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Charts Compasses and Navigation Instruments

Charts

CHART MAKES

Lay your charts out on a flat surface.

Both of these charts are practice charts, <u>they must never be used for navigation!</u> As you can see they are copies of real Admiralty charts, but they have been considerably altered to make them more useful for training.

Admiralty charts are probably the most commonly used charts in Britain. There are other makes, which are made specifically for yachtsmen. They are normally perfectly adequate because they are based on the same surveys as the Admiralty charts; the manufacturers have usually just left off unnecessary detail. Especially, in an area with which the yachtsman is familiar this is not a disadvantage.

One of the manufacturers is **Stamfords**, who produce a range of charts that cover the popular yachting areas of Britain and the Continent.

Advantages of Stamfords charts are that they are waterproof, tear resistant and many incorporate several harbour plans on one chart. This alone can save a considerable amount of money.

One advantage of Admiralty charts is that they are available world wide, which means that wherever you sail, you will not have to become familiar with other types of chart.

The choice of chart type is up to the individual, at the end of the day, once you are familiar with charts is makes little difference.

Most countries issue their own charts; many are very similar, with the same symbols being used. Most countries also share survey information, so they should all include the same features.

CHART CATALOGUES

Charts can be ordered from Admiralty chart agents. All agents have a catalogue, which lists every chart and publication. By looking through this you can identify those you will need for a particular passage.

The Admiralty also issue a leaflet. NW Europe Catalogue, one of which is included in your information. These include charts for the waters around the British Isles.

Look at your copy.

The blue boxes are the areas covered by each chart, with the number of the chart printed in the bottom left and top right corner. This number is how you normally identify a chart. In addition to this number charts also have a title which identifies the general area of coverage.

The two training charts are just numbered RYA Training Charts 1 and 2.

Another place you will find details of the charts you may need is on other charts. On Chart 2 look at the entrance of the Rive Dart, there is a magenta box with the number 2253 in the corners. This is the number of the chart that covers that area. Another source of this information is Nautical Almanacs such as Macmillan's. At the top right on page 31 in your practice navigation tables you will find the numbers of the charts for Dartmouth, AC is for Admiralty Charts, Imrays and Stamfords are Yachtsmen's charts and OS is the Ordinance Survey map for the land area.

CHART INFORMATION

Look at Chart 2. Under the title there is some important information. Which is explained below.

DEPTH IN METRES
These are metric charts. Most are now, but you will still find some Imperial ones in use. Imperial charts have depths in fathoms and feet (a fathom is 6 feet, about 2 metres). These charts are easily identified, as they are in black and white, not coloured like the metric ones.

SCALE 1:75 000 at lat 50°30'.
Chart scales vary dependent upon the use they will be put to. A vessel should carry a selection of charts, which cover a variety of scales. This should ensure there are large-scale charts for entering harbour and pilotage, medium scale charts for navigating on and small-scale charts, which cover large geographical area for planning passages.

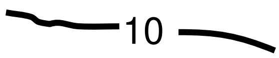
Depths are in metres and reduced to Chart Datum.

Chart Datum is the level below which the tide never falls, allowing for the movements of the Sun, Earth and Moon.

On the chart, all the blue and white coloured areas are permanently water. The numbers written in these parts are the minimum depths to be found at that point, in metres and decimetres. Normally there will be a greater depth of water as it is unusual for the tide to fall that low.

These numbers or **CHARTED DEPTHS** are not the only depth indication. There are also contour lines on the seabed. These join places of equal depth below chart datum.

Contour line, depth 10, below chart datum.



Charted depth, 10.6m below chart datum. 10_6

HEIGHTS are in metres. Underlined heights are drying heights above Chart Datum; all other heights are above Mean High Water Springs.

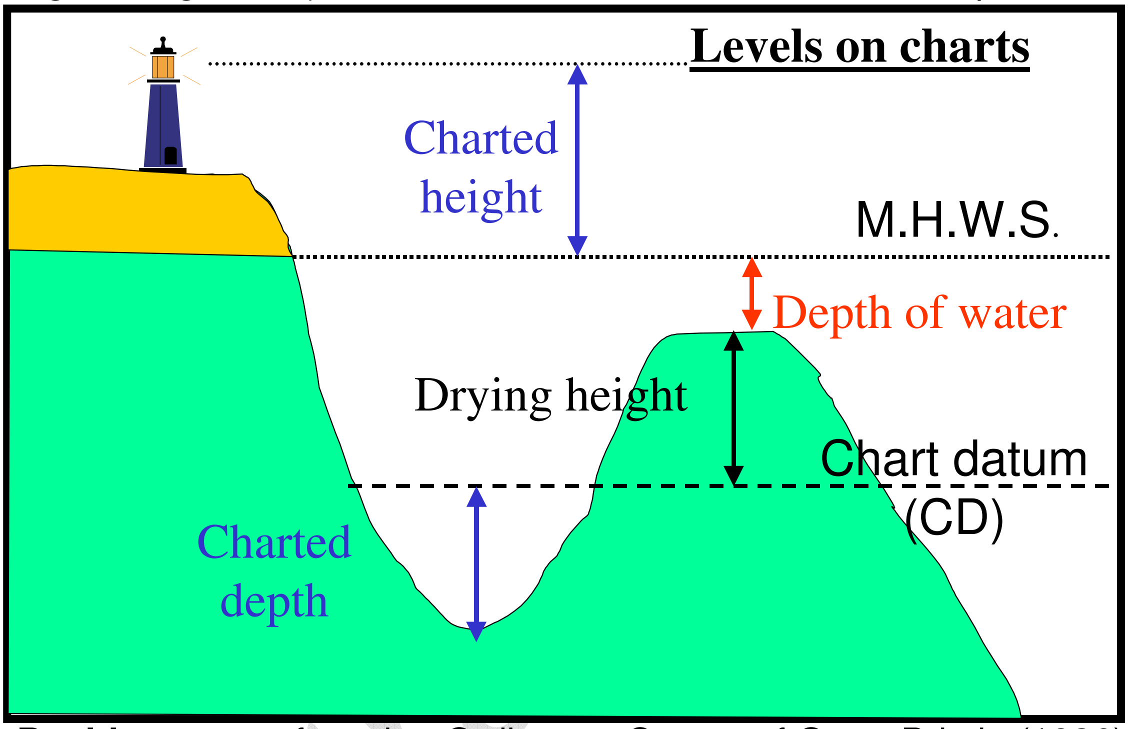
The green areas of the chart are sometimes covered and sometimes not. In these places there are numbers which are **DRYING HEIGHTS.**

Drying height 2.5m above Chart Datum. $\underline{2}_5$

If the tide falls to 0m the water level would be on the border between the green and blue areas.

The buff or yellow areas are above Mean High Water Springs and are nearly always uncovered. They may only cover if there is an above average high tide. For practical purposes we can say that these areas are always land.

Heights of land feature are called **CHARTED HEIGHTS.** They are measured above Mean High Water Springs (the average of the highest high tides) because this is the level which land maps use.



Positions are referred to Ordinance Survey of Great Britain (1936) Datum (OS 36).

When the curves of the Earth's surface are converted to a flat sheet, mapmakers have a model of the shape of the world, which affects the way the chart appears. Different organisations use different models for the shape of the Earth.

In the past this was not important, as the differences were very small compared to the level of accuracy of navigation. However, Global Position System (GPS) navigators give a position to 3 decimal places, around Britain this is a theoretical accuracy of about 2 metres. This is obviously ridiculously accurate as the charts were not surveyed to this level of accuracy, and in practice the system should probably only be relied on for an accuracy of 100 metres.

Because GPS uses a datum called WGS 84 (World Geodetic System 1984) for a model of the world, where is a built in error when converting GPS positions to positions on a chart using OS 36 datum.

Further down on the chart, there is a special warning about the use of satellite derived positions on this chart. As you can see it is a very small error in this part of the world. However, you should always check to see which datum has been used, and what the error is, because in some places the error may be significant.

To be strictly accurate, GPS positions should be corrected by the amounts given. To avoid this you may find in the set up menu of your GPS receiver that you can change the datum to match that of the chart you are using.

If you look on Chart 1, the Datum used is European Datum 1950, which is different again; there are many datums in use.

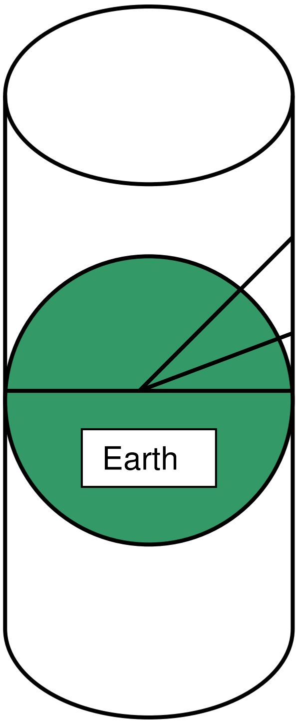
Many new charts are being printed which use WGS 84 as their datum, this means they will match positions given on your GPS navigator, so in future this will be less of a problem. There are thousands of charts to change, so this will take some time!

Navigation marks: IALA Maritime Buoyage System - Region A (Red to port).

This tells you the buoyage system in use in the area covered by the chart. There are two systems, A and B, system B buoyage mainly being used in America. We will look at this in more detail later in the course.

Projection: Mercator.

Mercator projection is the method by which the curved surface of the Earth has been drawn on a flat sheet of paper. There are other projections, which you will come across, in most cases they will have little effect on the way you use the chart.



Mercator Projection

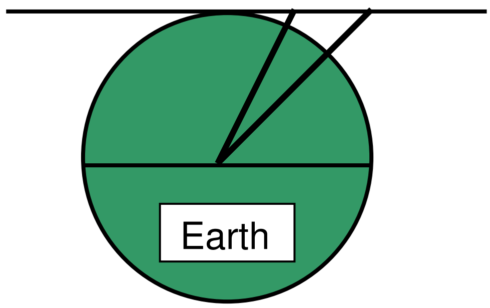
If you imagine a cylindrical screen around the Earth. Then project a line from the Earth's centre, through its surface on to the screen. So that the features on the surface are projected on to the screen.

This will give you an idea of how Mercator Projection works.

The major consequence of this projection is that the further north you travel, the divisions for latitude on the chart will become longer.

One factor with Mercator projection charts is the change in scale as you travel north up the chart. To demonstrate this, measure the distance between the 5' and 10' marks on the bottom right hand side of Chart 1. Now go to the top right hand side of the chart and compare this distance with the 5' between 20' and 25'.

There should be a slight difference. That is the effect of Mercator projection. We use the latitude scale (the one on the sides of the chart) to measure distance, because 1' of latitude is the same as 1 nautical mile **at that latitude**. As a result, when you measure the distance between two points on the chart, you should always go to the side of the chart at the same latitude to measure the distance.

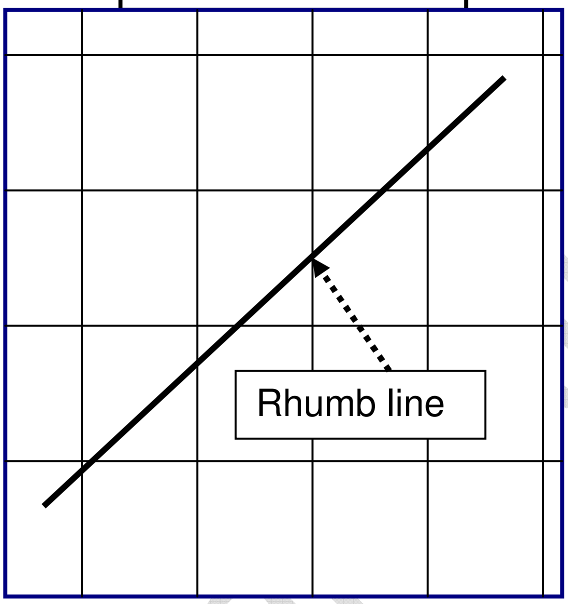


Gnomonic Projection

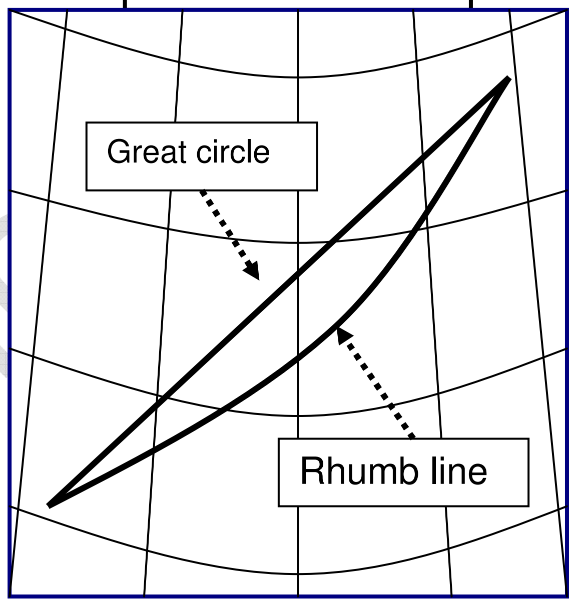
In Gnomonic Projection, the screen is placed tangential to the Earth's surface, and the features projected on to it.

Gnomonic Projection is used in Polar Regions, where Mercator Projection would not work.

Mercator



Gnomonic



On Mercator projection charts, lines of latitude are parallel, as are meridians of longitude.

Rhumb line course of 040° crosses each meridian (line of longitude) at the same angle.

A rhumb line course is used in all coastal navigation. If a passage is over 600 miles, it may be shorter to sail a great circle course. In practice, this in not always practical because wind, currents and weather systems all influence the best choice of route.

On Gnomonic projection charts, meridians converge and lines of latitude are curved.

Great circle routes, are straight lines, rhumb lines are curved.

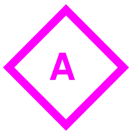
A great circle, is the longest circle that can be drawn around the Earth. A segment of it gives the shortest distance between two points on the Earth's surface.

Over long distances ships can save fuel by following the shorter great circle routes.

There is other information on the chart that we need to learn about at this stage.

TIDAL DIAMONDS

Spread around a chart are magenta coloured diamonds, each with a different identifying letter in the middle.



The letter used has no significance, they are labeled in alphabetical order.

On Training Chart 2, below the title information there is a table which allows us to calculate the direction and speed of the tidal stream at each of these **Tidal Diamonds**.

See the extract below:

Tidal streams referred to HW at Plymouth

Hours		Geographical Position	A 50°09'05N 4°44'95W	
		Directions of streams (degrees)	Rates at spring tides (knots)	Rates at neap tides (knots)
Before High Water	6	286	1.6	0.8
	5	290	2.8	1.4
	4	302	3.2	1.6
	3	318	2.9	1.5
	2	323	1.7	0.9
	1	000	1.0	0.5
High Water		080	1.3	0.6
After High Water	1	100	2.4	1.2
	2	111	2.5	1.3
	3	124	2.6	1.3
	4	126	1.9	1.0
	5	148	0.5	0.2
	6	283	1.1	0.5

The data in this table is referred to HW at Plymouth! So even though Plymouth does not appear on this chart we can look up the tidal stream information for this area by knowing the time of high water Plymouth.

On Practice Chart 1, you will find the same thing written above the tidal stream table. So even if you are sailing near St Malo in France, the tidal streams are calculated relative to high water at Plymouth.

We can do this because the tidal streams follow a pattern throughout the whole Channel area, and the tide in one area is directly influenced by what happens elsewhere.

To read this table:

The first column on the left is the key to the rest of the data. Information is given for six hours before and after high water Plymouth at hourly intervals.

The centre column tells us that the three figure numbers in the diamond A column are the direction of the tide in degrees true (measured from north), and the other two sets of numbers are the rates of tide at springs and neaps (we will cover this in more detail later, spring tides run at about twice the speed of neap tides).

The right hand column is the tidal stream information at the given latitude and longitude for each hour before and after high water.

We will return to tidal diamonds in detail later in the course.

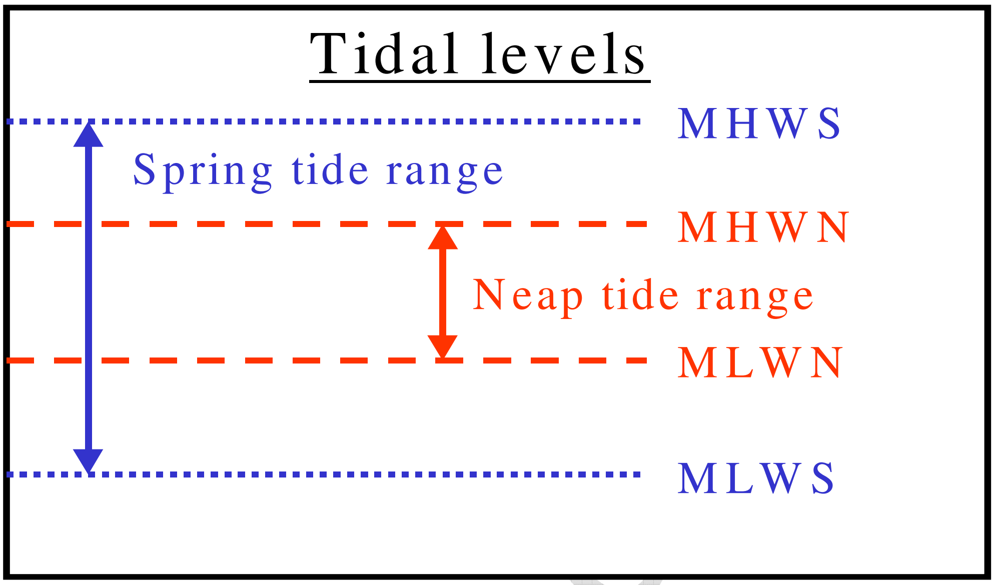
<u>Tidal levels</u>

Below the tidal diamonds table there is a table which gives the levels of the tide at certain times at important points on the chart.

MHWS **M**ean **H**igh **W**ater **S**prings
MHWN **M**ean **H**igh **W**ater **N**eaps
MLWN **M**ean **L**ow **W**ater **N**eaps
MLWS **M**ean **L**ow **W**ater **S**prings

The Mean is the average tide. It is a word used frequently in navigation.

MHWS is the average of the highest high tides,
MHWN is the average of the lower high tides,
MLWN is the average of the higher low tides,
MLWS is the average of the lowest low tides.



Warnings

Below the tidal levels table and at different places around the chart are warnings that are specific to the area covered by the chart. It is always a good idea to read these, most will not be relevant to small craft, but some definitely will.

One of the warnings concerns satellite derived positions. Positions on Global Positioning Systems (GPS) are referred to WGS 84 (World Geodetic Survey 1984) datum. This chart and many others are referred to OS36, so there is a correction to be applied to GPS positions before using them on this chart. As you can see it is so small in this case that it can be ignored for most practical use in a small craft.

On Practice Chart 1, there is a warning about the Race of Alderney, can you find it? It is certainly one you would need to read before sailing to the Channel Islands.

Source Data Diagram

In the Southeast corner of Practice Chart 1 there is a diagram, this diagram tells us the dates of the surveys used to create the chart.

Sometimes they were a surprisingly long time ago. In an area of rocks, little will have changed, but where there is sand or mud to move about, there may be considerable differences. There is not much that you can do about this, but a prudent skipper would behave cautiously in an area that was surveyed over a hundred years ago, with a lead line and sextant.

Compass Roses

You will notice that Compass Roses are positioned about the charts. On Practice Chart 1, these are in two parts. The outer ring is related to magnetic north and the inner to true north. We will look at these in more detail later, but they were essential for drawing directions on charts, before we used chart plotters which have a compass rose of their own.

Chart Symbols

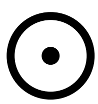
There is a standard system of chart symbols used internationally, and although there are different conventions from one country to another, it is fairly easy to read any chart once you have learnt the symbols.

The Admiralty publishes a book called Symbols and Abbreviations; this is given the number 5011, just like a chart.

It is probably impossible to know every symbol in use, but we should be striving to learn them all. Most can be grouped in to certain classes such as buildings or dangers and the general classification of the symbol is often obvious.

Inside the back cover of 5011, there is a key, which covers many of the most common symbols. If you find a symbol you do not know it is a good idea to find the most similar one from this key then turn to the appropriate section of 5011.

You will notice that many of the features used on charts are composite, which is they are made up of several pieces of information. An example is:



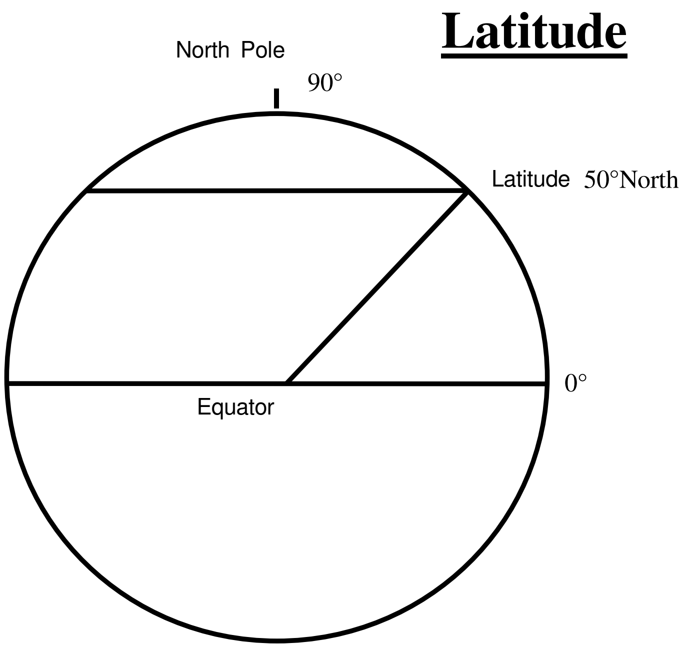
This symbol is used for many features; next to it will be a legend, which describes what it is, e.g.

Fs	Flagstaff
Bn	Beacon
Tr	Tower

It is worth having a look around the chart now. See if you can identify some of the symbols by looking them up in 5011.

Positions on charts

Positions can be given as a latitude and longitude.



Latitude is the angle at the centre of the Earth, between the Equator and where you are. It is expressed either north or south, and varies from 0° to 90°.

During this course you will only be north of the Equator, but one-day you may be sailing in the Southern Hemisphere.

On Chart 1, on the north west side of the chart you will find 50°00 north. This line, which forms part of a circle all the way around the World, joins all the points which are 50 degrees north of the Equator (° is the symbol for degrees).

Each degree is made up of 60 minutes (').

Moving north from 50°. You can see divisions for 05' and 10' north. The first of these would be written as 50° 05' N.

Each of these 05' divisions is made up of 01' divisions.

1' is made up of 60 seconds ("). We do not use seconds of latitude or longitude, as it is far too small a measure for us to draw to. Each minute is instead divided in to decimals (tenths).

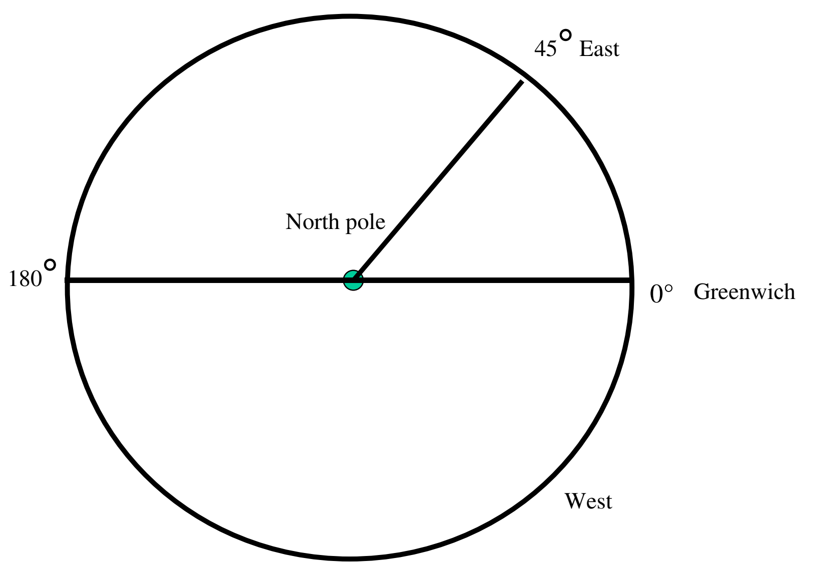
On the west side of the chart, there is a power cable (magenta wiggly line) which cuts the side of the chart. **This point is 49°50.6'N.** The next power cable south is at a latitude of **49°25.6'N**. Because of the scale of this chart, each minute is broken down in to 5 units of 0.2'.

Different charts have different scales. On Chart 2, the minutes are divided in to 0.1' units.

The point on the west side of the chart where the sea changes from white to blue (the 20-metre contour) is at a latitude of **50°12.16'N**.

On this chart we can be accurate to two decimal places.

Longitude



Longitude is the angle at centre of the Earth, between where you are and Greenwich.

It can be measured either east or west and varies from 0° to 180°.

On Chart 1, in the north east corner you will find the 5°00'W point. Travelling west the chart changes from green to blue at 5°12.0'W, then back to green at 5°12.3'W.

On Chart 2, there is not a whole number of degrees of longitude, so the **meridian** (line of longitude) nearest the centre of the chart has the whole longitude written out, 4°35.0'W. Notice that east of this point the next figure is for 4°30.0'W-not 3°30.0'W!

This often occurs, if you are not sure of the whole number of degrees on a chart; look at the Southwest or Northeast corner. In very small figures you will find the latitude and longitude of that point, just inside the border.

The latitude and longitude scales are completely different. With your dividers, try measuring 5' of latitude on Chart 2, then comparing this to 5' of longitude on the same chart. The latitude is much greater; in fact, the only place where the scales are equal is on the equator.

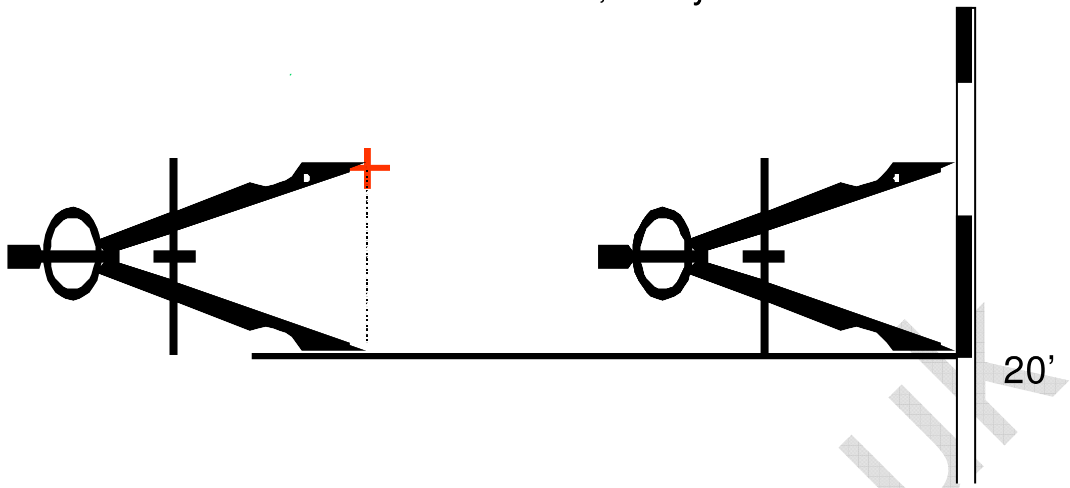
Navigation dividers are designed to be used one handed (you may need the other to hold on to your chart table!), and to be opened with the points crossed.

Because of the means of projecting the chart on to a flat sheet, used for Mercator projection, the latitude scale gradually increases the further north you travel. If you measure 5' of latitude on Chart 1 at the lowest point, then compare this to 5' of latitude at the top of the chart, you will see that there is a small difference.

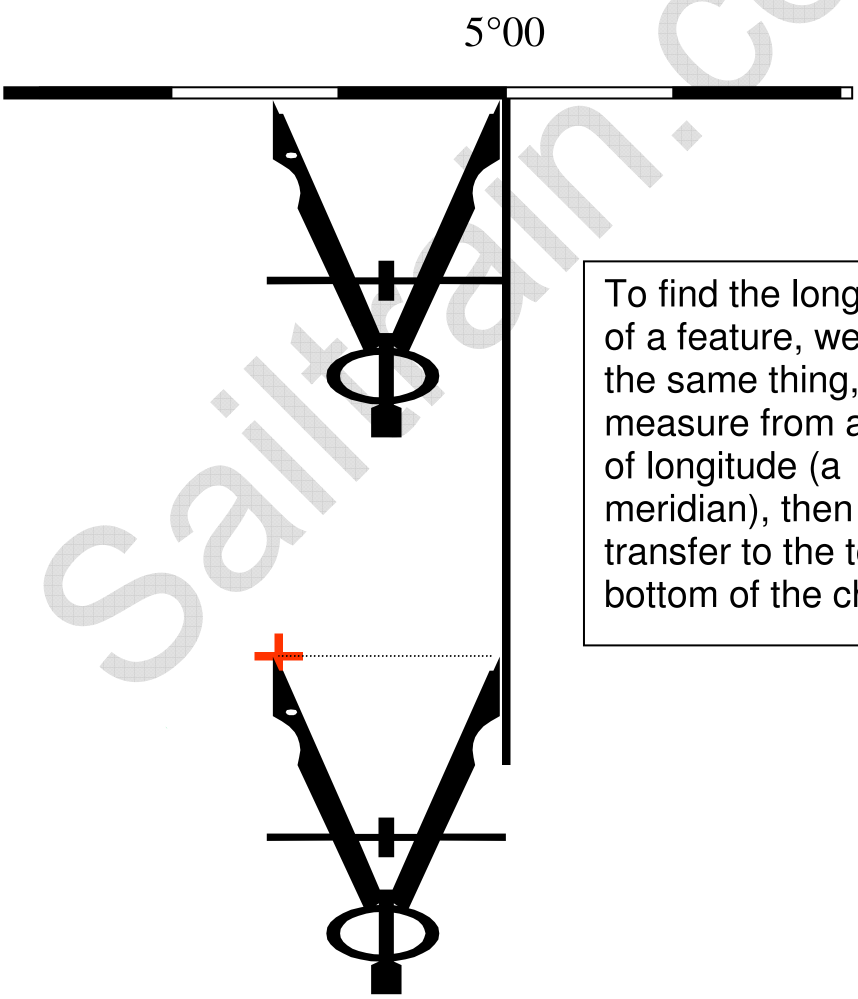
On this size of chart this is not important, but if you are travelling over 600 miles, the latitude scale will change noticeably and we need to take note of that when we measure distances on longer voyages.

Measuring Latitude and Longitude

To measure the latitude of a feature, use your dividers to measure



the distance between the point, and the nearest line of latitude (horizontal line on the chart), then transfer this distance to the side of the chart, measuring from the same line of latitude.



To find the longitude of a feature, we do the same thing, but measure from a line of longitude (a meridian), then transfer to the top or bottom of the chart.

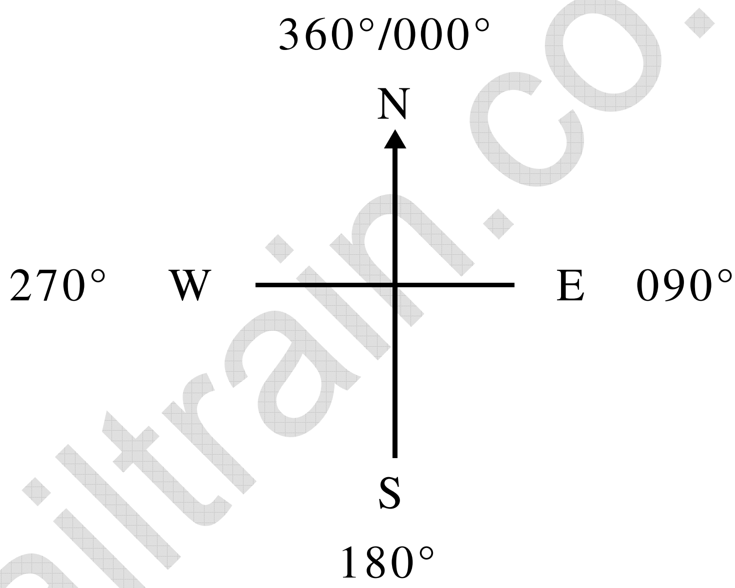
Plotting positions on charts

To plot a position on a chart we need to use the plotter as a straight edge. By drawing a line out from the side of the chart, at the correct latitude we can then use the dividers to measure off the longitude from a meridian, in the reverse of the operation to find the longitude of a point.

Bearings and Distances

A position can also be given as a bearing and a distance from a known point.

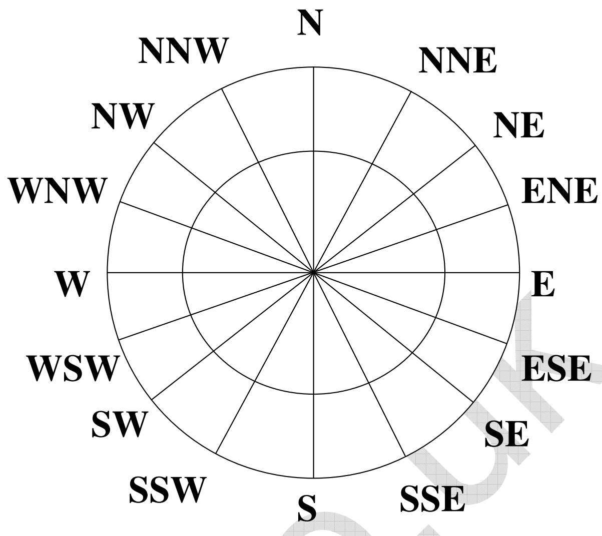
A bearing is a direction, expressed as a three-figure number. Bearings are measured clockwise from north.



Bearings are always given as three figures because if you only wrote down 35°, it could easily be mistaken for 350°. Direction can also be described by **Quadrantal Notation**; that is North, South, East and West. Old compasses were marked in this style, but it is obviously not accurate enough for our purposes.

Quadrantal bearings

Quadrantal directions can be given more accurately, most people are aware of the directions of north-east, south-east, south-west and north-west, but we can actually divide the 360 degrees of the circle down to 32 points, a point is $11_{1/4}$°. 1 point west of south is written as S/W. The Point between ESE and SE is SE/E and so on.



Measuring a bearing

On Chart 2. Draw a pencil line between the lighthouse at Start Point (50°13.30'N 04°38.50'W) and the South Walton Buoy (50°13.05'N 04°29.7'W).

Lay your plotter on the chart, so that one side is along this line. Make sure that the direction of bearing arrow is pointing towards the buoy.

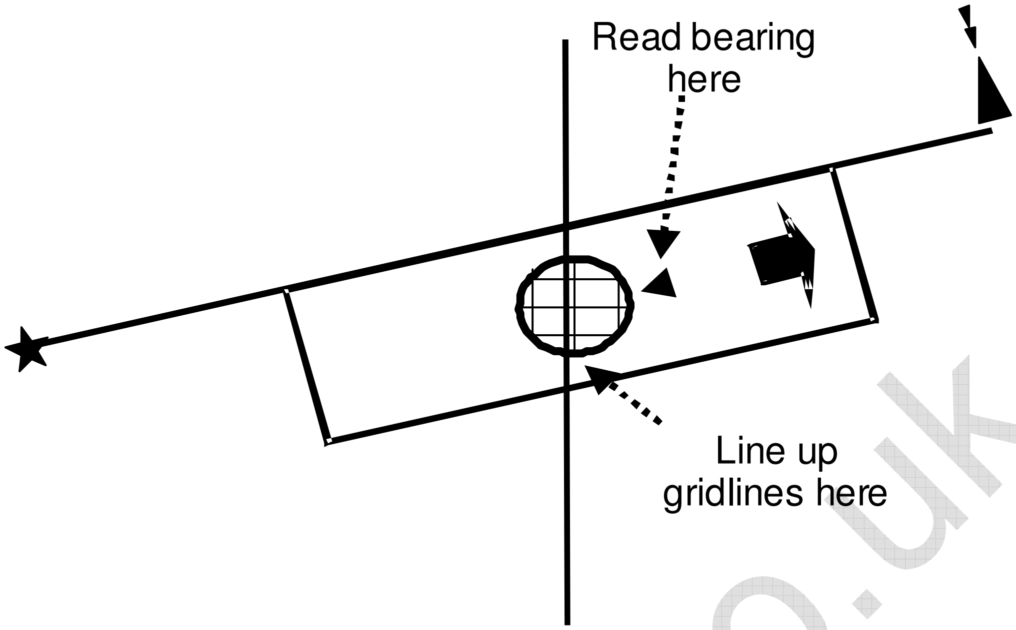
Rotate the compass, until the north mark is to the top of the chart.

Then line up one of the horizontal or vertical lines on the compass rose with a line of latitude or longitude, you may need to slide the plotter along the pencil line, until there is a suitable line under the compass rose of the plotter.

Then read off the bearing, at the marker on the body of the plotter.

The bearing should be 092°. This is a true bearing, because it has been measure relative to True North. A true bearing would be written-092°T.

Later in the course we will be using bearing other than true ones, it is important that they are correctly marked.



Now turn the plotter, so the direction arrow is pointing from the buoy, to the lighthouse, and check the bearing in that direction.

It should be 272°T.

That is the **reciprocal** bearing; of course, you could have just added 180° to the original bearing!

An easy mistake to make with the plotter is to place the compass rose 90 ° or 180° out of line, or to have the plotter itself pointing in the wrong direction. With practice you will learn to spot when you have done this, because you can compare the bearing with the approximate quadrantal bearing. E.g.;

A bearing of 210° is about Southwest, so the plotter should be pointing Southwest.

Plotting a bearing

To plot a bearing on the chart is very similar.

Find the South Walton Buoy again.

Turn the protractor until 135°T is set on the direction of bearing line.

Lay the plotter on the chart with one edge touching the buoy.

Swing the plotter round until the north mark is to the north and the grids on the compass rose line up with the grid on the chart.

Draw a line from the buoy in the direction of the arrow on the plotter.

This line should pass through the Oil Production Platform (see page 33, 5011) Devon Rover.

Distance

Distance is measured on the latitude scale, at the sides of the chart.

One minute of latitude is one nautical mile-at that latitude.

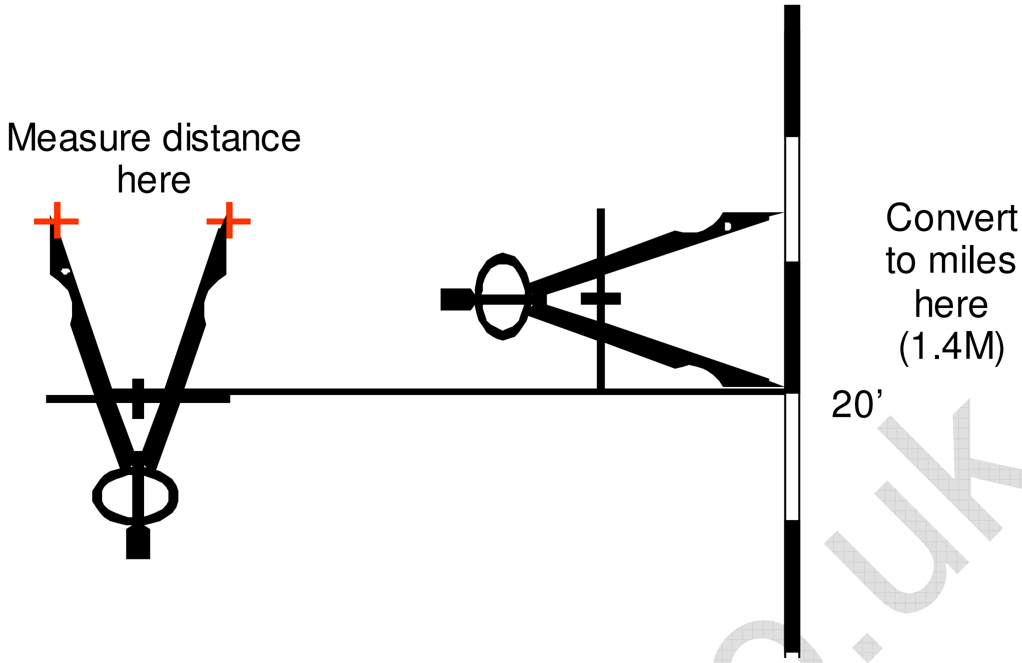
One nautical mile is 1852 metres.

One minute is one nautical mile (M) at that latitude because; the latitude scale increases the further north you travel.

In fact, the Earth is not a perfect sphere, so that the length of a nautical mile varies from place to place. By international convention it is standardised at 1852 metres.

A distance that is used in conversation is a **Cable**; a cable is 1/10 of a nautical mile. So you could say you were 3 cables from a buoy, as a means of describing your position. As a rough approximation a cable is about 200 metres (m).

Distances are measured with the dividers, and then transferred to the latitude scale to be converted into miles.



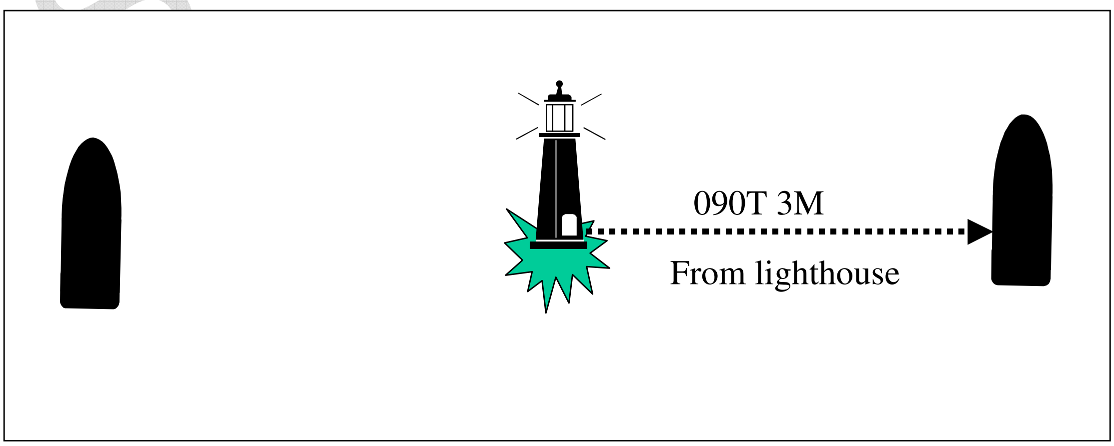
Measure the distance from the South Walton Buoy to The Devon Rover.

It should be 3.9M.

Writing a capital M after the distance signifies nautical miles. A lower case m is used to signify metres.

Describing a position

In a situation where we need to give our position, such as if we were in distress. We can describe our position either as a Latitude and Longitude or as a bearing and distance from a known point.



In the latter case, the standard convention is for the bearing to be **from** the know point. This avoids the ambiguous situation that may occur if the point has water on all sides.

Speed

Speed is expressed as **Knots**. 1 knot is 1 nautical mile per hour. A speed of 5 miles/hour would be called 5 knots. Not 5 knots/hour.

Chart corrections

Features shown on charts change, either because they are man made, or due to natural changes. Therefore, it is essential that our charts are **corrected**, or updated regularly.

The Hydrographic Office issue **Notices to Mariners (NTMs)** each week which cover all the changes, in all their publications world-wide. As there are thousands of charts and books on this list, it can be a bit cumbersome for a small boat skipper. In addition, they publish **Notices to Mariners** weekly on their website www.ukho.gov.uk. Obviously the latter are easier for most yachtsmen to use.

Another source is yachting magazines. They publish the more important changes and focus on those relevant to small craft.

Harbour authorities also publish details of changes for which they are responsible. Some have websites; most have a notice board where you can find copies.

To correct a chart, look up the number of the chart in the index at the front of the NTM, by the chart number there will be a list of all the corrections that relate to that chart. Each correction is given a number to identify it.

You then need to look up the correction to discover the details.

If a feature needs deleting, you just draw two fine lines through it and any associated writing. If a feature has been added, you will need to draw in the symbol as neatly as possible.

Special correcting pens are available, often in a pack with a stencil to help you draw in the symbols. At least you will need a very fine, waterproof pen.

After making the correction, you then need to write the number of the correction in the bottom left corner of the chart. This has been done on Chart 1.

This is so that anyone looking at this chart can tell if it is up to date. The last line of a chart correction gives the number of the previous correction on that chart, if this is not the last number that is written in the bottom left corner, a correction has been missed.

A chart, which is not up to date, is dangerous, as there may be new hazards, or more commonly, navigation aids may have been changed. This can make navigation especially difficult at night. **Always correct your charts!**

In pencil, correct Chart 1.

9821. CHANNEL ISLANDS-GUERNSEY-BUOYAGE AMENDED

Delete ODAS buoy Fl (5) Y5s 49°28.4'N 05°48.8'W

Last correction to chart: 1998/9752.

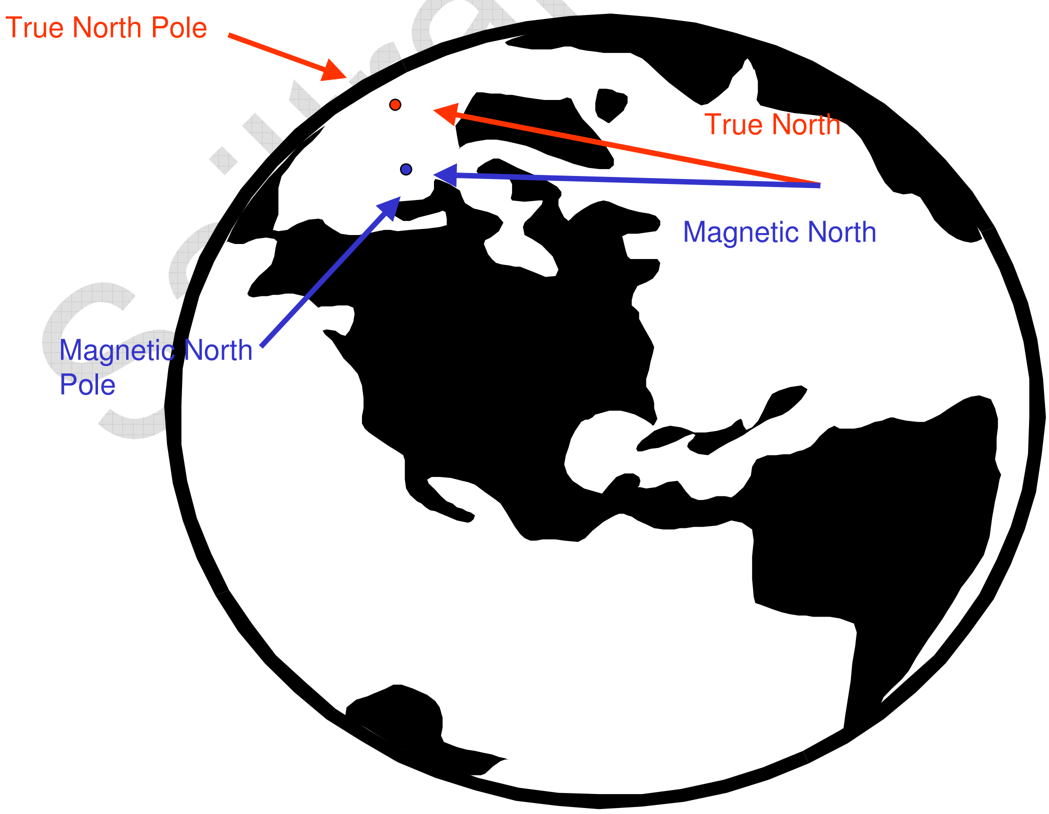
Compasses

A compass will point north, but unfortunately for mariners there are several things which affect where the compass indicates north to be.

Variation

Variation will nearly always be a factor in navigation. It is caused by the difference in position of the True North Pole and the Magnetic North Pole. The True North Pole is where charts are lined up on; all the lines of longitude run up to the True North Pole. The Magnetic North Pole is where our compasses point; it is near to Canada.

The effect of this is that in most parts of the World there is Variation. However, variation changes with position around the World. In some places, like the eastern Mediterranean Sea, where the two poles appear to be in line, variation is minimal. From the central North Atlantic, variations can be as much as 20° west. Whereas, in the Pacific Ocean, variation becomes easterly.



Local variation is indicated on the compass roses. Look at Chart1, in the north-east corner, the variation is 7° 15'W. In the north-west corner it is 7° 30'W.

So even over this small distance, there is a difference.

In addition, to variation changing with position, it also changes over time. This is caused because the position of the Magnetic North Pole moves in a small circle around the True North Pole over hundreds of years.

This annual change is indicated by the figure in brackets. On Chart 1, it is 6'E. This means that the variation is decreasing by 6' each year.

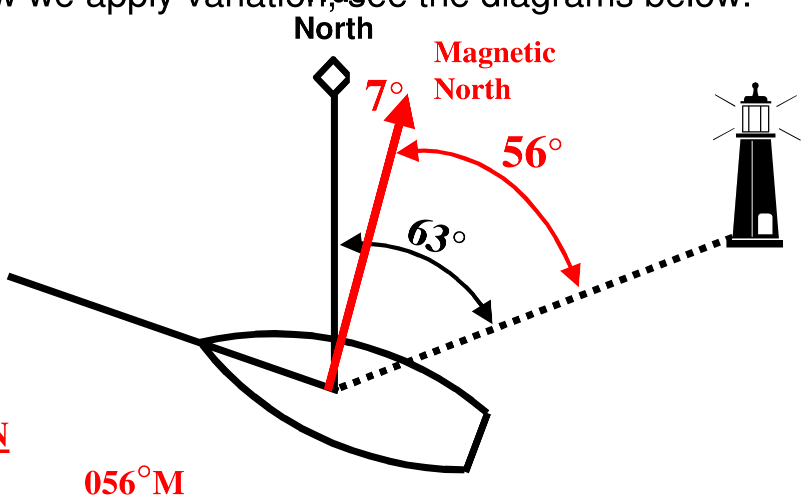
To find the variation for any given year we need the variation from the compass rose and the year for which it was correct, then add or subtract the annual change.

Variation 7° 15'W in 1997
Change -24'E (4 years at 6'/year)
Variation **6° 51'W** in 2001

This would be rounded up or down to the nearest whole degree for practical use. So the variation in 2001 is 7°W.

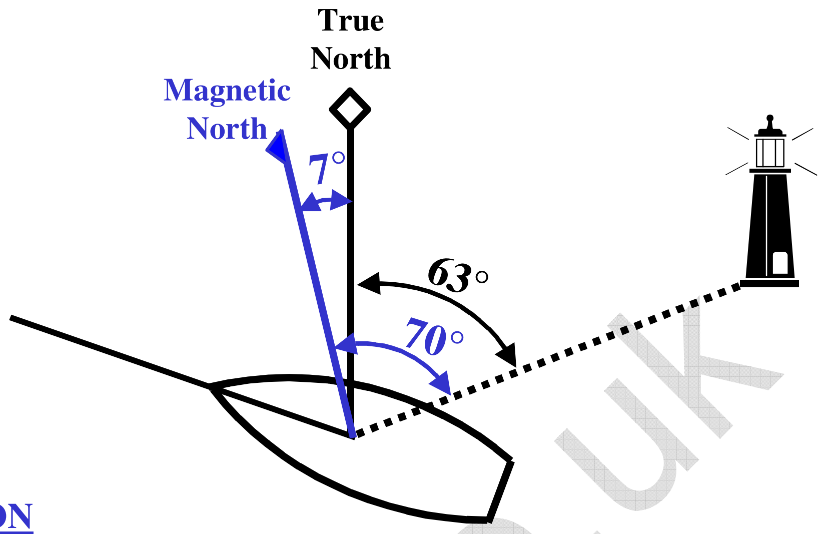
For all the chartwork you will be doing in this course the variation will be 7°W.

To understand how we apply variation, see the diagrams below.



EAST VARIATION

Magnetic Bearing	**056°M**
Variation	**7°E**
True Bearing	**063°T**



WEST VARIATION

Magnetic Bearing	**070°M**
Variation	**7°W**
True Bearing	**063°T**

You can see that sometimes you add the variation and sometimes you subtract it.

There are may rules and mnemonics to help you to do this, at first it seems difficult but when you have been doing this for a while you will be able to do it without a problem.

Many people use the word:

CADET

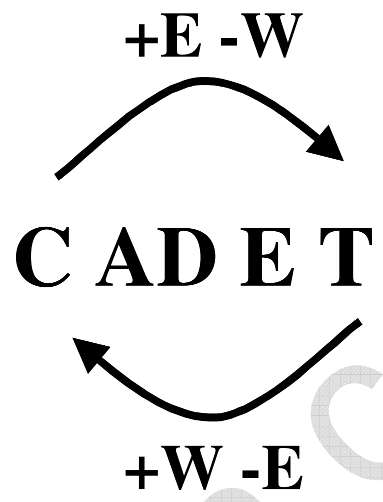
Compass bearings are magnetic, which is where the C of CADET comes from.

When changing from Magnetic to
True-ADD East.

C AD E T

From this one idea we can deduce all the other situations. If we are changing a bearing from Magnetic to true, when there is a west variation, we subtract.

For changes from True to Magnetic the situations are reversed. See the full diagram below.



It is vital that you also note if a bearing is True - T, or Magnetic - M.

Deviation

The effect of variation is the same for all boats in the same area at the same time. Deviation is specific to the boat and the course it is sailing on.

Deviation is caused by iron, magnets and magnetic fields (from electronic equipment), all of which influence the Earth's magnetic field around the boat.

This means that you should avoid placing any of the above items near where you will be using a compass. For the ship's main compass, this is easy enough, but consider the positioning of any loudspeakers for sound systems-will you be using a handbearing compass near any of them?

Another compass to consider is the electronic fluxgate compass for the autopilot. They are often hidden out of sight in lockers below. It is very easy to then put cans of food near them, and cause a deviation; the effects can be very interesting if the cans roll about in rough weather!

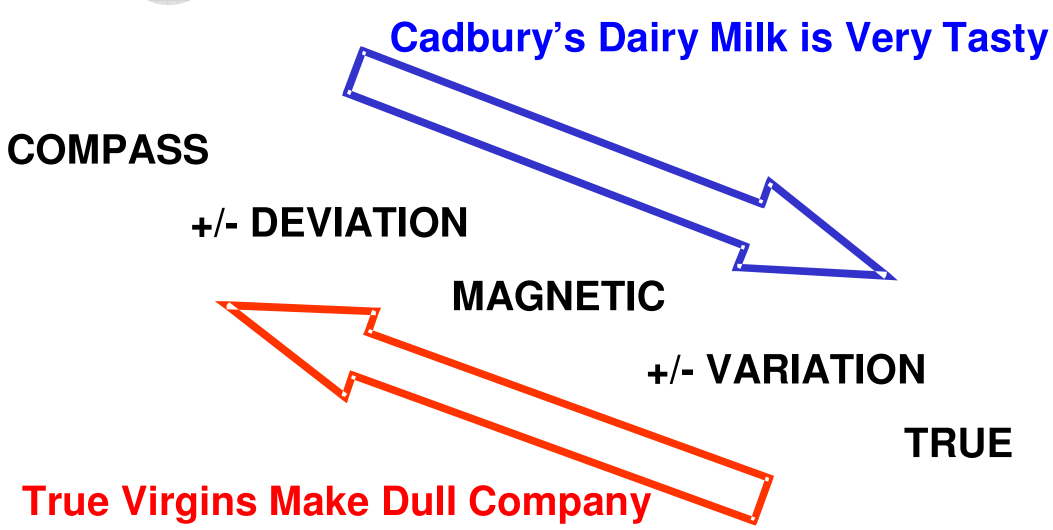
Most modern wood or fibreglass boats can reduce deviation to a very small amount, which can be ignored for practical purposes, provided that a suitable place has been found for the compass. If you have a steel or Ferro-cement boat, you will probably have a considerable deviation. This means that you should always have your boat corrected by a **Compass Adjuster**. Compass Adjusters measure the deviation and by altering the positions of the magnets built in to a compass can reduce the errors to manageable figures.

After your compass has been **swung** (checked for deviation) and adjusted, a deviation card will be created. An example is given inside the back cover of your Practice Navigation Tables (PNT).

From this you can see that the deviation varies with the boat's heading, so for each course we steer, there will be a different deviation to apply. On a course of 000°C, the deviation was 4°W. On a course of 135°C, the deviation was 6°E.

Deviation is applied in the same manner as variation, but there is a correct sequence to follow.

If you start with a compass course of 270°C (one with variation and deviation), you must find the deviation first, 4°W. Then using **CADET;** we subtract the deviation to get a magnetic course of 166°M. Using **CADET** again; we subtract the 7°W variation, to result in a true course of 159°T, which we can plot on the chart. So the sequence can be illustrated as follows:



From the diagram above, if you start with a true bearing of 154°T, and apply 7°W variation the magnetic bearing is 161°M, we then enter the deviation table in PNT to find that the deviation is 5°E, and the compass bearing is 156°C.

It is a good idea to check by running the calculation backwards, from a compass bearing to the true, hopefully you will get the number you started with! Occasionally you will find that once you have applied the deviation, that it may be more accurate to choose the next figure for deviation from the table. This occurs because the table is set up for use with compass bearings, but we may be entering it with a magnetic bearing, an example is:

293°T
7°W variation
300°M deviation 5°W is nearest
305°C

Re-entering the table with the compass course of 305°C, the deviation is found to be 6°W.

One degree is probably not going to matter in most of what we do on small craft, but it is useful to realise the limitation of this type of table.

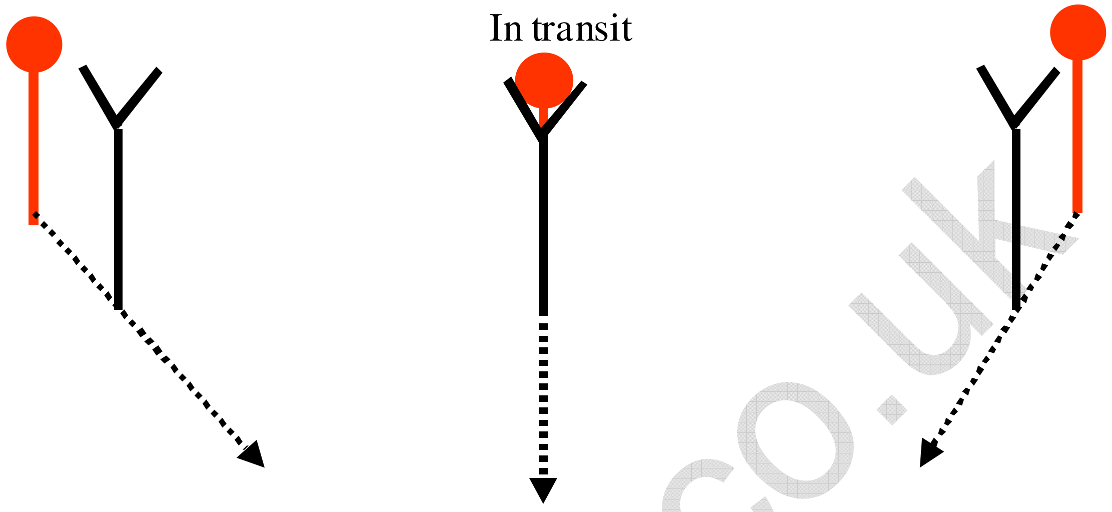
To sum up;

- A magnetic bearing is a true bearing, to which variation has been applied,
- A compass bearing is a true bearing, to which variation and deviation have been applied.

Swinging the compass

Ideally you will have your compass swung annually; it is particularly necessary after major work on the vessel, if it has been sitting still for some time and after a lightning strike (if it is still afloat!). Other than this there may be occasions when you think that there may be a deviation. The checks are quite simple.

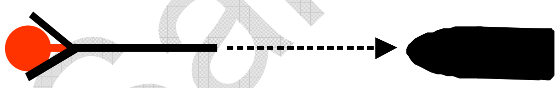
The most accurate method is to find a **transit**. A transit is a place where two objects are seen in line, when this occurs we can easily measure the true bearing of the transit on the chart. There are many natural transits, but you will find some marked on charts, particularly on harbour entrances-where they are marked as **leading lines**.



Transit

If we know the true bearing, we can add the variation to find the magnetic bearing. Then by comparing this to the compass bearing, we can deduce the deviation.

Point the vessel directly up the transit; this is easy to do when there is no current. Then read the heading on the ship's compass.



True bearing	270°T
Variation	7°W
Magnetic bearing	277°M
Compass bearing	280°C
Deviation	3°W

If you wish to make up a deviation table you could find transits all the way round from 000° to 360° and workout the deviation. If this is done at intervals of 30°, you will be able to plot a deviation table of your own.

A quick check for deviation, which is not very accurate but will pick up gross errors in wood or fibreglass boats, is to use the hand-bearing compass.

We assume that the handbearing compass has no deviation, this is not strictly true, but if you stand high up on the stern and sight down the centre line of the boat with the handbearing compass- any discrepancy between it and the ship's compass is the deviation.

Whilst not particularly accurate, this will work in an emergency. In fact, whenever I skipper an unfamiliar boat, I use this technique on each new course-until I am happy that the compass is correct.

<u>Deviation during this course</u>

For this course you will need to apply deviation to bearings when they are compass bearings, the letter 'C' after the bearing will denote this. You will also need to apply deviation if you are asked to find the **compass course.**

For any question involving deviation, use the table in PNT, except when the question is in the form of a compass check to find the deviation.

Bearings from GPS sets are not magnetic; they are calculated so there is no deviation involved. However, GPS receivers can be set to give bearings as true or magnetic.

Navigation instruments

There are numerous instruments available to assist the navigator, but the important ones are the basics that have been around a long time. If you have all the modern aids aboard, it is still a good idea to have some means of navigating if everything fails. Even if it only happens to you once in your sailing career, you will be glad you had a back up system in place.

- Clock.

A reliable clock that can be easily read when the logbook is being filled is still essential. It is then the standard time for everyone on the boat, and this saves people digging into their waterproofs to find their watch, if they have them sealed up in bad weather.

If the clock has an alarm, this will help to get the crew moving in the morning and make missing the weather forecasts less likely.

- Barometer.

A reliable barometer is essential, again it must be easily accessible to someone filling in the logbook, or they will not bother. The barometer should be adjusted occasionally; there are times when the air pressure should be obvious from the information given with a forecast.

- Echosounder.

I personally feel that a reliable echosounder is the most important instrument on the boat. When you are not sure of your position, a good watch on the changes in depth may indicate where you are, and will probably keep you in safe water!

The echosounder must be backed up, by carrying a lead line. A lead line can be used to:

- Check the calibration of the main echosounder.
- Used from the dinghy to sound the way in to shallow water ahead of the yacht.
- Act as a reserve if the main system fails.

There are limits to the operation of echosounders. Most will only operate to about 100m, in most situations this is adequate, but if you are entering somewhere like Las Palmas in Grand Canaria the first depth reading will be when you are only about 100m from the harbour!

- Interference.

All echosounders will suffer from interference from turbulent water, the most common cause of this is passing close astern of a ship, and it can be very disturbing to have the shallow alarm go off in mid channel! This disturbance may also be caused by turbulence in overfalls or in rough weather-especially in shallow water.

Occasionally, when over very soft mud, the return echo is lost and the instrument becomes unreliable.

- Alarms.

The shallow and deep alarms found on most sets are very useful for navigation. Obviously, a shallow alarm will assist you in avoiding running aground, but when either are set to a suitable depth they will give a position line. When sailing from Salcombe to Guernsey, a vessel crosses the Hurd Deep (not on the charts used for this course); this depth increase is very sudden and is a clear indication of the distance off the island.

The other alarm is an anchor alarm, this can be set for a range from the minimum to a maximum depth, if the anchor drags, the depth will change and the alarm sound, just remember to allow for changes of tide height!

- Log instruments

Modern logs may have many different functions; it is worth spending some time with the manuals to learn what all of them do (photocopy the manual as the pages of the original often stick together in a marine environment).

- Distance.

The distance function usually has two parts, a log and a trip log. The Log displays the total since the instrument was first fitted, and the trip log can be set back to zero.

If you use the trip log, be aware that it may zero itself when the engine is started or the battery voltage falls.

- Speed.

This function may offer:

Speed through the water.
Speed over the ground (only if interfaced with GPS).
Average speed since the log was switched on.
VMG. VMG stands for Velocity Made Good. This is the speed directly towards the wind, if you are beating, and can be used to decide the correct angle relative to the wind in which to sail.

- Calibration.

All logs will require calibration when first fitted. During the season, they will require re-calibration because the water flow over the hull changes as the bottom of the boat grows weed.

Many sailing boats will display different speed on port and starboard tack. This may be because:

(i) The impeller leaves the water when heeled to one side. A solution is to have two impellers fitted, one on each side.

(ii) The water flow is uneven across the hull.

You need to have a good idea of how accurate your log is and if there are any differences from one tack to the other. Remember that in rough weather, the log may under read because of the turbulence and the impeller leaving the water.

This may result in the situation where the vessel is closer to a landfall than expected; a potentially dangerous situation.

This last point is especially relevant to high-speed motor vessels. The log must be positioned where it remains in the water at all speeds.

Log types.
There are essentially two types of log:

Towed and through hull.

- Towed logs.

These are impellers that are towed behind the vessel; they may be electronic or mechanical.

Advantages.
(i) They are the most accurate (no interference from the

hull).
(ii) The require no electricity to run (mechanical ones only).

Disadvantages.
(i) They are awkward to use, especially in busy waters.
(ii) They can be caught around the propeller (easy to do at night when entering harbour).
(iii) They are easily fouled on floating debris.

▪ Through hull logs.

These are impellers that are inserted through the hull, and may be mechanical or electronic.

Advantages.
(i) They are out of the way, and require no effort to use.
(ii) If you need it, they have advanced functions and can be interfaced with the rest of the vessel's electronics.

Disadvantages.
(i) If they are fouled, they require removing from the hull (easily done with a little practice). If the boat is left for any time, the impeller should be removed and a plug put in to replace it.
(ii) On a long passage, they use electricity.

■ Satellite navigator.

Virtually all yachts have a GPS Global Positioning System) receiver aboard now. Many even have two or three, as the costs have fallen dramatically.

They may be a main unit built in to the vessel or a hand held device.

Having both can be a great back up for safety. If the main power fails, the aerial is damaged or you have to abandoned ship, a portable unit can be very useful. If you have a hand held unit aboard, ensure you have an adequate supply of spare batteries; some can use a considerable number!

As with all electronics, the best approach is to spend some time reading the manual and pushing the buttons until you are happy with all the functions available.

The system.
GPS signals come from 24 satellites, which are operated by the American Defence Department. It operates anywhere in the World 24 hours a day.

Now that the system is available at its full level of accuracy, positions can be found with a precision of about 10m. It is important to remember that the charts themselves are not drawn to this level of accuracy; in some parts of the World charted positions may be as much as ½ mile in error.

Positions are given related to a datum called WGS84. This datum is being used for new Admiralty charts as they are published, but as there are many using other datums, it is essential that the navigator check the chart for the datum being used.

Most modern GPS receivers can be adjusted to give a position in the datum of the chart in use. This function is normally found in the set-up menu. Alternatively, there is usually a function to correct the positions displayed on the screen by the amount give for the error on the chart. A third possibility is to correct the positions from the set manually for the given figures, before plotting on the chart.

- Position.

All sets will give a Latitude and longitude at a push of a button.

- COG and SOG.

All sets will give a Course Over the Ground (COG) and a Speed Over the Ground (SOG). This is invaluable for checking that what you have planned is actually happening. It is also useful for checking what the tide is doing.

- Waypoints.

Most sets will allow the entering of waypoints. These are places through which you wish to pass. Waypoints may be linked to form a route, which covers the entire passage.

Once waypoints are entered, the set will give information concerning:

- The time remaining before arriving.
- Distance to the waypoint.
- Bearing to the waypoint.
- Cross track error.

Cross track error is the distance in miles that the boat has been pushed to one side of the straight-line track between two waypoints. On a cross channel trip, this may be as much as 15 miles. This should not be thought of as an error, if you have calculated correctly, the tide will then push you back on to the ground track and cross track error will be reduced.

The most common error when using a GPS receiver is to enter the positions of waypoints incorrectly. A simple check, which must be performed every time you use waypoint navigation, is to compare the bearing and distance to the waypoint given by the GPS with the measured bearings and distance from the chart.

A useful means of plotting a position on a chart quickly is to plot the dot in the centre of a compass rose as a waypoint. The GPS display will then give the bearing and distance to that point. By laying a ruler or plotter across the compass rose at the given bearing, then measuring the distance off, a position can be plotted in seconds. Remember, that the bearing is towards the compass rose! This approach can be very useful in confined waters when speed is important, it is less useful out at sea.

- Chart plotters.

Many vessels are fitting a chart plotter that displays an electronic chart, interfaced with the data from the GPS (and all the other instruments aboard). These make life very simple for the navigator, especially when there is a repeater fitted at the steering point in the cockpit.

GPS navigators are one of the most useful pieces of equipment to have aboard, but it is important to maintain a written log and to have a system of checks to ensure the GPS receiver is working correctly.

It must also be remembered that electronic systems do not predict accurately where you will be in the future; the navigator still needs to be observing any changes to boat speed and course then planning as necessary.

Navigation

Fixing Position

One of the most important parts of going to sea, especially in coastal waters, is to know where you are at all times. There are several ways to do this.

Observation

The first skill to develop is the ability to look around the vessel, and know to within a small area where you are on the chart just by observation of the features in the area.

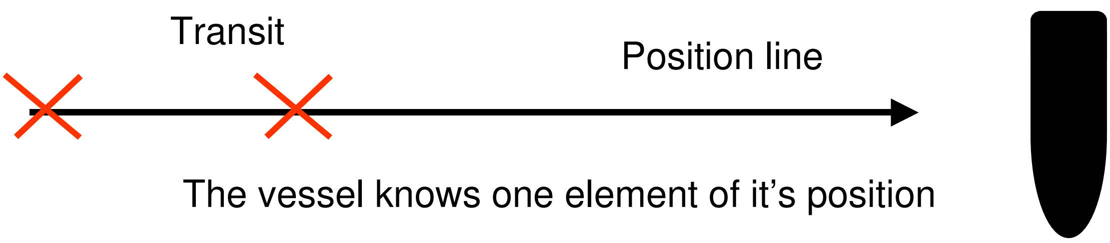
The reason I say that, is because one of the result of taking a navigation course is that the student's attention becomes focused on working on the chart and not looking where they are going. It can end up a bit like trying to drive a car, holding a map in front of you and not looking where the road goes! This is exactly what happens in many boats.

You must spend more time, looking around, at the water, weather, other boats, banks, the shore, buoyage and any other features as they pass, than looking at the chart. The information thus gained can then be related to the chart when you next go below. Lots of short visits to the chart table are preferable to sitting looking at it for long periods.

One problem you may well encounter is that you feel seasick when you first navigate. This is because it is a little like reading in a moving car. One way to reduce this risk is to minimise the time spent below; this is facilitated by good preparation.

Position lines

A **position line** is a line which can be drawn on the chart, which the boat can be said to be on. The standard symbol for a position



The vessel knows one element of it's position line is one arrowhead at the end of the line furthest from the object.

With a position line you only know that you are on that line, to find your position you must cross this first line with a second. This gives a **Fix.**

When you are sailing in an area that you are familiar with and do not need to navigate, you may be able to keep track of where you are, by using a series of single position lines from transits. This will help you know approximately where you are all the time.

Sources of position lines

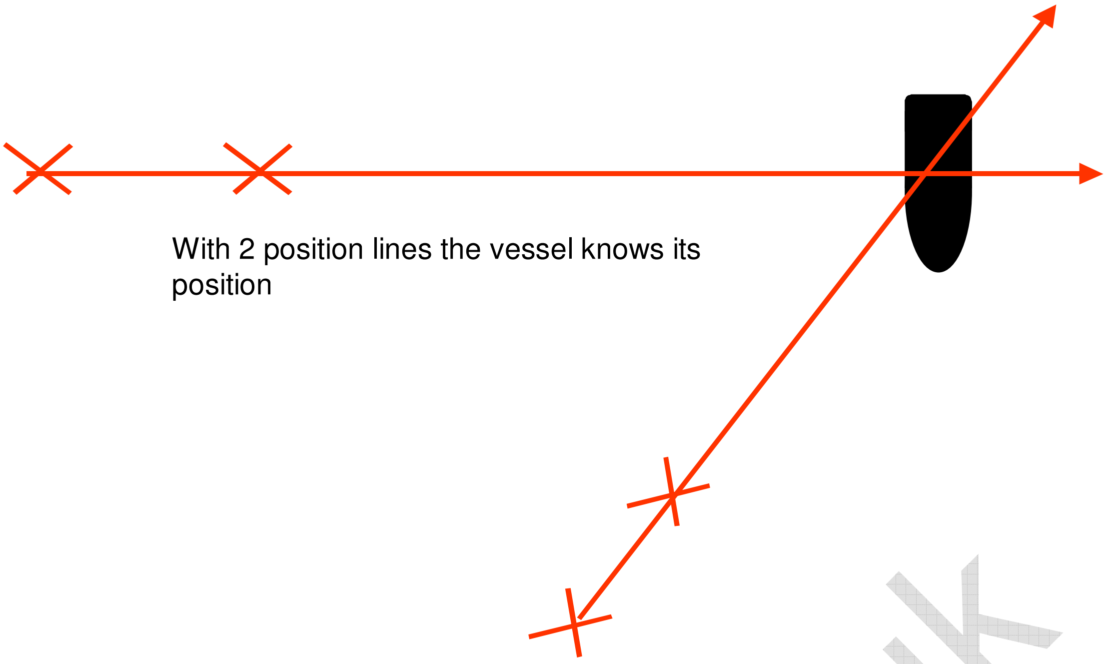
Transits, as in the example above, give the most accurate position lines, because there are no compass errors, and they are easy to use.

Bearings are probably the most commonly used position lines, because with a hand bearing compass it is very easy to take several bearings at the same time. A hand bearing compass does take practice to learn to use and may have unknown errors.

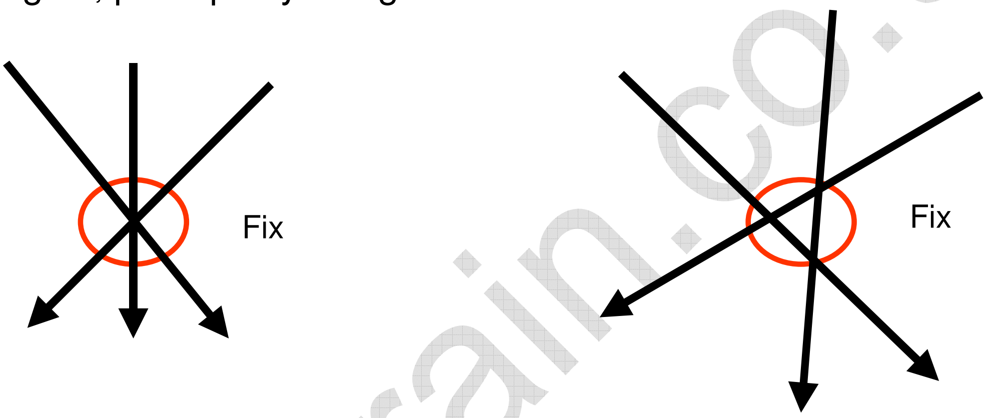
Depths, especially when taken on contour lines can give a position line. This is not very accurate, but absolute accuracy is not always important, a general idea of where you are, may be enough to indicate that you are in safe water.

Fixes

This fix is made up from only 2 position lines. The disadvantage of this is that if there is an error, you have no way of knowing. However, if you plot three position lines, when there is an error it will show up, because the lines will cross in a triangle. This is known as **Cocked hat**, the size of the cocked hat giving an indication of the level of accuracy of that fix.



If your fix results in a large cocked hat, it is probably better to try again, perhaps by using different features.

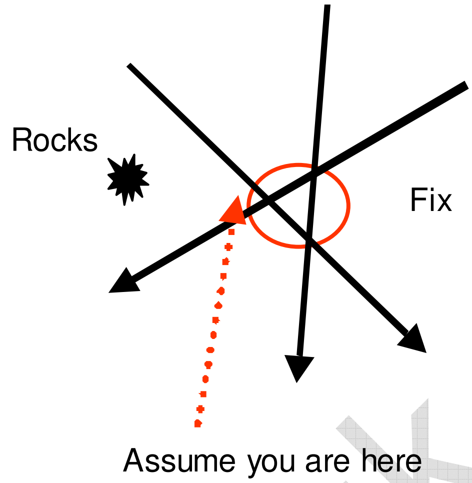


The size of the cocked hat gives an indication of accuracy

The standard symbol for a fix is to draw a circle around the area and write fix next to it. You should also record the time and the log reading when you take the bearings. This information is normally written next to the fix on the chart.

We have a standard way of working of the chart, so that if there are several navigators, they all use the same system, then you will not be woken up in the middle of the night because someone does not understand your chartwork.

When you plot a fix using a handbearing compass, it is not certain that you are at that spot. A prudent skipper would assume they are in that area, and if there were any hazards, would consider the vessel to be near to them.



Sometimes buoys are used to take the bearings, however, it is better to use land-based objects; these are less likely to move than a buoy. If there is nothing else that you can see, buoys can be used with caution.

Something to remember when you plot a fix is that it is where you **were** when you took the bearings-you will have moved since then!

If you recorded the time and the log reading at the time of taking the bearings, you will be able to deduce where you are now, and more importantly whether where you are going is safe.
A useful back up piece of information when you take a fix is the depth of water. If, after allowing for the height of the tide, the depth recorded and the charted depth do not agree, the fix should be treated with caution. However, if they agree, it tends to confirm the accuracy.

This kind of thinking is how you should run your vessel, especially in navigation there are no definite answers when we are out on the water. In the classroom we should strive for pinpoint accuracy in our working, but out on the sea there may be many unknown variables for the skipper to allow for.

Selection of targets

Before selecting the points for a **3-point fix** (a fix made up of 3 position lines), there are several things to consider.

- Are they on the chart?

- Can you identify them for certain?
- What is the angle between them? (60° or 120° are optimum, more than 30° will just about do)
- How far away are they? (if a long way off, a small error in the bearing will become a large error by the time it is plotted)
- Which order should you take the bearings? (if the boat is moving, the bearings ahead and astern will change the least and should be taken first)

Taking the bearings works best it you have an assistant to record the bearings as you take them. This way you will be able to take the fix quickly.

Handbearing compasses

There are several types of compass available:

- Fluxgate compasses are electronic and have an easily read scale, so they are good for people with poor eyesight, but they need to be kept level when used, a small tilt up or down can alter the bearings. You also need to carry a spare battery!

- "Puck" type, these are small units which you can keep hung around your neck. As with all equipment they take a little time to learn to use effectively, especially in rough weather!

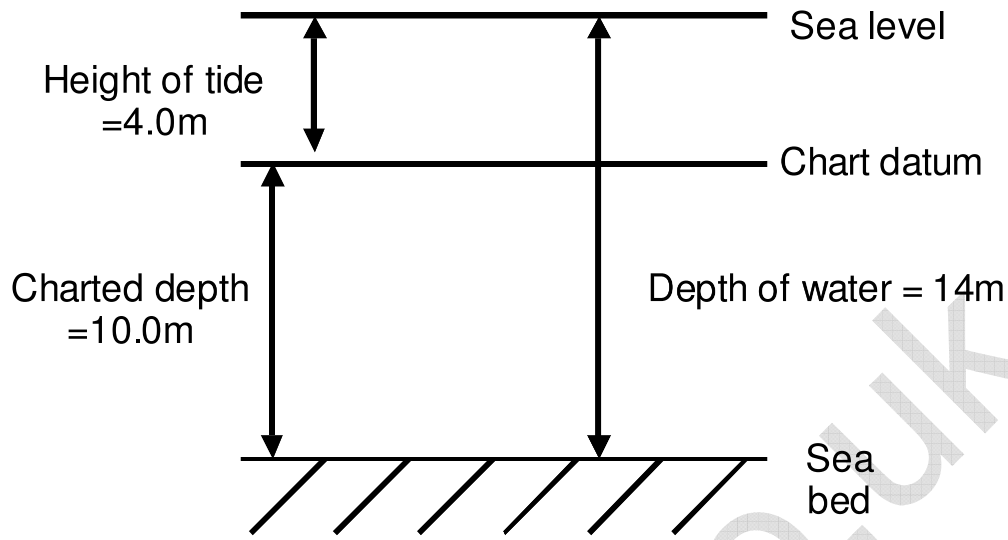
- Large compasses on a handle. The previous two has mainly superseded these. If they have a large display they may be of use to someone with poor eyesight, but as they can not be kept on a cord around the neck, or in a pocket they are difficult to use on a small vessel.

Any handbearing compass must have a light or some means of reading it in the dark.

Position line from a depth

A fix using a bearing and depth can be very useful. It is not always very accurate but is often good enough. The bearing is plotted as before, but the depth must have some allowances made to it.

If the depth shown on the echosounder is 14.0m and height of the tide is known to be 4.0m, the charted depth must be 10.0m. You then look along the bearing you have already plotted on the chart until it crosses the 10.0m contour line. Where they cross is your fix.



This method is only of use in an area with a gently shelving bottom. If it is very steep or undulating, it will not work well.

- 5. On Chart 2. A yacht observes the 2 F.G. 6M leading lights on North Coombe Island, in transit. If the depth is 35m, and the height of the tide is 5.0m, what is the yacht's position?
-
- **Fixing position with GPS**

Getting your position from a GPS receiver is a very simple task, all sets have a position button; on many it is labelled POS. When pushed it will display the vessel's position as a latitude and longitude.

When on passage if you are using the GPS, you must record the position at regular intervals in the ship's logbook and mark it on the chart.

A basic principal you should always work to when navigating is to have a back up to everything that you do. It is very dangerous to assume that everything is as it appears, even GPS positions can on very rare occasions be wrong or it may stop working because of a fault on the vessel.

The simplest back up system is to measure the bearing and distance between the last 2 plotted GPS positions. To see if they match the distance travelled through the water (from the log) and the direction steered (if there is a current you will have to allow for that, more about this, later in the course).

All this is more important if you are using an electronic chart plotter, especially one with a repeater in the cockpit. They are great tools and it is very easy to just look at the screen to check on the position, but if you do not have a hard copy of the information and you lose your electric supply there will be no record of where you are.

More advanced fixing techniques

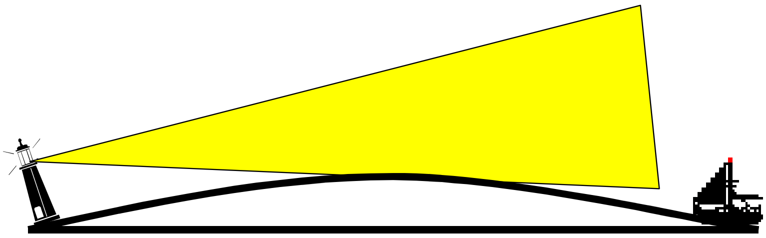
When we travel further offshore we start to encounter situations where the techniques we have been using become less useful.

Particularly on cross channel trips you will be in situations where you can only see one light at a time; we have two techniques that we can apply to give us a position when this occurs.

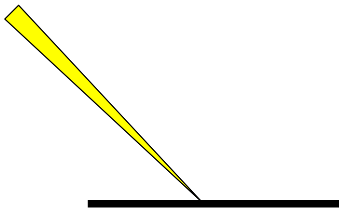
Rising and dipping lights

Because of the curve of the Earth's surface, lights will be out of sight even though the light may be powerful enough to reach as far a vessel. When this happens you will see a **loom** of light, which is the beam of the lighthouse shining in a beam across the sky. This will continue, until suddenly the light appears over the horizon.

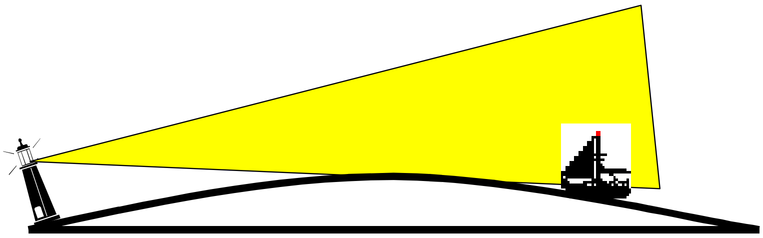
At this point, it is very simple to calculate the distance from the light, using a table in the almanac. We can take the bearing, so to plot a position on the chart all we do is plot the bearing, then measure off the distance from the light-that is the vessel's position!



Lighthouse over the horizon



View from a boat



Lighthouse in sight

View from a boat

Look inside the back cover of PNT. The table is one we use to calculate our distance off from a light when it just appears (or disappears) over the horizon.

We enter it with the height of eye above sea level, and the height of the light. The height of the light is written next to the lighthouse symbol on the chart.

So if Lizard Point Lighthouse rose over the horizon and the height of eye was 3m, we would be 21.0 miles from the lighthouse (Lizard Point light is 70m above MHWS).

To be accurate we should allow for the height of the tide.

If, when we saw the light the height of the tide was 2.8m we can find the height of the light above sea level by:

MHWS Lizard Point	5.3m
Height of tide	2.8m
Height to add	2.5m
Height of light	70.0m
Height of light above sea level	72.5m

Therefore from the table, the range of the light is 21.3M.

As you can see, the error if we do not allow for the height of the tide, will probably give you a position nearer the land than you really are, so in most cases you probably do not need to allow for the difference.

Transferred position lines and running fixes

The second method of fixing your position is again useful when on longer passages, but it can also be used when close to the shore. Although, this is not usually the best technique to use when in near to land, because it takes a lot more work than a 3-point fix.

Ideally you would use this technique when there is only one object to take a bearing from, a situation which might arise when approaching the coast at night.

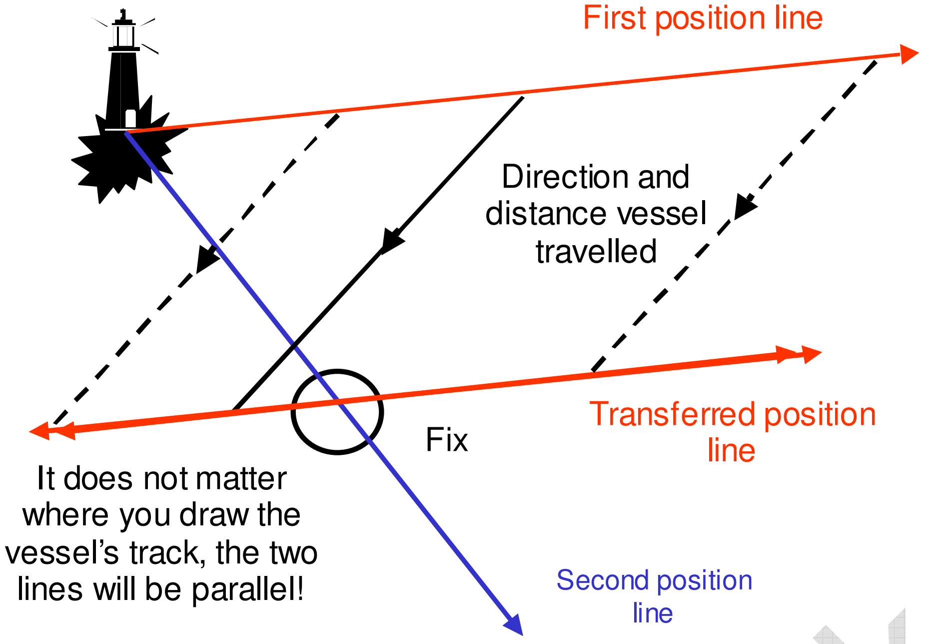
When you take a bearing and draw it on the chart, all you can say with any certainty is that you are on that line somewhere.

If you then sail on for 1 hour in a known direction, you can move the position line forwards by the distance that the vessel has travelled. You are now on the transferred position line.

If we then take a second bearing (it may be on a different object), we can cross the transferred position line with the second bearing to get a fix.

For this to work, you would also need to allow for any tidal set and drift during the hour.

The symbol for a transferred position line is to place two arrows on each end of the line.



We will return to this idea at a later part of the course.

Dead reckoning and estimated positions

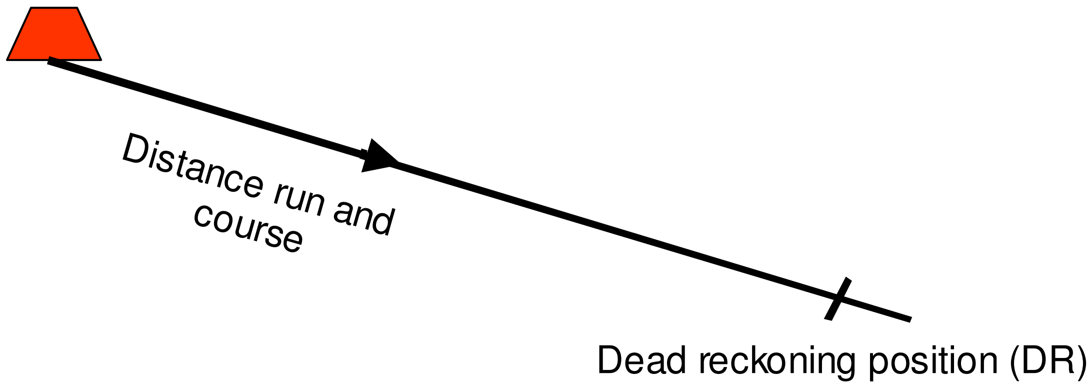
We have look at how to find out where you are by plotting position lines to obtain a fix. The biggest disadvantage of doing this is that it only works if there are features that can be used to create position lines. So how do we know where we are when far out to sea or in poor visibility?

The method we use is to draw lines that represent the movements the vessel has made over the Earth's surface.

Dead reckoning

If we have a known start point, such as a buoy or a fix, know which direction we have steered the boat and how far we have travelled, we can draw lines to represent these movements on the chart.

This gives us our new position.



Of course, **dead reckoning** does not take into account the tide, so is of limited use in most North European waters.

We have again used the standard notation, the **water track** is the direction and distance that the vessel travelled through the water, and it has one arrow, part way along. A DR position is marked with a small line crossing the water track, and writing DR next to it.

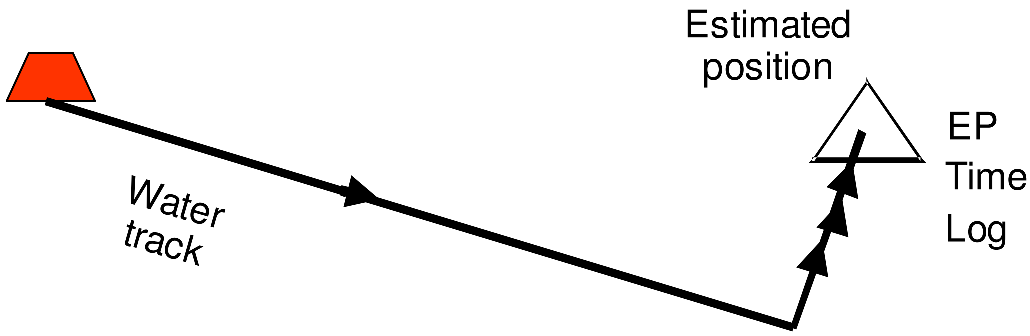
Estimated positions

An **estimated position** is the best guess that you can make for the boat's movement across the Earth's surface.

To start with, the extra information that we need to allow for is the direction of the tide (set) and the distance it has carried the boat (drift).

You begin as for the DR, but at the end of the water track, you draw in the **tidal vector.** This is the line that represents the direction of the tide and the distance it has carried you.

The tidal vector has three arrows, and the EP is indicated by a triangle around the position. An EP should also have the time and log reading of the time it was plotted.



The ship's logbook

Of course, when you are navigating a vessel for real, you will need to work out what course the boat has steered and how far it has travelled. This is why the **Logbook** is kept. In it you need to record details of when you passed buoys, what the log (the instrument which records the distance travelled through the water) read at that point, any changes of course and what courses were actually steered.

We normally also record weather information, wind force and direction, and the barometer reading. This information can be invaluable when you need to interpret the weather forecast.

All these factors will vary in accuracy; no one can steer a boat in a straight line. Instead of writing the requested course in the logbook, the best navigators estimate what the course actually steered was. One way of doing this is to encourage the helmsman to be honest in what they have really steered, there is no problem if the boat has been steered 10° off the requested course, as long as the navigator knows!

In addition, the log instrument may not be accurate. They need to be calibrated to the boat, and this will change as weed grows on the hull during the season.

You can see why an EP has lots of possible errors built in, so always treat them like any navigational system, with caution. A prudent navigator always backs up the navigation by cross checking it with something else! (The depth at the time of plotting the EP is a good check).

On a longer voyage, the logbook should be written up at least every hour and at any changes of course. If the logbook is not kept up dated and you need to call for assistance you may not have the necessary information to hand to pinpoint your position.

Below is an extract from a yacht's logbook.

	COMMENTS	COURSE	LOG	WIND	BAROMETER
0900	N.HURLESTON BUOY	000M	10.4	W4	1030
1000		000M	15.4	W4	1029
1100	ALTERED COURSE TO 345M	000M	19.3	W5	1028
1130	ALTERED COURSE TO 355M	345M	22.6	W4	1028

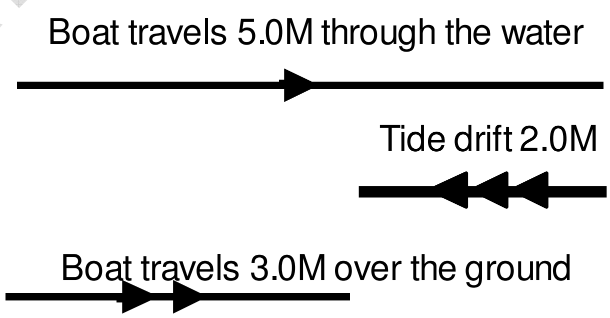
There is a specific way of filling out a logbook that is not obvious.

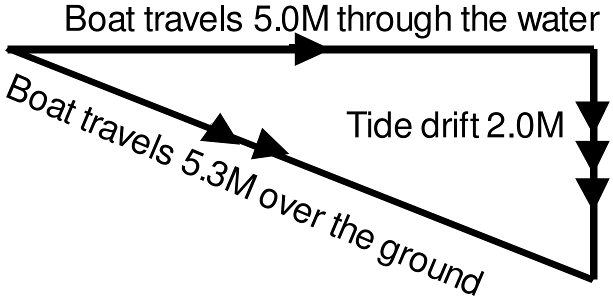
The entries mean that at 0900 the vessel was at the North Hurleston Buoy, steering 000°M. It followed that course until 1100, when it altered course to 345°M. This was not recorded in the COURSE column, because that is for what the boat has steered before 1100!

The new course appears at 1130, because between 1100 and 1130 the boat steered 345°M. This is the normal layout for the logbook.

Boat speed over the ground

It is important to realise that the speed through the water will always be different to the speed over the ground if there is a tidal stream. This is easy to imagine if the tide is travelling directly with or against the boat, but not so simple when it is travelling at right angles to it.





In each of the above diagrams, the boat travelled 5.0M through the water. In the first, the tide is directly against the boat, so the boat only covers 3.0M over the ground, in the second the boat covers 5.3M over the ground-but in a different direction.

The distance travelled over the ground is the **distance made good.** If it took one hour to make the passage the boat's **ground speed** in the first example would be 3.0kn whilst its water speed was 5.0kn. In the second example the boat's ground speed would be 5.3kn and its water speed would still be 5.0kn.

The direction the vessel travelled over the ground is the **ground track**. This is always marked with two arrows and usually given as a true bearing.

Normally you would not draw in the ground track when working up an EP. You have already travelled along it, if there was a hazard you would have already found it!

You are only drawing it in for this question; to highlight the way the boat heads in one direction, but physically travels in another.

Leeway

There is another factor we have to allow for, and that is the effect of the wind blowing on the side of the boat. The force of the wind drives the boat slightly sideways; this sideways motion is called **leeway.**

Leeway is at the maximum when a sailing boat is beating or sailing against the wind, but it will also occur when motoring if the wind is strong enough.

Factors, which increase leeway, are;

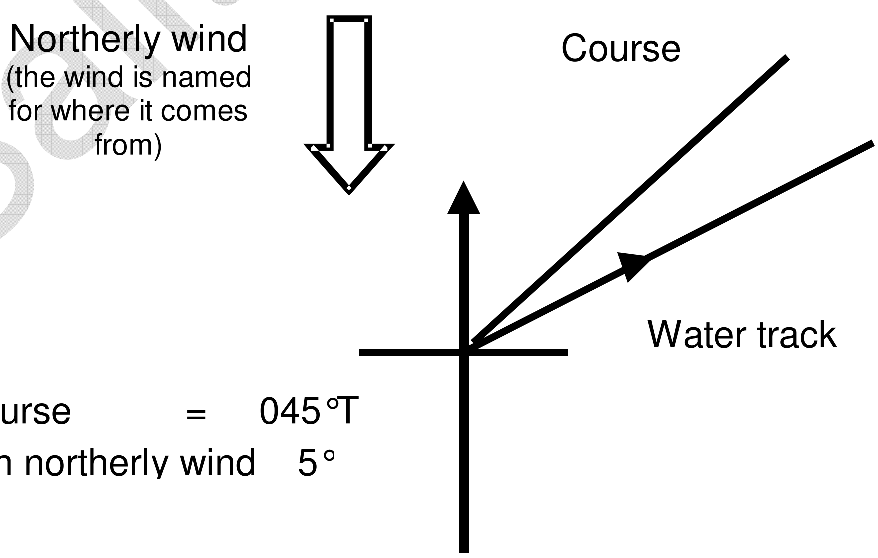
Wind angle.	A wind blowing on the bow will cause more leeway than one on the beam. There will be none with the wind astern.
Boat design.	Bilge keel yachts (twin keels) have more leeway than fin keeled ones.
Wind force.	The stronger the wind the more leeway.

Sea state.	Rough weather will increase leeway, because the boat will be carried sideways by breaking waves.
Boat speed.	Leeway increases as boat speed decreases.
Helming ability.	Novice helmsmen often increase leeway because they do not drive the boat efficiently, frequently sailing too close to the wind then too far off and making the boat heel excessively.

It is very difficult to decide how much leeway there is, but if you assume you are being pushed about 5° downwind when you are beating you will not be far out in normal conditions.

In practice most navigators guess at a figure, and then adjust it depending on how accurate the resulting navigation is. Over time, you will build up an idea of how the leeway of your boat varies with the conditions.

Leeway is always downwind. When we are plotting an EP. It has already happened to the boat, so the water track we draw on the chart is a combination of the course steered and leeway. At first it is a good idea to draw something like the diagram below.



Boat's course = 045°T
Leeway in northerly wind 5°

In this case the water track to plot on the chart is 050°T; this is the only line you plot. You never try to plot leeway on the chart, with an EP it is dealt with before you draw anything on the chart!

Leeway when beating

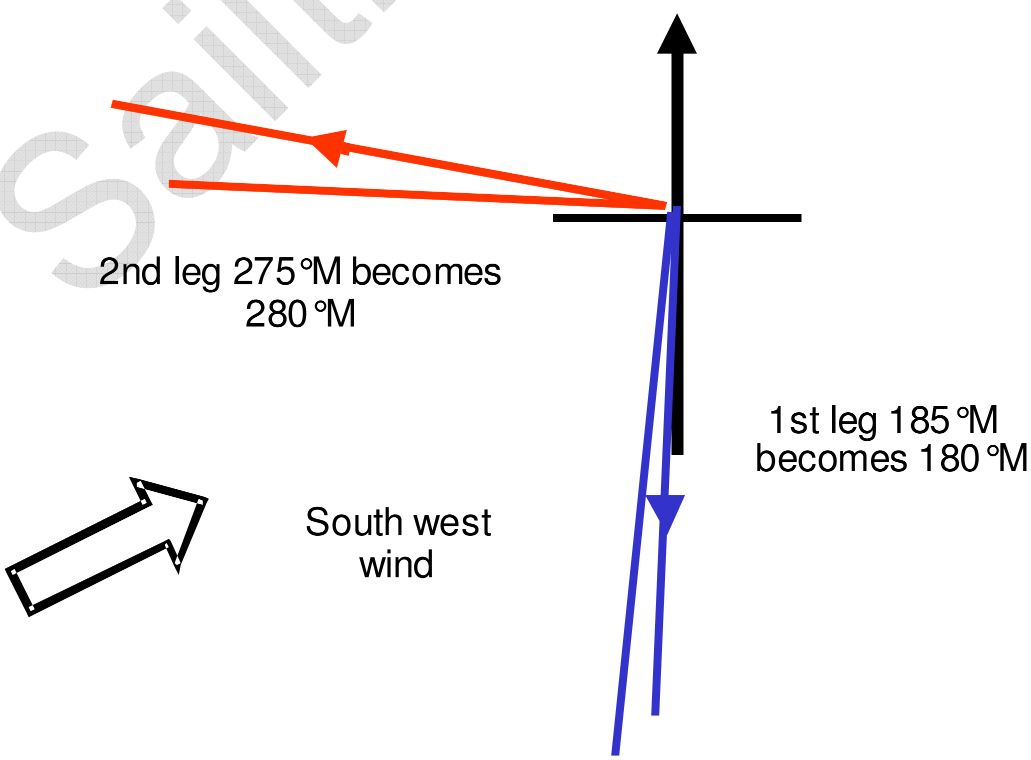
When you are beating against the wind, leeway is applied downwind on both tacks. This means that on one tack you will add leeway to the course steered and on the other you will subtract it.

Follow the example below.

TIME	COMMENTS	COURSE	LOG	LEEWAY	WIND	BAROMETER
0900	South Walton Buoy (50°13.05'N 04°28.70'W)	185°M	12.3	5°	SW5	999
0930	Altered course to 275°	185°M	14.6	5°	SW5	999
1000	Estimated position	275°M	16.6	5°	SW5	999

Between 0900 and 0930 the course steered was 185°M, allowing for leeway and variation the water track to plot on the chart would be 173°T.

Between 0930 and 1000 the course steered was 275°M, allowing for leeway and variation the water track to plot on the chart would be 273°T.



In all these questions, you have been given all the information that you need to complete the problem. A real navigator will need to work out the correct tidal information for each case. In the next step, we will be finding the tidal information as part of the exercise.

Finding the tidal stream with an EP

When we work out an EP, we need to find the start point, and then draw in the water track (allowing for any leeway if necessary).

Then we need to look up the tidal information for the day, to find the nearest high tide and range of tide.

Then we need to know which hour relative to high tide we will be finding tidal data for.

Then we plot the tidal vector, to find the EP.

Work through the following example.

Chart 1. Variation 7°W. July 1.

TIME	COMMENTS	COURSE	LOG	LEEWAY	WIND	BAROMETER
0801	Manacles Buoy (50° 2.8'N 05° 57.2'W)	090°M	14.3	0°	SW5	1013
0901	EP	090°M	24.3	0°	SW5	1012

Diamond E. Plot the EP.

Course	090°M
Variation	7°W
Water track	083°T No leeway.
Log at end	24.3M
Log at start	14.3M
Distance run	10.0M

	0601	
HW		
	0701	
HW+1		
	0801	
HW+2		Diamond E 061°T 1.4kn.
	0901	

Plot the water track from the buoy.
July 1
Plymouth BST
0631 5.3
1249 0.6
Range = 4.7m, therefore a spring tide.
Plot tidal vector from the end of water track.

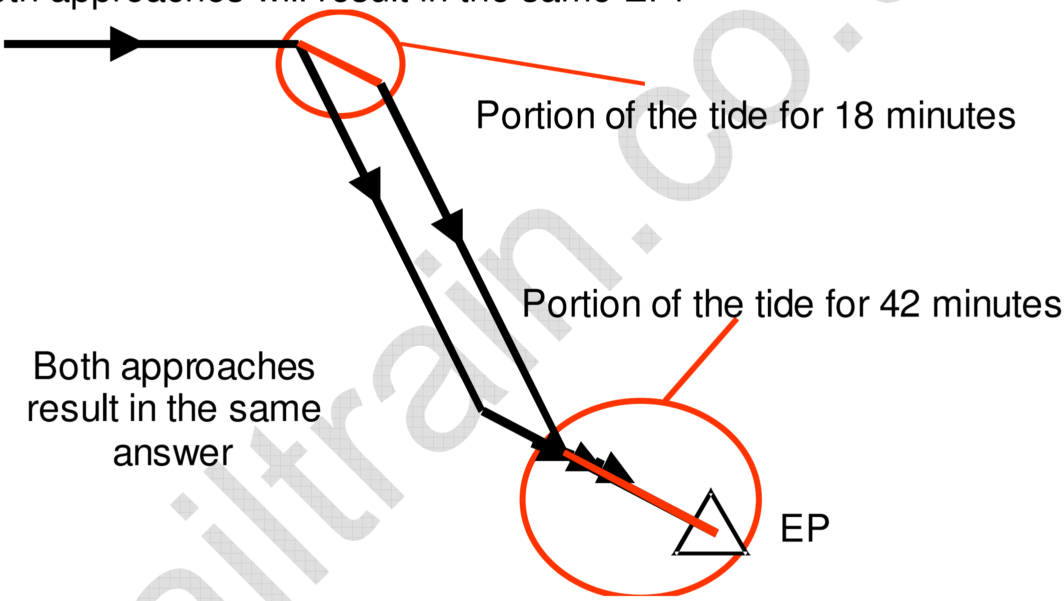
EP 50°4.8'N 05°39.7'W.

Plotting course changes during the passage.

If the vessel has changed course during the period that the EP is being plotted for, the simplest approach is to plot all the water tracks, then the tidal vector for the whole period on the end. This approach will involve the least work.

Instead of this approach, you could plot one EP for each part of the passage, if you do, you may end up working out how much tide to allow for odd period of time, such as when the course was changed after 18 minutes during a 1 hour trip.

Both approaches will result in the same EP!



Periods of time other than 1 hour

Not all questions will be for 1 hour. In practice you may draw an EP for any period of time. The important part is that the tidal drift is calculated of the correct period of time.

A tide of 2.0kn will give a tidal drift of 1.0M in 30 minutes and 0.5M in 15 minutes.

A tide of 2.4kn will give a tidal drift of 0.8M in 20 minutes.

So make sure you read each question and decide what the time period is, and then calculate the tidal drift for that period.

Plotting sequence

Find the start point.

Calculate the water track and distance run by the log (allow for leeway if required).

Plot the water track.

Find the tidal information that covers the period of the question.

Decide which hour of tide relative to high tide to use.

Look up tide stream on chart and convert to a distance run if necessary.

Plot tidal stream.

Measure the latitude and longitude.

Non-standard times and tides

The last few questions have all been set up in a simple way, either spring or neap tides and easy times of start and finish.

We will now move on to more complex questions that are closer to the problems you will encounter when you navigate for real.

With each of these questions look for the complications:

If the tide is not a spring or neap range you will need to use the computation of rates table on the front cover of PNT.

The times of the passages will not fit the times of high water so neatly either, and may require several pieces of information to complete the answer.

The courses will also be compass courses, which means you will need to apply deviation from the deviation table on the back cover of PNT.

Using EPs as a check on the GPS receiver

As you can see, working up an EP can become quite complicated! That is why it is very tempting to just take the position of the GPS receiver and plot that on the chart.

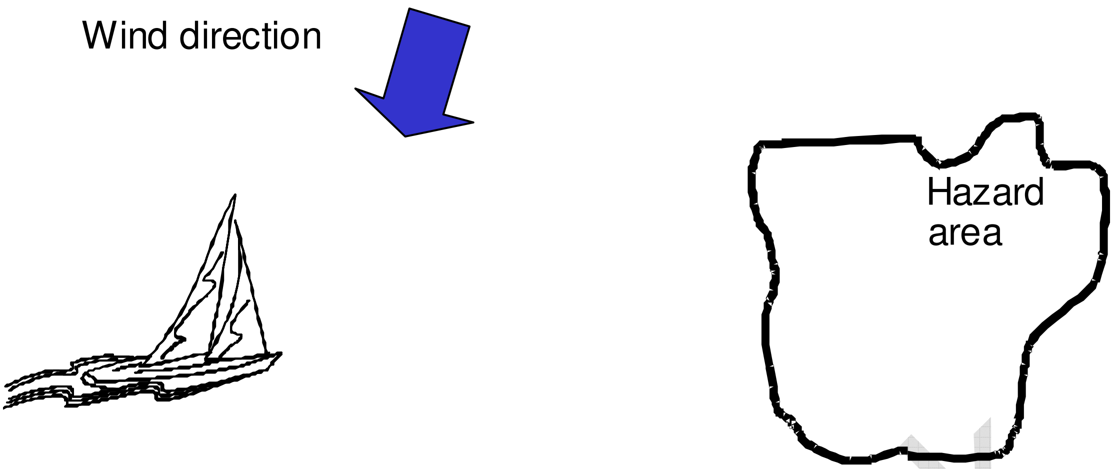
In principal there is no reason not to do that, but the safest approach is to plot an EP based on the logged information. Then plot the GPS position on the chart, as a check. You can probably rely, more on the accuracy of GPS than traditional navigation but there are two reasons to follow the procedure outlined above.

- You must run some system of checks in your navigation. Many vessels have been run aground when the crew believed they knew where they were. If there had been a self-checking system in place, it would have picked up any anomalies and would probably have behaved more cautiously. If you know you may be lost, you are safer than if you do not know you are lost!

- By plotting the EP before the GPS position you will maintain your feel for the accuracy of the information and retain the ability to make decisions based on uncertain information. Both skills which you will be glad to have, when your engine fails, the batteries run down and all you are left with a lead line and compass! (Ok, so you can get the spare hand held GPS out of its waterproof container).

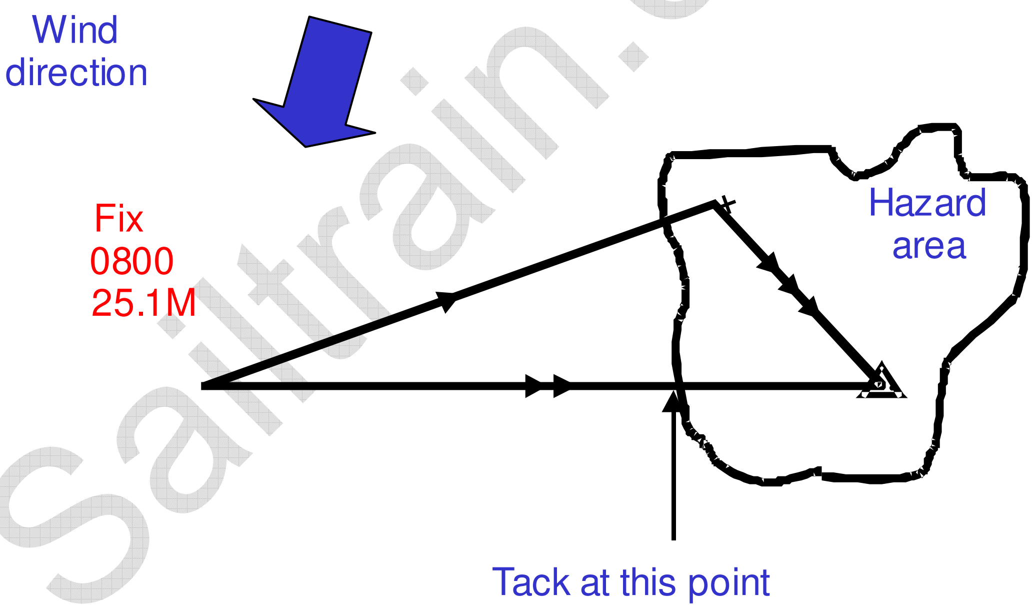
Using an EP to predict a future point

When we plot an EP it is based on what has happened. The information we use to construct it comes from the logbook. However, we can also predict what may happen in the future and use the principle of the EP to help us to avoid obstacles which may be unmarked by buoyage.

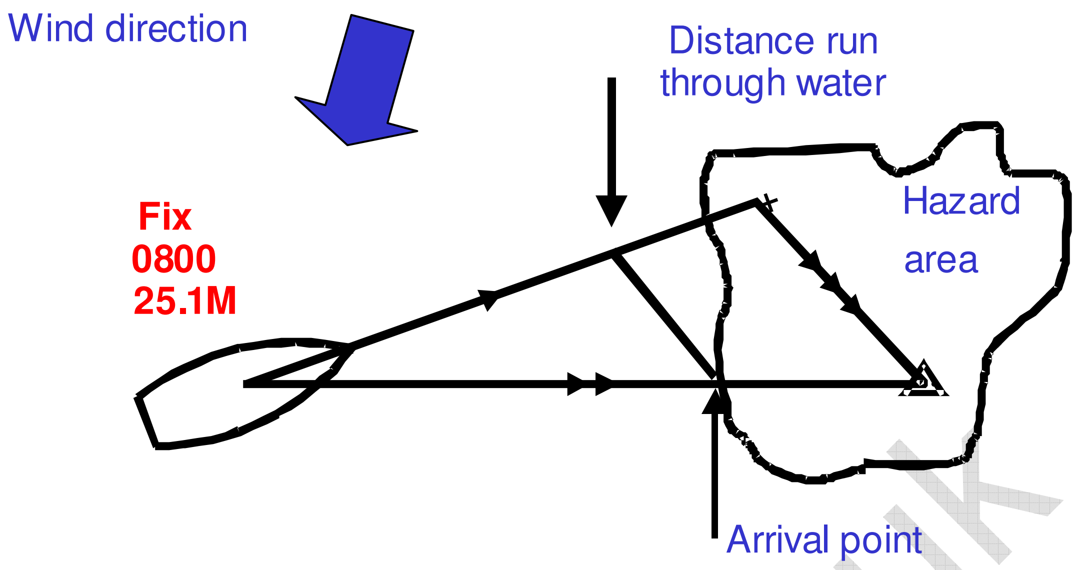


In the situation above, the vessel needs to know when to tack in sufficient time to avoid the unmarked shallows. If she relies on the log reading, this takes no account of how much the tide may push her on to the bank.

When this occurs we can predict the boat's speed and course based on what it is currently doing. Then plot an EP as if we had already made the passage.



If what we have predicted happens, we can see where we will hit the bank. To know what the log would read at that point, we just need to draw in a tidal vector from that point.



The distance to run through the water to reach the limit of safety is easy to find. Just measure the length of the water track to the new tide vector.

If we know the distance to run through the water, because we also know our speed we can also predict how long it will be before we must tack.

This technique is not one you will use often, but the principle can be useful, especially when beating up a channel in fog.

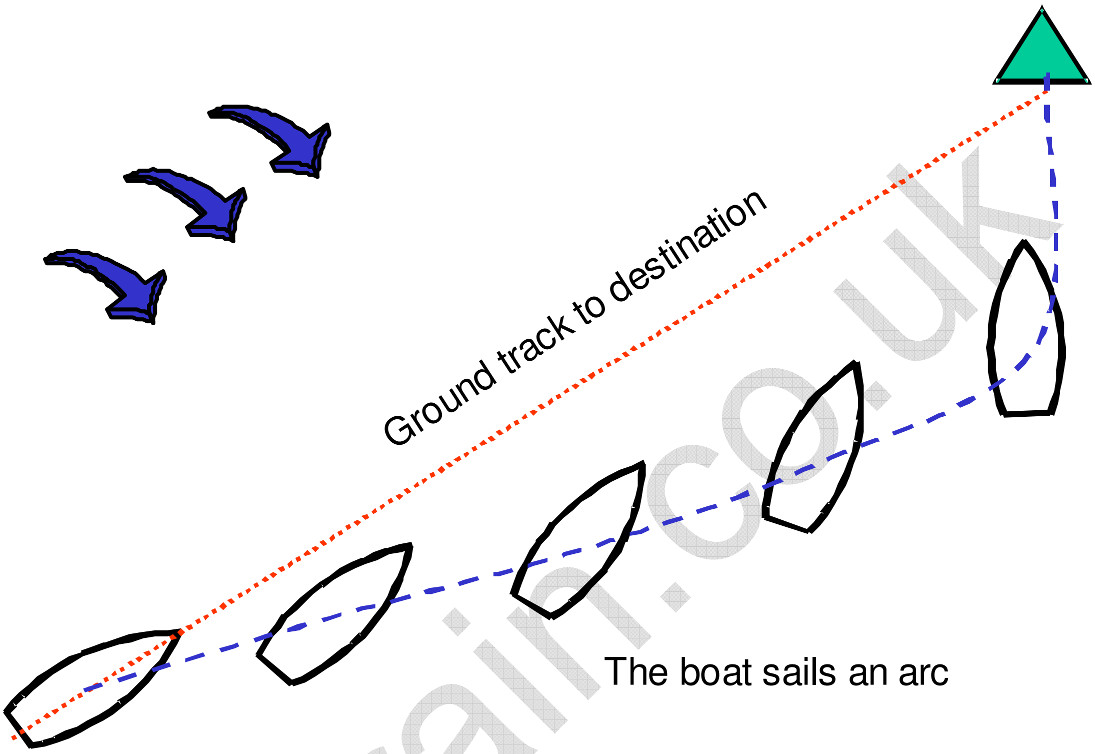
With this technique, you will have to judge for yourself how much of a margin for error to allow for. This is only a prediction of what will happen. If the boat speed or course steered change, you may need to rethink your approach.

Working out the course to steer to allow for the tide

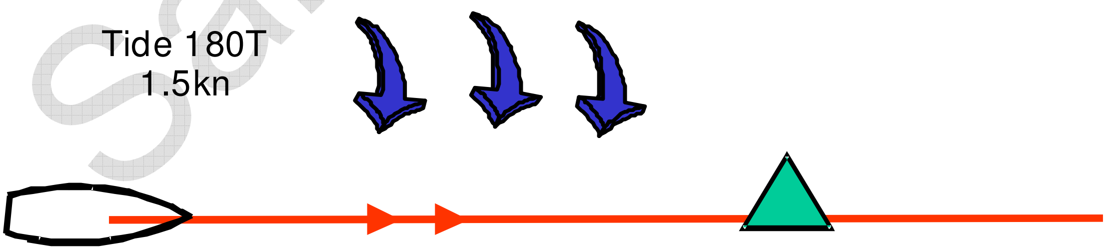
Before we make a passage across a current we must consider if we need to steer a course to allow for the tide. If there is a tide running across the route and instead of allowing for it, we just point the boat to the destination, we will end up sailing in an arc. This will take longer than doing some quick calculations first.

Not only will this approach take longer, but also you may be swept into a dangerous area or in a sailing boat, you may end up head to wind and unable to sail.

The first step is to draw in the ground track to the destination. When you do this, you **must** draw the line past the point where you



intend to stop, even if the line goes over the land! If you do not do this, sometimes you will be unable to complete the diagram correctly.



The next step is to measure the distance from the start to the destination, and by comparing this to the speed you expect to make decide roughly how long the passage will take.

When motoring the speed is easy to deduce but if you are sailing it is not so easy. With practice you will learn to guess what the speed will be in your boat on any heading. During the course you will always be told the boat's speed.

When we work out the approximate time of passage we are only looking to see if it will be 1 hour or more so that we know how much tidal information to look up. E.g.

- A passage of 6M at 5kn will take about 1 hour.
- A passage of 11M at 6kn will take about 2 hours.
- A passage of 5M at 10kn will take half an hour.

These figures take no account of the tide, so there is no point in trying to be very accurate at this stage.

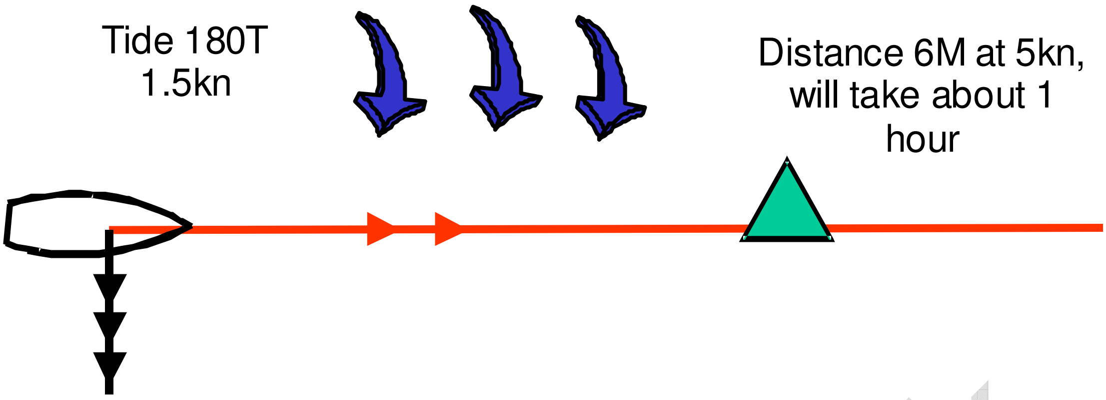
We will know the start time of the passage, so if it is going to take about 1 hour, we need to find the tidal stream information for that hour. If we expect it to take two hours, we need to find the tidal stream for those 2 hours.

We do this in exactly the same manner as for working out an EP. The only difference is we are not given the start and finish time; we need to work out the finish time for ourselves. This is easy to do.

A passage of 1 hour starting at 1024 will need tidal information for the period from 1024 to 1124.

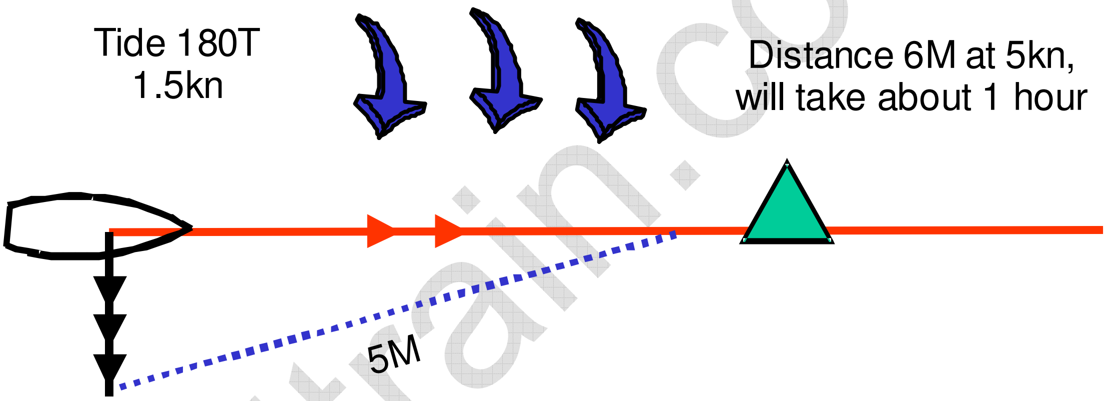
A passage of 3 hours starting at 1345 will need tidal information for the period from 1345 to 1645.

We then need to plot the tidal vector, from our start point!

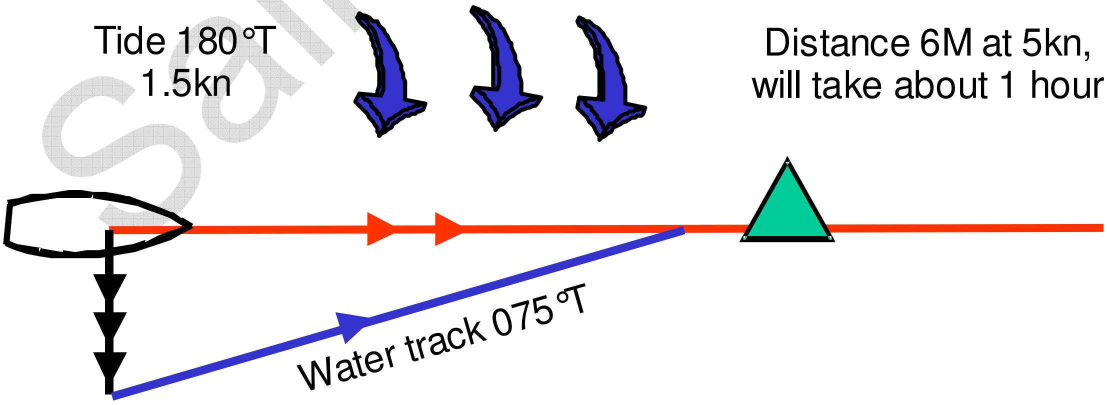


For us to work out the course to steer we must draw a triangle, each side of which represents the same period of time.

So our next step is to measure off the distance we expect the boat to travel through the water in 1 hour. In this case 5M.



If we then draw this line in, it becomes the water track.



It does not matter that the water track has not reached the destination, because you can assume that for a short period, conditions will remain similar, and you can continue on the same course. In practice, you would probably be able to see the destination and could approach it by eye.

The other possibility is that the water track will reach the ground track after the destination. When this happens, it means that the passage will take less than 1 hour, when you arrive at the destination you will stop!

Because of this you may have a course to steer which ends up running over the land, provided this is after the point you are aiming for it is not a problem.

The course to steer line very rarely ends at the destination, if it does, check through the process again. Make sure you have measured off the distance you expect the boat to travel through the water, from the end of the tide vector!

Estimated Time of Arrival (ETA)

The other element of working out a course to steer is calculation how long the passage will take. Having an idea of your ETA at the next point is one means of backing up your working, if the ETA passes and you have not sighted the destination, something may not be right!

To work out a time of passage we use the formula:

$$\text{Time} = \frac{\text{Distance}}{\text{Speed}}$$

Or **T=D/S**

You probably do this calculation frequently without realising it. If you need to drive 100 miles in your car and you estimate that you will drive at 50 mph, the journey will take 2 hours.

$$2 = 100/50$$

So the formula is not new, the only part that is, will be the concept of what we mean by speed.

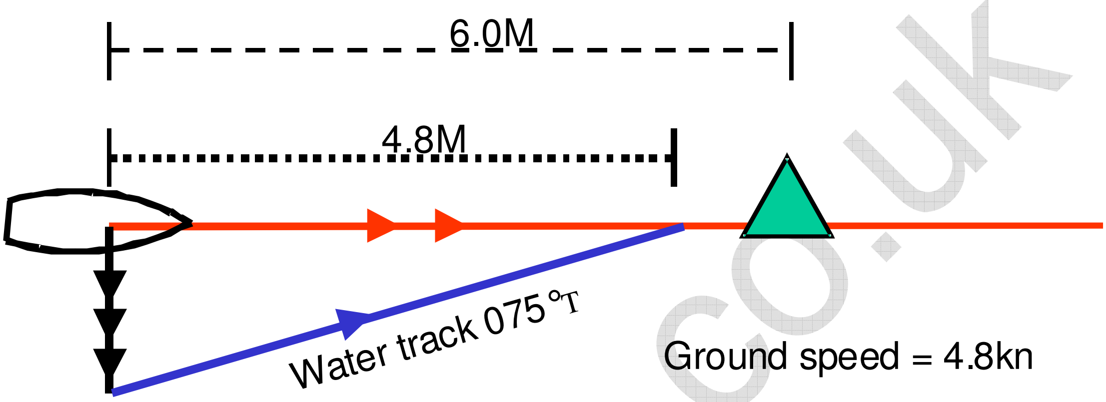
The speed of the boat through the water is not the speed towards the destination. To find that, we need to go back to the diagram we drew, and measure the length of the triangle along the ground track.

This line represents the distance the boat will travel over the ground in 1 hour, so we can find the speed.

In the example we drew earlier it is 4.8M long, so the boat's speed over the ground is 4.8kn, but the log would show 5kn through the water.

Using T = D/S T = 6M/4.8kn = 1.25 hours.
If you multiply 0.25 by 60 minutes = 15 minutes.

This passage would take 1 hour 15 minutes.



Not all questions will be for one hour, remember to measure the distance to the buoy and by comparing it to the boat's speed decide on the time period to allow for.

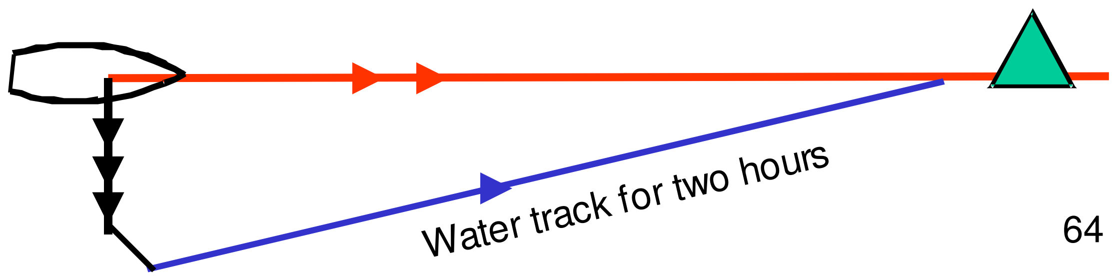
In a confined area like The Solent, it is likely that you will not be able to work out a course to steer over an hour because there is not sufficient room. The scale of the chart would also make it very difficult; a distance of 6M would be about twice the length of the plotter!

If the passage will take longer than one hour and it is in open water, the best approach is to find all the tidal information for the period of the passage, then plot the all the tidal vectors first followed by one long water track.

1st Tide 180T 1.5kn

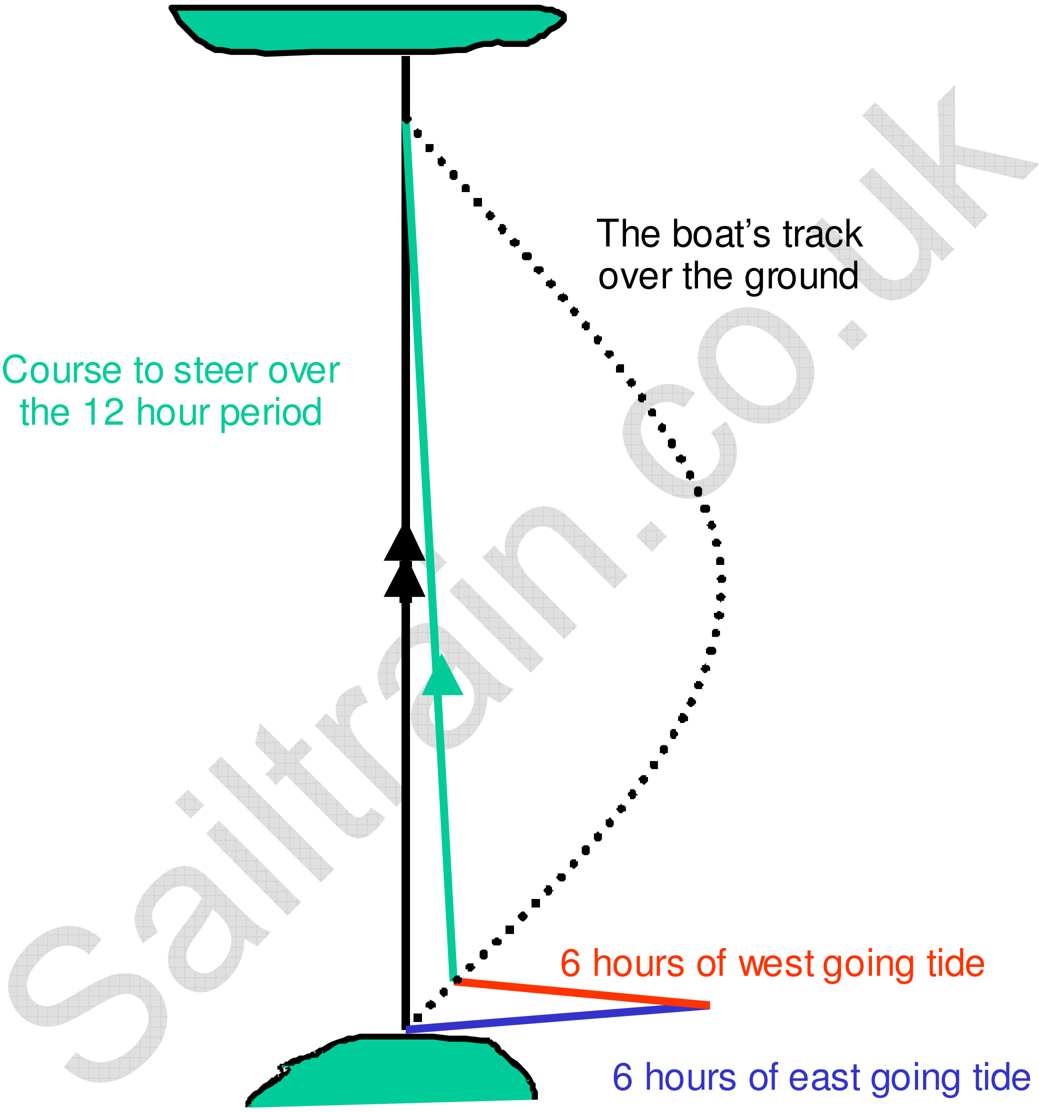
2nd Tide 155°T 1.0kn

Distance 12M at 5kn, will take about 2 hours



The other approach is to work out two separate courses to steer, one for each hour. This will work, but the passage will take longer and the navigation will involve more work.

The passage will take longer because some portion of the tides often cancels out, the longer the time of passage the more this will happen. If a cross channel trip takes 12 hours, it is likely that most of the tides will be cancelled out.



Leeway when working out a course to steer.

If you allow for leeway, it does not affect any of the working we have been doing up to now, because the line we take from the chart is the water track.

This means that you find the water track and ETA, then **before** you apply variation, and especially the deviation, if there is any, you allow for the leeway.

More complex courses to steer

We are now going to add some extra complications to the questions that will bring them closer to reality.

These will include deviation, if deviation is required to be included in a question it will ask for the **Compass course.**

The time periods will also be more complex. As long as you lay the times out as in the worked examples this should not be a problem, just include all the times indicated.

Short cuts

As part of your passage plan, it is rarely worth working out the course to steer to allow for the tide beforehand, apart from the first leg. The reason is that it becomes less accurate if you do not reach each of the points on the passage at the time you predicted.

The best approach is to calculate the course, as you are approaching the point where the change is required. To do this you need to be very quick at chartwork.

There are some short cuts that most experienced navigators use. As part of you planning the night before you need to fill in the tidal stream atlas for the entire passage.

Now when you need tidal information you look on the page that covers the relevant period. It is easy to extract the speed of the tide. To find the direction, just measure the angle with your plotter, the plotter can then be transferred directly to the chart and the tidal vector plotted. This technique can also be used when plotting an EP.

The other short cut we use is to use a scale for distance, instead of the latitude scale and the dividers. The best scale is one of those on your plotter. This will save you picking up the dividers a then swapping back to the plotter several times.

We use a scale by treating one unit from the plotter as 1 mile on the chart. Provided you do this for all the distances the diagram is exactly the same shape-no matter what the scale. The only difference is the size of the triangle; the angles all remain the same.

Follow the example below.

At 1230 a vessel leaves the Safe Water Buoy (49° 49.6'N 04°52.0'W) on route to the EC'B' Buoy (50° 03.3'N 04° 45.4'W), making 12kn. The time of high water at Plymouth is 1200 on a spring tide.

- Plot the ground track. Measure the distance (14.2M).
- Estimate time of passage (1 hour).
- Fill in the tide atlas.
- 1230-1330 is HW+1 hour.
- Tidal stream 3.4kn (spring).
- Direction with plotter (097°T).
- Plot tidal vector on chart.
- Use scale on plotter to measure 3.4 units (inches or cm)
- Use plotter to measure 12 units for the water track.
- Plot water track. 001°T/008°M

If the tidal atlas is already written up you will be able to work up the course in a couple of minutes, which is a much more realistic time scale than spending 20 minutes working in lots of detail.

To find the time of passage. We must measure the length of the ground track. In this case it is 12 units or 12 knots. The only distance we measure with the dividers is the real distance from buoy to buoy! Time of passage is 14.2M/12kn = 1 hour 11 minutes.

Try reworking some of the questions you have previously done until you are happy with this approach but save it for when you are afloat. If you use it for the course work, there may be slight differences from the official answers. Using the plotter to measure distances on an arbitrary scale can not be used for an EP because they need to be plotted in real miles.

Creating a transit for a course to steer

Over short distances there is a means of getting the correct course to steer to allow for a cross current instantly.

If you are heading directly towards a buoy it will remain steady against the background or in transit. To arrive at the buoy you just aim towards it, see which way you are being set by the current, then gently turn in to the current, until the buoy remains in transit with the background. As you move out in to a stronger current you may need to alter the course slightly to maintain the transit.

This will only work if there is land behind your destination and over short distances.

GPS and courses to steer

Some chart plotters have tidal data installed and are capable of working out the course to steer to allow for a cross current, but most do not.

What the GPs will give you is the direction to a **Waypoint.** A waypoint is a place you want to go to, either the final destination or literally a point on the way. You can enter waypoints in the GPS receiver as part of the passage plan.

If you steer in the direction of the waypoint, you will be swept down tide, and the bearing to the waypoint will gradually change as you are swept off course. This is the same situation we looked at before with traditional navigation.

There is another function on a GPS receiver that we can use. That is the COG function (Course Over Ground), this tells you the route the vessel is making over the ground. For short distances you can adjust your course until the COG matches the bearing to waypoint, you are then heading directly to the destination in the same manner as the transit method.

However, if you use this on passages over one hour (the tide will change direction) you will not be sailing the shortest route and this technique should not be used.

Tide Streams and Heights

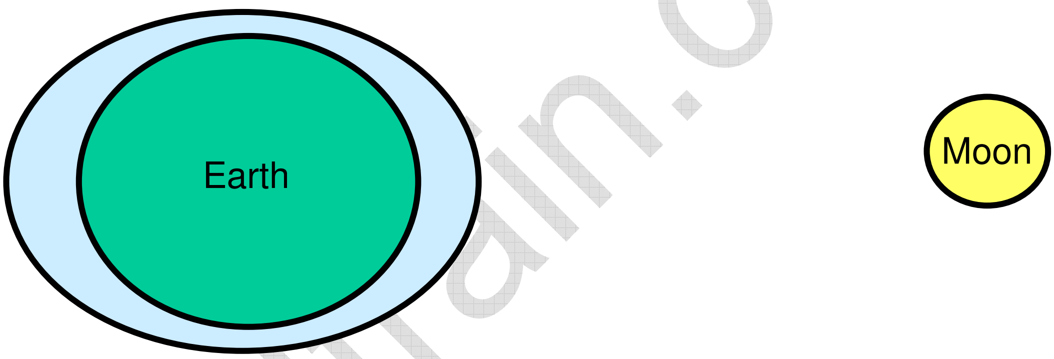
Tides

What causes the tides?

The main cause of the tides is the Moon. The moon exerts an attraction on the Earth. This gravitational attraction causes a bulge in the water on the Earth' surface at the point nearest to the Moon.

This is because at that point the forces are at the greatest. However, what is not so obvious is why there is a second bulge in the water-on the opposite side of the Earth to the Moon.

This occurs at the point furthest from the Moon, because the gravitational attraction of the Moon is weakest at that point.



These bulges give us high tides and the points in between, where the water level is depressed gives us the low tides. As the World rotates in 24 hours, in any 24-hour period we will have two high tides and two low tides.

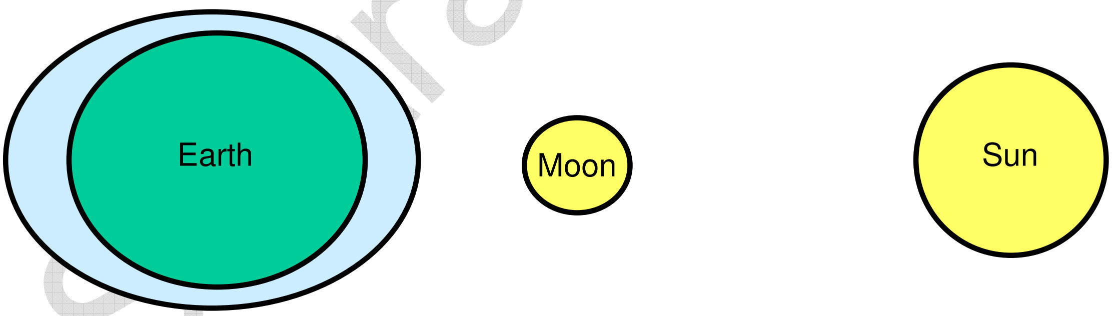
This is not strictly correct because the Moon rotates round the Earth, this movement causes the time of high water to become later by approximately 50 minutes each day.

In addition, to the Moon, the Earth is affected by the gravity of the Sun. Because of the great distance to the Sun, the Moon's effect is about 20 times that of the Sun.

The forces from the Sun and Moon can either work together or against each other. When they work in concert, the tides will fall lower and rise higher; this is known a **spring** tide. If the forces cancel out, the tides will not rise so high or fall so low; this is a **neap** tide.

Neap tides

Spring tides



As it takes the Moon a month to rotate around the Earth, Spring tides occur at two weekly intervals, with a gradual change over a week to a neap tide. So in 1 month there will be two neap and two spring tides.

When the Earth, Moon and Sun are in line, there will be a full or new moon. That is, you will see all the disc of the Moon at full moon, and at new moon the dark side will be towards us and not visible. On clear nights you may be able to see a pale new moon because of the reflection from the Earth shining on the Moon.

This means that spring tides occur at full and new moon, in fact, there is a delay of 2 days for the tides to reach the maximum.

In the same manner, at neap tides you will be able to see half the Moon (the first and last quarter).

Knowing this you can take a rough guess at whether it is a spring or neap tide without looking in the tide tables. In Macmillan's Almanac the phases of the moon are marked in the tide tables.

<u>**Tidal ranges**</u>

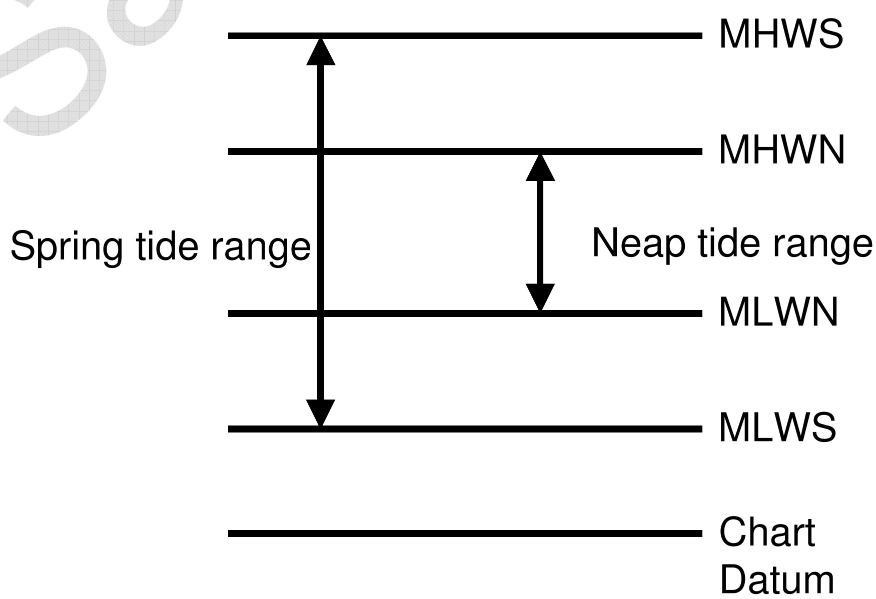
The **range** of the tide is the difference in height between low and high tide. On a spring tide the range is about twice the range of a neap tide.

You will come across the following terms frequently.

Mean High Water Springs.
Mean High Water Neaps.
Mean Low Water Neaps.
Mean Low Water Springs

The word mean, means the average. So low water spring tides are not the lowest tide. As it is the average, some must be lower!

The diagram below shows you the relationship between the tidal levels. All tide heights are measured above **Chart Datum,** which is the level below which the tide never falls.



If the range of a spring tide is about twice that of a neap tide, and it still takes about 6 hours to go from high to low tide, the speed of a spring tide will be about twice that of a neap tide.

Tide tables

There are many types of tide tables. The Practice Navigation Tables are extracts from Macmillan's Almanac, which is one of the most popular almanacs available in Britain. It is published annually and covers many ports in Europe from Germany to Portugal. A publication of this type is invaluable if you are going to sail any more than a few miles from your homeport. At the other end of the scale, if you only sail locally, you may find a simple tide table available at your local chandlers for 20p is sufficient.

Turn to page 23 in your PNT.

This is the page for Plymouth. Always check that you are looking up information for the correct port!

In the top left corner there is a box noting the time zone the tables are correct for. The time zone is UT or Universal Time. As far as we are concerned this is the same as GMT.

Under the time zone is written: For Summer Time add one hour to the non-shaded areas.

During the period of the year when BST is on force, we must add one hour to the times given in the table to bring them in to line with the time we are using.

When you are dealing with tidal information, it is valuable to rewrite the information you will be using, but I suggest that you start by drawing a box around the day in question. This will ensure that if you look away, you will come back to the correct place! (In the real book, cross out each day when it is finished, you will not need the information again).

Many of the problems people encounter during this course are caused by untidy working, get into the habit now of laying your work out in a standard manner and keep it tidy. Remember, when you are skippering a boat, the navigation will be only one of your responsibilities, if you are untidy, you will lose track of what the numbers mean.

We are going to look at May 4th.

May 4	
Plymouth BST	
0103 0.7	
0713 5.4	We need to know if this is a spring or a neap tide.
1325 0.6	This is found by subtracting low water from high.
1934 5.4	

5.4m - 0.7m = 4.7m
To decide if this range is a spring or neap tide. Look on the top right corner of page 25. In the mean range box, the figures for a spring tide range is 4.7m and for a neap is 2.2m (these figures only apply to Plymouth!).

Therefore this is a spring tide.

It may seem a lot of work to lay this information out like this for each question that you do, but if you can establish a thorough method of working from the beginning you will make fewer clerical errors. Most of the errors in navigation are not caused by a lack of understanding, but by untidy working.

Tidal Streams

For the first navigation questions you are given the tidal stream data. Once you have been introduced to the concepts you will have to work out your own information.

There are two sources of tidal stream data:

Tidal Diamonds
and
Tidal Atlases.

Tidal Atlases

Tidal atlases are used for planning passages, and can be used to find detailed tidal data for navigation.

There are several types of atlas:

Admiralty Atlases. The Hydrographic Office publishes atlases for most British and European waters. They are very easy to use and cover a range of scales, from one that covers just the entrance to Portsmouth Harbour to one that covers the North Sea.

Yachtsmen's Atlases. There are several publishers who sell atlases with yachtsmen in mind, they often have other information that may be of use-such as tidal height calculators and can be very useful.

Almanacs. Most almanacs include tidal stream atlases, they are small and not very detailed, but are adequate for most purposes, and they are all included in the price of the Almanac! We will be using the ones on pages 6-9 in PNT; they are an extract from Macmillan's Almanac. Turn to it page 7 now and find the diagram for high water Plymouth.

The information is given as an arrow in the direction of the current, the bolder the arrow the stronger the tide. If we want to find the direction of the tide a little more accurately, we can measure the direction of the arrow with our plotter. Just line the grids up with the side of the chart.

Find the east going arrow just north of Cherbourg, the rates of the tide are given as 16.34. This means that the neap rate is 1.6 knots and the spring rate is 3.4 knots. Remember that the spring rate will be about twice the neap.

If you measure the direction of the arrow with your plotter you will find it is about 088°T.

You will notice that there are diagrams for the period from 5 hours before high water Plymouth to 6 hours after. Each diagram represents what the tide does during the period of one hour. To use the atlas we need a time of high water at Plymouth.

On May 3rd it is 1854 BST and the range is 4.7m, so this is a spring tide.

The diagram for high water covers the average tidal conditions for one hour, from half an hour before, to half an hour after high water. In this case from 1824 to 1924.

Write these times below the diagram, then for the one before, write 1724 to 1824, and so on until you have put times to each of the diagrams before and after high water.

If you fill the atlas in like this for each day, it is very easy to see the pattern of the tides. This helps you to plan when to start and end a voyage when you are planning a trip. The period when the tide is in your favour is called a **Tidal Gate** or **Tidal Window.**

Tidal Diamonds

Spread around the chart there are points for which tidal data has been collected and tabulated for us to use. These points are indicated by tidal diamonds, a magenta diamond with an identifying letter in the middle.

On Chart 2 the table with the information is below the title. It includes diamonds from A to G, for each there is a latitude and longitude.

Can you find diamond E on the chart?

Look back at the table. Printed on the top is: Tidal Streams Referred to HW at Plymouth.

Diamond E is near Torquay, but we still use HW Plymouth for the calculations.

To find the tidal stream at diamond E, 3 hours before HW - place a ruler under the line of figures and read off the data in the correct section.

211°T 0.6kn or 0.3kn.

Tidal direction information is always given in true because it is never used on a compass, only on the chart. The rates are given in knots, obviously the higher rate is springs.

To be strictly correct the data should be used for half an hour before to half an hour after the tabulated times, in a similar manner to the tidal atlas.

For example, if HW was at 1200.

	0930
HW-2	
	1030
HW-1	
	1130
HW	
	1230
HW +1	
	1330
HW+2	
	1430
HW+3	
	1530
HW+4	
	1630
HW+5	
	1730
HW+6	
	1830

In this example, if we were on a passage between 1330 and 1430, we would use the information for HW+2.

This may seem a long process, but until you are very familiar with the concept I suggest that you use the layout above to work out which hour relative to high tide that you need data for.

Non-spring or neap tides

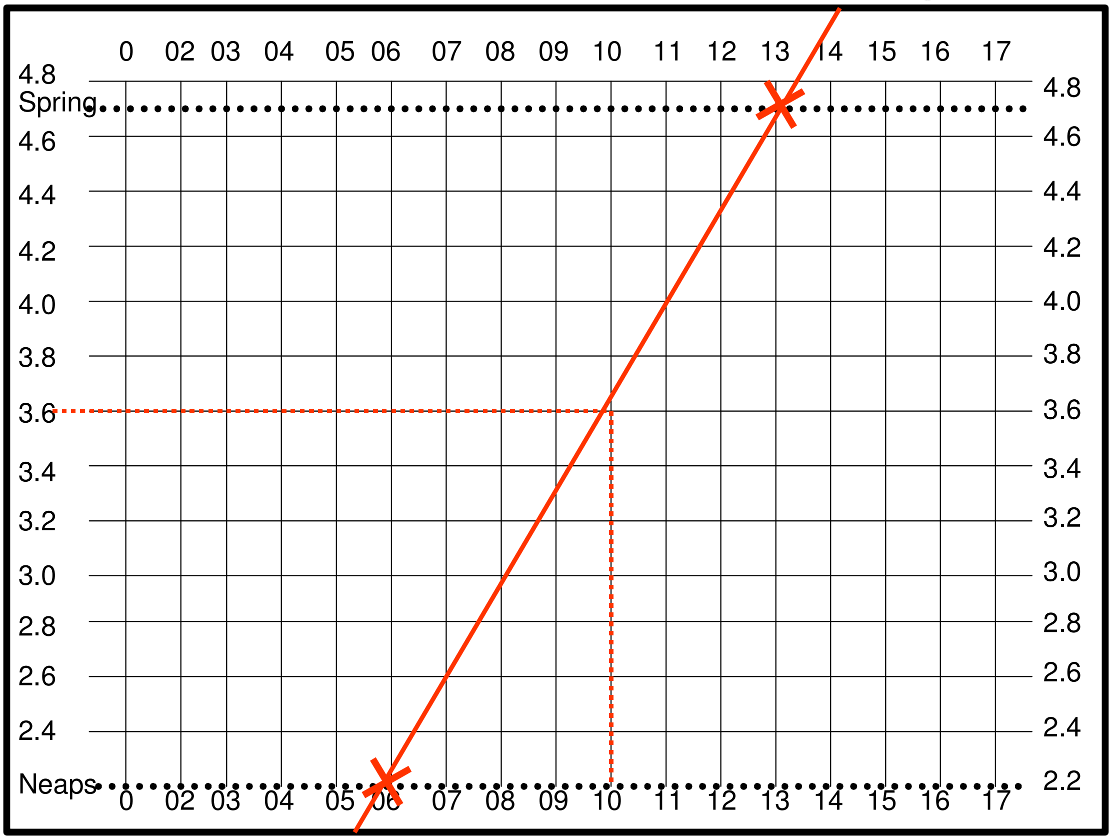
Most tides will not be exactly a spring or neap tide, but will fall between, occasionally you will also experience tides of a greater than spring range or less than a neap range.

In any of these situations we may need to be more accurate with our workings than just accepting the tabulated figures. Follow the example below:

Chart 2.
What will be the direction and rate of the tide at Diamond A, at HW if the range of the tide is 3.6m?

From the chart, the spring rate is 1.3kn and the neap 0.6kn.

As this tide in not a spring or neap tide, to answer this we need to use the computation of rates diagram, which is found inside the front cover of PNT. These are normally found in Admiralty tidal atlases.



To use the diagram:

- Mark with a cross the neap and spring tidal rates on the dotted lines which denote the ranges for those tides at that port. Note that the figures along the top and bottom are in tenths of a knot.

- Then draw a sloping line through and past both crosses.

- On the left side, find the range of the tide in question, and draw a line to the right, until it crosses the sloping line.

- From the point where the two lines cross, draw a line up or down to find the rate of the tide for that range.

The tidal rate is 1.0kn for a tidal range of 3.6m.

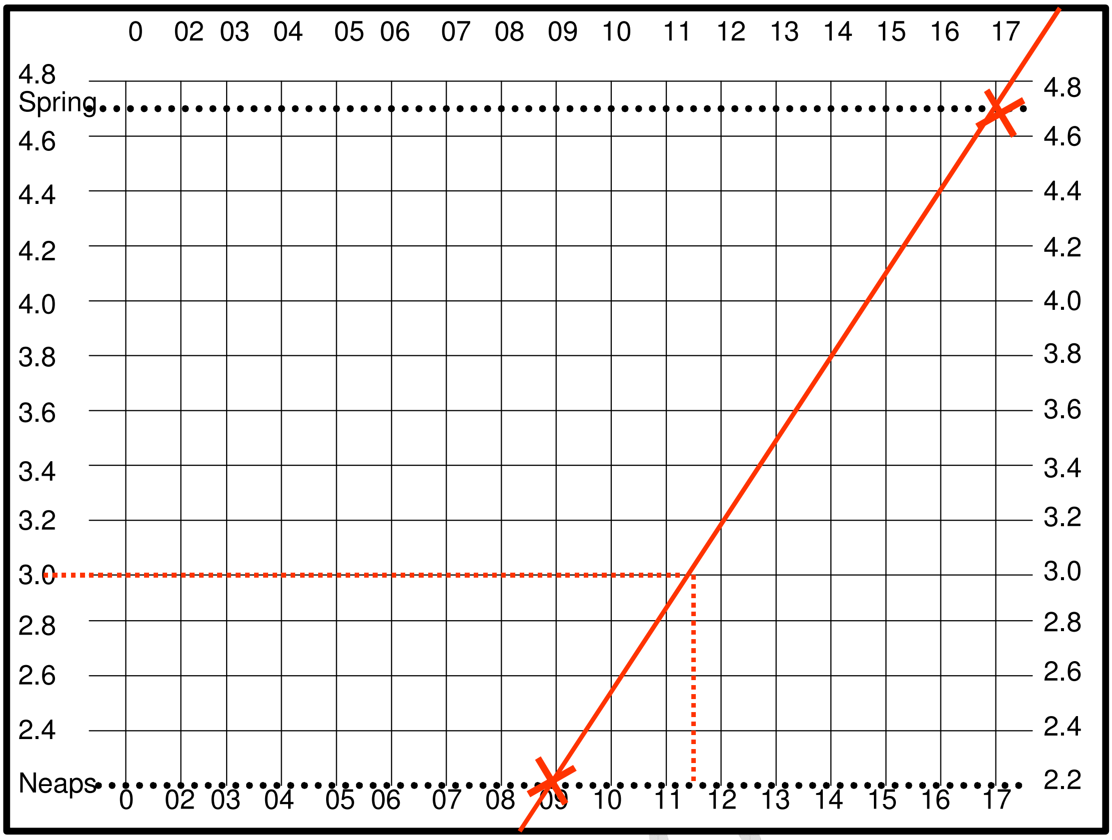
Let's try again with a real tide.

What is the rate of tide between 0742BST and 0842BST on April 24th at diamond A, on Chart 2?

April 24
Plymouth BST
0417 1.6
1012 4.6
Range is 3.0m, therefore a midway tide. Note that we use the two times, which are either side of the period of the question, when we decide which range to use.

	0742	
HW-2		Diamond A tidal stream = 323°T 1.7kn and 0.9kn.
	0842	
HW-1		
	0942	
HW		
	1042	

Plot the crosses and lines.



The tide between 0742 and 0842 at diamond A on April 24th is 323°T at 1.15kn.

Multiple hour calculations

If we need to find the tidal stream information for a period of longer than one hour we need to ensure we use all the information.

What is the tidal stream between 1033BST and 1233BST on August 9th at diamond G, on Chart 2?

August 9
Plymouth BST
0833 2.2
1500 4.4
Range is 2.2m, therefore a neap tide.

1030
HW-4 Diamond G tidal stream = 223°T 0.8kn.
1130
HW-3 Diamond G tidal stream = 226°T 0.7kn.
1230
HW-2
1330
HW-1

1430
HW
1530

For any navigation we would need to use **both** the pieces of tidal data.

A more complicated type of question is when the times of the question do not fit the tide times so neatly.

What is the tidal stream between 1028BST and 1228BST on August 22nd at Diamond A, on Chart 2?

August 22
Plymouth BST
0501 1.7
1128 4.6
1731 1.8
Ranges are 2.9m and 2.8m, therefore a midway tide. Note that there are two different ranges.

0958
HW-1 Diamond A = 000°T 1.3kn and 0.5kn.
1058
HW Diamond A = 080°T 1.3kn and 0.6kn
1158
HW+1 Diamond A = 100°T 2.4kn and 1.2kn.
1258
We are looking for the tide between 1028 and 1228, this is two hours, but we need to look up three hours of data.

We will use the information for HW-1 for half and hour, then that for HW for one hour and finally that for HW+1 for half an hour. We also need to interpolate, using the computation of rates table.

The results are:
HW-1 000°T 0.7kn, 0.35M.
HW 080°T 0.8kn, 0.8M.
HW+1 100°T 1.5kn, 0.75M.
Note that we have converted the speeds to distances, because that is what we plot on the chart.

Set and Drift

It is very important that you keep a clear idea of whether you are dealing with a speed or a distance. It is very easy to think they are interchangeable when you are working for 1-hour periods.

If the tidal stream is 2kn, in 1 hour it will travel 2M, but in half an hour only 1M. The distance the tide travels in a period may be referred to as the **tidal drift,** whilst the direction may be called the **tidal set.**

Accuracy of tidal stream information

The data from the atlas and tables comes from the same sources, so if you find a place in the atlas where there is a diamond on the chart, you will see that the information is the same. Compare the information for diamond J on Chart 1 with the same place on the tidal atlas.

The way that tidal data is presented leads to the impression that it is very accurate. It is important to remember that the figures given are only averages and may vary considerably from the tides you experience.

The weather may be one cause of inaccuracy. Strong winds may hold the tides back, then when they do run the rate may exceed the tabulated figure.

A prudent navigator is always assessing the accuracy of the information used. Every time you pass a navigation buoy or a fishing marker, look at the tidal flow and guess for yourself what the rate and direction is. If necessary, alter the figures from the tables to suit what you observe. Always remember that navigation is an art, not a science!

Other methods of determining the tidal stream

One method of measuring the rate of the tide is to stop next to a buoy, keeping it steady alongside your vessel. When you can see that you are not moving relative to the buoy, read the log (gives the boat speed through the water), and you will know the speed of the tide, the direction will be the reciprocal of the boat's heading.

A similar result could be achieved on a calm day by anchoring.

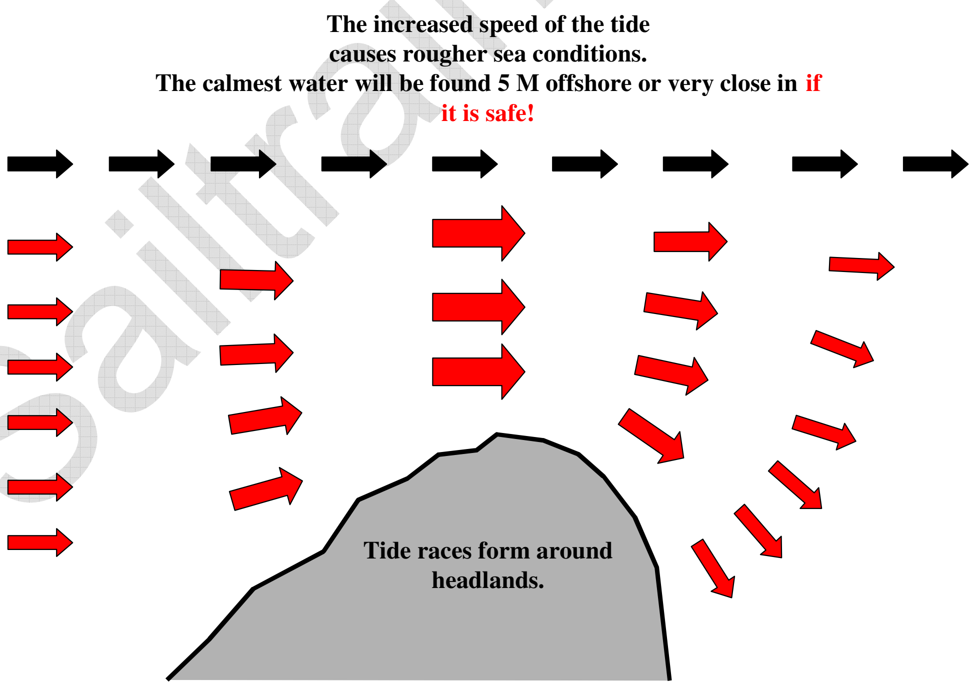
Some modern GPS systems when interfaced with an electronic chart plotter will calculate the tidal information, from the difference in speed and heading relative to the ground and water.

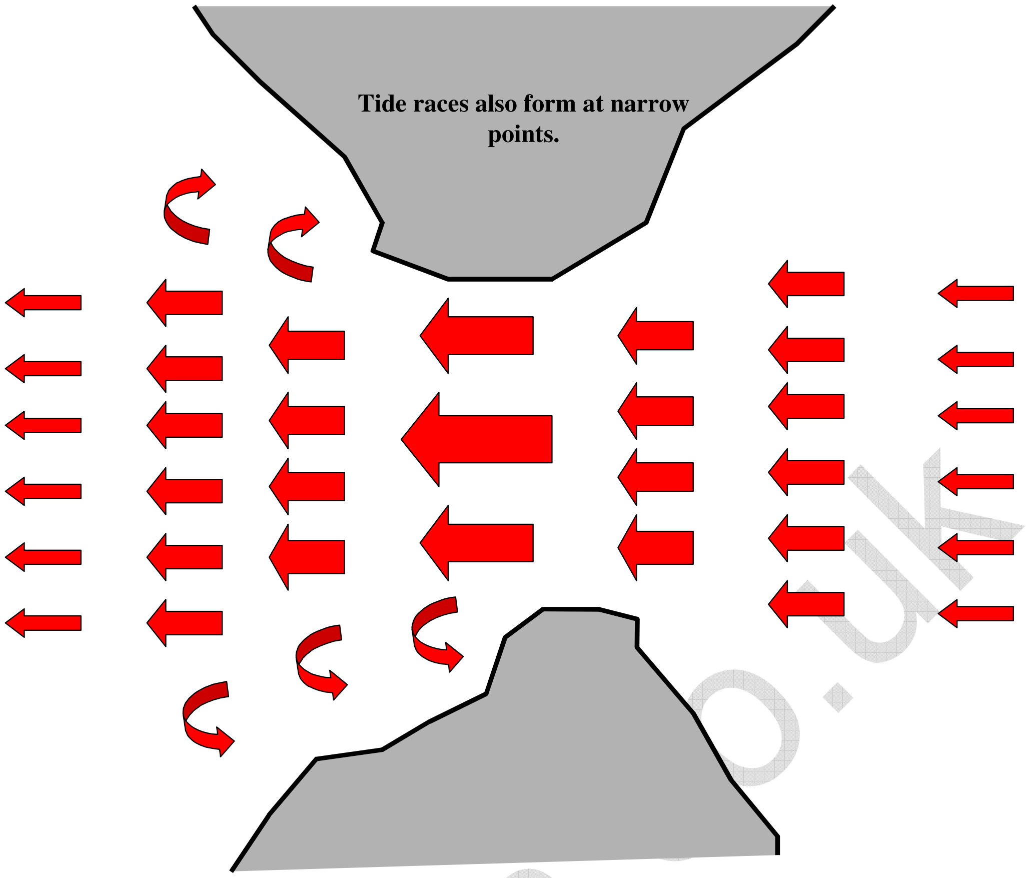
You can also buy software packages with tidal stream information, but that is making life too easy!

Tidal hazards

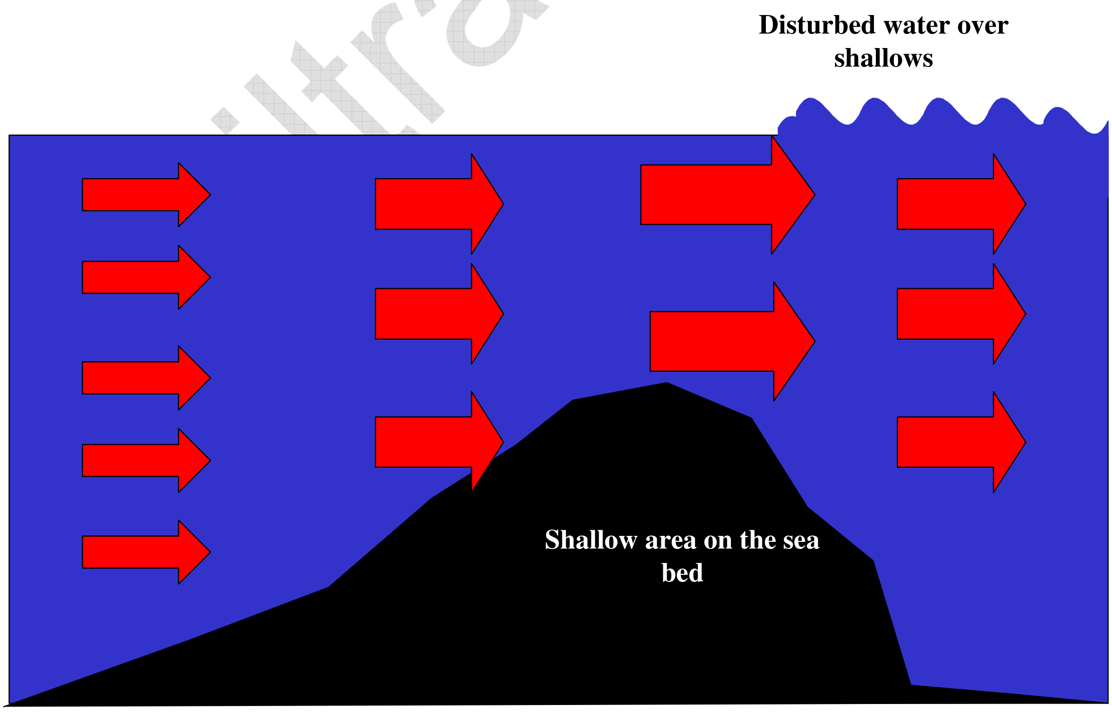
When the tide runs it can affect the sea-state and produce either calmer or rougher conditions that expected.

On Chart 1, there is a warning about the Race of Alderney, this is a potentially dangerous place, yet may small craft sail there every year. They can only do so by understanding the forces involved.
Tide races will occur anywhere that the speed of the tide is accelerated by a constriction, such as a headland or narrowing in the channel.





A similar feature is an area of **overfalls.**



Overfalls will occur when the tide flows over a shallow patch on the seabed, often this is within a tide race!

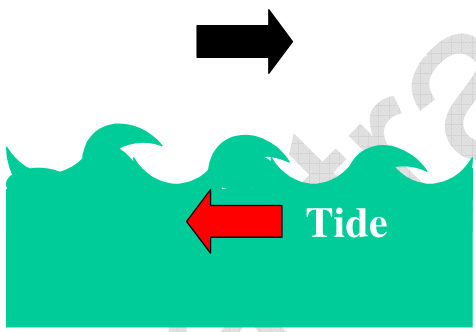
Tide races and over falls are marked by these symbols.

On Chart 1, find Alderney, you can see, there are several places with these symbols. Alderney causes a constriction to the flow of the tide and also there are several areas where the depth shallows considerably. At times the tide stream can reach 10kn for short distances close to Alderney, not a place to get your navigation wrong!

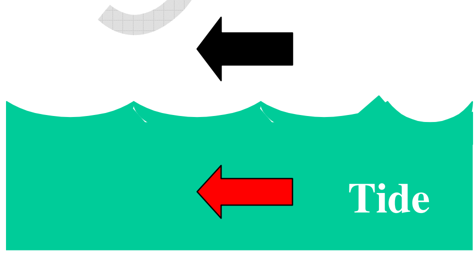
Wind and tide conditions

The direction of the wind relative to the tide will have a major effect on the sea state experience.

When the wind blows against the tide the waves become steeper and break, but when the tide turns the waves flatten and lengthen



Sea roughest with wind against tide.



Sea calmest if wind with tide.

giving much more pleasant conditions.

On top of this, the skipper needs to consider the effect of shelter and exposure to the wind direction. In an area like the Solent, the conditions in the Western Solent will be very different to the Eastern Solent when there is a strong southwesterly wind blowing.

Warnings of tide race and overfalls

We have seen two of the clues that there may be unusual tidal conditions in an area, either the symbols above or the warning given on Chart 1. Other sources of information are the Almanac and Yachtsmen's Pilot Books. Both of these give passage-planning information, and anyone venturing in to an unfamiliar area must read these publications.

Find page 34 of PNT. There is a section on the Alderney Race giving details of when it is best to pass through and when not to be there!

On page 15 of PNT, is information from a pilot book covering the entrance to Salcombe: This also gives details of tidal dangers.

In the absence of this sort of data the times to avoid tide races or overfalls are:

- In strong winds.
- When the wind is blowing against the tide.
- When the tide is at its strongest.

The safest times to pass through a tide race are:

- When the tide is slack.
- When the wind is with the tide.
- At least 5 miles offshore or very close in, but only if you know the waters.

Provided you follow these guidelines there is nothing to fear, and you will be able to be tied up in harbour before the sea-state becomes unpleasant or dangerous.

Tidal Heights

What is the height of the tide at a specific time?

So far we have only looked at the tabulated tidal information on the heights of the tide. This is fine if all we wish to know is the height if high and low water, but often you will need to know the height of the tide at other times of the day.

Turn to page 25 of PNT.

The curve that is drawn there represents the tide rising from low water to high water, then falling back down to low water.

At the bottom of the curve there are times before and after HW, so now you can see that at Plymouth the tide rises for nearly 6 hours and falls for just over 6. Compare this to the curve for Portsmouth on page 61.

The tidal curve for each **standard** port is very different in shape. You can see that the curve is not always even. There may be steep parts and flatter sections. Where there are two curves, a dotted one and a continuous one, these represent the pattern of the tide on neap and spring tides respectively. From the tidal range box you can see that the dotted line is for a neap tide.

If the range of the tide in question is not a spring or neap range, you can interpolate between the two lines by eye.

Standard Ports

For the tidal stream information we always worked with the data for Plymouth. Tidal heights are different; we need to use the information for the nearest port that is tabulated.

Around the coast are standard ports, these are harbours for which tide tables have been calculated, most are major commercial ports but not all.

To start with, the questions we will do, will all be based on standard ports, you must find the tide table for the port in question, there is an index at the front of PNT.

Turn back to pages 24 and 25 of PNT.

We are going to find the height of tide at 0538 on 6th May at Plymouth.

To use the curve you will need to know the times and heights of high and low water for the day in question.

I suggest that you lay your work out as follows:

May 6
Plymouth BST
0227 0.6
0838 5.3
1447 0.7
2055 5.4
Range is 5.3 - 0.6 = 4.7m therefore a spring tide.

The nearest high water to 0538 is 0835. Write 0838 in pencil in the box below HW on the diagram on page 25.

In the box for HW-1 enter 0738, and 0638 then 0538 in the HW-2 and HW-3 boxes respectively.

To enter the heights of the high and low water in the diagram, draw a sloping line from 0.6m on the bottom LW line up to 5.3m on the top HW line.

Back on the time part of the diagram, follow the line up from where you wrote 0538, until it cuts the tidal curve (we use the solid line, because this is a spring tide). Then using a plotter or ruler, draw a line left until you reach the sloping line you drew. Then draw a line from that point up or down to the depth scale. You should have a depth of 3.8m.

The height of the tide at 0538 BST is 3.8m.

What we have just done will be a small part of a bigger problem, so get in to the habit of laying the workings out tidily and labelling each number as you go, if you do not you will become very confused about what the numbers mean.

Can you now find the height of the tide at 1008 BST on May 6th?

First, the diagonal line we drew earlier must be erased. The new line must be drawn between a low water height of 0.7m and a high water height of 5.3m. This is because these two levels are the heights of the tides on either side of the time in question.

This is an important point later, when you are working with questions which involve finding the tide height at two different times.

Write in the times after HW. 1008 is HW+1 hour 30 minutes. On the time section of the diagram you will notice that each hour is broken down in to 10-minute sections. So finding 1 hour 30 minutes before high water is easy enough.

It is possible to be accurate to about 5 minutes with these curves. Remember, this is very different to when we found the tidal stream information, which covered an hour. With tidal heights we are working to the nearest minute!

Go through the same process as before to find the height of the tide at 1008.

The height of the tide at 1008 is 4.7m.

<u>Foreign ports and time zones</u>

So far we have only dealt with ports which are operating in UT and BST. However, if you go to France you will encounter a different situation, because of the time zones.

Look at page 51 of PNT, Cherbourg.

You can see in the top left the time zone information.
In all British ports the time zone is UT, but in all French ports it is -0100. This means that to convert the times on the tide tables to UT you subtract one hour.

For each 15° of longitude you travel to the east, the time zone changes one hour. In zone -0200 you would subtract 2 hours from the times in the table to find the correct time in UT.

Some questions may be in French Standard Time (the time in the tide tables for French ports), and some in French Summer Time.

If a question is in French Summer Time you will need to add one hour to the times from the tide table in the same manner as for a British port in the summer.

In practice many people keep the boat's time as BST when they are in France, if you are there for a weekend this is a sensible approach. However, local clocks will be one hour ahead, which may be a problem if you look up the lock opening times in a port like Binic (page 59, PNT), in the Harbour Master's office window.

So lets find the height of the tide at Cherbourg at 2132 French Summer Time on May 6th.

May 6
Cherbourg French summer time.
1827 1.1
0002 6.4
Range is 5.3m, therefore a spring tide.

2132 is HW-2 hours 30 minutes.

The height of the tide from the Cherbourg curve at 2132 is 4.6m.

Notice that the height graduations are in 0.2m units not 0.1m as in the previous questions.

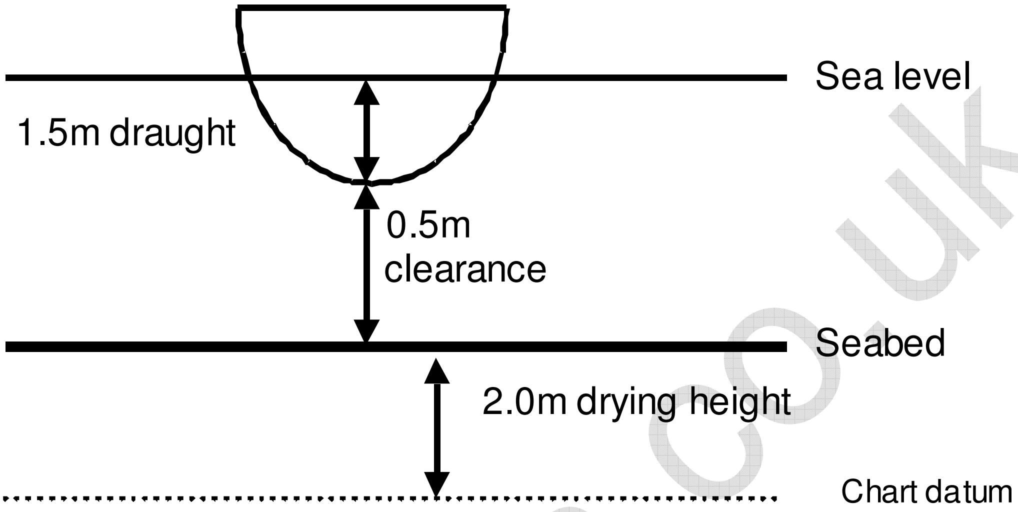
<u>What is the time when the tide reaches a required height?</u>

By this method you can find the height of the tide at any time of day, but sometimes we need to know when the tide will reach a certain height.

An example would be when there is a sandbank or bar that you need to cross to enter a harbour (like Salcombe). If the bar you need to cross has a drying height above chart datum of 2.0m. Your boat has a draught of 1.5m, but you wish to have a clearance below the keel of 0.5m, you need a height of tide of:

2.0m Drying height
1.5m Draught
<u>0.5m</u> Clearance
4.0m

With this type of question it is worth drawing out the information, some situations will be much harder to work out than this one.



Follow the working for the next example.

On a **rising** tide, on the **afternoon** of June 1st, when will the height of tide reach 4.0m at Falmouth?

June 1
Falmouth BST
1207 0.6
1744 5.2
0032 0.5
Range of tide is 4.6m, therefore a spring tide.

From the curve, the tide rises to 4.0m at HW-2 hours 10 minutes = 1534 BST.

When will the tide fall back to 4.0m again?

The tide will fall to 4.0m at HW+2 hours 40 minutes = 2024 BST.

Did you remember to re-draw the diagonal line for the new range of tide? In this example it did not make much difference to the answer, but sometimes it will.

Remember to draw out the information in the following questions, it will help you to see what it is you are trying to find out.

Anchoring in tidal waters

When you anchor, you encounter a slightly different problem. You need to ensure that you will stay afloat after the tide has fallen.

The whole key to this type of problem is to find the **fall** of the tide. That is the amount the tide will fall between the time that you anchor and low water. If you subtract this from the clearance you have under the keel when you arrive, the result will be the clearance at low water.

After you have done this, if you found that the water was too shallow it would be necessary to raise the anchor and move-not a good way to impress your crew!

A much better approach is to calculate the minimum depth in which to anchor now, to ensure that after the tide has fallen there will be sufficient depth left.

To do this, decide on the minimum depth at low water (draught plus the clearance), then add the fall of tide between now and low water. If you have this calculated before you arrive in the anchorage, you can motor around looking at the echosounder until you find a spot that is at the required depth or deeper.

Secondary ports

All the ports that we have dealt with up to now have been standard ports-that is ones for which tidal data is tabulated. However, most of the ports you visit will be secondary ports, at these ports you must calculate your own times and heights of high and low tide.

Turn to page 32 of PNT and look at the information for Brixham.

Brixham is a secondary port, so there is not a tide table for it, but under the title you will see written:

Standard Port Plymouth (←)

This means that Brixham is a secondary port of Plymouth, and to calculate the tide information you need to start at Plymouth. The standard port is always found in the almanac in the direction of the arrow.

Follow the layout below to find the tides for July 22nd. From page 24 in PNT:

July 2
Plymouth UT Note that we have left the times in UT.
0017 0.5
0623 5.4
1241 0.5
1844 5.7

Turn back to page 32 of PNT. Under Standard Port Plymouth is a table of figures.

Times				Heights			
HW		LW		MHWS	MHWN	MLWN	MLWS
0100	0600	0100	0600	5.5	4.4	2.2	0.8
1300	1800	1300	1800				
Differences BRIXHAM							
+0025	+0045	+0010	+0000	-0.6	-0.7	-0.2	-0.1

This table gives the differences for the times and heights of the tide between Plymouth and Brixham.

The times section is divided in to high and low water. The first two columns are the approximate time of high water on a neap tide and then on a spring (this is not always the case, sometimes they will be reversed). Thus, high water on a spring tide will be about 0600 and 1800, and on a neap approximately 0100 and 1300.

Below these times are the differences we need to apply to the data for Plymouth to change it for use at Brixham.

From the table, if high water Plymouth occurs near to 0100 or 1300, high water at Brixham will be 25 minutes later.

Conversely, if high water at Plymouth occurs near to 0600 or 1800, high water will be 45 minutes later at Brixham.

The low water conversion follows the same pattern. A low tide at 0100 or 1300 will give a difference of +10 minutes and for one at

0600 or 1800 there is no difference between Plymouth and Brixham.

This should be laid out as follows when you do the calculation.

Follow the layout below to find the tides for July 24th. From page 24 PNT.

July 2

Plymouth UT			Brixham UT
0017	0.5	+0010	0027
0623	5.4	+0045	0708
1241	0.5	+0010	1251
1844	5.7	+0045	1929

To find the height differences between Brixham and Plymouth you must compare the height of the tide at Plymouth with those tabulated for the standard levels of MHWS, MHWN, MLWN and MLWS.

Standard Port Plymouth (←)

Times				Heights			
HW		LW		MHWS	MHWN	MLWN	MLWS
0100	0600	0100	0600	5.5	4.4	2.2	0.8
1300	1800	1300	1800				
Differences BRIXHAM							
+0025	+0045	+0010	+0000	-0.6	-0.7	-0.2	-0.1

From this table, if the height of the tide at Plymouth is about 5.5m, it will be 0.6m less at Brixham. If it is 4.4m at Plymouth, the height at Brixham will be 0.7m less. The low water differences are found in the same manner.

This leads to the following:

July 2

Plymouth UT				Brixham UT		BST
0017	0.5	+0010	-0.1	0027	0.4	0127
0623	5.4	+0045	-0.6	0708	4.8	0808
1241	0.5	+0010	-0.1	1251	0.4	1351
1844	5.7	+0045	-0.6	1929	5.1	2029

The last step is to add the hour for BST, this is left until last because the times for the time part of the conversion are in the standard time of the port, in this case UT (in France it will be French Standard Time).

Although this is a long process, I suggest that you write down each stage as you go along. If you do not, it is very easy to lose track of what you are trying to achieve. This is especially important when you think that this is only one step of a larger calculation.

We will now do the same thing for Torquay (page 32 PNT) on 26th May.

May 26

Plymouth UT				Torquay UT		BST
0524	2.0	+0000	-0.2	0524	1.8	0624
1131	4.2	+0025	-0.7	1156	3.5	1256
1754	2.2	+0000	-0.2	1754	2.0	1854
2348	4.4	+0024	-0.7	0012	3.7	0112

Range is 2.2m, therefore a neap tide.

Because the real times of high and low tide at Plymouth do not match the ones given in the table, I have selected the nearest one when deciding which difference to use. Although this is not strictly accurate if the tide on the day in question is not a spring or a neap tide; it is accurate enough for our purposes. Later in the course we will look at how we deal with non-spring or neap tides in detail.

Now work out the following in full, and keep the answer, you will need it later.

Tidal height calculations at secondary ports

If you need to find the height of the tide at a specific time at a secondary port, the first step is to convert the standard port's information to that of the secondary. You can then do all the processes we have already covered, but you use the standard ports curve with secondary port's figures.

The only thing to remember, is that, when you decide if it is a spring or a neap tide, do so on the range for the standard port, obviously the range at the secondary port will be different.

Tidal heights in the Solent

In the Solent, many of the harbours experience a double high water. What this means is that the tide rises to high tide, then falls for about 1 hour before rising again to a second high tide. This makes the time of high water difficult to identify with any accuracy.

For this reason most of the secondary ports have their own tidal curve, but they are centred on the time of low water, because this is easier to identify. You use them in exactly the same manner as we have been, but we work from the nearest low water time.

The curves are found on page 62 on PNT.

You will notice one other difference. On the curve for Lymington and Yarmouth there are three curves, one each for spring and neap ranges plus another for a range between them. Obviously, you use the curve for the range nearest to the range on the day in question.

Non-spring and neap tides

Of course, most days the range of the tide is not exactly a spring or a neap range. In many cases the method of choosing the time or height that is nearest is to that for the day, is quite adequate.

However, as you become more skilled at navigation it is useful to be more accurate in your workings. So next we will look at how to cope with these mid range tides.

We will find the times and heights of high and low tide at Bray on June 10th.

June 10

St Helier UT	Braye UT
0140 9.0	
0755 2.9	
1346 8.9	
2028 3.2	

Range 6.0m, therefore a midway tide.

Standard Port St Helier

Times				Heights			
HW		LW		MHWS	MHWN	MLWN	MLWS
0300	0900	0200	0900	11.0	8.1	4.0	1.4
1500	2100	1400	2100				
Differences BRAYE							
+0050	+0040	+0025	+0105	-4.8	-3.4	-1.5	-0.5

A high water of 9.0m is between the two tabulated figures of 11.0m and 8.1m. Therefore the difference to apply for a height of 9.0m must be between -4.8m and -3.4m.

There are several methods of interpolating to find the correct difference to apply. However, you eventually need to be able to look at the table and interpolate by eye. You can not afford to spend a lot of time working out tidal heights, if you are at sea there are far more important aspect of running a boat to concentrate on.

The numerical difference between 11.0m and 8.1m is about 3.0m.

9.0m is about 1 metre higher than MHWN, 1.0m is about a third of the difference between MHWS and MHWN.

Therefore, the difference we select from the bottom line will be about a third of the difference between -4.8m and -3.4m. About -3.8m! The second high tide is very close in height, so the difference will also be -3.8m.

If you do not follow this, look at the diagram below.

11.0 10.9 10.7 10.5 10.3 10.1 9.9 9.7 9.5 9.3 9.1 8.9 8.7 8.5 8.3 8.1
-4.8 -4.6 -4.4 -4.2 -4.0 -3.8 -3.6 -3.4
^

Height of tide 9.0m, difference -3.8m.

We can do the same thing for the low water heights of 2.9m and 3.2m.

4.0 3.7 3.5 3.3 3.0 2.7 2.5 2.3 2.0 1.7 1.4
-1.5 -1.4 -1.3 -1.2 -1.1 -1.0 -0.9 -0.8 -0.7-0.6 -0.5
^ ^

This gives us a difference of -1.1m and -1.2m.

Standard Port St Helier

Times				Heights			
HW		LW		MHWS	MHWN	MLWN	MLWS
0300	0900	0200	0900	11.0	8.1	4.0	1.4
1500	2100	1400	2100				
Differences BRAYE							
+0050	+0040	+0025	+0105	-4.8	-3.4	-1.5	-0.5

A high tide time of 0140 is between the given figures of 2100 and 0300. Therefore the time difference to apply must be between +0050 and +0040 minutes.

By rounding 0104 down to 0100, this is two hours before 0300, or about one third of the difference between 2100 and 0300. Thus the difference to apply must be about one third of the difference between +0050 and +0040 minutes. About +0047 minutes.

In the same way the difference for high water at 1348 is about +0048.

For the low water times of 0755 and 2028 the differences are about +0059 and +0102 (0105 is one hour five minutes-not 105 minutes).

This gives us:

June 10

St Helier UT				Braye UT		BST
0140	9.0	+0047	-3.8	0153	5.2	0253
0755	2.9	+0059	-1.1	0854	1.8	0954
1346	8.9	+0048	-3.8	1434	5.1	1534
2028	3.2	+0102	-1.2	2130	2.0	2230

Range 6.0m, therefore a midway tide.

Tidal levels on charts

Earlier in the course we looked at the tidal levels box on the charts. This table records the levels of MHWS, MHWN, MLWN and MLWS at important points on the chart.

This information allows us to make a guess as to whether it is possible to pass over a bank or under a bridge at the times of spring or neaps.

Using Chart 1.
What is the depth of water over a bank that dries 3.0m at Looe?

MHWS Looe	5.4m
Bank dries	3.0m
Depth	2.4m

What is the depth over the same bank at MHWN?

MHWN Looe	4.2m
Bank dries	3.0m
Depth	1.2m

Very quickly you can see that you may be able to cross this bank at springs, but it would not be advisable at neaps. At least you can make a decision as to whether it is worth working the heights out more accurately.

This can be very useful in some of the Brittany ports; some can be entered at springs. Then, over the next few days the level of high tide drops off enough that you can not leave. You may end up being stuck until the next spring tide! This is known as being **Neaped**.

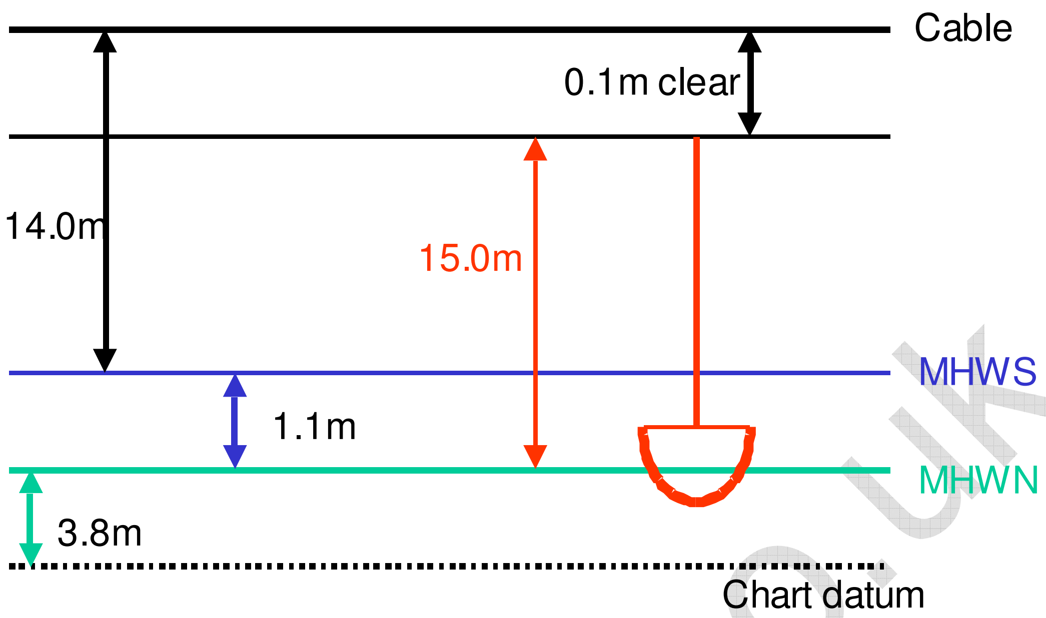
Air draught

The height of a vessel is known as its air draught. If you plan to pass under a bridge or electric cable you will need to know your air draught and how to calculate if you will clear the obstruction.

On Chart 2, there is a cable across the River Dart at Stoke Gabriel. The symbol next it means that the clearance is 14.0m above MHWS. If your boat has a mast height of 15.0m, what will be the clearance at MHWN?

MHWS Dartmouth	4.9m
MHWN Dartmouth	-3.8m
Tide level below MHWS	1.1m
Wire height above MHWS	+14.0m
Wire height above the water	15.1m
Mast height above water	-15.0m
Clearance	0.1m

Not enough! See the illustration below, it may help to draw one like this as you work out each part of the question.



Further up the River Dart at Tuckenhay, there is another cable. This symbol is different because this is the safe electrical clearance below a high voltage cable. With these it is not enough just to clear the cable. There is a risk of current arcing from the wire to your mast: it is not safe to just judge by eye if your mast will clear the cable!

Whenever you pass under a bridge, it always seems very close to your mast, even when you have worked the heights out; it can still be a scary experience passing under a bridge for the first time.

The twelfths rule

This is a short cut to working out the height of the tide, which can be useful. It works on the principle that the tide rises or falls to a regular pattern and is effective in areas where the tidal curve is smooth and preferably where the periods between high and low tide are 6 hours.

A good example that fulfils these criteria is St Peter Port on page 38 of PNT; a port where it would not work well is Portsmouth on page 61.

To use the rule you need to find a twelfth of the range of the tide, then apply it as follows.

HW 1200 5.2m
LW 1800 0.4m
Range = 4.8m, therefore 1/12 is 0.4m.

The tide would fall to the following pattern:

1200			5.2m
1300	-1/12 of range	-0.4m	4.8m
1400	-2/12s of range	-0.8m	4.0m
1500	-3/12s of range	-1.2m	2.8m
1600	-3/12s of range	-1.2m	1.6m
1700	-2/12s of range	-0.8m	0.8m
1800	-1/12 of range	-0.4m	0.4m

This can be a very useful quick method of estimating the height of the tide; it is not very accurate in the Solent.

Passage Planning and Making

Preparation.

Before you start to plan any passage, there are certain factors that should be considered, they can be broken in to two areas:

(1) Crew considerations.

(2) The boat and its equipment.

(1) Crew considerations.

The weakest link in any passage is frequently the crew. A safe skipper will consider the following points in relation to the crew and expected voyage.

■ Their experience.
Ideally, the experience and skills should be spread widely amongst the crew. Many yachts are run so that the skipper is the only one on board who really knows what is happening and how to deal with all the complicated jobs aboard, such as navigation, VHF radio use, and boat handling under power. In this case, if the skipper is disabled, the crew has little knowledge to draw on to bring the boat to port safely.

One of the aims of the skipper must be to train and trust the crew to perform all the tasks that the skipper can. Obviously, this will take time but any opportunity to pass on skills and knowledge should not be missed. You may think that if the crew can do the tasks the skipper has been doing, that there is nothing left for the skipper to do, this is not the case, the skipper will find that he is able to work at a higher level, and plan further ahead.

I always think that the best skippers are those who do not appear to do anything-but the boat runs smoothly and nothing goes wrong. This only happens when the crew is well trained and the skipper is planning ahead!

■ Health.
Consider the health of the crew before any passage. If you are undertaking a long voyage that will be some days from medical

assistance, this could be vital. However, the stresses of sailing, especially in rough weather could also trigger problems for anyone suffering from a heart condition, diabetes or epilepsy.

■ Seasickness.
If a crew is prone to seasickness they may become a liability in rough weather and just add to the skipper's workload. This does not mean that you should not take them to sea, it just requires some prior thought.

Factors that increase the risk of seasickness are:
- Sailing in the open sea early in a cruise.
- Rough weather.
- Sailing to windward or straight down wind.
- Long passages (people are rarely sick if at sea for only 2 hours).
- Working on the foredeck.
- Going below (cooking, navigating or using the heads).
- Eating and drinking too much the night before.
- Stress.
- Diesel or other smells below.

A prudent skipper will consider the passage plan in the light of these factors and modify it as appropriate for the crew.

■ Crew desires and expectations.
To run a happy ship it is a good idea to ask the crew what they expect and would like to do, people's expectations vary a huge amount! Some people are happy changing a headsail on the foredeck in a force 7, others idea of a good cruise, is a trip to as many public houses as possible!

■ Crew compatibility.
On a small boat in bad weather conflicts between crewmembers can ruin a cruise. Try to find a crew where everyone is able to work together.

(2) The boat and its equipment.

The following factors should be considered when planning a passage:

■ Suitability of the craft.

Not all vessels are suitable for all passages; the skipper must consider the size and type of boat.

- State of maintenance.

Sailing a vessel that has been poorly cared for can be very stressful as well as dangerous. Frequently, one small fault leads to another until a major problem has developed.

- Consumable supplies.

Are adequate supplies aboard and where can they be replenished? This list includes: Food, water, fuel and gas for cooking.

On a power driven vessel, or if there is little wind, the skipper must have a good idea of the fuel consumption and likely range at different speeds and conditions.

- Equipment.

Does the vessel have suitable equipment aboard?

  - Safety equipment.
  - Tools.
  - Navigation, charts, pilots, almanac etc.
  - Domestic equipment.

Detailed planning

Planning a passage should start with some basic research, after all, there is no point in planning a voyage, and only to discover that you can not enter the harbour you planned to visit because it is too shallow!

This research should cover the following basic points:

(1) Is the weather suitable?
(2) Are there any restrictions on leaving the homeport?
(3) Are there any restrictions on entering the port of destination?
(4) Are there any restrictions on route (shallows or hazards)?
(5) When will the tide be in our favour?

(1) Weather.

The weather forecasts must be studied for several days before the voyage begins, it is not enough to turn up on the first day and get the current forecast. If you do this, you will not have a feel for how the patterns are moving through.

Specifically, we are looking at:

- Safety.

Is it safe to make the planned passage in the forecast conditions?

- Boat speed.

Wind force will obviously influence boat speed, especially in a sailing vessel, but the direction will also make a big difference to speed and comfort.

In a power driven vessel, the wind over tide conditions may become a major factor in planning. A high speed planing craft will travel at perhaps 30 knots when the wind and tide are together but only 10 knots when they are opposed.

- Visibility.

Will the visibility be suitable to make the passage? Factors which will reduce the visibility are, fog and mist, heavy rain, snow and even sand storms!

- Comfort.

How comfortable will the passage be? When people attend sailing courses at a school they will be sailing in virtually any conditions. If you are on holiday, you or your crew may not wish to sail when conditions are unpleasant.

I recently sailed a boat to Northern Spain from the South Coast for a Yachtmaster Ocean course. The passage was to windward in winds from force 5 to 8, and whist it was good experience for the students. It could not be described as enjoyable!

A few days after we arrived in Spain, many other British vessels began to arrive, they had waited then left after the wind had changed direction, and had a very pleasant crossing. If you are on a long cruise, it may pay to wait for the right weather to start.

(2) Departure restrictions.

There is no point in planning a passage if you can not leave port when you need to. Restrictions may be caused by:

- Lock gate operating times, not all locks are 24 hours.

- Entrance too shallow, many harbours have a bar or are closed by a sill. See page 54 of PNT, Granville.

- Will the tide rise sufficiently? Some harbours are not accessible at neap tides. See page 59 of PNT, Binic.

- Ferry traffic may delay departure. In busy harbour like Calais or Dover, it may be necessary to wait over an hour to be given a departure slot, as there is so much commercial traffic.

- Some harbours are not accessible in the dark, as they are unlit.

(3) Arrival restrictions.
Any of the above may apply.

(4) Passage restrictions.
Is the passage in deep water or are there any areas that we must pass through with sufficient rise of tide?

Are there any sections that can only be crossed in daylight?

(5) Tidal streams.
When do you need to leave to make optimum use of the tides? On a short trip, it should be possible to make the entire passage with the tide. However, on longer trips it may be necessary to sail against the tide, it makes sense to do so in places where the tide will be weakest.

The tide will be weakest in bays and strongest off headlands. In an area of very strong tidal streams, such as a passage from Cherbourg to St Malo, it may be necessary to anchor for a few hours in a bay off Sark.

<u>Where to start?</u>

No two passages are the same and only experience will tell you which information is required before setting off. Obviously, having a suitable weather forecast is of primary importance, and this is the first place to start your planning.

Once you have decided that the weather is going to be suitable for the passage that you wish to make, the next step will always revolve around tidal information. The important factor is the **tidal gates.**

A tidal gate, is a tidal element that has to be passed through between certain times: They are either related to the tide height or flow.

- An example of a gate caused by a tidal height, would be the bar at the entrance to Salcombe harbour.

We have already dealt with this in the pilotage sections, and when calculating tidal heights.

- A gate caused by the tide flow, is the period when the tide is flowing in the required direction.

To find the period of favourable tide we normally use the tidal stream atlas, filling it in with the times of the tides for the whole day.

If we wish to make a passage from Falmouth to Fowey on 28th August in daylight, we would start by looking up the tidal information for Plymouth for that day.

28th August
Plymouth BST
0603 5.4
1222 0.6
1823 5.7
0049 0.3
Range = 4.8m therefore a spring tide.

High water in the morning is 0603BST, so on the diagram for HW Plymouth, on page 7 of PNT, we would write, 0533 to 0633.

This period covers the hour from half an hour before to half and hour after high water Plymouth.

We then need to fill in the diagrams for the hours before with the correct times, then do the same for the times after HW Plymouth (use page 8 as well).

By observation, the tide first starts to run from Falmouth to Fowey, 1 hour before HW, or 0433 to 0533. Therefore, the earliest the tide would be in our favour is 0433BST.

The latest the tide is in our favour is 4 hours after HW, or 0933 to 1033. Therefore, the latest time to arrive at Fowey is 1033BST.

Our tide gate is 0433 to 1033BST.

We can also do this for the later time of HW; this gives us the tide gate as being between 1653 and 2253BST.

Neither of these options is ideal, the choice depends on how much you like an early start!

- Preparation time.

An important factor to allow for is the time it takes to get from your mooring to outside the harbour and sailing. Even in a small harbour it will take about half an hour to clear the harbour, in Falmouth it may take an hour as the moorings are some distance from the entrance.

If the time available to make the passage leaves little room for delay, this preparation time must be allowed for. A similar period may be required at the destination!

In the morning, at a normal rate of activity, allowing for boat checks, breakfast and visits to the ablutions, most crews will take between $1^1/_2$ and 2 hours to go from their bunks to sailing. Alternatively, most crews can be up and ready in 10 minutes, if everything is prepared and breakfast is eaten underway!

- Daylight.

For this passage I would probably choose to catch the tide at 1653BST, this would require casting off the mooring at 1550, at the latest. For most people, this would give a more enjoyable trip than casting off at 0330BST!

We would need to be arriving off the entrance at 2250BST, so it would be dark, but most of the passage would have been in daylight. We should be moored or anchored by 2330BST.

In fact, the passage is about 20 miles; at an average of 5 knots, we should arrive about 2100 and be moored by 2130. In plenty of time to visit the pub!

Entering a harbour in the dark is probably the hardest part of skippering a boat, even more so if it is one with which you are not familiar. A factor to consider is whether it is better to leave a harbour in the dark, then arrive in daylight. If the destination is particularly difficult, this may be the deciding factor.

In an area where there are no lit marks and numerous hazards or for anyone with little experience (basic Dayskipper level), the hours of daylight should be considered to be the limits of passage making.

The skipper should always know how long the tide gate will be open, and constantly checking the vessel's progress against the distance and time remaining.

It is very unusual for a passage to proceed as planned, if you are not going to make the next tidal gate you must know in plenty of time. This allows the skipper to decide:

- To carry on, but arrive much later than first planned.
- To speed up the boat (sail change or engine).
- To change the destination.

Not making the tidal gate must never be a surprise!

Ground track and distances.

The next step is to draw on the chart the required ground track. As this is done, we need to look for any navigation aids, that may help and for any hazards on or near the route we plan to take.

For a daylight passage from Salcombe to Dartmouth, we will start from the leading line over the bar at Salcombe.

The first hazards are the tide races and overfalls at Prawle and Start Points.

To avoid them we will plot a track of 135°M from the Bar for a distance of 2.8M. Then, 085°M for 5.3M.

This clears the overfalls. A track of 018°M for 4.0M will take us to the unlit red buoy; this clears the Skerries Bank.

A course of 012°M for 3.5M will bring us to the buoys at Dartmouth entrance.

■ Course to steer to allow for the tide.
These tracks are over the ground; we then need to consider if we need to work out a course to steer to allow for the tide. If a course to steer calculation is required, we only do the first leg of the passage, the others should be calculated just before they are required. In this way, the information for boat speed and tide will be as accurate as possible.

We may also choose to place a waypoint in the GPS for each of these turning points, this would make this passage very simple!

■ Clearing lines.
At this stage, it would be prudent to put some clearing lines on the chart to ensure we clear the tide races.

Assuming good visibility, a bearing of 083°M or less on the south end of South Coombe Island will clear the rough water.

A bearing of 017°M or less on the daymark east of Dartmouth would ensure we clear the eastern end of the Skerries Bank (in practice this may not be visible, in this case the eastern edge of the land may well be clear).

These clearing lines are our back up system; they act as a check to our course steered.

■ Aids to navigation.
We may also think about what we will see that may help us fix our position. In an unfamiliar area we may not see these marks but it is useful to have some prepared.

We may see:
Start Point Lighthouse.
Skerries Point Lighthouse.
Radio masts at East Prawle and Start Point.
The Old Lighthouse on South Coombe Island.
Churches at Slapton, Strete and Stoke Flemming.
Day Beacon at Dartmouth.

We will pass the red unlit buoy on the Skerries Bank.
In addition, the red and green buoys at Dartmouth entrance.

- Hazards on route.
  - Salcombe bar.
  - Overfalls at Prawle and Start Points.
  - Skerries Bank.
  - Rocks near Dartmouth entrance.
  - Commercial traffic in Dartmouth.

Pilotage plan.

We now need a pilotage plan for leaving harbour and arrival. It is easy to forget that getting out of a harbour can be just as difficult as arriving. Remember that it will look completely different going out.

If possible it as a good idea to have a look outside the harbour so that you have a good picture of where you will be heading in the first few minutes. The start and end of passages are often the most difficult, equipment is being stowed, sails going up, there is lots of traffic and usually there is limited space to manoeuvre.

Recording the plan.

A clear record of all this information needs to be kept where it will not get lost. Writing it on the blank pages of the logbook is one approach, another that works well, is to have a hardback notebook to keep details of passage plans.

Cross channel passages.

When we sail longer distances we start to encounter different problems.

■ Cross channel tides.

The first cross channel voyage for many people is from The Solent to Cherbourg. This is a good choice because the arrival is straight forwards and the facilities good once you are in harbour.

The special factor with this trip is that the distance is 60M from the Needles to Cherbourg, at an average speed of 5kn, the passage will take 12 hours.

In theory, a 12-hour passage means that the tides cancel out. In practice, the tides on the French side are always the strongest, and so an offset has to be allowed for.

We normally do this by calculating the total east and west going tides, subtract one from the other, and the resultant is the distance we will be offset.

Hour	West tide.	East tide.
1st	0.5M	
2nd	1.2M	
3rd	2.5M	
4th	2.6M	
5th	1.3M	
6th	0.4M	
7th		1.0M
8th		2.1M
9th		3.2M
10th		3.0M
11th		2.8M
12th		1.0M
Totals	8.5M	13.1M

Result 13.1-8.5= 4.6M to the east.

We could work out a course to steer for an offset of 4.6M. In practice this is quite difficult, the triangle would be 60M on one side and only 4.6 on the other, difficult on the average chart!

One approach is to draw it on an Admiralty tidal stream atlas; it works because they are to scale.

An easier method relies on the fact that a course change of 1° over a 60M distance changes the position of the end point 1 Mile. So if we measure the Track as being 180°M, for a tidal offset of 4.6M, we could steer 185°M and this would allow for the tide!

Aiming off
As it is difficult to be certain how long a passage will take it is prudent to aim off to one side of the destination. The two factors to allow for are:

- The tide.
- The wind.

Ideally, we want to be up tide and upwind of the destination, then as we get closer and the ETA is more predictable, to close in towards it, using the wind and tide to carry us to it.

If the wind and tide are contrary, it is often better to be up tide, and sail against the wind for a short distance. The skipper would have to judge this for each situation.

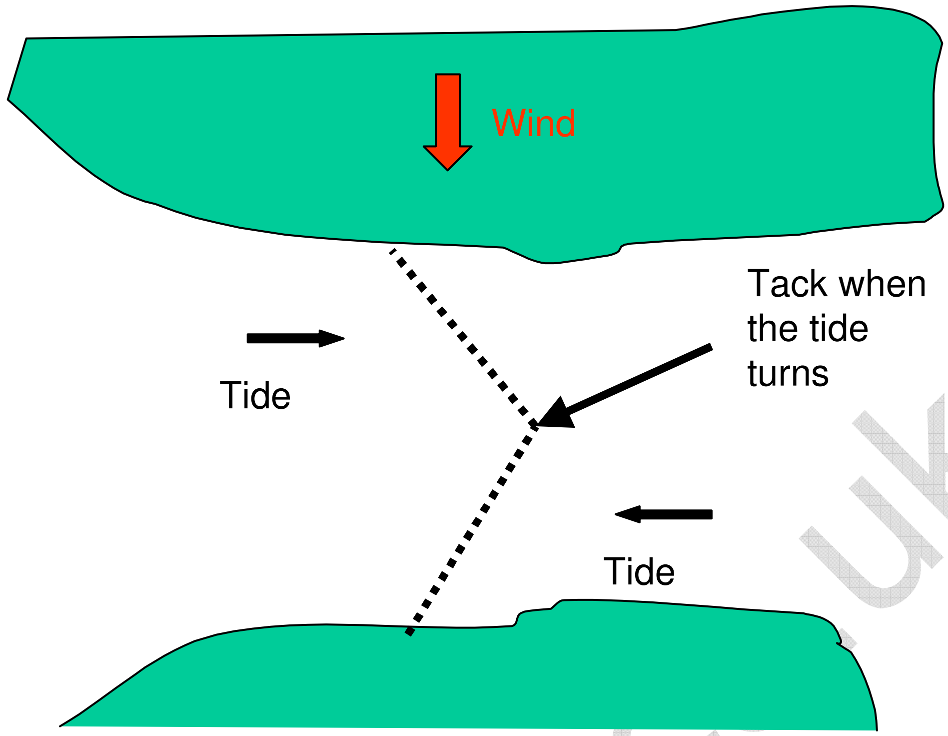
Beating.
Planning for an upwind leg is very difficult, especially in regard to how long it will take. As you gain experience with a particular boat, it becomes easier.

With novice crews I usually double the distance to the destination, with experienced helmsmen adding 50% is usually sufficient.

- Lee bowing the tide.

A concept that is useful to know about, is that of **lee bowing** the tide.

This means that if you are beating across the Channel you arrange to tack at the turn of the tide. The intention being, to have the tide on the lee side of the vessel.



This decreases the angle between tacks and improves the apparent wind.

If this is done it will reduce the crossing time to the minimum possible.

In practice, it can be very hard to arrange for this to happen exactly as described, but it is a factor that an experienced skipper should consider.

Bolt holes.
Any voyage may need to be cut short for a variety of reasons ranging from, the boat going too slowly to make the passage in the allotted time, to some sort of disaster or injury to the crew.

With this in mind part of the plan should be to consider what the options would be if a change of plan is required. The skipper must have this information available to assist with making changes to the plan. If this aspect is forgotten, it will be very difficult to make the best decision in an emergency.

Factors to consider are:

- The accessibility of the harbour. Are there tidal restrictions and does it have an all weather entrance? Cherbourg is a good example of a harbour with 24-hour access. It can be entered no matter how bad the conditions.

- The facilities available. If you need some emergency repairs, will suitable services be easily accessible? If you were cruising in the Channel Islands and needed some repairs, St Peter Port would be better than St Malo for a British vessel because all services are available; they speak English and if necessary the crew can take the ferry home.

Part of the passage plan should be to prepare a pilotage plan for any boltholes on the way.

It may be that the only boltholes are the port from which the vessel departed, or the destination. If a boat is sailing from Alderney to Cherbourg, the only sensible options are to return or carry on. If the vessel had travelled more than a few miles, the only option would be to continue, because it would not be able to return against the tide!

Forecasts.
When you travel to an unfamiliar area, it is a good idea to make a list of all the weather services available and place it near the chart table. The almanac is a good source of this information, but it is not always easy to find it. Page 4 of PNT has some weather services listed, with their times and frequencies.

In addition to these, a Navtext receiver can be invaluable when abroad. The broadcasts are printed out in English and they have a greater range than VHF radio.

Even cruising in Southern Ireland, I found the navtext service valuable, for the first week I was there, I could not understand the accents on the radio, and I did not know the locations of the headlands they gave as the limits of the different forecasts. Seeing this information printed out meant I could spend time finding the area concerned!

HW Plymouth is 1130BST. HW St Malo is 1300BST. HW St Helier is 1230BST.

Customs and paperwork.

Travelling from one country to another by yacht, in the European Union is very simple. Provided the crew are EU citizens and you are not carrying prohibited goods you are essentially free to come and go as you wish.

The Channel Islands and the Canary Islands are not part of the EU and when visiting these places it is necessary to obtain and complete a customs form. These can come directly from a customs officer (if you can find one!) or most marinas on the south coast hold stocks of them. When completed with the details of the crew, destination and return date, this form can be posted in one of the blue Customs and Excise boxes found in most yachting harbours.

On returning from a non-EU country, it is necessary to contact the customs and give the details of your voyage. In practice, the numbers listed in the Almanac are for answer-phones, and it is very unusual to speak to a person.

- Flags.

On arrival from a non-EU country (including the Channel Islands), a vessel should fly a yellow 'Q' flag until cleared by a customs officer.

When arriving in a non-EU country, a 'Q' flag should be flown, until customs formalities have been completed. This applies when travelling from one Channel Island to another. In some countries it is a requirement to arrive at specific harbours to clear Customs.

When in a foreign country, a vessel should display a **courtesy flag** on the starboard signal hoist. A courtesy flag, is a small version of the countries national flag.

- Other papers.

For a vessel to travel abroad it must be registered, either as a British Ship or on the Small Craft Register, and the registration documents carried.

Evidence of the vessel's insurance and VAT status may be requested in some countries.

■ Passports.
Even in EU countries, passports should be carried be everyone.

■ Qualifications.
There are many debates about required qualifications. In most cases, they are only compulsory if you visit inland waterways. However, if you have skippering or radio qualifications, it is prudent to carry them when abroad. An International Certificate of Competence is usually sufficient for most purposes, even for a qualified Yachtmaster; it is worth obtaining this certificate.

Up to date details concerning all of the above, especially regarding specific countries can be obtained from the RYA.
RYA House
Romsey Road
Eastleigh
Hampshire
SO50 9YA 02380 627400

Passage making

Making a passage brings together all the planning, pilotage and navigation aspects we have dealt with so far. Every passage will be different and there is no correct way to make a passage.

The guidelines are:
- Can you put an accurate position on the chart quickly?
- Is the direction you are heading in safe?
- When will you arrive at the next turning point?
- Will you make the next tide gate in time?
- Is the crew going to remain in a suitable condition to run the vessel?
- What is the weather likely to do during the rest of the passage?

■ Position.
Whist it is not essential to know exactly where the vessel is, you must know that you are in safe water and your approximate position. You should also be able to plot a fix or EP if required.

Plotting an EP means that the logbook should be up to date, and the last entry no longer than 1 hour ago.

- Heading.

The navigator should be constantly checking that the direction the vessel is heading is correct and that it will remain in safe water for a known period of time. On a short trip, this may just require looking at the course over the ground function of the GPS, on a longer leg reference must be made to the future tide and wind direction.

- Next waypoint.

Knowing when you will arrive at the next turning point makes planning easy. With the waypoint function of the GPS, these are ready calculated, but do not place too much faith in it. The time to go function will vary as the boat speed changes.

Without GPS, the navigator must be comparing the distance to go with the speed over the ground for the previous few hours to calculate the next ETA.

- Next tide gate.

Obviously, the arrival time at the next tidal gate is of primary importance to the navigator.

- The crew.

The yacht should be organised in such a way, that if necessary the voyage could continue indefinitely. It is easy to put off rest or eating on the assumption that you will be in harbour in a few hours, only to find that for some unforeseen situation you will be at sea for an extra 12 hours!

I try to run a boat on the belief that I am at sea, until I get in, not until the time I had planned to get in to harbour!

Where possible, proper meals should be served up, if this is not going to be an option because of bad weather, sandwiches could be prepared before departure (making sandwiches underway is harder than cooking a meal).

On any passage over 10 hours, a watch keeping system should be planned and adhered to. This may be as simple as people taking a couple of hours below in the middle of the passage, or one of the more formal systems may be required.

An ideal watch system is 3 watches, each taking 4 hours on watch, 8 hours off. One of the off watches does the catering and domestic care of the boat. However, not many pleasure yachts have a large enough crew for this system.

A workable system on a yacht with a small crew is 3 hours on duty, then 3 hours off. If you do this, for the first three days you will be exhausted, after 3 days, your body will adapt.

The minimum period to be off watch should be 3 hours, this allows for a decent rest once you are below and out of your sailing clothes, then time to get ready again before going on deck again.

Ideally, a watch system should roll over so that people are not always on watch at the same time of day every day, it is not much fun always being on watch between 0000 and 0400!

The person who must get plenty of rest is the skipper. It is easy to think you are indispensable and that you must be on hand to deal with any problems. If you do this, you may find that at the critical point at the end of the voyage, you are too tired to make good decisions.

The skipper sometimes has to be a little selfish, and ensure they are well rested!

A little planning can make it much easier for the skipper to go off watch. All passages have difficult parts and easier sections. The skipper should be off watch in the easier parts.

For the passage in Question 5, from Plymouth to St Peter Port, the difficult parts would be:

- Leaving Plymouth.
- Crossing the traffic lanes in the area of EC'A' buoy.
- Approaching and traversing the Alderney Race.
- Approaching Guernsey and the last 7 miles.

When the skipper goes off watch, firm instructions must be left with the crew on deck about when to call the skipper. If this is not done, many people will leave calling the skipper up on deck until it is too late.

Depending upon the experience of those on deck, these instructions may include calling the skipper when:

- The boat can no longer steer the required course.
- The speed falls below a set limit.
- The visibility deteriorates.
- Any other vessels appear on the horizon.
- The wind increases above a certain speed.

I also tell the crew, that I want to be called in enough time to do something about other traffic, not just in time to be a witness!

With a well trained crew, they should be capable of being left to make most of the decisions above, but until you know their abilities, it would be foolhardy not to leave some instructions about when to be alerted.

Before the skipper goes off watch, he must know that the course for the next few hours is safe and that it will place the vessel in the correct position when the tide and weather are allowed for.

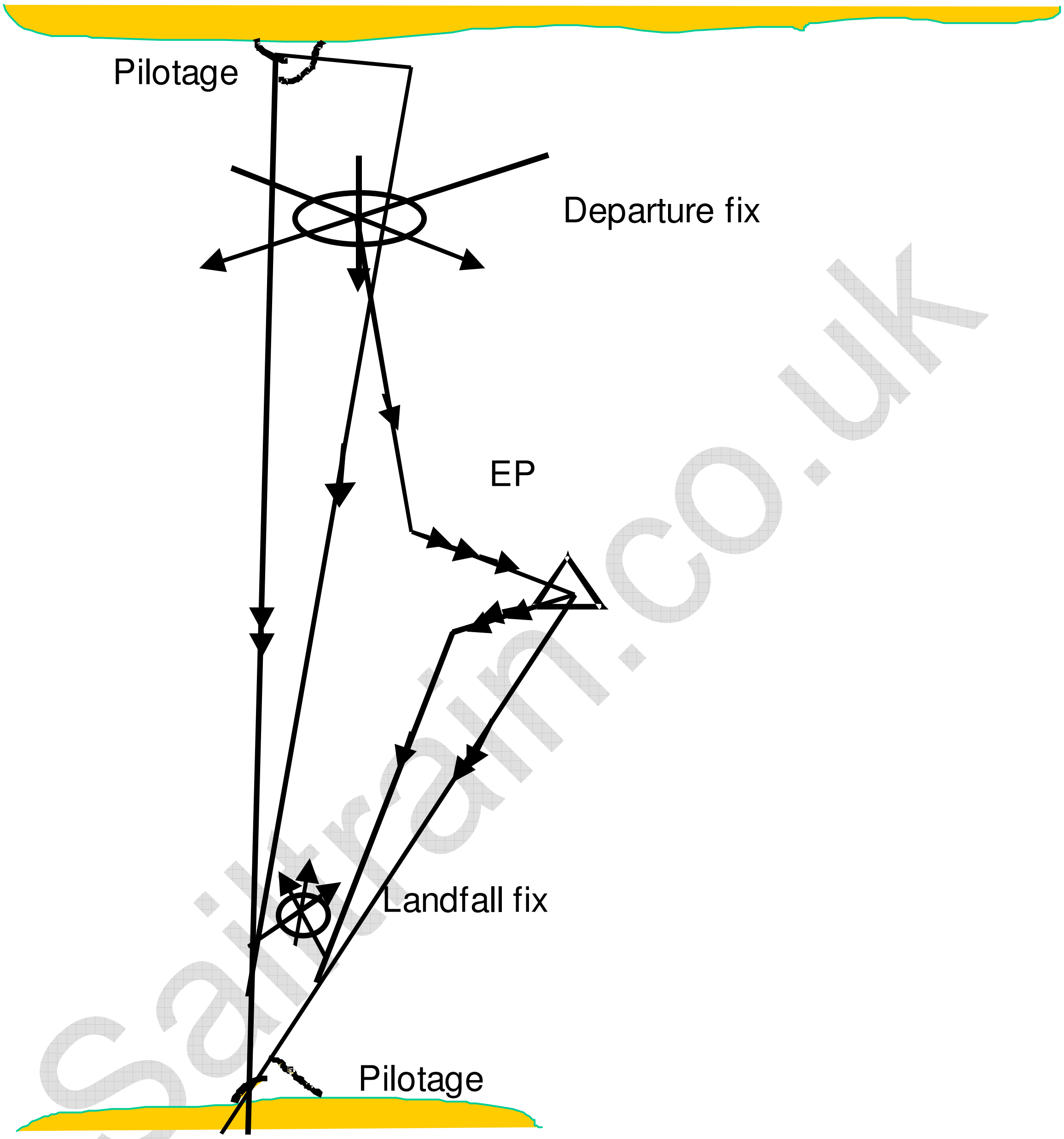
- Weather.

Once on a passage it is easy to forget to monitor the weather. The minimum is to record the barometric pressure at hour intervals. Ideally, forecasts should be followed in case of any unexpected changes which may force a change of plan.

Navigation.
The pattern of navigation on a long open water trip follows the following format.

- Pilotage out of harbour.
- A departure fix, as land disappears.
- A course to steer to the destination.
- Hourly EPs plotted.
- Each time the distance to the destination halves, recalculate the course to steer and ETA.
- When land is sighted, plot a landfall fix.
- Course to steer to the destination.
- Pilotage in to harbour.

In practice, many people rely on the GPS to give their position instead of plotting EPs. If you do this, it is a good idea to still plot an EP each hour; this will act as a check and keep you in practice for the day when GPS is not available.



Even with GPS, you will still need to monitor the course to steer and ETA's, as most sets will not do this for you.
This is the pattern of navigation activity on an open water passage. Obviously, not all the information would be left on the chart at the same time.

Seamanship

Ropework

Knots

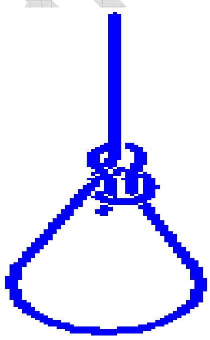
There are a few knots that anyone going to sea will need to know. They require practice until you can tie them in the dark when sailing along!

It is essential to not only know the knots but when to apply them, a good knot is one which can be untied easily but will not come undone when required.

- Figure of eight.

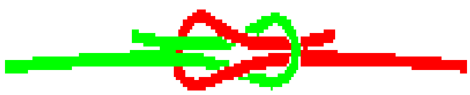
Normally used as a stopper knot to prevent the rope end pulling through a fitting.

- Bowline.



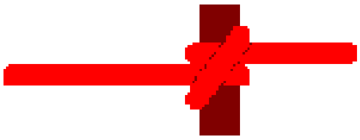
Gives an adjustable but non-slip loop in the end of the rope, has many uses from mooring to tying a bucket to the boat.

- Reef knot.



Used when you need to join two ropes of equal diameter, especially for sail ties around the main sail of to hold a reef in.

- Clove hitch.

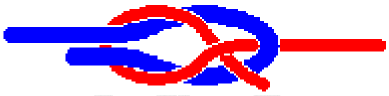


Ideally should be used when there is an even pull on both ends of the rope, such as when used to lash the tiller amidships. Is often used for fenders but in this situation, it may slip through unless an extra half hitch is tied round the rope.

- Round turn and two half hitches.

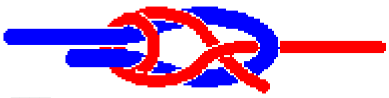
This knot can be tied and untied under load. Because it is adjustable as it is tied, it is a good knot for fenders or mooring, provided the tail end long enough.

- Sheetbend.



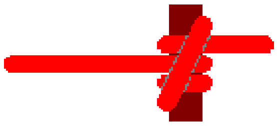
This is used to join two ropes of unequal diameter but works best when the knot is kept under load.

- Double sheetbend.



To prevent the knot slipping through when not loaded it is advisable to use a double sheet bend.

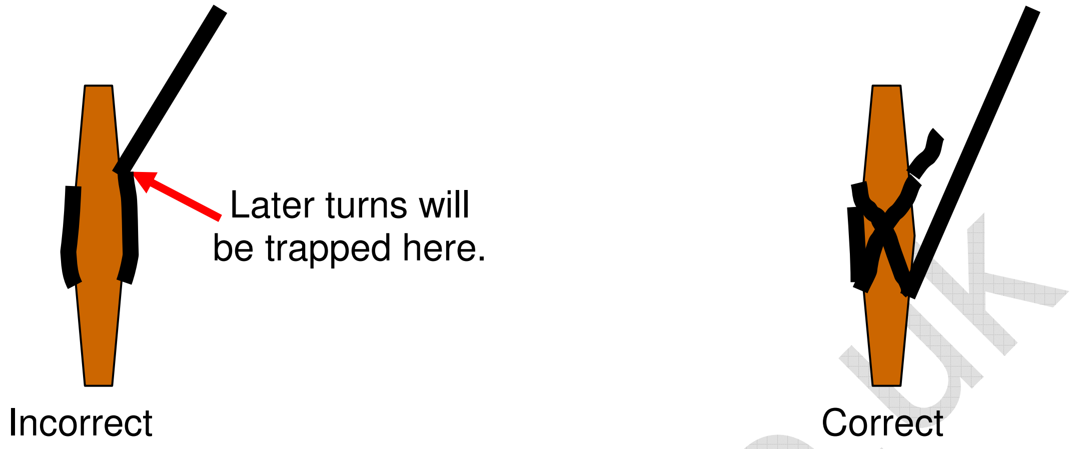
- Rolling hitch.



This knot can be tied to a thicker rope that is under load, it will then allow you to pull along the thicker rope. The classic use for this is to clear a riding turn on a winch. It is tied to the sheet ahead of the jammed winch; the tail is then run back to another winch and pulled tight. The sheet should then loosen on the winch and be capable of being freed off.

Fastening a rope to a cleat

When winding a rope around a cleat, there is a correct end of the cleat to take the rope to.



The rope should always run to the furthest end of the cleat, this ensures that the loaded rope does not trap the next turn.

The first turn should go right round the cleat, then be followed by two figure eight turns and finally once more right round. This can be summarised as finishing the rope with an **OXO.**

- Locking hitches

It is common practice to put a locking hitch on the last turn, although there is nothing wrong with this, there are problems associated with using locking turns on cleats.

The problem is that if there are not sufficient turns round the cleat, the load will pull the lock tight. This often happens when inexperienced people copy what they have seen done, but all they do is put locking turns round the cleat with no OXOs.

That is the reason most training organisations do not use locking turns. However, if you are leaving a boat for any time, it is probably prudent to finish off the mooring ropes with a lock-after the OXOs!

Types of rope

Ropes are made of different materials. Each of these materials has different characteristics, making them more suitable for some tasks.

- Nylon

The main quality that nylon has is that it stretches under load. This makes it very suitable for anchoring, mooring and towing; all situations where the rope is subject to shock loading. If the rope could not give to the shock, it would snap.

- Polyester or Terylene

Polyester ropes do not stretch. Ropes used on the running rigging should be made of polyester, because in this situation we need to be able to load the sails accurately. If the rope stretches, the sails would soon be sagging in the wind.

- Polypropylene

Ropes use for safety equipment should be of polypropylene as it floats. If you throw a rope to someone in the water, it must float, to give him or her a chance to reach it. A floating rope is also less likely to foul the propeller.

- Kevlar

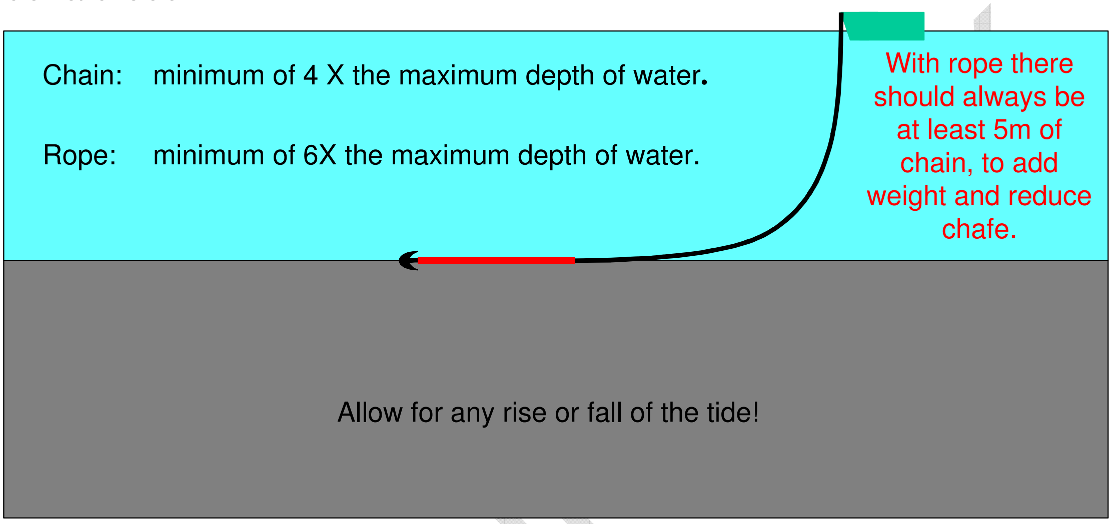
Kevlar ropes are very strong for their weight. As they are expensive, they are only appropriate for racing vessels.

Anchoring

Before you decide where to anchor there are a few considerations to take in to account.

- Depth:

Is the water shallow enough for the length of cable carried? Is it deep enough for the boat, now and later? How much cable should be laid out?



- Local bylaws:

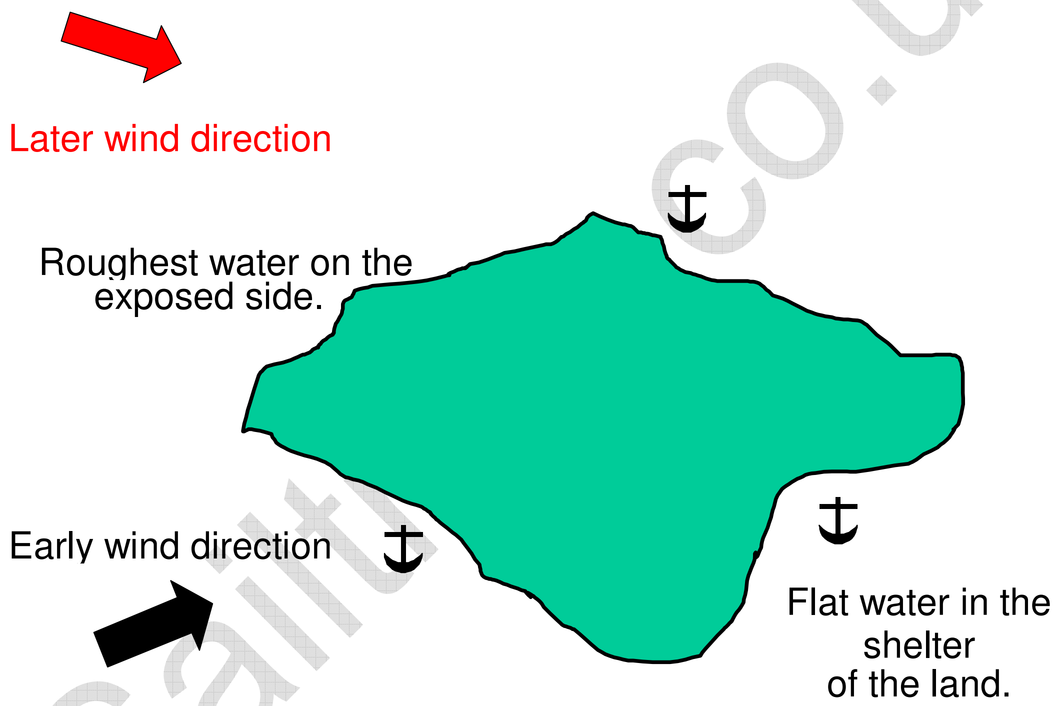
Busy harbours may ban anchoring altogether, and certainly, it is not advisable to anchor in the fairway of busy harbours.

- Facilities:

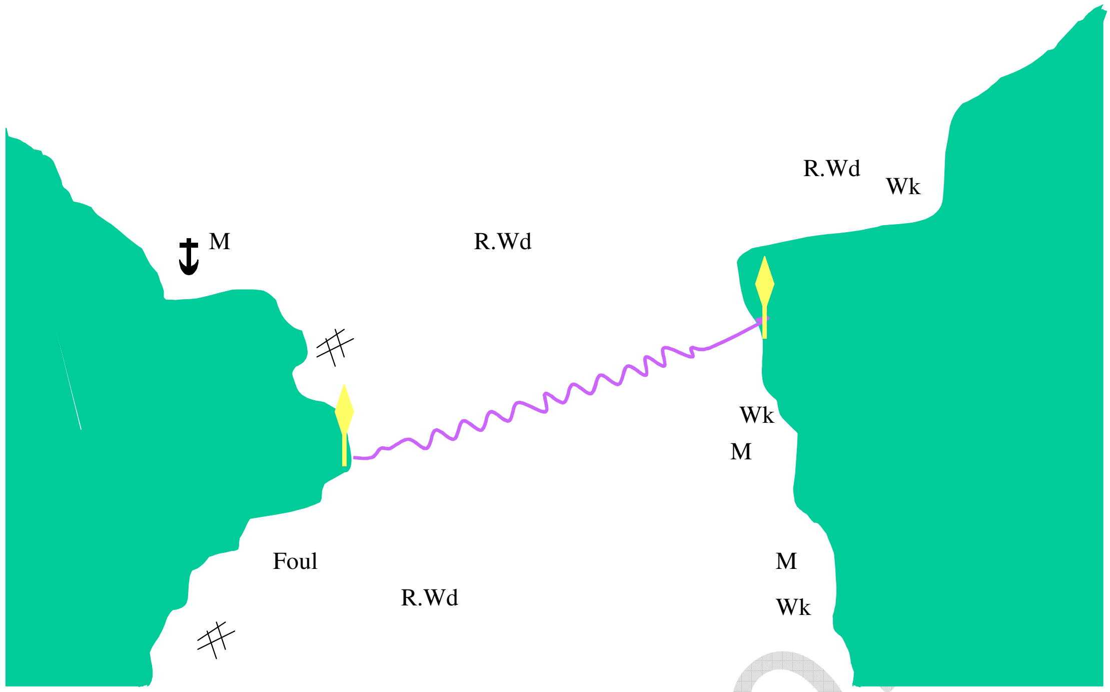
Are you going to want to land ashore? Will the access point be available at all states of the tide? A beach may cover completely at high tide, or when the tide falls, you may be left with a long walk over soft mud.

■ Anchor watch:
Do you need to set an anchor watch? Not a popular plan, with most people on holiday. Will the anchor alarm on the echosounder or GPS be sufficient to warn you if the anchor drags?

■ Shelter:
One of the main reasons to anchor is to stop and rest. If the boat is rolling and bouncing you will not find the stay very restful, especially at night. The best anchorage is usually at a point where the wind is offshore and there is little current. Consider that a place which is completely sheltered when you arrive may well change completely if the wind direction shifts or the tide runs in a different direction.

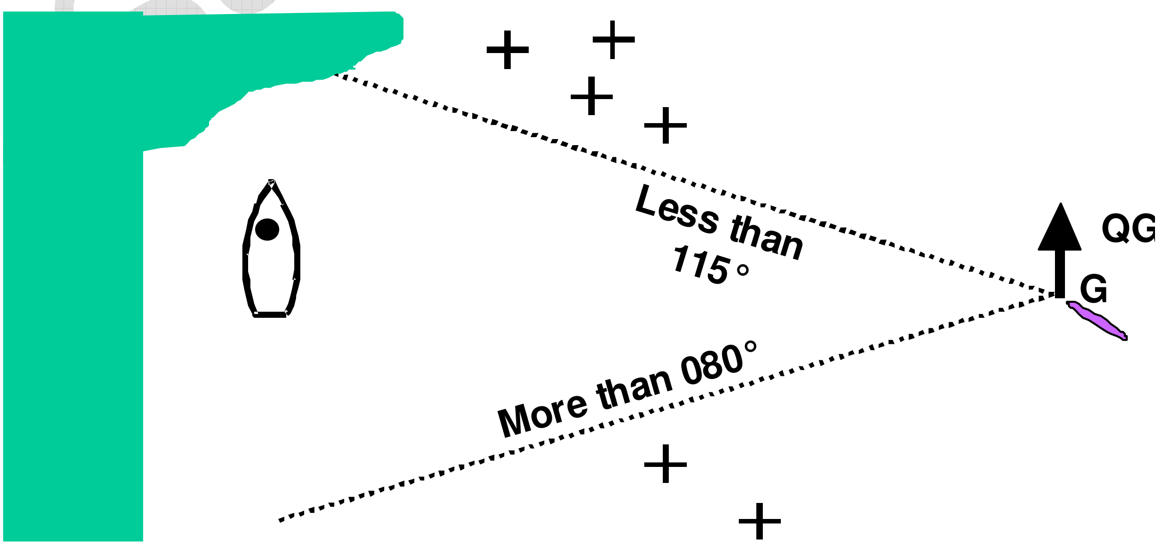


■ Holding:
The quality of the bottom is indicated on the chart. Ideal materials are mud and sand; both will provide a good surface for the anchor to dig into. The worst holding is often in rock and weed, weeds tend to bind around the anchor and prevent it from digging in. An anchor will only hold on a rock bottom when it hooks into a protrusion or crack in the rocks and if the wind or current change the anchor will drag until it catches on something else.

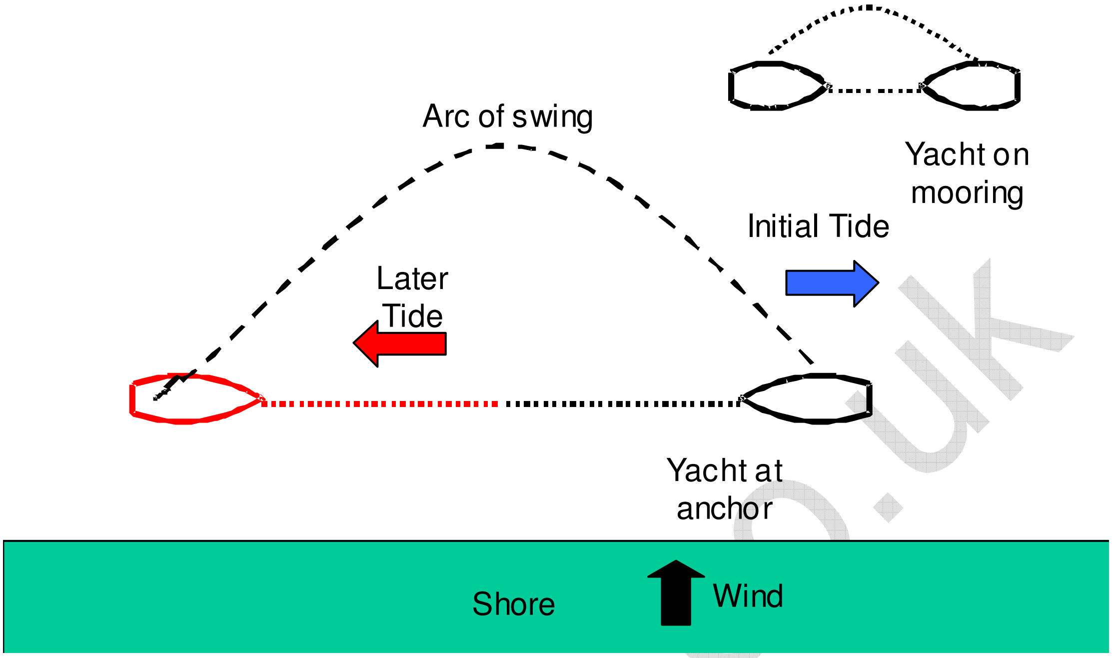


■ Obstructions on the bottom:
Before anchoring check the chart for cables or gas pipes, the shoreward ends may be marked by diamond shaped yellow or white signs. There may also be wrecks or remains of wrecks on the bottom; these may be marked by the word **Foul** or the symbol #. Often areas where there are obstructions or it prohibited to anchor have an anchor symbol with a cross and perhaps a limit symbol.

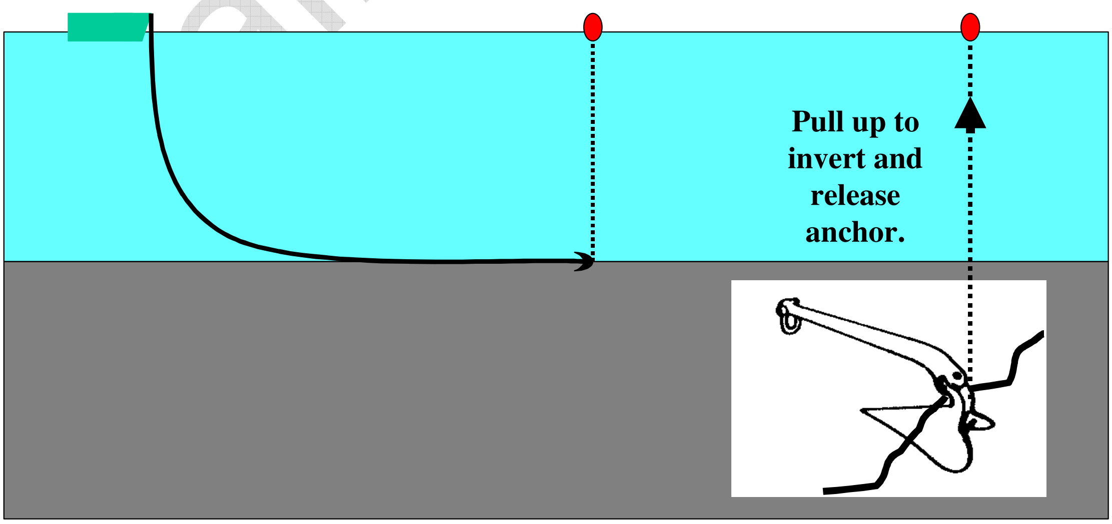
■ Departure in an emergency:
If the conditions change, can you leave the anchorage in a hurry, perhaps in the dark? It may be a good idea to pre-plan clearing lines for a night- time departure.



■ Swinging room:
When the wind or the tide change the boat will swing to a new direction, will it swing clear of moored vessels, the shore or any obstructions?



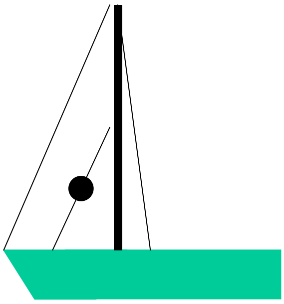
■ Tripping Line:
A tripping line is a line attached to the lower end of the anchor. It enables you to upend the anchor if it becomes stuck under an obstruction. The disadvantages are that you or another vessel can catch them on the propeller or another vessel may try to use it as a mooring buoy! I would normally only advocate the use of a tripping line if I was in a place where there may be debris on the bottom, such as in a harbour area.



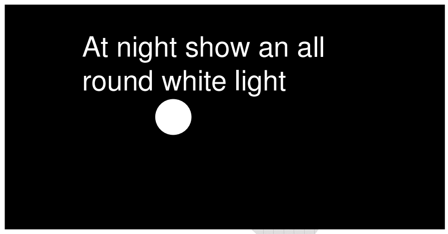
Once anchored, checks should be made that the anchor is not dragging. This can be done by:

- Reversing gently against the anchor to bed it in.
- Checking transits ashore for movement.

The anchor ball should be raised in the forepart of the vessel, and if it will be dark, the all round white anchor light lit.



Day time signal for a vessel at anchor is a black ball.



Anchor types

There are many types of anchor on the market; the best advice when it comes to buying one is to look at what other boats in the area are using. As the boat should have a main or **bower** anchor and a secondary **kedge** anchor, may be an idea to have 2 different types, then if one does not hold, the other may!

- Fisherman's anchor:

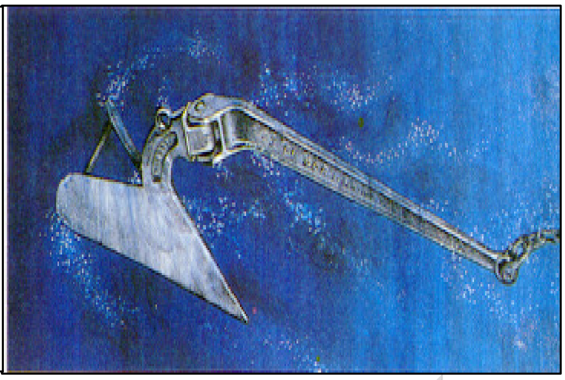
The best anchor for a rocky or weedy bottom, as it will dig through the weed and find a crack to lodge in. That is about the only advantage.

They have poor holding for their weight in other materials and it is easy to damage the boat with the **flukes** (the points).

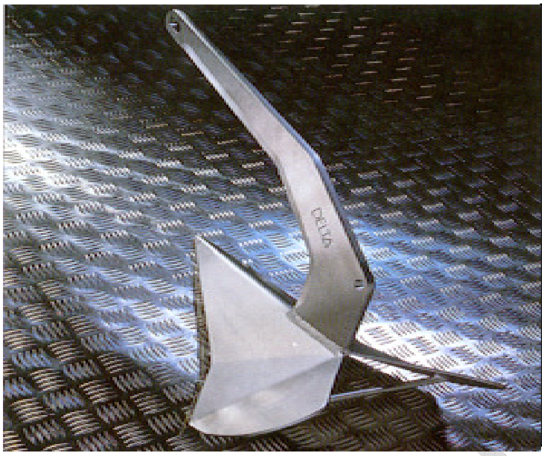
- CQR anchor:

These have a good holding power to weight ratio.

They may capsize and take some time to dig in again. The moving parts can trap fingers.



- Delta anchor:



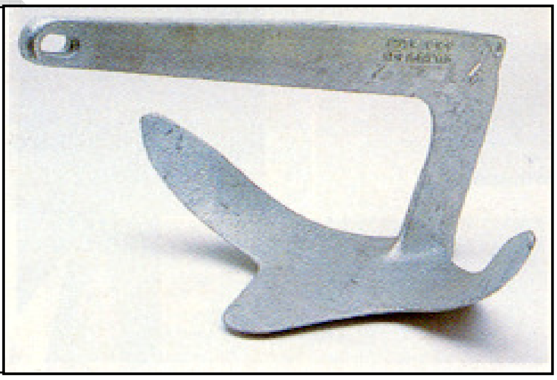
These have all the advantages of a plough anchor, but without the moving parts to nip fingers.

This may make them harder to stow but they are easy to "self launch" if kept on the bow roller.

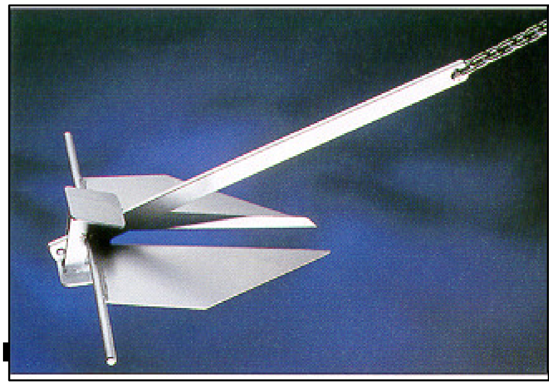
- Bruce anchor:

These have a good power to weight ratio and hold well except in very hard or weedy bottoms.

There are no moving parts to catch fingers but they can be difficult to stow.



- Danforth anchor:



These have the best holding power in soft mud but they may be difficult to break out.

Because of their size and moving parts, they are difficult to handle and stow. Poor holding on rock.

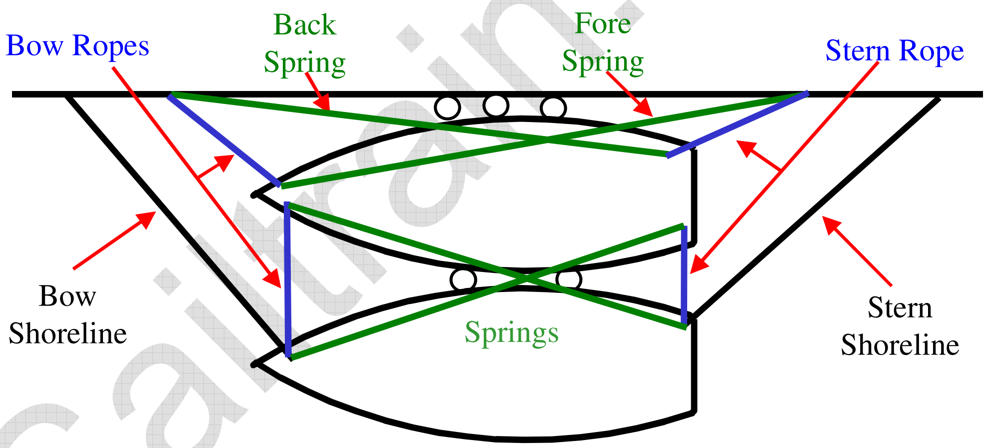
These are really only of use in a dinghy.

It is a good idea to take and anchor if you row ashore in a remote or exposed area, and this one is ideal as it folds up.

Mooring alongside in a non-tidal situation

When you moor alongside the first two ropes to be attached are probably the **bow and stern lines**. If you are only staying a few minutes, this may be all that you need.

If the boat is left moored only on these two ropes it will move backwards and forwards and twist in at the bow or stern. To prevent this we need to rig **springs.** These are ropes that run diagonally from the bow to the pontoon, near the stern, and from the stern to the pontoon near the bow.



Fore spring stops the boat going forwards
Back spring stops the boat going backwards

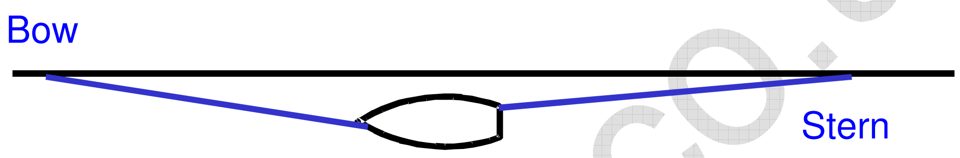
The exact position is not critical; they may run from a centre cleat to points forward and aft. What is important, is the tension on the ropes, by correctly tensioning the springs the boat can be positioned parallel to the pontoon. If mooring alongside another vessel the first ropes will be the **breast ropes** between the two vessel's bows and sterns. Then the springs and shore lines. One extra element to consider is to offset the mast of two sailing boats, so that if they roll towards one another the mast or spreaders do not clash.

In practice, it may take a few minutes to work out the best lie for the mooring ropes so that they do not chafe on fittings on either vessel.

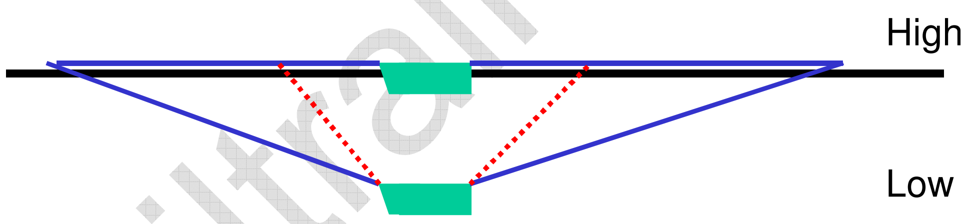
Mooring alongside in a tidal situation

If you are mooring alongside in a place where the vessel will rise and fall with the tide, you will either need to have someone tending the ropes continuously or to rig long ropes.

The minimum length of ropes is for them to be three times the range of the tide in length. This applies to all the ropes between the boat and the shore.



Mooring warps should be at least 3X the range of the tide in length



The idea is to make the triangle formed by the mooring rope as long as possible, the longer it is, the less difference there is between the length of the side for high tide and one for low tide.

For simplicity, the springs have been left out of the above diagram.

Pollution control

In recent years, there has been a noticeable reduction in the quantity of rubbish and pollution on the sea; this is especially true in harbours. Many places where there was visible rubbish floating have now been cleaned up

20 years ago, most boats would probably have thrown all their rubbish other than plastics over the side. When one person does this it is not noticeable, but with thousands of boats in use, anything that goes into the water soon builds up. This is still true of biodegradable items like food; even apple cores float around for weeks before rotting away!

I remember walking on the beach at Deal in Kent and finding piles of plastic cutlery off the cross-channel ferries. Obviously, they threw all the waste food overboard and the cutlery eventually ended up on the beach, over time the quantity built up to surprising proportions. The last time I visited the same beach, there were none.

These changes have partly come about because of the changes in attitude, but mainly from legislation that has introduced much greater care of the environment. Some countries enforce these rules with considerable force, imposing heavy fines for even quite small pollution events.

It is part of the responsibility of every skipper to ensure that boating activities have the minimal effect of the environment. This can be achieved by following these guidelines:

Dealing with wastes

- Rubbish

This includes all food, domestic and operational waste produced on board (not sewage).

- Principles
    - Put no rubbish in the sea.
    - Retain rubbish aboard, until it can be disposed of properly ashore.

There are strict rules on dumping rubbish at sea, backed up by fines.

- Good practice
    - Remove excess packaging before stowing food below.
    - Plan for waste aboard. Arrange a good waste bin, strong and sufficient bags.
    - Recycle if possible.
    - Set an example and expect your crew to take care with waste.

- Food waste
    - Do not dump any skins or peelings in to the sea if they will take a long time to rot.
    - Do not dump any food within 3 miles of the shore (12 in the North Sea or the English Channel).
    - Discharge nothing but washing up water, when in marinas, harbour or anchorages.

- Oils and oily wastes
    - Regulations are aimed at commercial shipping, but leisure craft are not exempt from the same legislation.

- Principles
    - Prevent any discharge of oil, fuel or similar substance in to the sea.

- Good practice
    - Maintain fuel lines, connections and seals in good condition.
    - Separate the engine and main bilge to minimise the risk of contaminating bilge water.
    - Do not pump water in to the sea if it is contaminated by oils or toxic substances.
    - Absorb spilt oil with pads and dispose of them ashore.
    - Dispose of oil ashore in proper reception facilities.
    - Use biodegradable oils (if possible) and unleaded fuel.
    - Consider the polluting effect of 2 stroke outboards.
    - Avoid spillage when filling tanks.
    - Service engine to minimise exhaust pollution.

- Sewage

It is common practice to use direct-discharge sea toilets, with increased usage of boats and their concentration in certain areas we should be considering fitting holding tanks. In many cases, this will only be feasible when purchasing a new vessel.

- Principles
    - Do not discharge a sea toilet where doing so would damage the water quality.

- Good practice
    - Use the facilities ashore when possible.
    - Do not discharge toilets in to non-tidal are weak tide areas (locked marinas).
    - Do not discharge near bathing beaches, busy anchorages or shell fish farms.
    - If possible fit and use a holding tank, discharge it in a proper facility or at least 3 miles offshore.
    - Do not empty chemical toilets in to the sea.

- Toxic wastes

Include
    - Antifouling paints and any residue.
    - Old batteries.
    - Cleaning chemicals and solvents.

- Principles
    - Keep toxic chemicals out of the environment.
    - Do not use TBT based antifouling (it is illegal on yachts).

- Good practice
    - Use the least toxic antifouling that is effective in local conditions.
    - When cleaning off old antifouling, prevent dust and scrapings being dispersed by the wind or water.
    - Encourage your harbour to install a facility that collects residues from antifouling removal.
    - Minimise the use of detergents, if possible use a pressure washer.
    - Dispose of old batteries in a dedicated facility.

Dealing with wastes

- There are legal requirements placed on anyone who operates a place of landing from the sea regarding waste management. These include:
- Consulting users about their needs.
- Preparing for the management of all ship borne waste.

- Users can assist by:
- Telling operators of facilities if they are adequate.
- Provide feedback.
- Use the facilities.

Habitat and species protection

The British and European, coastline has an abundance of wildlife and law protects large parts of the coast.

- Good practice
  - Learn about the conservation factors relevant to the sub tidal area, the inter-tidal area and the shore of the areas you visit.
  - Be aware of:
  - Statutory management schemes.
  - Local by-laws.
  - Voluntary agreements.

- Avoid damage and disturbance
  - When afloat, stay away from nesting sites and minimise disturbance from wash or noise.
  - Land at recognised points. In remote places avoid damage to wildlife habitats (ground nesting birds) and disturbing vulnerable species.
  - Follow guidelines for minimising disturbance of whales and dolphins (www.wdcs.org).
  - Avoid anchoring or running aground in areas where you may damage seabed species.

Vessel's stability

In the last few years, there has been considerable publicity in the media concerning yachts capsizing and remaining inverted. Whilst most of these incidents have occurred in the southern oceans to extreme racing boats, there have also been a few events that have involved cruising vessels.

In the past yacht design, was governed by the materials used, this is still true but modern materials and construction methods have allowed yachts designers to radically change the shape of boats.

There has always been a tendency for ideas from the racing world to spill over in to cruising. Whilst this has produced some very valuable changes and innovations (where would we be without modern roller furling equipment?). There is also pressure for less desirable factors to become the standard by which boats are measured.

Racers accept a higher level of risk than most cruisers are prepared to take on, but they are also doing so in an environment where there are many other vessels in the same race or a level of safety cover unavailable to the cruising yachtsman.

Modern cruising yachts are faster and far more comfortable to live aboard than in the past. In addition, equipment is lighter and easier for small crews to use, the down side is that the boats are lighter in construction, and some of the changes in shape that improved accommodation has caused can detract from the seaworthiness of the yacht.

To sum up, in the past we always used to consider (rightly or wrongly) that if a yacht was capsized, she would quickly roll back on to her keel. With modern vessels, this may not be the case.

The purpose of this section is not to scare people into not going to sea, the type of situation we will discuss are extreme conditions, only found in exposed areas of ocean. Fortunately, most us will never experience anything even close to a capsize in a yacht.

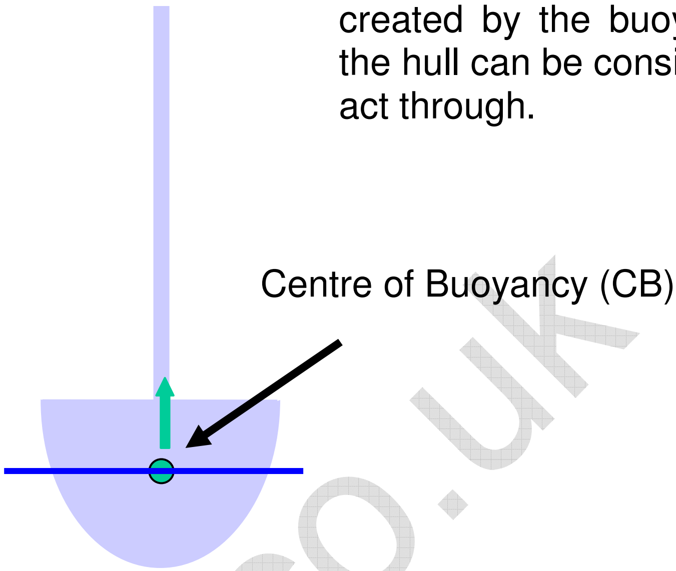
There are some very technical terms; all you really need is a broad understanding of the principles involved.

Centre of buoyancy (CB)

The position of the centre of buoyancy changes as;

- The vessel heels.
- The vessel is loaded.
- The trim of the boat.

The centre of buoyancy is the point that the forces created by the buoyancy of the hull can be considered to act through.



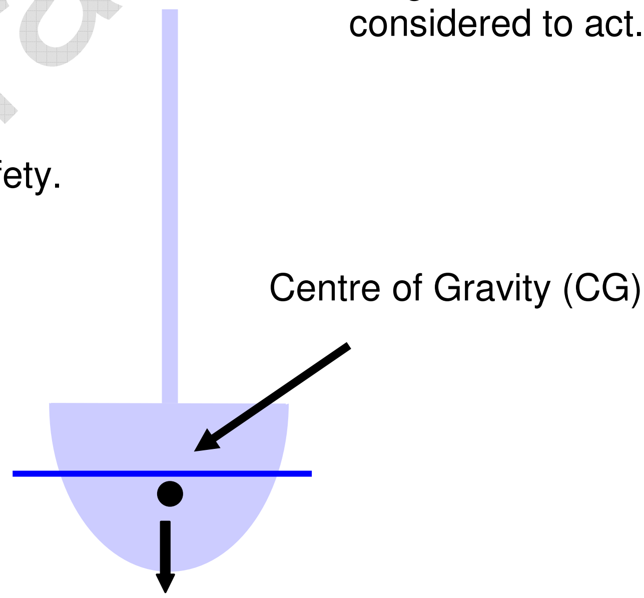
Centre of gravity (CG)

The position of the centre of gravity is governed by:

- The structure and weight distribution.

The lower the centre of gravity the better for safety.

The centre of gravity is the point through which the weight of the vessel can be considered to act.



Righting lever (GZ)

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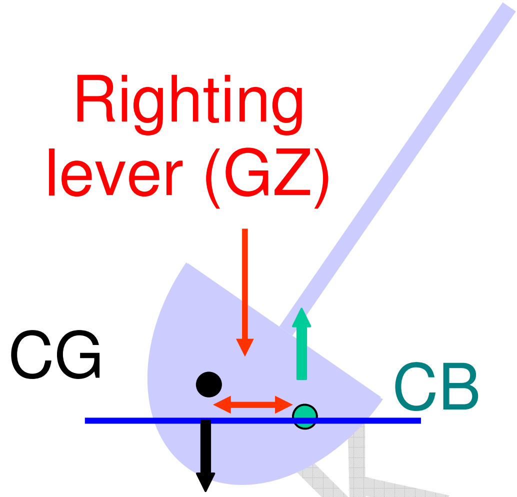
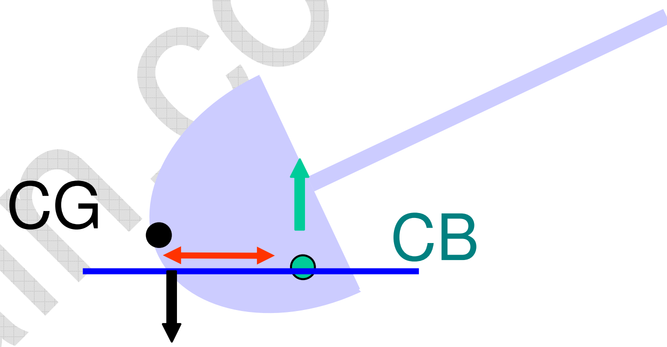
The centre of buoyancy and the centre of gravity create the righting lever.



Angle of heel

- As the boat heels, RM increases.
- RM reaches a maximum at about 60° of heel.

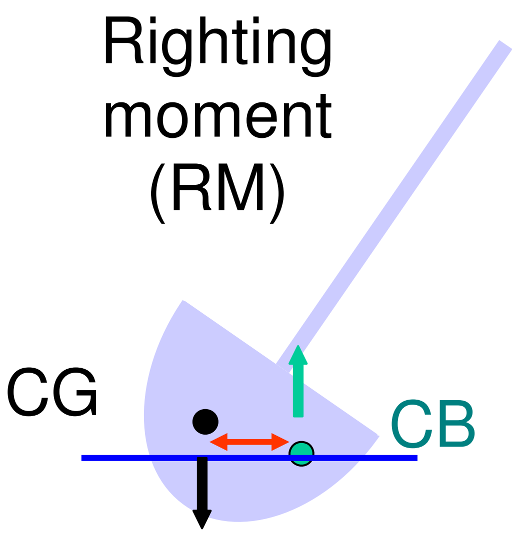


Righting Moment (RM)

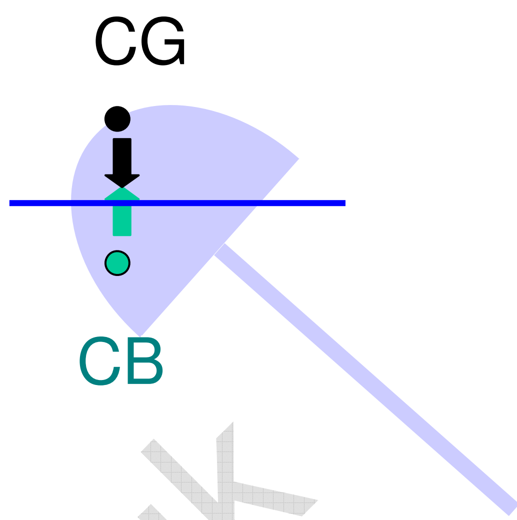
- GZ times the weight = RM
- The weight of the boat affects its stability.

When the weight is multiplied by the GZ, it gives the RM.

A heavier boat gives a higher RM and is harder to heel!

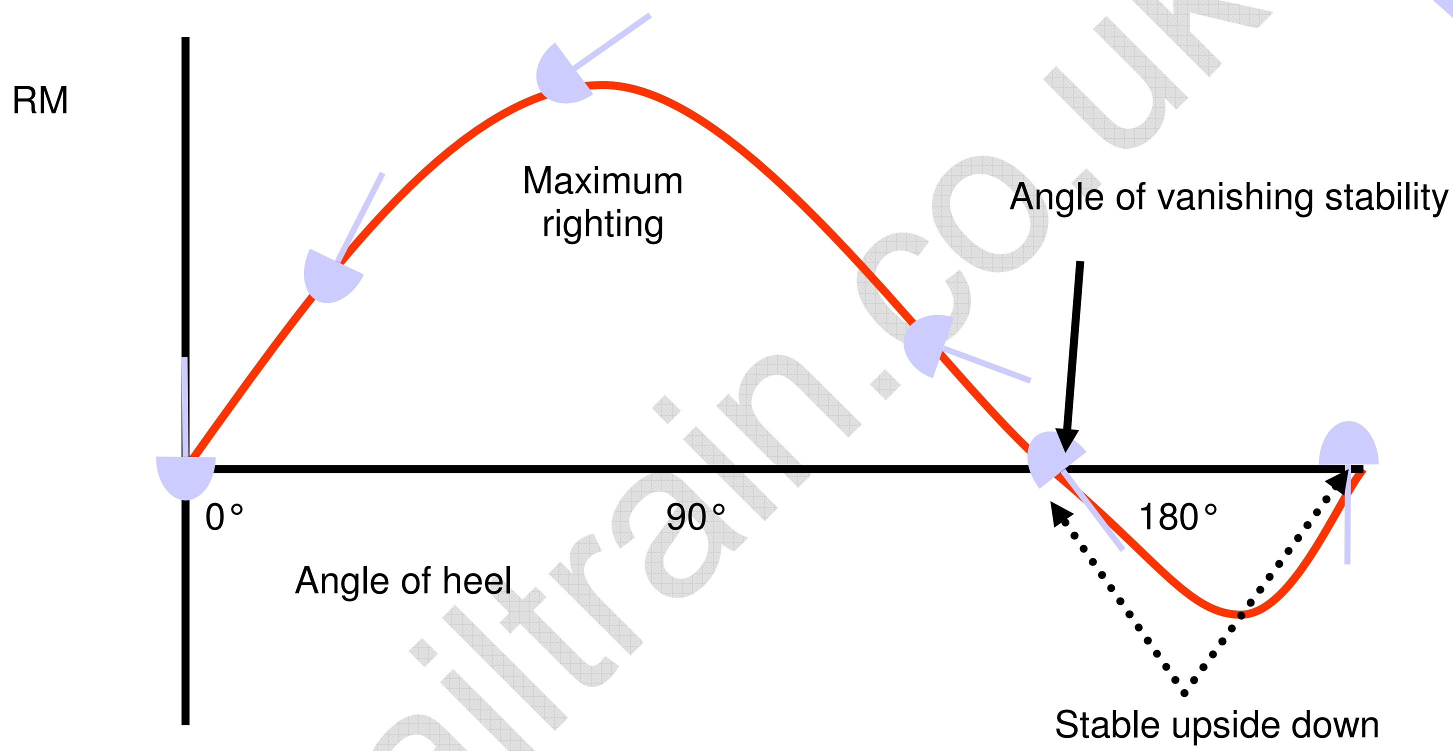


Point of vanishing stability



- As the boat heels more, RM decreases, until;
- RM is zero.
- The boat can invert!

Righting moment curve for flat water



What the above diagram tells us, is that if a boat heels far enough, it becomes stable upside down. The point where this occurs is known as the **Angle of Vanishing Stability** or **AVS.**

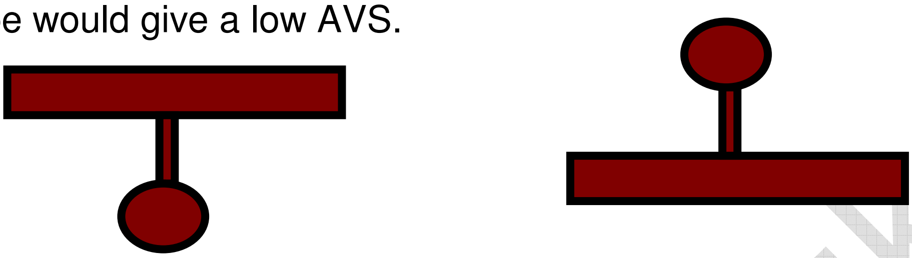
Boats will not normally heel past their AVS. Obviously, the wind alone could not make this happen, the sails are under water. The only way for this to occur is for the force of the water to push the boat over.

A vessel which inverts will remain inverted until a wave rolls it past its angle of vanishing stability, then it will return to the correct orientation.

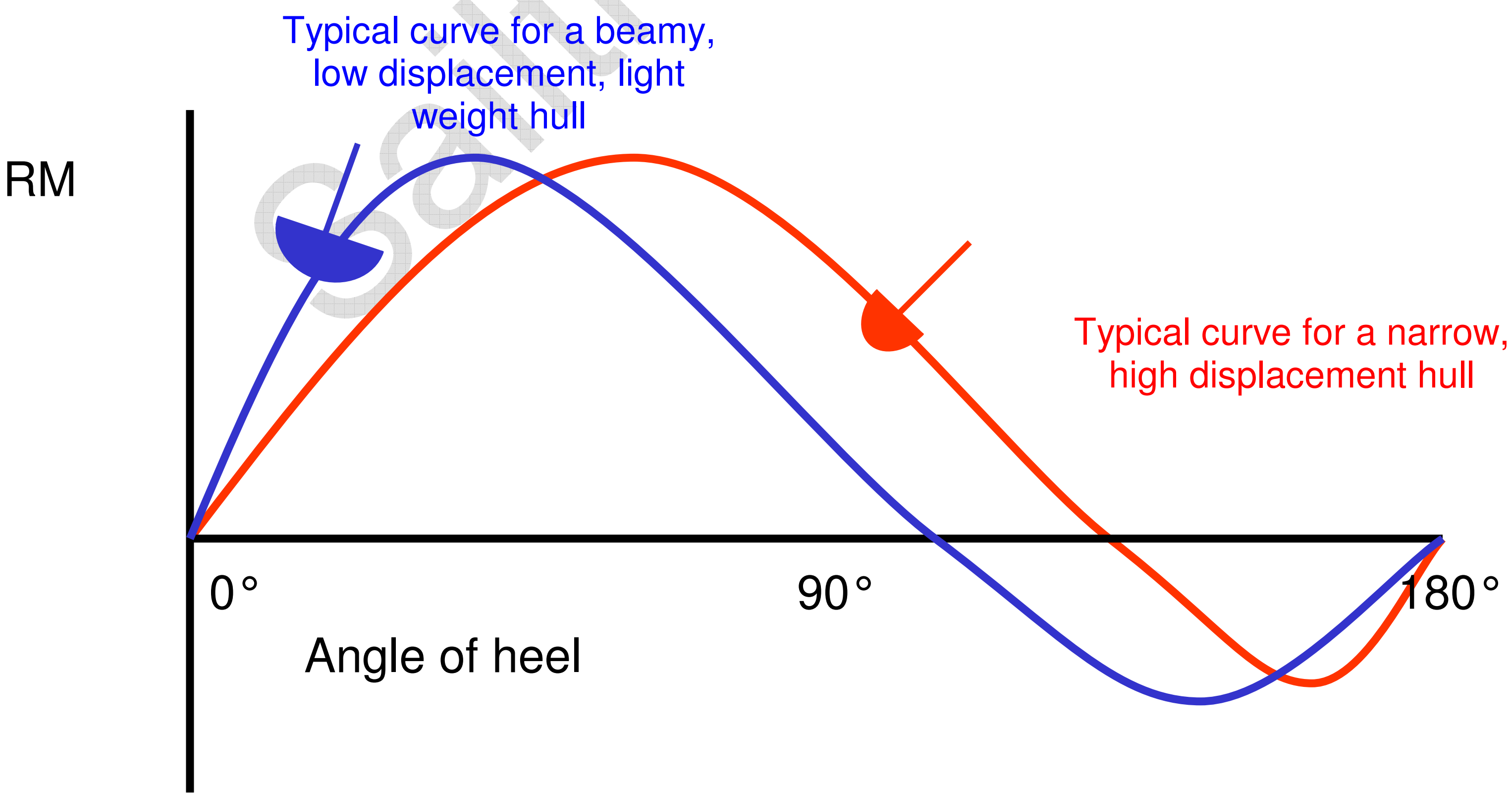
Factors affecting the angle of vanishing stability.

- Hull shape.

If the hull is like a plank lying on its broad side, it is difficult to tip it initially, but would be very stable upside down. This sort of hull shape would give a low AVS.



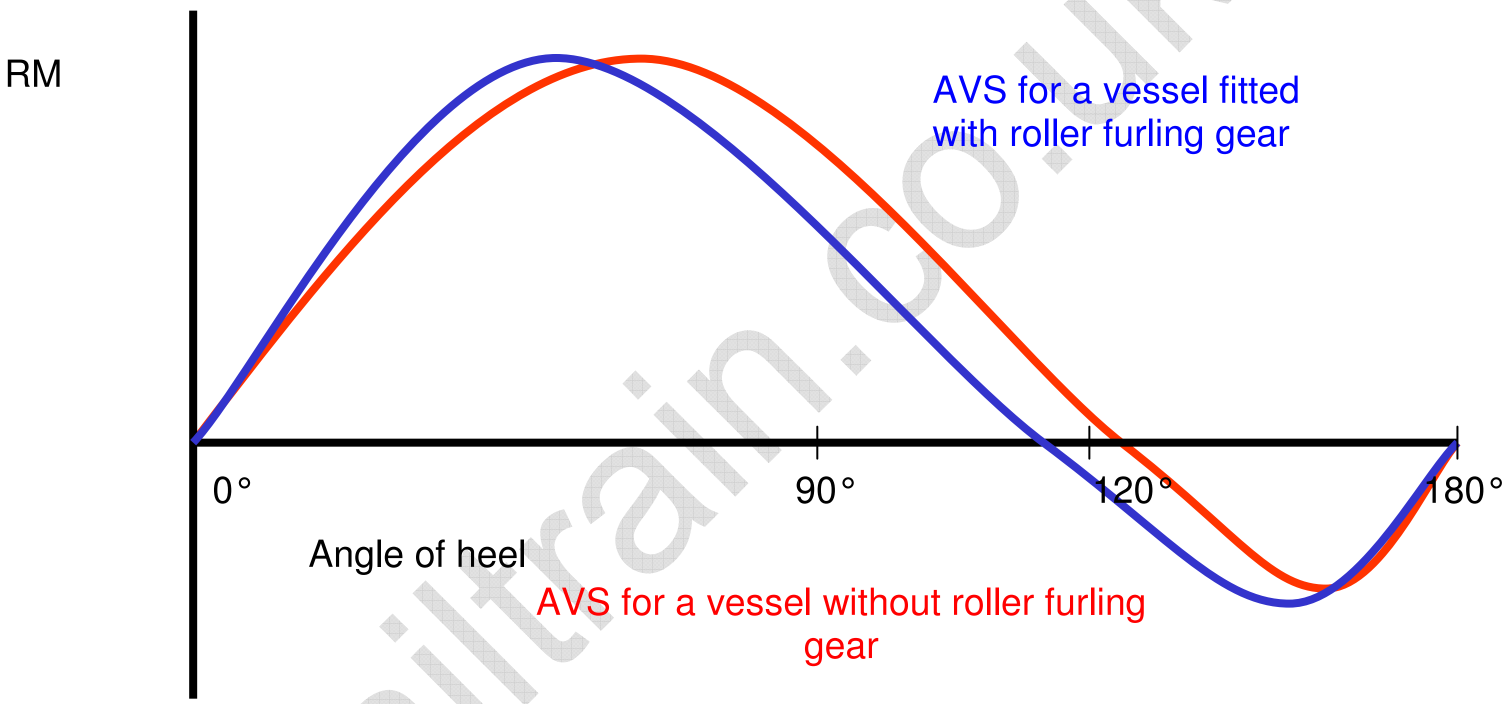
If the hull is shaped like a plank on its narrow side, it is easy to tip at first but very unstable upside down. A hull of this shape has a high AVS.



- Weight distribution

Placing heavy weights low in the hull improves stability by lowering the CG. For this reason, fuel, water and heavy equipment should be stored as low as possible.

Raising the CG by fitting roller-furling gear, radar and aerials up the mast reduces stability. Because of the length of the lever, a small increase in weight at the top of the mast can have a large affect. Before fitting an in-mast furling mainsail system, consider how heavy the main sail is to lift, all that weight and more will be spread up the mast!



Factors which may cause a capsize

- Flooding
  A vessel with a large amount of water below can become very unstable.

- Free-surface effect
  The free-surface effect is large amounts of water rushing unimpeded across the boat it will make a boat extremely unstable. It is what sank the Herald of Free Enterprise.

- Large breaking waves
  A breaking wave has a rotational component, which could roll a yacht over.

- Anything which moves the COG upwards

- Resonant rolling and broaching
  Resonant rolling occurs when heading downwind, especially with a spinnaker set. It may lead to a broach or an uncontrollable turn up in to the wind.

Factors that improve stability

- Pump out the bilge water regularly

- Increased length

- Heavy displacement for the size of vessel

- A high ballast ratio or a heavy keel in relation to the boat's overall weight.

- High angle of vanishing stability

- High re-righting factor

- A good RM at 90° of heel

- Modest beam to length ratio

- Good but not excessive freeboard

- Minimal topside flare

- Absence of large nearly flat areas of deck (increases inverted stability)

- Large angle of heel before flooding can occur (look out for hatches not set on the centre line of the vessel, keep hatches closed)

- Increased keel profile area

- Absence of bulwarks (allows water to run off the deck quickly)

Rough weather

A yacht will only capsize in extreme conditions, if you understand where not to be and what not to do you will probably never experience a capsize.

In rough weather **DO:**

- Be aware of category and capability of your boat (some boats are only designed for use in estuaries)
- Close hatches, wash boards etc (keep the water out)
- Pump out bilge regularly
- Be alert for strong gusts and down-draughts (near cliffs)
- In large seas, avoid being caught beam on to a breaking waves

In rough weather, **DO NOT:**

- Sail through areas of overfalls, tide races or areas where the bottom shelves rapidly
- Sail in conditions that are outside your level of experience or the category for which your yacht was designed.

EU Recreational Craft Directive Design Categories

The EU has included in its design directive a classification based on the stability of the yacht and the area for which, it is designed to be used.

Category	Type	Wind force	Wave height
A	OCEAN	>F9	>4.0m
B	OFFSHORE	«F8	«4.0m
C	INSHORE	<F6	<2.0m
D	SHELTERED WATERS	<F4	<0.5m

How to find out about a yachts stability rating

Most new yachts are now given a stability test when they first come on to the market, so the broker should be able to give you this information.

For a second-hand boat, look in the yachting press, when a magazine tries out a boat they often look at its stability. Most magazines offer a back issues service where you can get a copy of an old report. Alternatively, many classes of boat have an association; members are often very helpful to anyone thinking of buying a vessel in their class.

Attitude to stability

The idea of this section is to promote awareness of the issues on yacht stability not to deter anyone from going to sea. It is very unlikely you will ever be on a vessel that heels more than 90°, which leaves a big margin for error. If you do ever get into a big storm, remember the points discussed here!

Safety at sea

Safety on boats is a way of life, it is not just enough to fit certain pieces of equipment and hope that you will never need to use them.

Planning
You need to think through any safety related incidents and come up with a plan of action that fits your situation and boat.

Examples are a fire drill, or procedure for recovering a man over board.

The standard methods taught on practical courses are not always feasible, especially, if as is common, there are only two or three people on board.

In the case of a real incident you may find that what you have planned does not work, but it will probably point you in the direction of the correct action. One of the first reactions in an emergency is often to freeze and do nothing, in a man over board situation this could have fatal consequences. If you have an established plan that is well practised, it is much easier to switch in to automatic mode whilst you get over the shock.

Practice
Many of the ideas that you will read in magazines or hear about will not work effectively aboard a specific boat, and it is only by practising your drills that you will find out what your limitations are.

Daily checks
Many major incidents are the culmination of a series of small problems, which as each one manifests itself become a serious situation. One method of reducing problems is to carry out thorough daily checks of the engine system, all joints and fittings above deck, operation of the lights and a final check below for hatch closure and security of stowage.

Running maintenance
A boat should be run in a manner that would allow it to remain at sea indefinitely, that is if a problem develops, deal with it immediately if possible rather than leaving it until you are next in harbour.

The very experienced sailor and writer, Eric Hiscock had a philosophy that is worth following.

He considered that he had a sealed box on board which held all his credit, the only way to keep the box in credit is to carry out repairs and routine maintenance tasks. Each job or check performed would put credit in the box, but of course there is no way of checking how much credit is left.

Credits are removed from the box every time you make a mistake or have a near miss whether you notice it or not.

The day you run out of credits, you sink!

Therefore, the aim is to keep paying in credits, because you never know when you might need as much as possible.

Crew briefing
When a new crew come aboard, you must spend time covering the basics of safety with everyone, remember you may be the casualty.

The briefing should include:
Lifejackets (put one on)
Harness (put one on)
Harness attachment and movement on deck
Flares (get them out)
Liferaft
VHF and mayday (place procedure card by radio)
Bilge pumps (minimum of two) and where the holes are in the hull
First aid kit
Bolt croppers (to cut rigging if dismasted) and torch stowage
Engine start procedure
Life buoys and man over board procedure
Gas safety and fire extinguishers
Winch, boom and mainsheet traveller safety

Establish rules for the wearing of lifejackets and harnesses, these may include;

Harnesses; (to stop you leaving the boat)

If they feel they want to (why not all the time?)
At night
In reduced visibility (fog, heavy rain or snow)
In rough weather (depends on the crew and boat what is rough)
Non swimmers
Children
Any one being sea sick
If short handed (3 is short handed, there would only be 2 left)
If anything happens to affect the handling of the vessel (rudder failure, engine failure-can you guarantee to sail back to a casualty?)

Show new people the **jackstays** (the tapes or ropes running the length of the deck, to which we attach the harnesses), any 'D' rings in the cockpit area for the crew to clip their harnesses to and discuss the other places it is safe to clip on to.

- The mast
- Standing rigging (wires to support the mast, not in extreme weather)
- The pushpit and pulpit
- Not the guard rails or running rigging (ropes which move)

Lifejackets; (to stay afloat if you are in the water-a harness is better)

If they want to
Every time you use the dinghy (there are far more fatalities rowing ashore in safe harbours than at sea in yachts)
In reduced visibility (you may be involved in a collision)
If anything happens to affect the integrity of the boat
Non-swimmers
Children
If you enter the water for any reason (cut ropes off the prop etc)

Safety equipment
Equipment, appropriate to the vessel and cruise should always be carried aboard. There was an incident a few years ago where a small motor boat was launched in fine weather off the Welsh coast, it was taken out a few yards to check the engine. When the engine

cut out, the boat drifted across to the Devon coast. The crew were badly dehydrated and sunburnt by the time they were rescued.

Being on the water has potential for danger at any time.

Fire extinguishers
Everyone should be aware of the location of the fire extinguishers fitted aboard and how to use them.

There should be:
One in each cabin, near the exit
A fire blanket near the cooker
An automatic gas extinguisher in the engine compartment
2 buckets with lanyards (lots of water outside!)
If possible another large extinguisher in the cockpit locker

Extinguishers come in different types, each have limitations;

Water
Can not be used on oil or electrical fires, and there is plenty of water around, so these are not often found on yachts.

Dry powder
Can be used on most fires but are very messy.

Foam
Can be used on most fires on a yacht.

Gas
CO^2, Halon and BCF are ideal in an engine compartment, but CFC gasses are being phased out and replaced with other more environmentally friendly ones.

Flares
Flares have two purposes, to attract attention over a long distance and to pinpoint the vessel in trouble.

The use of distress flares indicates that there is **grave and imminent danger to life or a vessel**. As such, they should only be used on the instructions of the skipper.

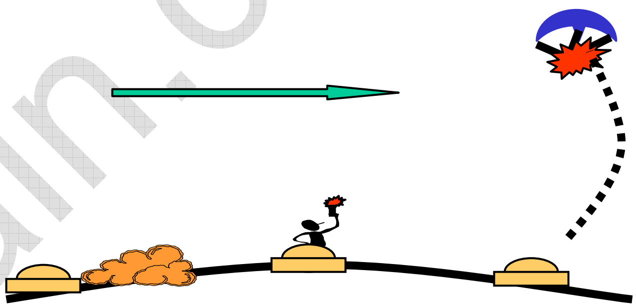
■ Handheld red.
This type of flare is visible up to about three miles in daylight or at night. They should only be used if you can see, land, a boat or an aeroplane, if you can not see them, no one can see you!

■ Orange smoke.
These may be hand held or floating, both have a range of two to three miles and can only be used in daylight when you can see a potential rescuer.

■ Red parachute.
Parachute flares are rockets, which rise to about 300 metres, then drift down with a bright red light on a parachute. Because of the height these flares can be seen up to 25 miles away, but only if the weather is clear enough.

When you fire a parachute flare it will turn in to the wind slightly, so they should be fired about 10-15 degrees downwind of the vertical. They will then fly straight up.

When you fire a parachute flare, fire two at about five minute intervals. If the first one is seen by a watch-keeper on a ship, this will allow enough time for the skipper to be alerted, and for him to see the second one for himself. You are much more likely to be picked up if you follow this pattern.



Recommended number of flares

Inshore 5 miles from land	Coastal 7 miles from land	Offshore Over 7 miles from land
2 hand held red 2 orange smoke	2 hand held red 2 orange smoke 2 parachute red	6 hand held red 2 buoyant orange smoke 4 parachute red

■ White flares
White flares are not distress flares. A hand held one can be used to indicate your presence to a ship if there is a risk of collision. White parachute flares have been used for illumination at night in the case of a man over board.

It may be worth carrying white flares for these rare occasions but they must be stored apart from those used for indicating distress.

EPIRBs

An EPIRB is a transmitter that will send a distress signal up to a satellite system from anywhere in the World or up to aircraft if they are in range. With one, you can easily alert the emergency services, in situations where you would be out of range of normal communications.

Whist useful for coastal sailors, EPIRBs are essential for anyone contemplating an ocean crossing. They are registered to the specific boat, so if it is triggered the rescue services know exactly what they are looking for and to check that the boat is at sea (Many alerts are accidental).

Because EPIRBs are registered to the boat they must never be swapped from one vessel to another without being re-registered.

Some boats are fitting personal EPIRBs. These are small transmitters, which will trigger an alarm on the yacht if the wearer falls overboard. The receiving unit then allows the operator to get a bearing back to the casualty, thus assisting greatly in the search.

These are very useful devices, but as with all safety equipment, it needs regular practice to be useful in a real emergency.

Management

Many yachts are run in a manner that if the skipper is incapacitated, there is no one left with the skills to handle the boat.

One of the signs of a good skipper is that he never seems to do much, but things never go wrong, and everything seems easy. This occurs when the crew has been trained properly, thus freeing up the skipper to plan and think ahead. The better skipper you are, the more moves ahead you are thinking about, then when you have to act, you already have the answer.

One main aim of the skipper must be to teach the crew everything you know. You may think that if you do that, there will be nothing left for you to do, in fact, you will find that you are freed up to work at a higher level-you will find plenty of tasks!

Leaving a passage plan

It is prudent to leave word ashore of your plans and when you expect to arrive, this could be with the Coastguard but a better plan is to leave details with a friend or relative who is briefed to contact the Coastguard if you are overdue.

The Coastguard, operate a scheme called **CG66**. This is a form that you fill in annually, it includes the details of the boat and its equipment plus contacts. The Coastguard keeps this information, and in the event of you being overdue or a partial Mayday message being heard, they can access the vessel's details (your shore contact may know nothing about boats!).

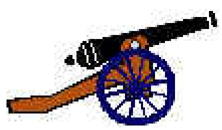
A CG66 form is found on the back cover of the Maritime and Coastguard Agency (MCA) booklet "Safety Guidelines for Recreational Craft Users" which is included this pack.

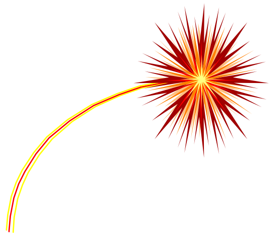
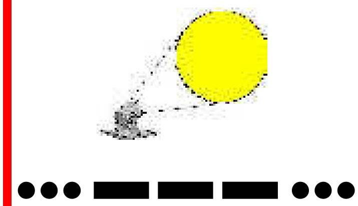
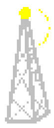
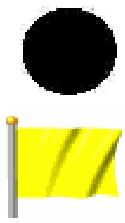
Sending a distress signal

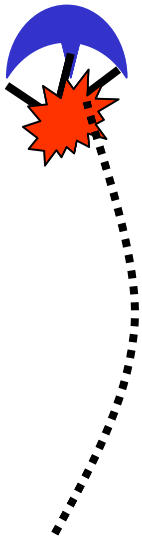
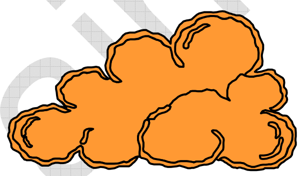
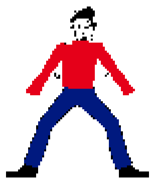
There are many means of indicating that you are in distress, the internationally recognised ones are from Annex IV of the International Regulations for the Prevention of Collisions at Sea. A copy is included here.

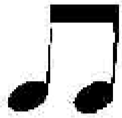
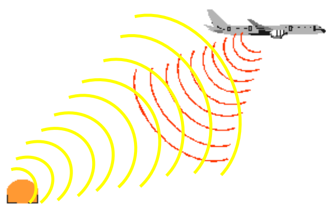
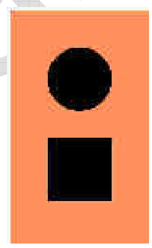
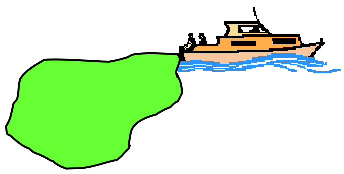
ANNEX IV
DISTRESS SIGNALS

1. The following signals, used or exhibited either together or separately, indicate distress and need of assistance:

a) a gun or other explosive signal fired at intervals of about a minute;		(a) Not many vessels in Europe will carry guns or explosive devices, but in other parts of the world, you may come across this signalling method (just make sure they are not firing at you!).
(b) a continuous sounding with any fog-signalling apparatus;		(b) This is a very simple method of attracting attention, which requires minimum equipment but is obviously only of use when very near other vessels.

<table>
<tr><td>c) rockets or shells, throwing red stars fired one at a time at short intervals;</td><td></td><td>(c) A very useful method of attracting attention when some distance from any possible observers.</td></tr>
<tr><td>(d) a signal made by radiotelegraphy or by any other signalling method consisting of the group (SOS) in the Morse Code;</td><td></td><td>(d) On small craft, this is a useful back up method summoning assistance, especially if sent by a powerful signalling light.</td></tr>
<tr><td>(e) a signal sent by radiotelephony consisting of the spoken word "Mayday";</td><td></td><td>(e) This is probably the most effective method and will normally be the first means of summoning assistance. Especially, when linked to a radio with DSC capability.</td></tr>
<tr><td colspan="3">Mayday Mayday Mayday, this is Irina Irina Irina, Mayday Irina; our position is 2 miles south of the Needles Lighthouse. We are on fire and require immediate assistance, 4 people on board, over.</td></tr>
<tr><td>(f) the International Code Signal of distress indicated by N.C.;</td><td></td><td>(f) With the size of flags carried on most vessels, you could probably shout as far as this signal could be recognised! However, once hoisted, this signal requires no further effort to be maintained.</td></tr>
<tr><td>(g) a signal consisting of a square flag having above or below it a ball or anything resembling a ball;</td><td></td><td>(g) This signal suffers from the same problem as flags. In addition, most people would probably not recognise it!</td></tr>
<tr><td>(h) Flames on the vessel (as from a burning barrel, oil barrel, etc.);</td><td></td><td>(h) This may seem obvious, but the boat itself does not need to be on fire. It may be possible to light some oily rags in a bucket. This could be useful if you have used all your distress flares!</td></tr>
</table>

(i) a rocket parachute flare or hand flare showing a red light;		(i) Again, a very useful mechanical means of summoning aid. Ensure you have sufficient for the area you will be sailing in. In addition, it is often recommended that parachute flares be fired in pairs with about a 5-minute gap between them. This is because the person who sights a flare may not be the skipper. By firing a second one a few minutes later, the aim is to give the person who is responsible for the decision making on board enough time to reach the bridge and to see the flare for themselves.
(j) a smoke signal giving off orange-coloured smoke;		(j) Useful up to a range of 2 miles, especially when indicating the vessel in distress to a helicopter when there are several other craft in the vicinity.
(k) slowly and repeatedly raising and lowering arms outstretched to each side;		(k) This is surprisingly effective at short range and may be all that is required when in a small vessel in busy waters.
(l) the radiotelegraph alarm signal;		(l) This is not relevant to most small craft.

<table>
<tr><td>(m) the radiotelephone alarm signal;</td><td></td><td>(m) A two-tone audio signal rarely heard on small craft.</td></tr>
<tr><td>(o) Approved signals transmitted by radio-communication systems, including survival craft radar transponders.</td><td></td><td>(o) A radar transponder, is triggered by the signal from a search craft, and transmits a signal, which shows up on the search craft's radar screen and aids fine positioning of a life raft.</td></tr>
<tr><td colspan="3">2. The use or exhibition of any of the foregoing signals except for the purpose of indicating distress and need of assistance and the use of other signals which may be confused with any of the above signals is prohibited.</td></tr>
<tr><td colspan="3">3. Attention is drawn to the relevant sections of the International Code of Signals, the Merchant Ship Search and Rescue Manual and the following signals:</td></tr>
<tr><td>(a) a piece of orange-coloured canvas with either a black square and circle or other appropriate symbol (for identification from the air);</td><td></td><td>Very useful for summoning assistance from helicopters and other aircraft. Has the benefit that it will last indefinitely and can be left unattended.</td></tr>
<tr><td>(b) A dye marker.</td><td></td><td>Very useful for summoning assistance from helicopters and other aircraft. Can be easily attached to man overboard equipment or lifejackets.</td></tr>
</table>

You can use any of the above methods but sending a Mayday message is one skill everyone should learn.

Sending a Mayday message

Probably the most effective means of indicating that you are in distress is to transmit a Mayday call.

A Mayday call tells everyone in the area that you are in trouble and obliges them to come to your assistance if possible, but it also imposes radio silence to prevent your messages being covered up.

The sequence of the message is fairly obvious.
- Tell people you are in trouble.
- Who you are
- Where you are
- What the problem is
- Assistance you need
- People on board
- Let them reply

Normally a Mayday is sent on channel 16, this is the distress and calling channel on VHF radio but any other channel can be used.

The format should be;
Mayday, Mayday, Mayday
This is Irina, Irina, Irina
Mayday Irina
My position is 50°10.3'N 01°45.3.W
We are on fire and require immediate assistance
5 people on board
Over
Then wait for a reply!
When you give your position there are two options:

- Latitude and longitude
  The advantage of this method is that most boats have a GPS navigation system next to the radio. For one of the crew to send a Mayday, they only need to know the sequence (which can be read off a procedure card) and how to find the position from the GPS. The skipper can then delegate this job to someone who does not know how to navigate, if that is appropriate.

- Bearing and distance
  The advantage of using a bearing and distance to describe your position is that anyone hearing you knows approximately, where you are, but it does take some navigation0 skill to use.

  With a bearing and distance, the direction is always given **from the point** not from the vessel!

To train the crew in radio use, they should be encouraged to use the radio (under supervision) to contact any marinas that you call.

Helicopter rescues

If a helicopter is sent to your assistance, there are several points to consider.

- Communication is impossible once the helicopter is overhead, brief the crew before it arrives.
- Have a hand held flare ready to pinpoint the vessel (imagine trying to find a specific boat in the Solent on a summer day).
- They will contact you by VHF radio, monitor the radio, but do not transmit unless called. The pilot is listening to the winchman giving him directions on the approach.
- Either motor directly in to the wind with the sails down or sail close hauled on port tack (the helicopter crew will instruct you).
- Clear the decks of any loose equipment that may blow away or be sucked in to the engine intakes.
- Have a bucket ready to lower the winch line into, gloves may be useful.
- Do not attach the cable to the yacht, or let it snag on anything.
- When the cable is lowered, let it earth out on the deck or water before touching it (there is a static build up in flight).
- Follow the diver's hand signals when he has been lowered. He is lowered, and then you pull him in to the boat.
- Follow the diver's instructions when he is on the boat. A helicopter crew perform, hundreds of rescues each year, they know what they are doing!

If the sea-state is too rough for a man to be lowered to the deck, the helicopter may lift you from a liferaft or dinghy. Occasionally you may be told to jump into the water and be rescued from there. In this case ensure you are wearing lifejackets and only enter the water one at a time when told to.

Dinghy safety
The most dangerous time in yachting is when using a dinghy, even in an apparently safe harbour there may be a current running and exit from the water almost impossible.

When using the dinghy;
- Always wear a lifejacket
- Use a boarding ladder if one is available
- Take a torch if it could be dark for the return
- Take the pump
- If using an outboard, take the oars
- If landing in an exposed area, take a small anchor
- Do not overload the dinghy, and load it evenly

Practical safety training
If you are in distress, the last thing you should be doing is working out how to use your survival gear. It is strongly recommended that you take some basic sea survival courses and a VHF radio license.

Practical training in the use of a liferaft and flares are not only fun and interesting but also may one day save your life.

Fire drill
One exercise you can set up for yourself is to imagine a fire below, on a sunny day in mid channel, which soon becomes uncontrollable. Then go through all the actions that would need to be performed.

This will include:
- Alert the crew
- Start to fight the fire
- Send a Mayday (quickly, you can always cancel it, also work out your position)
- Cut fuel and gas if appropriate
- Get everyone on deck away from the smoke
- Lifejackets on
- Prepare liferaft
- Collect warm clothing
- Collect flares box
- Collect EPIRB and hand held VHF if available
- If necessary launch liferaft and abandon ship
- Cut painter free from yacht and paddle away
- Take sea sickness tablets

- Post lookouts, activate EPIRB and use hand held VHF

Water and food are not priorities in this case; you could drown or die of cold long before you starved. On an ocean trip, a grab bag should be prepared with basic equipment and supplies for longer survival.

You can see from this list, that there are many things to be done at once. That is why the crew must be trained to handle the basics, then the skipper is free to organise and oversee the operation.

Preparation for heavy weather

As encountering heavy weather is always a possibility, the boat should be prepared for it every time you go to sea.

This starts with the construction of the fittings, a useful exercise is to imagine the boat upside down, would the heavy items like the cooker or batteries leave their fastenings and fly around the boat?

Although this is an unlikely situation, it can happen so it should be prepared for! If there is anything that would move in rough weather, I suggest you reinforce the fastenings.

After this, each time you leave harbour, the last check you need to do is to look below and see if everything is stowed, this is especially important with inexperienced crews.

One area to take care of is the chart table, the only thing that should be on the chart table, is the current chart. Everything else must be stowed away when it is finished with, or it will end up on the floor.

Having things lying on the floor will not only damage them if any water comes below but it will be a hazard to movement below.

In heavy weather, the sail area should be gradually reduced, before it is necessary, especially at night. Reefing the main and changing or rolling the headsail can do this.

If you have a roller headsail, you will find that when the wind rises above about force 6, the sail begins to sag and will not set properly. This means that there must be a separate storm jib available. The storm jib can be hoisted on a removable forestay, around the roller-furled headsail (difficult in practice), or loose luffed (nearly impossible to control in a gale).

Whichever system you use, you must have practised with it first, and do not forget to try it out in real gale strength winds. A system, which works perfectly on a calm day in harbour, may not work at all at night in rough weather!

Storm trisails that replace the mainsail are coming in to fashion again. Because they have a lower centre of gravity and are set with no boom, they can be very useful in heavy weather. The disadvantage is that they are not easy to a sail upwind with, and are cumbersome to use in a confined area like the Solent. Trisails are really useful for ocean sailing, less so for coastal waters.

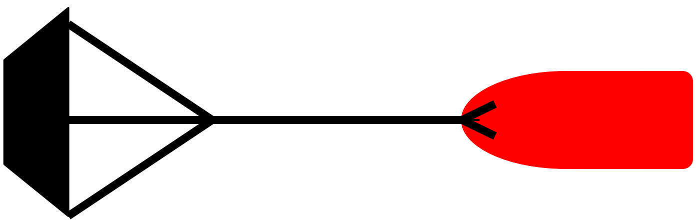
Extreme weather tactics
In extreme weather, there are a variety of approaches and philosophies that can be employed.

■ Run for shelter
If you can reach safety before a storm arrives, this must be the best approach. However, remember that it is the land and shallow water that presents the most danger in storms. If you can not reach harbour before the storm, you may have to make the tough decision to stay out at sea rather than approach the coast.

■ Gain sea room
If a storm is coming, the boat should be heading to where you will have the most sea room. The sea room primarily needs to be in the downwind direction, allowing for any wind shifts!

■ Lie to a sea anchor
A sea anchor is a large parachute that is streamed over the bow. The idea is that it holds the bow up to the waves, which then break down either side of the boat. A sea anchor will prevent the boat loosing too much ground to leeward.

They work best in heavy displacement, long-keeled, cruising yachts. They place large stresses on the



boat fittings and if the boat is forced backwards by a wave, the rudder can be sheared off a modern fin keel yacht.

Once deployed, the anchor is probably irrecoverable until the storm has passed, otherwise it may be necessary to jettison it.

- Heave too

Heaving too either under storm sails or in extreme conditions under bare poles can be effective in a buoyant, long keeled yacht. Again, this tactic minimises the ground lost to leeward.

Most modern fin keel yachts heave too, beam on to the waves, this would be extremely dangerous in a storm, as the yacht would be rolled over.

A combination method that has worked is to run the engine sufficiently to keep the boat's head up in to the sea. This is only an option if the cooling water inlet stays below the water and the engine can pump oil as large angles of heel.

- Run off before storm

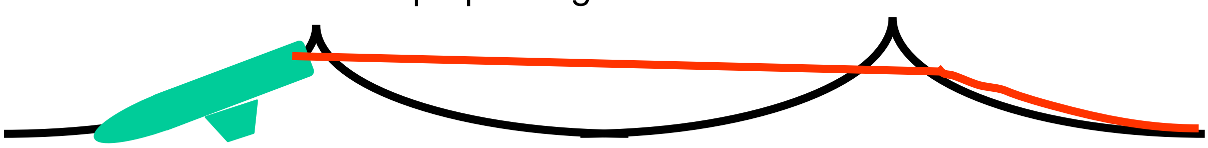
Running downwind (with sails or bare poles) can be a good tactic in a modern, fast yacht: if there are sufficiently skilled helmsmen to do so for hours, and plenty of sea room!

The danger of running, is that if you travel faster than the waves, it is possible to dig the bow in to the back of the wave ahead, the boat then stops, is picked up by the next wave and rolled end over end **(pitchpoling).** It is also very easy to broach on a breaking wave and end up beam on to the sea.

- Trailing warps or drogues

To slow the boat down long ropes can be let out the back; they need to be in a loop and to reach two wavelengths back if possible. The idea is to stop the boat surfing faster than the waves. A similar approach is to use purpose built small drogues, similar to small sea anchors.

Rope pulls tight across waves



The danger of slowing the boat is that you may be **pooped.** This occurs when a wave breaks on the stern of the boat, filling the cockpit and possibly smashing in the main hatch.

- Release oil

An old technique is to pour oil on the sea to reduce the breaking waves. Apart from the environmental considerations, few yachts would carry sufficient to have any effect. Although some people have reported success with pumping cooking oil out through the heads whilst lying **ahull** (hove to under bare poles).

- Conclusion

As you can see, there are no definite answers.

A prudent skipper will read as much as possible about the tactics employed by other people and consider their relevance to their own boat. Magazine articles are very informative and the following two books, published by Adlard Coles will give you lots of examples and ideas:

Total Loss and Heavy Weather Sailing.

Action in fog

Fog is one of the scariest situations at sea. If possible, avoid fog by staying in harbour.

Navigating a boat in bad visibility is very stressful and exhausting, you will also find that after a while you start to imagine that you can see things!

The dangers in fog are:
- Collision
- Getting lost and not being able to find harbour
- Hitting a hazard

The tactics we employ when the fog appears must address these points.

Collision avoidance
- Sound a fog signal
- Post lookouts on the bows (change them frequently)
- Have the engine ready for use (warmed up)

- Monitor the port control VHF channel (ships call in their position at this symbol)

- Avoid busy waterways and harbours with a lot of shipping
- Stay in shallow water (too shallow for ships!)
- Hoist radar reflector
- Operate your radar if fitted

To avoid getting lost

- Plot a fix as soon as you realise visibility is reducing
- Maintain good navigation and records
- Follow a contour line if possible
- Aim off to one side of your destination

To avoid hitting a hazard

- Find shallow water and anchor until the fog clears
- Change your route or destination to an area with no dangers
- Monitor the depth constantly
- Set a clearing depth (a minimum depth)

Not all these concepts can be used at the same time; you will need to decide on your tactics based on the situation at the time.

On a Coastalskipper or Yachtmaster practical course, you will probably practice fog navigation. It is only by practising that you begin to believe in your ability to find your way around safely. Try navigating your way around from down below in good visibility, before you have to do it for real!

Signalling

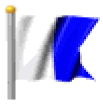
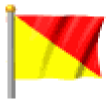
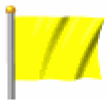
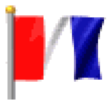
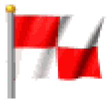
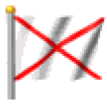
Even though, most communications will be by VHF radio or even email through a satellite link! There is still a place for the older systems of signalling.

The use of flags or Morse Code can be a good back up means of summoning assistance, but through the International Code of Signals (Interco) it can allow communication, on any of a vast range of subjects that may be required in an emergency.

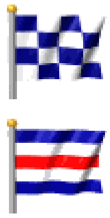
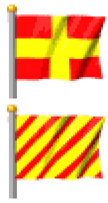
The reason this is possible is that the code uses sequences of dots and dashes, flags or phonetic pronunciation that mean the same thing in all languages. All you require is for both parties to have a copy of the code!

For example:
The letters 'KT' mean, "You should send me a towing hawser."
The letters 'KT1' mean, "I am sending you a towing hawser."

In practice, most signals will be simple, single letter messages and although you do not need to memorise the entire code; there are a few signals that are useful.

Letter	Morse code	Flag	Meaning
A	● ▬		I have a diver down, keep well clear.
O	▬ ▬ ▬		Man overboard.
Q	▬ ▬ ● ▬		I request free pratique (customs clearance).
T	▬		I am engaged in pair trawling.
U	● ● ▬		You are running in to danger.
V	● ● ● ▬		I require assistance. (not a distress signal)

Two flag signals.

NC	▬ ● ▬ ● ▬ ●		I am in distress and require immediate assistance.
RY	● ▬ ● ▬ ● ▬ ▬		You should proceed at slow speed when passing me.

Signalling by light or sound

This is the most likely method of signalling that will be used by yachtsmen. Obviously, a good timing and rhythm to communicate effectively.

If we take a dot as 1 second or unit of time, the correct spacing is as follows:

■ Dot	1 unit
■ Dash	3 units
■ Space between each dot and dash in a letter	1 unit
■ Space between each letter or symbol	3 units
■ Space between each word or group	7 units

This covers all you need to know about signalling. If you wish to learn more, obtain a copy of the International Code of Signals.

Flag Etiquette

A vessel's ensign is the senior flag and should be flown from the most important positions. This is at the stern; this tradition dates from the days when ship's officers were quartered at the stern of the vessel.

The ensign shows the nationality of the vessel and should be displayed when land or other vessels are in sight. In harbour or at anchor, the ensign should be displayed between 0800 and sunset or 2100 if this is earlier. However, between 1^{st} November and 14^{th} February the ensign is displayed between 0900 and sunset.

The tradition of lowering the ensign was begun to reduce the cost of ensigns. If they are only displayed during the day, they last much longer than if they are displayed all the time!

The normal ensign for a yacht is the Red Ensign, the flag of the Merchant Navy. Some privileged clubs may have a special warrant to fly a special ensign. This will be a white ensign for the Royal Yacht Squadron, or a blue ensign or a defaced blue ensign (one with the emblem of the club). A special ensign should only be flown with the relevant club burgee.

A courtesy flag is a small flag of the nation that the vessel is visiting. One should be flown from the starboard crosstrees when in the territorial water of a foreign country and should never be below any other flag aboard except the ensign and club burgee.