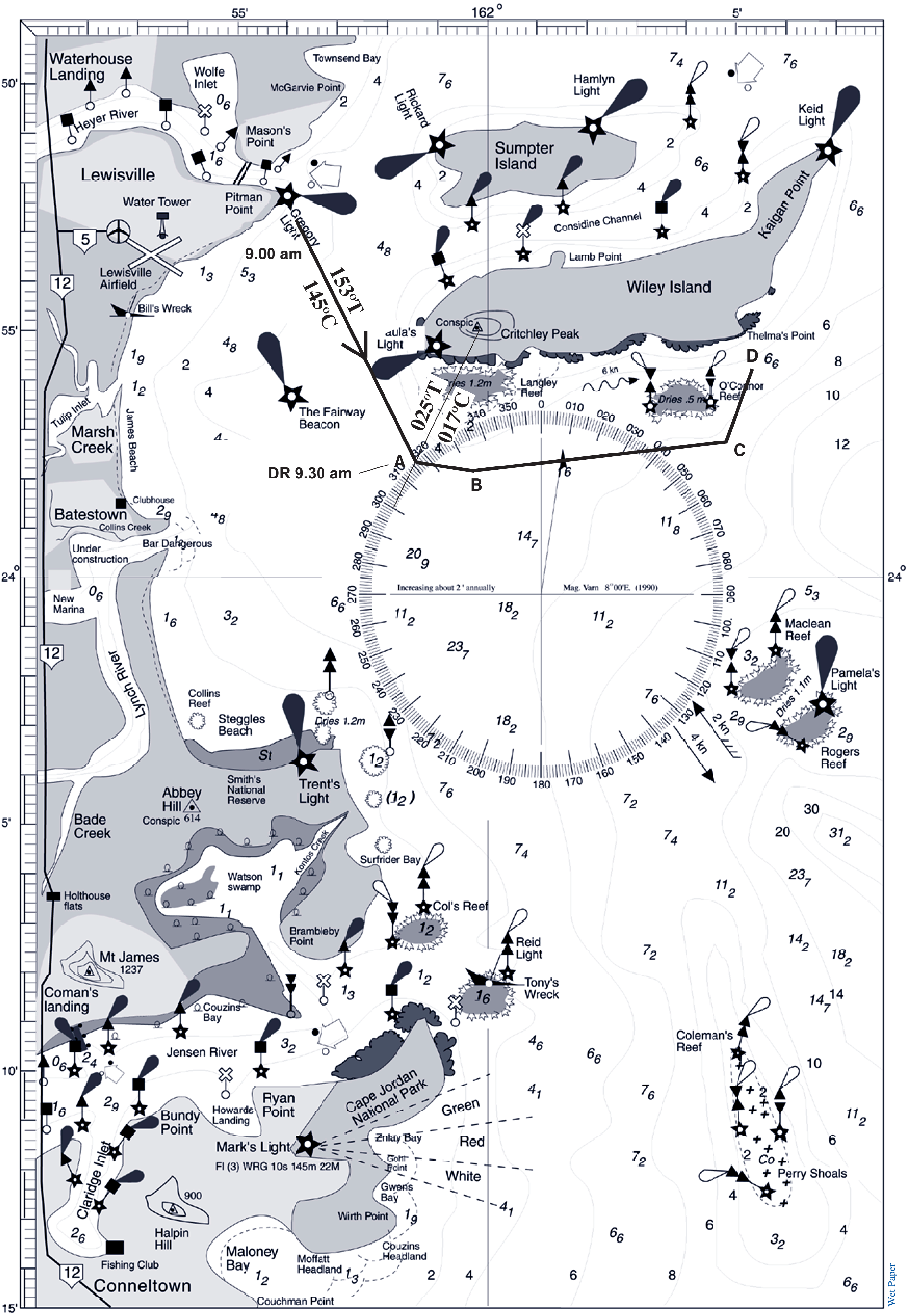
			Position			Course		
Entry	Date	Time	Lat	Long	Var	True	Mag	Speed

Figure 58.1 A voyage record log

3. As you should have only about a mile to go to point A, you get your hand-bearing compass ready, and take a bearing on Critchley Peak. The reading is 22°C, so you are not yet up to point A.
   - Over the next few minutes, the compass bearing of Critchley Peak will decrease, and when it gets to 17°C, you know you are at point A and can alter course to point B.

Questions

1. Lay off a course from position A to position D as outlined in the figure opposite.
   a. How far is it from A to B, B to C and C to D ?
   b. What are the true bearings from B to Critchley Peak and Paula's Light?
   c. When you are supposed to be at position C, what compass bearings should you get on Critchley Peak and Keid Light?
   d. What compass course should you steer from A to B? You propose to make 10 knots, what is your ETA at position B?
   e. What is your compass course from B to C?
   f. What is your compass course from C to D?
2. A fishing trip is planned to Rogers Reef from the Fishing Club at Connelltown. Lay off a compass course from midway between the two reefs at the entrance to Jensen River to Rogers Reef. You plan to leave at 0800 hrs.
   a. You can make 12 knots. Estimate your ETA at Rogers Reef.
   b. The fishing is lousy and you stay for only one hour. Avoiding all water below 4 m, plot the shortest course to the marina in Lynch River.
   c. When you pass Maclean Reef Light, what compass course do you steer?
   d. You make 6 knots, what is your ETA at the marina?
   e. You left the fishing club in the morning. How far have you travelled during the day?


55'
162°
5'
50'
55'
24°
24°
5'
10'
15'
Waterhouse Landing
Wolfe Inlet
Townsend Bay
McGarvie Point
Heyer River
Mason's Point
Rickard Light
Hamlyn Light
Sumpter Island
Keid Light
Lewisville
Water Tower
Pitman Point
Gregory Light
Considine Channel
Kaigan Point
Lamb Point
Wiley Island
Lewisville Airfield
9.00 am
153°T
145°C
Bill's Wreck
Conspic
Critchley Peak
Thelma's Point
Light
D
Dries 1.2m
Langley Reef
6 kn
O'Connor Reef
Dries .5 m
Tulip Inlet
Marsh Creek
James Beach
The Fairway Beacon
025°T
017°C
C
A
DR 9.30 am
B
Clubhouse
Batestown
Collins Creek
Bar Dangerous
Under construction
New Marina
Increasing about 2' annually
Mag. Varn 8°00'E. (1990)
Maclean Reef
Pamela's Light
Dries 1.1m
Rogers Reef
2 kn
4 kn
Lynch River
Collins Reef
Steggles Beach
Dries 1.2m
St
Trent's Light
Smith's National Reserve
Abbey Hill
Conspic 614
Bade Creek
Holthouse flats
Watson swamp
Kontos Creek
Surfrider Bay
Col's Reef
Brambleby Point
Reid Light
Tony's Wreck
Mt James 1237
Coman's landing
Couzins Bay
Jensen River
Coleman's Reef
Cape Jordan National Park
Ryan Point
Howards Landing
Bundy Point
Green
Red
White
Mark's Light
Fl (3) WRG 10s 145m 22M
Zinlay Bay
Golf Point
Gwen's Bay
Wirth Point
Claridge Inlet
Halpin Hill
900
Perry Shoals
Co
Maloney Bay
Couzins Headland
Moffatt Headland
Fishing Club
Conneltown
Couchman Point
Wet Paper

Worksheet 20 Set and Drift

To allow for currents such as ebb or flood tides (Figure 60.1), the navigator must allow for set and drift.

The ship's navigator has to set a course either to port or starboard of the course line. If the set is known (by checking charts) then the navigator can successfully navigate for these currents.

Worked example

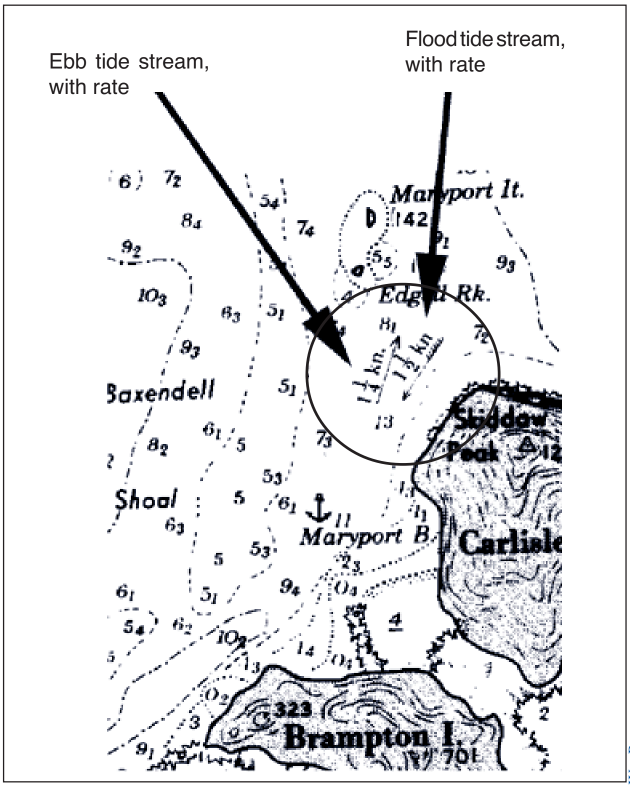
Your boat is positioned at Point A (Figure 60.2), North West of Edgell Rock and you wish to plot a course to Solder Island making allowance of currents in this area.

The boat's speed is say 4 knots.

The direction the current is flowing (the set) is 18^{0}.

The current speed (the rate) is 1.25 knots.

1. Place the direction of the current on the boat's course line. This may be at any point. (See Figure 60.2).
2. Using dividers, measure off the distance the current (drift) will run in 1 hr from A and mark it on the current line. Call this X.
3. Space the dividers to the distance the boat will travel in 1 hr and place one point of the dividers at Point X (on the current line) and sweep round until it touches the boat's course line. Mark this and call it point Y.
4. XY is the course to steer so with parallel rulers work out the T.C. and convert it to C.C. by subtracting the 9^{0}E error.
5. Steer the boat for one hour at 4 knots on C.C. 293^{0} and re-check your position. Make the necessary corrections after this time.



Wet Paper

Figure 60.1 Ebb and flood currents

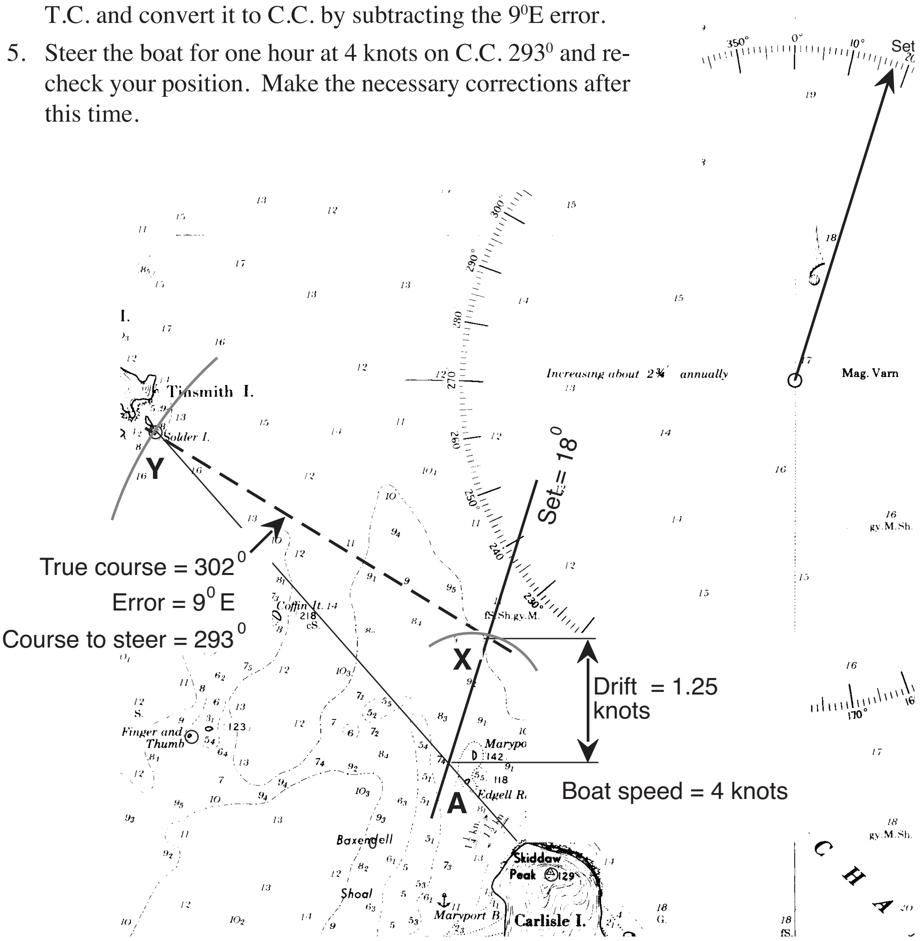


Figure 60.2 Calculation of set and drift

Wet Paper

Some set and drift terms

Leeway

This is the amount which a vessel drifts or makes to leeward of her course by compass when she is steaming with the wind on her side.

The set

This is the **direction** in which a current or tidal stream is flowing.

The drift

This is the rate at which a vessel deviates from its course due to wind, current or tidal influences.

Tidal streams

These are marked on charts by arrows pointing in the direction of the set with the rate of the set marked on the shaft. A current is marked with an arrow pointing in the direction of the set. The arrow has a wriggle on the shaft with no arrows. The rate of the set is marked on the shaft.

Set and drift questions

1. At 0615 you depart the anchorage west of Carlile Island, steering a compass course of 261^0 (C) at 5 knots. At 0703, Allonby Island bears 334.5^0 (C) and Skiddaw Peak (129) bears 069.5^0 (C).
   a. What is your fixed position at 0703?

   b. What set and drift have you experienced since departing the anchorage?

2. From a position 1.5 nautical miles north of the centre of Cockermouth Island, you steer a compass course of 315^0(C) at 6 knots for 1 hour.
   At this time you fix your position as follows:

Carlisle Is (E)	184^0
Tinsmith Is (N)	260^0
Cockermouth Is (E)	134^0

   a. What is your fixed position at this time?

   b. What set and drift have you experienced?

3. You wish to sail from one nautical mile South of Allonby Island to Anchorage at Maryport B near Carlisle Island.
   You will experience a set and drift of 1.25 Nautical miles at 20^0T. Your speed is 4 knots.
   What is the compass course you will need to steer and how long will it take you to reach your destination?

Dead reckoning

Dead reckoning is the determination of a position by projecting a known position for courses and direction. It is also called an estimated position.

It is believed to have developed from when the speed of the ship was determined by throwing a floating object into the water (dead object) and estimating the vessel's speed relative to that object.

This vessel speed together with the course being steered was used to estimate its position at a future time (dead reckoning).

Worksheet 21
Choosing an objective

Before leaving you should study the chart along the path you would like to go. As you study the chart you should take particular notice of any dangers involving depth, currents and tides and shipping channels.

When you have decided your course you should then mark the course. Any dangers should be avoided and at least (if possible) one mile (to 5 miles) should be marked around the danger.

If it is a lee shore then a greater margin of safety should be marked. To mark this danger a circle is best used around the danger and your course is to go around it.

Worked example

We have camped overnight at Maryport Bay on Carlisle Island and want to go to the anchorage at Goldsmith Island for the next night. We have heard that there is some good fishing at the 10 fathom line off Allonby Island and around Specie Shoal.

Set a course for these places.

Step 1 First decide on where you are and mark it on the chart. We call this Position 'A' (20 degrees 47.6 south, 149 degrees 16.7 east). You will need to use your parallel rulers for this job.

Step 2 Next mark the next position you wish to go to on the chart. We call this Position 'B' (20 degrees 45.4 south, 149 degrees 9' east). Finally make a line between the two.

Step 3 Now use the parallel rulers to find the direction. Remember to use your compass rose! Plot the following courses.

Step 4 When you plot the course write the course next to the line in the following manner. TC = 286^0

Now complete the following exercises

1. Plot the following courses. For each of the legs maintain speed at 6 knots.
   a. From position B to the 13 fathom mark at Specie Shoal (Position C)
   b. From Position C to the windward anchorage at Goldsmith Island .4 Nm from Ingot Island (Position D)
   c. From Position D to 1 Nm east of Soldier Island (Position E
   d. From position E to Geranium Shoal (Position F)
   e. From Position F to A (Allow for a ebb tide)
2. While steering a compass course of 300^0C and a speed of 5 knots, Hill 448 Tinsmith Island was 260^0 at 0700. At 0800 the same hill had a compass bearing of 205^0C. What was your latitude and longitude at 0800?

____

____

____

3. The light on Coppersmith Rock has a height of 88ft. It can be seen at a distance just above the horizon. It is estimated (using a sextant) to have an angle of 1^0: How far are you from the rock?

____

____

Figure 62.1 Flying into Brampton Island from the South

Worksheet 22 Where are we?

Use the Cape Hillsborough Chart. Deviation for the card on the chart. Variation — use 10°E

Worked example

What is your position, in latitude and longitude (to 0.1') for each of the following fixes? In each case, the ship's head by compass is given as 20°C:

Compass bearing A

- Hill 670 Cockermouth Island 118°C
- Hill 129 Carlisle Island 217°C
- Hill 448 Tinsmith Island 271°C

Step 1 Convert the compass bearing A to its true bearing on the chart

Can	=	Compass	=	118°C
Dead	=	Deviation	=	4.5° E
Men	=	Magnetic	=	122.5°
Vote	=	Variation	=	10° E
Twice	=	True bearing	=	132.5°T

Step 2 Draw the line using your parallel rules

Step 3 Repeat for the other two bearings and your position is where the lines intersect

Questions

What is your position, in latitude and longitude (to 0.1') for each of the following fixes? In each case the variation is 10°E and your ship's head by compass is given.

1. Course 180°
   - Hill Allonby Island 275° C
   - Finger Island (of Finger and Thumb Is) 27° C
   - Hill 323 Brampton Island 128° C

2. Course 60°
   - Maryport Lt 65° C
   - Coffin Lt 342° C
   - Water depth 10 fathoms

   What type of bottom would you expect if you decided to throw a line over to go fishing?

3. Your starting position A is 2 nautical miles north of Hill 670 on Cockermouth Island (N). Your True Course is 285°T and your speed is 4 knots
   a. What is your dead reckoning (DR) position after 1 hour?
   b. What is the latitude and longitude of position A
   c. How far will you be from Tinsmith Is after 1 hour and what will be your True bearing?

4. Course 300°
   - Locksmith Island is a True bearing of 40° T and a distance of 2.5 nautical miles

5. Course 130°
   Coppersmith light 356° C
   Radar shows the light at 2.5 Nautical miles.
   What will be the depth of water?

6. Course 350°
   Full inlet on southern side of Goldsmith Island is visible as is the Strait between both Linne Island and Tinsmith Island as well strait between Ingot Islets and Goldsmith and the depth of water is 10 fathoms

Transit and deviation exercises

Use the Cape Hillsborough Chart

1. Hill on Allonby Island and Hill 932 on Linne Island are in line on a bearing of 10°C. (Year is 2002)
   What is your deviation?
2. You alter your course and the same features come into line on a compass bearing of 0°C.
   What is your deviation?
3. You steer 10° by compass when you can see the Bullion Rocks behind the Western Side of Allonby Island on a compass bearing of 308°C.
   What is your deviation? What is the error in deviation (from the card)?
4. You are sailing approximately north when the northern tip of Tinsmith Island and the southern tip of Linne Island come into line on a compass bearing of 241°. What is the deviation from the course you are steering?
5. Locksmith Island and Hill 932 on Linne Island give a transit bearing of 118°C.
   What is your deviation?
6. Silversmith Island (NE) and Blackcombe Island (N) are in line when steering a course of 330.5° by compass. The transit bearing of the two islands is 271.5°C by compass. Calculate the deviation for this course.

Worksheet 23
Rule of twelfths

Worked example

This rule is used as a guide to determine tidal height. Because the wave that the Earth spins through is not symmetrical, the rise and fall of the tide is not equal. A simple rule has to be found to work out how much water is under a boat at a certain time in the tide.

This rule is called the **rule of twelfths** because it divides the time and height by 12.

The formula works on the height of water that changes between the tides — called the tidal range. The calculations are as follows:

- In the **first** and **sixth hour** of the tide the height will drop by 1/12
- For the **second** and **fifth hour** of the tide the height will drop 2/12
- During the **third and fourth** hours it will drop 3/12

If the tidal range is 6 m and you want to find out how much the tide has fallen 3.5 hours after HW, an approximate answer is as follows:

In the first hour
The tide falls 1/12 x 6 = 0.5 m

In the second hour
The tide falls 2/12 x 6 = 1.0 m

In the third hour
The tide falls 3/12 x 6 = 1.5 m
The tide falls 1/2 x 3/12 x 6 = 0.75 m

Total fall = 3.75 m

Hours	1	2	3	4	5	6
Fraction of tide rising or falling	1/12	2/12	3/12	3/12	2/12	1/12

Questions additional information

Q2.LAT is 2.25, therefore at HT depth should be 6.25m

Q4.LT 1400 hrs is 0.5m

Questions ** See additional information notes below*

Read the worked example and answer the questions below. Assume all areas have two high and two low tides each day and the tide heights are similar.

Q1.If the tidal range at Gladstone was 4 m and the time of high tide was 1 p.m., predict the height of the tide at 3 p.m. on the same day. Depth of water at low tide is 2m.

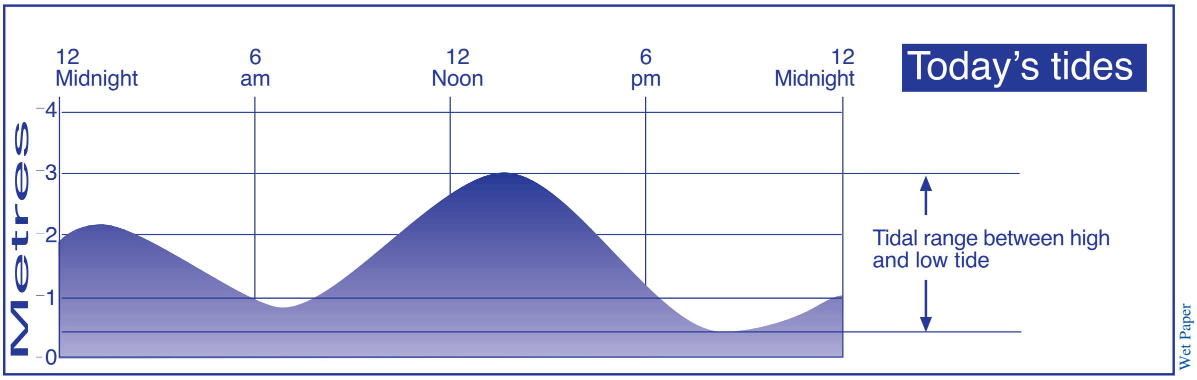
Q2.An amateur fisherman is fishing in a depth of water of 6 m. It is 9 a.m. and the tide for that day is high tide of 4 m at 8 a.m. Calculate the depth of water at 12 midday.

Q3.Bar crossing at a river mouth area is a problem when the tidal flow is great as this increases wave height. The tides for a day when ocean conditions were suitable for safe boating were as follows:

Time	Height (m)
0140	3.10
0744	0.74
1411	3.84
2044	1.00

Predict possible safe crossing times.

Q4.Your vessel has a draft of 2.4 m and you wish to enter a channel that is shown on the chart as having a depth of 1.5m. A check of the tide book reveals on that day a high tide of 3 m occurs at 8 a.m. You wish to have at least 0.5 m clearance for safety. Calculate the period of time (giving the times) when entry into the channel would be safe.



Section 9 Radar and GPS

Many vessels now rely on electronic navigation. This term is used to describe navigation involving electronics in any way. This type of navigation is important for offshore-navigation where the mariner can only see the sea.

Figure 65.1 Modern navigation instruments contain computer chips for radar, sonar, GPS and many more.

Navman

Radar

(Stands for **Ra**dio **D**etecting **a**nd **R**anging.)

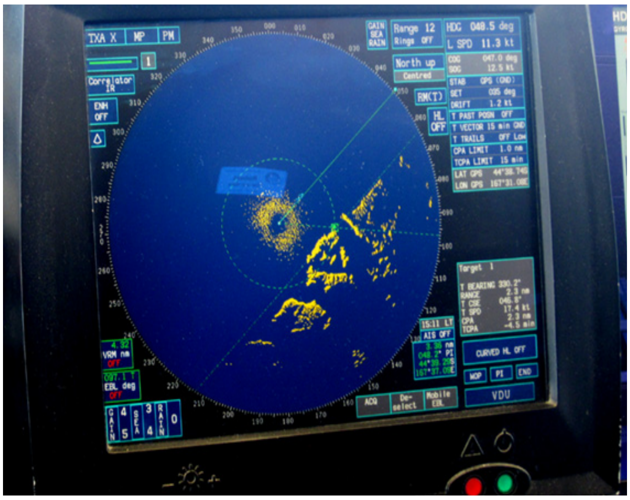
Radar is, perhaps, the best coastal navigation instrument since it eliminates so many of the problems of visual navigation. It is however subject to incorrect readings in strong rain squalls.

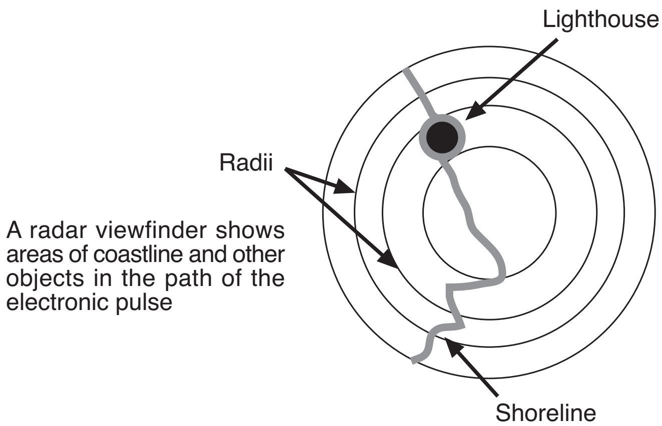
It can 'see' in the dark, penetrate fog and mist and combine all the usual coastal navigation plotting systems into one. This enables the navigator to check a boat's progress at regular intervals without leaving the wheelhouse.

Radar works on a similar principle to the depth sounder. An electronic pulse is transmitted from the scanner which 'bounces' back off shore or other objects close by. The 'echo' is picked up by the receiver. As the scanner on top of the wheelhouse rotates through 360 degrees, these echoes are converted into a map-like picture on a cathode tube with the boat as the centre of the picture, and the local scene spread out around a 360 degree horizon.

The set incorporates a method of measuring bearings and distances enabling the navigator to carry out position plotting. Because of a number of limitations, radar must be used with caution. One of its biggest problems is the tendency of the pulse to 'echo' only off certain objects.

A cliffy coastline, for example, will usually present an excellent picture on the radar screen, whereas a low sandy shoreline may show up only faintly, perhaps not at all. Navigation marks such as buoys or channel indicators may not show up too well on the screen unless they are fitted with radar reflectors. These reflectors increase the strength of the radar echo and create a much stronger 'blip' on the screen.





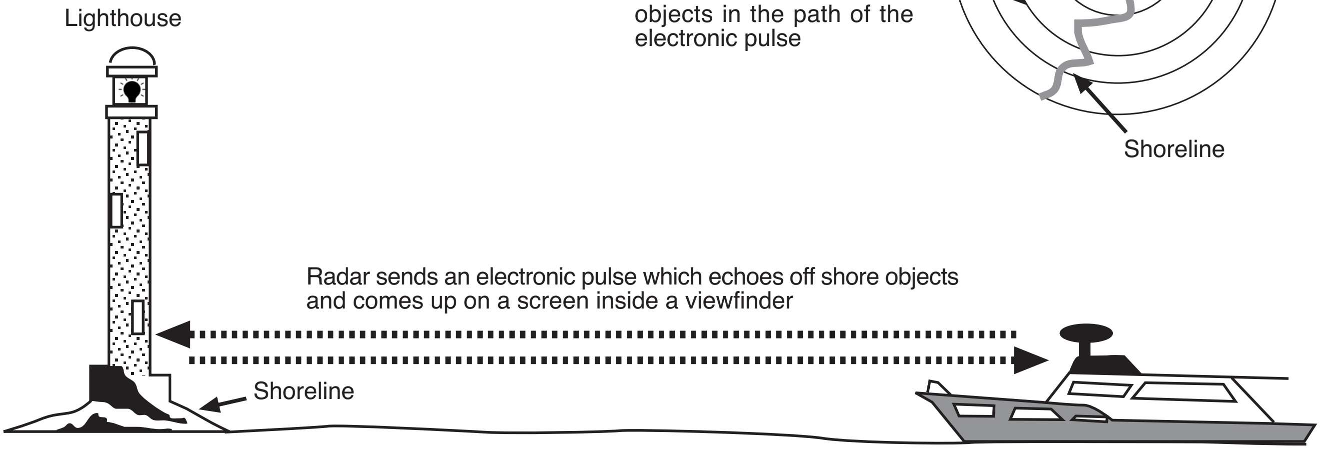


Figure 65.2 How radar works

Wet Paper

The Global Positioning System GPS

The Global Positioning System or GPS, determines the position and speed of a vessel at sea very precisely from a number of satellites 10,900 miles above the Earth.

Each satellite sends out signals which are interpreted by the GPS navigator on board the vessel (Figure 66.3).

Position determination usually requires that the GPS navigator is receiving signals from four satellites. It then calculates the latitude, longitude, altitude and time. Each satellite transmits signals allowing the user to find its position and time of transmission.

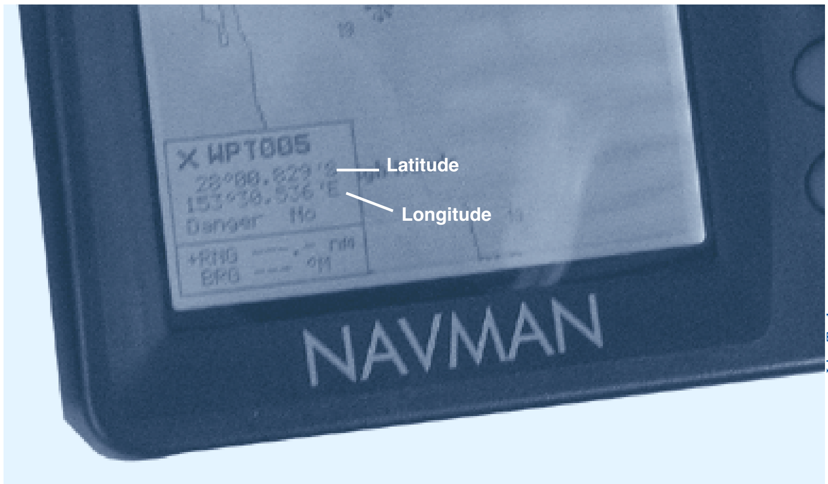
The transmission delay (Δt) is found by comparing the time of transmission to the arrival time.

The transmission delay (Δt multiplied by the speed of light (c) equals the range (R) to the satellite.

A GPS relies on a power supply and has to be replaced by traditional navigation position fixing methods when this supply fails.


Wet Paper

Figure 66.1 A GPS and chart plotter mounted at the helm



Lisa Taylor

Figure 66.2 Display

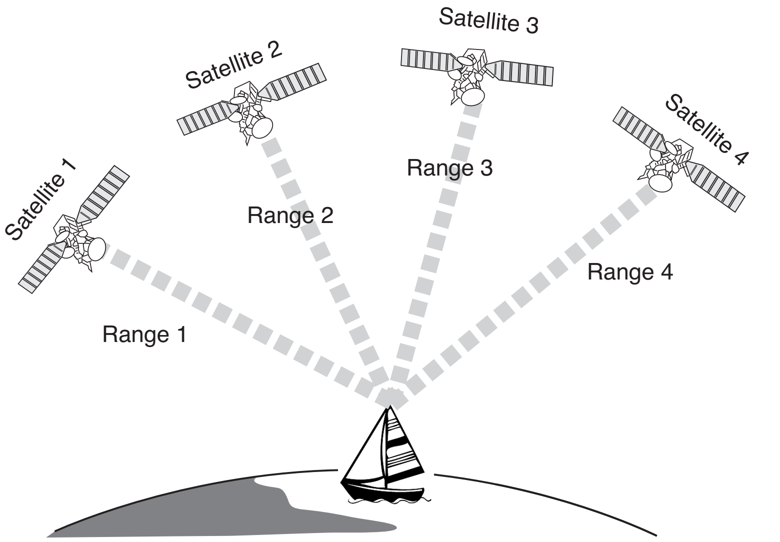


Figure 66.3 The receiver position is determined by the intersection of the spheres centred around each satellite with a radius equal to the respective range.
Wet Paper

Datum checking

- It is advisable to switch the unit on and select the correct chart datum before departing. Many boat ramps have signs showing datum points.

  GPS units require time to initialize, and the skipper needs time to assess the accuracy of the position information prior to starting the voyage.

  - The accuracy of GPS units can be compromised by power failures or poor electrical connections.
  - Always ensure your electrical charts are updated with supplier upgrades. When going to a waypoint in a straight line, check what is in between your boat's initial location and the waypoint.
  - The figure below shows a GPS image of a track around a headland from A-B. One chart uses a datum called WGS 84 and the other AGD 66 (an out of date datum).
  - Use the wrong datum and you end up on the rocks.

Figure 67.1 GPS check sign

Waypoint navigation

Many vessel owners who have a GPS receiver program a number of latitude and longitude positions into their receiver to help compute courses.

These positions are called waypoints and can be used to show a safe path to a particular place — usually a favourite fishing or dive location.

When these way points are called up, the GPS receiver will show the course to steer and the distance that the vessel has to travel from one waypoint to another.

As the vessel arrives at the waypoints, a signal beeps and the next waypoint is automatically displayed on the receiver.

A GPS receiver can also be attached to an autopilot, which will track the data and steer the ship through a number of course changes.

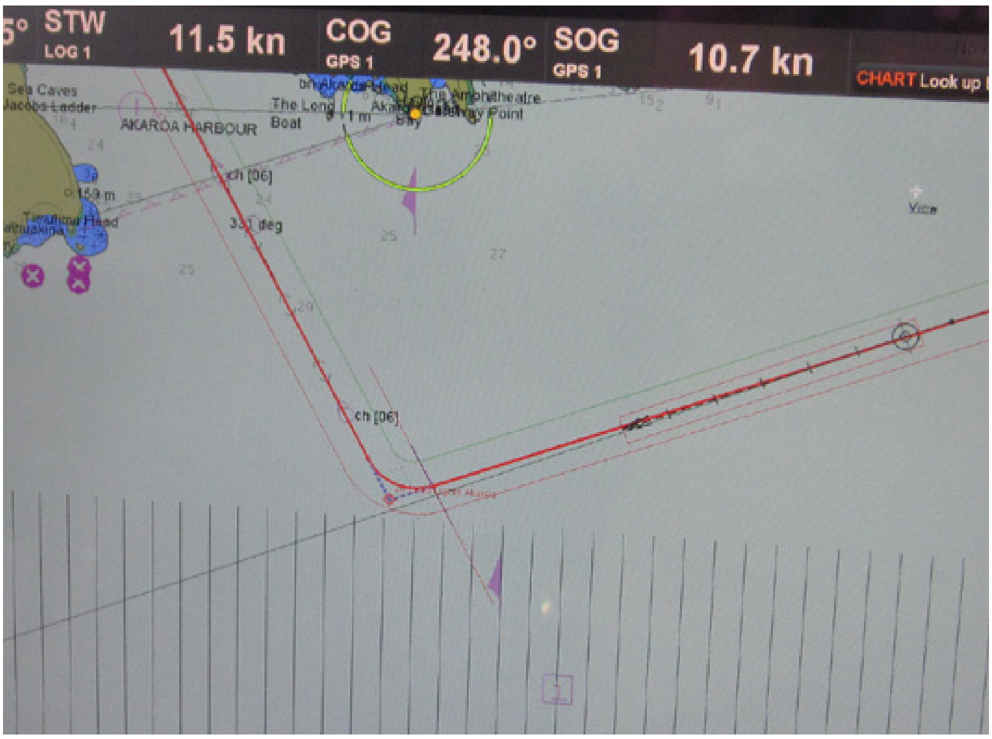


Figure 67.2 Screen of a ship's chart plotter

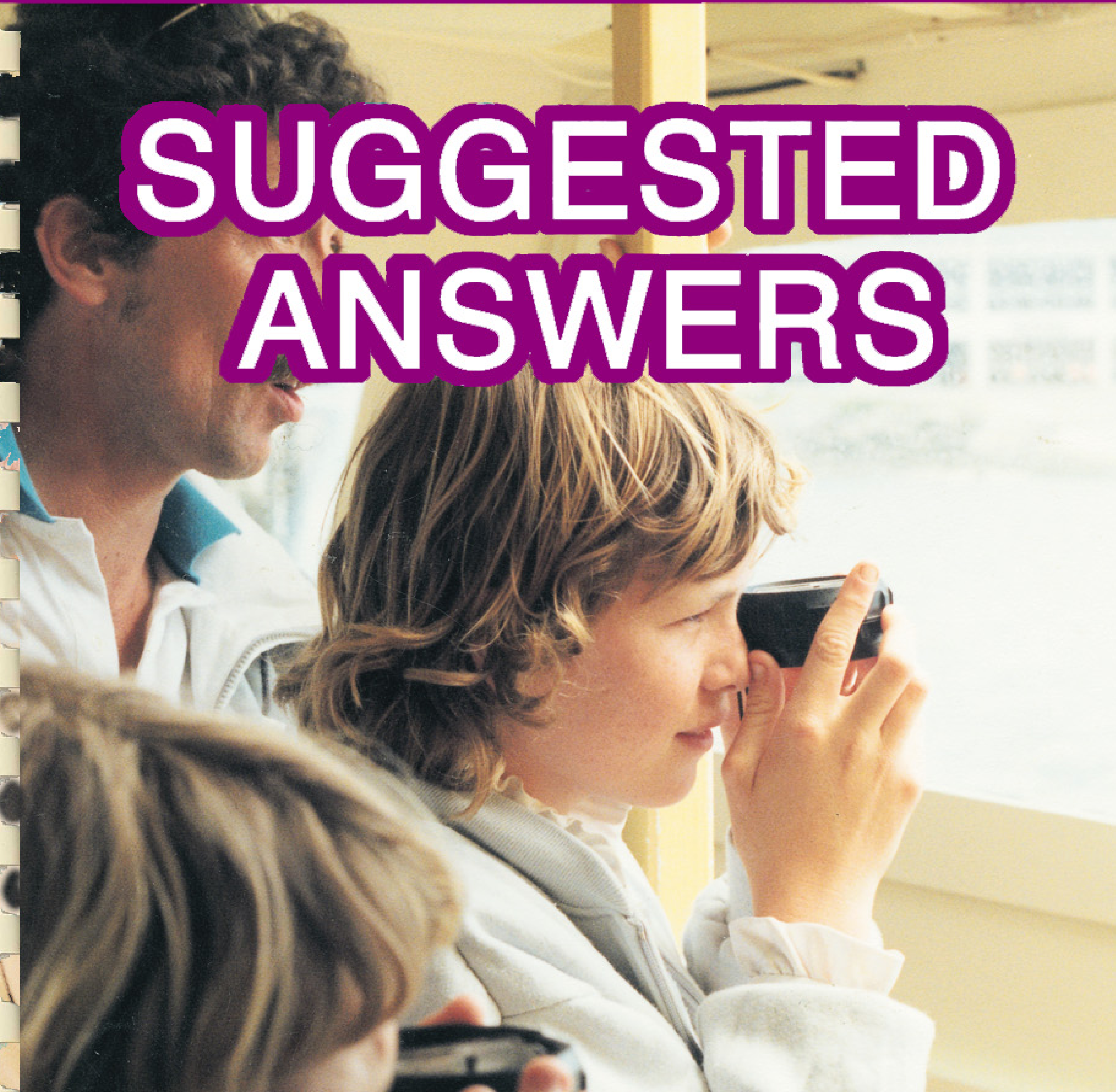
Marine Science

For Australian Students

Navigation Worksheets

2nd Edition

SUGGESTED ANSWERS



Contents

Worksheet 1 Research and review

1. "In 1519, with five ships and about 260 men, Ferdinand Magellan left Spain on the first circumnavigation of the globe. He was born in Oporto, Portugal in 1480 and enlisted in the Portuguese navy in 1505.

   Here he learned seamanship and naval warfare under Portuguese viceroys in India.

   Magellan wanted to try to reach Southeast Asia by sailing westwards across the Atlantic Ocean. Magellan was killed in a fight with islanders in the Philippines, so although he had masterminded the first expedition to sail around the world, he did not complete the voyage himself. In fact, the first person to sail around the world was a Malaysian, who had travelled back to Europe with Magellan many years earlier.

   Later, he accompanied Magellan as an interpreter on the circumnavigation." From:

   http://www.didyouknow.cd/aroundtheworld/sailing.htm and,http://www.nmm.ac.uk/server/show/conWebDoc.142

2. A sextant is used to measure angles to objects in the sky such as stars.

   "An Englishman, John Hadley in 1731, invented the sextant. It was mainly used at sea to determine a ship's latitude or distance from the equator. In fact, the invention of the sextant laid the foundation of modern navigation.
   The device consists of an arc of a circle, marked off in degrees, and a movable radial arm pivoted at the centre of the circle. A movable mirror is fixed at the end of the arm. The other end extends to the scale.

   A telescope is mounted on the sextant, and a glass mirror is mounted in front of the telescope.
   To operate the sextant, the operator looks through the telescope straight at the horizon. And then by moving the mirror the sun or any particular star is made to appear exactly on the horizon. The arm, which moves the mirrors, gives the required measurement of the angle. From this angle and the exact time of day, the latitude is determined by means of published tables.
   The knowledge of latitude is very useful for navigators as it tells them, at which place of the earth they are."

   From:

   http://www.4to40.com/earth/science/index.asp?article=earth_science_sextant

3. Could include
   - radio
   - GPS
   - fish finders, depth sounders,
   - mobile phones with satellite navigation

4. Students own answers

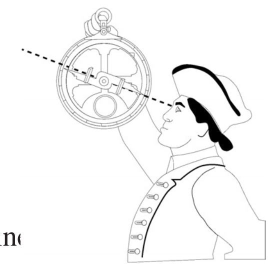
5. Students own answers

6. No landmarks to follow.

   Maybe in some busy waterways with 'no clue' boaties in marinas

7. Very bad weather, recreational boaties, crew stress, major ship failure (engin
   All ships have to carry a ships pilot in these waters.

8. Students own answers



Worksheet 2 Library/internet research

Students own answers

Worksheet 3 Pilotage questions

1. a) Isolated danger
   b) Special marker
   c) Safe water marker
   d) South cardinal marker

2.

a) Port lateral marker	keep mark to port when entering harbour
b) Starboard lateral marker	keep mark to starboard when entering harbour
c) Special marker	refer to chart for meaning
d) North cardinal marker	safe water north of mark
e) South cardinal marker	safe water south of mark
f) West cardinal marker	safe water west of mark
g) East cardinal marker	safe water east of mark
h) Starboard lateral buoy	keep mark to starboard when entering harbour
i) Port lateral buoy	keep mark to port when entering harbour

The following answers are form the hard copy book

3. - Left one is a north cardinal marker with two black triangles pointing up as a top-mark
   - Right hand side one is an east cardinal marker with two black triangles up top. The top one points up and the bottom one downward.
   - Remember: the top-marks of cardinal markers point to where the black would be on the post. Eg. Since a west cardinal marker has top-marks that point into each other, that's where the black on the post is – in the middle (yellow above and below).

4. a) Port lateral marker
   b) East cardinal marker
   c) Port lateral marker
   d) South cardinal marker
   e) Special marker
   f) Isolated danger
   g) Safe water

5. Lighthouse flashes a single white flash at 15-second intervals. Its height above water level is 46 metres and is visible for 26 miles.

6. The mark is a North Cardinal mark, so presuming the mark is warning vessels to avoid shallow water between it and the headland, the headland is South Head.

Worksheet 4 What day is it?

Corrections:

Q1. UCT should be UTC

Errata - in the table swap the hrs +'s to -'s

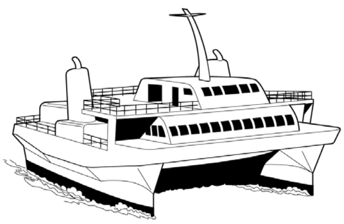
Q5. The cricket fan should be at 150°E

In the table the hours are all incorrect, swap the +'s with the -'S

Answers

1. a) 2300 hrs
   b) 1300 hrs
   c) 0900 hrs
   d) 1700 hrs
2. Difference in longitude is 30° due to 360°=24hours
3. Countries that are on both sides of the 180° meridian need to maintain the same day in their country, the line deviates to accommodate this.
   Deviates around several places eg Siberia, Alaska, Aleutian Is, Kiribati, Fiji, Cook Is, and Tonga.
4. Australia has 3 time zones due to the large East-West distance spanned.
   They are: East Coast UTC +10, Central Aust UTC+9.5, Western Aus UTC+8
5. Greenwich is UTC+0 and the fan in East Coast of Australia is UTC + 10 so 11am in Greenwich is 9pm East Coast Australia.
6. London 1200 hours

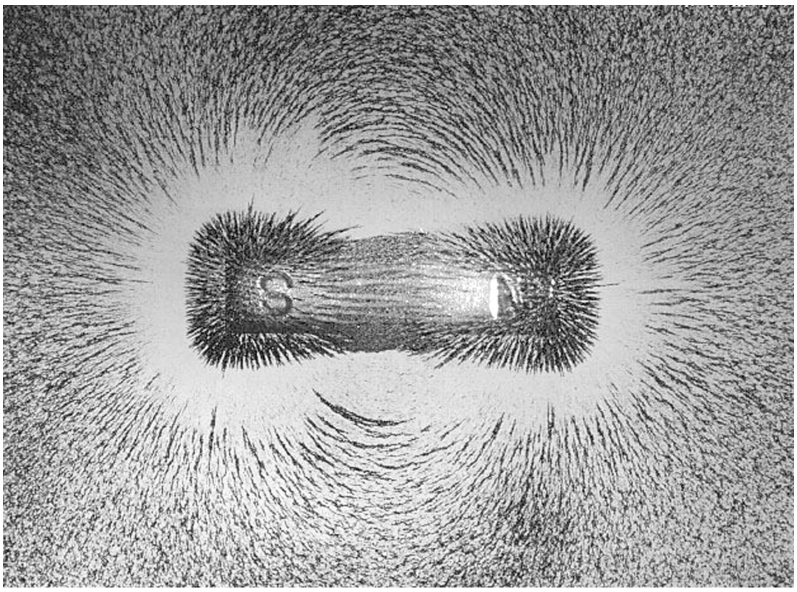
New York	0700 hours
Beijing	2000 hours
Paris	1300 hours
Los Angeles	0400 hours
Calcutta	1730 hours
Moscow	1500 hours



Worksheet 5 Magnetic fields

1. Strength of magnet decreases with distance from ends of the magnet. There are less iron filings accumulating further from magnet poles.
2. Iron filings standing up indicate that magnetic field is perpendicular to the paper surface. (i.e. is 3-dimensional)
3. The compass needle acts like a large iron filing and lines up with the magnetic field lines outlined by them.
4. The magnetic field is strongest at each end (pole) of the magnet. The large number of filings attracted to the poles indicates this. If the magnet were cut in half, two magnets would be created, each with half the strength of the original.
5. A compass is a magnetised steel needle.
6. The ends of the magnet have the strongest force.
7. By mounting the magnet so that it is free to swing, such as by a thread. The end that points north is called the North-seeking pole. (In fact the earth acts as a huge magnet whose North pole is near the earth's south pole).

Results



Extension activity

1. Material containing iron eg steel or equipment which produce magnetic fields such as electrical coils.
2. Most large vessels are made of steel and use some form of compass. Magnetic compasses must be adjusted to counteract the steel and/or the effect of the steel on the compass direction must to taken into account (Deviation).
3. While aluminium does not affect the compass, any steel or electrical equipment producing magnetic fields would have an effect.
4. A fluxgate compass would be more accurate.
5. Answers will vary. (Birds are known to use the earths magnetic field for navigation)

Worksheet 6 The use of a hand bearing compass

Results

Students should get a range of bearings.

Metals should affect the readings.

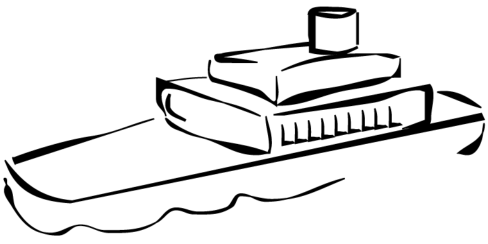
Students should keep as far away as possible from metal objects when taking bearings

Worksheet 7 Making a compass rose

1 - 2. Students own answers

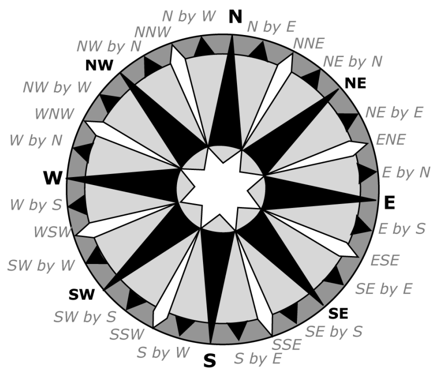
Worksheet 8 Your local chart

1 - 11. Students own answers



Worksheet 9 Hypothetical Bay

1. Northernmost Latitude = 09^{o} 32’ S
   Southernmost Latitude = 43^{o} 39’ S
2. Easternmost Longitude = 153^{o} 40’ E
   Westernmost Longitude = 112^{o} 55’ E
3. Greenwich is in London, England. Its longitude is 0^{o}.
4. Rockhampton
5. Schools’ latitude will vary.
6. a) Southern hemisphere (latitude increases down the page)
   b) Australian continental shelf.
   c) Hypothetical Bay is 12 nautical miles (22km) north-south, and about 4 Nm (7.5km) east-west.
7. Soundings, currents, beacons, buoyage direction, sector lights, tidal currents etc.
8. Deepest = 31.2m south of Roger’s Reef
   Shallowest = Dries 1.2m. Reef near Trent’s light
9. Refer page 30 students workbook.
10. Approximately 1.2m at lowest tide
11. Pilotage = navigation using geographic points and /or navigation marks
    Buoyage = specific navigational meaning of marks and buoys
12. 2.6m to 2.9m at lowest tide
13. Thelma’s Point is position Latitude 23^{o} 55’ S, Longitude 162^{o} 05’E.
14. Mangroves and mud.
15. Bar at mouth, new marina under construction.
16. Abbey Hill (614m), Halpin Hill (900m), Mt St James (1237m).
17. Wiley Island, Sumpter Island.
18. 4 knots.
19. Coral (Co) Rocks and coral.



Worksheet 10 Your own chart

Students own answers

Worksheet 11 Chart features

1. Single red flash every 2 seconds
   Group of three white flashes repeated each 10 seconds
   Group of two green flashes repeated each 5 seconds
   Group of two white flashes repeated each 6 seconds; height of light is 33m and is visible to 7 Nm
   Single green flash every 6 seconds
   Sector light with group of two white, red or green flashes repeated each 10 seconds.

2. Cy – Clay

   Co – Coral

   M – Mud

   Si – Silt

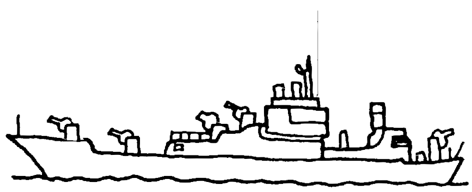
   Wk - Wreck

   S/M – Sand over Mud

   Wd – Weed

   St – Stones

3. Refer page 30 students workbook.



Worksheet 12 Latitude, longitude and nautical miles

1.

Object	Latitude	Longitude
Gregory’s Light	23° 52.2’S	161° 56.0’E
Paula’s Light	23° 55.3’S	161° 59.0’E
Pamela’s Light	24° 02.5’S	162° 06.8’E
Tony’s wreck	24° 08.1’S	162° 00.0’E
Fishing Club	24° 13.5’S	161° 52.6’E
Airport	23° 53.0’S	161° 52.6’E
Rickard Light	23° 51.2’S	161° 59.0’E
Hamlyn Light	23° 50.8’S	162° 02.2’E
Mouth of Kontos Creek	24° 08.6’S	161° 56.7’E
Ryan Point	24° 10.3’S	161° 55.3’E
Halpin Hill	24° 12.8’S	161° 52.7’E

2. a) Lewisville Airfield
   b) Gregory Light
   c) MacLean Reef
   d) Bundy Point
   e) Pamela’s Light
   f) Mark’s Light
   g) Holthouse Flats

3. Keid Light and Pamela’s Light
   Rickard Light and Paula’s Light

4. Keid Light and Rickard Light

5. a) 4 miles
   b) 7 miles
   c) 11.2 miles
   d) 28 miles
   e) 16 miles
   f) 28 miles

6. a) 4 miles X 3 miles
   b) 1 mile X 0.8 mile
   c) 0.5 mile X 1 mile
   d) 2miles X 9 miles

Worksheet 13 Distance, speed and time

1. D = S x T = 9 x 10 = 90 Nm
2. D = S x T = 4 x 6 = 24 Nm
3. D = S x T = 10 x 2 + 5 x 3 = 20 + 15 = 35 Nm
4. S = D / T = 10 / 2 = 5 knots
5. S = D / T = 5 / 3 = 1.7 knots, very poor speed, could row faster!
6. S = D / T = 35 / 3.5 = 10 knots
7. T = D / S = 20 / 5 = 4 hours
8. T = D / S = 32 / 4 = 8 hours
9. About 11.5Nm. Minimum sounding at bar is 1.2m (10Nm from fishing club).

   Therefore need at least 2.9m-1.2m = 1.7m of tide to cross.

   Can leave the club anytime as there is enough water depth this morning, but must reach the bar near High tide. (0930hours). At 6 knots, 10Nm takes 1.7hours, so must leave before 0748hours.
10. 6Nm
11. a) Distance = 8.4Nm,

    Speed = 12knots

    T = D/S

    8.4Nm/12knots

    = 0.7 hours

    = 42 minutes

    Arrives at 0800 + 0042 = 0842 Hours

    b) Thelma's Point is approx. 9Nm from position at 0842 hours. Wet Paper 1 could do 25 knots in this direction across the wind.

    T = D/S

    = 9Nm/25knots

    = 0.36 hours = 22 minutes.

    So Wet Paper 1 could easily make it to Thelma's Point for an early lunch from about 0930 hours!
12. Whyamber would take T = D/S = 8.4Nm / 5 knots = 1.7 hours plus another 1.8 hours.
    Total time for Whyamber is 3.5 hours. She would arrive by 1130 hours.
13. The restaurant at Marsh Creek is 6Nm, 11km or about 10 minutes by bus from the airport. It is also about 3 Nm north of the new marina, about 5 minutes by bus.

    However, as Lynch River bar is dangerous, whale watching is unlikely to be based at this marina.

    A more likely location is Jensen River Inlet, which is 20Nm or 1 hour by bus from the restaurant. Bus timetable needs to take account of these distances, plus time for whaling trip from Jensen River.

Worksheet 14 Compass conversions

1.

True	300°T	201°T	95°T
Variation	10°E	10°E	10°E
Magnetic	290°M	191°M	85°M
Deviation	5°W	4°W	2.5°E
Compass	295°C	195°C	82.5°C

2. Variation (2005) = Variation (1970) + (annual increase x no. of years passed)

= 9°25'E + (2' x 35)

= 9°25'E + 70'

= 9°25'E + 1°10'

= 10°35'E ~ 11°E

3. Variation (2007) = Variation (1972) + (annual increase x no. of years passed)

= 7°45'E + (4' x 35)

= 7°45'E + 140'

= 7°45'E + 2°20'

= 10°05'E ~ 10°E

4. Variation (2010) = Variation (1984) + (annual increase x no. of years passed)

= 9°55'E + (3' x 26)

= 9°55'E + 78'

= 9°55'E + 1°18'

= 11°13'E ~ 11°E

	True	Variation	Magnetic	Deviation	Compass
5.	230°T	11°E	219°M	8°W	227°C
6.	075°T	10°E	065°M	3°E	062°C

7.

Great Navigators	Magnet Uses
Patient, accurate, thorough, observant	Compass, electromagnets, electricity,

8. Plus or minus the Total Error given

a) 116°T	b) 004°C	c) 015°T
d) 112°T	e) 181°C	f) 282°C
g) 317°T	h) 345°C	i) 165°T

9. Total Error is the difference then plus or minus 5°E Variation

a) Error 6°E Dev 1°E	b) Error 12°W Dev 17°W	c) Error 16°W Dev 12°W
d) Error 1°E Dev 4°W	e) Error 28°W Dev 33°W	f) Error 6°E Dev 1°E
g) Error 6°E Dev 1°E	h) Error 9°W Dev 14°W	i) Error 15°E Dev 10°E

10. Deviation and Variation together give Total Error

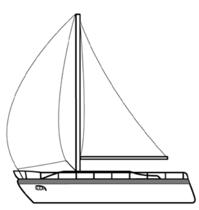
a) 11.5°E	b) 13.5°E	c) 11.5°E	d) 16.5°E
e) 10°E	f) 11°E	g) 14°E	h) 17°E
i) 4°E	j) 7°E	k) 7.5°E	l) 3°E
m) 0°	n) 7°E	o) 8°E	p) 8°E

11. Total Error plus or minus Variation equals Deviation

a) 6.5°E	b) 7°W	c) 2.5°E
d) 6.5°E	e) 0°	f) 2°W
g) 5.5°E	h) 3.5°E	

12. Total Error plus or minus Deviation equals Variation

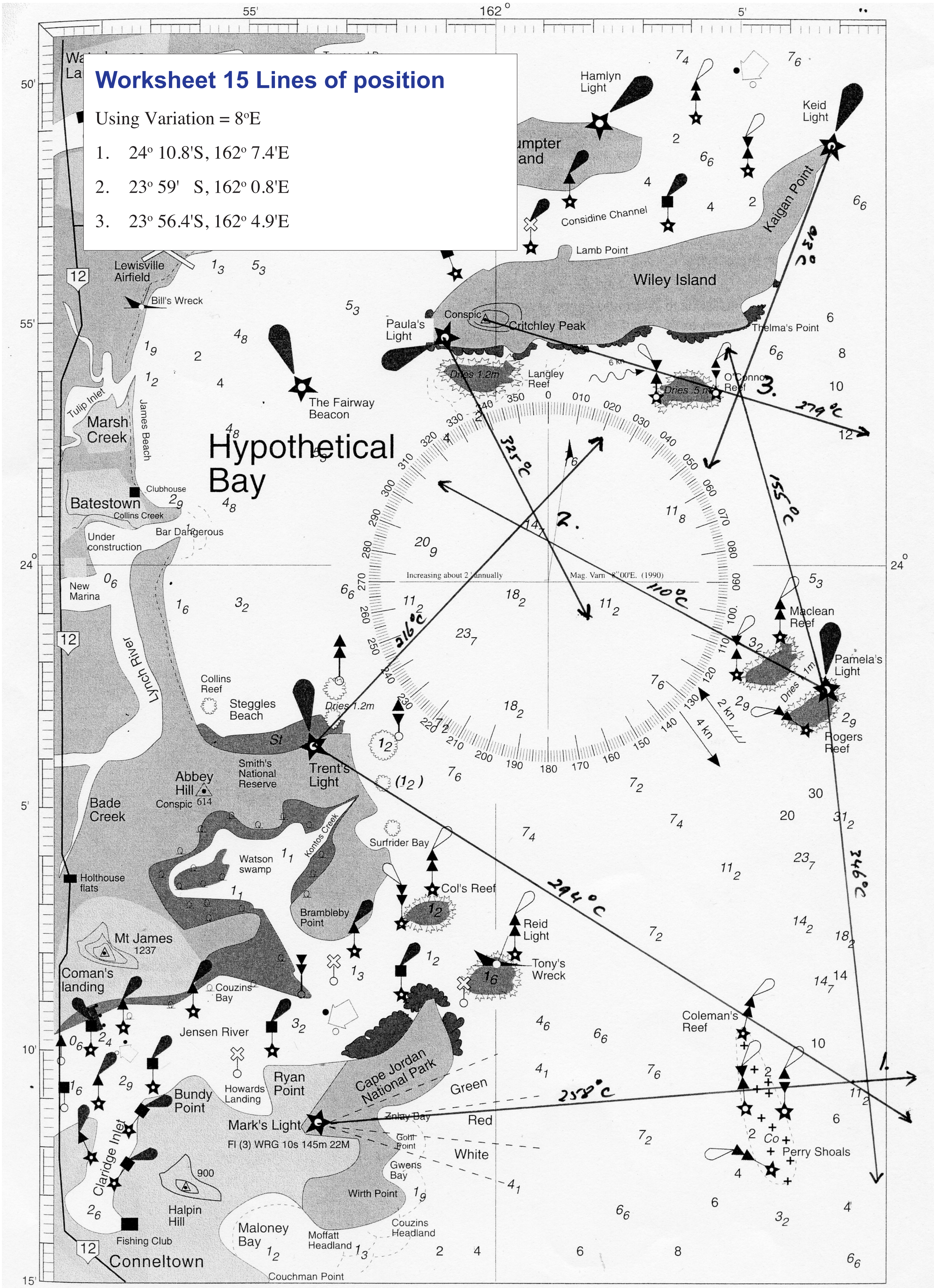
a) 9.5°E	b) 8.5°E	c) 10.5°E
d) 8°E	e) 10.5°E	f) 11°E
g) 10°E	h) 8.5°E	



Worksheet 15 Lines of position

Using Variation = 8°E

1. 24° 10.8'S, 162° 7.4'E
2. 23° 59'   S, 162° 0.8'E
3. 23° 56.4'S, 162° 4.9'E



Worksheet 16 Compass courses

1. a) 135°T

   b) 088°T

   c) 358°T

   d) 042°T

2. See chart opposite

3. Variation (2008)

   = Variation (1990) + (annual increase x number of years passed)

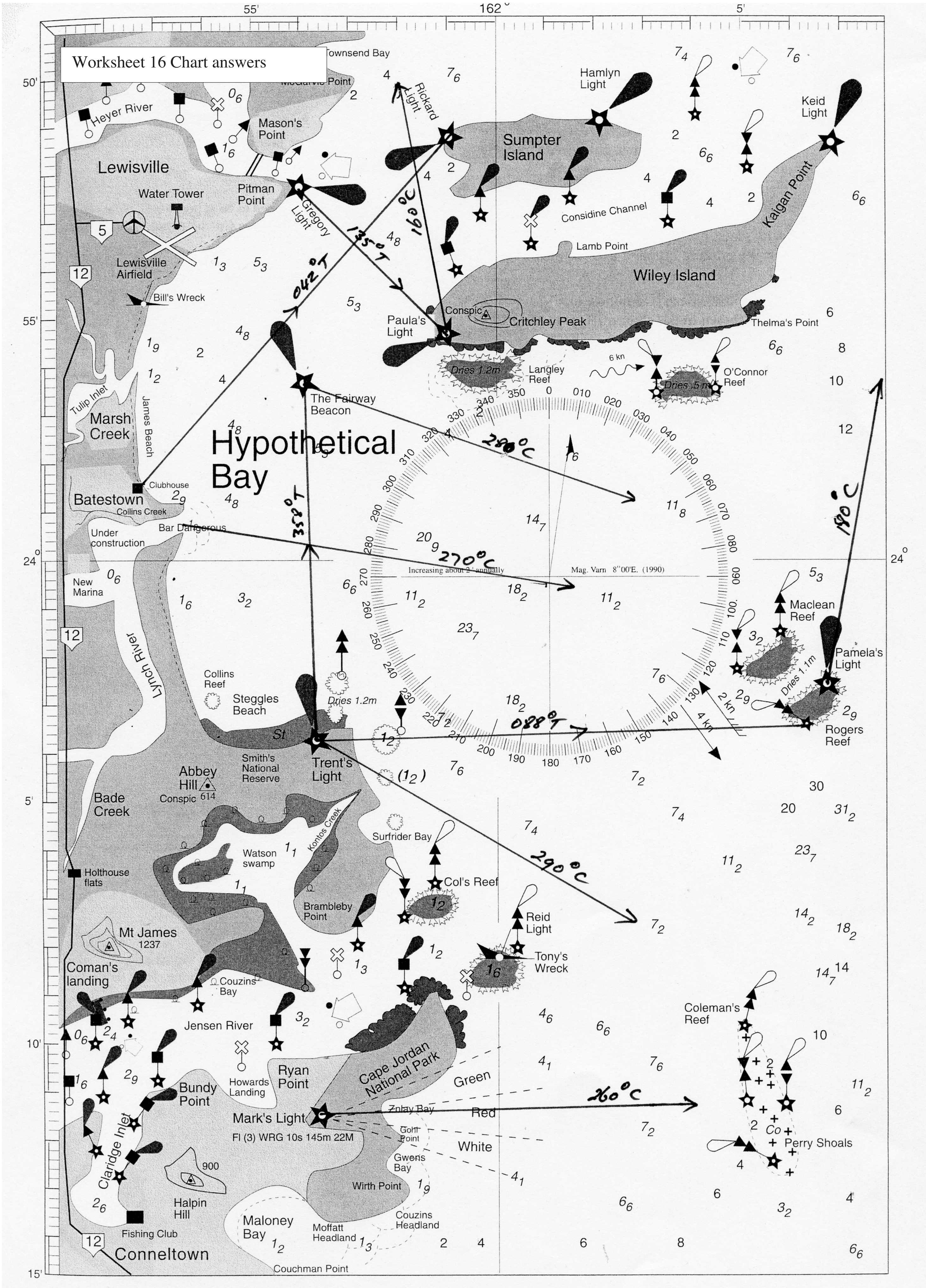
   = 8°00'E + (2' x 18)

   = 8°00'E + 36'

   = 8°36'E ~ 9°E to nearest degree.

	True	Variation	Compass
a) Fairway Beacon to Gregory Light	358°	9°E	349°
b) Gregory Light to Rickard Light	070°	9°E	061°
c) Batestown C'house to Nth tip Maclean Reef	103°	9°E	094°
d) Pamela's Light to Keid Light	001°	9°E	352°
e) Keid Light to Hamlyn Light	275°	9°E	266°

Worksheet 16 Chart answers



Worksheet 17 Chartwork

1. a) Hempel Rock — Lat: 20° 44.4' S, Long: 149° 13.8' E

   b) Coppersmith Rock Lighthouse — Lat: 20° 36.0' S, Long: 149° 07' E

   c) Hill 670 Cockermouth Island — Lat: 20° 46.3' S, Long: 149° 24.0' E

2. See chart opposite

   a) Variation is 10° E to the nearest whole degree.

   b) T.C.=334°   C.C. = 324°

   c) 4.2 miles

   d) 42 minutes

   e) See answer chart (10 fathoms line)

   f) Allonby Island   TB = 283°

      Brampton Island Hill   TB = 141°

      Tinsmith Is Hill   TB = 350°

   g) Finger and Thumb Rock.

   h) Steered the wrong course, steel interference, current and tide

3. a) See chart opposite

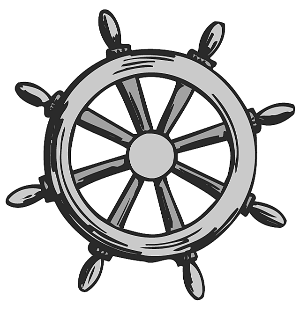
   b) 20° 38.6’ S, 149° 15.2’ E

   c) 1.4 miles

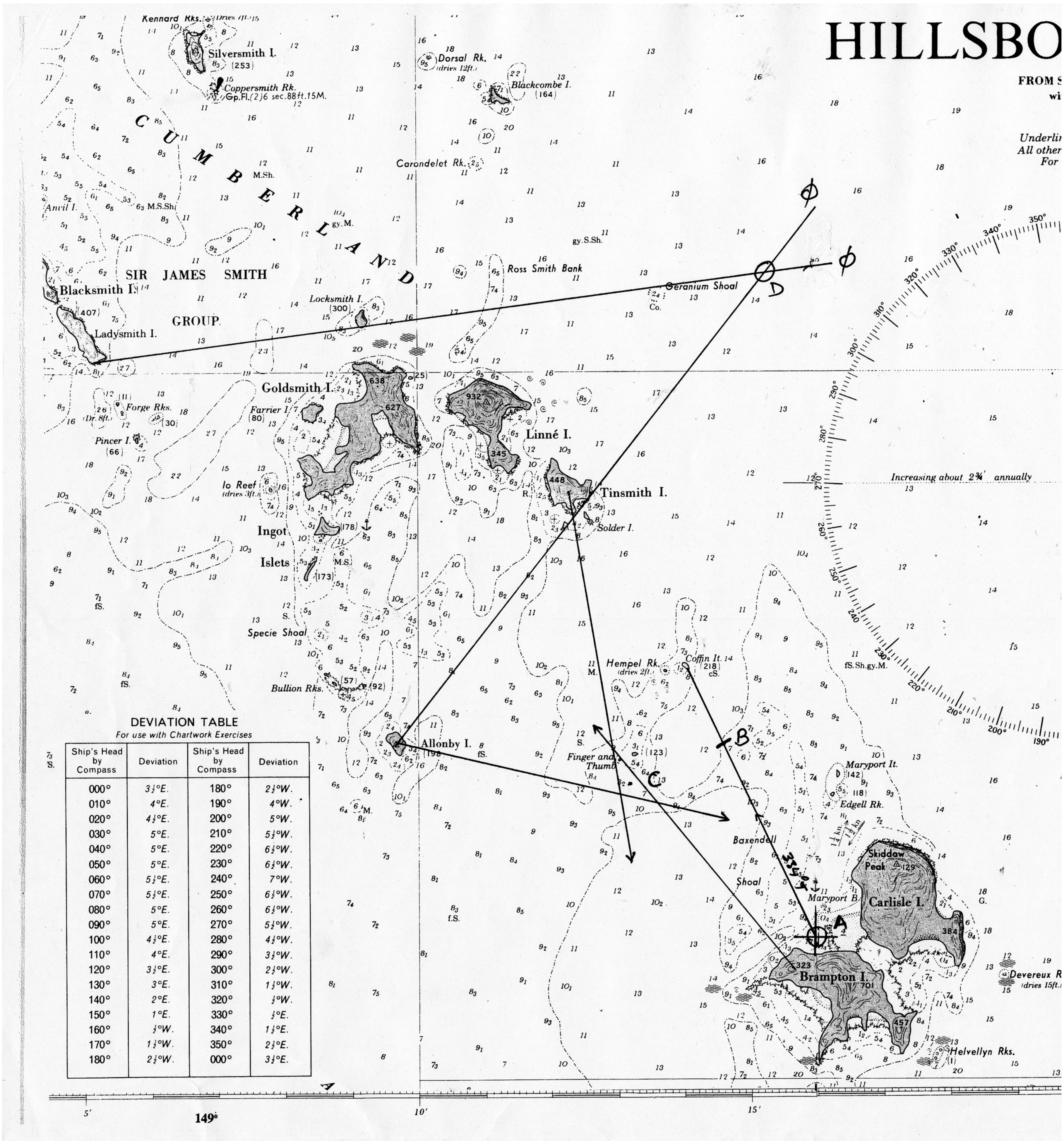
   d) TC = 261° CC = 251°

   e) 14 minutes

   f) 7.9m (2 fathoms and 4 feet = 4.9m. Add 3m tide)



Worksheet 17 Chart answers



DEVIATION TABLE

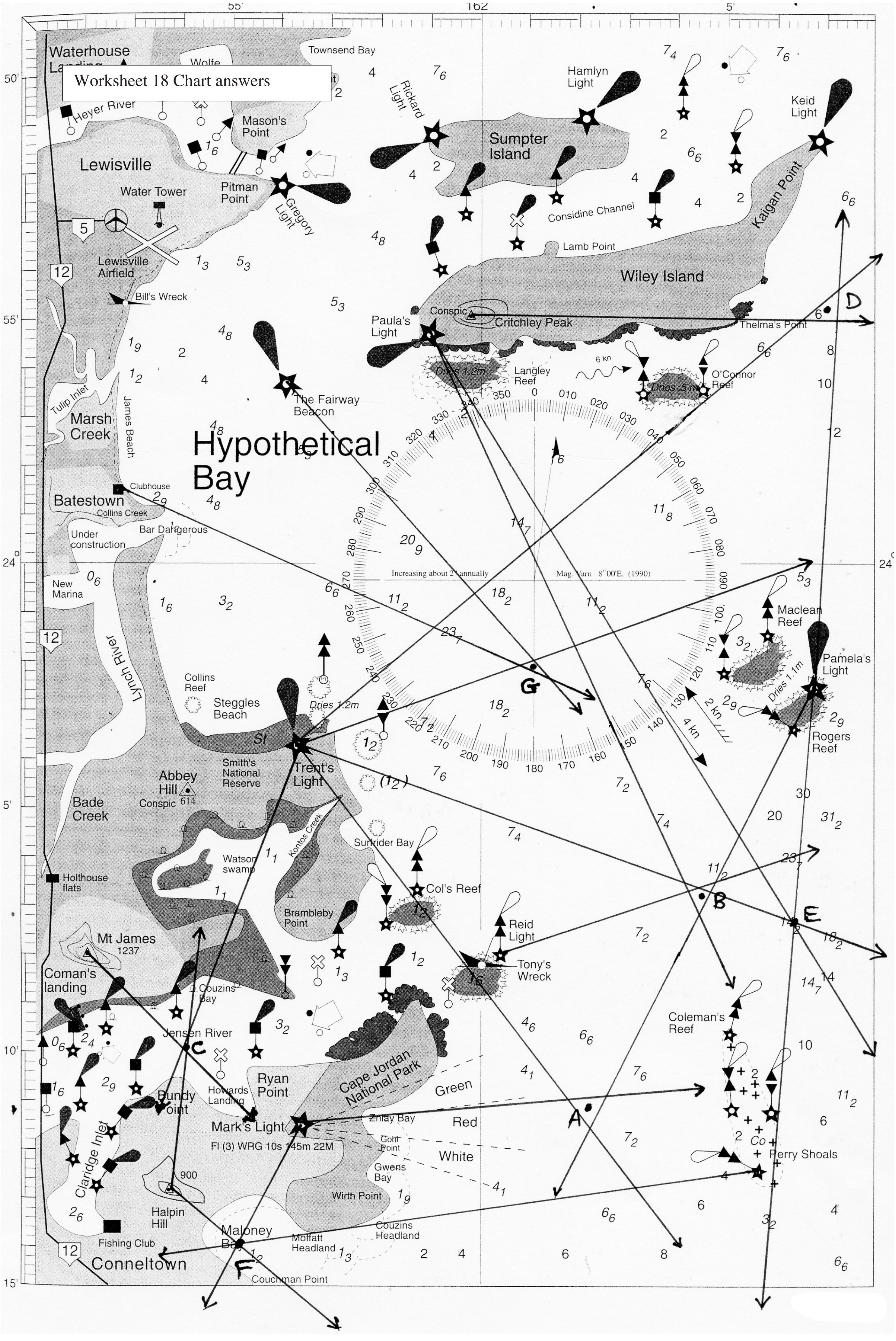
For use with Chartwork Exercises

Ship's Head by Compass	Deviation	Ship's Head by Compass	Deviation
000°	3½°E.	180°	2½°W.
010°	4°E.	190°	4°W.
020°	4½°E.	200°	5°W.
030°	5°E.	210°	5½°W.
040°	5°E.	220°	6½°W.
050°	5°E.	230°	6½°W.
060°	5½°E.	240°	7°W.
070°	5½°E.	250°	6½°W.
080°	5°E.	260°	6½°W.
090°	5°E.	270°	5½°W.
100°	4½°E.	280°	4½°W.
110°	4°E.	290°	3½°W.
120°	3½°E.	300°	2½°W.
130°	3°E.	310°	1½°W.
140°	2°E.	320°	½°W.
150°	1°E.	330°	½°E.
160°	½°W.	340°	1½°E.
170°	1½°W.	350°	2½°E.
180°	2½°W.	000°	3½°E.

Worksheet 18 Position fixing

Suggested answers using Variation = 8° E

1. 24°11'S, 162°02'E
2. 24°07'S, 162°04.5'E
3. 24°10'S, 161°54'E
4. 23°55'S, 162°07'E
5. 24°07'S, 162°06'E
6. 24°14'S, 161°55'E
7. 24°02'S, 162°01'E


Worksheet 18 Chart answers
Waterhouse Landing
Townsend Bay
Heyer River
Mason's Point
Rickard Light
Hamlyn Light
Sumpter Island
Keid Light
Lewisville
Water Tower
Pitman Point
Gregory Light
Considine Channel
Lamb Point
Kaigan Point
Lewisville Airfield
Bill's Wreck
Wiley Island
Conspic
Critchley Peak
Paula's Light
Thelma's Point
D
Langley Reef
Dries 1.2m
6 kn
O'Connor Reef
Dries .5 m
Tulip Inlet
Marsh Creek
James Beach
The Fairway Beacon
Hypothetical Bay
Batestown
Clubhouse
Collins Creek
Under construction
Bar Dangerous
Increasing about 2' annually
Mag. Varn 8°00'E. (1990)
New Marina
Lynch River
Maclean Reef
Pamela's Light
Dries 1.1m
Rogers Reef
Collins Reef
Steggles Beach
G
Dries 1.2m
2 kn
4 kn
St
Smith's National Reserve
Trent's Light
Abbey Hill
Conspic 614
Bade Creek
Surfrider Bay
Kontos Creek
Watson swamp
Holthouse flats
Col's Reef
Brambleby Point
B
E
Reid Light
Tony's Wreck
Mt James 1237
Coman's landing
Couzins Bay
Coleman's Reef
Jensen River
C
Cape Jordan National Park
Green
Red
White
Bundy Point
Howards Landing
Ryan Point
Mark's Light
Fl (3) WRG 10s 145m 22M
Finlay Bay
Goff Point
Gwens Bay
Wirth Point
A
Perry Shoals
Co
Claridge Inlet
900
Halpin Hill
Fishing Club
Maloney Bay
Moffatt Headland
Couzins Headland
Conneltown
Couchman Point
F

Worksheet 19 Laying off and plotting

Correction

See the correction on the page opposite

Answers

1. a) A – B is 1.2Nm,
   B – C is 5.2Nm, and
   C – D is 1.6Nm

   b) B – Critchley's Peak is 001^{o}T, and B – Paula's Light is 343^{o}T

   c) C – Critchley's Peak is 288^{o}C, and C – Keid Light is 011^{o}C

   d) A – B is 090^{o}C, ETA is approx. 0945 hours

   e) B – C is 076^{o}C

   f) C – D is 011^{o}C

2. a) ETA at Roger's Reef is approx. 0935 (0800 + 0135)

   b) On Chart but not really possible to navigate Lynch River (not<4m)

   c) 287^{o}C

   d) 1215 (0935 + 0240)

   e) Total distance travelled during day is 35Nm (19Nm + 16 Nm)

Worksheet 20 Set and drift

Suggested answers using Variation = 9^{o}E

1 a) CC = 261^{o} TC = 270^{o}
   Allonby bears 334.5^{o} C = 343.5^{o}T Skiddaw bears 069.5^{o}C = 078.5^{o}T
   Position at 0703 is 20^{o} 48.4'S, 149^{o} 10.6' E

   b) 0703-0615 = 48 minutes.
   Speed is 5 knots,
   so
   D = 5knots x 48/60 = 4Nm
   Set = 224^{o}T and Drift = 1.5Nm

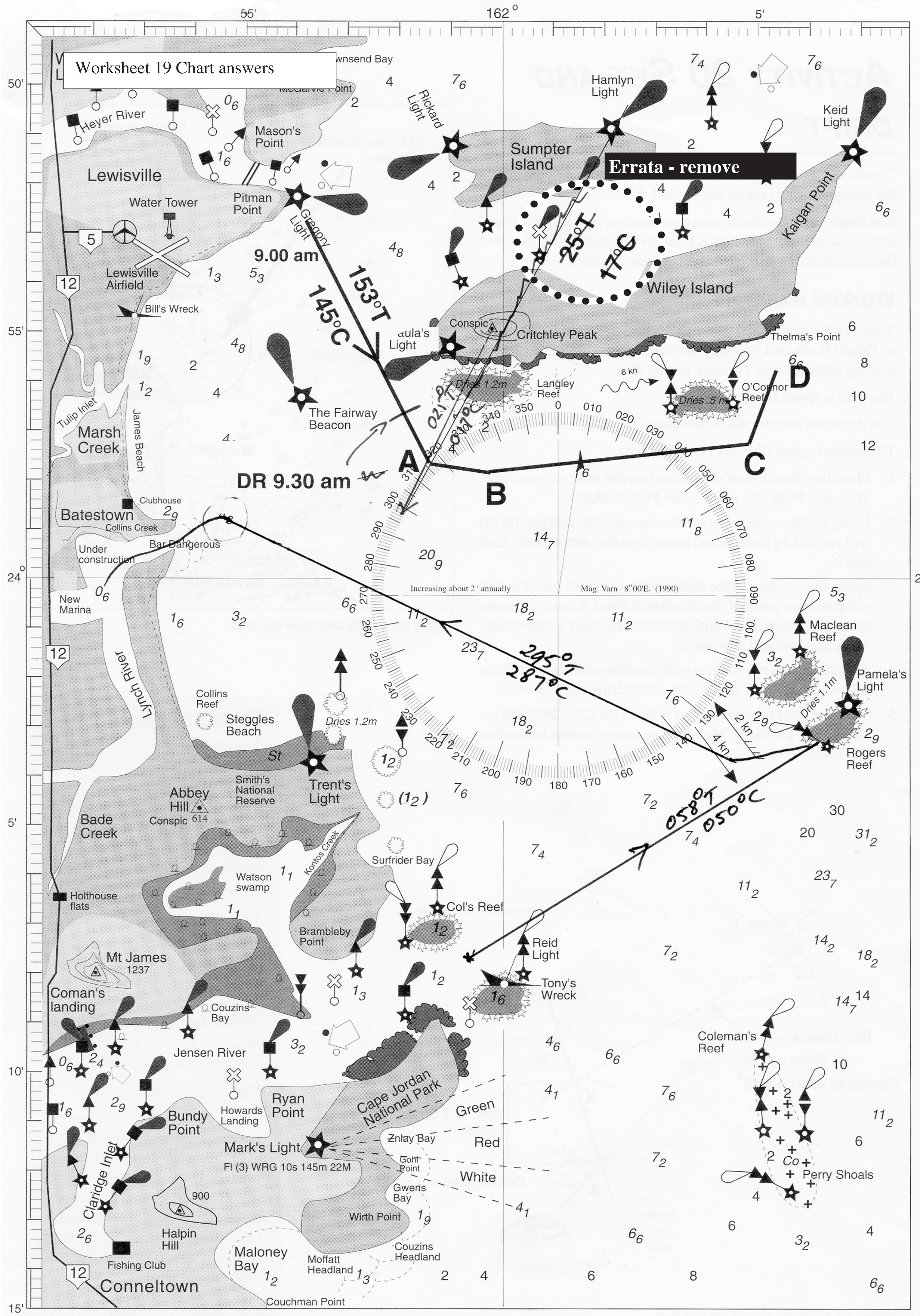
2 True course is 324^{o}, bearings are 193^{o}T, 269^{o}T and 143^{o}T.

   a) Fixed position after 1 hour is 20^{o} 41.4'S, 149^{o} 19.7'E

   b) Set = 203^{o}T Drift = 1.4Nm

3. True course to steer is 116^{o}T, so compass course to steer is 107^{o}C

   D = 5.8Nm, so T = 5.8 / 4 knots = 1.45 hr = 1 hr 27 minutes.



Worksheet 19 Chart answers
Errata - remove
55'
162°
5'
50'
55'
24°
5'
10'
15'
Townsend Bay
McGarvie Point
Heyer River
Mason's Point
Lewisville
Pitman Point
Water Tower
Gregory Light
Rickard Light
Sumpter Island
Hamlyn Light
Keid Light
Kaigan Point
Wiley Island
Conspic
Critchley Peak
Paula's Light
Thelma's Point
Langley Reef
Dries 1.2m
O'Connor Reef
Dries .5 m
6 kn
The Fairway Beacon
Lewisville Airfield
Bill's Wreck
Tulip Inlet
Marsh Creek
James Beach
Batestown
Clubhouse
Collins Creek
Bar Dangerous
Under construction
New Marina
9.00 am
153°T
145°C
25°T
17°C
021°T
013°C
DR 9.30 am
A
B
C
D
Increasing about 2' annually
Mag. Varn 8°00'E. (1990)
295°T
287°C
2 kn
4 kn
058°T
050°C
Maclean Reef
Pamela's Light
Dries 1.1m
Rogers Reef
Lynch River
Collins Reef
Steggles Beach
Dries 1.2m
Trent's Light
Smith's National Reserve
Abbey Hill
Conspic 614
Bade Creek
Surfrider Bay
Kontos Creek
Watson swamp
Brambleby Point
Col's Reef
Reid Light
Tony's Wreck
Holthouse flats
Mt James 1237
Coman's landing
Couzins Bay
Jensen River
Coleman's Reef
Perry Shoals
Bundy Point
Howards Landing
Ryan Point
Cape Jordan National Park
Mark's Light
Fl (3) WRG 10s 145m 22M
Green
Red
White
Znlay Bay
Goff Point
Gwens Bay
Claridge Inlet
Halpin Hill
900
Wirth Point
Fishing Club
Conneltown
Maloney Bay
Moffatt Headland
Couzins Headland
Couchman Point

Worksheet 21 Choosing an objective

1. Variation- use 10°E

   a) On chart, direct course 332°T

   b) On chart, direct course 028°T

   c) On chart, indirect course to avoid rocks, shoals 096°T, 075°T

   d) On chart, direct course 359°T

   e) On chart, 170°T assuming ebb tide of 1.25 knots occurs over the whole course, (unlikely)

2 Course is 300°C which is 310°T

Hill 448 CB = 260° TB = 270° at 0700 hrs

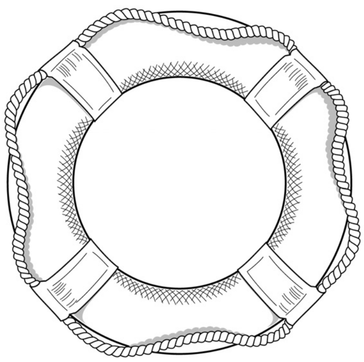
Hill 448 CB = 205° TB = 215° at 0800 hrs

Distance run between fixes is 5Nm. Position at 0800 hrs is 20°38.4'S, 149° 14.6'E

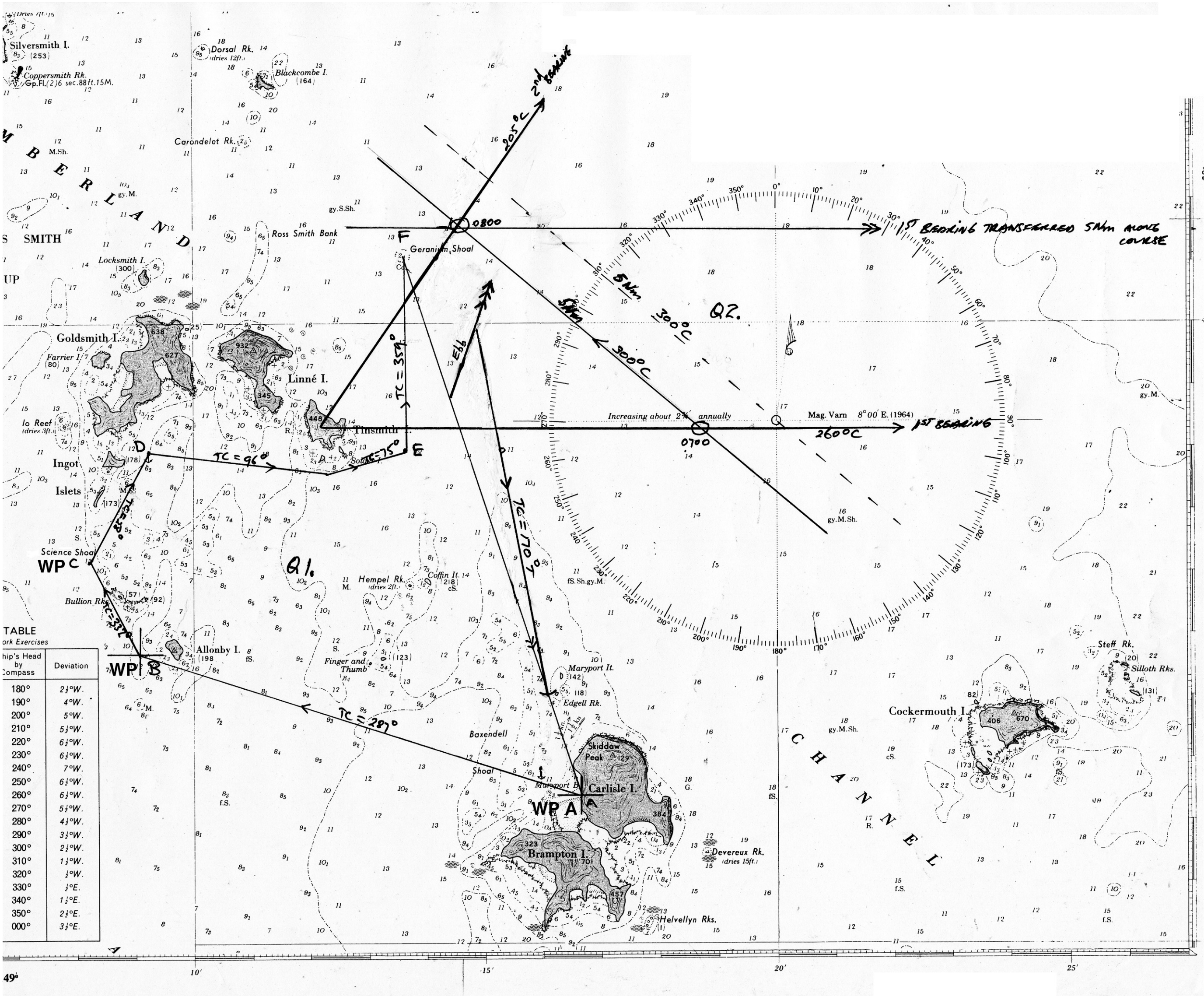
3. Height of light is 88 feet or 26.8m.

Distance from lighthouse is h/tan1° = 26.8 x 57.3 = 1536m or 1.536km.

4. Solution not possible as Mansall Island is not on chart!



Worksheet 21 Chart answers



Worksheet 22 Where are we?

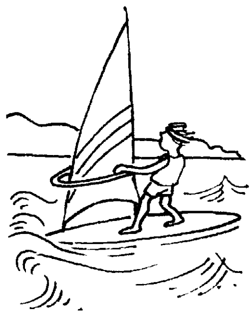
Obtain deviation using Deviation Table in bottom left of Hillsborough Channel Chart

		Compass	Deviation	Magnetic	Variation	True
1.	Hill, Allonby Is.	292°C	2.5°W	289.5°M	10°E	299.5°T
	Finger Is.	027°C	2.5°W	024.5°M	10°E	034.5°T
	323 Brampton Is.	128°C	2.5°W	125.5°M	10°E	135.5°T
2.	Maryport It	065°C	5.5°E	070.5°M	10°E	080.5°T
	Coffin It	342°C	5.5°E	347.5°M	10°E	357.5°T
	10 fathoms deep					

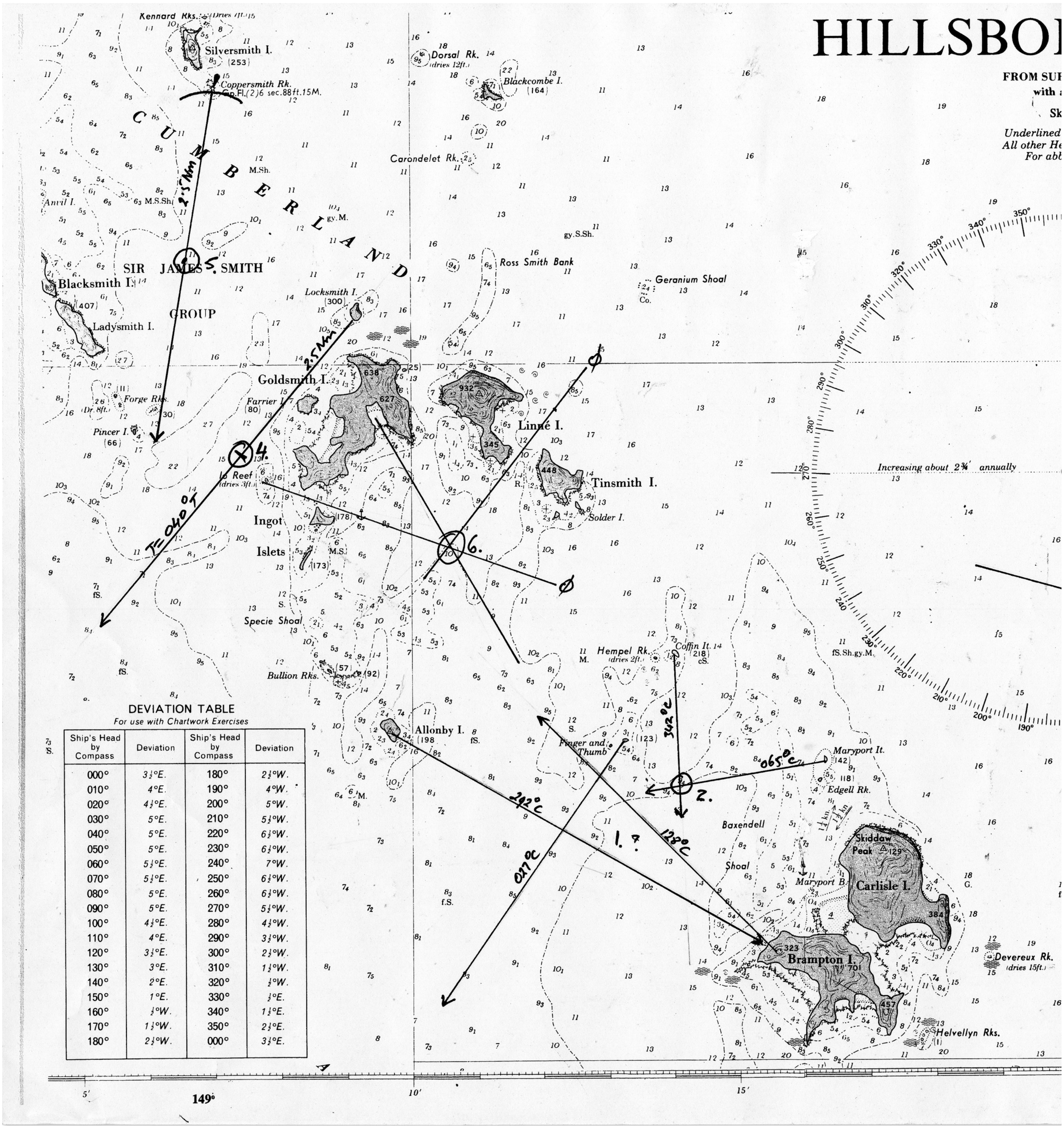
Quicker to use Total Error. 1. TE = 7.5°E 2. TE= 15.5°E

Errata - change Allonby bearing to 275°C

1. Doesn't work, cocked hat too large to estimate within 0.1'
   Suggest change Allonby bearing to 275°C
2. 20°46.1'S, 149°14.2'E.
   Seabed is composed of fine sand.
3. D = S / T
   = 4 / 1
   = 4 Nm
   a. DR after an hour is 20°43.3'S, 149°19.9'E
   b. Position A is at 20°44.3'S, 149°24.1'E
   c. Tinsmith Is. is still 7.1 Nm away on a bearing of 282°T
4. Course is 300°C.
   TE = 7.5°E.
   TC =307.5°T
   Position is 20°41.3'S, 149°7.4'E
5. Course is 130°C. TE = 13°E.
   TC = 143°T
   Depth is approximately 11 fathoms.
   Coppersmith light bears 356°C = 009°T
6. Course is 350°C. TE = 12.5°E. TC = 002.5°T.
   Coordinates must be approximately 20°42.5'S, 149°10.6'E



Worksheet 22 Chart answers



DEVIATION TABLE

For use with Chartwork Exercises

Ship's Head by Compass	Deviation	Ship's Head by Compass	Deviation
000°	3½°E.	180°	2½°W.
010°	4°E.	190°	4°W.
020°	4½°E.	200°	5°W.
030°	5°E.	210°	5½°W.
040°	5°E.	220°	6½°W.
050°	5°E.	230°	6½°W.
060°	5½°E.	240°	7°W.
070°	5½°E.	250°	6½°W.
080°	5°E.	260°	6½°W.
090°	5°E.	270°	5½°W.
100°	4½°E.	280°	4½°W.
110°	4°E.	290°	3½°W.
120°	3½°E.	300°	2½°W.
130°	3°E.	310°	1½°W.
140°	2°E.	320°	½°W.
150°	1°E.	330°	½°E.
160°	½°W.	340°	1½°E.
170°	1½°W.	350°	2½°E.
180°	2½°W.	000°	3½°E.

Transit and Deviation Exercises

Errata - See note below

Variation (2002) = 8°E + (2.75' x 38)

= 8° + 104.5'

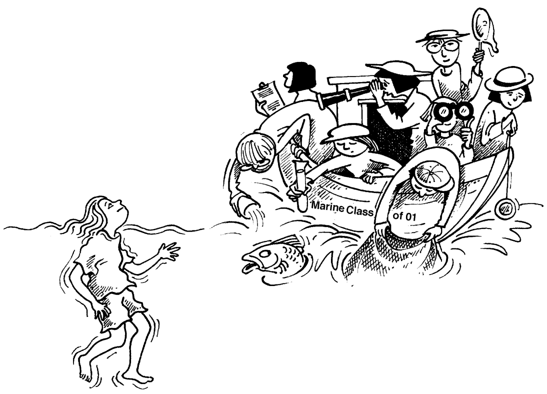
= 8° + 1°44.5'

= 9°44.5’ ~ 10°E

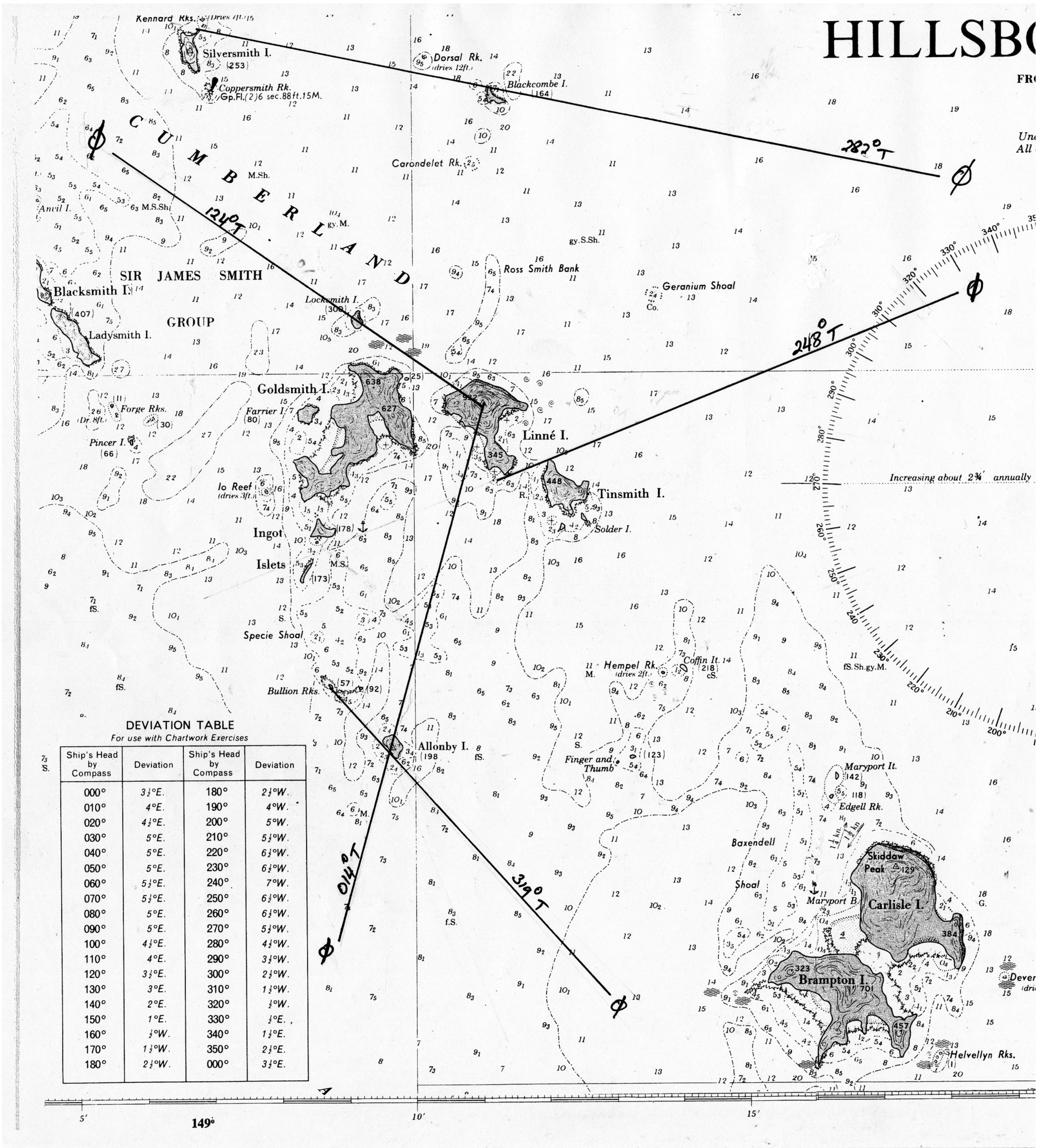
	Compass	Deviation	Magnetic	Variation	True
1.	010°C	6°W	004°M	10°E	014°T
2.	000°C	4°E	004°M	10°E	014°T
3.	308°C	1°E Card 4°E	309°M	10°E	319°T
4.	241°C	3°W	238°M	10°E	248°T
5.	118°C	4°W	114°M	10°E	124°T
6.	285°C 271.5°C	13°W Card 0.5°E	272°M	10°E	282°T

Note:

- In Question 6, ships head of 330.5°C should result in a Deviation of 0.5°E (from card) whereas transit bearing of 265°C results in D=13°W. Suggest change question to read 271.5°C.



Worksheet 22 Chart answers



DEVIATION TABLE

For use with Chartwork Exercises

Ship's Head by Compass	Deviation	Ship's Head by Compass	Deviation
000°	3½°E.	180°	2½°W.
010°	4°E.	190°	4°W.
020°	4½°E.	200°	5°W.
030°	5°E.	210°	5½°W.
040°	5°E.	220°	6½°W.
050°	5°E.	230°	6½°W.
060°	5½°E.	240°	7°W.
070°	5½°E.	250°	6½°W.
080°	5°E.	260°	6½°W.
090°	5°E.	270°	5½°W.
100°	4½°E.	280°	4½°W.
110°	4°E.	290°	3½°W.
120°	3½°E.	300°	2½°W.
130°	3°E.	310°	1½°W.
140°	2°E.	320°	½°W.
150°	1°E.	330°	½°E.
160°	½°W.	340°	1½°E.
170°	1½°W.	350°	2½°E.
180°	2½°W.	000°	3½°E.

Worksheet 23 Rule of twelfths

Errata - See note below

1. Tidal Range (TR) at Gladstone = 4m

   Assume there is 6 hours between high and low tide, therefore

   At 1pm, High Tide (HT) height = Low Tide (LT) + TR

   = 2m + 4m

   = 6m

   Tide height at 3pm

   = HT – 1/12 of TR – 2/12 of TR

   = 6m – (1/12 x 4m) – (2/12 x 4m)

   = 6m – 0.333m – 0.666m

   = 5m

OR 6m - (1/12 + 2/12) x 4m

= 6m - 3/12 x 4m

= 6m – 1m

= 5m

2. At 9am, depth

   = 6m HT 0800 4m

   Tide at 1200

   = HT – (1/12 x TR) – (2/12 x TR) – (3/12 x TR) – (3/12 x TR)

   = 4 –

Note:

CANNOT SOLVE WITHOUT KNOWING Tidal Range or L.A.T

SUGGESTION – STATE L.A.T AS 2.25m, therefore at HT depth should be 6.25m. In one hour tide has retreated 0.25m or 1/12 of TR.

TR = 0.25 x 12 = 3m

2/12 x TR = 0.5m and 3/12 x TR = 0.75m

Tide height at 1200

= HT – (1/12 x TR) – (2/12 x TR) – (3/12 x TR) – (3/12 x TR)

= 4m – 0.25m – 0.5m – 0.75m – 0.75m

= 1.75m

Depth at 1200

= Tide + LAT

= 1.75m + 2.25m

= 4m

Worksheet 23 Rule of twelfths - page 62 (Continued)

3. Since tidal movement is a problem, cross when this is minimal around each low and high tide. Do not cross the bar halfway between each high and low tide when it is moving the fastest. Depending on the conditions a greater depth of water may be required so high tide would be better than low tide. Best time is 1411 hours.

4. Assume there is 6 hours between low and high tide.

   Required depth

   = Draft + Safety Clearance

   = 2.4m + 0.5m

   = 2.9m

   HT 0800 3m

   Depth at HT

   = LAT + Tide height

   = 1.5m + 3m

   = 4.5m

   There is plenty of room to pass through the channel at HT at 0800

Errata - See note below

Note:

SUGGESTION – GIVE ADDITIONAL INFO - LT 1400 0.5m

TR

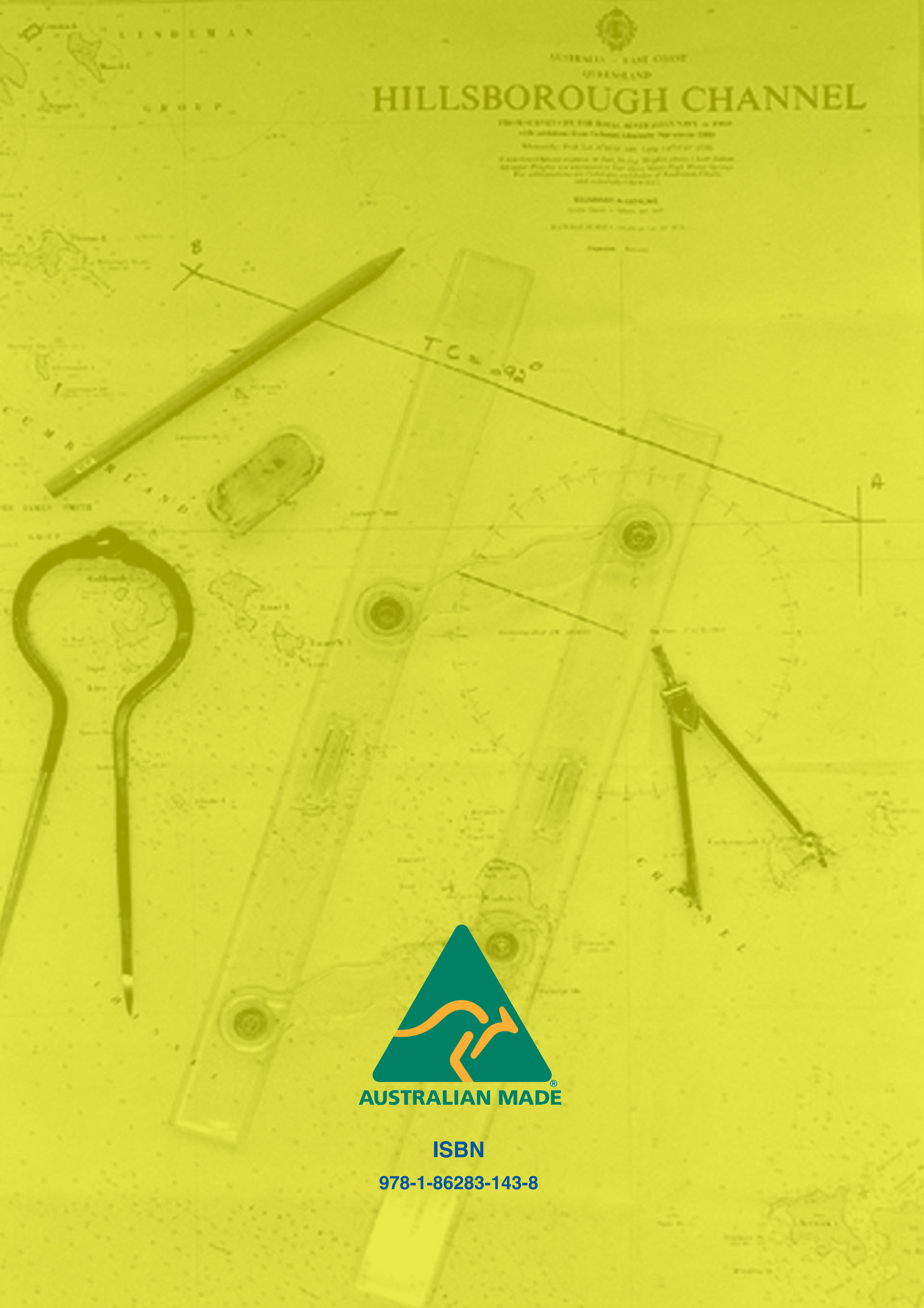
= HT – LT

= 3 – 0.5

= 2.5m

TIME	Depth (m) (LAT + tide)	
0800	4.5	- 1/12, 0.21
0900	4.29	- 2/12, 0.42
1000	3.87	- 3/12, 0.625
1100	3.245	- 3/12, 0.625
1200	2.62	- 2/12, 0.42
1300	2.2	- 1/12, 0.21
1400	2.0	LT+1/12

Must pass through channel earlier than 1130.



AUSTRALIAN MADE

ISBN

978-1-86283-143-8