MASTER OF YACHTS 200 TONS LIMITED

Tuition Notes published by International Yacht Training Worldwide

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Updated March 2014

Contents

1

Introduction

The aim of this course is to increase the candidates' nautical knowledge, and develop the skills to competently and safely take on the duties and responsibilities required when in charge of a power or sailing vessel up to 200 gt.

The expected learning outcomes are that the student understands the theory and practical applications of:

Basic Safety Procedures and use of equipment
Collision regulations
Chartwork
Navigation, pilotage and passage planning
Tides, Tidal Streams and Tidal calculations
International and (Local) Collision Regulations and buoyage
Meteorology
Vessel Handling
Anchoring, berthing and MOB
Towing and other emergency procedures
Seamanship, Ropework
Safety, Emergencies and contingencies
Basic stability and construction
Master of Yachts Business and Law

As with all IYT Worldwide courses, the depth of knowledge is designed to increase as the student progresses through the various levels of training.

This is not a beginner's course.

Course Outline

The layout of these notes is the suggested order in which the course may be covered by an instructor. However IYT Worldwide recognises that each school may have a different set of circumstances and student requirements to facilitate. It is therefore perfectly acceptable that the order in which the material is covered may be altered provided that the content is covered logically and fully, complying with the stated syllabus and depth of knowledge.

2

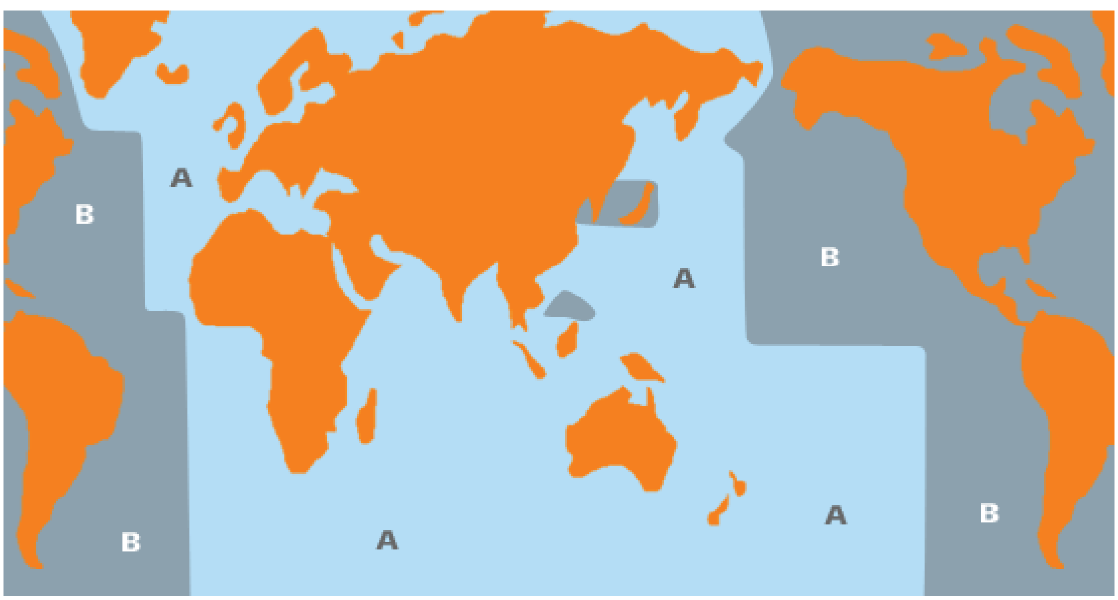
International Regulations for Preventing Collisions at Sea

In 1910 the first internationally agreed set of rules, or code, setting out the behaviour required of vessels under certain conditions in order that they should keep clear of each other came into being. First set out in the Brussels Regulations of 1910 these rules have been updated and added to over the years. The Rules were updated by a conference of the International Maritime Organization in 1972 and are usually referred to as the 72 COLREGS or just the COLREGS. Subsequent amendments have been and continue to be made to the Rules to keep them up to date. A current copy should always be carried by every vessel. Most maritime authorities have adopted the COLREGS in full with or without local or national variations to suit their individual requirements.

It is not necessary to know all of the Rules off by heart but a thorough knowledge of the COLREGS is essential, it is totally unacceptable to say "I don't know what it is, or what to do, but I'll look it up in the Almanac". This attitude causes accidents and endangers others as well as yourself. The full text of the COLREGS is readily available from many sources and may be downloaded from various web sources at no cost.

Possibly the most difficult section to learn is this section which deals with the lights required by vessels operating under different circumstances at night. Computer programs are available to help but perhaps one of the best ways to learn the COLREGS lights is with a set of playing card sized cards which have various combinations of lights in colour on a black background on one side and the description of the vessel (s) the lights represent printed on the back. These cards are readily available from most marine stores and are quite inexpensive.

Buoys and Marks
To help ensure safety and to clearly mark out obstacles and hazards that exist both in and under the water there exists an internationally agreed sets of marks and lights. These are developed with the assistance of the "International Association of Lighthouse Authorities" (IALA) There are two major systems covering the world, as follows:



IALA Maritime Buoyage System
Buoyage Regions A and B

Region A (IALA A) covers all of Europe and most of the rest of the world except for the areas covered in **Region B (IALA B)** which is North America, South America, Japan, The Philippines and Korea. Fortunately the differences between the two systems are few. The most important is that which deals with the "direction of buoyage" which defines on which side of a channel the Lateral or Channel Buoys or Marks are placed.

For both IALA A and IALA B, the shapes, when returning from sea, are conical buoys or (triangles if fixed) to starboard, can shaped buoys (or square if fixed) marks to port. These Lateral or Channel Marks define the limits of the navigable water across a channel, though designed in principle to define the limits for large commercial ships they are also vital for the safety of smaller vessels. It is almost never wise to attempt to pass between a channel mark and the shore behind.

Marks can either be a buoy floating in the water or a pole set into the rocks or sea bed which will be painted in the correct colour and carry the required shape at the top.

IALA A leave red to port, green to starboard when returning from sea.
IALA B leave red to starboard, green to port when returning from sea.

This section is intended to present a synopsis of the Rules and present them pictorially where possible.

Common to both areas:

Isolated Danger Mark

This buoy indicates a navigation hazard such as a partially submerged rock, recognised by the black and red bands and top-mark of two black balls.
The light is WHITE and exhibits 2 quick flashes at intervals of 5 seconds.

Safe Water Mark

Used to indicate the end/start of a channel, open, deep and safe water lies ahead. It may also used to indicate the start and end of a buoyed section of a narrow channel, or a line of these buoys can be used to mark a safe route through shallow areas. Sometimes known as a Fairway Buoy, the colour is red and white vertical stripes with a top mark of a red ball.
The light is WHITE and may either flash Morse code “A”, occulting, Isophase or long flash every 10 seconds (L Fl 10s) [2].

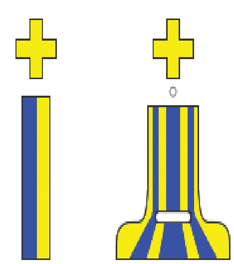
Special Mark

Placed to indicate the boundary of an obstruction, administrative area such as a speed limit, water skiing or mooring area, or to highlight other features such as outfall sewerage pipes. The mark is yellow in colour with a yellow X top-mark.

The light is YELLOW and consists of one quick flash with intervals of 5 seconds.

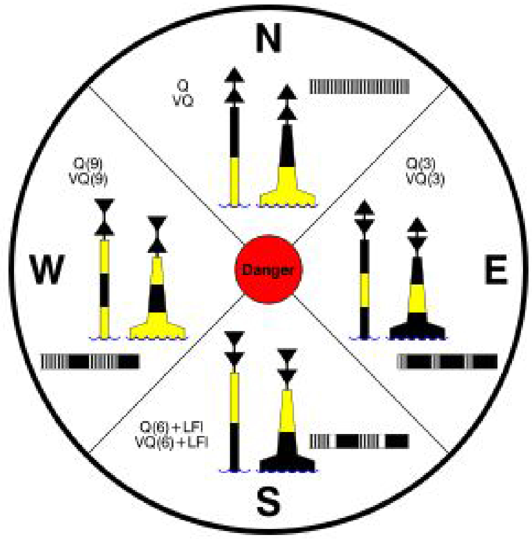
Wreck Buoy

Used to temporarily indicate a wreck until the wreck is cleared or permanent marks are set up. The colour is blue and yellow indicating that there is a serious danger existing and the mariner must keep clear.



The light is an alternating BLUE AND YELLOW flashing sequence. This may be made even more distinctive when a group of wreck buoys are deployed around a wreck site and the flash characteristics are synchronized to all show the same flash/eclipse cycle at the same time by utilizing an integral timer.

Cardinal Marks



Buoys or marks used to indicate the position of a hazard and the direction of safe water/ safety as a cardinal/compass direction relative to the hazard by:
Indicating that the deepest water is an area on the named side of the mark
Indicating the safe side on which to pass a danger

Each cardinal mark indicates one of the four compass directions by:

1. The direction of its two conical top-marks
N - both point up,
S - both point down,
W - towards each other (Wine glass/Waist shape - W)
E - away from each other, bases together (Egg shape - E)

2. The colour pattern of black and yellow stripes, which follows the orientation of the cones - the black stripe is in the position pointed to by the cones (e.g. at the top for a north cardinal, in the middle for a west cardinal)

3. The distinctive WHITE flashing light characteristics, quick or very quick flashes.
The pattern indicates the direction of the cardinal point with a number of flashes based on the clock face position which corresponds to the direction of the cardinal point.
N - continuous flashes
E - 3 flashes
S - 6 flashes (plus 1 long flash to help make it easily distinguished from West
W - 9 flashes

Lateral Marks

A lateral buoy/mark is used to indicate the edge of a channel, either port side or starboard side relative to the direction of buoyage. (This is usually a nominally upstream direction towards the river's source or the direction into the harbour from the sea. Where there may be doubt, it will be labeled on the appropriate chart.
A vessel heading in the direction of buoyage (e.g. into a harbour) and wishing to keep in the main channel should: keep port marks to its port (left), and keep starboard marks to its starboard (right).

IALA A

Port marks are red, can shaped and may have a red flashing light of any rhythm.
Starboard marks are green , cone shaped and may have a green flashing light of any rhythm
"Is there any red port left"

IALA B

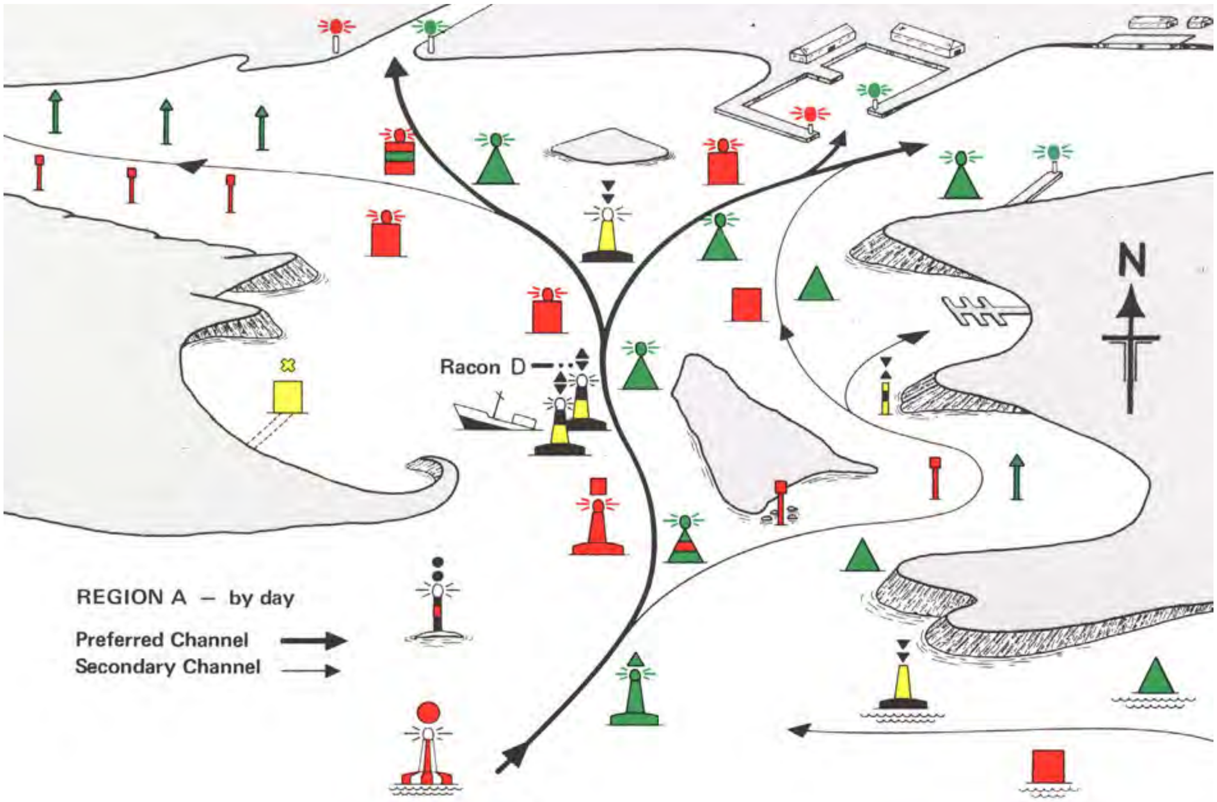
Port marks are green, can shaped and may have a green flashing light of any rhythm.
Starboard marks are red, cone shaped and may have a red flashing light of any rhythm
"Red right returning"

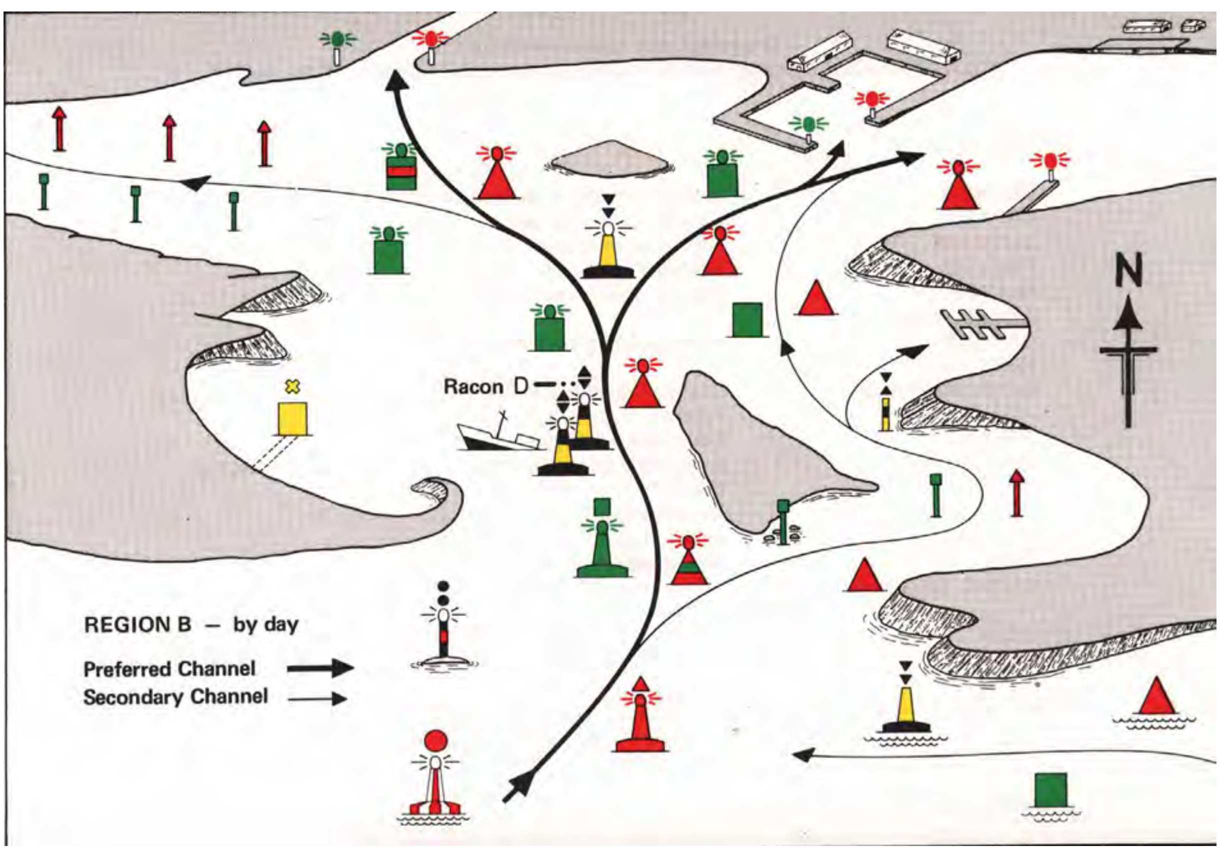
Both regions

Port marks are square/can shape or have a can shape topmark
Starboard marks are conical or have a conical shaped topmark

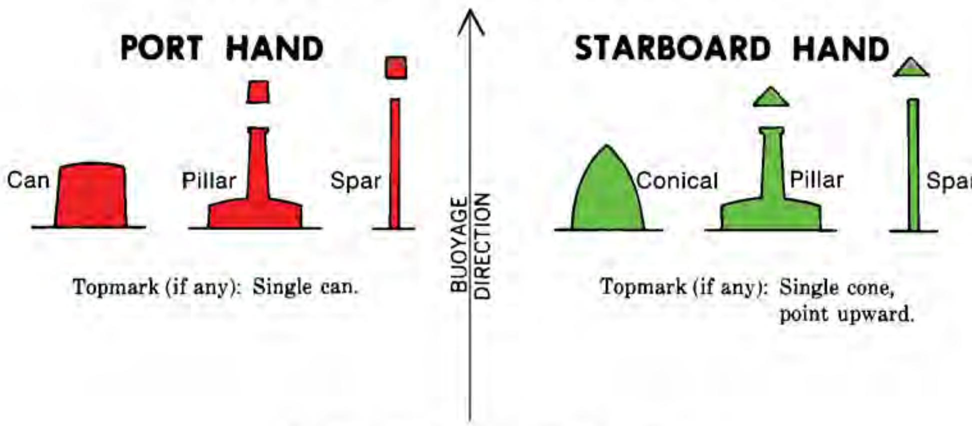
Bifurcation/Preferred Channel Mark

These marks are coloured with red and green horizontal bands indicating that a "preferred" channel and secondary channel are available. Vessels wishing to use the preferred /deep water channel observe the top colour of the mark, and vessels wishing to use the secondary channel observe the bottom colour.

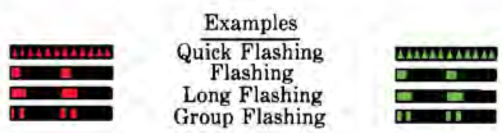

Racon D
REGION A – by day
Preferred Channel
Secondary Channel
N

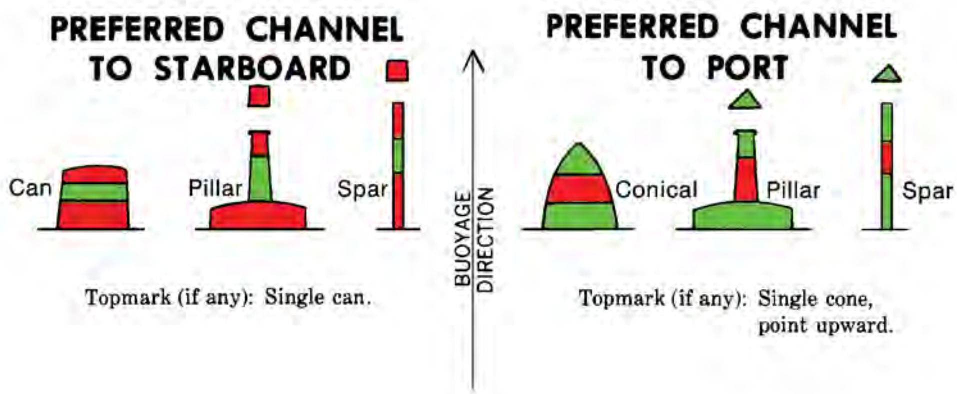

Racon D
REGION B – by day
Preferred Channel
Secondary Channel
N

IALA MARITIME BUOYAGE SYSTEM
LATERAL MARKS REGION A



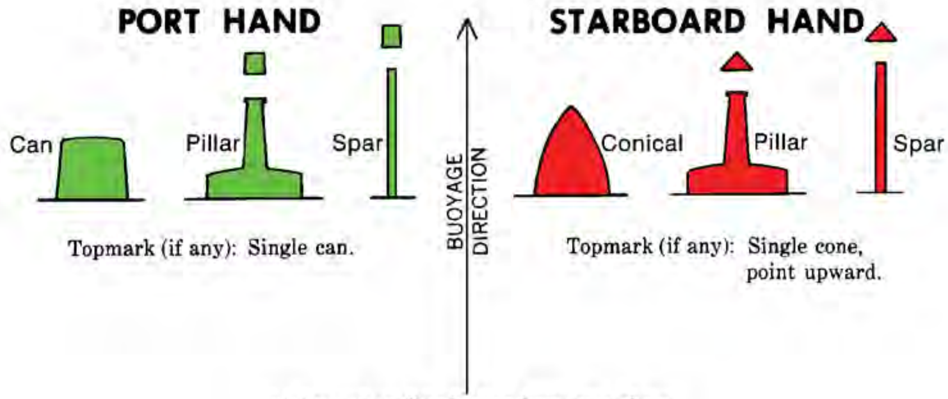
Lights, when fitted, may have any phase characteristic other than that used for preferred channels.



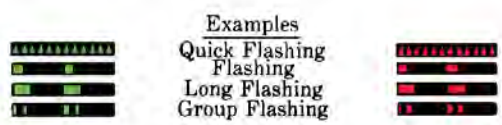


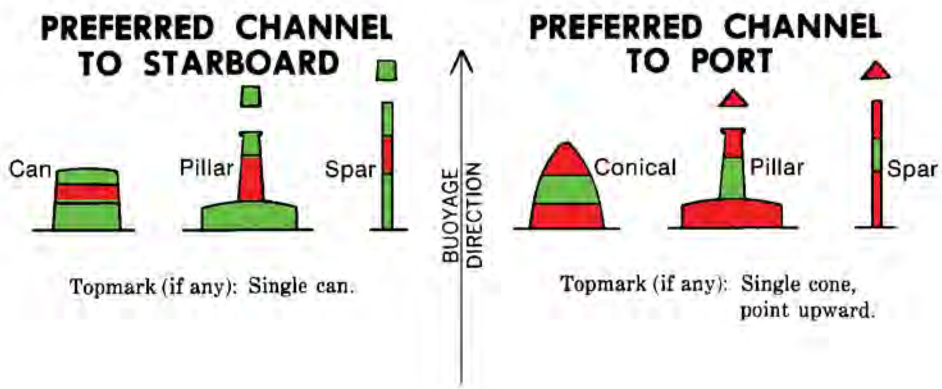
Lights, when fitted, are composite group flashing Fl (2 + 1).

IALA MARITIME BUOYAGE SYSTEM
LATERAL MARKS REGION B



Lights, when fitted, may have any phase characteristic other than that used for preferred channels.





Lights, when fitted, are composite group flashing Fl (2+1).

The 72 COLREGS

The COLREGS consist of 38 rules which are set out in 5 parts, as follows:

- Part A: General
- Part B: Steering and Sailing Rules
- Part C: Lights and Shapes
- Part D: Sound and Light Signals
- Part E: Exemptions

Part A, General

Part A defines that the Rules apply to all vessels (regardless of size) on the high seas and to all waters connected to the high seas that are navigable by seagoing vessels.

The Rules, however, allow appropriate authorities to operate special rules in harbours, rivers, lakes and inland waterways but state that any such special rules should conform as closely as possible to the COLREGS.

In Europe there is a complete set of regulations for inland waterways, rivers, lakes and canals (CEVNI: Code Europeen Des Voies De Navigation Interieure), while the U.S. has the Inland Navigation Rules which apply on the inland waters of the United States. The point at which the rules change from International to Inland is marked on U.S. charts by the words 'COLREGS DEMARCATION LINE."

Many of the Inland Rules wherever you sail are in fact identical to the International Rules.

Part A also contains definitions which should be understood:

Power driven vessel:	any vessel propelled by machinery
Sailing vessel	vessel under sail provided an engine is not also being used.
Fishing vessel	vessel using nets, lines, trawls, etc., which restrict manoeuvrability.
Not under command	vessel which is unable to manoeuvre as required by the Rules due to some exceptional circumstance. (e.g.: damaged steering).
Restricted in ability to manoeuvre	vessel which is unable to manoeuvre as required by the Rules due to the nature of her work. (e.g. dredging, surveying, pipe or cable laying, towing, etc.).
Constrained by draft	power driven vessel which cannot deviate from her course due to her deep draft relative to the surrounding depth of water.
Underway	vessel which is not at anchor, or made fast to the shore, or aground.
Restricted visibility	visibility restricted by fog, mist, heavy rain, snow, etc.

Part B, Steering and Sailing Rules

This section defines what action must be taken by vessels to avoid collisions under specific circumstances.

One of the most important of all the Rules is Rule 5 which is given here verbatim:

Lookout "Rule 5"

Every vessel shall at all times maintain a proper lookout by sight and hearing as well as by all available means appropriate in the prevailing circumstances and conditions so as to make a full appraisal of the situation and of the risk of collision."

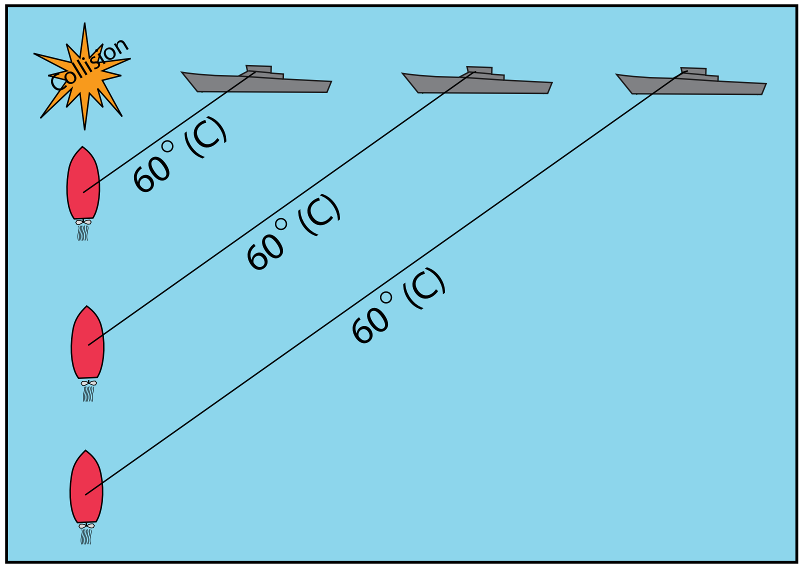
Safe speed "Rule 6"

Vessels shall at all times proceed at a safe speed taking into consideration visibility, traffic density, manoeuvrability of the vessel, background lights at night, state of the wind, sea, current, and proximity of navigational hazards.

Risk of Collision "Rule 7"
Vessels shall use all available means to determine if risk of collision exists. Risk of collision shall be deemed to exist if the compass bearing of an approaching vessel does not appreciably change; risk of collision may sometimes exist with a large vessel, a tow or a vessel at close range even if the bearing does change appreciably.

If there is any doubt, risk of collision shall be deemed to exist.

Assumptions shall not be made on the basis of scanty information, especially scanty radar information.



Action to Avoid Collision "Rule 8"
Any action taken to avoid collision shall be positive, made in ample time and with due regard to good seamanship. A change of direction and/or speed shall be large enough to be obvious to the other vessel - avoid small successive changes in speed and/or direction.

Narrow Channels "Rule 9"
Vessels should keep as close as practical to the starboard side of a channel or fairway. A vessel less than 20 meters, a sailing vessel or a fishing vessel shall not impede the passage of a vessel that can only safely navigate within a narrow channel or fairway.

'Give Way', 'Stand On'
If risk of collision exists between two vessels correct application of the Rules will require one vessel to give way and confer right of way to the other vessel. The vessel required to give way is called the Give Way vessel and the vessel with right of way is called the Stand On vessel; both vessels have specific responsibilities under the Rules.

Action by Give Way vessel "Rule 16"
The Give Way vessel shall take early and substantial action to keep clear.

Action by the Stand On vessel "Rule 17"
The stand on vessel must maintain her course and speed.

The stand on vessel may, however, take action to avoid collision by her manoeuvre alone, as soon as it becomes apparent to her that the vessel required to keep out of the way is not taking appropriate action in compliance with these Rules.

When, from any cause, the vessel required to keep her course and speed finds herself so close that collision cannot be avoided by the action of the give-way vessel alone, she shall take such action as will best aid to avoid collision. She should not alter course to port for a vessel on her own port side.

Overtaking "Rule 13"
Any vessel overtaking any other vessel shall keep out of the way of the vessel being overtaken. A vessel is deemed to be overtaking if she is coming up with another vessel from a direction more than 22.5° abaft her beam. In other words at night time only the stern light of the vessel being overtaken would be visible.

If a vessel is in any doubt as to whether she is overtaking she must assume that she is overtaking and act accordingly.

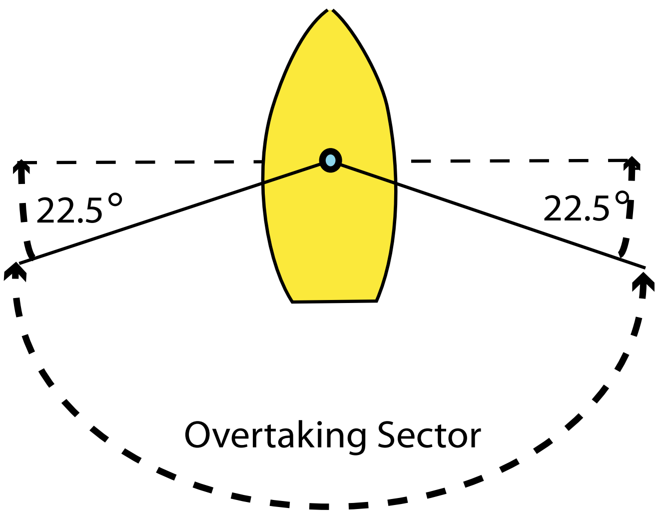


Fig 2 Overtaking

Power driven vessels meeting head on "Rule 14"
When two power driven vessels are meeting head on both alter course to starboard.

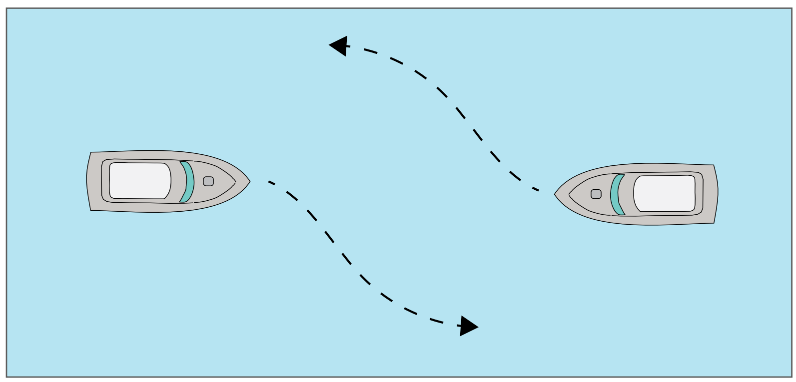


Fig 3
Power vessels meeting head on - both turn to starboard

Power driven vessels crossing "Rule 15"
When two power driven vessels are crossing, or converging, and risk of collision exists, the vessel which has the other on her own starboard side must give way.

The give way vessel should avoid crossing ahead of the other vessel if possible.

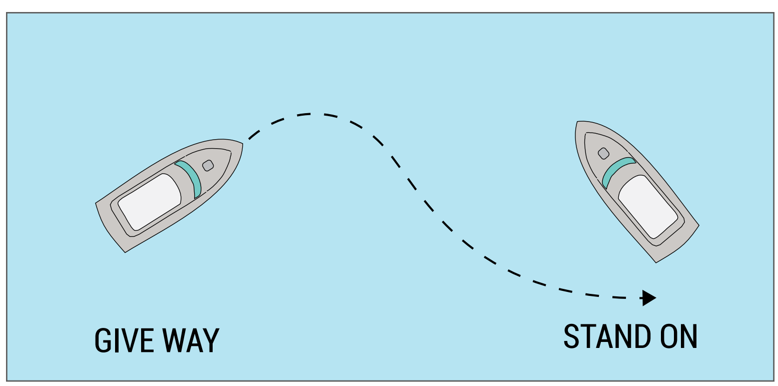


Fig 4
Power vessels crossing or converging:
Give way to vessel on your starboard side,
Stand on for vessel on your port side.

Sailing vessels "Rule 12"

When risk of collision exists between two sailing vessels the wind direction relative to the vessels determines which is the give way vessel and which is the stand on vessel. There are three Rules for sailing vessels:

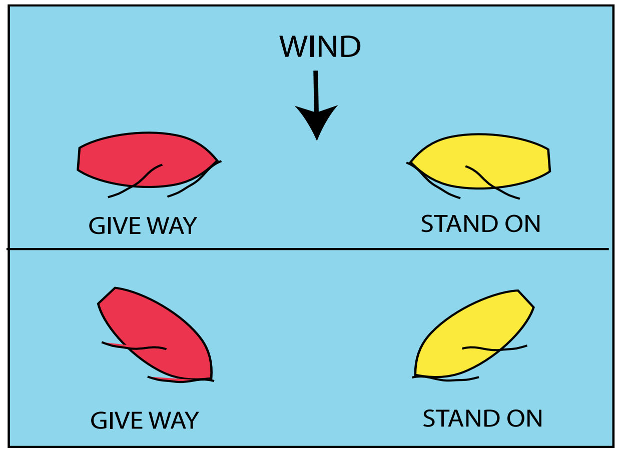


Fig 5

Port tack gives way, Starboard tack stands on.

(i) When each (sailing vessel) has the wind on a different side, the vessel with the wind on the port side shall keep out of the way of the other.

In other words a boat on port tack gives way to a boat on starboard tack. A sailing vessel with the wind coming over the port side is said to be on port tack, when the wind is coming over the starboard side the vessel is said to be on starboard tack.

The main sail indicates visually which tack the vessel is on as it will be carried on the opposite side to the side over which the wind is blowing.

(ii) When both have the wind on the same side the vessel which is to windward shall keep out of the way of the vessel which is to leeward.

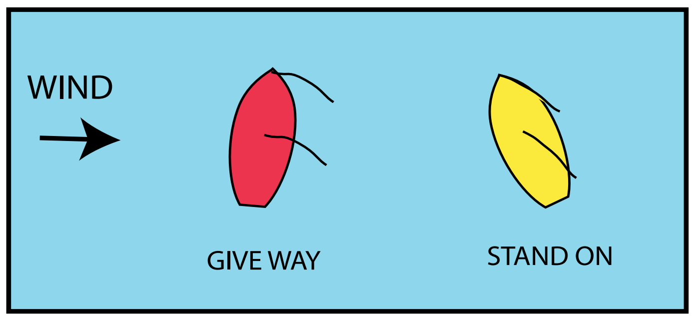


Fig 6

Same tack: windward boat gives way

(iii) if a vessel with the wind on the port side sees a vessel to windward and cannot determine with certainty whether the other vessel has the wind on the port or on the starboard side, she shall keep out of the way of the other.

In figure 7 the yacht B, on port tack, cannot see which side the mainsail of the other boat, A, is being carried on as it is obscured by the large headsail.
B, on port should therefore give way.

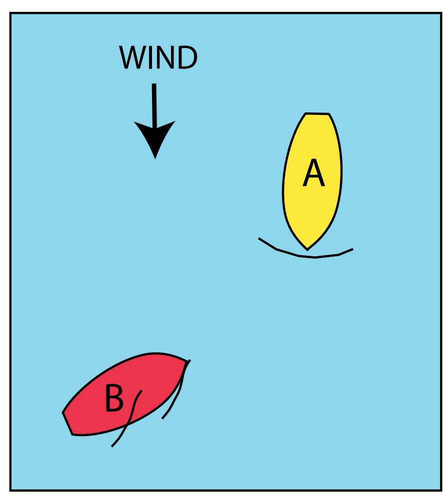


Fig 7

If in doubt port tack, B, gives way

Conduct of vessels in restricted visibility "Rule 19"

This Rule applies to vessels not in sight of one another when navigating in or near an area of restricted visibility.

- Every vessel shall proceed at a safe speed;
- A power driven vessel must have her engines ready for immediate manoeuvre.

A vessel which detects by radar alone the presence of another vessel shall determine if risk of collision exists. If risk of collision exists she shall take avoiding action in ample time, but where possible she shall not:

- Alter course to port for a vessel forward of the beam (unless overtaking);
- Alter course toward a vessel abeam or abaft the beam.

Every vessel which hears the fog signal of another vessel forward of her beam (unless it has been determined that risk of collision does not exist) shall:

- Reduce speed to minimum; (but should maintain steerage way);
- If necessary take all way off;
- Navigate with extreme caution until danger of collision is over.

Responsibilities Between Vessels "Rule 18"

A power-driven vessel underway shall keep out of the way of:

1. a vessel not under command;
2. a vessel restricted in her ability to manoeuvre;
3. a vessel engaged in fishing;
4. a sailing vessel.

A sailing vessel underway shall keep out of the way of:

1. a vessel not under command;
2. a vessel restricted in her ability to manoeuvre;
3. a vessel engaged in fishing.

A vessel engaged in fishing when underway shall, so far as possible, keep out of the way of :

1. a vessel not under command;
2. a vessel restricted in her ability to manoeuvre.

Any vessel other than a vessel not under command or a vessel restricted in her ability to manoeuvre shall, if the circumstances of the case admit, avoid impeding the safe passage of a vessel constrained by her draft, exhibiting the signals in Rule 28.

(The signals in Rule 28 are three all round red lights in a vertical line at night or a cylinder by day)

Traffic Separation Schemes (TSS) "Rule 10"

Traffic separation schemes have been set up at various places which experience heavy concentrations of shipping. The object of these schemes is to separate shipping into two distinct lanes. All vessels going in one direction proceed in one lane and all vessels going in the opposite direction proceed in the other lane; a no-go zone separates the two lanes. The system is similar to a motorway with a central barrier dividing traffic moving in opposite directions.
Traffic separation schemes are printed in magenta colours on charts.

For example there is a TSS between Dover and Calais, The Dover Straits, on practice chart 5055.

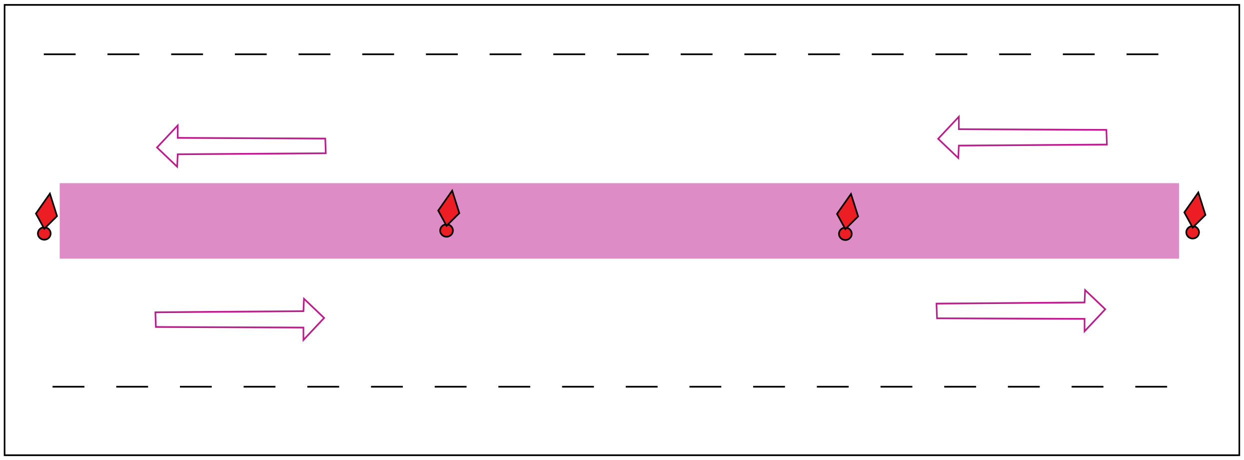


Fig 8
Traffic Separation Scheme. The arrows show the direction of travel.
The separation zone is not always marked with buoys as is shown in this example

TSS Rules
A vessel using a traffic separation scheme shall:

- Proceed in the general direction of the traffic flow for that lane;
- as far as is practicable keep clear of a separation zone;
- Normally join or leave a traffic lane at the ends of the lane, but if joining or leaving from either side of the lane shall do so at as small an angle to the lane as practicable;
- As far as practicable avoid crossing traffic lanes.
- If a vessel must cross traffic lanes she should cross on a heading of 90° to the general direction of traffic flow.
- Vessels of less than 20 meters, sailing vessels and fishing vessels do not have to use traffic separation schemes but may use inshore traffic zones (if one exists).
- Vessels should not normally enter or cross a separation zone except to avoid immediate danger or to engage in fishing.
- Vessels should not anchor in a traffic separation scheme.
- Vessels less than 20 meters in length and sailing vessels shall not impede the safe passage of a power driven vessel following a traffic lane.
- Fishing vessels shall not impede the passage of any vessel following a traffic lane.

Crossing on a heading of 90°
It is important to appreciate that a vessel should cross a separation scheme on a heading of 90° to the direction of travel rather than counteracting the effect of current and leeway to give a ground track of 90°. Crossing on a heading of 90° gives a shorter crossing time and makes it easier for shipping to appreciate that the vessel is crossing the scheme and not joining it.

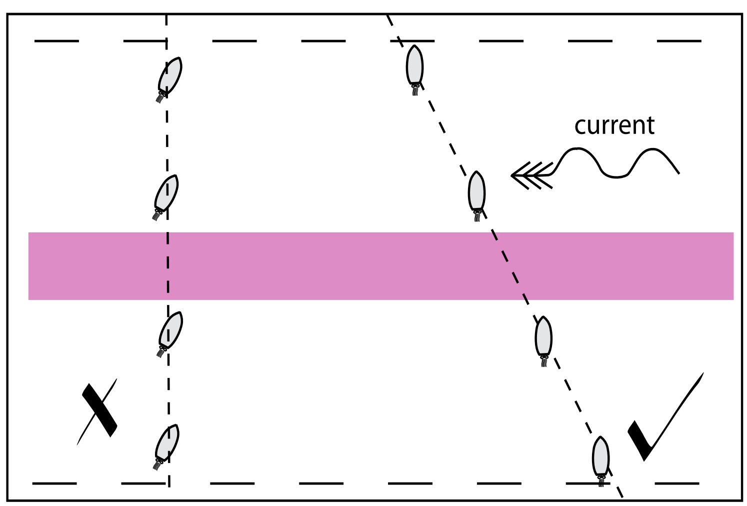
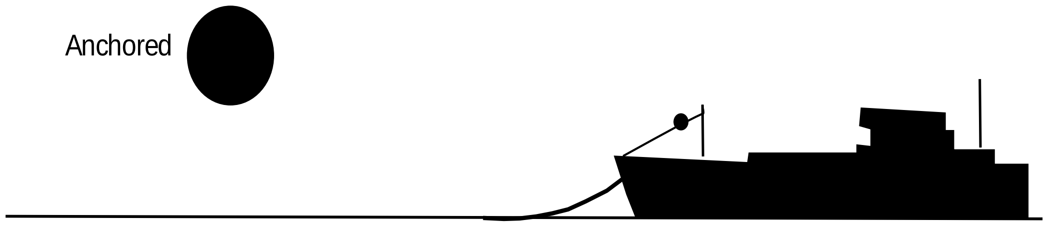


Fig 9
Cross a TSS on a heading of 90°

DAY SHAPES

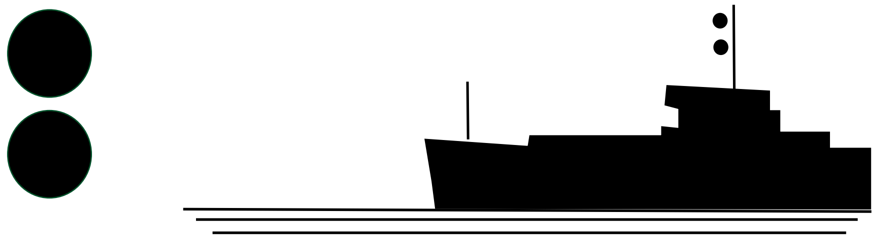
1

Anchored



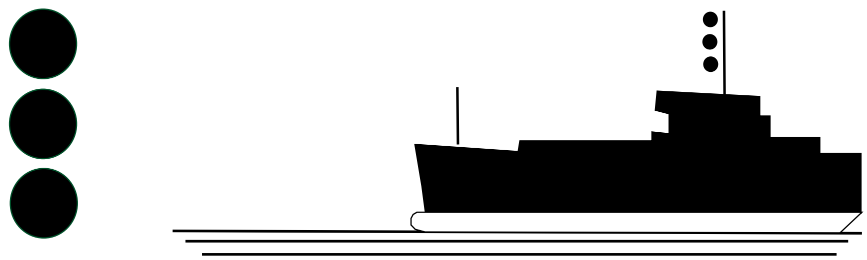
2

Not
under
command



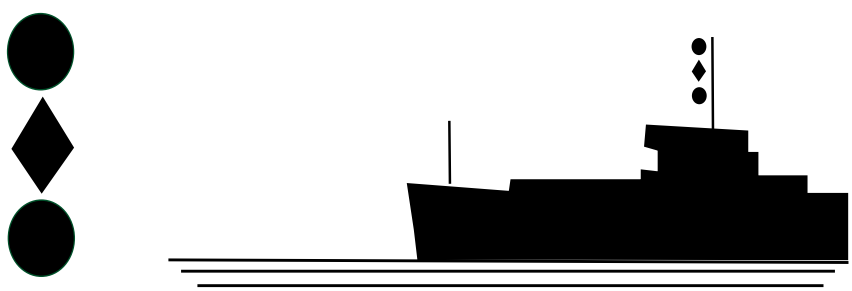
3

Aground



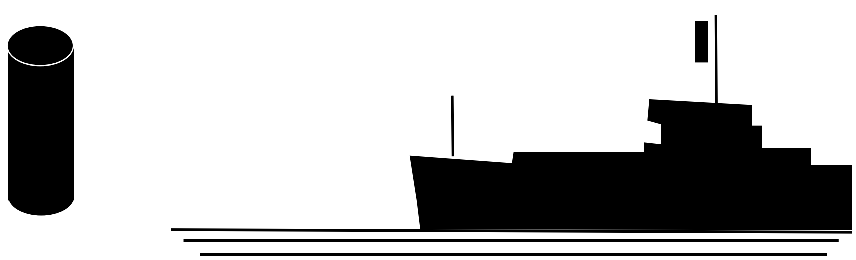
4

Restriced
in
ability
to manoeuvre



5

Constrained
by
Draft



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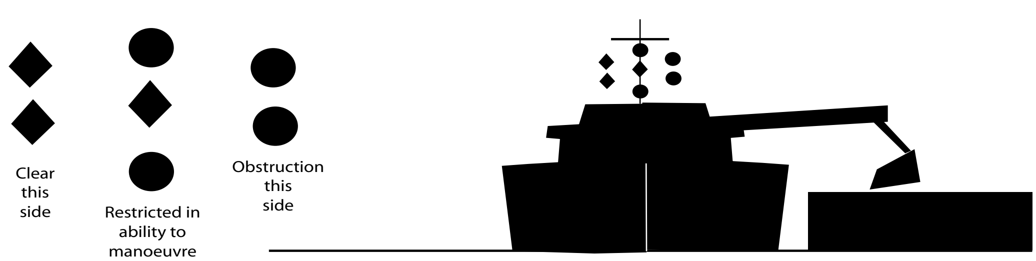
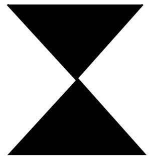
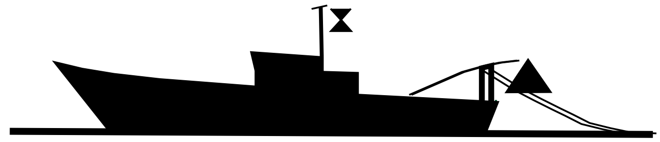


7

Fishing

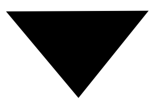


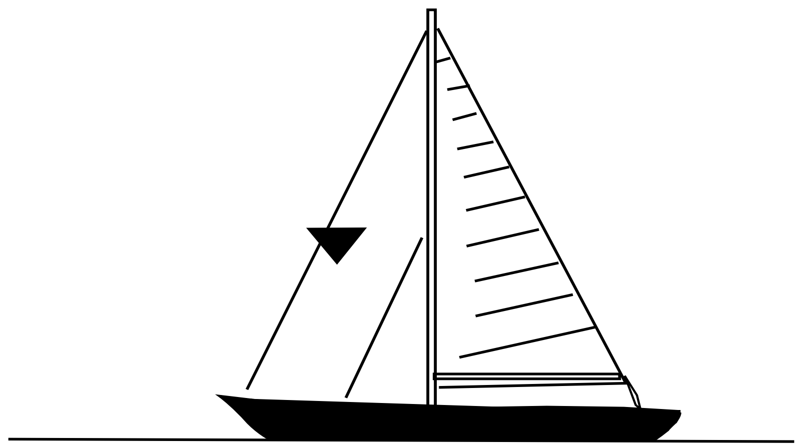
+, when outlying gear extends more
than 150 m horizontally,
cone, apex up, in direction of gear.



8

Motor Sailing





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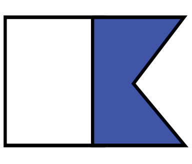
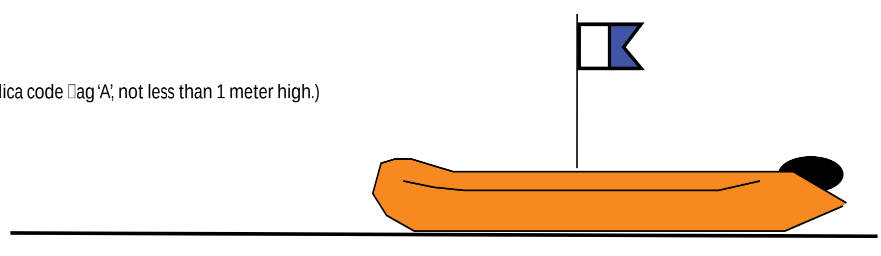
Diving Operations



(Rigid replica code flag ‘A’, not less than 1 meter high.)



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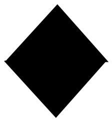
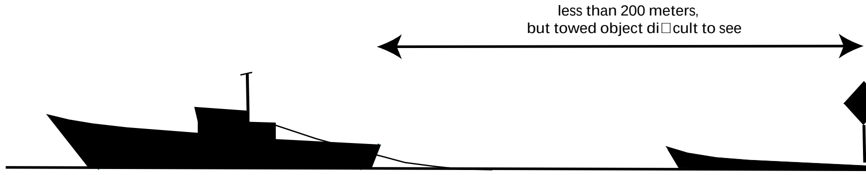
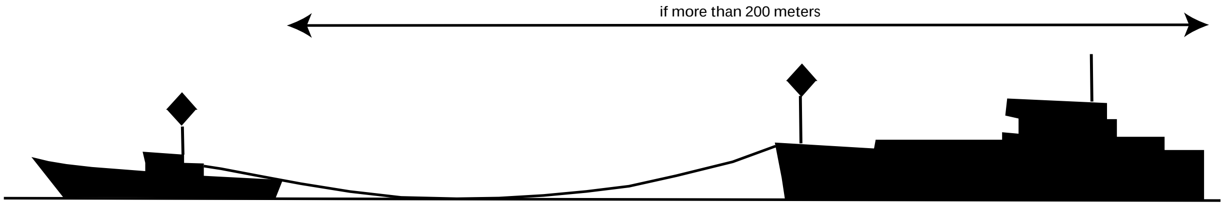
Towing







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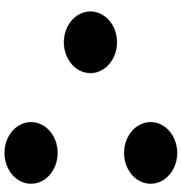
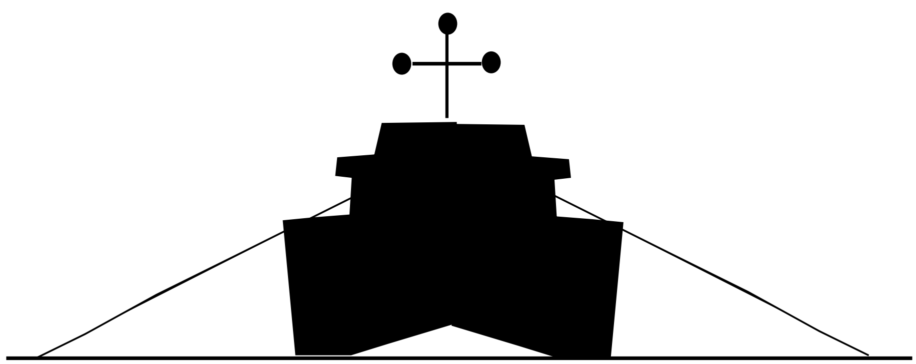


Minesweeping



■	= 1 second horn blast = short
▬	= 4 to 6 second horn blast = prolonged

Morse 'U" ■ ■ ▬
Means "You are running into danger":
This signal is often used by oil rigs, etc.

Sound Signals In Poor Visibility

Sound Signal		Every
▬	Power underway, making way	2 min
▬ ▬	Power underway, not making way	2 min
▬ ■ ■	Vessel sailing; vessel fishing; restricted in ability to maneuvre; constrained by draft; not under command; vessel towing or pushing	2 min
▬ ■ ■ ■	Last manned vessel of tow	2 min
■ ▬ ■	Warning from vessel at anchor	when required
■ ■ ■ ■	Pilot vessel on duty	when required
5 secs	Vessel at anchor: Rapid bell for 5 secs. (+ gong aft for 5 s if vessel > 100 m)	1 min
1 2 3 — — 1 2 3 5 secs	Vessel aground As for at anchor + 3 strokes on bell before & after rapid bell rings	1 min

Maneuvering and Warning Signals For Vessels In Sight Of Each Other

■	I am altering course to starboard
■ ■	I am altering course to port
■ ■ ■	I am operating astern propulsion
■ ■ ■ ■ ■ (Or More)	I do not understand your intentions! I doubt you are taking sufficient or appropriate action to avoid collision
▬ ▬ ■	I intend to overtake on your starboard side
▬ ▬ ■ ■	I intend to overtake on your port side
▬ ■ ▬ ■	Agreement by overtaken vessel
▬	Approaching blind bend in channel
▬	Reply from vessel on other side of bend

LIGHTS

Lights using combinations of white, red, green and yellow colours are used at night and in restricted visibility to convey information regarding a vessel's

- aspect;
- method of propulsion;
- size.

Additional lights are used to indicate if the vessel is:

- towing;
- fishing;
- Not Under Command;
- Restricted in Ability to Manoeuvre;
- Constrained by Draft;
- aground;
- at anchor.

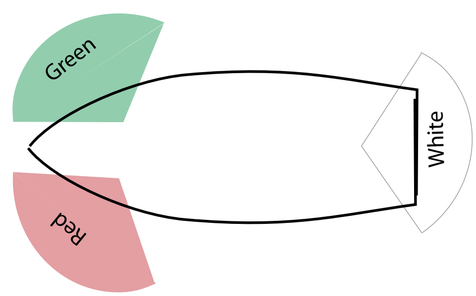
When attempting to decipher the meanings of a vessel's lights try breaking the lights down into sections by identifying the basic lights and then concentrate on the lights that remain. Usually the most important decision is whether risk of collision exists; if risk of collision does exist it is obviously necessary to work out details of the other vessel before deciding on the correct course of action.

Perhaps the best sequence is to decide the vessel's

1. aspect (ahead, astern, port, starboard);
2. propulsion (i.e. under power, under sail, being towed);
3. length;
4. other information (i.e. towing, fishing, Restricted in Ability to Manoeuvre, Not Under Command, etc.)

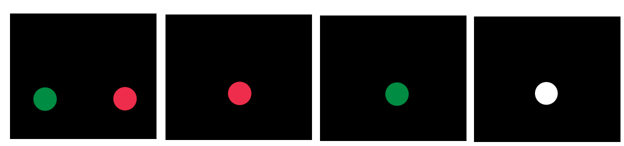
Side lights and stern light

A vessel underway (not at anchor, or made fast to shore, or aground) shows three basic lights, two sidelights and a stern light:
a green light on the starboard side,
a red light on the port side, and
a white light at the stern.
The sidelights each cover an arc of 112.5°, the stern light covers the remaining 135°.



Sidelights and stern light of vessel underway

From directly ahead the green and red sidelights would both be visible at the same time, altering course would mean that only one of the sidelights would be visible, either red or green depending upon the course change. From a position astern of the vessel only the white light would be visible.

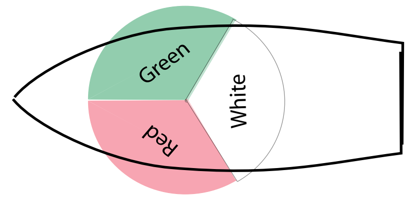


These three basic lights are for a vessel underway but note that this vessel is not under power, it may therefore perhaps be under sail, oars or being towed.

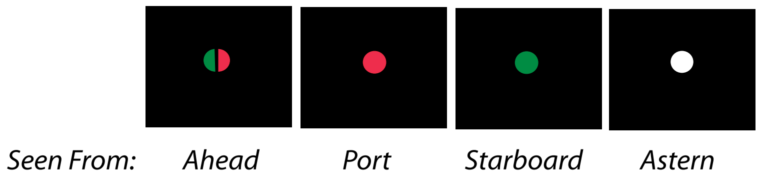
Extra lights are added when the vessel is under power.

Sailing vessels less than 20 meters may use a combined side and stern light
A sailing vessel less than 20 meters (65 ft) in length may combine side and stern lights in one lantern carried at or near the top of the mast. A combined lantern uses only one bulb instead of three and thus uses 1/3 of the electrical current that would be used by 3 lights: an important consideration for smaller yachts.

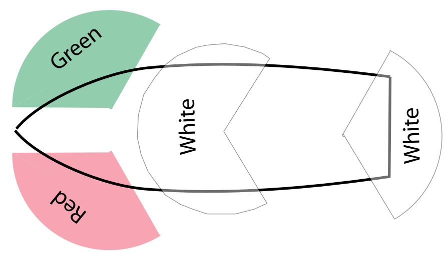
Note that this combined lantern must not be used when the yacht is using her engine.



Sailing vessels less than 20 meters may use a combined side and stern light

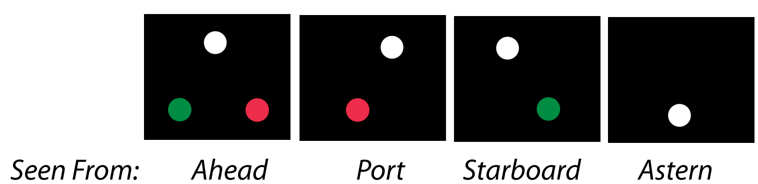


Power driven vessels
A power driven vessel underway less than 50 m (164 ft) in length shows a white masthead light above the sidelights. A masthead light covers the same arc as the sidelights combined.

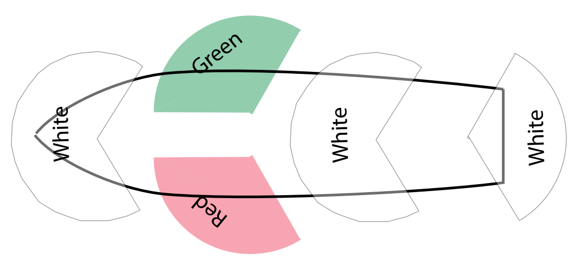


Power driven vessel underway, less than 50 meters in length

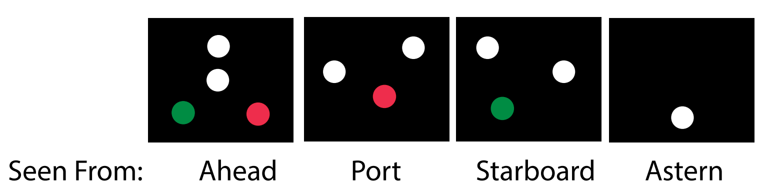
From directly ahead the green and red sidelights would be visible with the white masthead light above, altering course would mean that only one of the sidelights, either red or green depending upon the course change, would be visible with the white masthead light above it. From a position astern of the vessel only the white light would be visible.



A power driven vessel underway which may be greater than 50 m in length shows a white masthead light forward and a second masthead light behind and higher than the forward masthead light.



Power driven vessel underway, which may be greater than 50 meters in length



Towing
A vessel which is towing another vessel or object must show in addition to the normal sidelights and stern light:

- A yellow stern light directly above the white stern light and covering the same arc;
- two masthead lights in a vertical line if the length of tow is less than 200 meters;
- three masthead lights in a vertical line if the length of tow is greater than 200 m.

Seen from directly ahead two white masthead lights in a vertical line may indicate a power driven vessel greater than 50 m in length or it may be a power driven vessel less than 50 m with a tow of less than 200 m. However if it is directly ahead a change of course is obviously required; when the course is altered the two white masthead lights will either appear to separate (= power > 50 m) or they will remain in the one vertical line (= power vessel < 50 m, towing, length of tow < 200 m), in which case look very carefully for the sidelight(s) of the towed vessel. A similar situation arises when three masthead lights are visible in a vertical line, the solution becomes apparent in the same way.

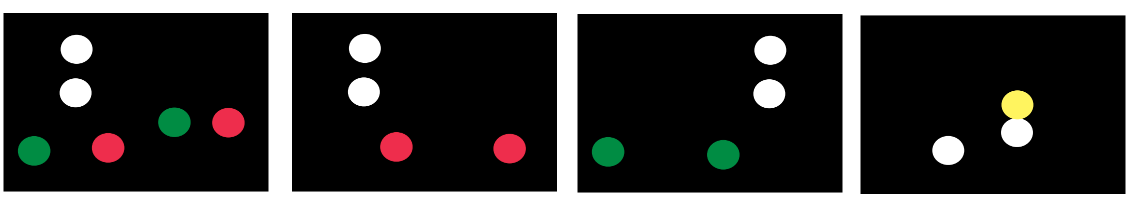
Similar lights are required for a vessel pushing unless the pushing vessel is rigidly connected to the vessel being pushed in which case they are lit as one single vessel only.

Towed vessel
A vessel being towed shows red and green side lights and white stern light, i.e. the lights of a vessel underway, not under power; a vessel being towed alongside shows the same. When two or more vessels are being towed the first in the tow shows sidelights and the last shows a sternlight. A vessel being pushed ahead, but not rigidly connected to the pushing vessel, shows her sidelights only.

Towed objects
Objects and partly submerged vessels being towed must be lit with an all-round (360°) white light at the front and another at the back. Two further all-round whites must also be placed at the maximum breadth if the object is greater than 25 m in breadth.
A towed object greater than 100 m in length must also have an all-round white light at least every 100 m along its length.

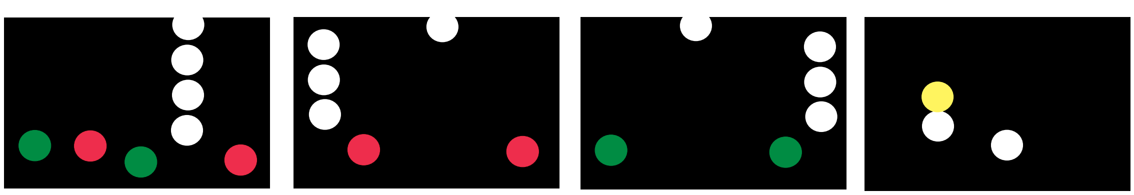
Assistance and Distress, etc.
Where for sufficient cause it is impossible or impractical for the towing vessel and/or the towed vessel to display the required lights all possible measures should be taken to indicate that a tow is taking place and to light the towed vessel.

Fig 14
Vessel < 50 m towing, length of tow < 200 m



Seen From: Ahead Port Starboard Astern

Fig 15
Vessel > 50 m towing, length of tow > 200 m



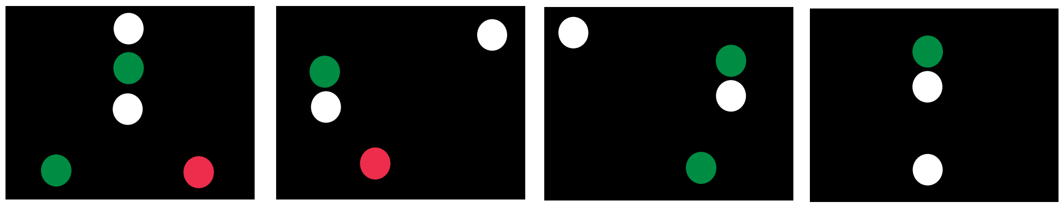
Seen From: Ahead Port Starboard Astern

Trawlers

Vessels underway when trawling show two all round-lights, green over white, in a vertical line. When the trawler is making way (moving under power through the water) she must also show her two side lights and stern light; if the trawler is greater than 50 m in length a white masthead light must be shown above and behind the all-round green light.

Fig 16

Trawler > 50 m, underway, making way



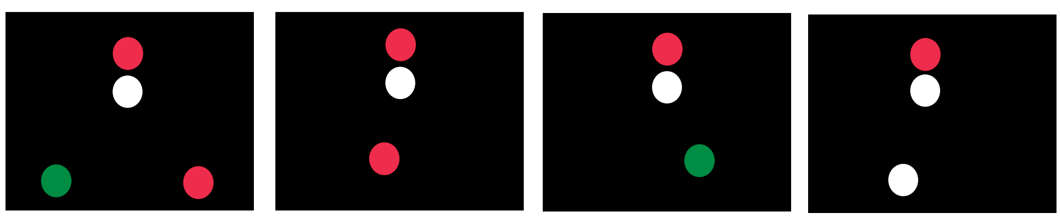
Seen From: Ahead Port Starboard Astern

Fishing vessels

Vessels when fishing other than trawling show two all round-lights in a vertical line, red over white. When the fishing vessel is making way she must also show her two side lights and stern light. Note that a fishing vessel does not show white masthead steaming lights, therefore her length cannot be determined, but, if there is outlying fishing gear extending more than 150 meters horizontally, an all-round white light (or cone apex up in daylight) is shown in the direction of the gear.

Fig 17

Fishing other than trawling < 50 m, underway, making way



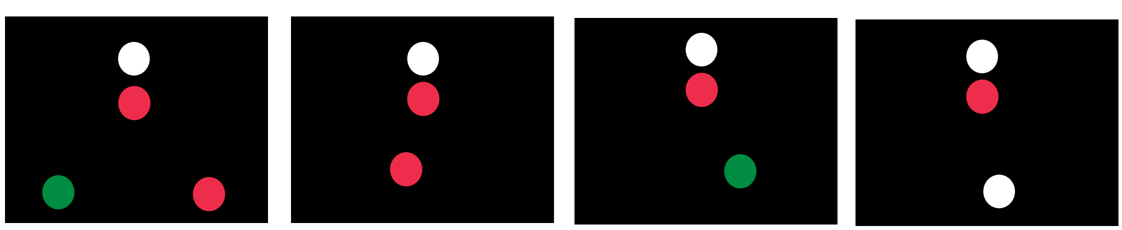
Seen From: Ahead Port Starboard Astern

Pilot vessel

A pilot vessel on duty shows, at or near the masthead two all-round lights, white over red, in a vertical line plus sidelights and stern light when under way.

Fig 18

Pilot vessel on duty, underway



Seen From: Ahead Port Starboard Astern

Vessels Not Under Command

A vessel Not Under Command shows two all round lights, red over red, plus sidelights, and stern light when under way. As no steaming lights are used length is not known.

Fig 19

Not Under Command, underway, (length not known)

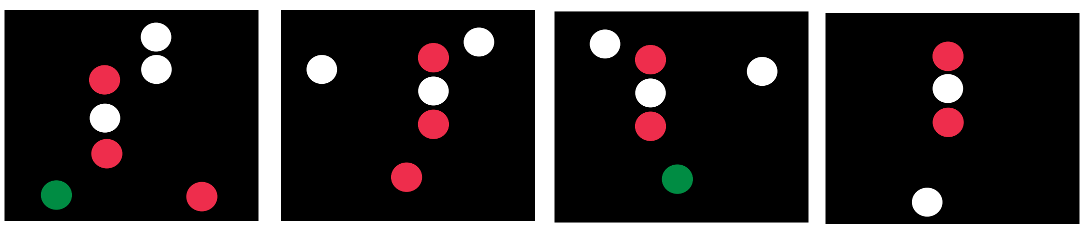
Seen From: Ahead Port Starboard Astern

Restricted in Ability to Manoeuvre

A vessel Restricted in Ability to Manoeuvre shows three all-round lights, red over white over red, plus sidelights, stern light and appropriate masthead lights when under way.

Fig 20

Power vessel > 50 m underway, Restricted in Ability to Manoeuvre



Seen From: Ahead Port Starboard Astern

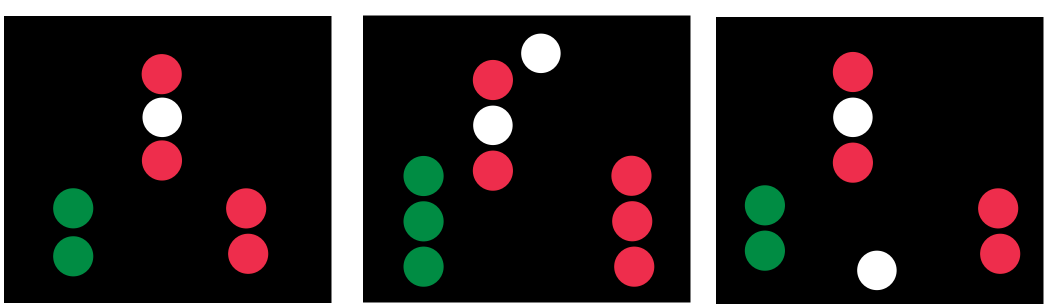
A vessel engaged in underwater operations may show the safe side to pass with two all-round green lights in a vertical line and the obstructed side shown by two all-round red lights in a vertical line.

Fig 21 A vessel engaged in underwater operations

Unknown not underway pass 2 x green side

Ahead, < 50 m underway pass 3 x green side

Astern underway pass 2 x green side

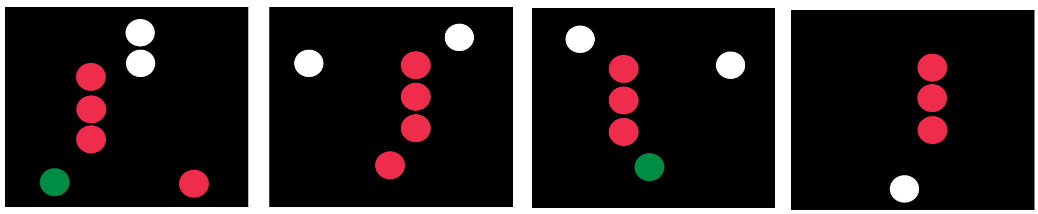


Vessel Constrained by Draft

A vessel Constrained by Draft shows three all-round red lights in a vertical line plus sidelights, stern light and appropriate masthead lights when under way

Fig 22

Power vessel > 50 m underway, Constrained by Draft



Seen From: Ahead Port Starboard Astern

Vessels at Anchor

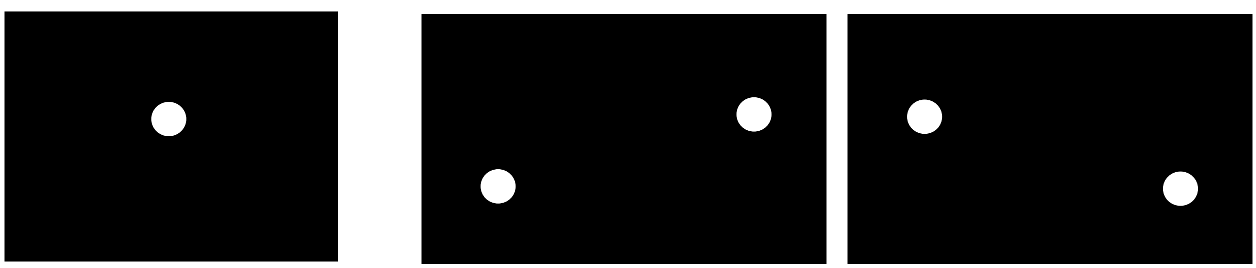
A vessel at anchor, less than 50 m in length, must show an all round white light where it may best be seen.

A vessel at anchor, greater than 50 m in length, must show in the fore part an all-round white light and a second all-round white light at or near the stern which is lower than the forward light.

If a vessel at anchor is greater than 100 m in length she shall use available lights to illuminate her deck.

Fig 23

Vessels at anchor



< 50 m *> 50 m, starboard side* *> 50 m port side*

Vessel aground

A vessel aground shall use the anchor lights appropriate to her size plus two all-round red lights in a vertical line.

Fig 24

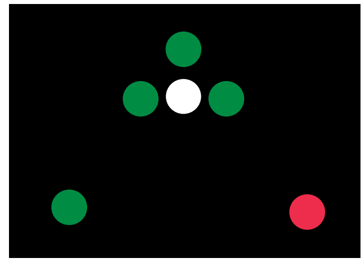
Vessel aground

< 50 m *> 50 m STARBOARD* *> 50 m PORT*

Minesweepers

A minesweeper, sweeping mines at night shows three all-round green lights at the masthead in a triangular pattern plus sidelights and masthead light(s) when underway. This light combination means that it is dangerous to approach to within 1000 meters.

Fig 25
Minesweeper, less than 50 m, underway, ahead



'Small boat' exemptions

A motor driven vessel of less than 7 m in length and with a maximum speed of not more than 7 knots may have an all-round white light only when underway.
A sailing boat of less than 7 m in length and a rowing boat when underway may use a white light from a torch or lantern which should be used in sufficient time to prevent collision.
A vessel of less than 7 m in length does not have to exhibit the anchor or aground lights if it is not in a narrow channel, fairway or anchorage, or where other vessels normally navigate.

Special lights

Some additional lights are specified in the Rules:

Trawlers may exhibit:

when shooting nets two white lights in a vertical line;
when hauling nets a white light over a red light in a vertical line;
when nets are fast on an obstruction two red lights in a vertical line.

Each vessel engaged in pair trawling may also exhibit:

a searchlight directed forward onto the other vessel of the pair.

Purse seiners may, when hampered by their fishing gear, exhibit:

two yellow lights in a vertical line flashing (1 sec) alternately.

An air-cushion vessel in non displacement mode shall exhibit:

a yellow flashing light as well as sidelights and masthead light(s).

A sailing vessel underway may, as well as sidelights and stern light, exhibit

a red over a green all-round light at the top of the mast but these lights must not be used with a combined (tricolour) masthead light.

Signals to attract attention:

a vessel may direct the beam of a spotlight in the direction of danger.

Technical details of lights and shapes

Annex 1 of the Rules details the correct spacing, positioning, light intensity, size etc., of the lights and shapes. Many leisure boats are sadly deficient in their compliance with the Rules. Lights which cannot be seen or are angled incorrectly lead to confusion and danger. Many pulpit mounted sidelights on sailing boats are obviously pointing in the wrong direction due to damaged steel work and many need a thump to get them to work.
Fines are imposed in some countries for not having a motor sailing cone aboard a yacht.

Note that the Rules actually state that a power driven vessel underway less than 50 m in length must show one white masthead light and *may* show *two* masthead lights if she wishes. Most leisure craft, small boats, yachts, etc., don't carry the optional light. Seeing two masthead lights it would therefore be more correct to consider the vessel ".... power driven, *probably* over 50 m.....". Vessels over 50 m must, of course, have the second masthead light.

Distress signals

Annex IV of the Rules details the international Distress signals which are:

1. a gun or other explosive device fired at intervals of about 1 minute;
2. a continuous sounding with any fog signalling apparatus;
3. rockets or shells, throwing red stars fired one at a time at short intervals;
4. a signal sent by any method of the Morse Code group **... --- ...** (SOS);
5. a signal sent by radiotelephony consisting of the spoken word “MAYDAY”;
6. the International Code Signal of distress indicated by NC;
7. a signal consisting of a square flag having above or below it a ball;
8. flames on the vessel (as from burning tar barrel or oil barrel, etc.);
9. a rocket parachute or a hand flare showing a red light;
10. a smoke signal giving off orange coloured smoke;
11. slowly and repeatedly raising and lowering arms outstretched to each side;
12. the radiotelegraph alarm signal **. . . . . _______** ;
13. the radiotelephone alarm signal;
14. signals transmitted by emergency position-indicating radio beacons (EPIRB);
15. approved signals transmitted by radio communication systems.

Whales

A new requirement agreed in the middle of 1998 by an international marine convention requires that vessels over 300 DWT must give way to whales in designated waters off the east coast of the U.S. The designated waters are off the coasts of New England and Florida. Ships entering theses designated areas must give their position to the Coast Guard who will give the positions, direction and speed of pods of whales which can be seen by satellites. (Deadweight tonnage is the maximum weight of cargo, people, stores, fuel and water that a ship can carry when floating at her summer load draft.)

Inland Navigation Rules

It is very important for the Watchkeepers on board every vessel not only to know the international rules but also the local and Inland rules for the waters they are navigating. The various inland rules for different regions and countries are too numerous to cover within these notes and research is needed prior to entering another administrations territorial waters.

In EU Waters this is the CEVNI Code, (see above), but care must be taken to know the main rules and there are further rules used by the individual States of the EU too!

In the USA, the Inland Navigation Rules apply on the inland waterways of the U.S. COLREGS demarcation lines are printed on charts and given in United States Coast Pilots of the respective area. Generally the international rules are similar to the inland rules.

Canada has Modifications and additions to the COLREGS which apply to all vessels in Canadian waters or fishing zones. These may be found in the various sailing directions and Almanacs covering Canadian waters.

3

Meteorology

Meteorology may be defined as the study of movements and phenomena in the earth's atmosphere, especially with regard to weather forecasting. Meteorologists obtain information from a wide range of sources including dedicated weather satellites, weather balloons, ocean weather ships, aeroplanes, commercial shipping, weather buoys, manned and unmanned weather stations, radar installations, etc. This information is the basis for a combination of skill, experience and computer systems, which allows meteorologists to produce weather predictions or forecasts. Despite the sophisticated equipment the forecaster's expertise still plays a very significant part in the forecasting process.

When we use the term 'weather' we mean the atmospheric conditions existing at a specific place over a relatively short period of time. The conditions of general interest to us normally are whether it is warm or cold, raining or dry, sunny or cloudy, foggy or clear, windy or calm and so on. Seafarers are interested principally in wind strength and wind direction as these are usually the two single factors which have the most effect on anyone taking a boat to sea, both from the point of view of safety and of enjoyment.

Nowadays we are lucky to have easy access to many different sources of high quality weather forecast information; the aim of this section is to help you to fully understand these forecasts so that you can form an intelligent picture of the changes likely to occur in the weather and the sea conditions in a particular area.

It is important to appreciate that even a basic understanding of atmospheric conditions and how they interact will help immensely when trying to decide how the actual weather and sea conditions will develop in a specific area. In some instances the following explanations have been simplified where a full understanding of a complex subject is not required.

Wind
Wind is simply the movement of air. Winds are caused by air flowing from an area of high pressure to an area of low pressure.

Air
The earth is surrounded by a layer of what we call the atmosphere or just 'air'. Air is invisible and yet it is nevertheless composed of matter. Dry air is composed of nitrogen (78% by volume), oxygen (21%) argon, (1%) and the remainder is made up of trace gasses which include ozone (at high altitudes), hydrogen and carbon dioxide. Pollutants are present in air as well; these include carbon dioxide and various sulphur dioxides. Air also contains a quantity of water in the form of either water vapour or droplets of water; the actual percentage of water contained in the air varies from less than 1% to about 4%.

As air is composed of matter it must have weight. Thus if air has weight it must also exert pressure on anything beneath it. The earth is completely surrounded by an envelope of air and this air, having weight, exerts pressure continuously on the earth's surface. This pressure is called atmospheric pressure, i.e. the pressure exerted by the atmosphere.

Atmospheric Pressure
The amount of pressure exerted by the atmosphere on the earth's surface at any place depends upon the depth and weight of the air above that place. The heavier the air, the greater will be the pressure it will exert on the place beneath it. Atmospheric pressure is measured by a barometer and the measurements are in units of barometric pressure, or 'Bar' for short. Barometric pressure is measured over a period of time on an instrument called a barograph. One bar is divided into 1000 parts, each one being called a 'millibar' (mb), that is 'one thousandth of a bar'.
The modern unit of measurement is a hectopascal (hPa); it has the same value as a millibar, 1000 mb = 1000 hPa.

Atmospheric pressure around the world varies, very roughly, between a low of 970 millibars and a high of 1030 millibars. Although atmospheric pressure around the world is changing continuously the average pressure is taken as being 1013 millibars, at sea level, 15° C/59° F Going upwards from sea level atmospheric pressure decreases because the depth of the atmosphere above is also decreasing; for this reason cabins of high flying aircraft are pressurised.

Heavy air, light air

Most substances, including gasses, expand when they are heated and contract when they are cooled. Air behaves in this manner, its volume increases when it is heated and decreases when it is cooled.

This means that when air is heated it becomes lighter and when it is cooled it becomes heavier. A place which has warm air above it will be subject to low atmospheric pressure whereas an adjacent place which has cold air above it will be subject to high atmospheric pressure. Air flows from an area of high pressure to an area of low pressure so the wind will blow from the high pressure area towards the low pressure area. The greater the difference in the pressure between the two places the faster the air will move; the faster the air moves the stronger will be the wind.

A car or bicycle tyre is pumped up to a high pressure; if the tyre is punctured the air will flow out of the tyre (high pressure area) into the surrounding air (low pressure area) until the pressure in the tyre and the surrounding area are the same. The higher the initial pressure in the tyre the faster will be the rush of air when the puncture occurs.

Heat from the sun

The earth has no heat source of its own, all the heat experienced on the earth comes from the sun's rays. It is this heat from the sun which supplies the energy that causes the changing weather systems throughout the world.

The sun's rays only heat solid objects so they do not heat the air directly but they do heat both the land and the sea which absorb the heat from the sun. Air which is close to the warm surface of the sea and the land is in turn warmed by this contact. Put another way the sun heats the earth and the earth transfers some of this heat back to the air which touches its surface. It follows that air which is some distance from the earth's surface does not receive the same heat and therefore air becomes colder the higher it rises in the atmosphere. This is one of the reasons why hot countries can have snow on high mountains.

Air circulation

As was explained above, when air is heated it becomes lighter and being lighter than the surrounding air it will start to rise. A hot air balloon is a good example, the air trapped in the balloon is heated with a gas flame so that it expands and becomes lighter than the air surrounding the outside of the balloon. The 'bubble' of light air rises lifting the balloon with it.

Air which is heated will become unstable and rise but as it ascends through the atmosphere it will begin to cool until it loses its heat. When it becomes cold and heavy it will start to descend back to the earth's surface where it will once again be warmed and start to rise again, thus a continuous system of circulation is set up.

The bonfire analogy

A bonfire may be used as an example of how heat begins and maintains a circulation system. When a bonfire is burning you can clearly see smoke and sparks being carried upward by the rising air which has been heated by the flames. The air which rises up must be replaced and so cooler surrounding air flows into the base of the fire, causing a draught, or 'wind'. The hot air is cooled and becomes denser as it ascends until it eventually stops rising and starts to sink back down to ground level.

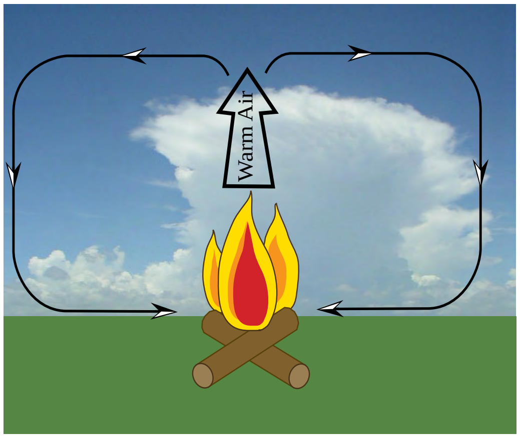


Fig 1
Bonfire analogy

Finally it is drawn into the base of the fire where it is heated continuing the cycle until the fire, which is the heat source providing the energy keeping the circulation going, dies.

Water

Water is constantly evaporating from the oceans, seas and lakes and is absorbed by the air in the form of water vapour. The warmer the air is the more water vapour it can absorb. This absorption process can be clearly seen as 'steam' after a shower of rain on a hot day. Energy, supplied by the sun in the form of heat, is required to convert water into water vapour. If the moist air becomes cooled the water vapour condenses back into water droplets causing clouds, fog and rain; at the same time the energy contained in the water vapour is also released back into the atmosphere. This release of energy is responsible for much of the active weather we experience.

Tropical hurricanes derive their terrific energy largely from the release of latent heat which occurs when water vapour absorbed from the warm sea surface is cooled and condenses into torrential rain.

The world's air circulation.

The sun does not heat the earth's surface uniformly, for example it is obviously much warmer near the equator than it is at the North or South poles. This imbalance between the heat experienced at different latitudes causes the general weather patterns of the world.

Near the equator the sun's rays fall directly on the surface of the earth and the air which is in contact with the surface is heated, expands, and rises upwards. The atmosphere is divided into two physically distinct layers, the layer nearest to the earth's surface is known as the troposphere and the next layer above is known as the stratosphere. The rising warm air cannot pass out through the troposphere but it must keep moving because it is being pushed by the warm air rising continuously behind it and so is forced into two separate streams, one moving northward and the other southward.

The air stream is now becoming colder due to its altitude, and it is therefore becoming heavier; eventually the stream of air descends to the earth's surface where it is once again warmed, completing the circulation cycle.

The air heated over the equator falls back to earth at around about latitude 30° N and 30° S . As the air rising off the equator is warm the atmospheric pressure near the equator will be low and as the air descending at 30° N and 30° S is cool the pressure at these latitudes will be high. Each hemisphere has two more similar circulation systems giving a total of three systems, or 'cells', for each hemisphere.

Figure 2 shows how areas of high and low pressures would appear if there were no large land masses on the surface of the earth. However there are of course large land masses and these have a great effect on the general weather patterns of the world.

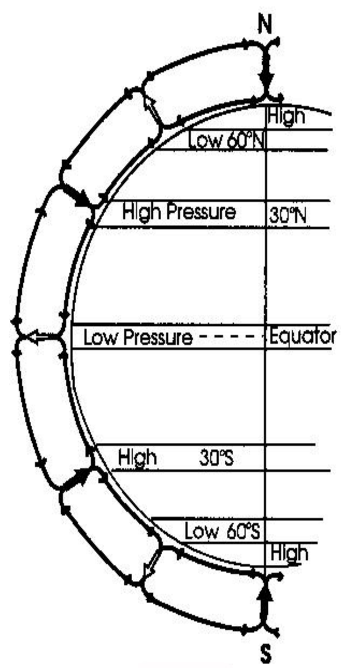


Fig 2
The theory of the world's air circulation

Coriolis force

The earth is revolving continuously around its own axis, completing one revolution in 24 hours. This spinning causes anything which moves freely over the earth's surface to be deflected to the right of its path in the northern hemisphere and to be deflected to the left of its path in the southern hemisphere. A moving air mass is effected by this force, which is known as Coriolis force, and air flowing from an area of high pressure to an area of low pressure will not move in a straight line but will in fact be deflected to the right of its path in the northern hemisphere.

Looking at figure 2 it can be seen that there are belts of high and low pressure around the world. If it were not for Coriolis force the wind would blow directly from the high pressure areas to the low pressure areas.

The wind blowing from the high pressure belt at 30° N to the low pressure area at the equator would be a north wind, that is it would blow from the north towards the south but Coriolis force deflects it to the right of its path and so the wind actually blows from the north east.

Likewise the wind blowing from the high pressure belt at 30° N to the low pressure area at 60° N would be a south wind but being deflected to the right of its path it becomes a west wind.

Large, land masses generate areas of high and low pressure and large cold land masses generate areas of high pressure.

The polar front

Note in particular the band of low pressure along latitude 60° N; within this low pressure belt lies what is called the polar front. The polar front is where the air from the polar regions and the air from the temperate regions meet.

An important feature of the polar front is that the two air masses do not gradually mix with each other, rather the boundary between the two air masses is clearly defined.

The polar front is of great importance because the depressions or 'lows' very often form initially along this front.

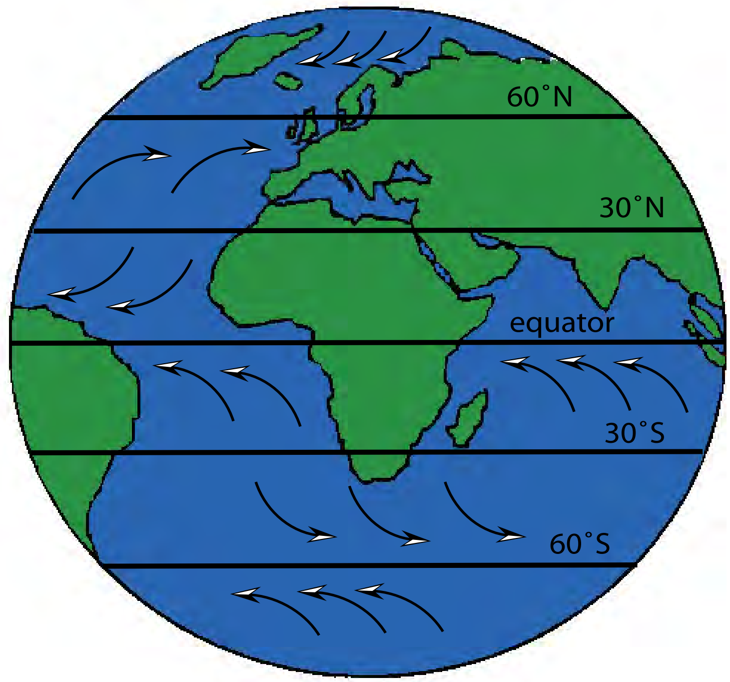


Fig 3

General direction of the Trade Winds and prevailing winds of the world

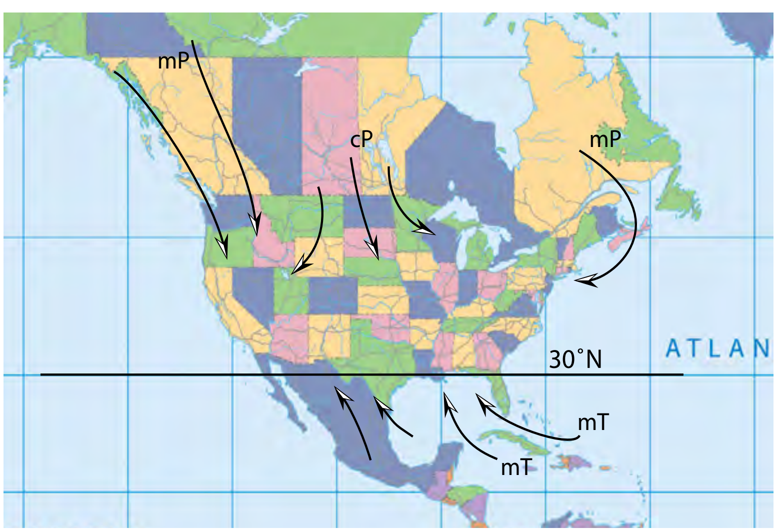


Fig 4

The different air masses that affect the US in summer.

Air masses

Large masses of air are constantly on the move, these air masses exhibit definite characteristics depending upon where they originated from and what seas or lands they have passed over before they reach us. Air masses are of importance in understanding weather forecasting because disturbed weather conditions occur when two air masses having different temperatures and water content meet.

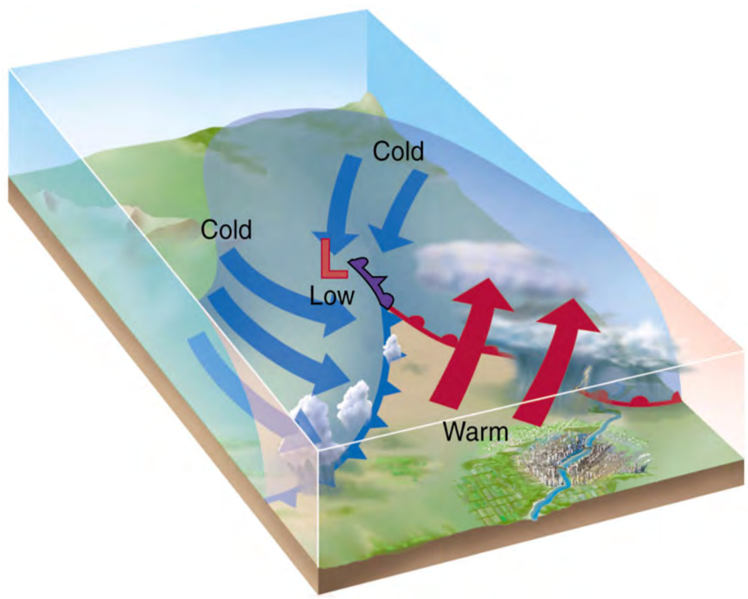
The air masses which affect the US for example, come either from the cold polar regions or from the warm sub-tropical and tropical regions and can reach us from over land or from over the ocean.

Isobars
The term isobar comes from 'iso' meaning equal and 'bar' meaning barometric pressure. Isobars are lines which are drawn joining places of equal pressure. They are in effect similar to contour lines drawn on a map showing hills and valleys. The closer isobars are together the steeper will be the atmospheric pressure gradient between them and the stronger will be the wind. Isobars far apart indicate calm conditions, isobars close together indicate strong winds.

Depression
A depression is the name given to a region of closed isobars with low pressure on the inside, also called a 'low'. The wind circulates in an counter-clockwise, or cyclonic, direction around the centre of low pressure in the northern hemisphere.

Secondary depression
If a depression is halted suddenly a wave may form on its trailing cold front. This secondary depression may not develop sufficiently to be of any consequence or it may quickly develop into a full blown deep depression giving rise to severe conditions. Secondary depressions can mature and move very rapidly.

Anti-cyclone
A region of closed isobars with high pressure on the inside; also called a 'high'. The wind circulates in a clockwise direction around the centre of high pressure in the northern hemisphere, due to the Coriolis effect.



Warm sector
The area of relatively warm air within a depression.

Cold sector
The part of a depression which is distinguished by relatively cold air.

Front
A line of separation between cold and warm air masses.

Warm front
The boundary line between the warm air of a warm sector and the cold air in front of it. In other words there is warm air behind a warm front.

Cold front
The boundary line between the warm sector and the cold air following behind as the depression moves along its path. In other words there is cold air behind a cold front.

Occluded front
In a depression the cold front moves faster than the warm front. When the cold front catches up with the warm front they combine and the result is called an occluded front.

Ridge
A ridge is an area of high pressure which lies between areas of lower pressure. As the pressure is high the weather will be good .

Trough
A trough is a valley of low pressure or the opposite of a ridge.

Squall
Sudden short lived strong storms are called squalls.

Jet streams
Jet streams are rivers of air which travel at speeds of 50 to 250 knots around temperate and sub-tropical latitudes. They occur at a height somewhere between 5,000 and 10,000 metres and they are associated with the movements of depressions.

Bomb
Meteorologists use the word used to describe a depression in which the pressure drops by 1 millibar per hour over a period of 24 consecutive hours. Needless to say a pressure drop of this magnitude indicates violent winds.

Wind direction in a high pressure system

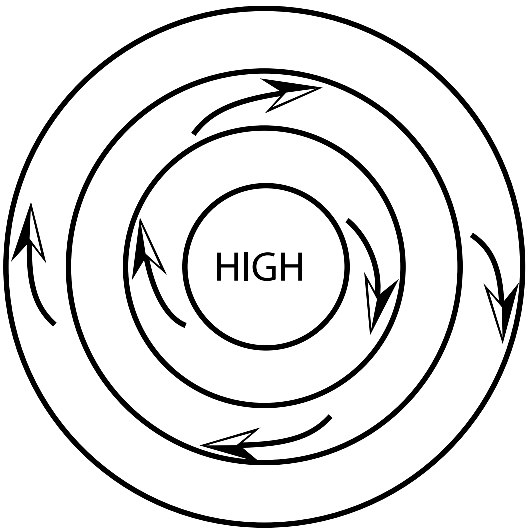
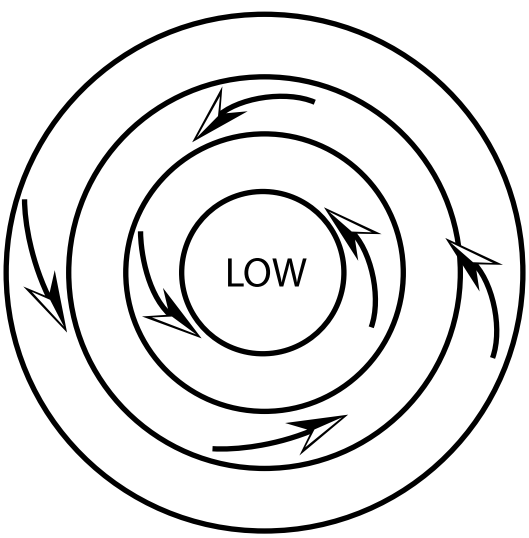


Fig 5
Wind direction round a High

As was explained earlier wind blows from a high pressure area towards a low pressure area. Coriolis force deflects the wind to the right of its path in the northern hemisphere and so wind blowing outward (diverging) from the centre of a high pressure area will spiral outwards in a clockwise direction.

The wind direction is not quite parallel to the isobars but will be pointing out from the centre of high pressure. The isobars in the figure opposite are drawn as concentric circles to make the drawing as clear as possible, in reality the isobars would be much less uniform in appearance.

Wind direction in a low pressure system



The wind in a low pressure system will be blowing inwards towards the centre of low pressure. (Converging) The wind direction will not be quite parallel to the isobars but as the air is flowing inwards the wind direction will also be a little inwards towards the centre of low pressure. As in the previous diagram the isobars are drawn as concentric circles for clarity, again in reality the isobars will be much less uniform.

It is important to note that in the southern hemisphere a high pressure system circulates in an anti-clockwise direction and a low pressure system circulates in a clockwise direction

Fig 6
Wind direction round a Low

Frontal depressions
A front is where two air masses with different properties meet. There is a clearly defined boundary between the two air masses. If the warm air mass pushes into the cold air mass, or vice versa, a kink or wave appears along the front.

The pressure starts to drop at the bulge because warm unstable air is replacing the cold stable air. As the warm air in the wave rises up it is replaced by more warm air rushing in behind it, and Coriolis force deflects this wind to the right of its path setting up a cyclonic (counter clockwise) wind circulation around the centre of low pressure. Heavy clouds develop as the moisture which is contained in the rising warm air condenses with height. The warm front is shown by 'bumps', the cold front by 'spikes'.

The deepening depression moves off in a north easterly direction (roughly in the direction of the isobars in the warm front) driven by the wind above it. It may move at any speed up to 50 knots or even more.

Mid life
As the pressure at the centre of the low falls so does the pressure difference, or gradient, increase causing stronger winds. Cold air moves faster than warm air and so the cold front begins to catch up on the warm front gradually reducing the size of the warm sector. The depression has expanded and may spread over thousands of miles.

Occlusion
The cold front has now caught up with the warm front over some of its length. As cold air is heavier than warm, the cold air pushes underneath the warm air starting from the centre of the depression.

Eventually the whole of the warm sector is raised up and as warm air can no longer feed the depression it dies. An occluded front is shown by having both bumps and points drawn on it.

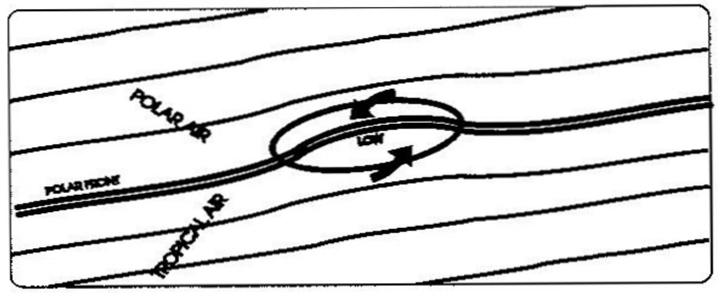


Fig 7

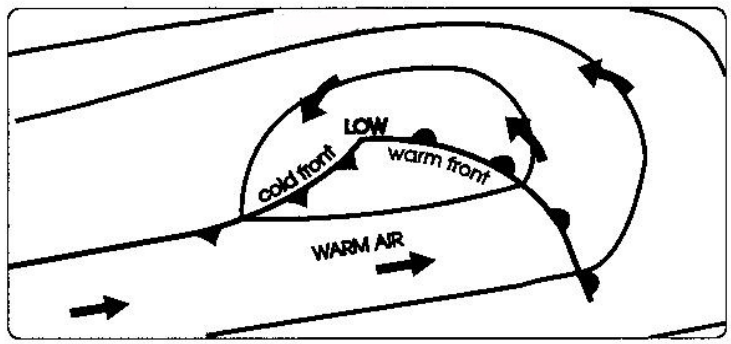


Fig 8

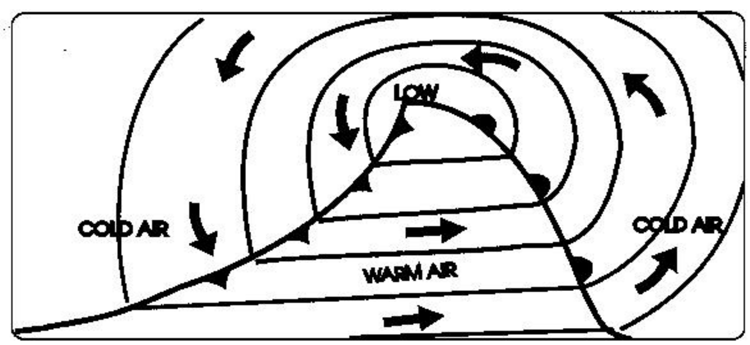


Fig 9

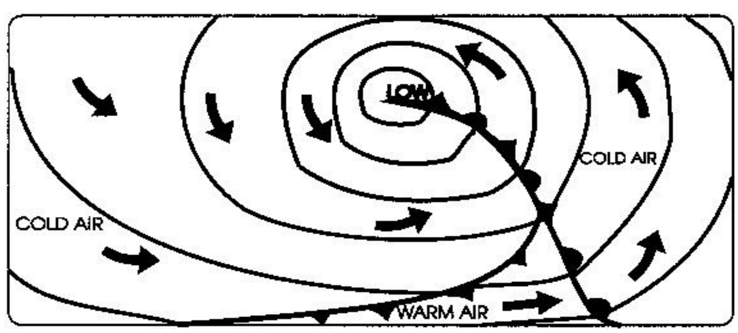


Fig 10

Rules for depressions

No two depressions are the same but in general terms:

- ♦ Depressions usually move from SW to NE in the north Atlantic .
- ♦ A depression usually moves along a track parallel to the isobars in the warm sector.
- ♦ If a depression has been moving steadily in the same direction for 12 hours it will probably continue on the same track for the next 12 hours, as long as it does not meet land.
- ♦ If two similar sized depressions are close to each other they will often rotate around each other and combine.
- ♦ If a depression meets land, the source of its energy in the form of the warm humid air will be cut off and it will weaken.

Other sources of depressions

Depressions form in areas other than on the polar front. The most common causes of these are:

- ♦ Polar lows: cold air warmed when a cold air mass moves over warm seas.
- ♦ Heat lows: air being heated by hot land masses.
- ♦ Lee lows: a low pressure area can form in the lee of a mountain subjected to a flow of air.

Backing

A wind which is changing in a counter-clockwise direction (e.g. W-S-E-N) is said to be backing.

Veering

A wind which is changing in a clockwise direction (e.g. S-W-N-E) is said to be veering.

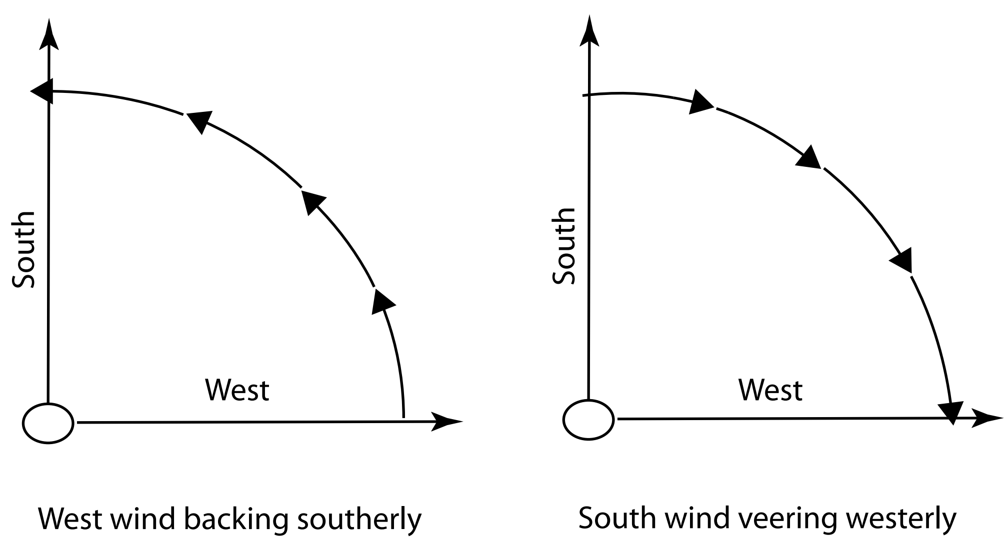


Fig 11
Backing and Veering wind

Remember that wind direction is given as the direction from which the wind is blowing. In other words a west wind comes from the west, a south wind comes from the south.

Clouds

When warm air is cooled it can no longer contain the water vapour it is has absorbed and the water vapour condenses into droplets of water which are visible in the form of clouds. Air can become cooled in a variety of ways; it will be cooled if it is forced to rise, for example, and warm air will be cooled where a cold and warm air mass meet at a front.

Cloud types

Clouds have different shapes depending on their physical properties and the conditions which caused their formation. The altitude and the shapes of clouds can give a good indication of what type of weather may be expected. Cloud shapes and altitudes are named using Latin words in a system devised in 1803 by Luke Howard, a chemist. Clouds are white when they are illuminated by the sun, if they are in shadow they appear black, the colour is of no significance.

Cirrus Cirrus means 'hair', cirrus clouds are thin wispy, or feathery clouds, at a very high altitude. The word 'cirro' is used as a prefix to denote high altitude clouds.

Cumulus Cumulus means a 'heap', cumulus clouds are clearly outlined heaped up clouds.

Stratus Stratus means a 'layer' and the term is used to define a uniform flat sheet of cloud cover. Cirrostratus is thus a layer of thin, uniform, high altitude cloud.

Nimbus Nimbus means 'rain' or 'storm' and the word is used in conjunction with the terms above, thus a layer of low cloud giving rain is called 'Nimbostratus' and heaped up rain clouds are called 'Cumulonimbus' clouds.

Alto Middle level clouds are prefixed 'alto', thus Altocumulus refers to middle level heaped up clouds.

Changes in conditions as a depression passes to the north of you.

When a depression approaches and passes to the north of your position there will be definite changes in wind direction and strength, cloud type, barometric pressure, precipitation and perhaps temperature.

Figure 12 below shows two views of a depression; the figure is in two parts, the top figure shows the depression from above, the lower drawing shows a section through the depression. The depression is moving in a NE direction, passing over the yacht at A.

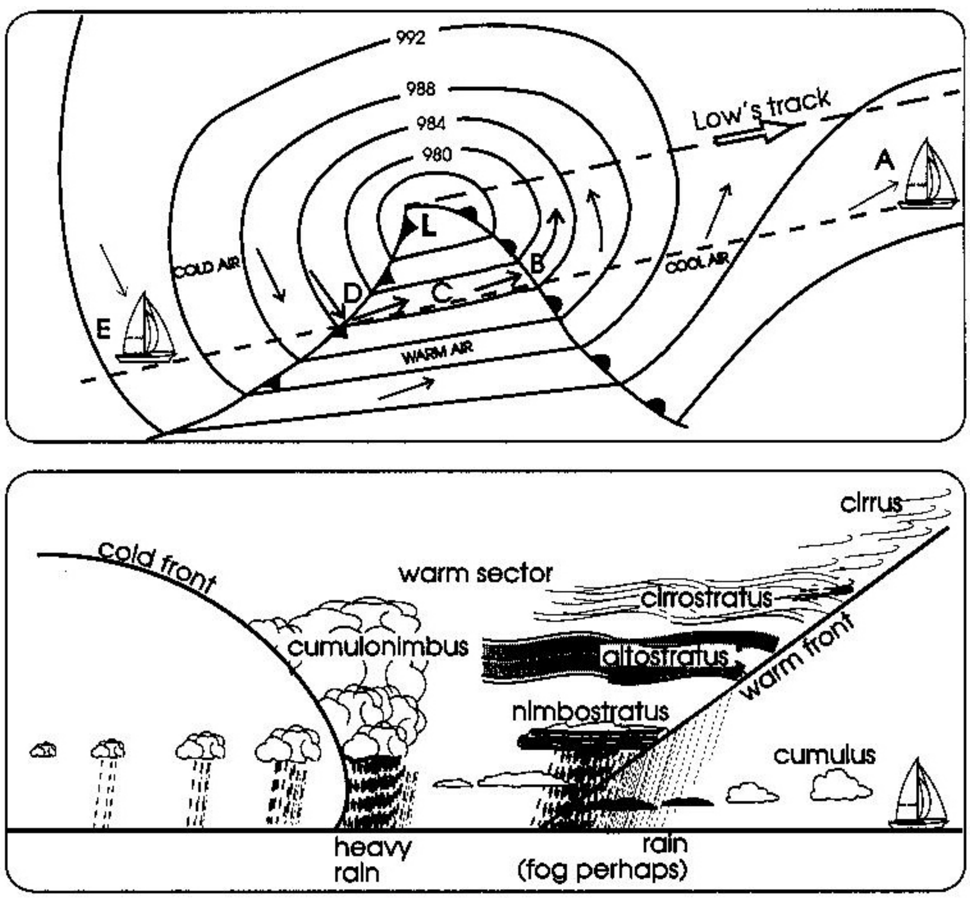


Fig 12

Weather and cloud conditions as a front progresses

Initially the yacht at A is experiencing light winds from the SW.
As the depression approaches the yacht the wind will begin to freshen, thin wispy cirrus (mare's tails) will appear high in the sky, followed by cirrostratus. The barometer will start to fall. Small, puffy, cumulus clouds will become more frequent giving way to low dark nimbostratus clouds at the warm front, B, where the yacht will experience rain together with a decrease in visibility.

The wind will continue SW as the warm front passes and the rain will give way to drizzle, perhaps fog, the wind may increase, the barometer will steady and the temperature may increase. The atmosphere will be damp and humid with low clouds.

In the warm sector the yacht at C will have low clouds, perhaps clearing to bright spells before the approach of the cold front. The barometer will be steady, or fall only slowly, and the wind will remain from the SW.

At the cold front, D, the wind will veer to the NW and increase, becoming strong and possibly squally. There will be heavy rain with big cumulonimbus clouds perhaps accompanied by thunder and hail. The barometer will start to rise quickly and the temperature will drop. After the depression has passed the rain will turn to showers, and the wind will moderate.

How conditions may be expected to change when a typical depression, with warm and cold fronts, passes to the north of a vessel.

	APPROACH OF WARM FRONT	AT WARM FRONT	IN THE WARM SECTOR	AT THE COLD FRONT	WHEN COLD FRONT IS PAST
WIND DIRECTION AND STRENGTH	Backs to W. then S.W. and increases	Continues S.W. May increase, often squally	Steady S.W. May continue to increase	Sudden veer W. to N.W. with strong squalls	N.W. to N. Strong, gusty, moderating
PRESSURE	Falls quickly	Stops falling	Steady	Rises quickly	Rise slows down progressively
TEMPERATURE	Small rise	Rises	Steady	Falls quickly	Falls slowly
CLOUDS	1. Cirrus 2. Cirrostratus 3. Altostratus	Nimbostratus	Thin, low Stratus clouds	Cumulonimbus	Cumulus, clearing
RAIN	Rain starts	Heavy rain	Drizzle	Heavy rain, perhaps thunder	Showers, dying off
HUMIDITY	Slow increase	Rapid increase	Steady	Slow decrease	Quickly decreases
VISIBILITY	Slowly decreases	Poor	Poor	Poor	Improves quickly, becoming good

Changes in conditions when a depression passes to the south of your position
If a frontal depression passes to the south of you the fronts will not pass over your position. You will not therefore experience the sudden changes of wind direction associated with the passage of fronts or the temperature changes. As the low approaches the barometer will fall, cloud cover will thicken, the wind will begin to back continuously and there will be rain. After the centre of the low has passed to the south of your position the barometer will start to rise, the wind will have backed through NE to NW and the rain should become lighter. Large cumulonimbus clouds along the cold front to the south of you will be visible.

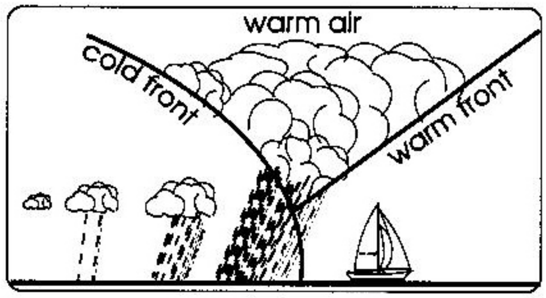


Fig 13
A cold front occlusion

Occlusions

Looking at the section through the depression in figure 13 it will be seen that the warm front is not vertical but at an angle; the curved cold front is also at an angle. The cold front travels faster than the warm front which means that the cold front will eventually catch up with the warm front. When this occurs the heavy cold air pushes under the warm air ahead of it, like a wedge, lifting the warm air off the surface of the sea or land. This is called a cold front occlusion and it gives rain at the occlusion, followed by weather conditions similar to those normally experienced with the passage of a cold front.

Buys-Ballots law

Buys-Ballot, a Dutch professor, gave us this simple rule to locate the centre of a depression:

" If you stand with your back to the true wind in the northern hemisphere the centre of low pressure will be about 90° to 130° on your left hand side".

The wind felt at ground level is not the true wind; the direction of the true wind can be seen from the direction in which the low clouds are travelling.

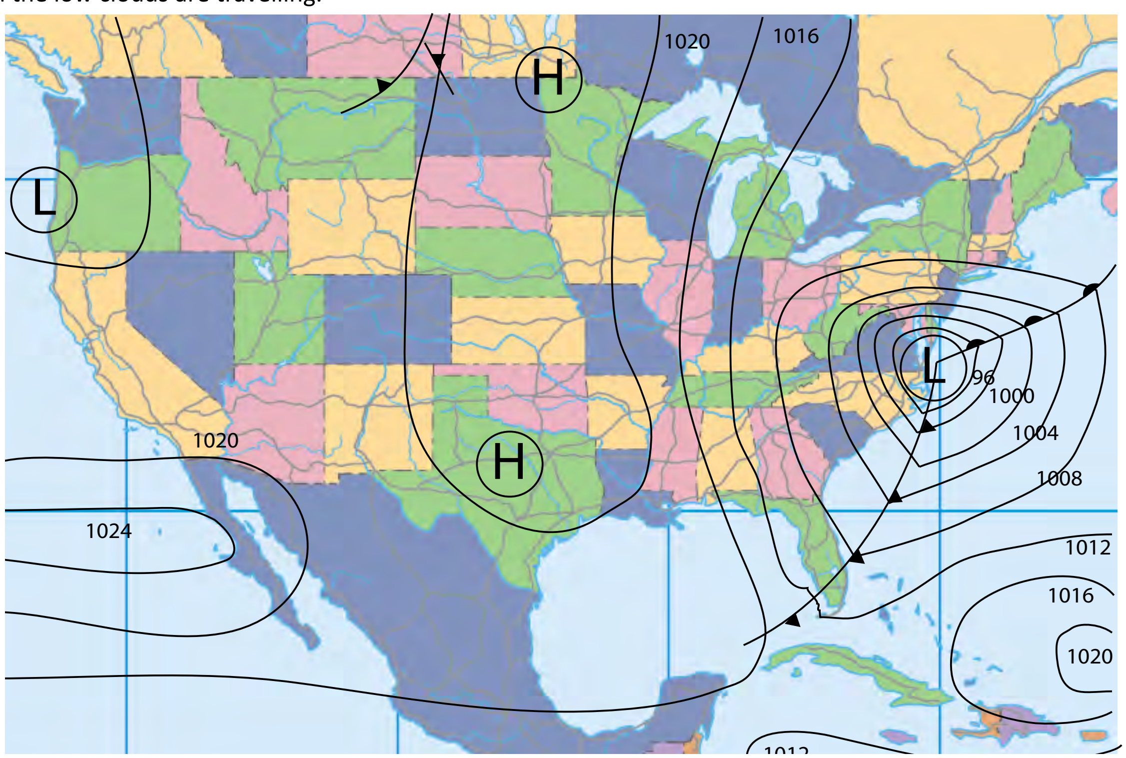


Fig 14

A frontal depression centred over the middle of the east coast of the US is moving in a north east direction, roughly parallel to the isobars in the warm sector. The winds associated with this depression are moving in a counter clockwise direction around the centre of the low. An anti cyclone or high pressure area covers the central U.S. The winds circulating around the anticyclone are circulating in a clockwise direction. The isobars between the high and low pressure system are being squashed indicating high(er) winds in this area. A cold front is approaching Florida, when it passes through the wind there will veer from SW to NNW and become gusty with a fall in temperature and the possibility of showers. The isobars on this weather map are drawn at intervals of 4 millibars.

High pressure systems

High pressure systems, or anticyclones, appear on a weather map as a system of closed isobars with high pressure at their centre. The isobars in a high pressure system are usually spaced far apart indicating light winds. Anticyclones normally move slowly or even remain stationary for some time giving settled weather. The wind flows outward from the centre of high pressure and, due to the Coriolis force, is deflected to the right of its path in the northern hemisphere, thus giving winds in a clockwise direction around the centre of the high.

Anticyclones are formed of (relatively) cold, stable, air which is slowly sinking thereby giving the outward flow of air from its centre. Cold air contains only a small amount of moisture and therefore cold air does not generate clouds. In summer anticyclones usually give clear skies, and sunny, warm weather although nights can be cool. Anticyclones can deflect depressions so that they pass to the north, however when this happens the isobars between the two systems may become noticeably compressed giving strong winds. In winter high pressure systems give cold days with frost at night and the possibility of fog over warm seas.

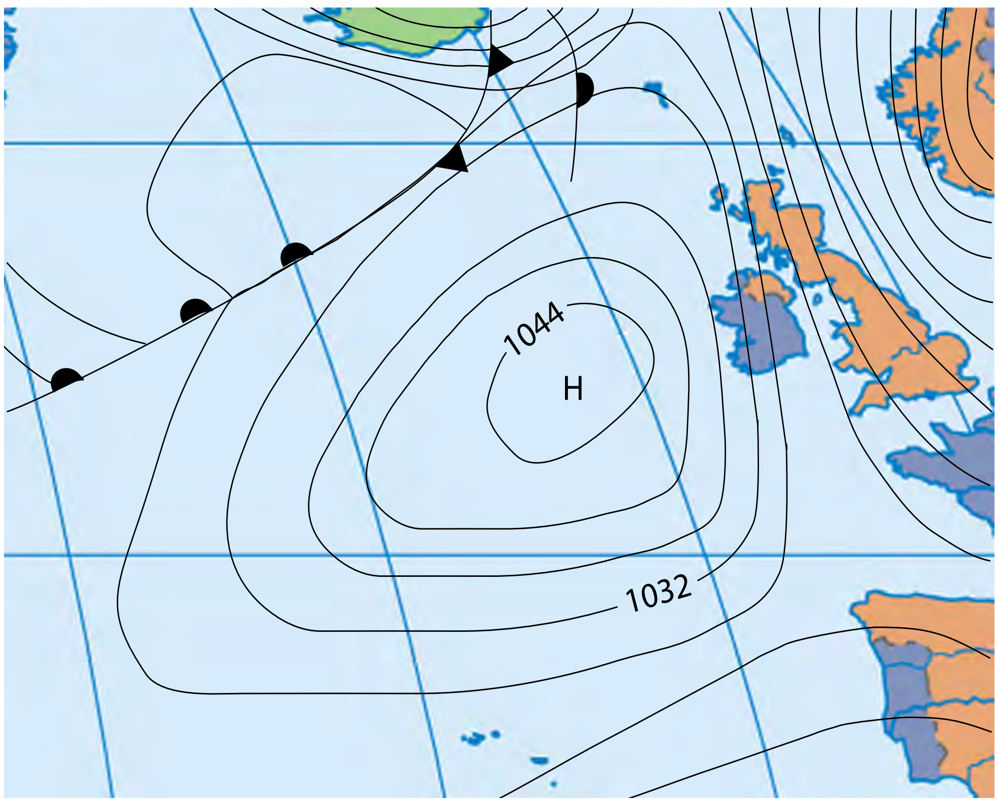


Fig 15

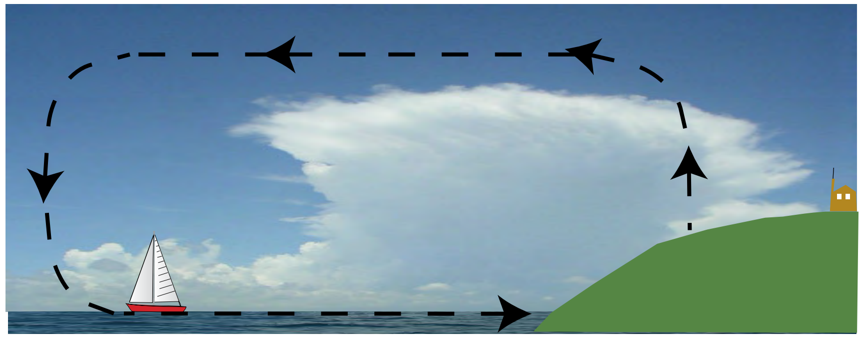
An anticyclone (high pressure system therefore the wind blows in a clockwise direction around the centre of the high pressure) covering a large part of the north Atlantic. The isobars over Ireland and the U.K. are close together, squeezed between the high in the Atlantic and the low over Scandinavia. The anticyclone is keeping a low over Iceland well to the north. Ireland is experiencing strong, cool, NW winds. If the anticyclone continues to build and drift in a north easterly direction Ireland can look forward to settled weather with light winds as the wider spaced isobars drift over Ireland. The isobars on this weather map are drawn at intervals of 4 millibars.

Sea breeze

A sea breeze is a wind which blows locally from the sea towards the land during the daytime.

If the land becomes heated by the sun during the day the air in contact with the land is heated and rises upwards. Cool air flows in from the sea to replace the air rising off the land and so a circulation system is set up.

Usually sea breezes begin about half a mile offshore around about 1000 to 1100, reach their strongest by 1400 and have stopped by 2000.



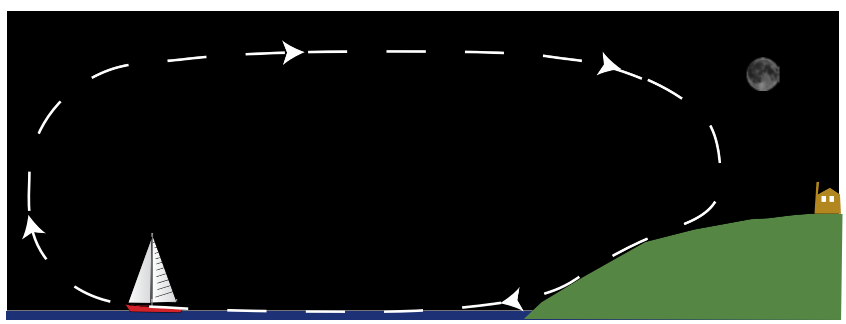
How a sea breeze is generated during the day

Fig 16
Sea breeze formation

If there is no appreciable gradient wind the sea breeze will initially flow from the sea directly towards the land but as the day passes the wind will be deflected to the right and will end up blowing more or less parallel to the shore.
Sea breezes are common during weather associated with high pressure systems. A sea breeze will modify the wind direction and strength of the gradient wind, that is the wind associated with the isobars of the prevailing weather system. Sea breezes can be as strong as force 4 and if this combines with an onshore gradient wind the overall wind will be strong.
A sea breeze will not develop if the gradient wind is 25 knots or more. If the sea breeze and the gradient wind are in opposition one may cancel out the other, giving calm conditions. Sea breezes here seldom extend more than 10 miles offshore and are strongest near the coast.

Land Breeze

At night the land cools and the air in contact with it is cooled and flows down and out to sea. Contact with the sea, which is relatively warm, heats the air which rises up and flows back towards the land where it is cooled and a circulation is set up. A land breeze starts at the land and works its way out to sea. Land breezes are not as strong as sea breezes and they are not felt as far out to sea as a sea breeze might be.



How a land breeze is generated at night

Fig 17
Land breeze generation

Rain

Clouds are formed of minute droplets of condensed water vapour. When this vapour is further condensed, by cooling as the cloud rises for example, it will form into larger droplets of water. These droplets of water amalgamate and increase in both size and weight as the cloud ascends until finally they are too heavy to remain airborne and the drops of water fall down in the form of rain.

Hail

Strong air currents within a cloud may carry rain drops upwards where they freeze before falling to earth as hail stones.

Snow

If the air is cold enough to freeze condensed water vapour the vapour will form into ice crystals which fall as snow.

Thunder and lightning

If a rising air current carries water droplets up high enough so they freeze into ice crystals, they will rub and bump into each other. Those which loose an electron will become positively charged; those which gain an electron will become negatively charged. When the buildup of these opposite charges becomes great enough, a lightning flash occurs. These can occur within a cloud, from one cloud to another, or between the cloud and the ground or water. A lightning flash is incredibly powerful; up to 30 million volts at 100,000 amps! The boater must certainly take precautions to protect onboard electronics, and the personnel's safety.

Fog

Fog is defined by meteorologists as <1 kilometre of visibility. Fog is composed of droplets of water, formed when air is cooled to it's dew point,

Types of fog

· **Advection fog**, or sea fog, occurs when warm moist air flows over a cold sea surface. This condition is more likely to arise in the late spring, or early summer before the sea has warmed fully

· **Radiation fog**, a land based fog, occurs during cold clear nights when the land loses the heat it absorbed during the day. The cooler land in turn cools the air in contact with it causing dew to develop. If there is a breeze it will spread the cooling effect through a greater depth of air and fog may form. Fogs which develop on land in this way can drift out to sea. Radiation fog is most likely to occur during anticyclones in the winter months; industrial areas are especially prone to radiation fog due to the higher concentration of dust particles in the air.

· **Frontal fog** may occur where two air masses of different temperatures meet. If both air masses have a high moisture content fog will form at the front between them. Frontal fog will usually be less than 50 miles in width. When rain, after descending through a layer of warm air aloft, falls into a shallow layer of colder air at the earth's surface, there will be some evaporation from the warm raindrops into the colder air. Under certain conditions this will raise the water vapour content of the cold air above the saturation point and frontal (also called rain, or precipitation) fog will result.

· **Arctic smoke** is the name given to fog caused by extremely cold air passing over warm water.

How fog is dissipated

· If the sun warms the air enough the water droplets will be reabsorbed as water vapour and the fog will disappear. During our winter months the sun may not generate sufficient heat to clear the fog and it may remain for some days.

· Wind can clear fog by mixing the layers of air.

· Fog should clear with a change of wind direction bringing air from a different source, such as occurs at the passage of a front.

The Beaufort scale

A numerical system of defining average wind strength by visual reference to the sea state was devised by Admiral Sir Francis Beaufort in 1808.

BEAUFORT FORCE	GENERAL DESCRIPTION	SEA STATE	WIND SPEED	WAVE HEIGHT
0	Calm	Sea like a mirror	0 - 1 kn	
1	Light air	Small ripples without foam crests	1 - 3 kn	
2	Light breeze	Small wavelets, short but more pronounced, crests glassy but do not break	4 - 6 kn	1/2 foot
3	Gentle breeze	Large wavelets, crests start to break, scattered white horses	7 - 10 kn	2 feet
4	Moderate breeze	Small waves becoming longer, fairly frequent white horses	11 - 16 kn	3 1/2 ft
5	Fresh breeze	Moderate waves, becoming longer. Many white horses some spray	17 - 21 kn	6 ft
6	Strong breeze	Large waves, extensive white foam crests and spray	22 - 27 kn	9 1/2 ft
7	Near gale	Sea heaps up, white foam streaks blown in wind direction	28 - 33 kn	13 1/2 ft
8	Gale	Moderately high waves, crests break off, visibility affected	34 - 40 kn	18 ft
9	Strong gale	High breaking waves, dense streaks of foam	41 - 47 kn	23 ft
10	Storm	Very high tumbling waves, sea looks white with large patches of foam, visibility badly affected.	48 - 55 kn	29 ft

The wave heights given are for waves in the open sea. Sea conditions will be modified by the proximity of land, in fact conditions may be more dangerous near land than in the open sea. One wave in ten may be expected to be about 30% higher than the wave heights suggested in the table.

Wind speed

The wind speeds are given in knots but the wind seldom, if ever, blows at a steady rate, particularly near land. For this reason the Beaufort scale is useful because it indicates an average wind strength.

Wind speed in metres per second

Continental forecasts often give wind speed in metres per second rather than in knots. To convert m/sec to knots multiply by 2, thus 10 m/sec = 20 knots and 5 m/sec = 10 knots.

The effect of friction

Above about 600 metres the wind moves parallel to the isobars and is called the true wind. The wind below 600 metres is subject to friction from both the land and the sea as it moves over the surface of the earth. The surface of the land is composed of mountains, valleys, forests, and so on and is much rougher than the sea. The wind is therefore subjected to more friction as it passes over the land than when it passes over the sea.

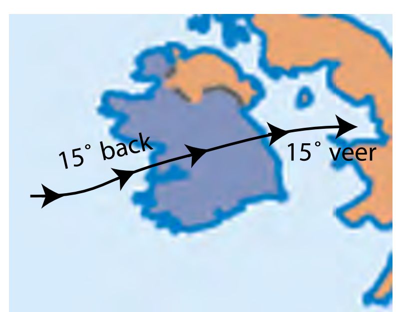


Fig 18
Effect of land on wind direction

Friction effects the wind in two ways, firstly it slows the wind down and secondly it changes the direction of the wind. Due to friction, and the earth's rotation, the true wind is backed by roughly 15° over the open sea and by up to 30° over the land. This means that the wind blowing off the land will in effect be veering, through as much as 15° perhaps, for a few miles out to sea.

Local effects
Hills, mountains and valleys can cause local effects such as changes in wind direction and strength as well as back eddies and areas of calm.

The barometer
A barometer is an instrument which indicates the atmospheric pressure. Barometers originally consisted of mercury in a long glass tube but modern instruments, known as aneroid barometers, are much more compact. A single reading of barometric pressure gives no worthwhile information; it is the rate of change of the pressure that counts and this can only be seen from a series of readings, hence the importance of recording barometer readings in the ship's log book. A barograph is an instrument which records the pressure either on paper charts or electronically.

Barometer

Other indicators of approaching strong winds:
- If the wind is backing and increasing at the same time it is likely that a trough of low pressure is approaching. The barometer would also be falling.
- Swell may indicate that there is a storm somewhere.
- High cirrus clouds increasing from the direction of low pressure are the forerunner of a depression.
- Gales with a rapidly rising barometer are likely to be more squally than gales with a falling barometer.

Weather forecasts (this information may change over time - every prudent seafarer will find current sources)
Marine/Shipping forecasts in English are available from a considerable number of sources around the world by both Radio and Internet. Information on the method of promulgation and times may be found from a variety of sources some examples are:

The British Admiralty List of Radio Signals ALRS - Volumes 1-1 and 1-2 amongst other information, feature radio stations broadcasting weather services and forecasts all around the globe.

In the UK, the Maritime and Coastguard Agency (MCA) is responsible for the provision of Maritime Safety Information (MSI) to ships at sea, which includes the broadcast of warnings and forecasts, the information is prepared by the Meteorology (The Met Office) who makes routine forecasts for broadcasting. The Met Office website is a very useful resource, http://www.metoffice.gov.uk/weather/marine/

The BBC Radio 4 issues shipping forecasts at the following local times, 00.48, 05.20, 12.57, 21.58. The BBC Weather web is also very comprehensive, http://news.bbc.co.uk/weather/coast_and_sea/shipping_forecast/

In Australia the Bureau of Meteorology provides the Australian and international maritime communities with weather forecasts, warnings and observations for coastal waters areas and high seas around Australia. Generally most of these services are provided routinely throughout the day, while marine weather warnings may be issued at any time when the need becomes apparent. initial warnings provide about 24 hours notice and are are renewed every 6 hours until ended. The BOM web site provides comprehensive and up to date information, http://www.bom.gov.au/marine/
Times of broadcast can be found on this site.

For the coastal waters of USA forecasts are available from various different sources but NOAA weather on VHF radio WX channels are of a very high quality.

The National Weather Service publishes a book entitled Worldwide Marine Weather Broadcasts. This publication contains weather broadcast schedules, both U.S. and foreign, from all over the planet, covering radiotelephone, radiotelegraph (Morse Code), and radiofacsimile transmissions. These schedules list broadcast times and geographic areas covered by the broadcast information, as well as station call letters, transmitting frequencies, and station locations.

For web coverage, the NOAA site gives access to both coatal and International coverage,
NOAA http://www.nws.noaa.gov/om/marine/mfvoice.htm
National Weather Service Marine Products Via USCG Mf Voice -Times on Web
2182 kHz Calling/Announcement frequency
2670 kHz Broadcast frequency

NAVTEX is an international automated direct printing service for t Marine Safety Information (MSI) to ships at sea. It is an integral part of the Global Maritime Distress and Safety System (GMDSS) that can provide all the safety information and weather required. The international system operates world-wide on a frequency of 518 kHz so there is no requirement for retuning of the receiver. The output on 518 kHz is in the English language no matter which part of the world the information is being received.

Inmarsat-C SafetyNET is an internationally adopted, automated satellite system for promulgating weather forecasts and warnings, marine navigational warnings and other safety related information to all types of vessels and is part of the Global Maritime Distress and Safety System (GMDSS). There are no user fees associated with receiving SafetyNET broadcasts.

This list is not comprehensive and any mariner travelling to new waters should research the local sourses before arrival.

Forecast format
The shipping forecasts are given in three parts, each part being of equal importance. Terminology is also standardised.

Gale warnings
Storm warnings are issued before the main forecast. Note carefully the time that the warning was issued, it may have been issued some hours before you heard it and it could therefore be quite close.

The general synopsis
The forecast starts with the general synopsis which gives the details and positions of the systems which are causing, or will effect, the weather. For example the synopsis may give the position of a depression, the direction in which it is moving and how fast it expected to move. It may also tell where it is expected to be in so many hours time.

The sea area forecast
The sea area forecast follows the synopsis and a forecast is given for each area covering wind strength, wind direction, wave height, weather and visibility for the next 24 hours.

International weather map symbols
An international system of pictorial shorthand is used to show details of weather on a weather map. Many marinas and harbour offices have dedicated television monitors with a continuous display of the forecast using these symbols. Although the international convention is to draw ½ a feather for each increment of 5 knots there will be little inaccuracy if you take ½ a feather as indicating one Beaufort force.

Note that a wind strength of force ten is shown by an arrow with a triangle at the end rather than five feathers; as the strength increases single feathers are added to the triangle.

A triangle with a single feather in front indicates hurricane force 12: *"Air filled with foam and spray. Sea completely white with driving spray; visibility very seriously affected. Probable wave height 45 feet".*

INTERNATIONAL WEATHER PLOTTING SYMBOLS

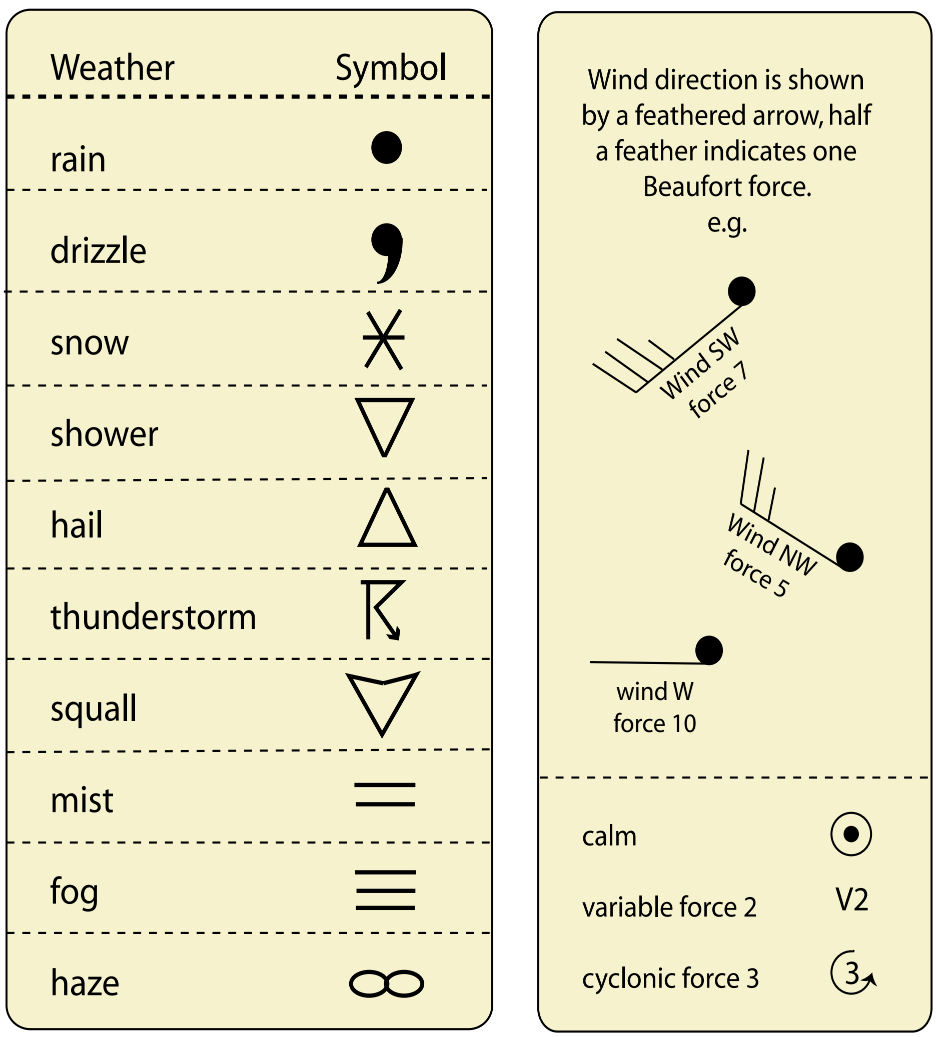
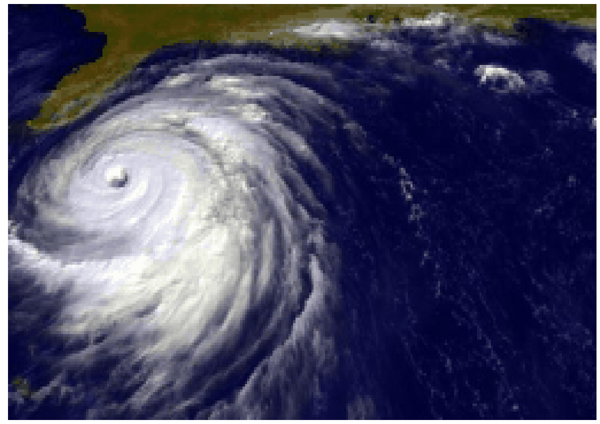


Fig 19
International weather map symbols

Tropical Revolving Storms

Tropical revolving storms (TRS)



Intense depressions forming in the tropical regions are known by various names such as hurricanes (Atlantic), typhoons (Pacific), cyclones (Indian Ocean). The terms *tropical revolving storm* or *tropical cyclone* are used to describe these intense low pressure systems. These storms can give rise to violent conditions in which yachts and their crews will often be unable to survive. Tropical cyclones do not occur with anything like the frequency of the depressions experienced in temperate climates such as Ireland.

Hurricanes can seriously damage your health

Anyone venturing into areas in which Tropical Revolving Storms occur should avail of every opportunity to learn about them, possible areas of refuge ('hurricane holes') and what, if any, forecasting facilities may be available.

Many marinas in the USA and elsewhere will not allow boats to enter if a hurricane is forecast, indeed some marinas may try to force boats already in the marina to leave. Insurance policies will often exclude cover for vessels even being stored in the water in hurricane prone areas during the hurricane season.

So-called 'hurricane holes' may well offer some degree of safety but not when they become filled with charter boats hastily anchored on hopelessly inadequate ground tackle.

Consider the following "A mature hurricane is by far the most powerful event on earth; the combined nuclear arsenals of the United States and the former Soviet Union don't contain enough energy to keep a hurricane going for one day. A typical hurricane encompasses a million cubic miles of atmosphere and could provide all the electrical power needed by the United States for three or four years.

In 1970, a hurricane drowned half a million people in what is now Bangladesh.
In 1938, a hurricane put downtown Providence, Rhode Island, under ten feet of ocean. The waves generated by that storm were so huge that they literally shook the earth; seismographs in Alaska picked up their impact five thousand miles away." (The Perfect Storm).

Source of energy

Air is composed of nitrogen, oxygen and water in the form of vapour. The warmer the air is the more moisture it can contain. In the tropics air is heated by coming into contact with the sea which has in turn been warmed by the sun. As the air becomes warmed it is able to absorb more moisture which is supplied by evaporation from the surface of the sea. Energy, supplied by the sun, is required to evaporate the water. The warm air mass containing the water vapour rises and is cooled. The water vapour condenses back into water and the latent heat, or energy, contained by the vapour is released.

Tropical cyclones obtain their terrific energy by evaporating water from the sea surface and releasing this energy when the moisture vapour condenses into the form of torrential rain. By the time the rising air mass reaches the upper limit of the cyclone, which can be 8 miles or more above the sea surface, the air has become dry and cold. This dry cold air moves rapidly outward from the centre of the hurricane and, being cold and therefore heavy, descends back to sea level Warmed by contact with the sea surface the dry air absorbs moisture once again and is drawn towards the low pressure area in the centre of the cyclone and the cycle begins to repeat itself. Cyclones, once started, are therefore self generating as long as warm, moist, surface air is available. There are no fronts, either warm or cold, in a tropical cyclone and the isobars are more or less circular.

Conditions required for formation of TRS

Three conditions must be fulfilled for a tropical cyclone to develop; the first condition is that of sea surface temperature. The rate of evaporation necessary to allow a TRS to form requires a sea surface temperature greater than about 27° Centigrade (81° Fahrenheit). Sea temperatures as high as this only occur in the North Atlantic, for example, during the summer and autumn of that hemisphere and usually on the western side, i.e. in the Caribbean and Gulf of Mexico. The Pacific and Indian Ocean southern hemisphere the water heats up in the Southern Summer.

The second requirement for a tropical cyclone to develop is the existence of Corioli's force which will set up an counter clockwise spinning motion in the northern hemisphere or clockwise in the southern hemisphere. Corioli's force does not exist until about 7° north, or south, of the equator.

The third requirement is for weak upper level winds.

Tropical waves

An elongated area of low pressure (a trough) of low pressure is known as a Tropical wave, as it originates in the tropics. Many originate as a cluster of thunderstorms If conditions are right, they may develop further into a Tropical Disturbance.

Tropical Disturbance

In tropical or sub-tropical areas when light winds have been circulating for 24 hours around an area of low pressure the air circulation is designated a tropical disturbance. A tropical disturbance is non frontal and may be approximately from 100 to 300 miles in diameter.

Tropical Depression

A tropical cyclone in which the sustained surface wind speed does not exceed 33 knots is called a tropical depression. At this stage the depression will be given a number.

Tropical Storm

When the sustained wind speeds at surface level reach from 33 knots to a maximum of 64 knots the cyclone is designated a tropical storm. The high speed circulation of the wind in the centre of the depression throws air outwards by centrifugal force and cold, dry (and therefore cloudless) air from high altitudes is drawn in to replace the outgoing air. Thus the cloudless, calm, centre 'eye' of the storm is formed. At this stage the storm will be given a name.

Hurricane

When the maximum sustained surface wind speed of the TRS exceeds 64 knots the TRS is designated a hurricane. A hurricane is also given a category number from 1 to 5, (Known as the Saffir - Simpson Scale) based on the maximum wind speed sustained over a period of 1 minute of time.

An international colour code is also used for the tracks on weather maps.

The categories are:

Category 1, wind speeds from 65 to 83 knots (red)
Category 2, 84 to 95 knots (light red)
Category 3, 96 to 113 knots (magenta)
Category 4, 114 to 134 knots (light magenta)
Category 5, 135 + knots. (white)

Scale Number (Category)	Sustained Winds (MPH)	Damage	Storm Surge
1	74-95	**Minimal**: Unanchored mobile homes, vegetation and signs.	4-5 feet
2	96-110	**Moderate**: All mobile homes, roofs, small crafts, flooding.	6-8 feet
3	111-130	**Extensive**: Small buildings, low-lying roads cut off.	9-12 feet
4	131-155	**Extreme**: Roofs destroyed, trees down, roads cut off, mobile homes destroyed. Beach homes flooded.	13-18 feet
5	More than 155	**Catastrophic**: Most buildings destroyed. Vegetation destroyed. Major roads cut off. Homes flooded.	Greater than 18 feet

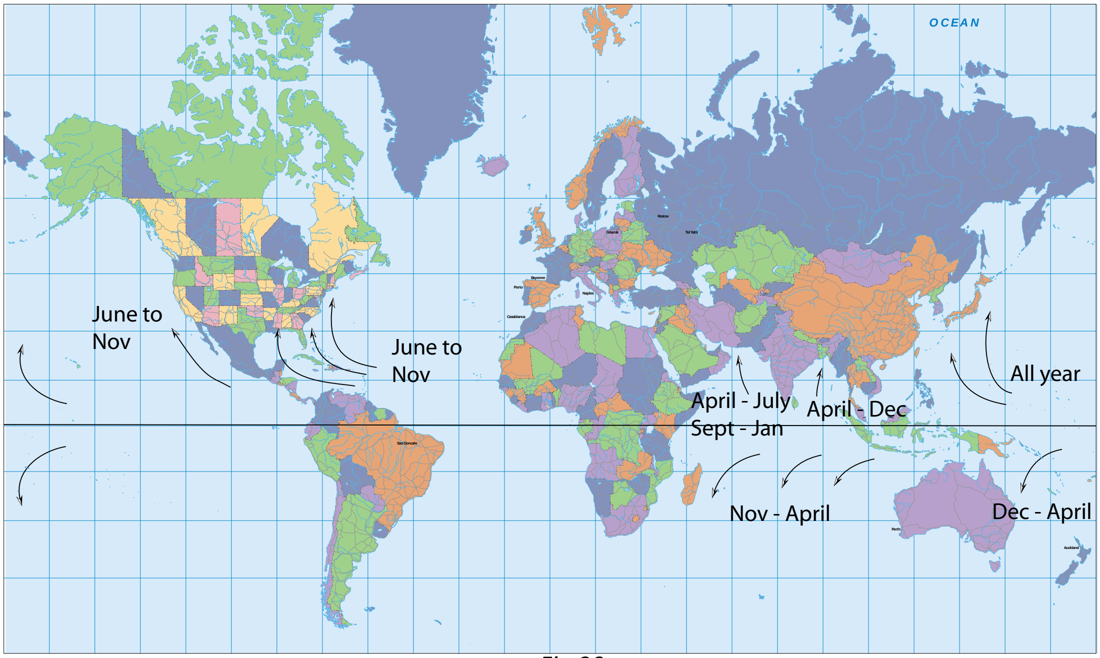


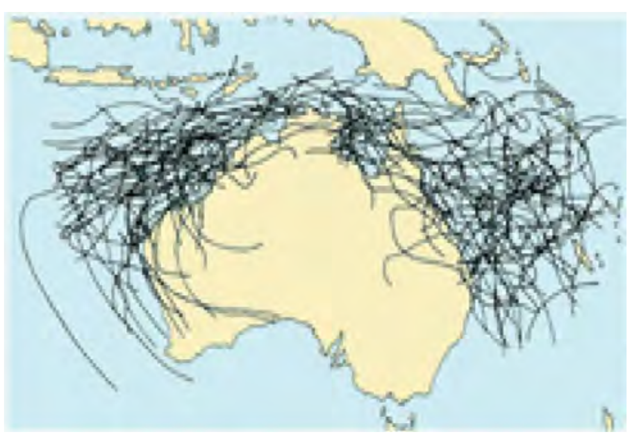
Fig 20
Areas which experience tropical revolving storms, their average paths, and the months in which they are most likely to occur.

Areas TRS prone

Western side of the North Atlantic	(50)
Eastern side of the North Pacific	(30)
Western side of South Pacific	(30)
Western North Pacific	(250)
Southern Indian Ocean	(60)
Bay of Bengal	(20)
Arabian Sea	(10)
North West Australia.	(10)

The figures in brackets indicate the average number of severe tropical storms recorded over 10 years.

No tropical cyclones had been recorded in the South Atlantic, until 2004, when one moved onto the coast of Brazil.



Australian cyclones show extremely erratic paths compared to other parts of the world. A tropical cyclone can last for a few days or up to two or three weeks and movement in any direction is possible including sharp turns and even loops, which makes the process of accurate forecasting particularly difficult.

North Atlantic TRS

The following numbers of tropical cyclones/hurricanes were recorded in the north Atlantic over the last 10 years:

YEAR	Named Storms	Hurricanes	Major Hurricanes
2004	12	4	2
2005	16	7	3
2006	15	9	6
2007	28	6	2
2008	10	8	5
2009	9	3	2
2010	19	12	5
2011	17	7	3
2012	19	10	2
2013	14	2	0
2014 predicted	17	8	3

Seasons

North Atlantic official hurricane season runs from June 1 until November 30, although hurricanes have occurred in every month of the year. The peak date statistically of the North Atlantic hurricane season is September 14th.

The Australian cyclone season runs from November to April, although very few have occurred in November..

Western North Pacific may have tropical cyclones during any month

Arabian Sea at the change of monsoon around October-November and May-June.

Generally hurricanes develop during the late summer and early autumn months of their hemisphere when the sea temperature has reached its hottest for the year. This means that they are rare from mid November until mid June in the Northern hemisphere and from mid May until November in the Southern hemisphere.

Path or Track

The direction along which a Tropical Cyclone is travelling.

Origins and tracks

In the northern hemisphere tropical cyclones originate north of the doldrums between about 7° and 15° north of the equator. The initial track is often between 275° and 350°. When the storm reaches about latitude 25°N the track turns (recurves) away from the equator and by the time the storm has reached 30°N it will often be travelling in NE direction.

Southern hemisphere tropical storms originate between 7° and 15° south of the equator and initially move in either a WSW or SSW direction recurving when they reach about 15° to 20° south. Having recurved the storm track usually continues in a SE direction.

Sometimes storms, both in the northern and southern hemisphere, do not recurve but continue along their original track until they reach the mainland where they usually die as they will be starved of their supply of warm surface water. Storm tracks do not always conform to any rules, many factors such as the upper level wind direction and adjacent areas of high and low pressure effect the storms ultimate path.

The Vertex

The furthest point reached by the storm's track before the storm recurves is called the vertex.

Eye of the storm

The centre of the storm, which will have light or no winds and clear skies, is called the eye. The eye will be from 10 to 30 miles in diameter and within this area winds may be expected to be light. Although the wind will be light in the eye of the storm at sea waves will be mountainous and very confused. For the crew of a yacht caught here survival may only be through resurrection!

Speed of advance
At the beginning a TRS will move along its track at a speed of 10 or perhaps 15 knots, the speed of advance increasing to between 20 and 25 knots after it has recurved. Speeds of advance up to 40 knots or more have been recorded.

Eyewall
The circle of clouds surrounding the eye of a tropical cyclone. The strongest winds will be in the eyewall.

Dimensions
Tropical cyclones cover a much smaller area than depressions in the higher latitudes. Tropical cyclones vary in size but in general terms may be about 300 miles in diameter and you may expect:

Winds of force 7 or more within 200 miles of the storm center,
Winds of force 8 or more within 100 miles of the storm center,
Winds of force 12 or more within 75 miles of the storm center,
Winds in excess of 150 knots have been recorded within 50 miles of the storm's center.

Significant wave heights
Sea conditions may be described in terms of significant wave height. Out of interest the relationship between wave heights and significant wave height is indicated by the following table, taken from the United States Coast Pilot, No.4.

Wave heights from Significant Wave Heights (SWH)

Most frequent wave heights	0.5 x SWH
Average wave heights	0.6 x SWH
Significant wave height (average height of highest 33%)	1.0 x SWH
Height of highest 10% of the waves	1.3 x SWH
One wave in 1,175 waves	1.9 x SWH
One wave in 3,000 waves	2.5 x SWH

From the table above if significant wave heights of 2 metres/6 feet were forecast the average wave height would be about 1 metre/3.6 feet, the height of the highest 10% of the waves would be about 2.5metres/7.8 feet and one wave in 1,175 could reach 3.5metres/11.4 feet.

In passing it is worth defining the difference between the terms waves and swell. Swell is usually defined as a wave outside its own area of generation whereas a wave has been formed and is maintained directly by local wind.

Breaking waves
Breaking waves are by far the most dangerous waves which a yacht can encounter. A wave will break, in theory, when its height to length ratio is 1:7; but in fact this ratio is usually nearer 1:14 when breaking occurs.

The breaking crest of a wave with a 10 second period will be travelling at a forward velocity of about 30 knots.

Warnings of approach of TRS
Radio warnings of the existence of a TRS and forecasts of its track are available inmost areas. Navtex, INMARSAT, Internet, Local radio stations, television stations, newspapers, weather fax machines, etc., will also give warnings and advice. Details of the radio frequencies and times of warning broadcasts are listed in the various weather source locations described above ie,in Admiralty List of Radio Signals or Worldwide Marine Weather Forecasts in the U.S.

Warnings by Approach of TRS by Observation
In the tropics barometric pressure varies very little from day to day and so barometric pressure should be recorded on a regular basis in the ship's log along with the usual navigational data.
If the barometer, after correction for diurnal variation, shows a drop of 3 millibars below the average for the time of year it may be assumed that a TRS is approaching. If atmospheric pressure, after correction for diurnal variation, is 5 mb below the mean pressure it is certain that a TRS is approaching and a cours of action must be decided upon.

The mean pressure and the correction for diurnal variation for the area and time of year is given in the pilot books for the area. As a rough guide diurnal variation is seldom greater than + or - 1.6 millibars. Diurnal variation is nil at 0100, 0600, 1300, and 2000 LMT.

Diurnal variation

During a 24 hour period atmospheric pressure rises and falls slowly independently of the effects caused by the passing of high and low pressure systems. Atmospheric pressure rises slowly to its maximum value at 1000 LMT and then falls until 1600 LMT. From 1600 LMT pressure rises again until 2200 LMT and then falls again until 0400 LMT. These daily variations in pressure are called *diurnal variation.* In the latitudes of Ireland and Britain the range of diurnal variation is small, about 0.5 of a millibar and so pass unnoticed by the yachtsman. In the tropics, however, the diurnal variation range is about 3 mb.

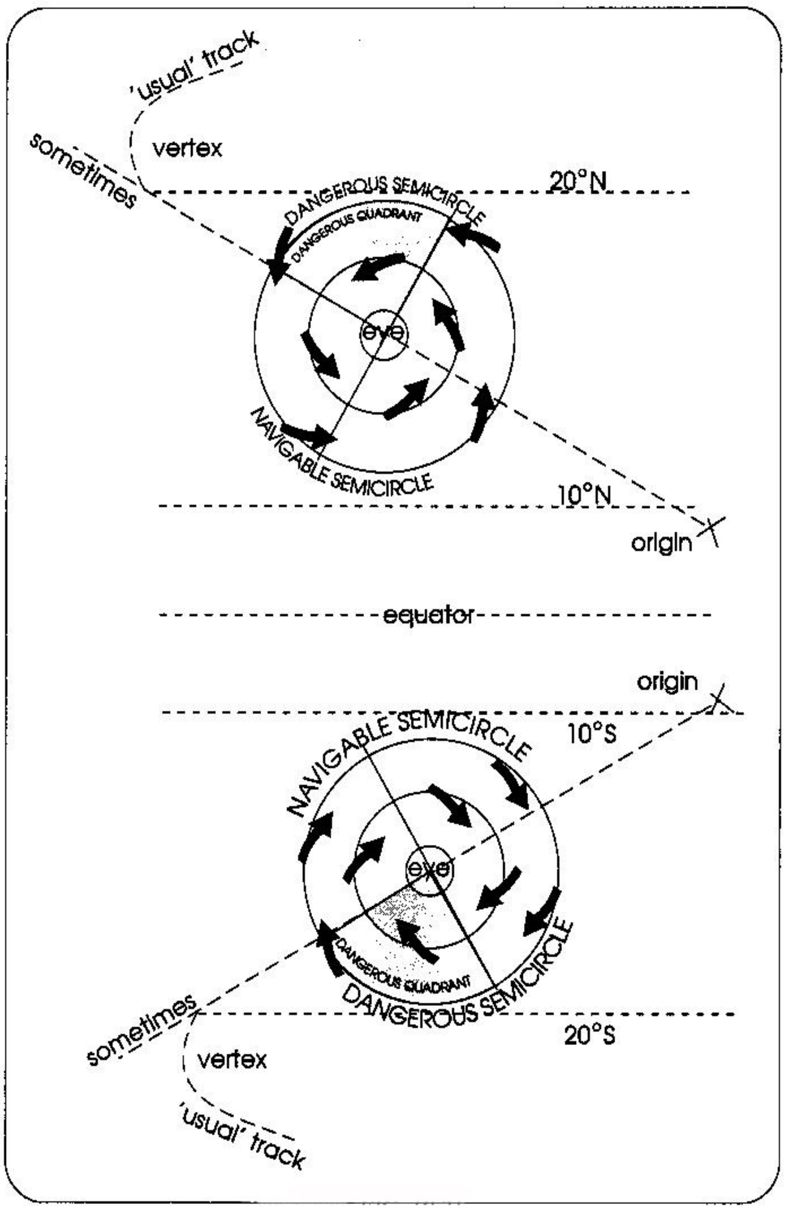


Fig 21
Tropical revolving storms, northern and southern hemisphere.
The arrows indicate the wind directions.

Barometric pressure

A slow fall in pressure during which time the diurnal variation is still discernible indicates that the observer is from 500 to 150 miles from the storm's centre.

A distinct fall hiding the diurnal variation indicates the observer is from 120 to 60 miles from the storm's centre.

A very rapid fall indicates the observer is from 60 to 10 miles from the storm's centre. The barometer may fall as much as 70 mb at the storm centre. (In 1975 a pressure of 870 mb was recorded at the centre of a typhoon).

Pressure will rise very rapidly as the storm passes.

When the storm center is 500 to 1,000 miles away, the barometer usually rises a little, and the skies are relatively clear. This is due to the sinking of the air due to the outflow from the cyclone. As the tropical cyclone continues to approach, the barometer usually appears restless, pumping up and down a few hundredths of an inch. It will then begin a sustained fall, the rate of decrease increasing as the cyclone gets closer.

Swell

An early indication of the approach of a tropical cyclone is the presence of a long swell. In the absence of a tropical cyclone, the crests of swells in the deep Atlantic pass at the rate of perhaps eight per minute. Swells generated by a hurricane are about twice as long, the crests passing at the rate of perhaps four per minute. Swells may be observed several days before the arrival of the storm.

Swell may extend as much as 1000 miles from a storm centre and will certainly be felt 500 to 600 miles from the centre. Higher and faster than usual swell should be taken as warning sign. As swell extends outward in concentric circle from the storm centre it may give an indication as to the direction of the TRS when away from the effect of land.

Radar

If radar is fitted it may be used to identify and track the centre of a TRS but this will depend upon the radar range and proximity of the centre of the storm.

Clouds

When the storm center is 500-1,000 miles away, Cumulus clouds, if present at all, are few in number and their vertical development appears suppressed. As the TRS comes nearer, a cloud sequence begins which resembles that associated with the approach of a warm front in the middle latitudes. Cirrus clouds appear when the storm is about 300-600 miles, which seem to converge, more or less, in the direction from which the storm is approaching. This convergence is particularly apparent at about the time of sunrise and sunset. The cirrus gradually gives way to a continuous veil of cirrostratus. Below this veil, altostratus forms, and then stratocumulus. These clouds gradually become more dense, and as they do so, the weather becomes unsettled. A fine, mist like rain begins to fall, interrupted from time to time by rain showers. The barometer has now fallen perhaps a tenth of an inch.

Wind

As the fall of the barometer becomes more rapid, the wind increases in gustiness to force 6-8. On the horizon appears a dark wall of heavy cumulonimbus, called the bar of the storm. This is the heavy bank of clouds comprising the main mass of the cyclone. Portions of this heavy cloud become detached from time to time, and drift across the sky, accompanied by rain squalls and wind of increasing speed. Between squalls, the cirrostratus can be seen through breaks in the stratocumulus.

As the bar approaches, the barometer falls more rapidly and the wind speed increases. The seas, which have been gradually mounting, become tempestuous. Squall lines, one after the other, sweep past in ever increasing number and intensity. With the arrival of the bar, the day becomes very dark, squalls become virtually continuous, and the barometer falls precipitously, with a rapid increase in wind speed. The center may still be 100 – 200 miles away. As the center of the storm approaches, the ever stronger wind shrieks through the rigging and the superstructure of the vessel. The rain falls in torrents. The wind fury increases. The seas become mountainous. The tops of huge waves are blown off to mingle with the rain and fill the air with water. Visibility is virtually zero in blinding rain and spray. Even the largest and most seaworthy vessels become virtually unmanageable and may sustain heavy damage. Less sturdy vessels may not survive. Navigation virtually stops as safety of the vessel becomes the only consideration. Words are inadequate to describe the awesome, and terrifying fury.

The Eye
If the eye of the storm passes over the vessel, the winds suddenly drop to a breeze, or dies, as the wall of the eye passes. The rain stops, the sky clears. Visibility improves. Mountainous seas approach from all sides in complete confusion. The barometer reaches it's lowest point As the wall on the opposite side arrives, the full fury of the wind strikes as suddenly as it ceased, but from the opposite direction. The sequence of conditions that occurred during approach of the storm is reversed, and passes more quickly, as the various parts of the storm are not as wide in the rear of a storm as on it's forward side.

Rules to avoid center of TRS
Three things must be decided before avoiding action can be considered. These are:
1. the bearing from the yacht to the center of the storm
2. the expected path of the storm
3. whether the yacht is in what is known as the navigable semicircle or the dangerous semicircle.

Navigable semicircle
In the Northern Hemisphere, that part to the left of the storm track (facing in the direction toward which the storm is moving) is called the navigable semicircle. (By observation, if the wind is backing)

1) A yacht in this semicircle has a free wind to run/reach away from the center of the storm, and,
2) When (if) the storm recurves its path will move the center of the storm away from the yacht.
3) The wind speed is decreased by the forward motion of the storm.

Avoiding action, Navigable semicircle
Reach/run at the best possible speed, keeping the wind on the starboard quarter, which will take the yacht away from the storm's path.

Dangerous semicircle
In the Northern Hemisphere, that part to the right of the storm track (facing the direction in which the storm is moving) is called the dangerous semicircle. (By observation, the wind is veering).

1) A yacht in this semicircle cannot escape by running or reaching before the wind. In this sector a yacht which is hove to, running or drifting is moving towards the storm's track or center. A yacht trying to move outward away from storm's track will have to beat to windward in gale conditions or worse.
2) Even if a yacht can make good to windward the storm when (if) it recurves may well pass over the yacht.
3) The apparent wind in this sector will be strongest due to the forward movement of the storm.

Dangerous quadrant
The forward, or leading, quadrant of the dangerous semicircle is called the dangerous quadrant. A yacht in this quadrant is in the most dangerous position of all. If it is considered feasible to run so that the yacht can cross the storms path and reach the navigable semicircle before being hit by the storm center then this is perhaps the best approach.

If it is felt that yacht may not cross the storm's path quickly enough the only option is to sail/motor to windward on starboard tack in the northern hemisphere, port tack in the southern hemisphere for as long as possible. If conditions become such that this is no longer feasible the yacht must heave-to and prepare for very heavy weather. In the other (rear) sector of the dangerous semicircle heave to in the hope that the storm will pass the yacht quicker than her leeway will move her near to the storm's center.

If it finally becomes necessary to run before the wind the yacht's progress must be slowed as much as possible to try to ensure that the center of the storm will have passed before the yacht reaches the storm's center line.

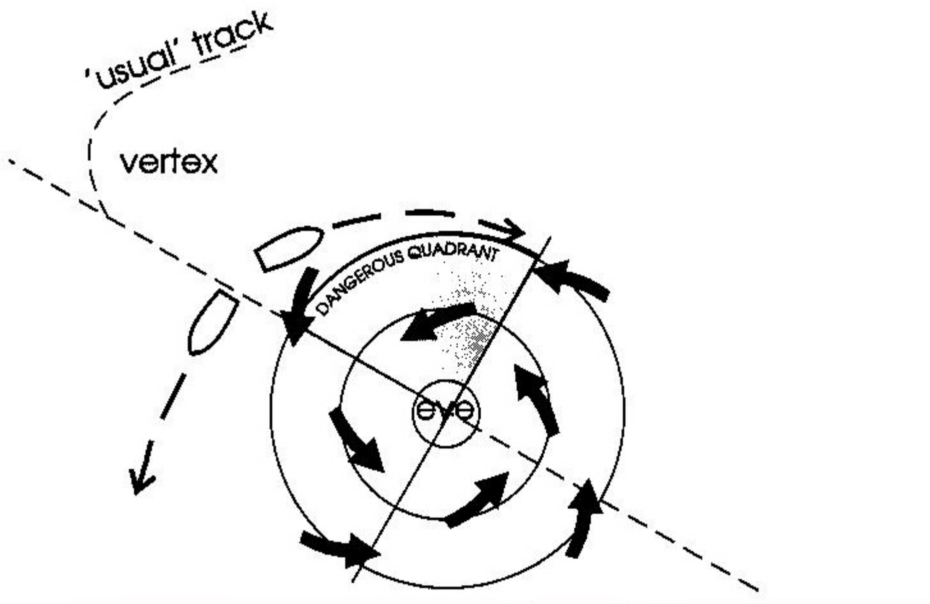


Fig 22
Avoiding action if a TRS is approaching in the northern hemisphere.

The boat ahead of the navigable semicircle has a free wind to run/ reach away from the approaching storm centre with the wind on her starboard quarter. This track will also take her away from the storm centre if the storm recurves.

The boat ahead of the dangerous quadrant has to decide whether she can run before the wind and reach the navigable semicircle before the center of the storm passes over her; if she does not have sufficient time to do this she must sail as close to the wind as possible for as long as the physical conditions allow in order to increase her distance from the storm center. As the wind and seas increase she may well have to heave-to or lie ahull or to a sea anchor, the aim then being to reduce the leeway to the minimum in the hope that the centre of the storm will pass before the boat drifts into the storm center. Her other problem is that if she does manage to beat to windward away from the storm's center she is increasing the possibility of the storm passing over her again if it recurves.

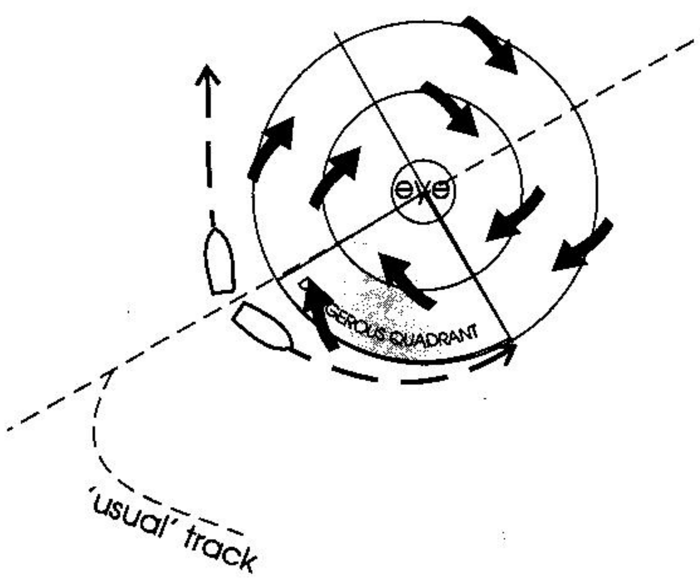


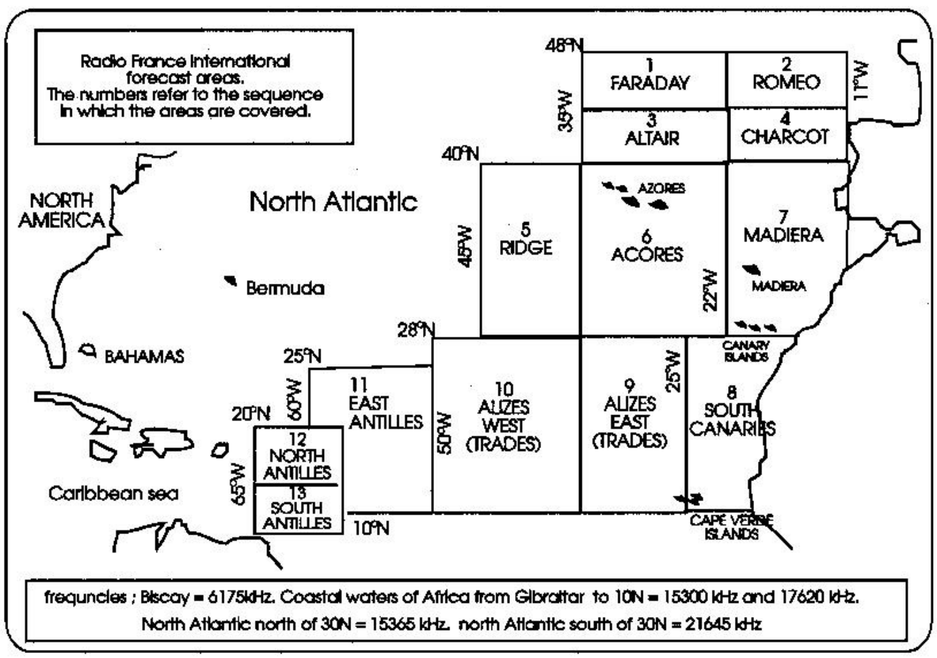
Fig 23
Avoiding action if a TRS is approaching in the southern hemisphere.

Radio warnings
Radio, internet and navtes/INMARSAT warnings of the existence of a TRS and forecasts of its track in English are available from a considerable number of sources around the world. (See section above regarding forecasting sources)

WWV Radio for example transmits TRS warnings for the north Atlantic on 2.5, 5, 10 and 20 MHz at 8 to 10 minutes past the hour. Details of the radio frequencies and times of warning broadcasts are in Worldwide Marine Weather Forecasts in the USA (Admiralty List of Radio Signals in the UK).

Weather forecasts
Forecasts in English are broadcast from Horta in the Azores at 0930 UT on 514.5 kHz, 3618.5 kHz and 13067kHz and at 2130 UT on 514.5 kHz, 3618.5 kHz and 6331 kHz.

Forecasts for a large area of the north Atlantic, including the tradewinds route from the Canaries to the Caribbean, are covered by forecasts in French transmitted by Radio France International (RFI) at 1138 UT. See Fig. 15.4 below. Non French speakers can use a tape recorder and dictionary to translate the basics easily enough. T



Hurricane warnings .
Obviously a radio receiver capable of receiving the required frequencies must also be aboard. Weather fax receivers are self explanatory.

Storm Alerts are given on local radio and TV in TS prone areas, and this can be supllemented by acces to the websites and forecasting services, the exampels of which are listed above under the Froecasting section.

Weather Forecast Services and Information
Below is some general information and resource material that is available around the globe. There are obviously more than these samples.

Admiralty List of Radio Signals ALRS series is a comprehensive source of information covering all aspects of Maritime Communications.
The volumes also feature radio stations broadcasting weather services and forecasts as follows:
Maritime Radio Stations The volumes 1-1 and 1-2 amongst other information, feature radio stations broadcasting weather services and forecasts all around the globe.

- Vol. 1-1 (NP 281-1) Europe, Africa and Asia (excluding the Far East)
- Vol. 1-2 (NP 281-2) The Americas, Far East and Oceania

Marine Weather Forecasts

UK - the Maritime and Coastguard Agency (MCA) is responsible for the provision of Maritime Safety Information (MSI) to ships at sea, which includes the broadcast of warnings and forecasts. This includes Navigation Warnings. **The Met Office** initiates warnings and prepares routine forecasts for dissemination on behalf of the MCA.
http://www.metoffice.gov.uk/weather/marine/

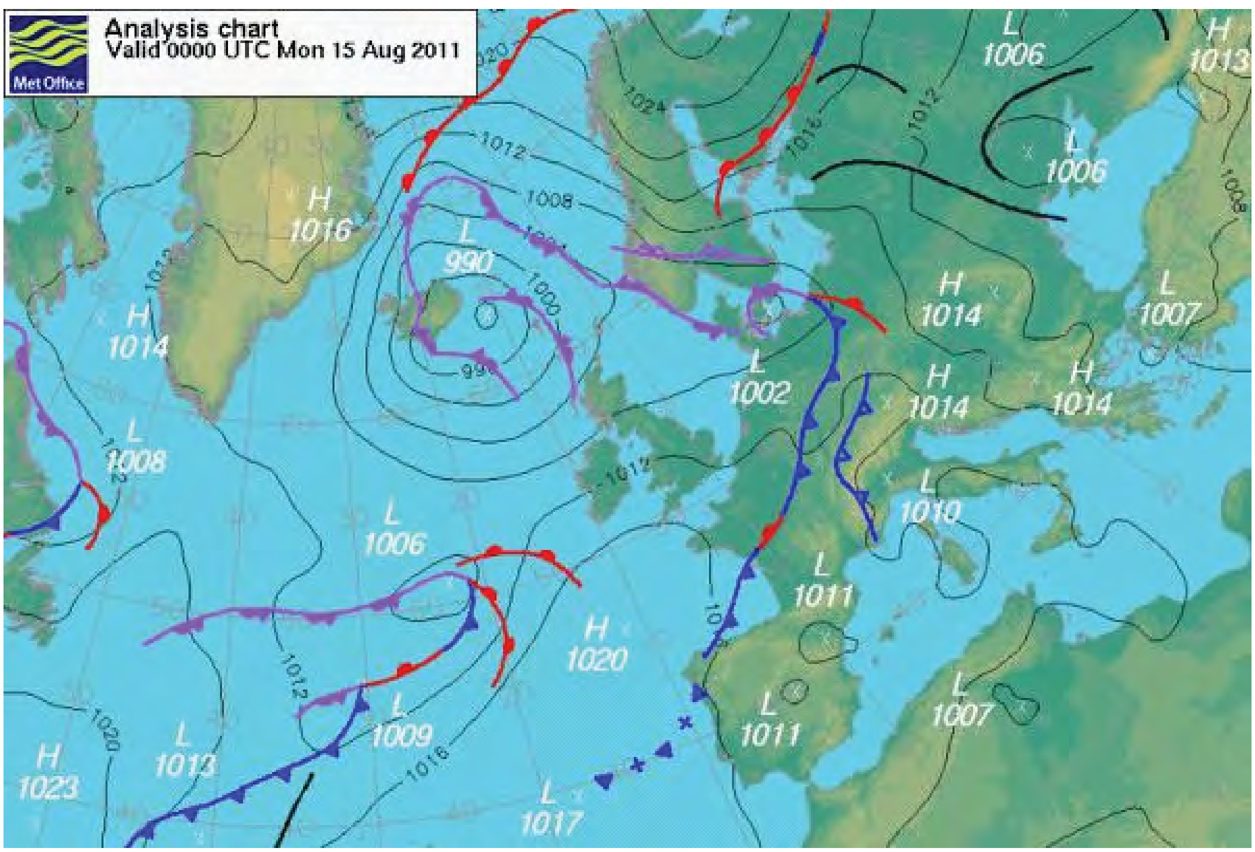


Fig 24
0000 UTC surface analysis
A ridge of high pressure lies over southern parts of the UK giving largely clear and cool conditions overnight for many. Further north, proximity to the area of low pressure northwest of Scotland gives spells of rain and showers here, moving through on the southwesterly wind.

BBC Radio Forecasts
The BBC broadcasts shipping forecasts on Radio 4 at the following times
00.48, 05.20, 12.57, 21.58
And publishes marine forecasts on its website
http://news.bbc.co.uk/weather/coast_and_sea/shipping_forecast/

The Shipping forecast for the British Isles follows a pattern based on sea areas:

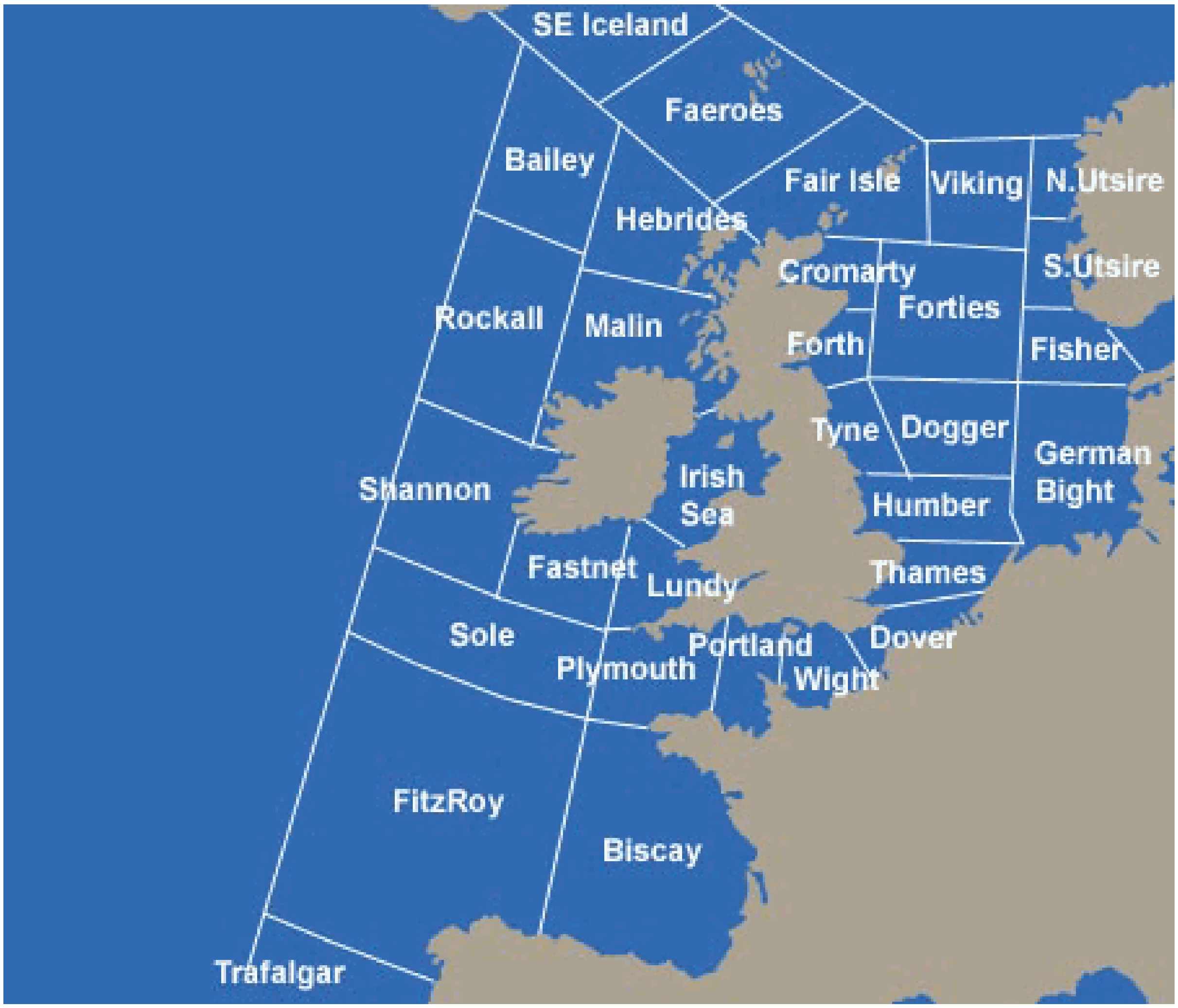


Fig 25
Shipping Forecast Sea Areas

Australia
The Bureau of Meteorology provides the Australian and international maritime communities with weather forecasts, warnings and observations for coastal waters areas and high seas around Australia. Generally most of these services are provided routinely throughout the day, while marine weather warnings may be issued at any time when the need becomes apparent.

They also publish information on the web:
http://www.bom.gov.au/marine/

Warnings for coastal waters are issued whenever strong winds, gales, storm force or hurricane force winds are expected. The initial warning attempts to provide around 24 hours lead-time and warnings are renewed every 6 hours.

Warnings to shipping on the high seas are issued whenever gale, storm force or hurricane force winds are expected. The initial warning attempts to provide around 24 hours lead-time and warnings are renewed every 6 hours.

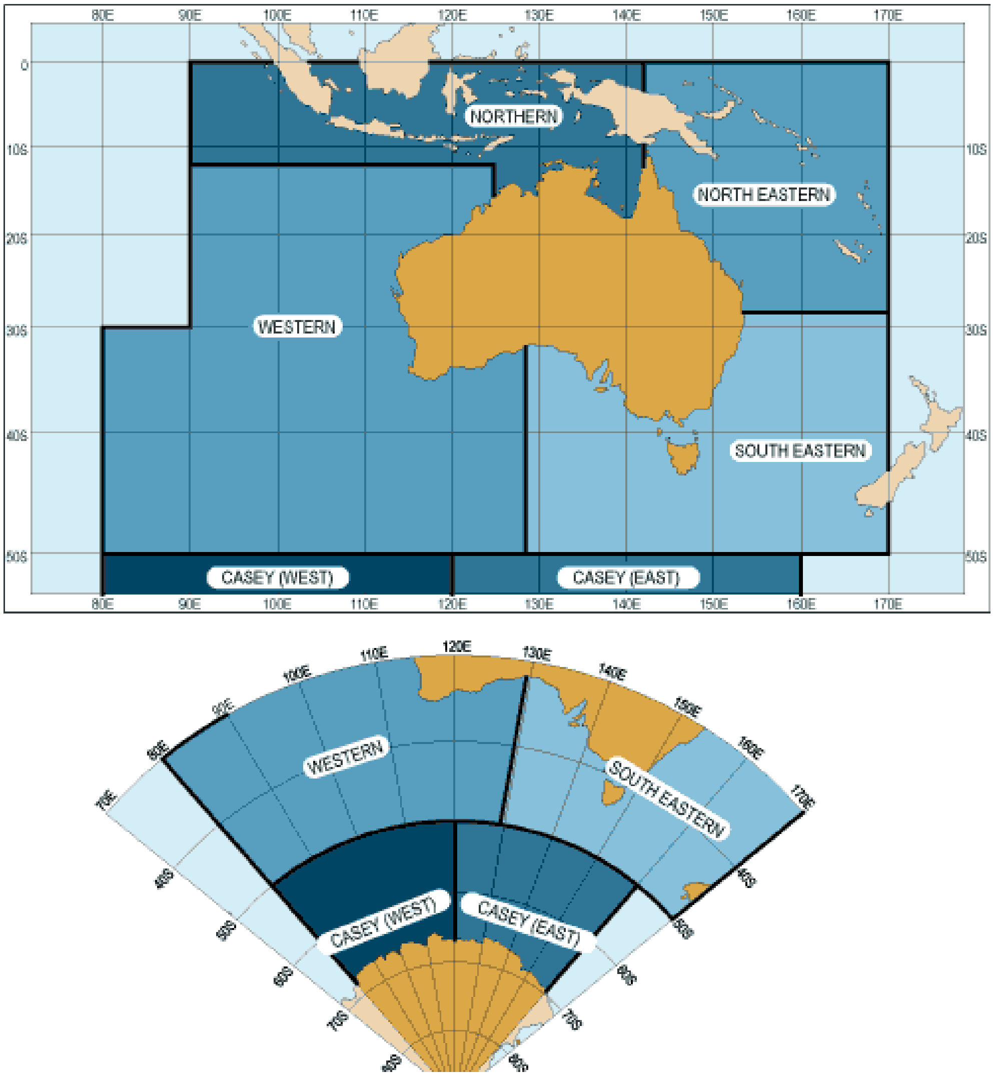


Fig 26
Australian Shipping Forecast Sea Areas

USA
National Weather Service Marine Products Via USCG Voice
2182 kHz Calling/Announcement frequency
2670 kHz Broadcast frequency
And VHF WX Channels
Times on Web, http://www.nws.noaa.gov/om/marine/mfvoice.htm

NAVTEX
An international automated direct printing service for the promulgation of Marine Safety Information (MSI) including weather, to ships at sea.
The simplest form of receiver incorporates a small printer which prints the output on a small roll of paper, but many units are now available at low cost which store the information in soft copy for access as and when required. The international system operates world-wide on a frequency of 518 kHz so there is no requirement for retuning of the receiver. The output on 518 kHz is in the English language no matter which part of the world the information is being received. The basic receiver can be programmed to receive specific transmitting stations and certain classes of messages,

Information on times for specific areas and weather information etc
http://www.users.zetnet.co.uk/tempusfugit/marine/navtex_notes.htm

INMARSAT-C SafetyNET
Inmarsat-C SafetyNET is an internationally adopted, automated satellite system for promulgating weather forecasts and warnings, marine navigational warnings and other safety related information to all types of vessels. There are no user fees associated with receiving SafetyNET broadcasts. SafetyNET broadcasts are performed using the Inmarsat satellite system of geostationary satellites.

Times and information on services can be found from, U.S. Coast Guard Maritime Telecommunications Information webpage for a complete description of SafetyNET including worldwide schedule information.
The British Admiralty List of Radio Signals is an excellent reference source for SafetyNET information.
A copy of the latest "The SafetyNET Users Handbook" (Electronic) is available from Inmarsat.

4

Chartwork Instruments

Five basic instruments are needed for chart work:

a pencil to draw lines,
an eraser to rub them out,
dividers to measure distances,
a ruler, and
a device, or "plotter", for measuring angles.

Pencil

Chart work requires a fair amount of drawing and in order to facilitate rubbing out lines pencils with soft leads should be used. The hardness or softness of a pencil lead is graded in letters and numbers, H for hard and B for soft. A 2B is softer than a B and is generally considered the best lead for chart work. You can of course use wooden pencils but they require constant sharpening which means constant searches for something to sharpen them with. After sharpening the line left by the lead becomes thicker as the point wears down.

Fig 1 Single handed dividers

By far the best pencils for chart work are the Mechanical /clutch type which are inexpensive and readily available. Mechanical pencils contain spare leads in the barrel and 2B leads can be bought as refills. Mechanical pencils are available to accept different lead diameters; 0.5 mm is the usual size but 0.7 mm is perhaps better. As the diameter of the lead is constant it does not need sharpening and simply pressing a button on the pencil gives a new piece of lead when needed.

Dividers

A cheap pair of dividers will do but single handed dividers are nice and are easy to use. Single handed dividers are so called because their bow shape enables them to be opened and closed with only one hand. They are usually made of brass with stainless steel inserts for the points.

Plotters

Many instruments are produced to enable angles to be measured or transferred on the chart. Navigators on ships with big stable chart tables favour either parallel or rolling rules but both need a totally smooth and steady platform and can therefore be difficult or even impossible to use in a small boat at sea.

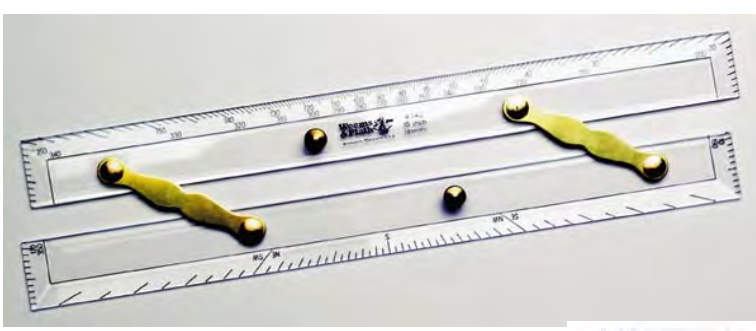


Fig 2 Parallel rules

Fig 3 Roller rules

The simplest of all chart instruments is perhaps the Douglas protractor which was designed for use by navigators of aeroplanes during the second world war. A protractor is usually circular but the Douglas protractor is square so that its edges can be used as rulers.
The Douglas protractor is inexpensive and virtually indestructible when made of impact resistant plastic and has no moving parts.

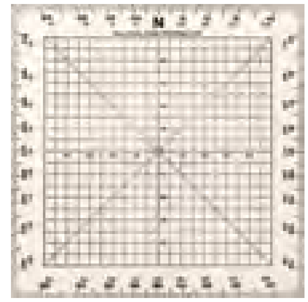


Fig 4 Square or Douglas Protractor

Lots of plotters of varying complexity have been designed specifically for use in small boats and of these by far the best is the Breton plotter. Designed originally by Capt. Yvonnick Gueret, from Brittany in northern France, the Breton has been copied, 'improved' and renamed by different people.

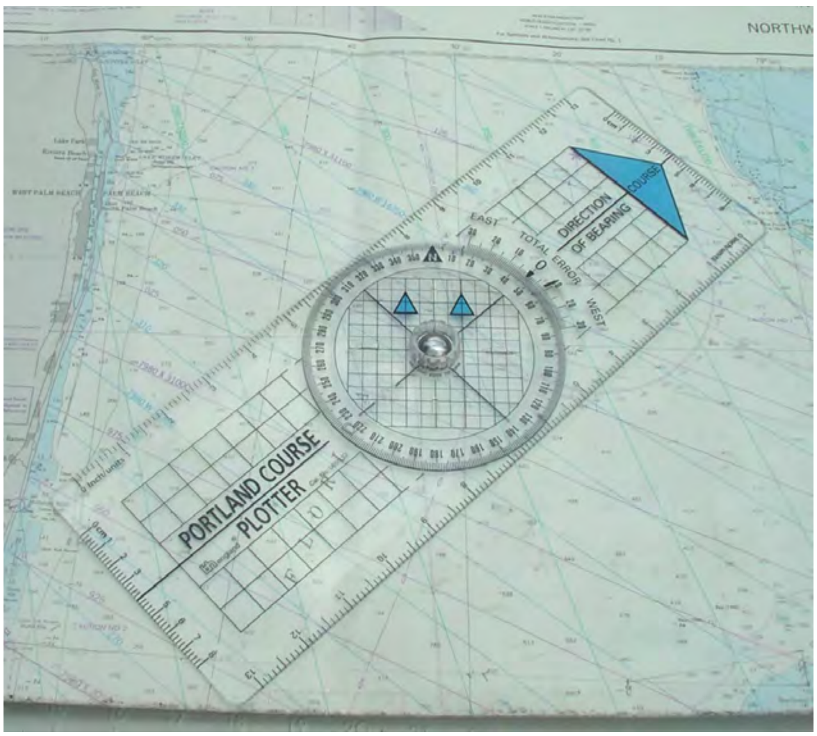


Fig 5 Breton plotter

The Breton plotter is tough, simple and quick to use and is recommended without hesitation for small boat chart work and navigation. When buying a Breton type plotter look for large clear numbers on the protractor and make sure it is tough and reasonably flexible.

The Breton type plotter consists of a rectangular base of transparent flexible plastic about 0.3 m/14" in length with a circular protractor mounted so that it can be rotated about its centre. The protractor is marked in one degree increments from 0° to 360° and has a series of vertical and horizontal grid lines to facilitate accurate lining up of the protractor.

Weems and Plath make a similar plotting instrument called 'bi-rola chart protractor'.

Some of the advantages of the Breton type of plotter are that:

- it can be used anywhere on a chart without requiring reference to a compass rose
- it can be used on uneven surfaces and surfaces which are far from horizontal
- it can even be used on a chart held on your knee in the cockpit
- it can be used to lift pilotage directions from chartlets and sailing directions
- it can be used to lift current directions from a current atlas
- it incorporates long straight edges for plotting.
- it is easy to read the bearing due to the large clear numbers on the protractor
- the bearing found or required remains clearly indicated on the protractor and can therefore be checked when memory causes doubt or fails completely.

5

Charts, Chart Projections and Publications

Charts are maps of the sea bed including adjacent land and its coastline. They contain an enormous amount of information which is necessary for navigation; this information is conveyed pictorially or in writing. In order to avoid the chart becoming cluttered written information is often presented in an abbreviated form. Navigators must be able to understand all the information presented by the chart and the significance of the abbreviations and symbols at a glance.

Most maritime countries have agencies which produce and maintain hydrographic data and information enabling the publication of navigational charts. Many small countries do not have their own individual chart publication service but may supply authoritative coastal and local information to hydrographic agencies of other nations.

The International Hydrographic Organisation is a body which promotes international co-operation between agencies involved in the production of charts and related publications, thus allowing free circulation of data between countries and nations. Information from mariners relating to charts, sailing directions and coast pilots is requested by all hydrographic agencies.

Hydrographic Agencies

British Admiralty charts (BA)
BA charts are published by the Hydrographic Office of the British Ministry of Defence and are available from approved chart agents. BA chart agents will also supply, free of charge, 'Home Waters Catalogue' (NP 109) which is a catalogue of BA north European charts from Denmark to Bordeaux on the Atlantic coast of France. NP 109 also lists other useful BA publications such as tidal stream atlases, pilot books, etc., for the area covered and includes names, addresses and telephone numbers of chart agents in Ireland and the UK.

A full catalogue of all BA charts called 'Catalogue of Admiralty Charts and other Hydrographic Publications' (NP 131) is also available for viewing at every BA chart agent or may be purchased also. Both are published annually.

Other Chart Agencies
Most Maritime nations publish their own charts usually form shared data, for example:

Australia: Royal Australian Navy Hydrographic Service
Canada: Canadian Hydrographic Service (CHS)
France: Service hydrographique et océanographique de la marine (SHOM)
Germany: Bundesamt für Seeschifffahrt und Hydrographie (BSH)
Greece: Hellenic Navy Hydrographic Service (HNHS)
Turkey: Seyir, Hidrografi ve Oşinografi Dairesi

USA
National Oceanic and Atmospheric Administration (NOAA) charts
U.S. charts are published at Washington, D.C., by the National Oceanic and Atmospheric Administration (NOAA) in the Department of Commerce.

The main agencies involved in the production of US nautical charts of interest are:
The National Ocean Service (NOS) who produce charts of the U.S. and its possessions, and the Defense Mapping Agency Hydrographic/Topographic Center (DMA or DMAHTC) now known as National Imagery and Mapping Agency (NIMA), who produce charts of the oceans and areas other than U.S. territorial waters.

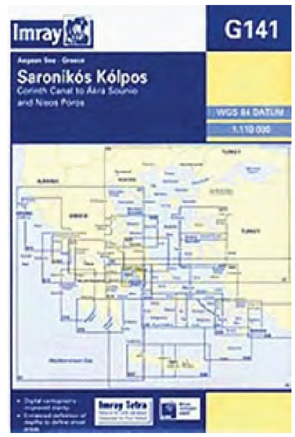
Chart catalogues are available from the publishers/stockists, NOS chart catalogues are free of charge, as follows:

Nautical Chart Catalog 1 - Atlantic and Gulf Coasts with Puerto Rico and Virgin Islands.
Nautical Chart Catalog 2 - The Pacific Coast including Hawaii, Guam and Samoa Islands.
Nautical Chart Catalog 3 - Alaska including the Aleutian Islands
Nautical Chart Catalog 4 - The U.S. Great Lakes and Adjacent waterways.

These catalogues show, harbour charts, coast charts, general charts and sailing charts available for the area covered together with their respective chart numbers. Written details are also given of the title and scale of each chart. Suppliers in the US and foreign agents are included together with brief information on other publications such as marine weather services charts, Coast Pilots, tidal current tables, tide tables and so on.

Small craft charts

Charts intended specifically for use aboard small craft, often called 'yachtsmen's charts' are produced by various chart publishers. Imray Laurie Norie and Wilson Ltd of England publish a number of yachting charts. These charts are based on information from British Admiralty charts and 'other sources' such as US, French and Dutch charts. These charts carry a disclaimer that "....no national hydrographic office has verified the information in this product and none accept liability for the accuracy......."

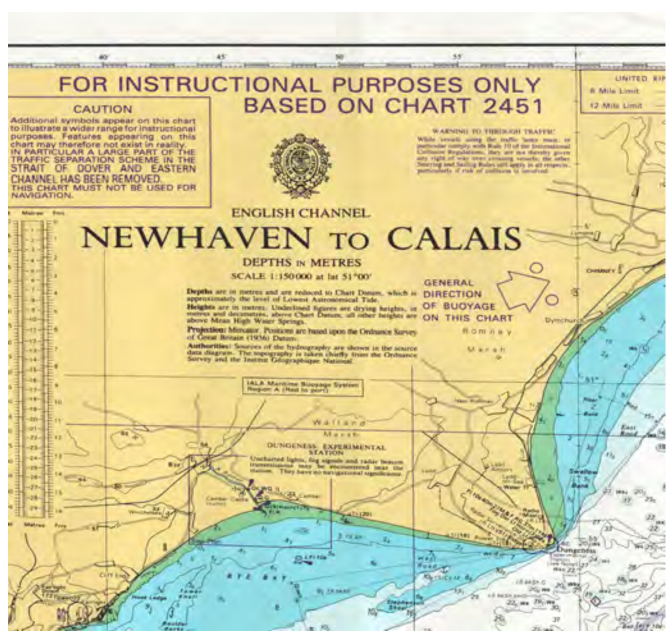


British Isles and Northwest Europe - Includes Imray C series for Medium scale, large sheet offshore passage making and Imray Y series charts for detailed small sheet coverage of rivers and estuaries.
Caribbean Sea - Imray Iolaire-charts
Greece and Turkey - Imray G Series charts
Mediterranean - Imray M Series charts
North Atlantic Ocean - Imray

Yachting charts are generally made to fold into a convenient size and have discarded information which the publishers do not consider of use to the small boat navigator. These charts may also use different colours to indicate land, sea, drying areas etc. Many of these charts are produced on waterproof and tear proof paper which has obvious advantages but rubbing out pencil lines can be a problem. They often include useful 'chartlets' of harbours and anchorages together with their approaches. Some may also have useful information, such as pilotage/buoyage notes printed on the reverse side.

Suppliers

Charts are available from chart agents and nautical book stores; most chandlers shops can supply yacht charts for the immediate area at least. Suppliers such as chart agents also stock Notices to Mariners which update ever changing navigation information usually weekly. Many are also approved to provide a chart updating service, which for a fee, provides the navigator with the most up to date "corrected" charts for their vessel.



General information on a chart:

Training Chart 5055 (based on BA 2451) Newhaven to Calais will be used for this course.

Note: NOT TO BE USED FOR NAVIGATION.

Publisher: responsible for the information in the chart ie “Hydrographic Office” – Part of the British Admiralty

Title: the area covered by the chart – “Newhaven to Calais”

Number: each chart has a unique number for the above - BA 5055. Adjoining chart numbers are given in the top, bottom and left margins;

P**rojection:** ie Mercator projection or gnomonic or other projection.

Edition and corrections: New editions of charts intended for navigation are published when required by the amount and significance of the changes in the area covered by the chart. Only the latest and most up to date charts should be carried aboard.

All charts are given a publication edition, but information is constantly changing so in order that the chart does not have to be reproduced each time there is a change, corrections are promulgated through “Notices to Mariners” and the changes are made on the chart and noted on the bottom left corner of the chart.

The chart 5055 was first published in 1979, and the latest version is 21 May 1993. As it is a training chart there are no correction noted in the left corner.

Notes, Warnings, Cautions: Charts may carry Notes, Warnings and Cautions, all of which should be read carefully. The chart may have references to these notes printed at various places on it; for example, on both the top and bottom the chart is clearly marked, “not to be used for navigation- see caution”. This caution is alongside the Hydrographic Logo and informs the user that some additional features and symbols have been added for training and may not actually exist, and that the Traffic Separation Zone information has been heavily edited.

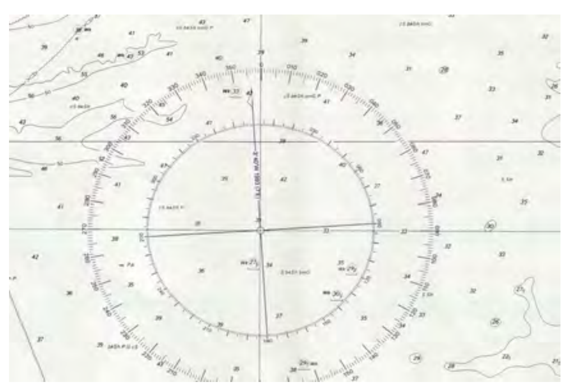
Warnings are listed on the right side of the chart and cover Ferry activity, wrecks etc.

Scale: In general terms charts may be considered in three groups of scales: large scale harbour plans, coastal charts covering perhaps 10 to 50 miles and small scale passage planning charts covering large areas; a large-scale chart covers a small geographical area while a small-scale chart will cover a larger area. Larger scale charts are recommended for their greater accuracy and use when close to land or in ports harbours and rivers etc.
Chart 5055 Scale is, 1:150,000 or 1/150,000 which means that one unit (a metre) on the chart represents 150,000 of the same unit on the surface of the earth.

Units of Measurement: European charts and International Charts will be in the “International” Format and have the words SOUNDINGS IN METRES in purple print on the upper and lower margins as well as in the title. US and US based charts produced by other Administrations will have the words SOUNDINGS IN FEET in purple print on the upper and lower margins as well as in the title.

Sometimes Fathoms are used for soundings or measurement of depths on the chart (1 fathom = 6 feet).

Always check very carefully what units of measurement are used on the chart and be careful when changing from one chart to another.



Compass Rose and Magnetic variation: The compass rose is located on several parts of the charts to enable bearings and angles to be plotted or taken off the chart. In the centre of the chart the Variation (Difference between True North and Magnetic North) is shown as an angle. There is also a note of the change in value annually which allows a calculation to be made for the current variation (The magnetic field of the earth is constantly in motion and changes all the time).

As there are various Compass Roses located on the chart the variation and the annual change may be different, so use the one closest to the area in which you are navigating on the chart. The 3 compass roses on chart 5055 show a range of variation from 3° 15' W to 3° 40' W, in 1993. There are actually two scales of degrees, one inside the other. The outside large rose shows true bearings whereas the inside smaller rose shows magnetic bearings, but only for the year shown.

The calculation required to allow for change in variation is covered in Section 8.

Latitude and Longitude: as with land maps the chart is divided in to a grid, and known as Latitude (on the sides of the chart) and Longitude (on the top and bottom of the chart). These are named – Latitude, North and South 0 to 90° and Longitude East and West 0 to 180°. See below for detailed explanation.

Horizontal geodetic datum: Is a function of the relationship between the Earth's shape and its representation on a chart and is used as the basis for the construction of the chart. The most common and generally accepted datum is known as WGS-84. Positions obtained by satellite navigation systems are usually referred to this datum. With charts using other datums a correction needs to be applied to a WGS-84 GPS position to agree. This is usually calculated by GPS receivers which can be set to display positions using alternate Datums.

It is important to check carefully which horizontal datum is used when using electronic position fixing aids such as GPS. Most GPS sets allow selection of one of hundreds of datums but usually use a default of WGS 84. On practice chart 5055 the datum is given as World Geodetic System 1984. This means that for practical purposes the chart can be used with a GPS set to WGS 84 datum without any changes required when plotting the latitude and longitude read out from the GPS directly on to this chart. (But remember that practice charts must not be used for navigation.)

Always check that your GPS is set to the same horizontal datum as the chart; if it cannot be set to the same datum corrections will have to be applied to the lat/long indicated by the GPS before plotting the position on a chart. The corrections required will be indicated somewhere in writing on the chart under the heading HORIZONTAL DATUM. Often the correction is in fact too small to be of any real practical concern but in some cases the difference can be considerable. Certainly if differential GPS is being used the changes should be taken into account.

(Many charts result from surveys done in the 19th century and therefore do not have the have the precision to use positions etc. derived from GPS and in particular the extreme accuracy of (differential) GPS positioning. GPS data also requires adjustment for the chart datum on which the chart is based).

Horizontal scale: Is the latitude on the chart where the horizontal scale on the chart scale is true (This is because a chart is a flat representation of a sphere).

Soundings datum: This is the datum to which soundings and drying heights on a chart are referred.

In areas effected by tides the actual depth of water at any place will change constantly as the tide rises and falls. It is therefore necessary to establish a fixed level, or datum, from which all soundings on the chart are measured. It makes sense to measure all soundings from the sea level at Low Water as then, for most of the time at least, the actual depth of water at any place will be deeper than the sounding on the chart giving a 'fail safe' system.

Tides are mainly caused by the relative positions of the earth, moon and sun, but these bodies are constantly moving in space relative to each other. Sometimes the forces combine to give very low tides and at other times the forces counteract each other resulting in tides which are not as low. A glance at any tide tables will show that the sea level at low water is different from day to day and often from one LW to the next successive LW.

Most International charts and British Admiralty charts use Lowest Astronomical Tide (LAT) which is the lowest tide that can be predicted due to the tide raising forces of the heavenly bodies.

Canadian charts use Lowest Normal Tides (LNT) which is the average of the lowest low water from each year over a 19 year period.

The USA uses Mean Lower Low Water (MLLW) with 'Mean' in this context means 'average', so MLLW is the average of the lower of the two daily tides of each day.

On International charts a sounding such as 3.5 indicates 3½ metres of water under Lowest Astronomical Tide (when the chart datum is "L.A.T.").

An underlined sounding like <u>04</u> indicates a height of 40 cm above L.A.T. Heights above Chart Datum on drying areas are given in metres and decimetres. The metres figure is underlined.

Depths are given from 0.1 to 20.9 in metres and decimetres, and from 21 to 31 in metres and half metres. Greater depths are rounded down to the nearest safest metre (for example, 32.7 metres is rounded down to 32 metres). The geographical position of a sounding is the centre of the depth figure.

In order to find the depth of water for any moment of time it is simply a matter of adding, algebraically, the height of tide found from the appropriate tide table to the sounding on the chart for the area in question.

As an example:
if the chart shows a sounding of 10 metres and the tide table gives 3.1 metres at that time, the actual depth should be 10 + 3.1 = 13.1 metres.

On US charts, if the chart shows a sounding of 10 feet and the tide table gives - 0.6 ft (negative) at that time the actual depth should be 10 - 0.6 = 9.4 feet.

Depth contours (Isobaths): These are lines which connect equal depths, similar to the height contours on a land map.

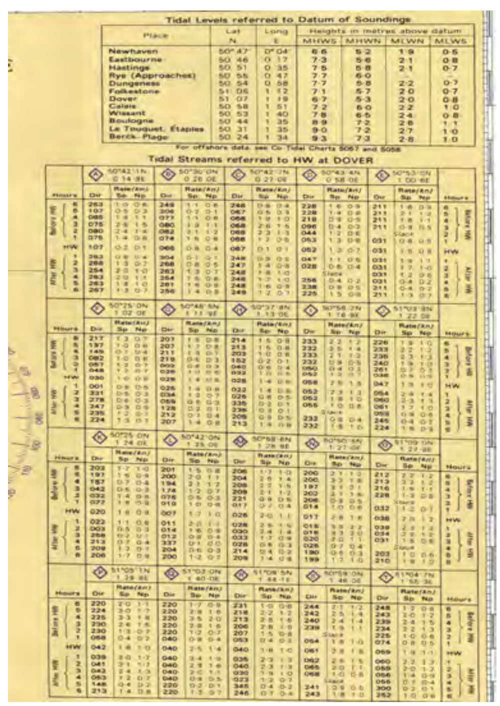
Charted Heights: The heights above sea level of charted objects such as mountains, lighthouses, and so on must also be measured from a suitable datum. If LAT/MLLW were used as the datum it would mean that most of the time there would be less actual clearance between an overhead obstruction and sea level than that shown on the chart.

The height of objects above sea level is taken from a datum referenced to High Water levels. B A Charts use, Mean High Water Spring (MHWS) as the datum for heights of objects and HAT for clearance heights, see below, while the US uses Mean High Water (MHW), unless noted otherwise.

Clearance Heights beneath an overhead obstruction such as a bridge, power line, etc., is measured from the underneath of the obstruction to the sea surface at Highest Astronomical Tide (HAT) on International Charts, thus ensuring that there will usually (but not always) be at least the charted height shown beneath the obstruction. .

Datum of Soundings box: Tidal Levels referred to on the chart give the height of tide above datum for the ports on the chart.

Tidal Stream information Tidal Diamonds: in this box are given the details of tidal streams based on High Water at Dover any day of the year. With HW Dover known the tidal stream may be calculated for every hour before and after High water at any of the Diamond locations, using either spring or neap tides. The stream is given by direction in degrees and speed in Knots and fractions of knots.


Tidal Levels referred to Datum of Soundings

Place	Lat N	Long E	MHWS	MHWN	MLWN	MLWS
			Heights in metres above datum			
Newhaven	50° 47′	0° 04′	6·6	5·2	1·9	0·5
Eastbourne	50 46	0 17	7·3	5·6	2·1	0·8
Hastings	50 51	0 35	7·5	5·8	2·1	0·7
Rye (Approaches)	50 55	0 47	7·7	6·0	—	—
Dungeness	50 54	0 58	7·7	5·8	2·2	0·7
Folkestone	51 05	1 12	7·1	5·7	2·0	0·7
Dover	51 07	1 19	6·7	5·3	2·0	0·8
Calais	50 58	1 51	7·2	6·0	2·2	1·0
Wissant	50 53	1 40	7·8	6·5	2·4	0·8
Boulogne	50 44	1 35	8·9	7·2	2·8	1·1
Le Touquet, Étaples	50 31	1 35	9·0	7·2	2·7	1·0
Berck-Plage	50 24	1 34	9·3	7·3	2·8	1·0

For offshore data, see Co-Tidal Charts 5057 and 5058

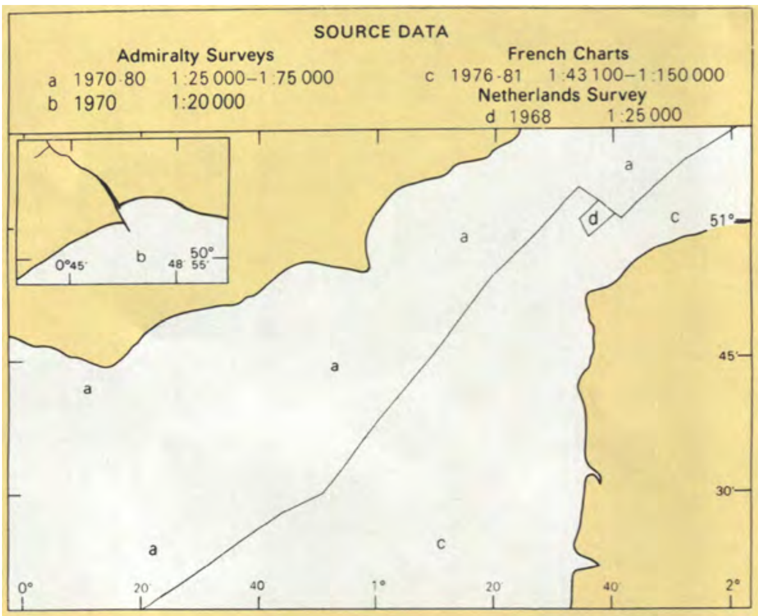
Tidal Streams referred to HW at DOVER

Sea bed qualities: Mud, sand, shells, weed, rocks, wrecks, pipelines, sand and other information that may be of use to the navigator.

Lighthouses, Beacons Buoys and other marks: Lights, lateral and cardinal marks

L**andmarks and conspicuous geographic formations on the shore:** Churches, radio masts, mountain tops, headlands, chimneys etc. that can be used for taking bearings for navigation and pilotage.

Source Data Diagram: Some charts may have a source data diagram which gives details of the various sources and the years from which the data on which the chart is based was compiled. Different areas of the chart will have been surveyed at various times and a small inset diagram shows when the various areas were last surveyed. The source diagram is usually printed somewhere on an area of land and is in the form of a small inset map of the whole chart area with the sea areas in white. (This is located below the warnings and inland of Boulogne)



The white coloured sea area is subdivided and each area has a lower case letter in it such as a, b, c, etc. These letters refer to information printed at the head of the box. On 5055 there are 4 sources listed, a and b are British Admiralty, c are French Charts and d from Netherlands Survey. The year of these surveys is listed and even though this is one of the busiest stretches of water in the world the source data is still based on the late 1960s and 1970s albeit updated by additional and on-going surveys.

Surveys carried out at the beginning of this century, or earlier, cannot have covered the area as comprehensively as would be expected of later surveys when electronic equipment and modern methods were employed. Any areas of charts with widely spaced, or an absence of, soundings should be treated with caution, particularly if the surrounding area is shallow or shoal. For example Imray chart No. B4, Martinique to Trinidad, carries the caution that "....with a few exceptions, official surveys of the islands of the Eastern Caribbean are of 19th century origin. Since then, topography above and below the water may well have become altered...."

Large Scale Chart of Rye Harbour: Some charts have added large scale "chartlets" where space allows covering areas that need more information to allow safe navigation. This is more detailed and has its own warnings. As the scale is different care must be taken to use the latitude scale on the chartlet for measuring distance.

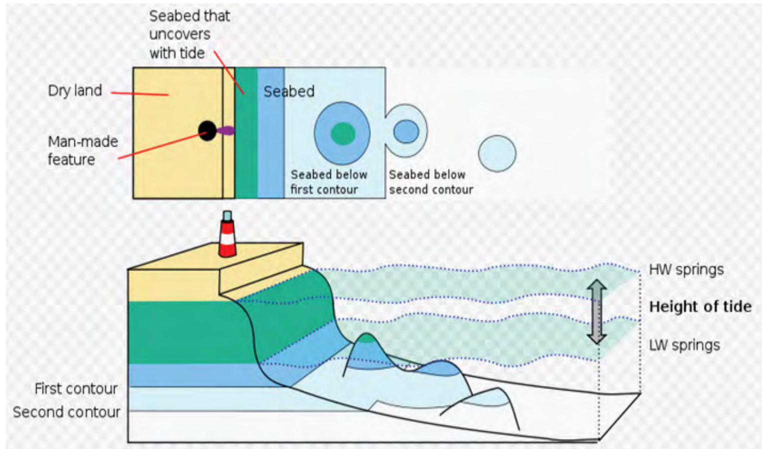
Charts, detailed information, Symbols and Abbreviations

Details of all the abbreviations, colours and chart symbols used on BA and other international charts can be found in Chart number 5011, Symbols and Abbreviations used on Admiralty Charts.

For U.S. charts these are found in Chart No. 1, United States of America, Nautical Chart Symbols and Abbreviations,

The latest edition of either of these should be aboard every boat.

Colours used on Charts



Land: Every BA/International chart shows land that is not covered with water in a yellow/gold colour. US charts vary depending on the publisher and may be yellow land or grey on DMA charts.

Areas which are covered and uncovered by the tide: are coloured green and may have underlined numbers printed on them indicating how high the area dries above water level at Chart Datum.

Shallow water: Coloured 2 shades of blue, on smaller scale charts, the darker blue indicates depths under 10 metres and the lighter depths under 20 metres. On larger scale charts "blue tints maybe shown to different limits according to the scale and purpose of the chart…"

Deep Water: Coloured white, with shallow areas highlighted in blue.

Depth contours: on small scale charts are every 10 metres up to about 40 meters and then depending on the scale of the chart it will vary; charts usually have contour lines as continuous lines with the contour value inserted at intervals, as below showing 30 metres.

The nature of the foreshore: is represented by different graphic representations and may also be given in writing; other descriptions which may be used are self-explanatory such as 'Mud', 'Sand', 'Coral' , 'Mangroves' etc.

Hills and mountains: if shown, are indicated by contour lines, as on a map; the highest point is shown by a dot with the height above Mean High Water Spring (MHWS) on international and BA charts, Mean High Water (MHW) on US Charts.

Buildings and objects on land: or landmarks, which may be of use to the navigator are depicted by various symbols. For example a landmark when the charted position is accurate is shown on the chart by a circle with a dot in the centre. The dot represents the exact position of the mark. Words or abbreviations may be used to describe the landmark such as MON (monument), TR (tower), FS (flagstaff), CHY (chimney) and so on.

⊙ CLOCK TOWER, ⊙ LOOK TR, ⊙ ABAND LT HO

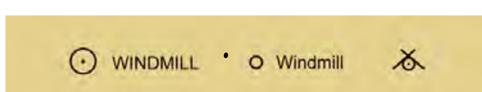
The height of the landmark above MHWS may also be included, such as on the Coast of France about 4 miles West of Calais, ✠ Sangatte Belfrey (27)

If the position shown on the chart is the approximate position rather than the exact position of the landmark, a smaller circle is used without the dot in the centre. The upper case letters PA (position approximate) may also be included.

○ Sign PA, ○ Tr, ○ Chy 45m

Other pictorial symbols may be used, a church spire for example could be depicted by a cross ✠

Windmills,



The type of lettering used on the chart is significant. Details of features that are floating or submerged at HW are in italics:
Adjacent to Royal Sovereign light off Eastbourne, “Wk Southern Head”
Features that remain above water at HW are given in upright letters:
Royal Sovereign, Fl 20s, 28m, 28M, Dia (2) 30s. (see below for explanation)

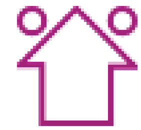


Fig
Direction of Buoyage symbol

Buoys, Direction of buoyage: navigational buoys are shown in shapes and colours which indicate the way they should be used for pilotage. A full description of Buoys and marks and their meaning has been covered in the Colregs Section 2.

The approximate position of the buoy is shown by the circle, or dot, which forms a part of the diamond shaped symbol representing the buoy. The position must be deemed approximate due to many factors such as scope of chain, susceptibility to damage, difficulty in maintaining position surveillance, etc.

Europe, Africa and Asia use IALA A red buoys are passed to port, green to starboard and in the direction of buoyage, generally the direction of the flood tide, but indicated thus on the chart to confirm the direction.

IALA A, on entering a channel from seaward the red buoys are can shaped and/or have a can shaped topmark if any, are left to the port side and the green ones are cone shaped with a cone shaped topmark and are left to the starboard side.

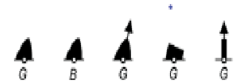
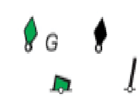
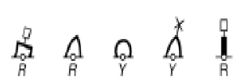
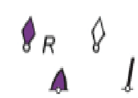
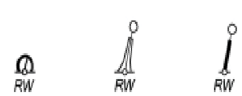
The IALA B system the colours of the buoys are reversed, on entering a channel from seaward red buoys (even numbers) and are cone shaped with a cone shaped topmark are left to the starboard side and green buoys (uneven numbers) and can shaped or have a can shaped topmark are left to the port side.

In areas where there is a chance of poor visibility, buoys have bells, gongs, horns or whistles; their details are printed on the chart. They are operated by the motion of the buoy in waves, and were critical for navigators before the advent of inexpensive radar. In the UK many fog signals which were positioned on lighthouses are being phased out as a cost cutting measure.

Charts and Light Lists contain the information to find any sound signals a buoy may have, but the sound is not designed to identify the buoy or beacon for navigation purposes. It does allow the navigator to pass clear of the buoy or beacon during low visibility.

Sound signals vary and the Chart/Light List used to determine the exact length of each blast and silent interval. The various types of sound signals also differ in tone, facilitating recognition of the respective stations; in the USA a bell usually indicates the starboard side of the channel and a gong marks the port side, but a check of the chart should be carried out to confirm.

The colour of a buoy is indicated by letters: G for green, R for red, B for black,
W for white and Y for yellow. If the buoy has a name or number it is printed somewhere beside it.

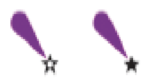
	Green and black *(symbols filled black)*	
	Single color other than green and black	
	Multiple colors in horizontal bands, the color sequence is from top to bottom	
	Multiple colors in vertical or diagonal strips, the darker color is given first	

The light colour and the characteristic is shown also. This will be described in greater detail later on in the course.

Lighted marks on standard charts

Lighted marks on multicolored charts

Lighthouses are shown by a dot with magenta flash or by a five pointed star with a magenta flash; the exact position of the lighthouse is at the dot or centre of the star.

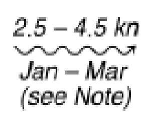


Lt	LtHo	Major light, minor light, light, lighthouse

A full description of the terminology regarding lights is given at the end of this section
Details of a light are given in abbreviated form, for example:
Royal Sovereign, Fl 20s, 28m, 28M, Dia (2) 30s. The light flashes every 20 seconds, the light itself is 28 metres high above MHWS and is visible for 28 miles (nominal range). It has a sound signal too, a diaphone – a horn producing a deep, powerful tone able to carry a long distances, which sounds 2 times every 30 seconds.

The colour of the light is only given if it is other than white; if the light in the example were green it would read "Fl G 20s ......". The height of a lighthouse is given from the sea surface at MHWS to the centre of the actual light source.

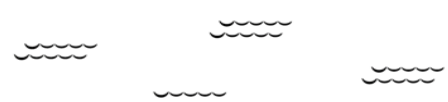
The general direction of the current may sometimes be shown by squiggly lines and an arrow head showing the direction.



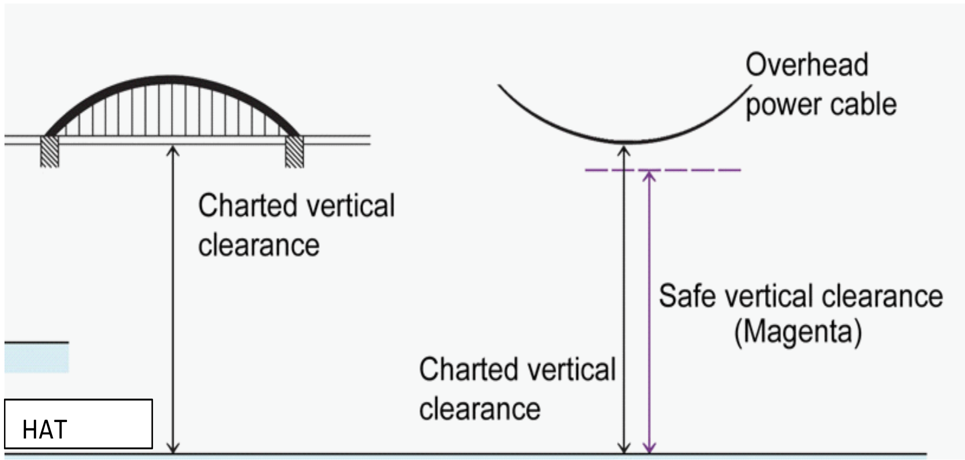
Ocean current with rates and seasons

Tides are shown with an arrow with the feathers on the end representing the current during the flood stream, the arrow without feathers the current during the ebb stream. The numbers give the general rate of the current, in knots.

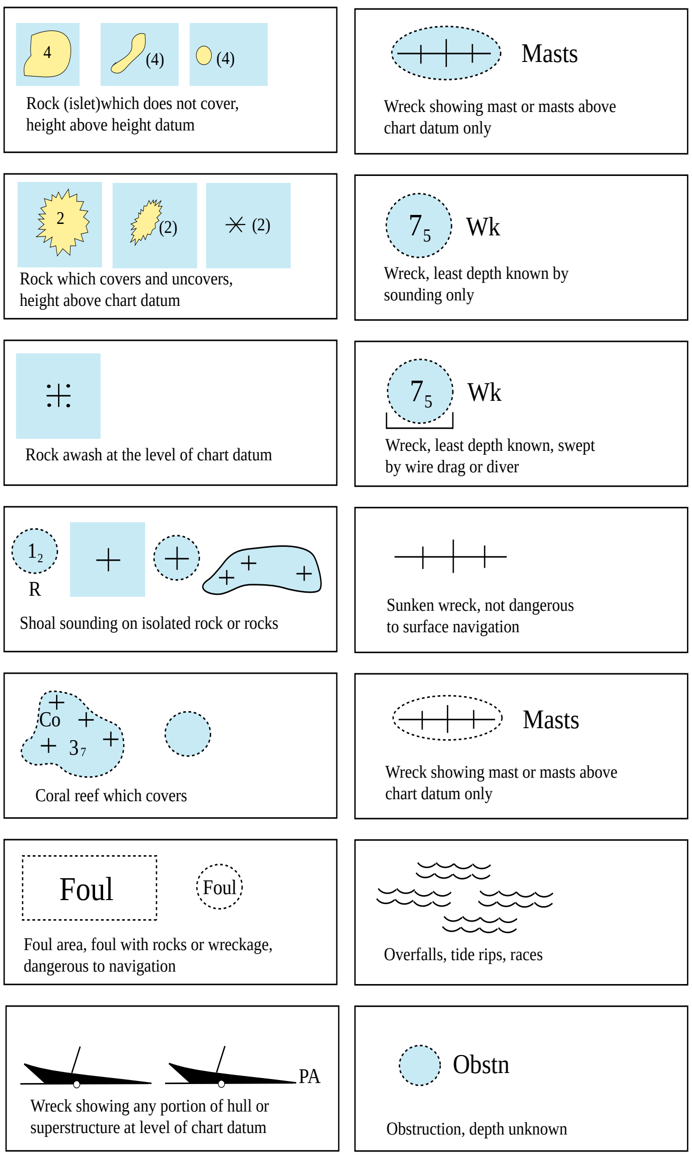
Tide rips and overfalls are areas where sea conditions can become rough, particularly when the wind and tide are going in opposite directions, called 'wind over tide'. Caused by headlands, shoal banks and rough sea beds in areas where the tide runs strongly these areas are shown on the chart by squiggles on the chart .
(The sea can also be rough in areas where there are no squiggles).



The vertical clearance beneath an overhead obstruction such as a bridge, power line, etc., is measured from the underneath of the obstruction to the sea surface at Highest Astronomical Tide (HAT) on International Charts.



Be very careful to allow sufficient clearance when passing under power lines especially as the figures for clearances beneath bridges/power lines may be inaccurate to a degree.



Examples of some Nautical Chart Symbols and Abbreviations

Other Publications required for Navigation information

Tide Tables: These give the height and times of high and low water for each day of the year for Standard Ports (these are the main shipping ports) and data to calculate the times and height of low and high water for secondary ports.

Tidal Stream Atlas: This supplements the tidal information on the chart and covers the whole area in question rather than just the individual points at each tidal diamond. These chartlets show the rate and direction every hour before and after high tide to enable accurate passage planning and position plotting.

Pilot/Nautical Almanac/Cruising Guide: These supplement the information on the charts that would otherwise overwhelm the space. It may have some of the same information, expanded such as harbour entry details and charts of a large scale to help the navigator. It may have tidal information, weather to be expected in the area, dangers, marinas, fuel and waste outlets etc.

Admiralty Notices to Mariners
Annual Summary: Contains important notices that are published each year and all TEMPORARY & PERMANENT notices affecting the Sailing Directions, which are in force at the end of the previous year. It also contains details of all of the I.M.O. adopted Traffic Separation Schemes.
Other useful information is as follows:

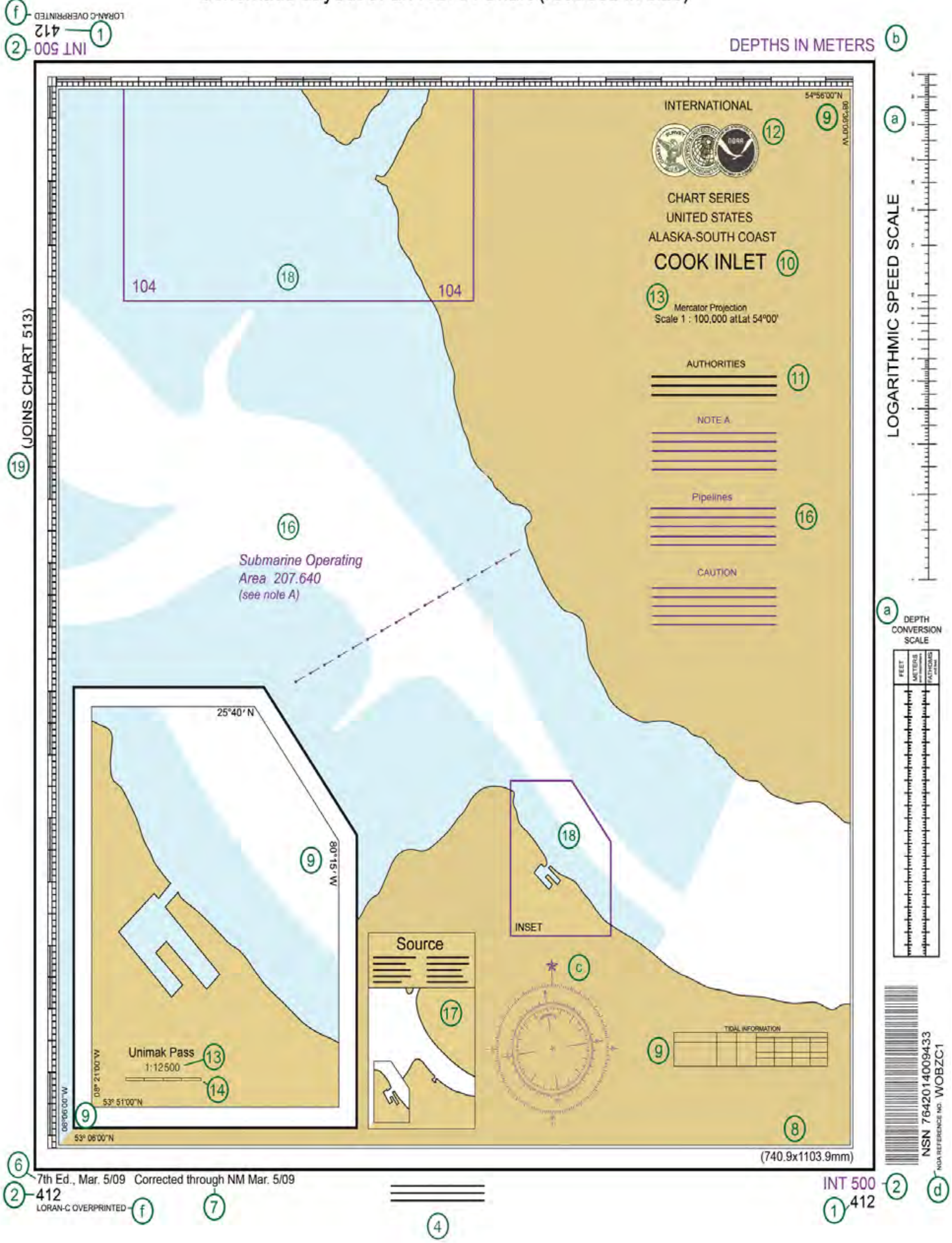
Notice 4 - Distress and Rescue at Sea and Helicopter operations.
Notice 5 - Firing Practice and Exercise areas.
Notice 13 - World Wide Navigational Services.
Notice 15 - Under Keel Clearance and Negative Tidal Surges
Notice 17 - Traffic Separation Schemes
Notice 19 - Carriage of Nautical Publications
Notice 20 - Protection of Offshore Installations

Weekly Notice to Mariner: Contains corrections required to keep charts and other publications up to date

Admiralty Sailing Directions: Amplifies charted detail and contain information necessary for safe navigation that is not available from the chart or other hydrographic publications. In particular, navigational advice is given for the area concerned, weather details, tidal or current information, information on submarine and fishing activities etc. All of which assist the navigator in selecting suitable safe courses.
Sailing Directions are kept up to date by means of SUPPLEMENTS and corrections via Notices to Mariners (Weekly). A list of such notices is published in the weekly edition of Notice to Mariners.

Admiralty List of Lights: Gives the latest details of the lights and fog signals of any of light structures, light vessels, light floats etc. with their elevation.

Schematic Layout of an NOAA Chart (reduced in size)



Legend for Schematic Layout of an International Chart NOAA USA

1	Chart number in national chart series
2	Chart number in International (INT) chart series
3	Chart datum
4	Publication note (imprint)
5	Copyright note
6	Edition note
7	Notice to Mariners corrections
8	Dimensions of inner borders
9	Corner coordinates
10	Chart title
11	Explanatory notes on chart construction, etc. To be read before using chart
12	Seal (s)
13	Scale of chart. Some charts have scale at a stated latitude
14	Linear scale on large-scale charts
15	Linear border scale on large-scale charts. On smaller scales use latitude borders for sea miles
16	Cautionary notes (if any), Information on particular features, to be read before using chart
17	Source Diagram (if any). The source Diagram should be studied before using the chart in order to assess the reliability of the sources. Navigators should be cautious where surveys are inadequate
18	Reference to a larger-scale chart
19	Reference to an adjoining chart of similar scale
20	Instruction to refer to complementary nautical publications
a	Conversion Scales.
b	Reference to the units used for depth measurement
c	Compass Rose
d	Bar code and stock number
e	Glossary: Translation of words on chart that are not in English
f	Identification of a latticed chart (if any)
g	Tidal and Tidal Stream information within the chart coverage

Lights Terminology

Occulting: A steady light with, at regular intervals, a period of darkness the duration of darkness being always less than the duration of light.
Isophase: A light with all duration's of light and darkness equal
Flashing: A light showing a single flash at regular intervals; the period of light being always less than the period of darkness.
Quick Flashing: 50 to 79 - usually either 50 or 60 - flashes/minute.
Very Quick Flashing: 80 to 159 - usually either 100 or 120 -flashes/minute.
Ultra Quick Flashing: 160 or more - usually 240 to 300 - flashes/minute.
Morse Code: A light which flashes at different durations in a group sequence, in such a manner as to reproduce a Morse character or characters.
Fixed & Flashing: A fixed light varied at regular intervals by a single flash of greater brilliance.
Alternating: A light that shows different colours in succession on the same bearing.
Period: The period of a light is the time in seconds for complete cycle of its sequence.
Thus, Fl (3) 20, means the 20 seconds is timed from the first flash in the group of three to the first flash in the next group three.

Range of lights
Range: Until 1971 the lesser of Geographical range (based on a height of eye of 15 feet) and Luminous range was charted. Now, when charts are corrected, luminous or nominal range is given.

Luminous Range: This is the range at which a light can be seen in a particular visibility and is governed by the power of the light. (Luminous range tables are used to make the calculations)
Nominal Range: This is the range that is used on British charts and is the luminous range when the meteorological visibility is 10 n.m. A table in the List of Lights can be used to estimate the range of lights in different visibilities.
Geographical Range: This is the range at which a light can be seen based only on the height of the light and the height of eye on the vessel.
Example
If the height of a lighthouse is 50 metres and the height of eye at the vessel is 10 metres, what is the geographical range of the light?
Using the 'Distance of Sea Horizon Table;
Height of light 50 m - distance of horizon = 15.0 miles
Height of eye 10 m - distance of horizon = 6.7 miles
Geographical Range = 21.7 miles
Providing the Luminous range of the light is greater than the Geographical range, then the light will be visible above the horizon at 21.7 miles, in good visibility.

Factors affecting visible range
The visible range of lights will be affected by fog, mist rain snow and smoke, and also by unusual atmospheric conditions such at temperature, pressure and humidity that reduce or increase detection ranges of lights.

Dipping and Rising Ranges
When a light drops below the horizon or rises above it, the light is said to have either 'dipped' or 'risen'. Using dipping tables a distance off can be calculated.

6

Angles, Latitude and Longitude

Angles

As chart work and navigation involves working with angles. By definition an angle is the space between two lines which both meet at one end in a corner.

Everyone is used to measuring distances in terms of inches, meters, miles, kilometres and so on, angles are the measurement of the distance between two meeting lines. The angle remains the same no matter how far the lines forming the angle are extended. Angles are measured in degrees, minutes and decimals of a minute.

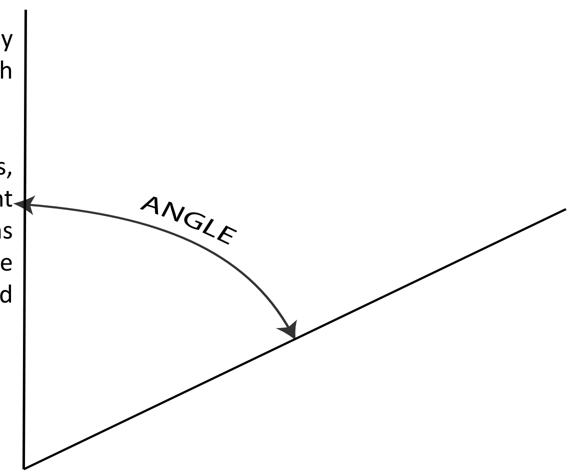
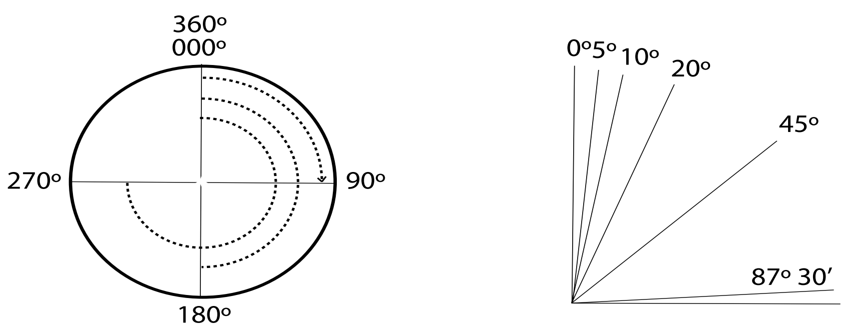


Fig 1 Simple Angle

Degrees

A full circle is divided up into 360 equal spaces of one degree each. The sign for degree is ° and so 360 degrees is written as 360°. One degree is subdivided into 60 equal spaces. Each space is called one minute and the sign for minute is ‘so 30 minutes is written as 30’. One minute can be further subdivided into tenths or decimals of a minute. Decimals of a minute are shown preceded by a decimal point.



There are 360º in a full circle, 180º in a half circle and so on.

There are 60 minutes in one degree and so 87 1/2 degrees is 87º 30’

Fig 2
360 Degrees in a circle

For example the tidal diamond “A” west of Royal Sovereign Light is 50 degrees 42 point 1 minute NORTH and 0 degrees 14 point 9 minutes East.

It written thus 50° 42’ .1 N and 0° 14’ .9 E.

Latitude and Longitude

It is easy to define a position by reference to known objects as for example Royal Sovereign Light. However, without local knowledge, this method of indicating the position of a place is of limited use and, of course, there are no reference points available out of sight of land. To overcome this problem a universally accepted grid reference system for indicating precise position anywhere in the world is used.

This grid system is similar to that used in crossword puzzles. The world is divided by imaginary lines numbered to form a grid reference system; the lines which run from the top to bottom of the world are called longitude and the lines which run across the world are called latitude. Any point on the earth's surface can therefore be defined precisely in terms of the latitude and longitude of its position.

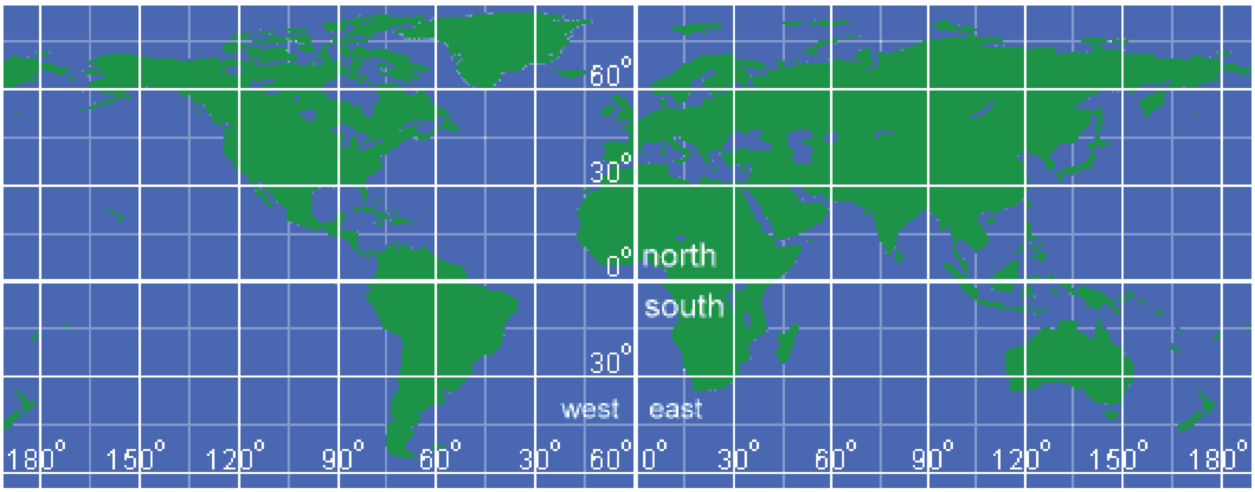


Fig 3 Lat and Long Grid

Latitude

Latitude is the angular distance measured from the centre of the earth either North or South of the equator. Imagine the earth cut in half from the top to the bottom in the same way that you would cut an apple in half. The equator is a line drawn across the centre of the earth from one side to the other. Latitude above the equator is named North and latitude below the equator is named South. Lines of latitude are parallel to each other and are therefore usually referred to as parallels of latitude.

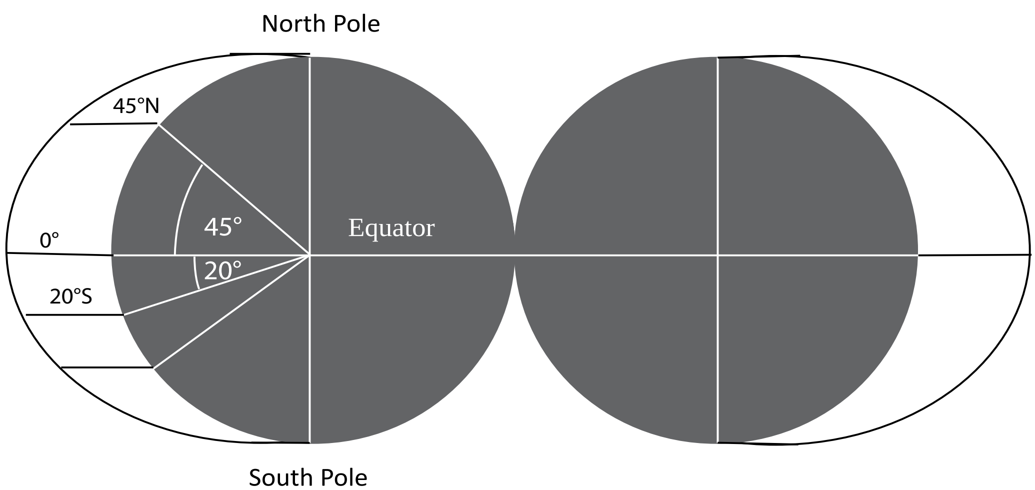


Fig 4

Latitude is angular distance, measured from the centre of the earth, North or South of the equator

Longitude

Longitude is the angular distance measured from the centre of the earth either East or West of longitude 0°. Longitude 0° is, by international agreement, the line of longitude which passes through the old Royal Observatory at Greenwich in England. This can be found on the training chart 5055 (and it is critical to remember which hemisphere you are in when at the junction, as here). Lines of longitude are not parallel to each other as they all converge and finally meet at the North and South Poles. Lines of longitude are called meridians of longitude. Longitude is measured in two directions from 0° to 180° West of the Greenwich meridian and from 0° to 180° East of the Greenwich meridian.

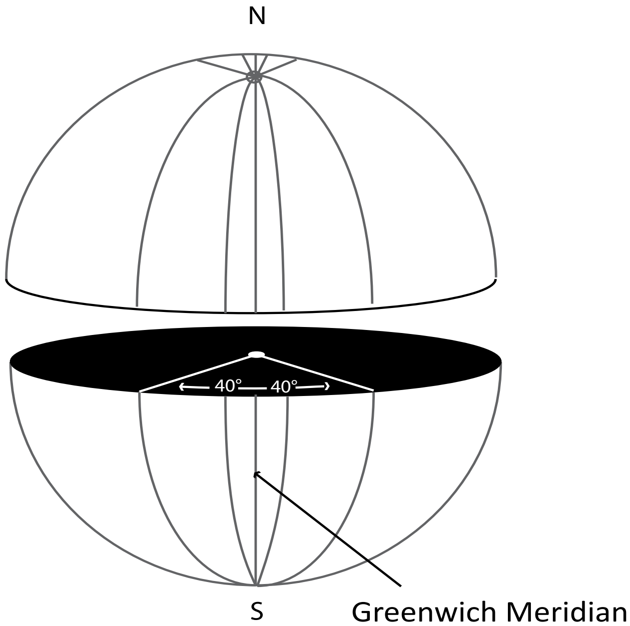


Fig 5
Longitude is the angular distance, measured from the centre of the earth, East or West of longitude 0°

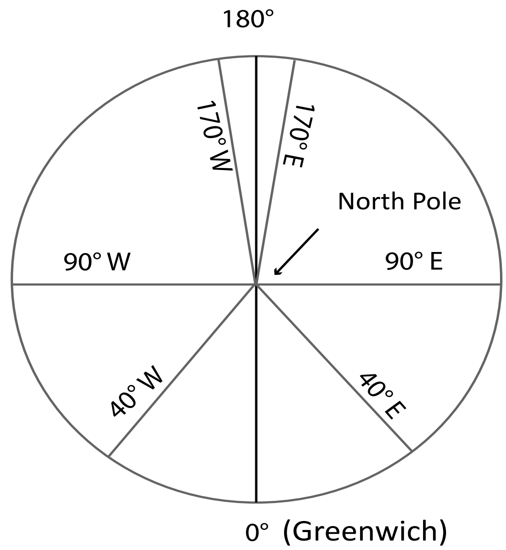


Fig 6
Looking down on the North Pole Longitude is measured 0° to 180° East of Greenwich, and 0° to 180° West of Greenwich.

Defining position by latitude and longitude - Convention gives latitude first followed by longitude.
Looking at Chart 5055 the **Latitude** scales are printed down the left and right hand sides of the chart. On the practice chart a parallel of latitude is printed across the chart at 51° N and at 5’ intervals above and below. Note that the parallel 5’ below 51° N is 50°55’ N.

The space between 51°00’ and 50°55’ is divided into 5 equal spaces each space therefore represents 1’ of latitude; these spaces are alternately coloured light and dark to make them easy to see. The 1’ spaces are further subdivided into 5 equal spaces each space therefore represents 1/5th of a minute or 0.2’.

Longitude scales are printed along the top and bottom edges of the chart and are read in exactly the same way as latitude but be careful to note whether the longitude is East or West of Greenwich. The practice chart shows a meridian of longitude printed at 0° and then 1° E and 2° E. There are meridians at 5’ intervals on either side. Again divided into 5 equal spaces each space therefore represents 1’ of longitude; these spaces are alternately coloured light and dark to make them easy to see. The 1’ spaces are further subdivided into 5 equal spaces each space therefore represents 1/5th of a minute or 0.2’.

There is also a printed indication that this is East longitude but it is obvious, by inspection, east of the 0° meridian of Greenwich.
It is important to be aware of the change in longitude notation when using a chart close to, or centred on, 0° longitude such as when in the English channel for example. It is very easy to misread minutes of longitude under these conditions.

In the chart extract shown, the position of the North Cardinal Buoy, "*Ruytingen W"* can be found by reading off the chart where marked.
The position, (Latitude and Longitude) of the buoy is thus: **51° 07'.0 N and 1° 50'.7 E.**

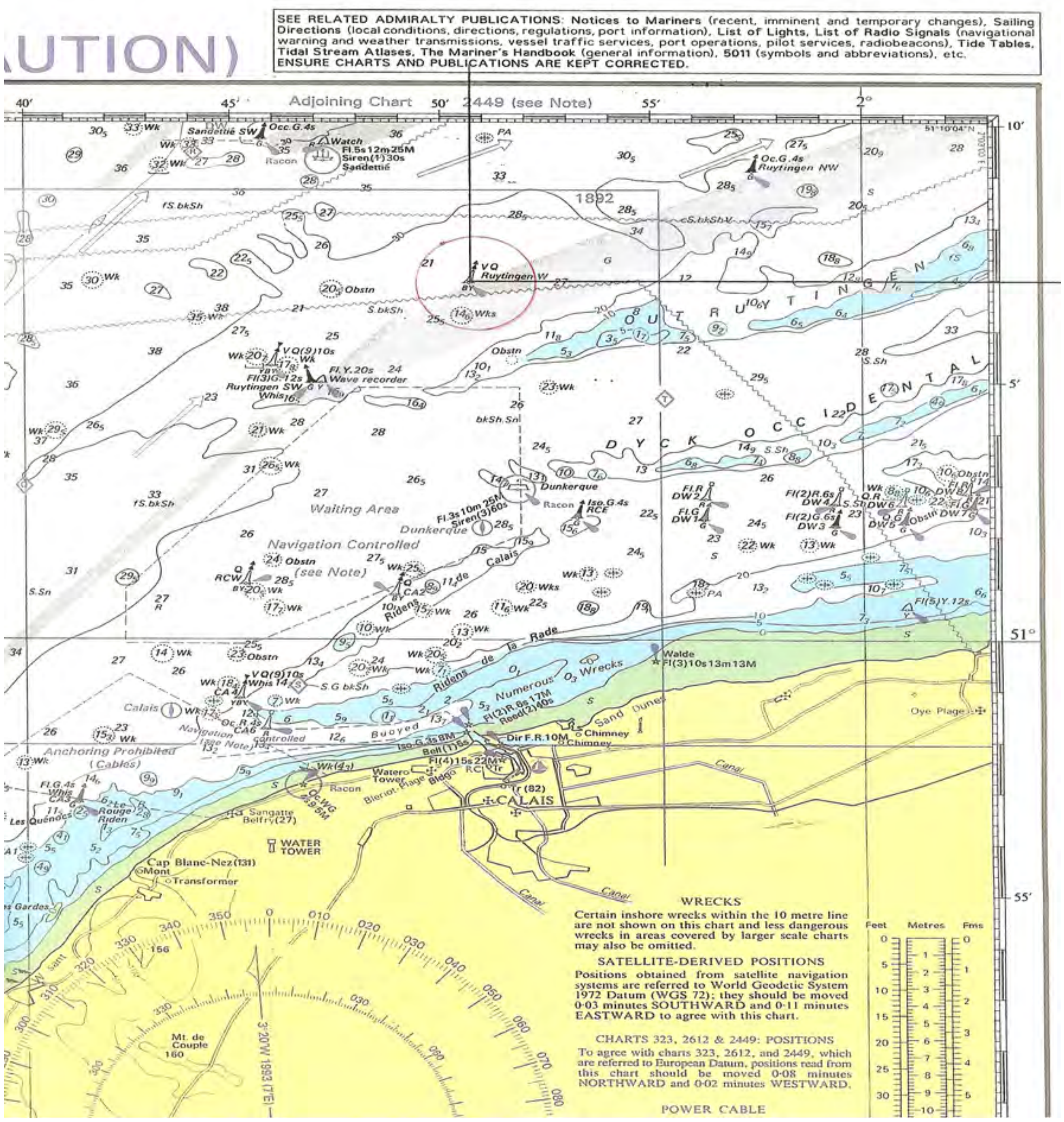


Fig 7 Position by Lat and Long

Chart work conventions

Symbols used in chartwork convey meanings of themselves. Different symbols are used internationally and the USA.
This course uses the international chartwork symbols.

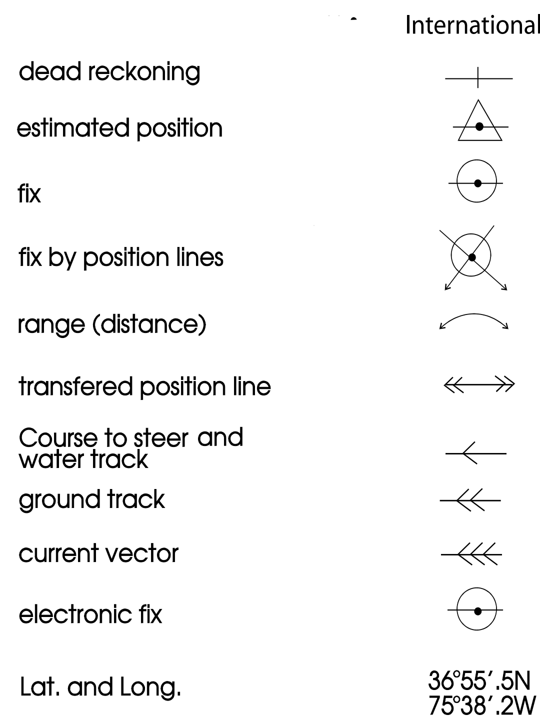


Fig 8
International chartwork symbols

7

Distance, Speed, Time and Direction

Distances at sea are measured in nautical miles. A sea mile, or nautical mile, is the length of 1' of latitude measured on the (smooth) earth's surface at latitude 48°. Latitude is an angular measurement from the centre of the earth to the earth's circumference but as the earth is not perfectly round the precise length of 1' of latitude varies slightly from the equator to the poles. The average length of 1' of latitude, and therefore of 1 nautical mile, is generally accepted as being 6,076 feet (1,852 meters). A nautical mile is longer than a statute mile which is 5280 feet (1,609 meters). The approximation of a statute mile being about 7/8 ths of a nautical mile is usually accurate enough if comparison is required for any reason. The relationship between statute and nautical miles is normally of no relevance as far as the navigator is concerned because all charts measure distances in terms of nautical miles so, as far as navigation is concerned, forget about statute miles from now on.

It is not necessary to write nautical miles either, just miles, or simply large M. 23 nautical miles is written as 23 miles or 23M. Miles are subdivided into decimals of a mile in the same way as minutes of latitude and so 23.2' of latitude is 23.2 miles. A 'cable' is a term still used sometimes in pilot books; a cable is 1/10th of a mile and so 2 cables means 0.2 of a mile.

Because 1' of latitude = 1 mile the latitude scale printed down the sides of the chart can be used to measure distances on the chart using dividers but note that due to the way Mercator's projection is formed it is necessary to measure miles from the latitude scale roughly opposite the area of the chart you are using.
The longitude scale printed across the top and bottom of the chart must not be used to measure distance because 1' of longitude is only equal to 1 mile at the equator, the length of 1' of longitude decreases north or south of the equator becoming 0 at the poles.

Speed
1 nautical mile per hour is called a 'knot'. If your boat is travelling at 5 knots it will cover a distance of 5 miles through the water in one hour and 2.5 miles through the water in 30 minutes. If it is travelling at 25 knots it will cover 25 miles throughout the water in one hour and 50 miles through the water in two hours, provided the speed remains constant. Do not say 'knots per hour', just knots.

Time
Times should always be given using the 24 hour clock using hours in the first two places and minutes in the second two places. 3 a.m. and 3 p.m. can lead to confusion whereas 0320 (spoken as "o three twenty") and 1520 ("fifteen twenty") are unambiguous. Avoid inserting dots, colons and so on between the hours and minutes but do not omit the initial zero in the morning hours. It is also incorrect, in navigation, to add the word hours after the numbers, in other words say "fifteen twenty" not "fifteen twenty hours".
The time zone or standard should be clearly defined as in:

1520 UT or UTC (Universal Time or Coordinated Universal Time);
2020 DST (Daylight Saving Time).

If Daylight Saving Time, or summer time, has been applied this should be stated as such 2120 DST.

Direction
A position on a chart can be defined by its latitude and longitude, distances can be found using the latitude scale and finally a way of indicating direction is needed. Direction is required in navigation for two purposes, firstly for defining a course to steer in order to get from one place to another and, secondly, for measuring the bearing from the observer to a specific object. Direction is measured clockwise as an angle using True North as the reference, or starting point, of 000°. True North means Geographic North, or the North Pole, and all charts are drawn so that North is at

the top of the chart. On a Mercator chart the sides of the chart and any straight lines printed parallel to the sides of the chart are all meridians of longitude which, if continued upwards, would eventually meet at the North Pole. True North therefore lies along the meridian of longitude which passes through the position in question and so a direction or bearing can be measured clockwise from this meridian.
Only whole degrees are normally used for small boat navigation. Degree scales, called “compass roses”, are printed at various places on charts for those who prefer parallel or rolling rules but they are not needed when using a Breton plotter.

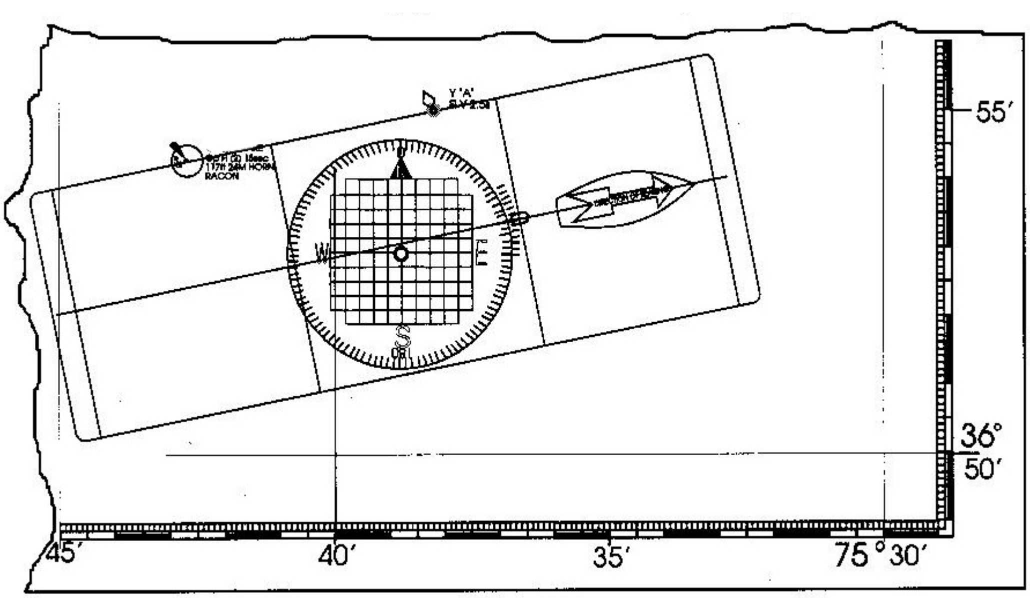
Position by bearing and distance

A position on a chart can be defined by its latitude and longitude or by the bearing and distance from a known charted object. For example on Chart 5055 the position of the yellow buoy Special Mark “CS2 FlY 5s Whis”, is:
50° 39.0’ N 0° 32.8’ E;

The position can also be defined as 136° (T) / 6.0 Miles from Royal Sovereign Light.

Using the Breton plotter to find a bearing from the chart:

1. lay the plotter on the chart so one edge just touches both the position and the charted object making sure that the ships head pointer, or arrow, engraved on the plotter body is pointing in the same direction as you are reading the bearing,
2. without moving the rectangular plotter body turn the protractor until the north point is facing north (i.e. upward on the chart),
3. to ensure the protractor is pointing *exactly* north turn it until any one of the engraved grid lines is parallel with any convenient line of latitude or longitude, or any printed line which is parallel to either the sides or the top or the bottom of the chart,
4. read off the true bearing against the zero mark on the plotter body.



The North point of the protractor must face exactly north on the chart, this is done by lining up one of the grid lines on the protractor with any convenient line which is parallel to either the sides or top and bottom of the chart. Note also that the “boat” or arrow engraved on the plotter must face in the direction in which the bearing is being read.
In this example above the bearing from Racon/Light to buoy ‘A’ is 79° True.
.

8

The Magnetic Compass, Variation and Deviation

The most important instrument on a boat is the steering compass. Compasses can be low tech or high tech but they all fulfill the same essential function of indicating the direction in which the boat is travelling and allowing the helmsman to keep the boat on the required course.

A compass is basically a magnetic pointer on a pivot which always points toward north. Sometimes the pointer is in the shape of a needle but more often the magnet is fixed to the underside of a circular disk or card. The compass card has a scale of degrees from 0° to 360° printed around its circumference and the compass case has a marker, or 'lubber Line', opposite which the scale is read.

A small boat steering compass is not normally marked at one degree intervals as the card does not have sufficient space, every 5° would be more usual and quite adequate. It is usually easy enough to judge 2½° by eye and unlikely that you would be able to hold a course in a small boat to a greater accuracy than that anyway.

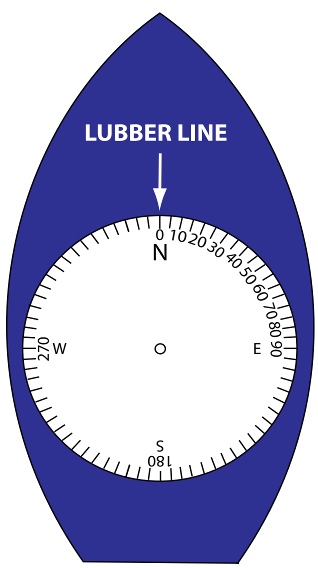


Fig 1
The compass always points to North.

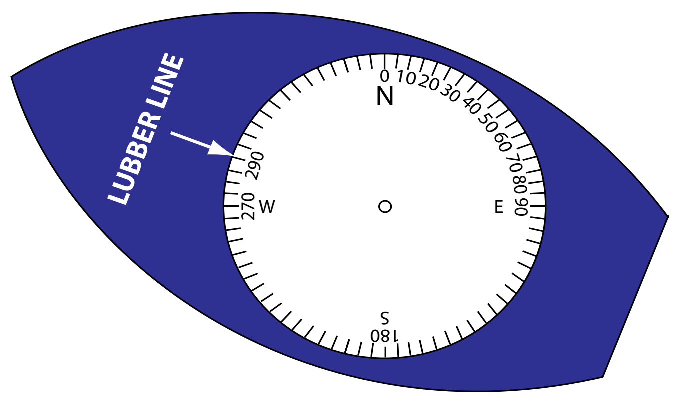


Fig 2
The boat is turned until the lubber line (which turns with the boat) points to the required course.

Bearings
A compass can also be used to determine your position by taking bearings of visible charted objects. To do this a hand held, or hand bearing compass is used. The hand bearing compass is pointed at a visible object which must also be shown on the chart, such as a lighthouse for example, and the reading, or bearing, shown by the compass is written down. A pencil line is then drawn along the bearing through the object's position on the chart and your position must lie somewhere along this line. If the process is repeated using a different charted object your position should be where the two lines meet.

Courses

In order to get from one place to another the True bearing from the departure point to the destination is found from the chart. The boat is then steered along the required course by reference to the compass. If you wished to get from Calais, CA6 Buoy, to Dover, at the SW entrance to the outer port, the course to steer would be 297°(T). The boat is turned until the compass indicates that the boat is pointing 297°(T) and is held on this course until the entrance is reached.

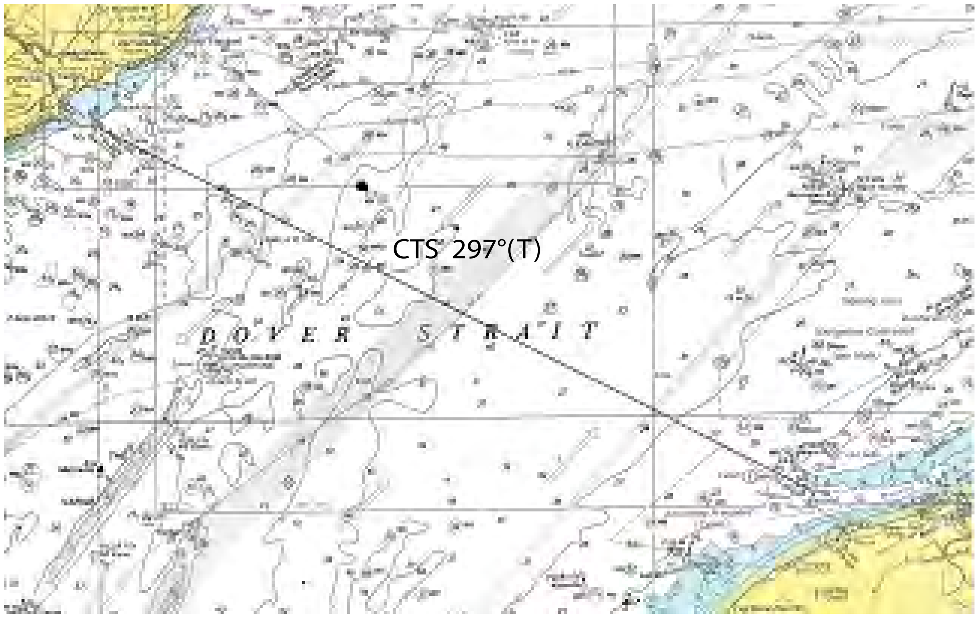


Fig 3 Course to Steer 297°(T)

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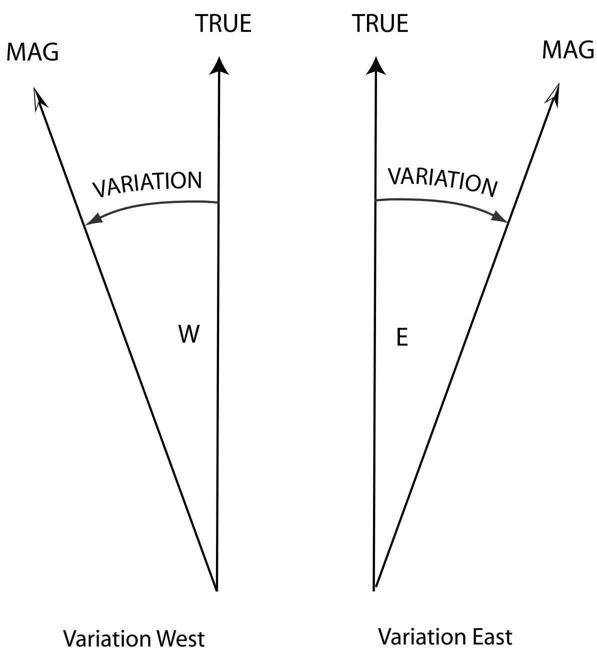


Fig 4

West and East Variation

Magnetic North

In effect the Earth may be thought of as containing a magnet situated at the north pole. This magnet pulls the compass needle towards it until the needle is pointing directly at it and then holds it in this position.

Unfortunately the earth's magnet is not exactly at the geographic North Pole but is in fact off to one side of True North. This position is called magnetic north and it is to magnetic north that the magnetic compass points. The problem is that charts are oriented towards True north and the meridians that are used as the reference from which directions are measured also point to True north.

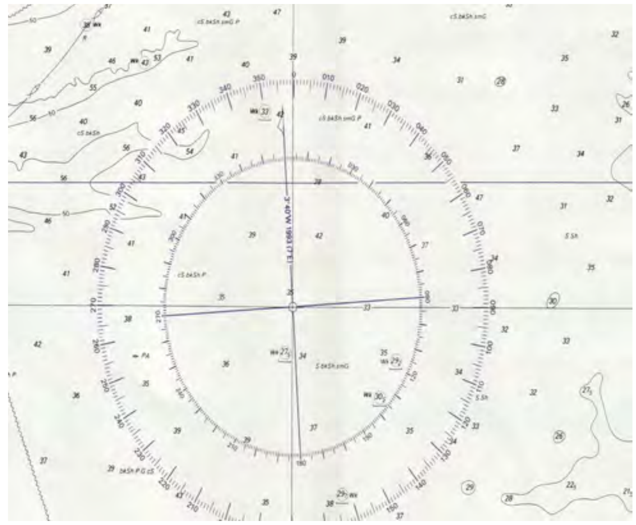
Variation

The angular distance between true north and magnetic north is called variation. If the compass points to the west of true north the variation is called West, if the compass needle points to the East of true north the variation is called East.

To find the variation for your area

The variation for the area covered by the chart is always shown in the several compass roses printed at a number of locations on the chart. They look like a protractor printed in magenta ink. The one to look at here is centred in the middle of the Channel.

There are actually two scales of degrees, one inside the other. The outside large rose shows true bearings whereas the inside smaller rose shows magnetic bearings, but only for the year shown.



Looking at the smaller inside magnetic rose, note the arrow drawn through it representing the direction of magnetic north and printed over this arrow is the Variation "3°40'W 1993 (7'E)".

The first part means that the variation in 1993 for this area was 3°40'W. The 7'E shows the annual change and it is named East, therefore each year the variation moving East and reducing by 7'.

To find the variation for the current year, say 2012, the number of years since is calculated, and the total change in variation is then applied, thus:
2012 – 1993 = 19 years. The total change since 1993 is 7' x 19 = 133' East (but there are 60' in 1° so 133' divided by 60 is 2° 13' E. Thus the variation for 2012 is 3°40'W - 2° 13' E = 1° 27' W which would be treated to the nearest whole degree, 1° W.

From the diagram you can see that if you wished to sail true north (000° (T) when in the area off Calais you would actually have to steer a magnetic course of 000°, written as 000° (M), the capital M in brackets indicating that this is a magnetic bearing which is the same as true in this instance as there is no variation.

It might seem logical to produce charts using magnetic north instead of true north as the reference but this is not done because charts, sailing directions and pilot books would have to be reprinted and changed frequently to reflect the continuously changing variation. It is therefore necessary to be able to convert true bearings to magnetic and vice versa.

When to apply variation

Remember that the chart is True and the compass is Magnetic.

A course or bearing taken from the chart to be used with a compass must be converted from true to magnetic.

A course or bearing taken from a compass for plotting on a chart must be converted from magnetic to true.

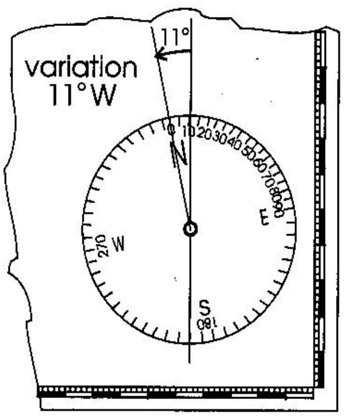


Fig 5

Rules for applying variation

To correct:
True to magnetic add westerly variation, or subtract easterly variation,
Magnetic to true subtract westerly variation, or add easterly variation.

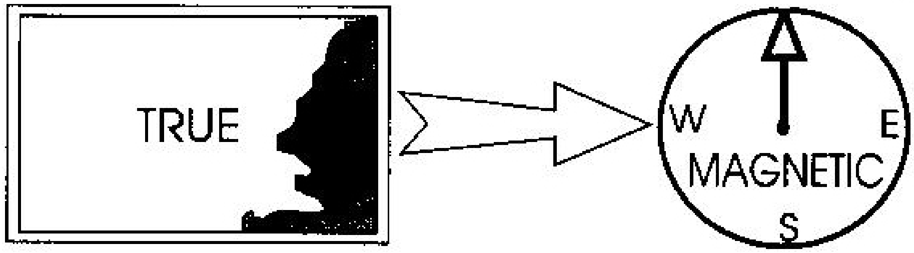
Variation West, Compass Best

There are many aide memoirs for these rules, perhaps the simplest is

'Variation West, Compass Best
Variation East, Compass Least'

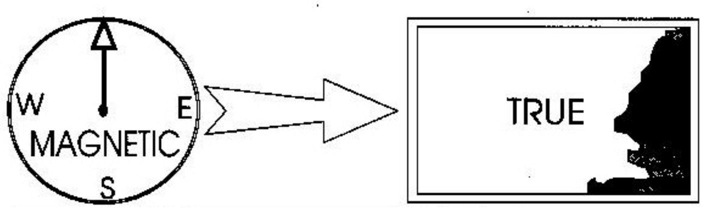
'Best' here means biggest or larger number, least means a lesser or smaller number. What the rhyme is saying is 'if the variation is west then the compass reading will be larger than the true reading, or, if the variation is east then the compass reading will be smaller than the true reading'.

Examples of correcting True bearings to Magnetic bearings:



True	Variation	Magnetic
070˚	7˚W	077
248˚	12˚W	260˚
180˚	4˚E	176˚
030˚	2˚E	028˚
359˚	11˚W	010˚

Examples of correcting Magnetic bearings to True bearings;



Magnetic	Variation	True
177˚	7˚W	170
228˚	5˚W	223˚
082˚	5˚E	087˚
230˚	2˚E	232˚
012˚	6˚W	006˚

Applying Variation

The True course to steer from CA6 Buoy, to Dover, at the SW entrance from the chart, is 297°(T). Although there is little difference in this example, if it was 6 or 7 degrees variation, not allowing for this would have a significant effect on where the vessel would end up!

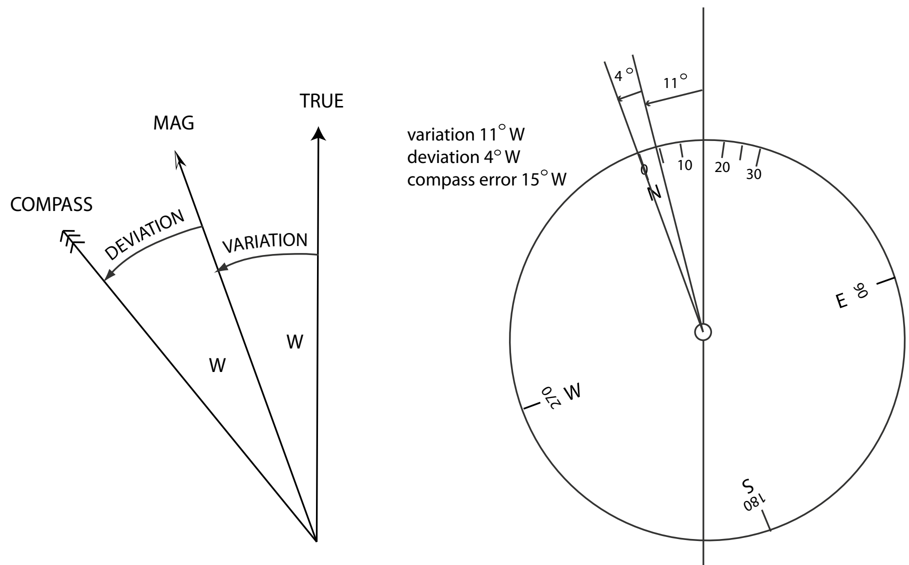
True	Variation	Magnetic
297°	**1° W**	**298°**

Therefore the magnetic course from CA6 Buoy, to Dover is 299° (M) and this would also be the course to steer if variation was the only magnetic influence, but there is another potential influence known as Deviation:

Deviation
The compass needle is pulled by the earth's magnetic field until it points to magnetic north. Local magnetic effects will also attract the compass needle deflecting it from magnetic north.

The angle between magnetic north and compass north is called deviation. Deviation can be east or west. If the compass points to the left of magnetic north deviation is called west, if the compass points to the right of magnetic north deviation is called east.

Compass error
The difference between compass north and true north is called compass error. Compass error is therefore the algebraic sum of variation and deviation. Note that there are now three headings for bearings and courses : True, Magnetic and Compass. A bearing or course is useless unless it is followed by (T) or (M), or (C).



Variation is the angle between compass north and magnetic north

The sum of variation and deviation is called compass error. Here the compass error is 15°W. In order to steer 000° (T) with this compass the compass course would be 015° (C)

Fig 6
Variation and Deviation

Causes of deviation
Deviation is caused by ferrous objects (those containing iron) being close to the compass. Engines, iron and steel keels, electric motors and cookers can all cause deviation and small portable objects such as pen knives, can cause deviation if they are close enough to the compass. Speakers in radios and VHF transceivers contain powerful magnets and if mounted too close to the ship's compass can cause large values of deviation. Steering compasses on steel boats are particularly prone to deviation whereas fibreglass and wooden boats are much better. Hand bearing compasses which are designed to be held close to the face can be effected by steel framed spectacles.

Deviation is not static as it changes as the direction of the boat changes and deviation caused by an iron or steel keel may change as the boat heels. Motor boats often have their compass close to a lot of instruments, many of which create magnetic fields.

When to check for deviation.
Deviation should be checked at least at the start of any passage, the start of the season and after any new equipment has been fitted which might cause deviation. It should also be checked on a new, chartered, or borrowed boat.

Using a hand bearing compass
One way of checking quickly whether the ship's steering compass is subject to deviation is to stand in a deviation free area at the aft end of the cockpit and sight along the fore and aft line of the boat using a hand bearing compass. Both the boat's steering compass and the hand held compass should show the same bearing, if they do not the difference between the two readings is the deviation of the steering compass on that particular heading.
In order to use this method it is obviously necessary to know that the area in which the hand bearing compass is being used is free from deviation; furthermore if an area in the boat can be proved deviation free this area can be used with confidence for all future bearings taken with a hand bearing compass.

To find a deviation free area
On most boats the after end of the cockpit has a good chance of being deviation free. Stand in a position thought to be deviation free and check the bearing of any distant fixed object, or landmark, with a hand bearing compass. Have the boat turned through a complete 360° circle while continuously watching the bearing of the object. If the bearing remains constant the compass is not being effected by deviation. If the bearing to the object changes as the boat turns the compass is being effected by magnetic influences on the boat; try another site and repeat the process.

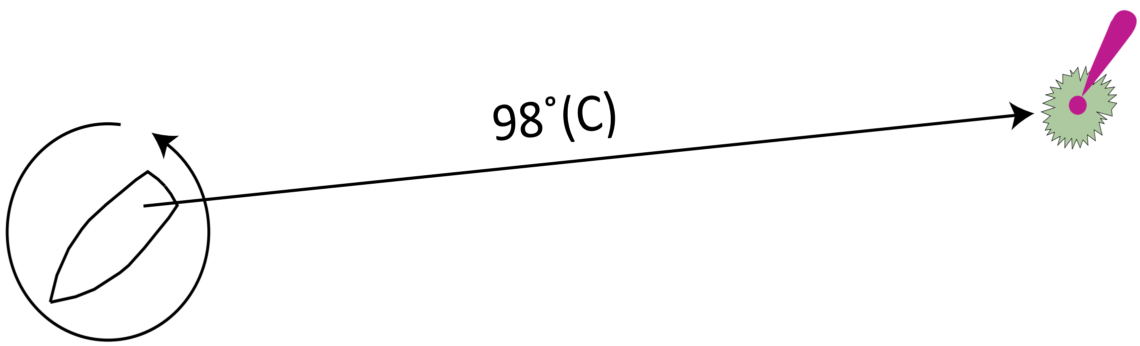


Fig 7

To check for an area free of deviation watch the bearing of a fixed object while turning the boat through a full circle. Provided the object is a good distance away and the boat is turned in a reasonably tight circle the bearing from the boat to the object will remain constant if there is no deviation.

If no area free from deviation can be found on the boat try using the hand bearing compass from a dinghy towed behind the boat.

Another method of checking for deviation is to line the boat up with two charted objects in line with each other, called a transit/range, ahead or astern. The true bearing of the transit is found from the chart, apply the variation for the area and the boat's compass should read the same, if it does not the difference is the compass deviation on that heading. If the true bearing is greater, the deviation is named east; if it is the lesser, the deviation is named west

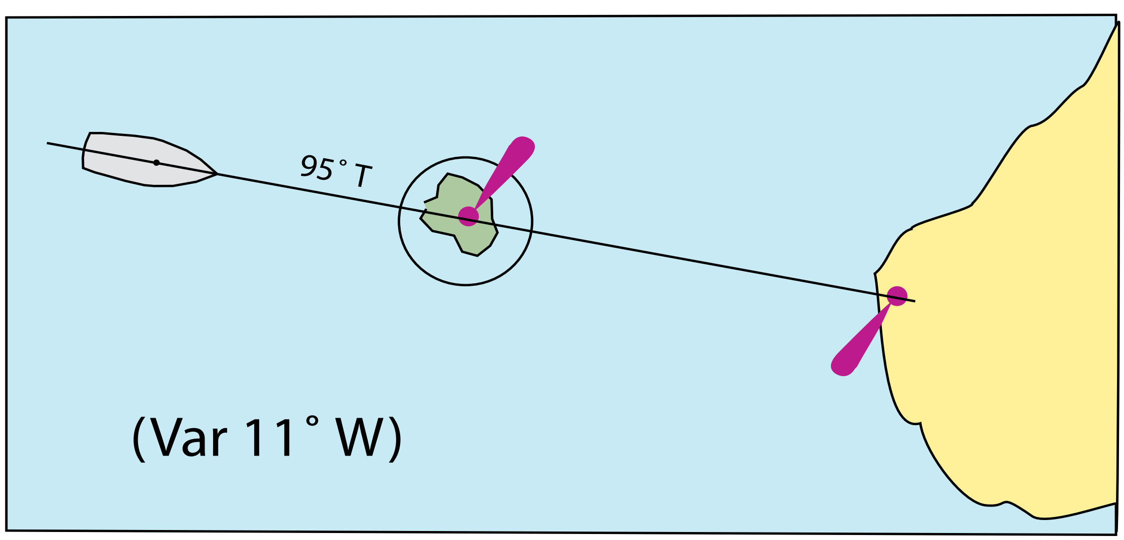


Fig 8

To check for deviation using a transit:
When the boat is lined up with the two lighthouses in line the steering compass should read 106°, if not the difference is deviation. The bearing of the transit is found from the chart.

If the steering compass has deviation there are various options.

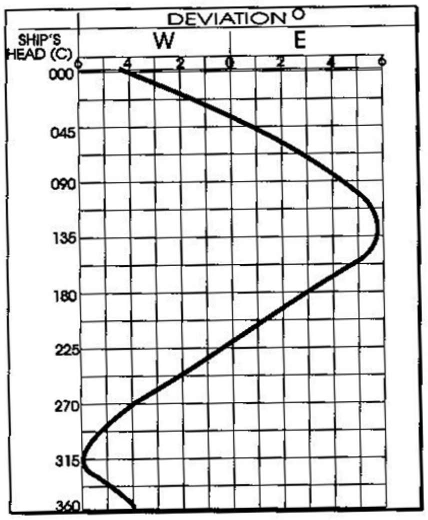


Fig 8 Typical deviation card

- Try to move the steering compass to a deviation free area,
- have the deviation removed by a qualified compass adjuster who will place magnets around the compass to counteract the magnetic fields causing the deviation.
- Buy one of the modern electronic compasses which can correct their own deviation,

  Check the deviation on different headings and draw them up in the form of a graph (called a deviation card) which is kept on board so that deviation can be found quickly for any heading.

  This is what a deviation card might look like. The deviation for any course can be read off the deviation card when required. For example:

  ships head 045° deviation = 1° E
  ships head 090° deviation = 4° E
  ships head 135° deviation = 6° E
  ships head 270° deviation = 4° W
  ships head 315° deviation = 6° W

Once found from the curve the deviation is applied to the magnetic course or bearing. For example

CA6 Buoy, to Dover	297° (T)
Variation 1° W	1° (W)
Magnetic	298° (M)
Deviation 4° W	4° (W)
Course to Steer (Compass)	302° (C)

Rules for applying deviation

Deviation is applied in exactly the same way as variation and so the same rhyme as before can be used - 'deviation west compass best, deviation east compass least'. Variation and deviation may seem confusing at first but understanding them is very important; their application will soon become second nature.

True Virtue Makes Dull Companions

The corrections for variation and deviation must be carried out in the correct sequence:

from true to compass = True ~ Magnetic ~ Compass,
from compass to true = Compass ~ Magnetic ~ True.

The mnemonic True Virtue Makes Dull Companions might help in remembering the sequence. If you have any difficulty working compass error problems use the mnemonic by making boxes as shown below: Then fill in the figures you know and the values in the remaining blank space (s) should become obvious.

True	Var	Mag	Dev	Compass

As an example use the bearing from Royal Sovereign Light to buoy 'CS 2' which is 136° True.

True	Var	Mag	Dev	Compass
136°	**1°**	**=137°**	**6° E**	**=131°**

The true course, 136° (T), from Royal Sovereign Light to buoy 'CS 2 is found from the chart and entered under True.
The variation, 1° W, is found from the magnetic rose on the chart and is entered under Variation.
The variation is west so compass is 'best' therefore Magnetic course is 136° + 1° = 137°.
The deviation from the deviation card is approximately 6° E (compass least).
Therefore compass course is 137° - 6° = 131° (C).
Long Passages note that deviation, if it exists, will change during a long passage.

Examples of corrections for variation and deviation

A.) Correcting from true (chart) to magnetic (compass)

True	Var	Mag
035°	10°W	045°
127°	5°W	
256°	3°E	
318°	12°W	
097°	4°W	
004°	004°E	
182°	15°W	
098°	7°E	
359°	6°W	

B.) Correcting from magnetic to true

M	V	T
283°	9°W	274°
108°	12°W	
343°	5°E	
027°	7°E	
184°	6°E	
127°	10°E	
000°	7°W	
278°	1°E	
002°	7°W	

C.) If you know your true course (from the chart) and your magnetic course (from a deviation free compass) you can find the variation for your area.

T	V	M
075º	4ºW	079º
039º		036º
246º		235º
137º		149º
200º		202º
359º		004º

D.) Try these

ºT	ºV	ºM	ºD	ºC
256	5W		6W	?
096	7W			098
061		064		060
	3E	307	9W	
	5E	022		019
	7W	359	0	359

Fluxgate Compass
A fluxgate compass is a more sophisticated, electronic version of the magnetic compass that requires electric power to operate. The data output allows it to be used in more ways than the traditional magnetic compass.

When an autopilot is in use, the fluxgate compass sends digital signals to the autopilot computer which will enable the vessel to maintain the heading set on the autopilot. The fluxgate compass can also interfaced with chart plotters and radar.

Marine fluxgate compasses always incorporate either fluid or electronic damping to help stabilise the unit from the vessel's pitching and rolling.

Gyrocompass
A gyrocompass finds true north by using an electrically powered, fast-spinning gyroscope wheel. This is normal equipment on ships and larger yachts.
They have a number of advantages over magnetic compasses:

- A gyrocompass is not influenced by magnetism
- They find true north, as opposed to magnetic north, and are not affected by Variation
- They are unaffected by deviation caused by the magnetic field of the vessel's hull and machinery.
- Greater accuracy with small errors
- Steady reading, less swinging in a seaway.

These advantages are a great help to the navigator as he/she does not have to make corrections from compass to True on the chart and vice versa

The Gyrocompass can also interfaced with gyro repeaters, chart plotters, radar and ARPA.

Gyrocompass Error
The total of the all the combined errors of the gyrocompass is called gyro error and is expressed in degrees E or W, just like variation and deviation. But gyro error, unlike magnetic compass error, and being independent of Earth's magnetic field, will be constant in one direction; that is, an error of one degree east will apply to all bearings all around the compass.

The errors to which a gyrocompass is subject are speed error, latitude error, ballistic deflection error, ballistic damping error, quadrantal error, and gimballing error. Additional errors may be introduced by a malfunction or incorrect alignment with the centreline of the vessel.

Application of Gyrocompass Error
To remember how to apply the gyro error, two memory aids are commonly used:

1. If Gyro is best (higher), error is west;
   If Gyro is least (lower), error is east.
2. G.E.T. -- Gyro + East = True

9

Tide Theory

Tides are of great significance to the navigator and it is essential to understand how tides may be used to help, rather than hinder, safe and efficient navigation, pilotage and passage planning. Tides effect navigation in two distinct ways: firstly, by the continual change in the depth of the sea caused by the rise and fall of the tide, and secondly, by the directional movement of the sea surface caused by the flow of the tidal streams.

Most, but not all, places experience two high tides and two low tides each day; this tidal regime being called semi diurnal (i.e. "half daily"). The coastal waters of the Atlantic and much of Northern Europe are subject to semi-diurnal tides. Some places, such as the northern shore of the Gulf of Mexico experience diurnal tides having only one high tide and one low tide each day. Enclosed areas of water such as the Mediterranean may only experience minimal or no tide effect at all.

The Pacific coast of the United States has a tidal regime called Mixed tide which usually has two high tides and two low tides each day but, on occasion, the tide may become diurnal with only one high and low water each day; there is often an appreciable difference in the heights of consecutive high and low waters of different heights

The cause of tides
Tides occur due to the gravitational effect of the moon and sun and because the earth is continuously spinning about its own axis, completing one whole revolution each day.

Gravity
There exists a force called gravity which tries to pull the earth and the moon together. To understand this gravitational pull effect it may be thought of as if it were a magnetic attraction between the moon and the earth continuously trying to pull them together. The earth and the moon would therefore collide were it not for a second force called centrifugal force.

Centrifugal force
Centrifugal force is the tendency to movement outwards from the centre of a spinning body. If you tie a weight to a piece of string and then swing it quickly round and round the string becomes taught as the weight attempts to move away from the centre, which in this instance is your hand holding the end of the string. If the string breaks the weight will fly away from the centre due to centrifugal force. The moon and the earth are continuously spinning through space around a common centre, called the 'barycentre', which gives rise to a centrifugal force trying to drag them apart. The earth and the moon would therefore separate from each other in space were it not for gravity which counteracts the centrifugal force. The two opposing forces of gravity and centrifugal force balance each other out and as a result the moon and the earth retain their relative distances from each other neither coming together nor flying apart.

The effect of gravity on the sea
In order to explain why tides occur it may help, initially, to think of the earth as being a sphere completely covered by water. The earth is a 'solid' sphere but the water surrounding it is fluid. Water also experiences the gravitational pull from the moon and so the water surrounding the earth is drawn towards the point on earth which is closest to the moon, forming a hump at that point. In effect the moon acts as if it were a magnet drawing the surface of the sea towards it. At the other side of the earth, opposite the moon, the gravitational pull from the moon is far less thus allowing the water to move away from the earth's surface forming a second hump.
Instead of a uniform depth of water over the earth's surface there are now two shallow points and two deep points with the depths changing gradually between them.

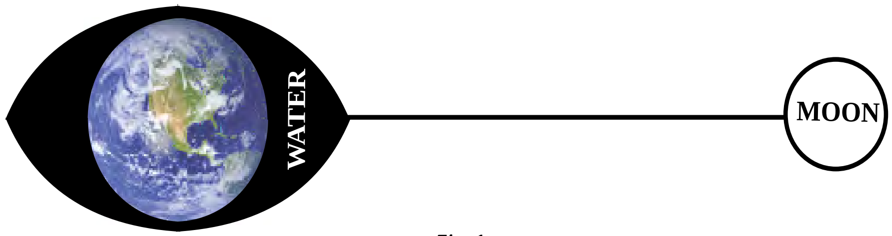


Fig 1
How the gravitational pull of the moon on the sea causes two deep points and two shallow points to develop. (The drawing greatly exaggerates the effect.)

Rotation of the earth
The earth is continuously spinning like a spinning top around its own axis, a line joining the north and south poles, taking 24 hours to complete one full revolution. Any particular place on the earth's surface will therefore pass through two low water points (low tides) and two high water points (high tides) every 24 hours.

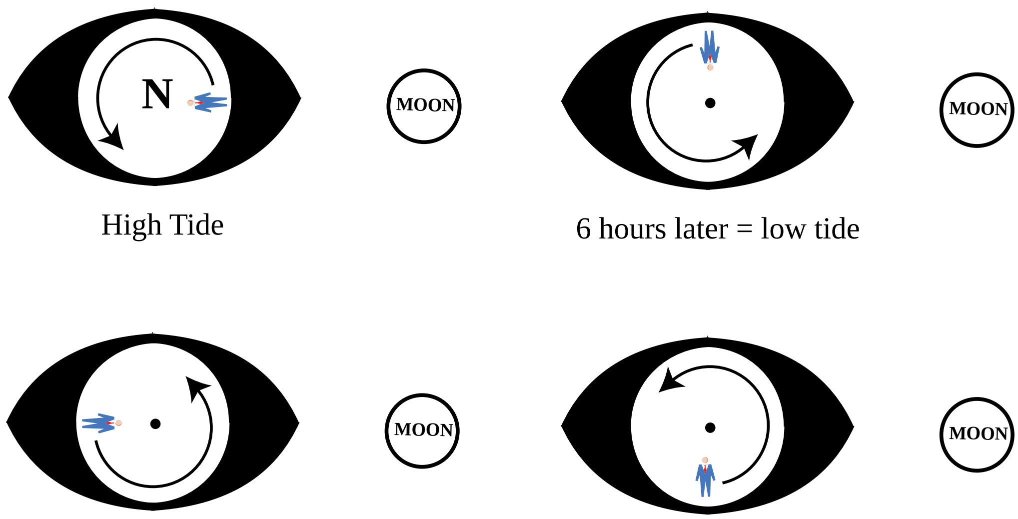


Fig 2 View these figures as if looking down on the north pole from a great height

Figure 2 above greatly exaggerates the gravitational effect of the moon, in reality tides in the open ocean, unaffected by the proximity of land, are no more than a couple of feet in height. The tide on the side of the earth nearest to the moon is slightly greater than that on the side of the earth opposite to the moon.

The lunar month

The moon does not remain in the same place but moves in an orbit around the earth. Because the moon is moving around the earth in the same direction as the earth is revolving around its own axis a lunar day is 24 hours and 50 mins long compared with a solar day of 24 hours. This means that it takes the moon about 24 hours and 50 mins to cross twice over the same meridian of longitude on earth and therefore the time interval between one high tide and the next will actually be 12 hours and 25 mins where there are two high tides per lunar day. High tide at a given place therefore occurs roughly 50 mins later each day.

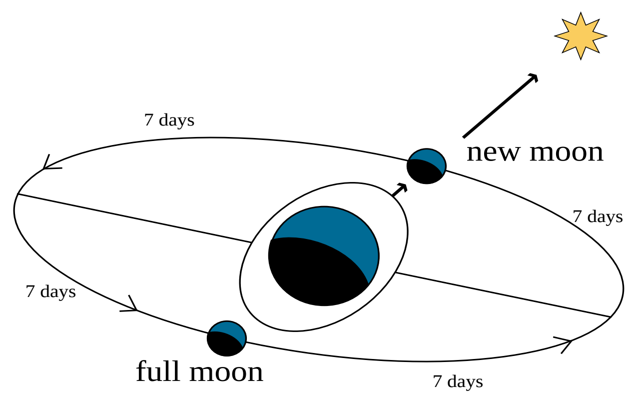
The sun's effect on tides
The sun's gravitational attraction effects the water on the earth's surface in exactly the same way as the moon does. Although the sun is physically much larger than the moon its gravitational attraction is less than half that of the moon's because it is so much further away from the earth. (The moon is about 240,000 miles/385,000 kms from earth whereas the sun is about 93,000,000 miles/149,000,000 kms away). However, due to the constantly changing relative positions of the earth, moon and sun the gravitational effects of the sun and moon sometimes combine together and sometimes partly cancel each other out.

When the attraction from the sun and moon combine together the range of the tide is great, high tides being higher than normal and low tides being lower than normal. These tides are called spring tides.

When the moon's pull is partly cancelled out by the position of the sun the range of tide is small, high tides are then lower than normal and low tides are higher than normal. These tides are called neap tides.

Spring tides
Spring tides occur when the sun and moon are in a direct line with the earth, that is at new moon and full moon.

The greatest spring tides of the year take place near the equinoxes during March and September at new and full moon.

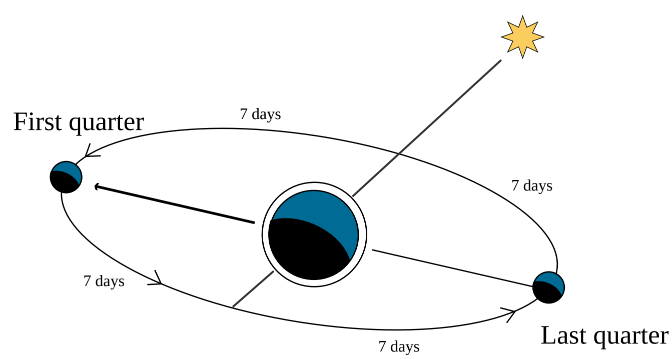


Spring Tides

Fig 3
Spring tides occur when the earth, sun and moon are in a direct line, that is at new moon and full moon.

Neap tides occur when the sun and moon are at right angles to each other, that is when there is a half moon. Neap tides occur when the sun and moon are at 90° to each other, the pull of the moon then being counteracted to an extent by the pull from the sun. Neap tides give a small tidal range as the high tide is lower than normal and low tide is higher than normal.

The time interval between spring and neap tides is not constant but as a rule of thumb can be considered as being 7½ days. In other words there will be a neap tide 7½ days after a spring tide and in a further 7½ days the tide will be a spring tide again.



Neap Tides

Fig 4
Neap tides occur when the sun and moon are at right angles to each other, that is when there is a half moon.

Tidal Heights

The effect of land on the tidal wave
So far we have considered a world totally covered by water but there are of course large land masses dividing the oceans and seas of the world. If it were not for these land masses the tidal wave caused by the moon and sun would travel continuously westwards at a speed of around 900 knots on the equator. However, because most of the large land masses lie in a north/south direction the tidal wave is interrupted, except in the Southern Ocean. This uninterrupted tidal wave in the Southern Ocean generates the north going tidal wave in the Atlantic which starts off the Cape of Good Hope and speeds northwards at about 600 knots reaching Greenland about 12 hours later.

Coastal tides
In the open ocean a rise in the depth of water of 0.3 m/1 ft or so would not be noticeable but in coastal waters tides can cause the depth to change by as much as 12 m/40 feet or more. The average range of spring tides at Burntcoat Head in the Bay of Fundy is 15.8 m/52.6 feet, whereas, at the other extreme, the spring range at San Salvador in the Bahamas is 1 m/3 feet.

Tides in coastal waters are caused by the fast moving tidal wave meeting large land masses, shelving sea beds, heavily indented coastlines and so on in just the same way that a wave runs up a beach due to its own momentum. Large land masses both constrict and compress the flow of water. The friction effect of a shelving sea bed causes the leading edge of the tidal wave to slow down allowing more of the wave behind to catch up, and combine with, the front of the wave thus increasing the overall wave height.

Tides still will not form to a noticeable extent unless the length and depth of the sea bed in the area is formed in such a way that the water in it will have a natural frequency of oscillation which is in sympathy with the passage of the moon and sun. Oscillation means to move to and fro between two points, a good example will be seen if you slop water up and down the bath using your hand as the wave generating force; if you get the frequency just right a wave will continue to occur at each end of the bath but if you change the frequency the natural period of oscillation will be lost and the periodic waves at each end will disappear.

Coriolis' force acting on tide generated currents can have a marked effect on tidal heights. The English Channel is formed by restrictions on either side, with England on one side and France on the other; the tides here flow strongly, roughly parallel to the shores, in an east/west and west/east direction. Coriolis' force deflects the mass of moving water to the right of its path giving spring ranges of 12 m /40 feet or more on the French coast but less than half this on the English side.

The Baltic does not have a wide enough opening to allow any significant tidal wave to enter and as it lies in a north/south direction there is not sufficient width to generate its own wave, therefore there are no appreciable tides there.

The Mediterranean, on the other hand, lies in an east/west direction but it has a restriction in the middle which defeats the natural period of oscillation needed to form tides and its opening to the Atlantic at Gibraltar is too narrow to allow sufficient of the Atlantic's tidal wave in to have any noticeable effect. The average range of tide at Valetta, in Malta, for example is about 1 cm/3 inches.

Tidal abnormalities
In some places the tides do not follow the normal rules, the area around the Solent on the south coast of England being a good example. This area, from Swanage to Selsey, has a tidal regime which is distorted; some of these places have a secondary high water occurring a few hours after the first high water or the tide may remain or stand at the same level without changing for 3 hours or so. Secondary low waters occur off the Hoek of Holland.

Very often the tide rises in an estuary quicker than it falls. These anomalies are due to many things such as the shape of the surrounding land, the depth of the sea bed, the momentum of the tidal wave and so on.

Bores
Bores are steep faced spring tidal waves that move quickly up estuaries and rivers causing a wave of anything from a few centimetres to a few meters in height. They form because the depth of water is too shallow to allow the wave to maintain its natural shape and the back of the wave catches up with, and adds to the front of the wave.
Although bores may present a real danger to small craft their occurrence is usually predictable and will be noted in the tide tables. The Pettitcodiac river in the Bay of Fundy and the river Severn in England experience bores.

Tsunamis, surges and seiches
None of the above are in fact tidal, being caused by natural forces, rather than lunar or solar tide raising forces but they are often called 'tidal waves' so they are included here. A tsunami (Japanese: 'a wave in a harbour') is caused by a sudden seismic upheaval such as an earthquake on the sea bed. This gives rise to waves of perhaps a metre in height in the open ocean travelling at speeds of up to 400 or 500 knots for thousands of miles. When these waves meet, and run up, a shelving sea bed, the wave heights can increase to 20 metres/70 feet or more with devastating results on low lying areas. A recent example was the 2004 Indian Ocean earthquake with a magnitude of 9.1, and following tsunami which killed an estimated 300,000 people in Indonesia, Sri Lanka, Thailand and India.

A surge is a rise, or fall, in the level of the sea caused by a change in atmospheric pressure. As the air above the sea has weight it exerts pressure on the surface of the sea, an increase in atmospheric pressure will force the sea down whereas low atmospheric pressure will allow the sea surface to rise up. A change in pressure of 35 millibars may cause a change in depth of 0.3 m /1 ft). A storm surge in January of 1953 raised the sea level in the southern part of the North Sea by 3 m/10 ft.

Hurricanes may well cause pressure drops of 90 millibars or more at their centres. If a storm surge occurs at the same time as a spring tide even more serious flooding can result over low lying ground.

Seiches may be caused by seismic or atmospheric conditions and they are seen as a sudden short lived rise and fall of the sea level. A seiche may result from the passage of a thunderstorm or line squall.

Strong winds
When strong winds have been blowing in the same direction for a few days the sea level can build up on a shore down wind (lee shore), however the increase in depth would generally not be much.

10

Tide Definitions

International and British Admiralty Charts: The following terms used to define tidal heights and depths should be understood to avoid confusion. (USA uses different terms and definitions so care should be taken using a US produced chart).

Chart Datum (CD)
Chart datum, or Sounding Datum, is a fixed reference level from which all depths and drying heights are measured on a chart. British Admiralty and International charts use Lowest Astronomical Tide (LAT).

Lowest Astronomical Tide (LAT)
LAT is the lowest sea level that can be predicted to occur under average meteorological conditions and any combination of astronomical conditions (positions of sun, moon and earth in any combination of relative positions). Occasionally Meteorological effects can cause the tide to fall below CD. A change in atmospheric pressure of 34 millibars/1 inch will cause the sea level to change by 0.3 metres/13 inches. (See Negative Storm Surges in the Annual Summary of Admiralty Notices to Mariners).

Highest Astronomical Tide (HAT)
HAT is the highest sea level that can be predicted to occur under average meteorological conditions and any combination of astronomical conditions (positions of sun, moon and earth n any combination of relative positions). Charted heights of features, which are never covered by the tide are measured from this point, and clearance beneath an overhead obstruction such as a bridge or power line is measured from the underneath of the obstruction to the sea surface at HAT.

Charted Depth
The charted depth is distance from chart datum to the sea bed or the depth of water at Chart Datum. Charted depths are also referred to as soundings.

Drying height
The drying height is the height above chart datum of features such as rock, wrecks and sand/mud banks that cover and uncover with the tide.

High water and Low water
High water is the highest point reached by any one tide. Low water is the lowest point reached by any one tide.

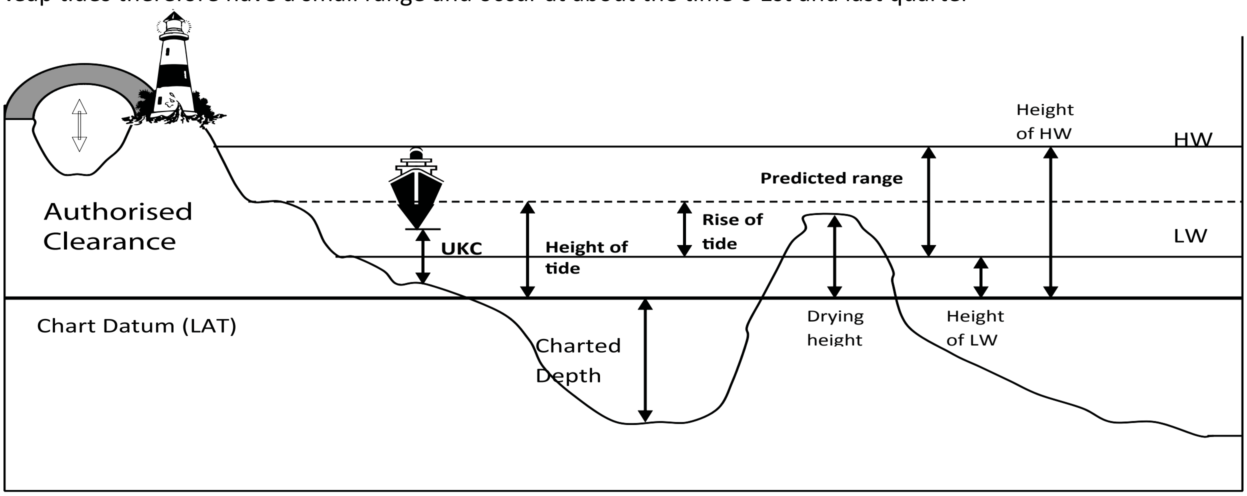
Range
The range of a tide is the difference in height between consecutive high and low waters. The range is therefore found by subtracting the height of tide at low water from the height of tide at high water. The range is always changing, even for successive high and low waters on the same day.

Duration
The time between successive high and low water

Height of tide
The height of tide is the height of water above chart datum at any moment in time. Tide tables give the height of the tide at the exact time of HW and LW only. The height of tide for any other specific time between HW and LW may be found using tide tables and tidal graphs. The height of tide thus found is added to the sounding printed on the chart to give the actual depth of water at the time in question. It is sometimes referred to as “reduction to soundings” because if you reduce the echo sounder reading by this figure you are left with the soundings or charted depths shown on the chart.

Spring Tides
A spring tide has a higher high water and a lower low water than the average tide for the area, therefore a spring tide has a big range. Spring tides occur at about the time of new and full moon.

Neap Tides
Neap tides occur in between spring tides and have lower high waters and higher low waters than the average tide. Neap tides therefore have a small range and occur at about the time o 1st and last quarter



Mean High Water (MHW)
The average height of all high waters recorded at a given place over a 19 year period

Mean High Water Springs (MHWS)
This level is calculated from the means of all high water spring tides throughout the year and is given above chart datum. Charted heights of features, which are never covered by the tide, used to be given above this level.

Mean Low Water Springs (MLWS)
This is calculated from the means of all low water spring tides throughout the year and is given above chart datum.

Mean High Water Neaps (MHWN)
This is calculated from the means of all high water neap tides throughout the year and is given above chart datum.

Mean Low Water Neaps (MLWN)
This level is calculated from the means of all low water neap tides throughout the year and is given above chart datum.

Mean Spring Range (MSR) and Mean Neap Range (MNR) To determine which tidal curve to use in the tide tables.

Flood Stream and Ebb Stream
When the tide is rising the stream is said to be flooding and when falling is said to be ebbing.

Rise of Tide
This is the height by which the tide has risen above the predicted LW. This should not be confused with Height of Tide, which is always measured above Chart Datum.

Depth of Water
Height of Tide plus (+) Charted Depth or Height of Tide minus (–) Drying Height.

Under-keel Clearance
This is the depth of water, usually in metres, between the vessels bottom and the seabed or obstruction.

11

Tide Calculations – Standard Ports

Tidal predictions around the world generally follow one of two standards, the USA and the UK. The international standard is actually based on the UK version and this is what is covered in this course.

In the U.K. the British Admiralty (BA) Hydrographic Office (HO) publishes Tide Tables each year. The HO has a very useful web service called Admiralty EasyTide. It provides tidal data for over 7000 ports worldwide together with some other useful information. A limited version can be obtained free of charge but a small fee allows an enhanced version to be accessed. The web address is: http://easytide.ukho.gov.uk/EasyTide/EasyTide/index.aspx

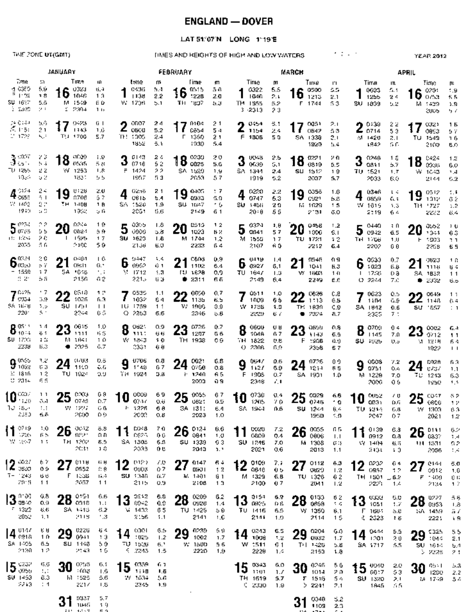
In addition to the BA, there are various nautical almanacs, such as a Reeds Nautical Almanac Published by Adlard Coles publications. Local tide tables can be found in nautical bookshops. local papers and marina offices; tidal prediction programmes can be bought for most PCs, tablets and phones, or obtained readily from the Internet.

When using the tables care must be taken to obtain the correct time; the time zone is usually given at the top of each page of the tide tables. Additionally it may be necessary to factor in daylight savings time if applicable. The heights shown refer to heights above the Chart Datum in use in that area.

Standard Ports

These are ports that have sufficient traffic to make the work and expense involved in publishing dedicated tide tables worthwhile. The times and heights of high and low water are tabulated for every day of the year and can be extracted straight from the table. They may however need to be corrected for local time differences and UTC and where Daylight Saving/Summer Time is in place.

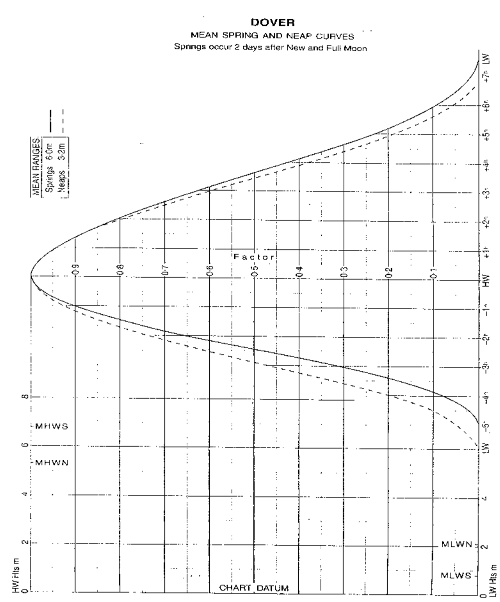
There are two parts to the Standard Port Tables, the Daily Tables and the Mean Spring and Neap Curve/Tidal Curve


ENGLAND — DOVER

LAT 51°07'N LONG 1°19'E

TIME ZONE UT(GMT) TIMES AND HEIGHTS OF HIGH AND LOW WATERS YEAR 2012

JANUARY FEBRUARY MARCH APRIL



Layout and use of Standard Port Tide Tables

Some important tips when using standard port tide tables:

a. Make sure you are using the correct tide table, check the name of the port at the top.

b. Always check carefully that you are using the correct month, day and date.

c. Times are in 24 hour clock notation, i.e. 1518 means 1500 hours and 18 minutes.

d. The zone time used for the predicted times is usually the standard time for the area and is given at the top of each page. Ensure that this is the actual time zone in use on that date, the predicted time being corrected if necessary.

Special care is needed for those ports whose time is changed during the year. In the British Isles, Europe, Australia and most other parts of the world, Universal Time is used for tidal predictions (UT can be considered the same as Greenwich Mean Time (GMT)) is shown throughout the year and a correction must be applied during the period of "Summer Time", which is + 1 hour ahead of UT.

e. The time zone will be shown - UT (GMT) for British Admiralty Tide Tables.

f. The predicted height of tide is given in metres and decimals (tenths) of a metre.

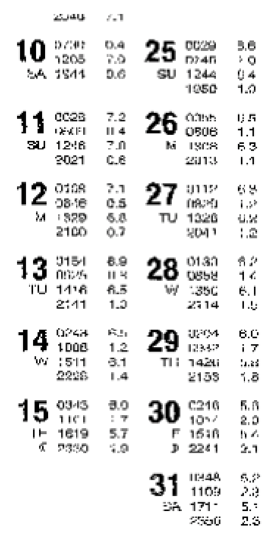
g. The height of tide given is the height above Chart Datum.

h. Check the Chart Datum. (They are different in UK and USA for example).

i. The tables do not say low or high water, the heights given will show which is which.

j. Underneath the date are printed the first few letters of the day, i.e. Tu = Tuesday.

k. The date of new moon and full moon is shown by symbols on some tide tables.



Day	Time	m	Day	Time	m
	[illegible]	[illegible]			
10 SA	[illegible]	0.4	25 SU	0029	[illegible]
	1205	7.0		[illegible]	[illegible]
	[illegible]	0.6		1244	[illegible]
				1950	1.0
11 SU	0028	7.2	26 M	[illegible]	[illegible]
	[illegible]	[illegible]		0506	1.1
	1246	7.0		1308	6.3
	2021	0.6		2013	1.1
12 M	0108	7.1	27 TU	[illegible]	[illegible]
	0846	0.5		[illegible]	[illegible]
	1329	6.8		1328	[illegible]
	2100	0.7		2041	1.2
13 TU	0151	6.9	28 W	0130	[illegible]
	[illegible]	[illegible]		0858	1.4
	1416	6.5		1350	6.1
	2141	1.0		2314	[illegible]
14 W	0248	[illegible]	29 TH	0204	6.0
	1006	1.2		[illegible]	[illegible]
	1511	6.1		1426	[illegible]
	2226	1.4		2153	1.8
15 TH ☾	0343	6.0	30 F ☽	0216	[illegible]
	[illegible]	[illegible]		[illegible]	2.0
	1619	5.7		[illegible]	[illegible]
	2330	[illegible]		2241	2.1
			31 SA	[illegible]	[illegible]
				1109	2.3
				[illegible]	[illegible]
				[illegible]	2.3

Using the Tide Tables to find HW, LW and range at Standard Ports

Finding the time and height of high and low water is simply a matter of looking up the tide table for the date in question.

To find the times and heights of HW and LW at Dover, England on Saturday 31st March. We look up the tide tables for the day, 31st, and port Dover, the time is in UT/GMT:

HW	0348	5.2
LW	1109	2.3
HW	1711	5.1
LW	2356	2.3

Note 1: In 2012 the clocks move forward to British Summer time, (Daylight Saving) Sunday, March 25 at 1:00 AM and return to GMT, Sunday, October 28 at 2:00 AM For ease of calculation the ships chronometer is usually kept on GMT/UT - Annual change is last Sunday in March to last Sunday in October.

Note 2: The first time shown is not necessarily the time of high water and sometimes there are only three times instead of four given for a particular day, for example, 10th March

The range of Tide in the evening is calculated:

	High Water Height	5.1 metres,
Less	Low Water Height	2.3 metres
Range		2.8 metres

The information found actually means is that:

High tide will be at 1711 GMT/UT, but by your watch 1811, adding the Summer time hour, and at that time there will be 5.1 metres of water in addition to the depths shown on the chart of the area.

Low tide will occur at 2356 (but watch time of 0056, 1st April) when there will be 2.3 metres of water in addition to the depths shown on the chart for the area.

One other fact that can be noted is that the tides on the 31st are NEAP tides; the range is 2.8 metres.

On the 10th March, the range in the evening is 6.4 metres, a SPRING tide range. See also the Mean Ranges Box on the Tidal Curves Page.

To Find the Times and Heights of Tides BETWEEN Tabulated HW and LW (Standard Ports)
Times and heights of tides that are in between the tabulated values are obtained using Mean Spring and Neap Curves. In the BA Tide Tables these tidal curves are reproduced before the standard port daily prediction tables; the one for Dover is shown above.

To find the height of the tide at a given time at a Standard Port

1. On the daily page, take the times and heights of HW and LW that occur either side of the required time.
2. On the grid adjacent to the standard curve for the port in question plot these heights.
3. Join the plotted points by a sloping line.
4. Calculate the time interval between the desired time before or after HW
5. Mark the appropriate time interval on the base of the graph - start at HW and work up or down hourly
6. Draw a vertical line from the time required point up to and meeting the chosen curves, spring or neap.
7. Use the predicted range of tide for the day in question, use the curve either for spring or neap tides (or interpolate between the spring and neap curves).
8. Draw a horizontal line from the time point on the curves to the sloping height line.
9. Read off the height from the sloping line.

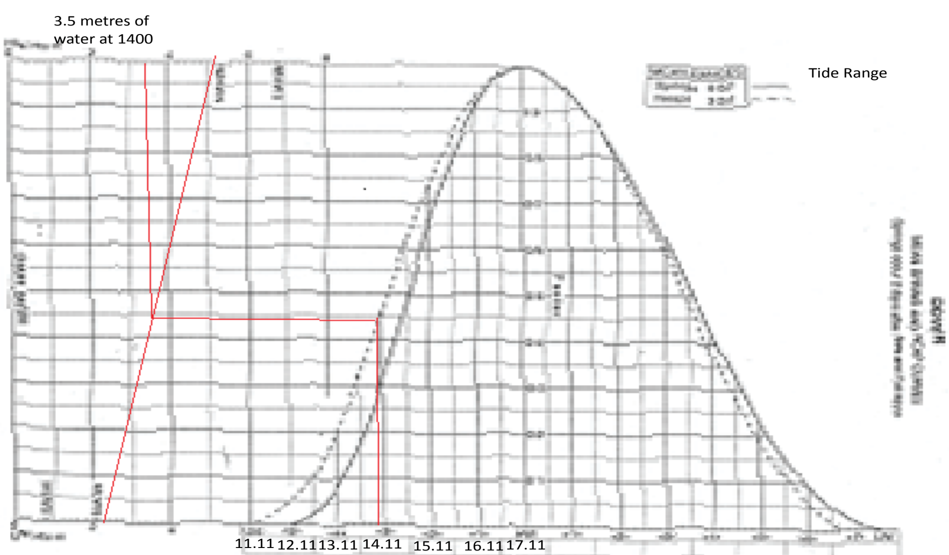
For example using the Dover tidal data and curve, calculate the height of tide at 1400 UT/GMT on the 31st March:
The times and heights of HW and LW at Dover, England on Saturday 31st March are:

	LW	1109	2.3
	HW	1711	5.1
	LW	2356	2.3
Range for day		High Water Height	5.1 metres,
	Less	Low Water Height	2.3 metres
		Range	2.8 metres
From tidal curves diagram		Spring range	= 6.0 m.
		Neap range	= 3.2 m.
		Range 31st March	= 2.8 m, so use the neap curve.

(If the range for the day falls between spring and neap range then interpolate between spring and neap curves).

Require the height of tide at	1400 GMT
Time of HW (nearest)	1711 GMT
Required time is	3 Hours 11 minutes before HW
Using the neap curve Height of tide at 1400 GMT is	3.50 metres

This is added to the Heights on the chart for depth of water at this time.



To find the time for a given height at a Standard Port

1. On the daily page, take the times and heights of HW and LW that occur either side of the required time.
2. On the grid adjacent to the standard curve for the port in question plot these heights.
3. Join the plotted points by a sloping line.
4. Plot the required height at the top of the graph and draw a line vertically to the sloping line.
5. From the intersection draw a line horizontally up to and meeting the chosen curve, spring or neap.
6. Use the predicted range of tide for the day in question, use the curve either for spring or neap tides (or interpolate between the spring and neap curves). DO NOT EXTRAPOLATE
   Check to see that you are using the correct side of the curve. (Is the tide rising or falling).
8. Draw a line from the required point on the chosen curve vertically downwards.
9. Mark the appropriate time interval on the base of the graph - start at HW and work up or down hourly and pick out the time of the required height.

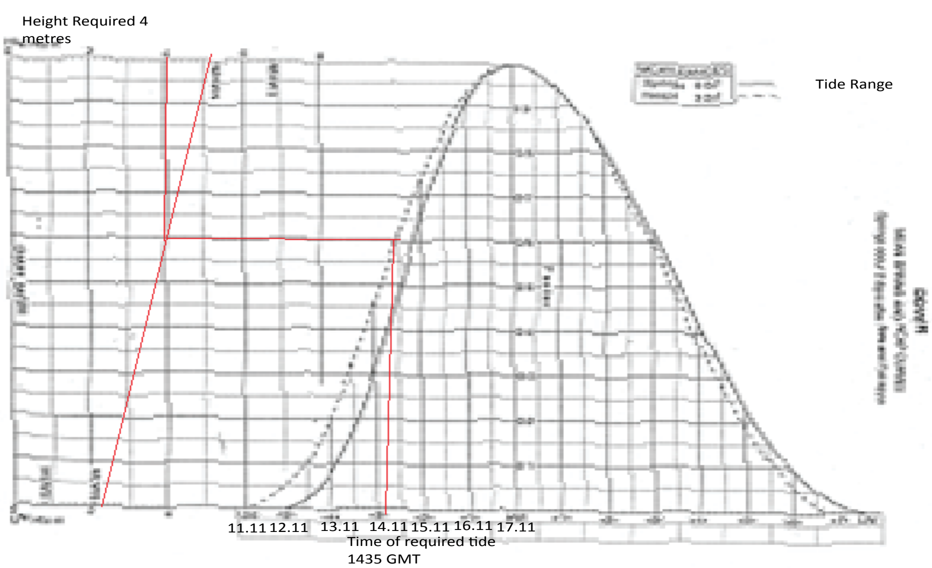
For example using the Dover tidal data and curve, calculate the time that the tide will reach a required height of 4.0 m above Charted Depth on the 31st March:
The times (GMT) and heights of HW and LW at Dover, England on Saturday 31st March are:

	LW	1109	2.3
	HW	1711	5.1
	LW	2356	2.3
Range for day		High Water Height	5.1 metres,
	<u>Less</u>	<u>Low Water Height</u>	<u>2.3 metres</u>
		Range	2.8 metres
From tidal curves diagram		Spring range	= 6.0 m.
		Neap range	= 3.2 m.
		Range 31st March	= 2.8 m, <u>so use the neap curve.</u>

(If the range for the day falls between Spring and Neap Range then interpolate)

The required height	4.0 m
Reached at	1435 GMT to which 1 hour must be added for BST

NOTE: Comparison of the calculated tidal range (2.8 m) with the small table of MEAN RANGES on the tidal curves diagram shows the calculated range as outside the neap curve. Do not extrapolate outside the tidal curves but use the neap curve (pecked curve). Never extrapolate beyond the curves. For ranges with values greater than the range value use the solid spring curve, and for ranges less than the mean neap values the neap curve must be used.



The Rule of Twelfth's

If there is no tidal information readily available and a quick calculation of approximately what the height of tide might be at a port, then it is possible to use the Rule of Twelfth's.

This will give a rough idea of the height of tide at a specific port. It should be clearly understood, however that this method is at best imprecise and may be dangerously misleading. It should only be used with tidal regimes which have uniform tidal curves and a period of close to 6 hours between consecutive High and Low waters.

The rule of twelfths states that the cumulative rise or fall of the tide is:

1st hour 1/12 of the range
2nd hour 2/12 of the range
3rd hour 3/12 of the range
4th hour 3/12 of the range
5th hour 2/12 of the range
6th hour 1/12 of the range

For example using only the Dover tidal height data calculate the height of tide at 1400 UT/GMT on the 31st March if we only have the times and heights of HW and LW at Dover, say from a Marina office or Newspaper,

		LW 1109 2.3	
		HW 1711 5.1	
Range for day		High Water Height	5.1 metres,
	Less	Low Water Height	2.3 metres
		Range	2.8 metres

So using the rule of Twelfth's our time required is 2 hours 51 minutes after LW, say 3 hours:
Therefore the 3rd hour the height will have gained 6/12 of 2.8 m or 1.4 m which should be added to LW height of 2.3 m giving a resultant ROUGH height at 1400 GMT of 3.7 m. Compared with the graph 3.5 m is close to the computed height at the same time using the tidal curve. BUT whist a useful tool it should not be relied upon except to give a rough idea of height at a certain time.
ALWAYS use the tide curve when accuracy is required

Finding the Direction and Speed of the Tidal Stream (Set and Drift)

While it is important to know the height, speed and direction of the tide at ports and harbours, the tide also affects vessels while underway, so it is vital to be able to establish what the set and drift are all the time the vessel is at sea; if used carefully there is a potential gain that an advantageous tide will give a vessel.

Once the times of high and low tides are known it is possible to find out what the tidal stream direction and speed are; that is the set and drift. This will allow the navigator to set a course to counteract any stream, or to work out an EP after sailing for a period without obtaining a fix.

Remember all the tidal information is based on predicted values. Barometric pressure and wind which cannot be taken into consideration in the tables can and do alter the actual values.

Barometric Pressure

Admiralty Pilots/ Sailing directions give the average barometric pressure for various locations, thus if the actual pressure is less than this the sea level will tend to be higher and conversely if the actual pressure is greater than the average, the sea level will tend to be lower.

Effect of Wind

An onshore wind will tend to push the water up against the coast while an offshore wind will tend to hold the water back thus lowering the coastal water level. Winds blowing along the coast will set up long waves - storm surges which will raise or lower the level depending upon the position of the crest and trough.

Charted depths especially in shallow water should be treated with caution Remember that charted depths are liable to change after a period of severe weather. The chart is not an infallible instrument.

There are 2 sources available for obtaining accurate tidal set and drift information.

Tidal Stream Atlas

Tidal Diamond Tables

To find the rate and direction of the tidal stream at Beachy Head for 31 March 2012 at 1400 GMT, the chart has a tidal diamond “A” approximately 2 miles south of the headland with the appropriate information for the location.

Tidal Streams referred to HW at DOVER

Hours	A 50°42'·1N 0 14·9E Dir	Rate (kn) Sp	Np	B 50°30'·0N 0 26·0E Dir	Rate (kn) Sp	Np	C 50°42'·7N 0 27·0E Dir	Rate (kn) Sp	Np	D 50°43'·4N 0 58·0E Dir	Rate (kn) Sp	Np	E 50°53'·0N 1 00·6E Dir	Rate (kn) Sp	Np	Hours
Before HW 6	263	1·0	0·6	249	1·1	0·6	248	0·8	0·4	228	1·6	0·9	211	1·6	0·9	6 Before HW
5	107	0·5	0·3	206	0·2	0·1	067	0·5	0·3	228	1·4	0·8	211	2·1	1·2	5
4	085	1·9	1·1	077	1·1	0·6	068	1·9	1·0	218	0·9	0·5	211	1·8	1·1	4
3	075	2·6	1·5	080	1·9	1·1	068	2·6	1·5	096	0·4	0·2	211	0·9	0·5	3
2	080	2·4	1·4	082	2·1	1·2	068	2·3	1·3	044	1·2	0·6		Slack		2
1	075	1·4	0·8	074	1·5	0·8	068	1·2	0·6	053	1·3	0·8	031	0·8	0·5	1
HW	107	0·2	0·1	066	0·8	0·4	067	0·1	0·1	052	1·3	0·7	031	1·5	0·8	HW
After HW 1	263	0·8	0·4	304	0·1	0·1	248	0·9	0·5	047	1·1	0·6	031	1·9	1·1	1 After HW
2	266	1·3	0·7	268	0·8	0·5	247	1·4	0·8	028	0·6	0·4	031	1·7	1·0	2
3	254	2·0	1·0	263	1·3	0·7	248	1·8	1·0		Slack		031	1·2	0·6	3
4	263	2·0	1·1	254	1·5	0·8	248	1·7	1·0	256	0·4	0·2	031	0·4	0·2	4
5	263	1·8	1·0	261	1·6	0·9	248	1·6	0·9	238	0·9	0·5	211	0·4	0·2	5
6	267	1·3	0·7	256	1·4	0·8	249	1·2	0·7	225	1·5	0·8	211	1·3	0·7	6

1. Find the time corrected for daylight saving if applicable) and heights of HW and LW at Dover on the 31 March

HW	0348	5.2
LW	1109	2.3
HW	1711	5.1
LW	2356	2.3

2. Check if springs tides, neaps tides or between, the tide range is neaps on this day
3. Find how many hours before or after HW Dover, at 1400 hrs GMT - the tide is 3 hours before HW Dover

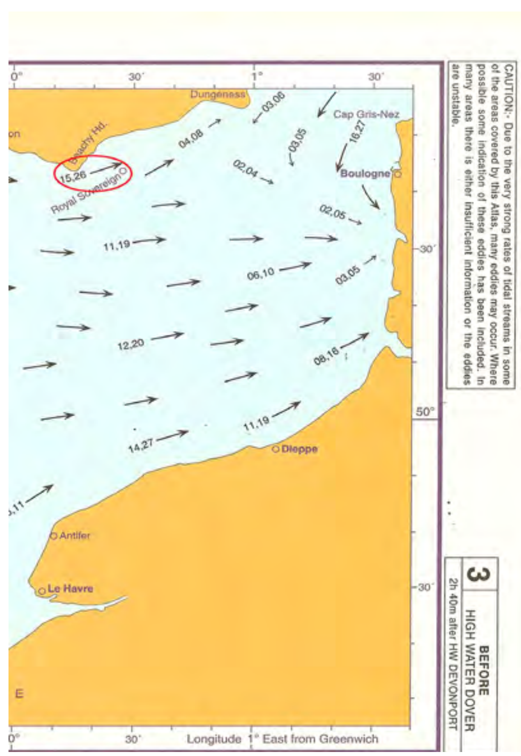
Either

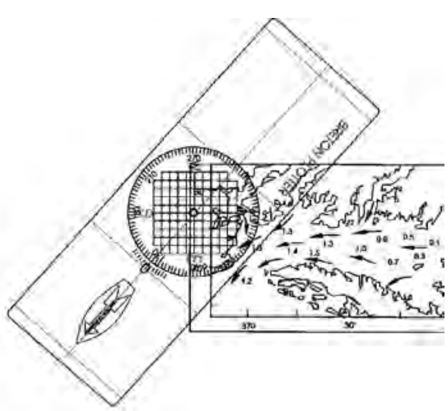
4. Find the nearest tidal diamond to your position – in this case tidal diamond “A” and read off the information at 3 Hours before High . There are neap and spring rates listed, and direction in degrees true. At “A” the speed is 1.5 knots for neaps and 2.6 knots for springs and the direction is 075° (T)

Or

5. Use the tidal stream atlas for the area, using the correct page, ie 3 hours before HW Dover, and pick the nearest arrow/s to give the direction and rate. The 2 figures represent the spring and neap rates, here 1.5 knots for neaps and 2.6 knots for springs.

15,26





To obtain the direction, the set, measure with the plotter the arrow closest to the area you want the information, the circled arrow is measured using a plotter and is 075° (T); the example here is from a different area.

Notes:

1. Charted heights are given above MHWS, to find the height of a light/bridge above CD, add the height of MHWS above CD to the charted height.
2. Always bear in mind that the tide table values are predicted and may not be absolutely correct; therefore the prudent navigator will always allow for discrepancies and be conservative to ensure adequate under keel clearance (UKC) in practice.

12

Tide Calculations – Secondary Ports

Secondary ports are ports that do not have their own dedicated tide tables. Tidal time and height information may be calculated for secondary ports by applying time and height differences found from the tides differences tables to the times and heights of High and Low Waters at a particular standard ports.

The standard port may not necessarily be the closest port geographically but one which has a similar tidal curve.

The time differences are based on normal weather conditions. (With strong gales the time and height may be affected considerably).
The secondary port time and height differences are tabulated in Part II of the BA Tide Tables. These tables for secondary ports are called Tide Difference Tables. A shortened version is below:

ENGLAND, SOUTH AND EAST COASTS

No.	PLACE	Lat N	Long W	TIME DIFFERENCES High Water Zone UT(GMT)		Low Water		HEIGHT DIFFERENCES (IN METRES) MHWS	MHWN	MLWN	MLWS	ML Z_0 m
89	**DOVER**	(see page 46)		**0000** and **1200**	**0600** and **1800**	**0100** and **1300**	**0700** and **1900**	**6.8**	**5.3**	**2.1**	**0.8**	
85	Hastings	50 51	0 36	+0000	-0010	-0030	-0030	+0.8	+0.5	+0.1	-0.1	3.85
86	Rye (Approaches)	50 55	0 47	+0005	-0010	⊙	⊙	+1.0	+0.7	⊙	⊙	⊙
86a	Rye (Harbour)	50 56	0 46	+0005	-0010	§	§	-1.4	-1.7	§	§	1.97
87	Dungeness	50 55	0 58	-0010	-0015	-0020	-0010	+1.0	+0.6	+0.4	+0.1	4.13
88	Folkestone	51 05	1 12	-0020	-0005	-0010	-0010	+0.4	+0.4	0.0	-0.1	3.92
89	DOVER	51 07	1 19	STANDARD PORT					See Table V			3.77
98	Deal	51 13	1 25	+0012	+0010	+0004	+0002	-0.5	-0.3	0.0	+0.1	3.56
99	Richborough	51 18	1 21	+0015	+0015	+0030	+0030	-3.4	-2.6	-1.7	-0.7	1.42
102	Ramsgate	51 20	1 25	+0030	+0030	+0017	+0007	-1.6	-1.3	-0.7	-0.2	2.73

⊙ No data.
§ Dries out except for river water.
★ See notes on page 342.
c For intermediate heights, use harmonic constants (see Part III).
j For intermediate heights, see pages xxii to xxiv.
x ML inferred.

Layout and use of Secondary Port Tide Tables
Some important tips when using secondary port tide prediction tables:
a. Find the page for the secondary port required, they are placed geographically from The Scilly Isles in the SW and work round the UK Coast towards the East (anti clockwise)
b. Note the name of the standard port in bold print at the top of the section.
c. The position of the secondary ports attached to the standard port are given in latitude and longitude.
d. Note the time differences which must be added to (+), or subtracted from (-), the times of high and low water at the standard port; the first two columns are for high tide, the second are for low tide. Times are in GMT/UT
e. Note the height differences which must be applied to the tabulated heights of high and low waters at the standard port.
f. Interpolate the time and height differences/corrections to the standard port as is usually the case, the standard port tabulated values do not coincide with the tabulated values for the secondary port.
g. Apply seasonal variation if significant. Seasonal variation is small. However, the seasonal changes in mean sea level do not always repeat themselves from year to year and it is worth remembering there may be as much as 0.3 m of water, above or below the average.

For the secondary ports in this area there is no seasonal change.

Using the Tide Tables to find HW, LW and range at Secondary Ports

1. For the date and time required extract the standard port times and heights of tide.
2. Convert the tide times and heights for the standard port by applying the secondary port differences, which in effect creates the secondary port's tide table for the flood or ebb for that time and date.
3. Use the calculated secondary port information with the curve for the standard port in exactly the same way that was done for the standard port in the last section, effectively replacing the standard port information with that of the secondary port.

For example, a secondary port, such as Folkestone, the reference standard port is Dover:

The time differences section is laid out thus and the times are in GMT.

				H. W.		L. W.	
				0000	**0600**	**0100**	**0700**
89 **DOVER**	(see page 46)			and	and	and	and
				1200	**1800**	**1300**	**1900**
88 Folkestone	51°05	1°12		-0020	-0005	-0010	-0010

The height differences section is laid out alongside the times as follows:

			HEIGHT DIFFERENCES IN METRES			
			MHWS	MHWN	MLWN	MLWS
89 **DOVER**	(see page 46)		**6.8**	**5.3**	**2.1**	**0.8**
88 Folkestone	51°05	1°12	+0.4	+0.4	0.0	-0.1

The time differences between the standard port Dover and the secondary port are the maximum and minimum differences under normal weather conditions. The time differences for a secondary port are interpolated linearly (that is in a straight line) for a 24 hour period between the values given for the standard port Folkestone. Predictions which fall between the times given for the standard port at the head of each column can be obtained by simple interpolation between the columns.

Time differences must NOT be extrapolated but only interpolated between the given values for times at standard ports, which give values throughout a 24 hour period.
So the HW time difference that occurs at Dover at, say, 2000 has to be interpolated between 1800 and 0000.

These secondary port calculations of heights of high and low water can be entered on the standard port curve and used to find the time for a certain height or the height at a certain time in the same way as for standard ports.
To calculate intermediate heights or times proceed as for a standard port. Use the predicted range at the standard port to interpolate between spring and neap curves.

Predictions which fall between the times given for the Standard Port at the head of each column can be obtained by simple interpolation between the columns. Time differences must NOT be extrapolated but only interpolated between the given values for times at Standard Ports, which give values throughout a 24 hour period.

An example of calculating heights and times at a secondary port such as Bognor Regis, with the standard port being Shoreham and using hypothetical data as follows:

a. Times at a Secondary Port

			H.W.		L.W.	
			0500	**1000**	**0000**	**0600**
81 **SHOREHAM**	(see page 42)		and	and	and	and
			1700	**2200**	**1200**	**1800**
73 Bognor Regis	50°47	0°40	+0010	-0005	-0005	-0020

The interpolation is carried out as follows:
If the HW time was 0500 at Shoreham we simply have to add 10 minutes to 0500 to obtain the time of HW at Bognor 0510.

However, it is rarely the case that the difference table times exactly coincide with the tabulated standard port times. If, for example, we require the HW time difference at Bognor Regis for a HW that, say, was at 0800 at Shoreham. We know that at 0500 hours at Shoreham, HW at Bognor Regis is ten minutes ahead (+0010) of Shoreham while at 1000 hours it is 5 minutes behind HW Shoreham (-0500). The time we require (0800) is three hours into the tabulated five hour Shoreham period (0500 to 1000). The total tide change time at Bognor has been 15 minutes in this 5 hour period so for 3 hours the difference will have changed 9 minutes (i.e. 3 minutes per hour: 15 min/ 5 hrs = (3 min/hr) x 3 hr = 9 min). So since we are moving from a positive to a negative time difference we subtract the 9 minutes from +0010 to give +0001. Thus at 0800 the HW time difference at Bognor is +1 minutes on from the HW at Shoreham. (We could also carry out the interpolation by drawing a graph of time difference (y axis) against time of HW at Shoreham (x axis).

Thus:

0500 to 1000	= 5 hours
Correction + 10 min to – 5 min total change	= 15 min
Required 0800, that is 3 hours after 0500	
So 3/5 x 15 min	= 9 min
From 05 00 where correction is +10 min	
So = 10 min - 9 min	= 1 min correction from HW time at Shoreham

b. Heights at a Secondary Port
Height differences also need to interpolated in a similar way. The interpolation is again assumed to be linear and usually can be carried out by inspection, although a calculator can be used or a graph drawn:

			HEIGHT DIFFERENCES IN METRES			
			MHWS	MHWN	MLWN	MLWS
81 **SHOREHAM**	(see page 42)		**6.3**	**4.8**	**1.9**	**0.6**
73 Bognor Regis	50°47	0°40	-0.6	-0.5	-0.2	-0.1

From the tables, at Shoreham a MHWS tide height of 6.3 m is 0.6 m less at Bognor (-0.6m), and 4.8 m at Shoreham is 0.5 m less (-0.5m) at Bognor. Or for a change of 1.5 m at Shoreham (6.3 - 4.8), Bognor changes by -0.1m (0.6 -0. 5). Thus for any given high tide value at Shoreham we apply the Bognor correction. If, say, the HW value at Shoreham was tabulated at 5.0 m we apply a -0.5m difference to obtain HW value at Bognor of 4.5 m. We do not need to interpolate here as 5.0 m is very close 4.8 m and Bognor only changes 0.1 m.

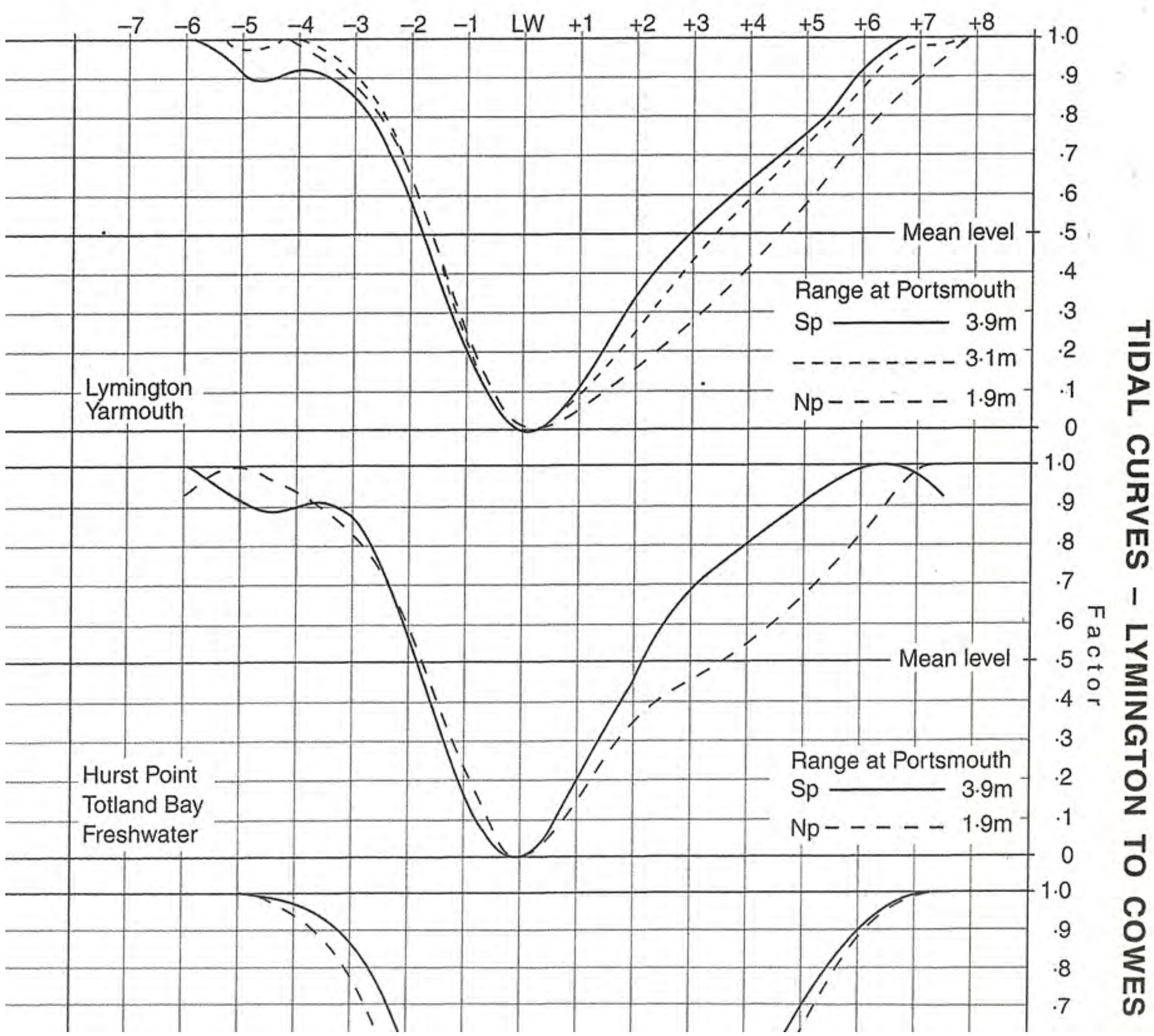
If the secondary port had a larger change we would have to interpolate. This could be carried out by plotting a graph - the height in metres for Shoreham on the bottom (x axis) and the height differences on the vertical (y axis). We plot two (x, y) points (6.3, -0.6) and 4.8, -0.5) and connect them with a straight line. We can then read off the height difference for Bognor for the height of HW at Shoreham -5.0m in this example - and apply the interpolated correction (nil in this case).

To Find the Times and Heights of Tides BETWEEN Tabulated HW and LW (Secondary Ports)
Use the calculated secondary port information with the curve for the standard port in exactly the same way that was done for the standard port in the last section, effectively replacing the standard port information with that of the secondary port.

Tidal Anomalies

There are some areas, for example the Solent on the UK's South Coast, where there are geographical features which lead to times and heights of HW and LW being harder to predict because they are not very well defined.

In this instance there are special tidal curve diagrams for use based on LW



13

Tidal streams, overfalls, tide races and bars

The level of the sea changes as the tide rises and falls. It follows that there must be a movement of water in one direction as the tide rises and a movement in the opposite direction as the tide falls. These horizontal movements of the sea surface are called tidal streams (currents in the USA). It is essential both to understand, and to be able to use, the available tidal stream information.

Consider a yacht sailing through the water at 5 knots directly against a stream of 3 knots; the yacht is actually only covering a distance over the ground of 2 nautical miles in one hour. If the yacht changes her time of departure so that she sails in the same direction as the tidal stream she would then cover 8 miles in 1 hour, which is four times as fast as the previous case.

The skipper of a fast motorboat may feel that the stream is not so important. However, if the boat in the examples above had been travelling at 20 knots through the water it would have covered 17 miles motoring against the stream and 23 miles motoring with it, a difference of 6 miles in each hour. The resultant saving in time and fuel costs must be worthwhile.

The effect of tidal stream during the past hours must be taken into account when working up an estimated position. Also you must also be able to find information for future hours so that you can plot a course to steer which will counteract the sideways movement of the predicted tidal streams.

Tidal streams are of considerable significance in some places where circumstances may give rise to conditions making a passage difficult, or perhaps impossible, at certain times during the flood or ebb stream. This is particularly the case where headlands project from the coast with the result that the tidal stream will speed up to get past.

Tidal Stream definitions

Flood stream

When the tide is rising, the flow in is called the flood stream.

Ebb stream

When the tide is falling, the flow out is called the ebb stream.
The tide may be said to be “flooding” or “ebbing”.

Rectilinear Tidal Streams

When the stream flows through relatively narrow channels it flows firstly in one direction and then reverses and flows in the opposite direction; tides that flow in two directions like this are known as rectilinear.
During the flow in each direction the speed, or rate, of the stream increases from 0 knots at high water slack, reaches its maximum speed about midway between high and low water slack and reduces to 0 knots again at low water slack.
Slack water occurs between the changes of direction with rectilinear currents.

Dover Straits is an example of “narrow channel”, the flood stream flowing generally in one direction and the ebb stream flowing back in the opposite direction. The tide runs parallel to the land which forms the physical barriers on either side.

Spring and neap rates

The currents will reach their highest speeds, or rates, during spring tides because a greater quantity of water must move between high and low water than at neaps, when the rate is least.

Bays Harbours and estuaries

Tides flood and ebb into and from bays, inlets, harbours and river estuaries and sometimes these tidal flows can be strong.

Tidal rips and overfalls

Strong currents rushing over rough or shoaling sea beds generate turbulence causing rough surface conditions with short steep waves. These rips and overfalls are often marked on the chart with a series of wavy lines and a note describing at what state of the tide they are most dangerous

Fig 1
Tidal Race, The Swinge, Alderney

Tidal races

Where the current is forced through a narrow restriction the rate of flow will increase and may create races which can often be dangerous to small boats under certain conditions. Currents in tidal races can reach or 9 knots and even more.

Wind against Tide

Waves are caused by wind blowing across the surface of the water. Waves will become larger as a result of the wind strength, time it has been blowing and the longer the stretch of water (fetch) it has been acting on. If the stream and wind are in the same direction then the waves tend to be smaller, but if the opposite is true, wind over tide will lead to choppy and short seas sometimes that can be very large and therefore not only uncomfortable but even dangerous.

Tide data Set and Drift
Set (Direction)
The direction is always given in degrees True and indicates the direction towards which the tidal stream is moving. For example if the direction is given as 90° the tide is flowing from west to east, if the direction is given as 180° the tide is flowing from the north towards the south.

Rate
The rate is the speed at which the stream is moving and it is given in knots. A rate of 2 knots means that the stream is moving a distance of 2 miles in one hour, 1 mile in 30 minutes, ½ a mile in 1 minute and so on. Two rates are normally given, the fastest being the rate for spring tides and the slowest is the rate for neap tides.

Drift
Drift is the distance that current has moved a vessel off its course. It is what people refer to as XTE (X Track Error).

Sources of Tidal stream information

This information may be available from different sources:
1. Tide Tables
2. Tidal stream arrows sometimes printed on charts
3. Tidal Stream Atlas chartlets
4. Tidal Stream Data for Magenta Diamonds printed on charts
5. Pilot books and cruising guides
6. Tide software/ internet (electronic tidal planners)
7. From practical observation

Tidal Gates

A Tide Gate is the term used to describe an area of coastal water where the tidal stream will at certain times make progress in a given direction difficult or conversely will help a vessel on her way. Usually associated with headlands, shallow patches of water and narrow channels where the tidal steam is concentrated and the speed of flow becomes greater than in open water.

A yacht or powerboat on passage may have to negotiate such areas and the timing of the arrival will have extreme significance on the passage as for example, the Dover Straits. Any boat leaving Folkestone using the North inshore Traffic Zone and make a passage North East when the tide is flowing in the same direction will have the benefit of the tidal stream helping her and her speed will increase by the speed of the flow. Arrive too late and the tidal stream will be flowing against the yacht which will slow her down. If the stream is fast and the yacht is tacking, then she may well be set back rather than gaining ground towards her destination. It may pay the yacht to anchor in a bay until the tide turns again.

The influence of wind may also affect the gate timing, if a fast tide is flowing against the direction of the wind it will cause waves to become steeper and possibly start to break, creating dangerous conditions, which effectively close the tide gate

A second issue is weather, if the wind is strong and blowing against the flow, the seas will become very step and confused even to the point of being dangerous. Thus a careful consideration of timing and expected weather MUST be part of careful passage planning.

A third consideration that the navigator must take into account is the effect of tidal flow into bays etc., and how this might affect the vessel, particularly if there are isolated dangers to be avoided, or the possibility of becoming embayed in a sailing yacht where a sailing vessel is set into the bay by both wind and stream, making it very difficult or even impossible for her to beat her way out.

Passage Planning

Planning the passage is therefore critically important, to catch the gate/s open, so as to benefit from the tidal stream going in the same direction as your vessel and avoid the problems of missing the tidal gate when a vessel will have to go against the flow.

The prudent navigator will carry the tide to his/her advantage and then will wait out the contrary flow until the turn back to the advantageous flow before venturing further.

Harbour Bars

A bar often forms at the entrance to a harbour or river estuary and will make a shallow and narrow area where the tidal stream will be concentrated. The effect of this bar with the wrong conditions can cause it to become dangerous with steep waves breaking right across the entrance. Bars can and do shift and change shape.

Crossing any bar should always be treated with caution, particularly when the tide is running strongly and there is an contrary wind. Even when there is little or no wind, any waves running into the entrance will be enlarged as it crosses the bar, especially if there is a river flowing outwards. Always allow for plenty of water under the keel by picking the crossing time at or close to the top of the tide. Even if the tidal information indicates there is plenty of water, remember that there will be significant waves and therefore that there will be less than that the expected level of water within the troughs.

Do not cross a bar in an unsuitable boat. Plenty of power is required to cross any bar and the waves likely to be encountered.

There are many factors to consider when preparing to cross a bar including having a suitable craft, local knowledge and the experience and preparation should a mistake happen. Therefore consideration should be given to:

Tide

The ebb tide is usually the most dangerous with the fast flowing water colliding with the incoming waves creating short and steep waves often breaking. Add to this the problem of water getting shallower as the tide drops thus creating a more dangerous situation.
A flooding tide is usually the preferred time to cross a bar either way.

Localised conditions such as heavy rain and flooding can add to additional volumes of water flowing through the entrance and there may be the added problem of floating logs and debris being swept out to sea over the bar.

Wind

A bar is affected by wind direction. An onshore wind with a flooding tide onshore wind tends to flatten the incoming waves. An offshore wind will have the same effect on the ebb tide but create dangerous waves during a flood tide.

Local Knowledge

The position of the bar changes and even the most up to date books and charts are likely to be out of date. Check with local Harbour Authorities, rescue organisations, fishing and diving professionals and find out if markers are out of position or sandbanks are on the move.

Crossing

Take white water square on with power applied to lift the bows, but not too much power causing the boat to launch. If possible avoid the peak where a wave is breaking. This minimises the chances of being knocked sideways and rolled. Take rolling swells at an angle and back off the speed as the vessel reaches the crest. When entering with the waves keep the vessel if possible on the back of the wave, and avoid surfing at that may well lead to a broach and roll over.

14

Currents

Currents
Ocean currents are generated by forces other than tides (such as wind, Coriolis, gravity and water density) but are also often of great importance to the navigator. Generally speaking currents run continuously in the same direction.

There are two types of Ocean Currents:
1. Surface Currents which are basically the top layer of the ocean (the upper 400 meters) and it is these that the navigator must be aware.

2. Deep Water Currents move around the ocean basins by density driven forces and gravity and do not affect the navigator.

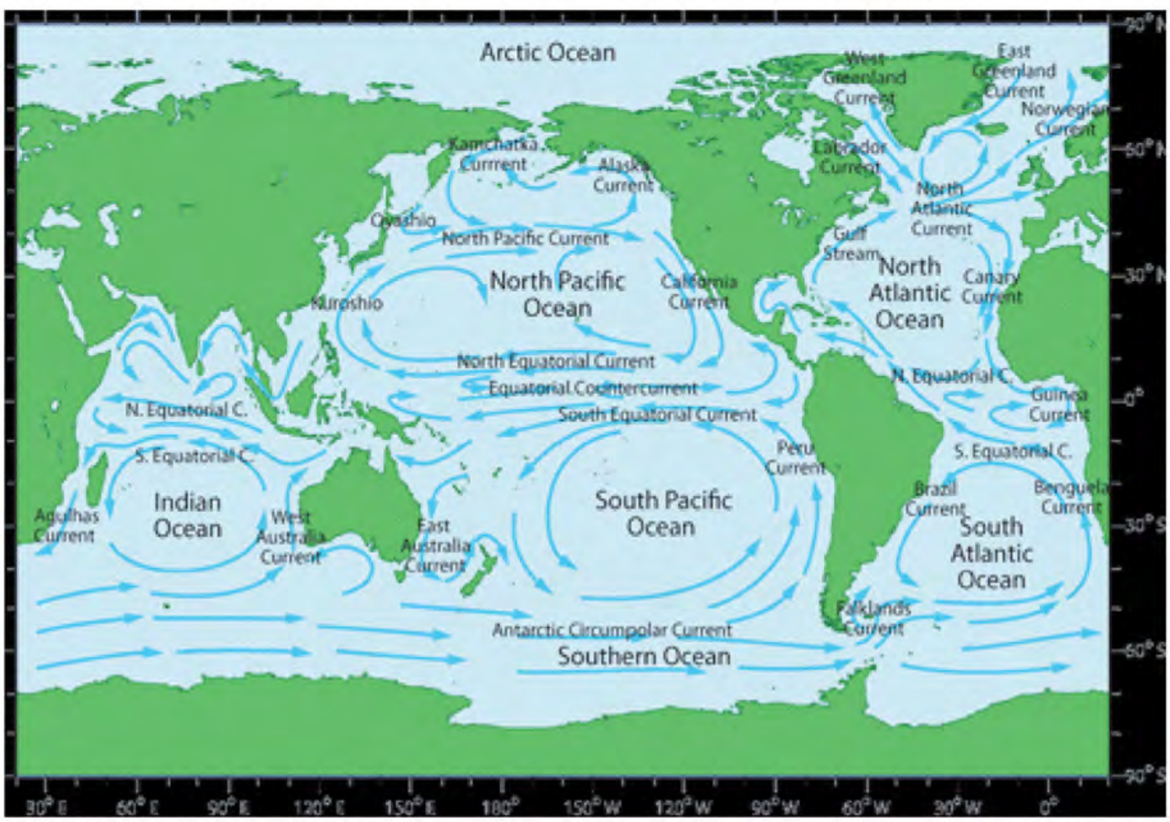


Fig 1
World Currents

In addition to the effect of a vessel's speed over the ground, a current, with wind blowing in the opposite direction can set up very bad seas; an example of where this is especially true is the Agulhas current off the South East coast of South Africa, and where occasionally so called "super waves" occur under the right conditions.

Where currents meet headlands or islands, which has the effect of restricting the flow of water, will result in a considerable speeding up of the current, which again has a significant effect on a vessel's speed.

Currents can be warm if they come from the tropics, or cold if from the higher latitudes. This in turn may have an effect on the weather, for example the cold California Current helps to produce the notorious fogs in San Francisco where warm moist air gives up its moisture on contact with the cold water of the current. The same is true off Newfoundland where the warm Gulfstream meets the cold air from the arctic, resulting in dense fog there, sometimes for days at a time. Reduced visibility is obviously of impact to the navigator.

Other examples of currents include the Gulfstream running up much of the east coast of the U.S. and eventually over to the shores of the UK, (where the British Isles benefit from a much more benign climate than would normally be expected at the same latitude, due to the warming effect of the current).

Current information can be obtained from the various Pilot Books as well as being marked on charts. The speeds and directions are given to allow the navigator to estimate the effect on a passage when planning a route.

15

Dead Reckoning and Estimated Positions

Dead reckoning comes from the term deduced reckoning which, in days gone by, used to be written as “ded. reckoning” in the ship’s log book. Dead reckoning is a procedure for deducing the ship’s position when no other means of visual or electronic position fixing is available. A DR position is deduced from the course steered and the distance travelled since the last reliable position fix.

DR position

The DR position is worked up as follows:

1. From the last known position draw a line along the course steered since leaving that position.
2. Mark off the distance travelled along this line since leaving the last known position.

The course steered will be known by the helmsman and should be entered in the ship’s log book. The distance travelled will be found from the ship’s distance log and should also be entered in the log book. As was mentioned earlier the distance log reading should also be written beside the last fix drawn on the chart. Take as an example the following “extract” from a yacht’s log book:

Time	Position	log	Course (C)	Wind
1300	36°54’.3 N 75°42’.8 W	300		SW 2
1400		306.5	104	SW 3

Suppose just after the position was fixed at 1300 heavy fog closed in and nothing has been visible since then. What is your position at 1400? The course steered from 1300 to 1400 was 104° (C) which is 093° (T) as the variation is 11° W and this boat has no deviation. The distance travelled since the last fix is the log reading at 1400 minus the log reading at 1300 = 6.5 miles.

The boat has therefore travelled 6.5 miles along a course of 093° (T) since the position fix at 1300.

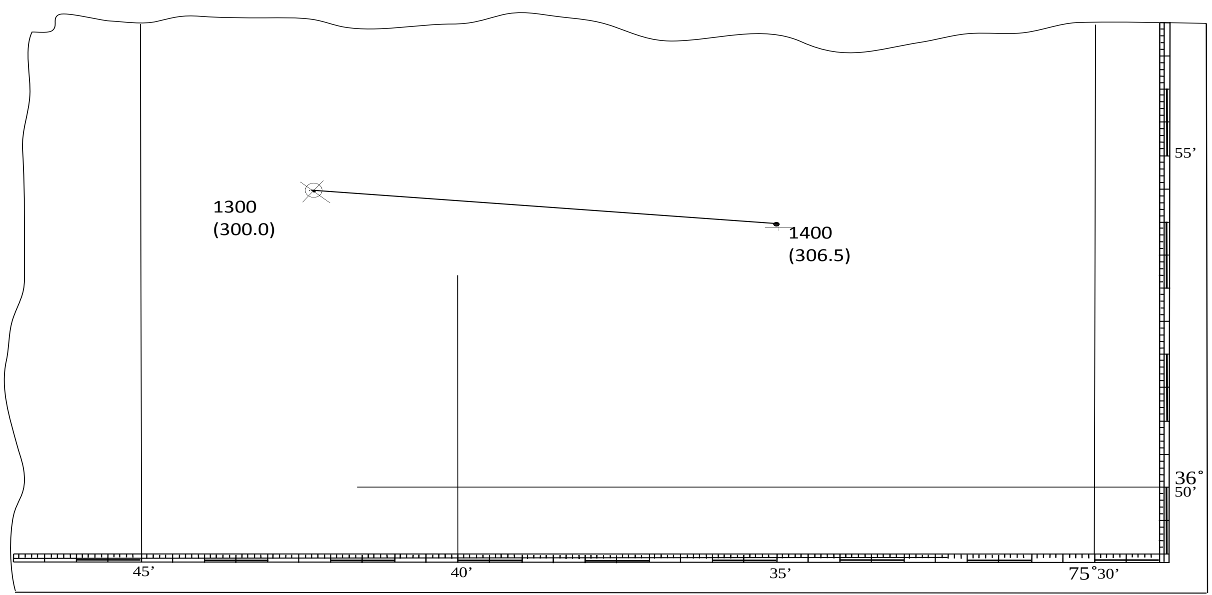


Fig 1

The DR is plotted and the time and log reading written on the chart.

A position derived from dead reckoning is only really valid if:

- there is no tidal stream to carry you off course;
- there is no wind to push you sideways (leeway);
- your distance log is accurate;
- there is no helmsman's error, and,
- the helmsman is not trying to cover up the fact that he drifted off course several times!

Estimated position (EP)

An estimated position expands on the basic DR to include in the plot the following quantifiable variables, where known, so that the best possible estimation of the position may be determined.

1. Tide set and drift is the direction and distance the tidal stream has moved the water and hence the boat during the time involved in the EP. Set and drift is found from the chart using tide diamonds, Tidal Stream Atlas and from an Almanac. Note that current direction is always given in degrees True.

2. Leeway is caused by the boat being pushed sideways as well as forwards by the wind. Motor boats with high topsides and flying bridges suffer leeway as well as sailing boats. Amongst the factors which decide how much leeway a boat will suffer are hull/keel shape, area of rigging and superstructure, wind strength and direction, course relative to wind direction (leeway is maximum close hauled, zero when head to wind or running), angle of heel (keel efficiency decreases as angle of heel increases) and sea state.

There is, unfortunately, no rule of thumb to define how much leeway a particular boat might make. One suggestion for checking leeway is to sight along the boat's wake with a hand bearing compass and compare its reading with the (reciprocal of) the steering compass.

Leeway can be as much as 20° or even more in some instances.

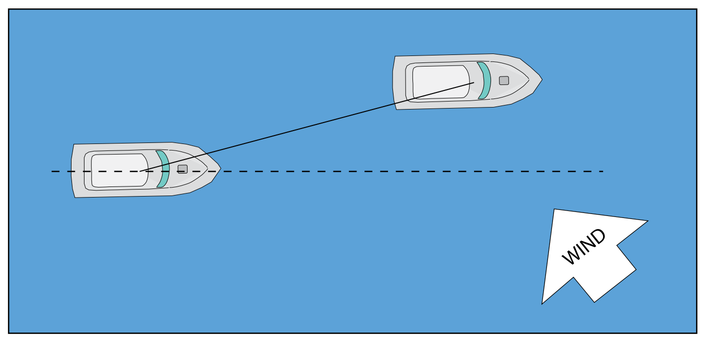


Fig 2

Steps in working up an EP

1. Apply estimated leeway to the True course steered to find the "water track";
2. From the last known position draw a line in the direction of the water track;
3. Mark off the distance run along the water track;
4. From the end of the water track draw a line representing the current set and drift.

This tidal stream vector (a vector is a line which has both direction and length) is drawn in the same direction as the tide was moving and its length is the distance in miles the stream has moved during the period of time for which the EP is being plotted.

For the sake of the example which follows below it is assumed that the tide was flowing 182° (T) at rate of 1.2 knots. This means that in 1 hour the tidal stream will have moved the sea surface, and therefore the boat, 1 mile in the direction of 182° T; this can be written simply as 182°/1M.

Example of an EP using an extract from a yacht's log book:

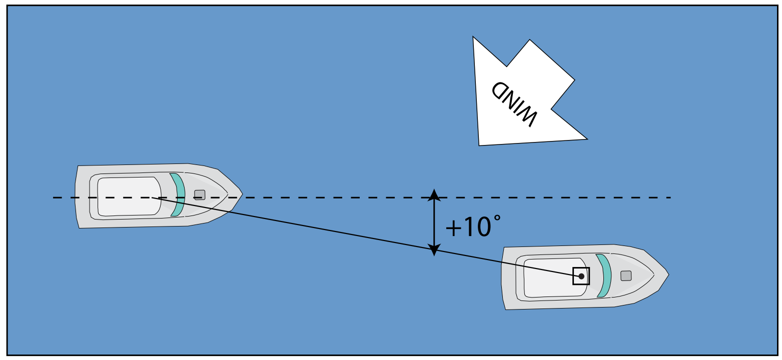
Time	Position	log	Course (C)	Wind	L'way	Current
1300	36°54'.3 N 75°42'.8 W	300	165°	NE 18	nil°	
1400		306.5	100°	NE 18	10°	182°/1.2 M

Plot the yacht's position at 1400.

Do all the 'maths' first, then the plot.

Course	100° (C)
Deviation	+ 4° E
	= 104° (M)
Variation	- 11° (W)
	= 93° (T)
Leeway	+ 10°
	= 103° (T)

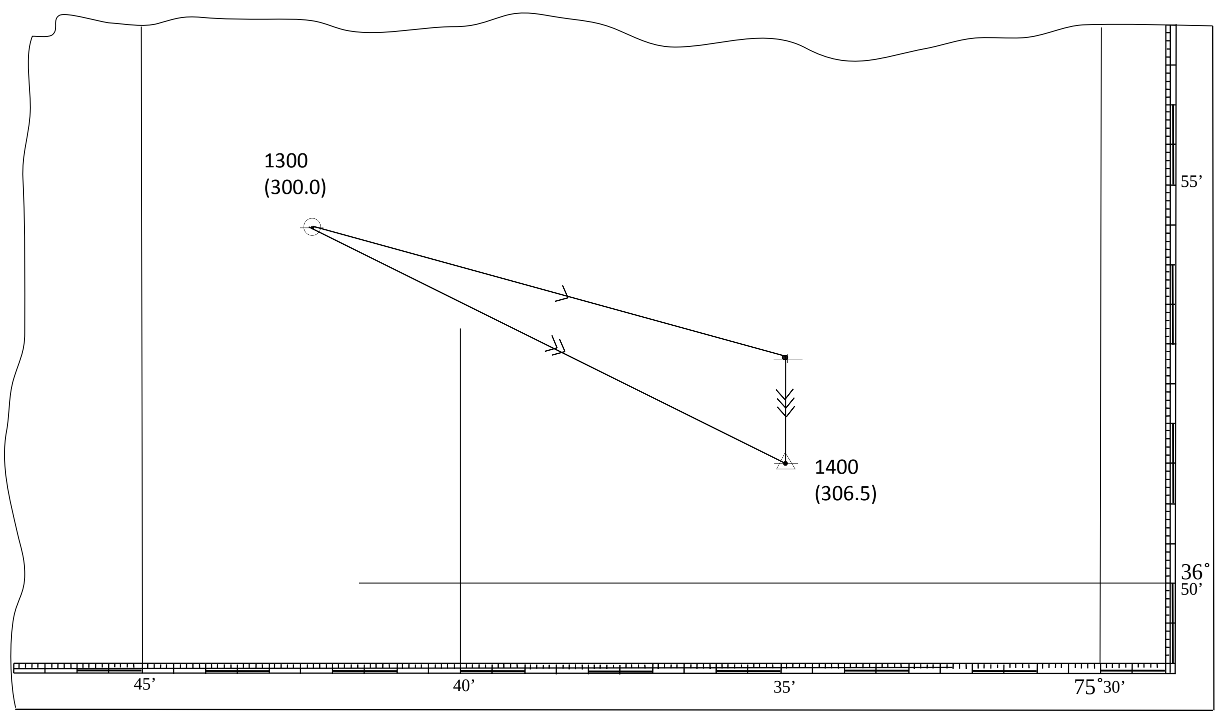
Log at 1400	306.5
Log at 1300	300.0
	= 6.5 Miles



Leeway was estimated at 10°. As the wind was from the Northeast it will have pushed the boat 10° to the south of its true course, i.e. +10°

Now, from the position at 1300

1. plot a vector 103° (T) / 6.5 M, and then, from the end of this vector,
2. plot the tidal stream vector 182° / 1.2 M.



Note that the water track is marked with one arrow, the ground track with two arrows and the tidal vector is marked with three arrows. The Estimated Position is shown by a triangle with a dot in the centre at the boat's position. Usually with an EP the only requirement is to find the estimated position so the ground track would not normally be plotted.

So far the examples have been for periods of one hour which require only one tidal vector to be drawn representing the set and drift of the stream. Most passages will take longer than an hour and will also probably involve course changes due to wind direction, hazards to be avoided and so on. An EP involving multiple course and tidal stream changes can be worked up in one of two ways.
The first way is to plot the course, distance and tidal stream separately for each individual hour and the second way is to plot all the courses and distances first and then plot all the tide vectors together.
Obviously each method must give the same final EP but the second approach is by far the easiest to plot, to read and to correct if mistakes are made. The two examples below show the result of plotting an EP using both methods based on the following 'log book' extract.

Time	Log	Course (M)	Wind	L'way	Position
1300	307.0	061°	W2	0°	Fix 36°54'.3 N 75°42'.8 W
1400	309.8	061°	W2	0°	a/c to 141° (M)
1500	313.8	141°	W3	0°	a/c to 061° (M)
1600	318.0	061°	W4	0°	EP at 1600?

The vectors which must be plotted to find the EP are: from 1300 to 1400: water track = 050° (T)/2.8 M; current = 174°/1.0 kn, from 1400 to 1500: water track = 130° (T)/4.0 M; current = 164°/0.9 kn, from 1500 to 1600: water track = 050° (T)/4.2 M; current = 172°/0.8 kn. (The current direction and rate given are just for the sake of this example.)

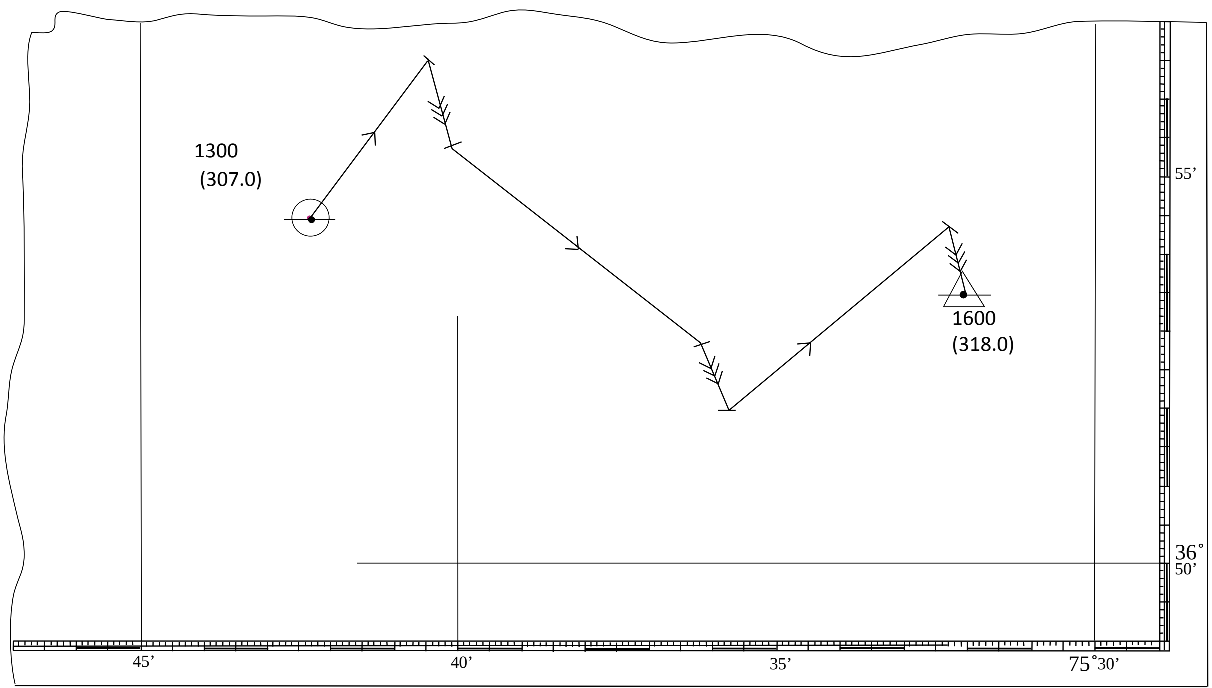


Fig 4
Water track and current vector plotted for each individual hour

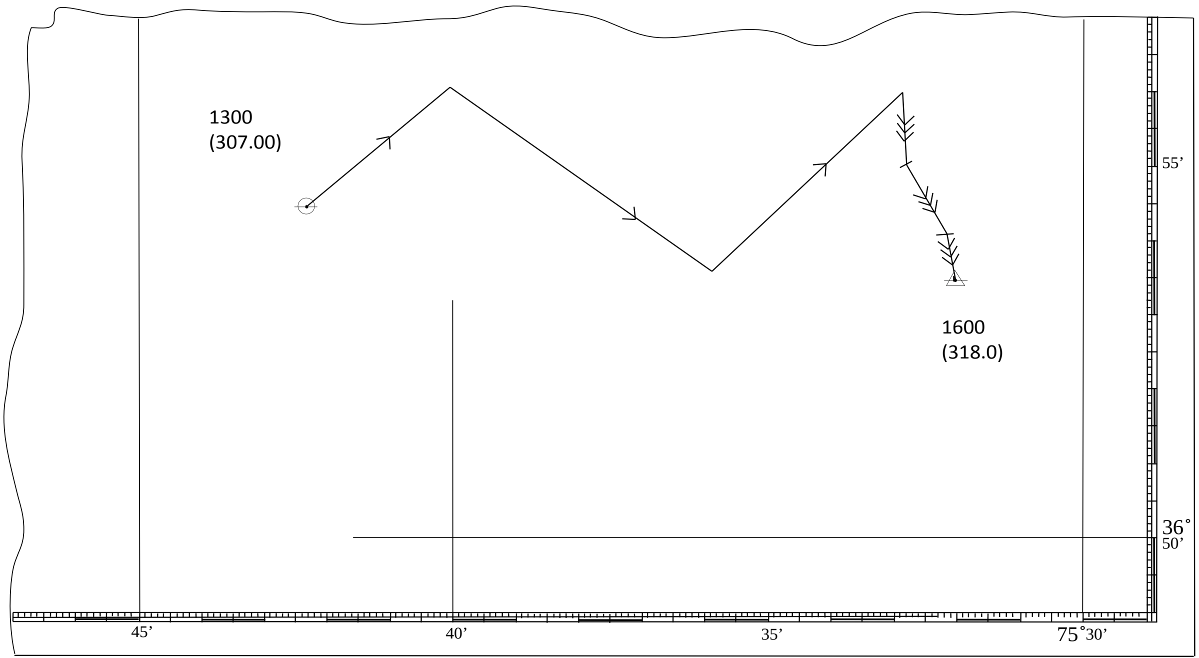
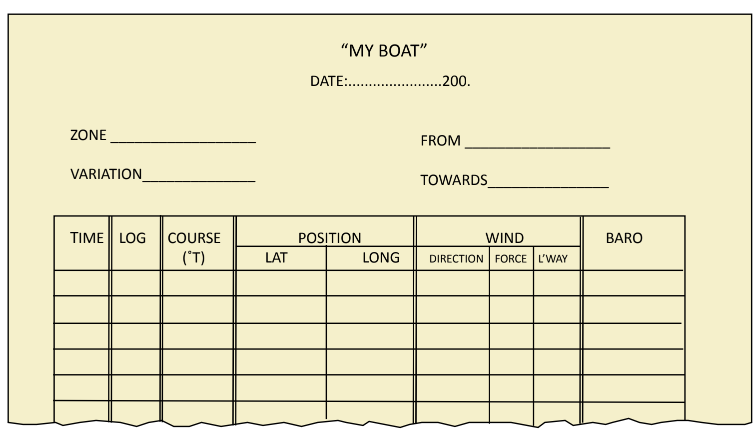


Fig 5
Water tracks plotted first, then all the tidal vectors.
The EP position is the same as that in Fig 4

The Log-Book
A small boat’s log-book, or log, is the book in which the information relating to the ship’s progress is recorded. Anything of navigational importance that has occurred on passage which may be required by the navigator must be recorded in the log-book.
Originally two black painted boards were used, the distance log reading being recorded on them using a piece of chalk. The boards were hinged so that they could be closed like a book to protect the writing and were known as ‘log boards’.
Remember that entries in the log-book relate to what has happened not what you would like to happen; in other words you will record the course which has been steered for the past hour, not the course that you hope to steer for the next hour.

Log-book headings
Log-books should be kept as simple as possible with only information of use to the navigator being entered.
Necessary headings are:
- Time
- Log (distance) reading
- Course steered
- Position
- Wind Direction
- Wind Strength
- Estimated Leeway
- Barometer Reading

The time of the entry is entered in the time column and then the reading from the boat’s distance log.


“MY BOAT”
DATE:......................200.

ZONE ___________________ FROM ___________________
VARIATION______________ TOWARDS_______________

TIME	LOG	COURSE (°T)	POSITION		WIND			BARO
			LAT	LONG	DIRECTION	FORCE	L’WAY	

Fig 6
Example of yacht’s log-book layout

The course steered is the average course steered since the last entry and the position is the boat's position at the time of the entry. The position could be entered as latitude and longitude or, alternatively, if the boat is close to a known object or buoy this can be recorded as the position, e.g. "Varne Light Vessel abeam to port 1/2 mile". The latter method avoids the possibility of making an error when writing out the latitude and longitude figures, the position is very easy to check on the chart and, furthermore, makes the log much more enjoyable reading later on.

The wind direction is usually recorded in general terms such as W (west), NW (north west), etc. and the wind strength is usually entered using either knots or Beaufort Force numbers, thus an entry for a force 5 wind from the north east would be "NE 5". The wind direction and strength entered are once again since the last entry in the log-book and are required so the navigator can decide what allowance must be made for leeway, if any.
The barometer reading is not required for navigation but is very important as local weather trends and changes will be indicated by changes in barometric pressure. The pressure is recorded from the barometer in inches or millibars at the time of the entry.

The first entry of a passage in the log will give the time, log reading, barometer and departure point but there will be no entry under Course as no course has yet been steered. From then on, depending on conditions, entries will be made in the log-book perhaps every hour for displacement boats and more often for fast boats.
Any alteration of course must be recorded as for example when a yacht tacks or a motor boat has to alter course for some distance to avoid a fishing fleet in its path. A log-book should also have space for 'remarks' where anything of interest can be recorded.

For a motor boat it is a good idea to include a space for 'Fuel' to record how much fuel is on board at the start of a passage and how much was taken on during the passage.

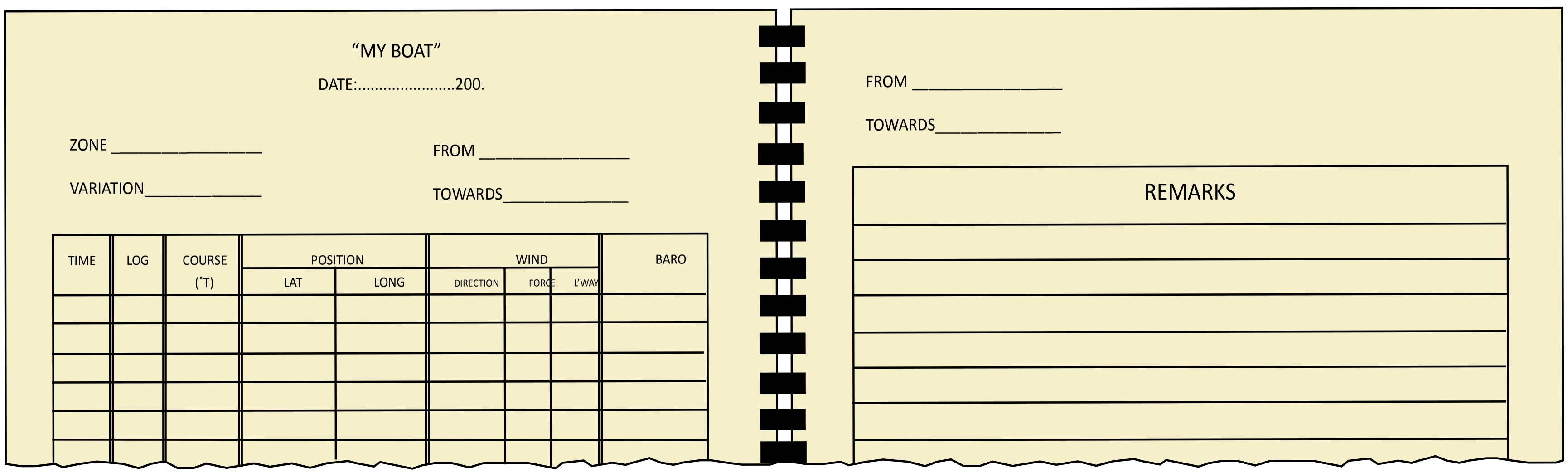


Fig 7
Suggested Yacht's Log Book Layout

16

Position Lines and Position Fixes

A navigator is never lost but he may be unsure of his position. Every opportunity should be taken to verify your position at sea even (or perhaps especially) when modern day electronic position fixing equipment, such as GPS is being used. Different methods and combinations of methods can be used to obtain a position fix, with varying degrees of inherent accuracy, but all methods use the principle of position lines in one form or another. Remember you may well be at risk if you are sure of your position and are wrong whereas if you are unsure of your exact position you will proceed with caution until you can verify your position.

Position line

A position line is a line somewhere along which the boat's position lies. One position line on its own cannot define position without additional information but in passing note that a single position line can be very useful, as although it does not tell you where you are it can confirm where you are not. For example a single position line can reassure you that you are not close to some danger if the position line, when drawn on the chart, does not run close to that danger.

Position lines are obtained from natural or man made objects or landmarks which are both conspicuous and shown on the chart. When deciding on an object from which to obtain a position line you must be absolutely certain that you know exactly which object you are looking at. Church spires can be a problem because there are often more than one in a small area and it may be impossible to decide from a distance which is which.

Visual position lines

A position line can be obtained by taking a bearing of an object with a hand bearing compass.

Other types of hand held compass are available including an electronic type which shows the magnetic bearing in digital form on a screen.

Having taken the bearing write it down so it is not forgotten and correct the magnetic bearing to True by applying variation. Now draw a line along the true bearing from the object on the chart. This line is a position line and the boat's position must lie somewhere along it. No correction was included for deviation as it is reasonable to assume that the handbearing compass was used from a deviation free position on the boat.

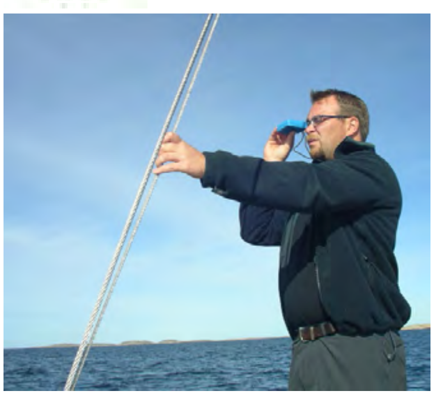


Fig 1
Taking a bearing of a light house using a hand-bearing compass.
Here the bearing to the light house from your position is 285° (C)

Using the Breton plotter to plot the bearing on the chart.
First correct the compass bearing to true:

T	V	M	D	C
274°	11°W	285°	0°	= 285°

The true bearing is therefore 274° (T).

1. Turn the protractor until 274° is opposite the 0 mark engraved on the plotter body *and from now on do not move the protractor disc from this position.*

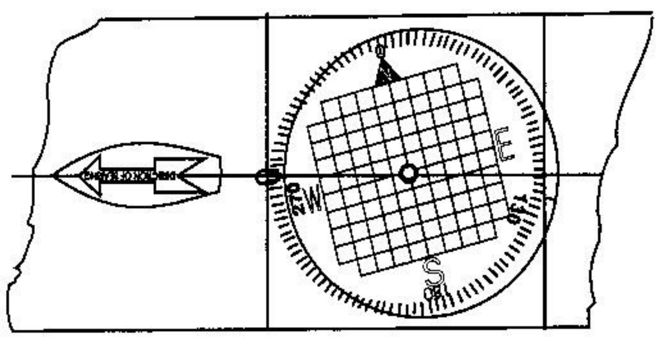


Fig 2
Protractor disc set to 274°

2. Put the plotter on the chart so that one edge is on the object from which you obtained the bearing - In this case the Lighthouse in Fig 1.
3. Turn the *whole* plotter until the North point on the protractor is pointing roughly to north but remember not to turn the protractor disc relative to the plotter body.
4. To ensure the plotter is pointing exactly north move the *whole* plotter until any one of the engraved grid lines is parallel to any convenient line of latitude or longitude printed on the chart.

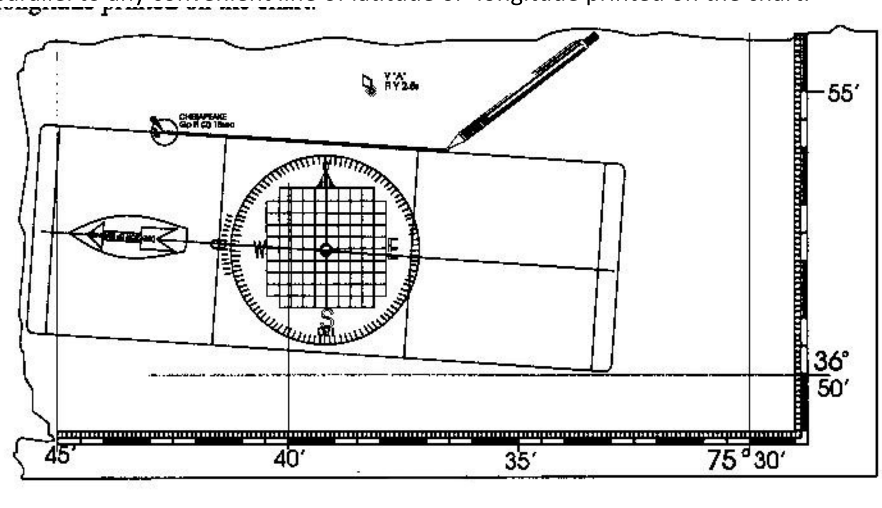


Fig 3
When the plotter is lined up correctly the position line is drawn on the chart

Before you draw the position line check that the direction arrow engraved on the plotter is pointing in the right direction, that is in the same sense as you took the bearing. If the direction arrow were pointing in the opposite direction you would be using the plotter upside down and the south point of the protractor would be pointing to chart north; this is an easy mistake to make until you become used to using the plotter.

Position Fix

A single position line does not, on its own, fix your position but if a second position line from a different source can be found it will give a position fix. Suppose at the same time that you took the bearing from your position to the Lighthouse, you also found that the bearing from your position to the yellow buoy "A" was 005° (C).
Correct 005° (C) to True (365°- 11°) = 354° (T).
Set the plotter to 354° and plot the position line through buoy "A" as before. Your position, at the time the bearings were taken, is where the two position lines meet.

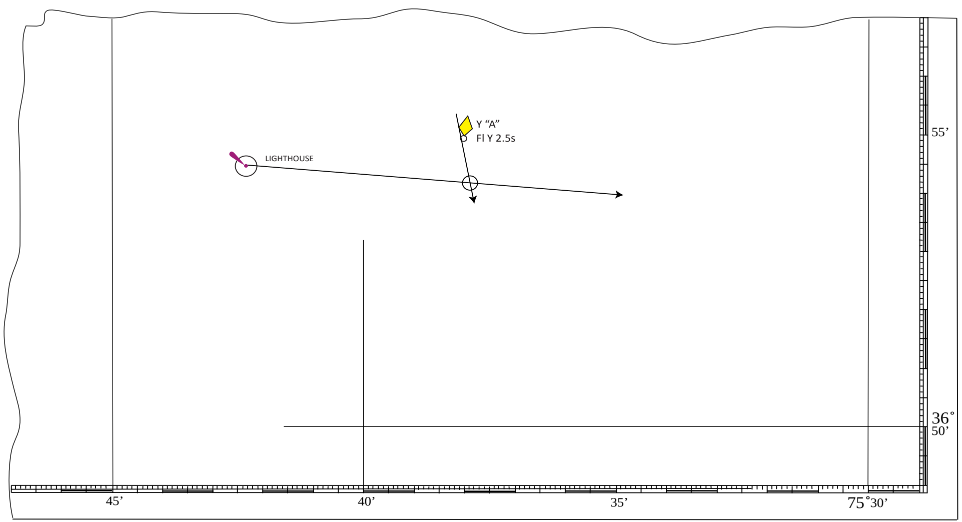


Fig 4

The boat's position is where the two position lines cross. These position lines have an arrow drawn at the end to indicate that they are position lines. The position fix is shown on the chart by the circle.

Whenever possible try to get a third position line as this will confirm your position or alternatively alert you to a possible error.

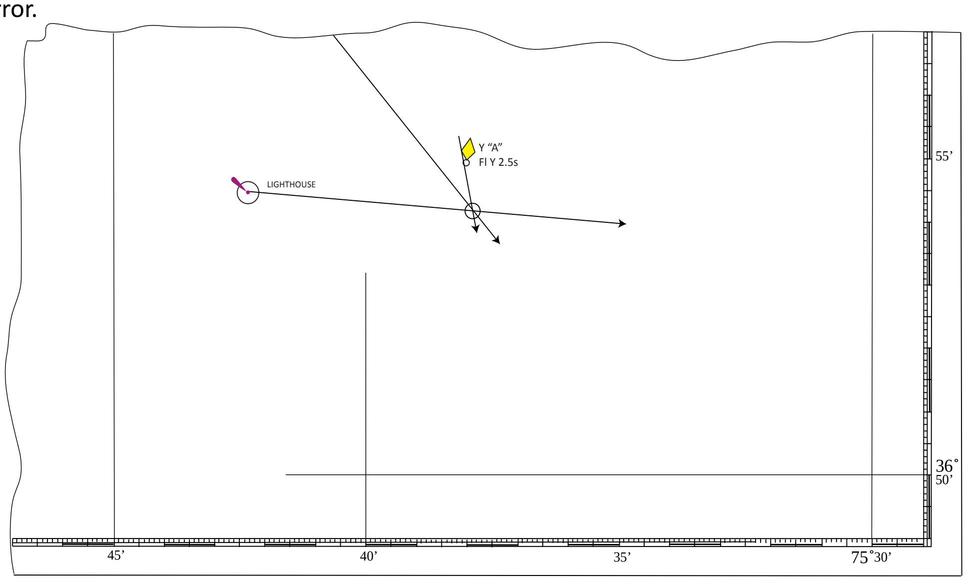
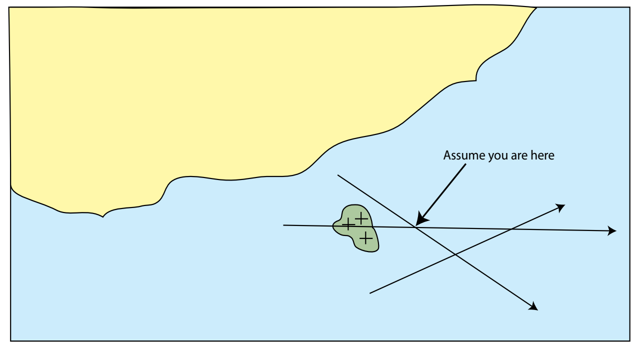


Fig 5 Three position line fix.

It is unlikely that three or more position lines will all intersect at the same point, rather they will form what is called a ‘cocked hat’. The size of this cocked hat should give you an idea of how reliable the fix is. Do not assume that you are in the centre off the cocked hat; it is much safer to assume you are at the position in the cocked hat that is closest to danger, and act accordingly, if danger exists.



Taking bearings at sea

Be careful! It is all too easy to forget to hold on when concentrating on taking bearings, even in calm weather an unexpected wash from a ship can make you lose your balance and go overboard.

Have a good look around to see what objects will be best and give a good angle of cut, an angle of about 90° is ideal for two position lines, 60° for three. Make sure you can positively identify their positions on the chart.

Take the bearing of each object and write down the name of the object and its associated bearing at once. If you don’t write them down straight away you may not remember which was which or forget the last bearing and have to do it all again. Write down the time of the fix and the mileage on the vessel’s distance log.

Go to the chart table, correct the bearings to true and plot the position lines. Beside the fix on the chart write the time of the fix and the mileage recorded on the ship’s log. The time and log readings are very important because you may well have to refer back to the fix some time in the future; if you don’t know how long it is since the last fix was taken or how far you have travelled since then the fix will be of no value.

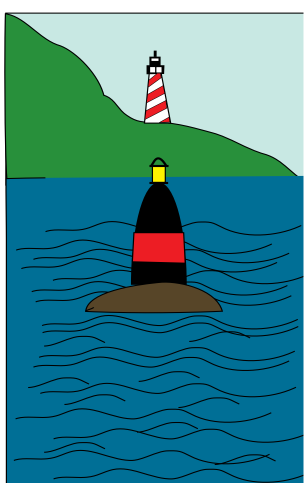
Sources of bearings

- Bearings can be taken of almost anything that is conspicuous, charted and unambiguous, for example:
- Light houses are usually easily seen by day and of course their light is visible at night.
- Buoys, beacons and marks are nearly always charted but they can move during storms. Make absolutely certain that the buoy you are taking a bearing of is the one you think it is.
- Water towers, TV towers, chimneys, aerials and church spires.
- Mountain tops, hill tops and small islands can be used if they have a clearly defined high point. Headlands can also be used if they are steep to, but not if they slope down gently.
- Conspicuous buildings such as forts and castles are often charted

Transit / Range

A transit (or range) occurs when two charted objects are seen by eye to be directly in line. A transit does yield a very accurate position line which may be plotted directly on to the chart without having to use a compass or do any calculations. Objects used to form a transit should not be too close together.

If you can get a compass bearing of another object with a good angle of cut at the same time as the transit occurs you will have a fix. This is easier with two people; one to watch for the transit and the other to take the bearing of the third object when told to.



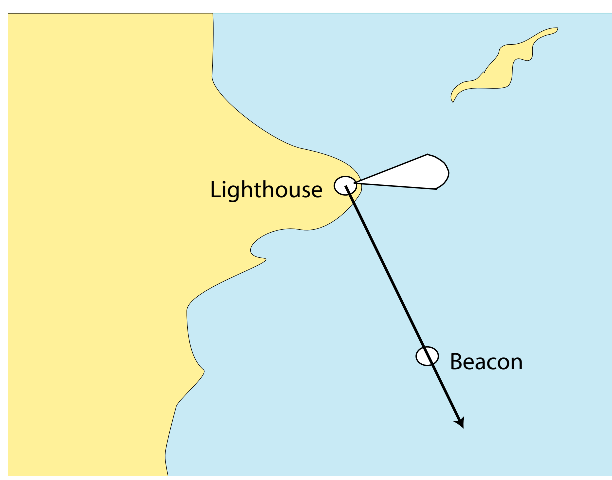


Fig 6 A transit / range

As it is seen from the boat

As it is plotted on the chart

Fix by Transit and bearing

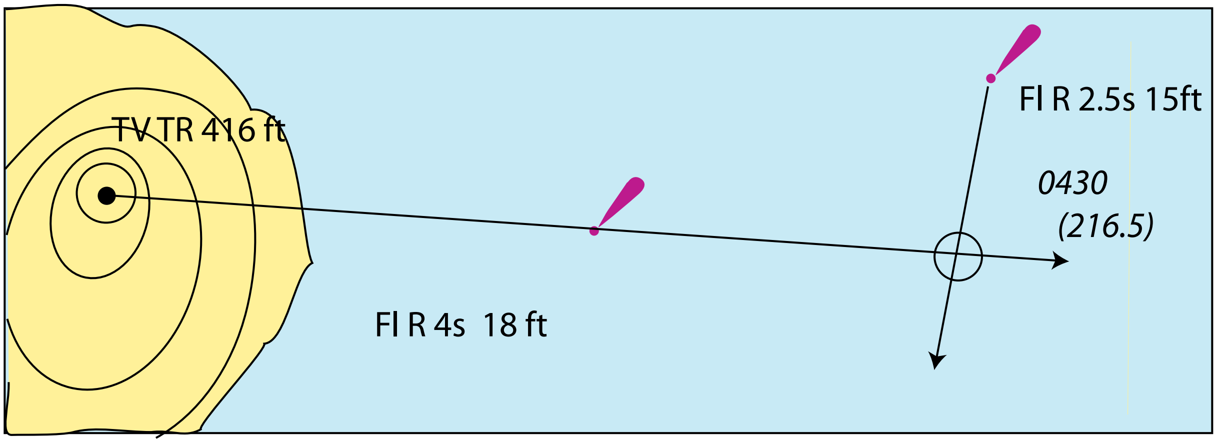


Fig 7
A fix by transit and simultaneous bearing of light structure. Note that a fix should always include the time and distance log reading at the time of the fix. To avoid confusion the log reading is in brackets.

Sectored light
Some light houses have sectored lights. The light changing colour when seen from the boat indicates that the boat is on the position line between the two sectors printed on the chart. Note that the use of red as a colour does not necessarily signify danger - check on the chart.

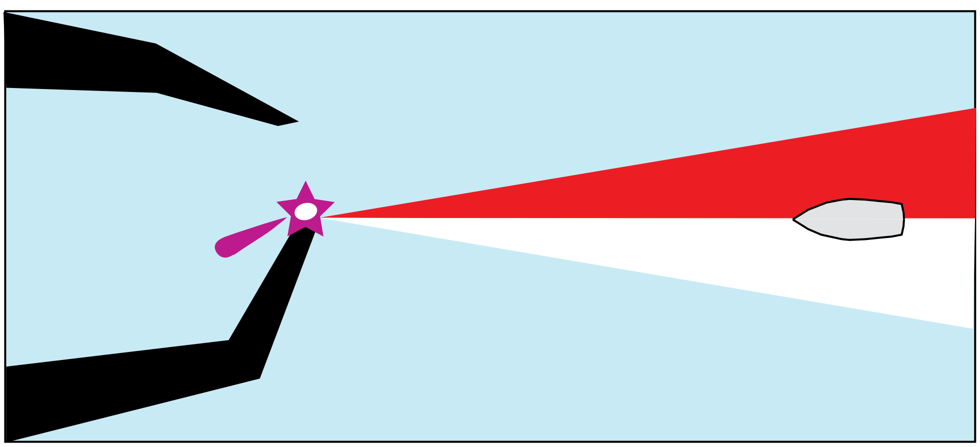


Fig 8
Position line from sectored light.

Clearly defined depth contour
If the seabed shelves rapidly it may be possible to use a depth contour as a position line. To be precise the height of tide should be taken into account. This method is seldom accurate and should be used with extreme caution.

However, it is definitely good practice when plotting fixes from any source, to check the depth on the chart against the depth shown on the boat's depth sounder.

Position circles

If the distance from a charted object can be found your position must lie somewhere on a position circle centred on the object with a radius equal to that distance.

Distances from objects can be found by using optical measuring devices, radar, and a sextant.

The distance from a lighthouse can also be found at night by using a simple table printed in nautical almanacs and Light Lists. To use this table it is only required to know the height of your eye above sea level and the height of the light above sea level. The light is watched until it is exactly on the horizon and the table gives the distance from the light at this moment. The position circle can then be drawn from the centre of the light on the chart. A bearing of the light at the same moment will give a fix, as would a position line from any other source.

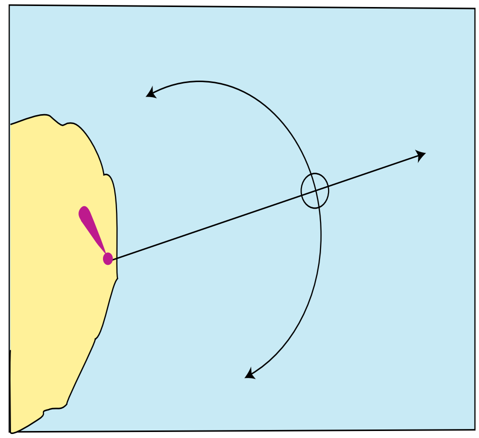


Fig 9 Position circle and LOP

Distance off table

LIGHTS - distance off when rising or dipping (M)							
Height of light		Height of eye meters 1	2	3	4	5	6
		feet 3	7	10	13	16	20
Metres	ft						
10	33	8.7	9.5	10.2	10.8	11.3	11.7
12	39	9.3	10.1	10.8	11.4	11.9	12.3
14	46	9.9	10.7	11.4	12.0	12.5	12.9
16	52	10.4	11.2	11.9	12.5	13	13.4
18	59	10.9	11.7	12.4	13	13.5	13.9
20	66	11.4	12.2	12.9	13.5	14.0	14.4
30	98	13.5	14.3	15.0	16.6	16.1	16.5
32	105	13.9	14.7	15.4	16	16.5	16.9
34	112	14.2	15	15.7	16.3	16.8	17.2
36	118	14.6	15.4	16.1	16.7	17.2	17.6

Fig 10

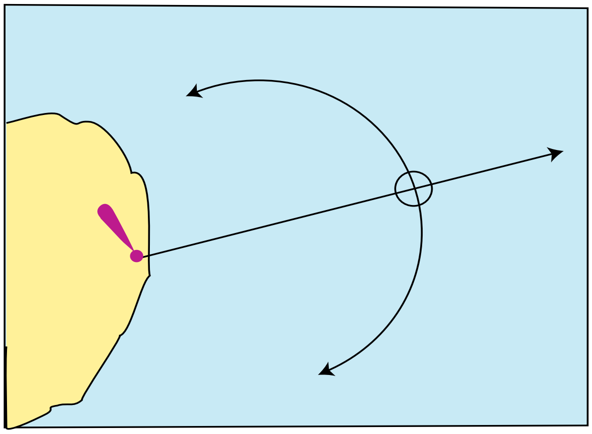
Extract from a typical table used to find distance off (from) a dipping or rising light on the horizon.

The table is entered with the height of the observer's eye above sea level against the height of the lighthouse found from the chart. The 'distance off' found from the table is in miles. The height of the lighthouse given on the chart is its height above the shoreline reference plane used on the chart (Mean High Water Springs) and therefore, strictly speaking, the height of tide at the time the observation was made should be found and the height of the lighthouse corrected accordingly. This correction is usually ignored in areas with tidal ranges of a few feet but where the tidal range is appreciable the correction should be applied.

A calculator may be used to find the distance off using the formula:
1.144 x (√ht of light + √ht of eye) , when the heights and answer are in feet, or
2.072 x (√ht of light + √ht of eye) , when the heights and answer are in meters.

A fix may be possible if a bearing to the object can be found or if a bearing from a different object can be obtained.

Most small boat radars do not give accurate bearings of objects under normal operating conditions but radar will measure distances accurately; use radar bearings with great caution; compass bearings are usually preferable.



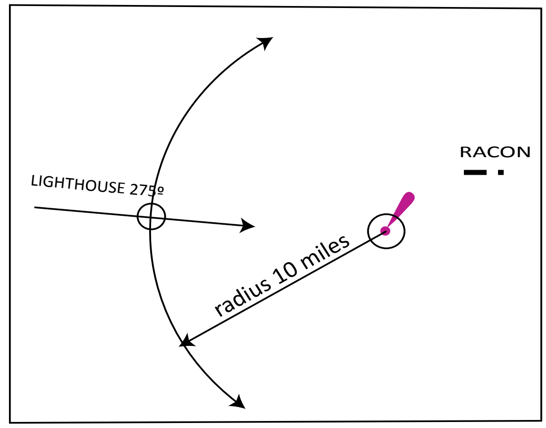


Fig 11 a *Fig 11 b*

Fix by distance and bearing,

of the same object *from one object and bearing from another*

Using two position circles

It is unlikely that two position circles will give a fix; usually the circles will intersect at two places giving two potential positions. It may perhaps be possible to decide which is the fix using radar bearings. A radar bearing is acceptable in this instance as it is only being used to decide which position is the correct one.

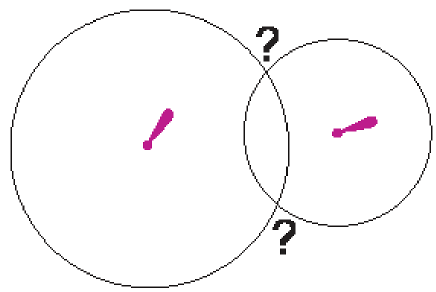


Fig 12

Using three position circles

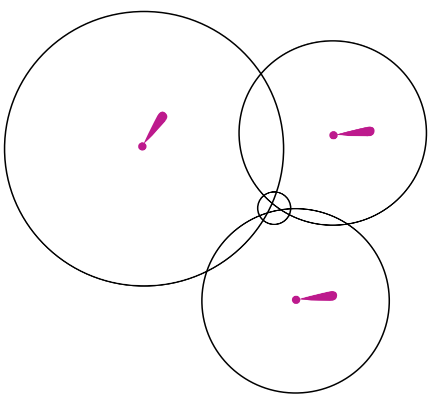


Fig 13

Position can be accurately plotted if it is possible to get distances simultaneously from three objects as the three circles will only all intersect at one point.

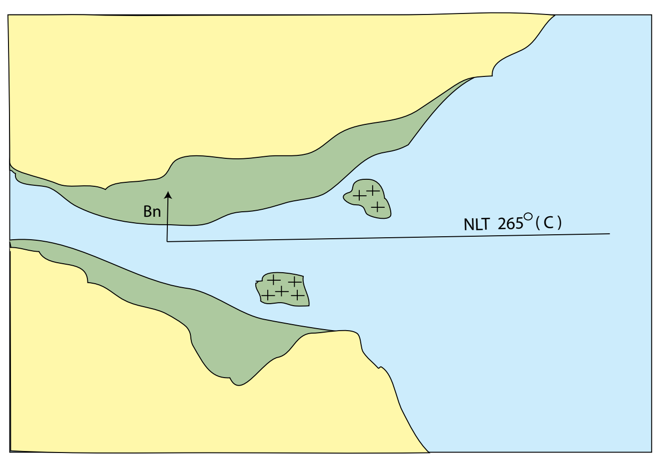


Fig 14
Safe clearing bearing

Using single position lines

As was pointed out earlier a single position line can be very useful in a number of ways, for example as a leading line to enter a harbour or anchorage whilst avoiding hidden dangers. Any charted object can be used as a reference point. A line, which is well clear of all dangers, is drawn on the chart through the object. Correct the bearing of the object along this line from true to compass. Keep checking the bearing of the object and alter course as required to keep the beacon bearing 265° (C).

In practice it is not easy to hold a precise course like this so when the boat is initially lined up on the required bearing to the beacon try to find something on the land directly behind the beacon which will serve as a visual transit. The second object doesn't have to be on the chart, anything such as a tree or rock will do. Don't use something that can move like a cow. It is much easier for the helmsman to hold the boat on course keeping two things ahead in line by eye than to have to hold a precise compass course.
All bearings should be corrected for variation (and deviation if necessary) beforehand so that they relate directly to the compass which will be used.

Harbour approach
A bearing of a charted object can be used when entering, or leaving, a harbor with outlying obstructions such as shoals, or wrecks.

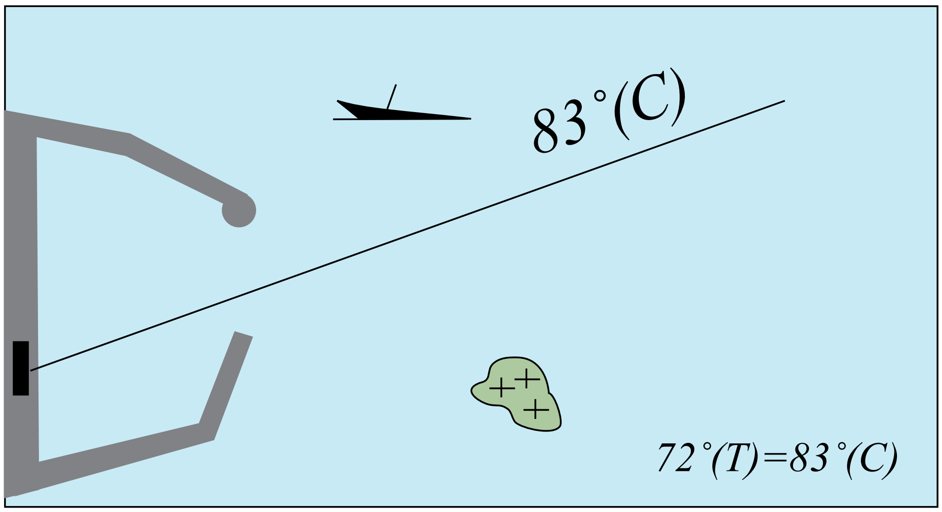


Fig 15
Here a back bearing of the end of conspicuous building is being used to avoid hidden dangers when leaving a harbour.

Clearing lines
Another approach is to draw two lines on the chart each one well clear of the hidden dangers and label them Not More Than and Not Less Than their safe compass bearing. Change course as the bearing to the object comes close to the NLT or NMT bearing.

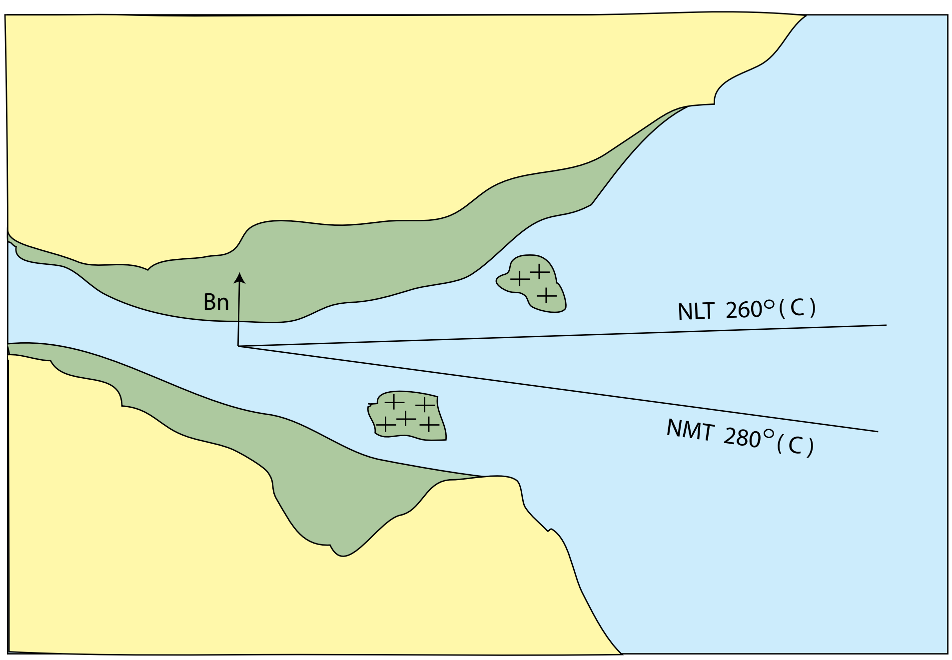


Fig 16
Not Less than 260° (C), Not More than 280° (C)

The running fix

A position fix can be obtained from only one fixed charted object provided that the boat is moving. The principle is as follows:

1) Take a bearing of the object with a hand bearing compass and record the bearing, distance log reading and the time.
2) Maintain as steady a course as is possible, until the bearing to the object has changed significantly.
3) Take a second bearing of the same object and record the bearing, distance log reading, average course steered and the time.

The running fix is then plotted as follows:

1) Plot the first position line through the object.
2) Plot the second position line through the object. (Your position must lie somewhere along this second position line.)
3) From anywhere on the first position line draw a vector representing the boat's course and the distance the boat travelled between the times of the first and second position lines.
4) From the end of the course/distance vector plot a vector representing the current set and drift, if any, for the time involved.
5) From the end of the current vector draw a line parallel to the first position line. (This line is called a 'transferred position' line and should have two arrowheads drawn at each end)
6) The boat's position is where the transferred position line and the second position line intersect.

Example:

Time	Log	Course (T)	Remarks
0900	45		Lighthouse. 245° (T)
1000	50	185°	Lighthouse 300°(T), current 0900 - 1000 + 215° /1 knt

1) Plot the first position line, 245° (T) to the light house.
2) Plot the second position line, 300° (T) to the light house.
3 From anywhere on the first position line plot the course steered and the distance travelled from 0900 to 1000: 185° (T) / 5 Miles.
4) Plot the current vector: 215° (T) / 1 Mile. (Assumed current for this example)
5) Draw a line through the end of the current vector, parallel to the first position line; this is called the transferred position line. Mark each end with two arrow heads, or write R FIX, beside the transferred position

The boat's position lies where the transferred position line cuts the second position line. Write the time and log reading beside the fix. To avoid clutter only the time and log reading at the time of the position fix would normally be written on the chart.

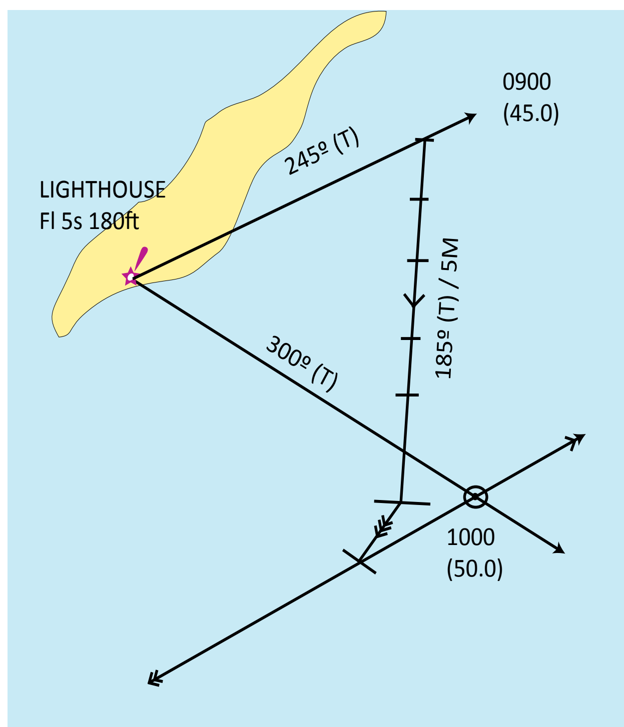
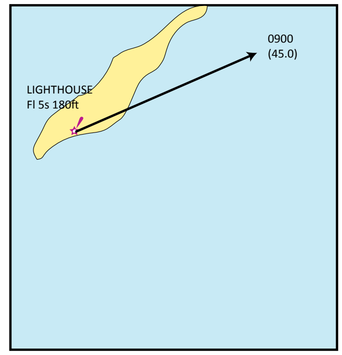


Fig 17
Position at 1000 from a running fix

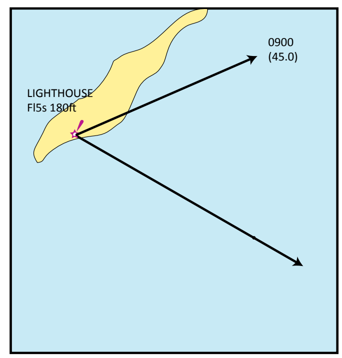
The running fix, step by step.

Time	Log	Course (T)	Remarks
0900	45		Lighthouse. 245° (T)
1000	50	185°	Lighthouse 300°(T), current 0900 - 1000 + 215° /1 knt

1) Plot the first position line, 245° T to the lighthouse.

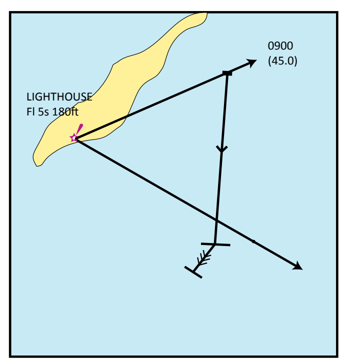


2) Plot the second position line, 300° T to the lighthouse.



3) From anywhere on the first position line draw a line representing
the course steered and the distance travelled
from 0900 to 1000 = 185° (T) / 5 Miles

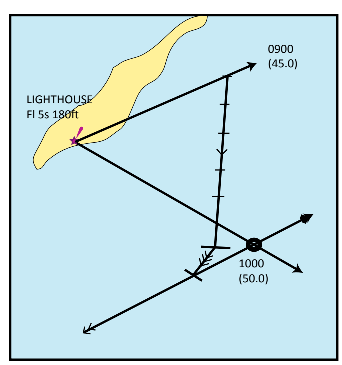
4) Plot the current vector
215° (T) / 1M. (Assumed for the sake of this example)



5) Draw the transferred position line through the end of the
current vector, parallel to the first position line.

The boat's position is where the transferred position line cuts the
second position line.

Write the time and log reading beside the fix.



Running fix from two different sources

A position fix can be obtained from two different charted objects even though they are not both visible at the same time. This situation could arise for example when sailing along the coast in restricted visibility.
The principle is the same as the previous running fix, the first position line derived from the first object is transferred to the time of the second position line.

Time	Log	Course (T)	L'Way	Remarks
2100	145			Lighthouse. 245° (T) Poor visibility!
2200	150	185°	Nil	Tank, Island 295° (T), current 2100 - 2200 + 215° /1 knt

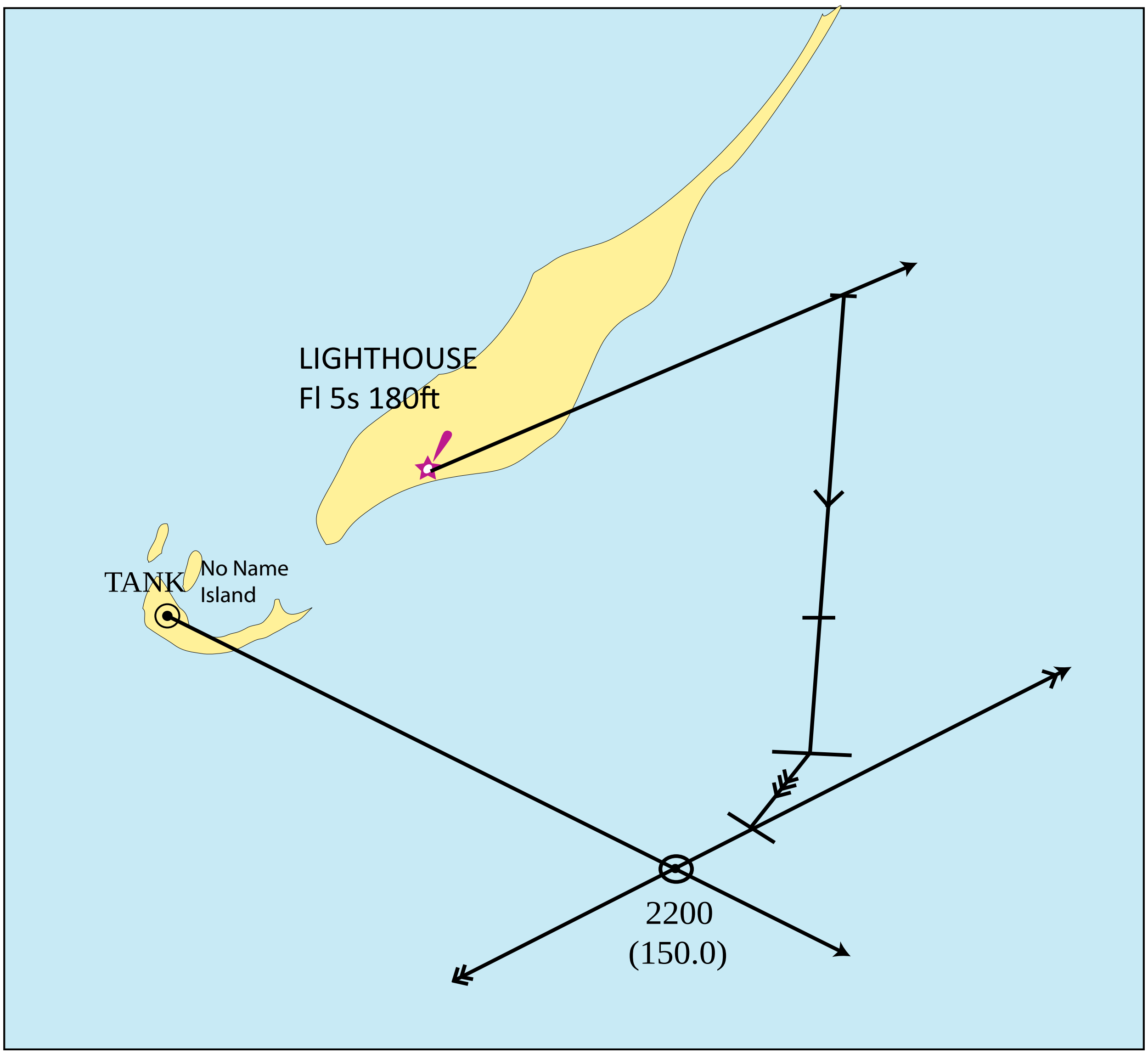
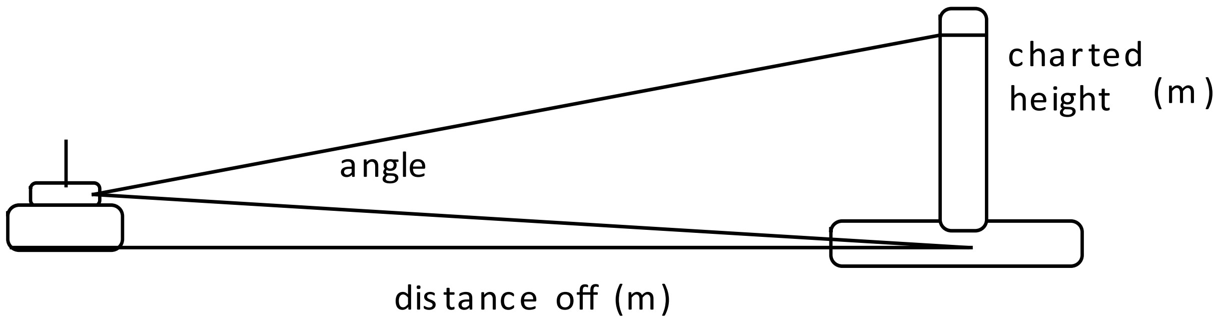


Fig 19
Running Fix derived from two different sources:
the first position line is from the Lighthouse,
the second is from the tank on No Name Island

Position Circle from a Vertical Sextant Angle (VSA)

A vertical sextant angle can be used to find the distance off a charted object such as a lighthouse. Distance Off tables make using an angle thus obtained relatively easy.



If the angle between the top of object and the horizon is measured using a sextant, then the distance off the object can be found.

$$\textbf{Distance off (m)} = \frac{\textbf{Height (m)}}{\textbf{Tan angle}}$$

Angle: This is measured in degrees and minutes and corrected for Index error.
Height of Object: Taken from the chart in metres.
Distance off: Given in metres from calculator using formula. You can also use distance off tables with the data from the chart and sextant angle.
To convert to nautical miles:

$$\textbf{Distance in miles} = \frac{\textbf{distance in metres}}{\textbf{1852}}$$

Example:

A lighthouse has a charted height of 62 metres. The VSA is 0° 26'.0.
Find the distance that the vessel is off the lighthouse.

$$\text{Distance} = \frac{\text{Height}}{\text{Tan A}} \quad \text{therefore Distance} = \frac{62}{\tan 0° 26'0} \quad \text{therefore Distance} = 8197.5 \text{ metres}$$

$$\text{Distance in miles} = \frac{8197.5}{1852} = 4.43 \text{ nautical miles}$$

A position circle can then be drawn by setting compasses at this distance and drawing a circle out from the light-house.

17

Course to Steer To Counteract A Tidal Stream

If you wished to cross from one side of a pond to the other side on a windless day you would, if there were no stream or current, simply row directly towards the spot you wanted to arrive at. If you rowed at 3 knots you would cross a three mile wide pond in exactly one hour, or a 6 mile wide pond in two hours and so on.

On the other hand if you rowed across a river aiming directly toward the point you wished to arrive at, the tide or current would carry you down stream from your objective unless you continually adjusted the boat's heading to compensate for the effect of the tidal stream.

A much more efficient approach is to compensate from the start for the sideways movement caused by the tidal stream by pointing the boat not towards the place you want to arrive at but somewhere upstream of it.

Course to steer (CTS)

In order to navigate a boat from one place to another at sea the effect of tidal streams on the boat's passage must be taken into account and compensated for. In addition to the effect of the tide, leeway, variation and deviation must also be included in order to find the compass course which the helmsman will steer so that the boat arrives where the navigator intended. This course is called the course to steer and is usually abbreviated to CTS.

Plotting a CTS

1. Decide on a suitable time scale; periods of one hour are usually easiest to work with.
2. Estimate what you expect the speed of the boat will be under the existing conditions.
3. Measure the distance from the departure point to the destination.
4. Divide the distance by the speed to find how many full hours the passage will take.
5. Find and write down the tidal stream direction and rate for each full hour of the passage.
6. Draw a line on the chart from the departure point (A), through the destination (B).
7. From the departure point plot the set and drift of the current for the first hour (AC).
8. Set the dividers to the distance the boat will travel through the water in 1 hour (4 Miles).
9. The true Course To Steer is then CD. With one point of the dividers on C mark where the other point cuts the ground, AB. Call this point D.
   Note that the tidal stream vector is marked with 3 arrows, the ground track is marked with two arrows and the CTS is marked with a single arrow.

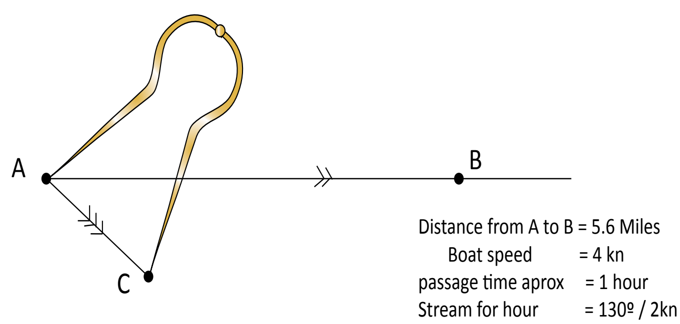


Fig 1 Plotting the tidal stream, set and drift for the first hour.

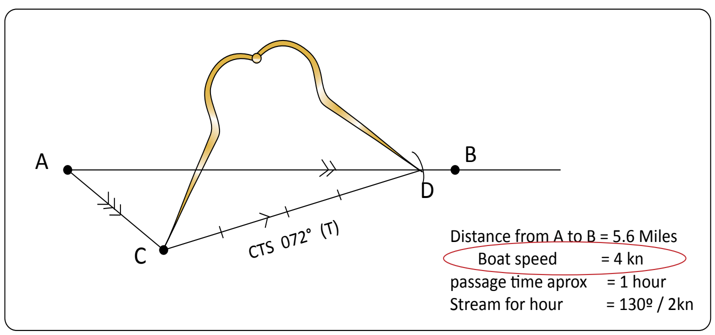


Fig 2
Plotting the distance the boat will travel through the water during the first hour

After one hour the boat will be at the position shown at D, not B where the passage is intended to end. This is quite correct; if the distance from D to B is appreciable a second course to steer will have to be plotted from D for the next hour. A common mistake is to just join C to B which will not give the correct course to steer. In the example above the distance from D to B is small and a second course to steer would not normally be required.

CTS for more than one hour

The course to steer for a passage which will take more than 1 hour can be found by one of two possible methods. Firstly the course to steer can be plotted for each individual one hour period or, secondly, a single course to steer for all of the passage can be plotted.

Plotting a CTS for each individual hour

As before you must first find the distance from the point of departure to the destination and estimate what you think the boat's speed will be under the conditions. Dividing the distance by the speed will give you a good idea as to how many full hours the passage should take, which in turn tells you for how many hours you need to find the tidal stream information. Once you know how many hours are involved in the passage the next step is to find the stream direction and rate for each hour of the passage using the Tidal diamond information and/or a tidal stream atlas. From the point of departure plot the first tide vector, AC and continue plotting the course to steer for the first hour as explained above and illustrated in Fig 2.

From Fig 3 below it can be seen that after the first hour has elapsed the boat will be at D. From D plot the tide vector for the second hour and find the next course to steer for one hour. Continue plotting the tide vector and the course to steer for each individual hour as required.

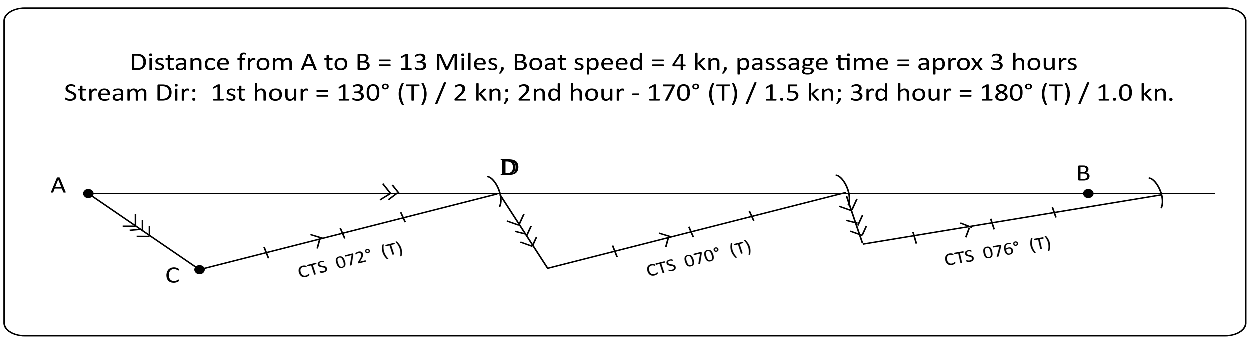


Fig 3

Plotting the courses to steer for three individual hours

Be careful not to make the mistake of simply joining the final course to steer to the destination, B. As with all the other course to steer vectors the final one is formed from the distance the boat will have travelled through the water for the hour, which is 4 miles in the example above. The fact that the vector ends a short distance past the required destination is of no significance because the boat will be moving along the ground track, AB, and will simply arrive at the destination in a little less than three hours.

The reason that the passage actually takes less than the three hours calculated initially is because the tidal stream for the first two hours is flowing a certain amount in the same direction as the boat is travelling, thereby helping by carrying the boat a small amount towards its destination. In other words the boat's speed over the ground is faster than its speed through the water.

In order to reach the required destination the boat will be steered on a heading of 072° (T) for the first hour, then the heading will be changed to 070° (T) for the second hour and, finally, the heading will be changed again to 076° (T) for the third hour. This method has the advantage of keeping the boat close to the required ground track (AB) which may be important if there are hazards on either side of the ground track, but it requires hourly course changes and does not always give the fastest passage time.

Plotting a single course to steer for the whole passage

The initial procedure is exactly the same as the previous example. Dividing the distance by the expected speed indicates approximately how many hours the passage will take. Find the tidal data for these hours and plot all of them, one after the other, from the departure point, A. From the end of the final vector (C) plot the course to steer. Remember once again that you must not simply join C to the destination.

In the example below the boat's speed is 4 knots and the passage time is three hours so the boat will have travelled 12 miles in the three hours. Therefore with the dividers set to 12 miles and one of its points on the end of the last tide vector mark where the ground track is cut by the other point of the dividers. The course to steer is found to be 073° (T) and this is the course which will be steered for all of the passage.

Often the distance from A to D is too long for an ordinary pair of dividers but a piece of paper or a ruler can easily be used instead. Simply lay the piece of paper beside the latitude scale at the side of the chart and mark off the distance representing the number of miles required. Place the piece of paper so that the first mark is on the end of the tide vector and then swivel the paper until the second mark touches the ground track.

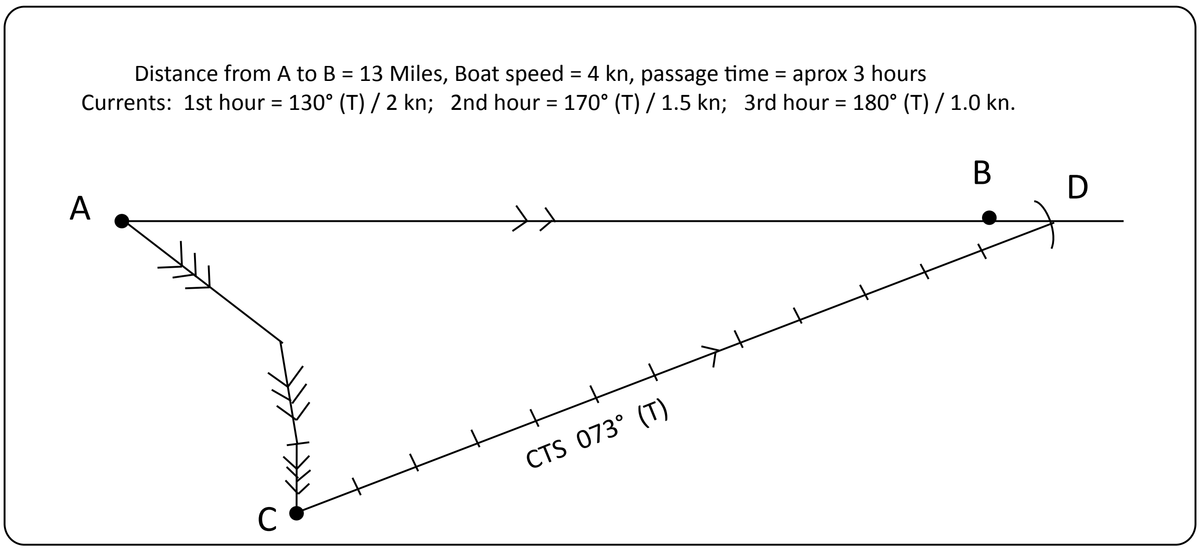


Fig 4 Single course to steer to counteract the tidal stream over three hours

The method above has the advantage that the boat's heading remains the same and does not require a course change every hour; it will also usually give the fastest passage time. It must be appreciated that the boat will often be quite some distance either up or down tide of the ground track and so consideration must be given to possible hazards on either side of the ground track.

CTS for less than one hour

Even though a passage will take less than 1 hour the course to steer is still found using a one hour time period. This is much easier than trying to work out mathematically both the tide set and the distance which will be travelled by the yacht in a specific number of minutes.

Looking at Fig 5 it can be seen that a boat leaving A on a heading of 072° (T) will move along the ground track AD and will therefore pass through the destination, B before the full hour has passed.

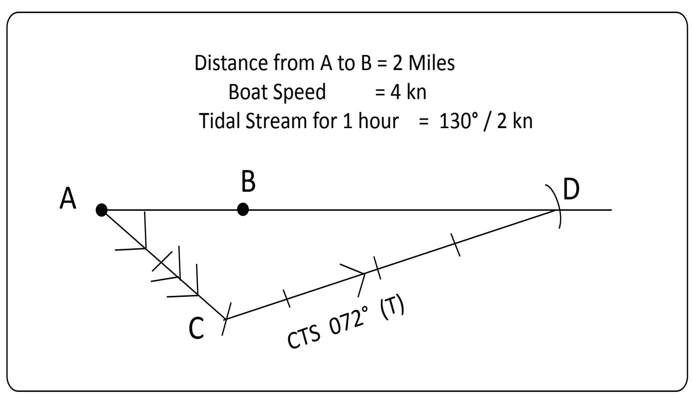


Fig 5
Course To Steer for a period of time less than 1 hour

The course to steer found in the examples above must have corrections applied for the effect of leeway (if any), variation and deviation (if any). These corrections must be applied in the following order:

1. Apply leeway angle toward the wind to counteract the effect of the wind.
2. Apply variation to give the magnetic course.
3. Apply deviation (if required) to give the compass course to steer.

Leeway

If conditions are such that you feel the boat will be subject to leeway remember that you must change the course to steer in order to counteract the effect of the boat being moved sideways through the water. The allowance for leeway is not normally drawn on the chart because if it were the chart would soon become cluttered with lines and be difficult to read, rather the leeway is just applied as a simple addition or subtraction.

In the diagram it can be seen that as the wind is blowing from the north the boat will be pushed to the south of the desired course unless the course to steer is changed to counteract this leeway.

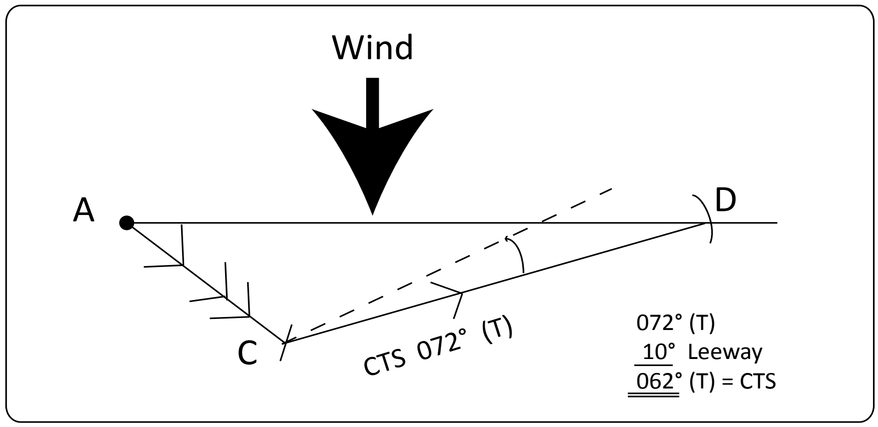


Fig 6
Adjusting the CTS to counteract leeway

The navigator estimates that, under the prevailing conditions, the boat will make about 10° of leeway and the correction is then applied towards the wind direction. This final true course to steer is shown drawn in the figure above as a dotted line but this line would not normally be plotted on the chart.

From the figure it can be seen that 10° must be subtracted from the initial true course to steer to find the true course to steer to counteract the effect of the leeway.

Finally the true course to steer must be corrected first for variation and then for deviation (if any) in that order. Using the figures from the diagram above and for example deviation of 3° E (practically this would be obtained from the vessel's deviation card)

Course	072° (T)
Leeway	-10°
	062° (T)
Variation (7° W)	+ 7°
	069° (M)
Deviation	3° E (-)
CTS =	**066°(C)**

Accuracy

The accuracy of the course to steer found will depend to a large extent on the accuracy with which you have predicted the speed of the boat. Speed is much easier to predict under power because a motor boat can often maintain a steady speed but a sailing boat's speed will vary with wind direction and strength. It may be necessary to update the course to steer as the passage proceeds, depending upon conditions.

Continuous direction ocean current

If a current is continuous in direction and speed, such as an ocean a simple current triangle can be quickly plotted on any piece of paper using whatever units of scale are suitable. The Breton type plotter is ideal for this as then no compass rose is necessary. The scale on the plotter edge can be used for units of miles. A '1 hour' vector triangle will give a course to steer for as long as the current remains constant.

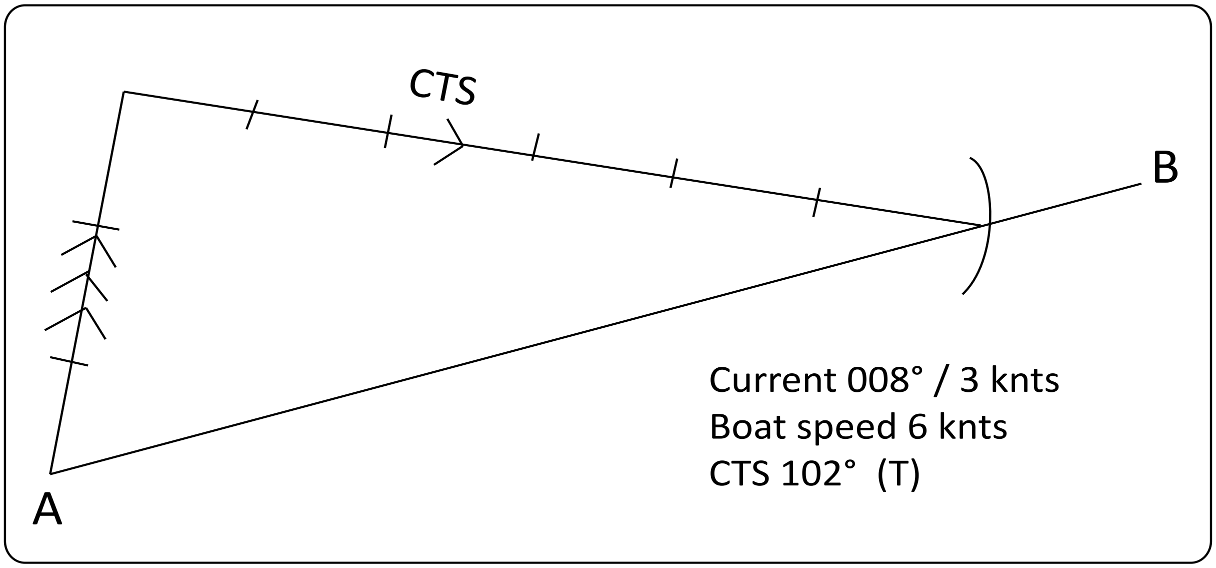


Fig 7

18

Electronic Navigation Aids

For centuries navigation was carried out using nothing more than a compass together with rudimentary charts and pilot books or sailing directions when these were available. The next step was the development of the understanding of the principles of celestial navigation or position fixing using the 'heavenly bodies', that is the sun, moon, planets and stars. In order to find the boat's position using celestial navigation methods the angle between the horizon and the heavenly body must be measured and the time of this sight must be recorded.

Initially celestial navigation enabled latitude to be determined with some accuracy but the determination of longitude remained impossible at sea because precise time, accurate to seconds, is required for longitude. Although the principle of determining longitude was understood, no chronometer had yet been built which could retain its accuracy at sea. Originally an instrument known as a 'cross-staff' was used to measure the angle between the sea horizon and the sun or other celestial body and in 1590 John Davis invented the 'backstaff' for measuring angles which in turn gave way to the double reflecting sextant in 1730, jointly credited to Godfrey in America and Hadley in England.

Precise time is not essential to ascertain latitude but it is a fundamental requirement in order to determine longitude using celestial navigation methods. The ability to deduce longitude at sea remained impossible until the invention of a chronometer with a movement that could compensate for the changes in temperature and humidity experienced at sea. Until such a chronometer became available a technique known as "latitude sailing" was often used. This method entailed sailing north or south until the latitude of the ultimate destination was reached and then sailing along this latitude until the vessel arrived at the destination. John Harrison produced the first chronometer in 1761 and chronometers, although very expensive, were generally available by 1800.

With a sextant, accurate time and a chart the position of a vessel at sea could now be defined with a precision which depended largely on the skill of the navigator and the sea conditions, provided cloud didn't obscure the sun or stars. Sextant sights are obviously impossible when the sun or stars are covered by cloud; in this situation the navigator was once again back to working up a Ded Reckoning or an Estimated Position.

Radio navigation aids
The ability to use radio waves travelling at the speed of light (161,875 nautical miles per second) to send information from a radio transmitter to an independent radio receiver has revolutionised communications and navigation in the 20th century.

The first radio navigation aid was the radio 'time signal' which enables a navigator to check the accuracy of the ship's chronometer, thus ensuring that sextant sights were timed precisely to the nearest second.

Then came Radio Direction Finding , or RDF as it is usually called. RDF, was the first system designed specifically for navigational purposes using shore-based radio transmitters and a receiver carried onboard the ship to give bearings for position fixes.

The development of short and long range radio navigation systems using land based radio transmitters was speeded up dramatically during World War 2. These systems included 'Decca', 'Loran' and 'Omega' all of which were designed to enabled quick and accurate position fixing in any conditions. The speed with which the equipment would yield a position fix became more and more important as the speed at which planes travelled increased.

The next huge step forward was the ability to put the radio transmitters into space aboard satellites giving us satellite based navigation systems such as 'Satnav' and then 'GPS'. The rapid development of computer technology has given rise to receivers which can do far more than just simply indicate their position and the miniaturisation of electronic components has allowed the development of affordable equipment suitable for the smallest of boats. ‘Hand held’ units the size of a pocket calculator which can run for up to 24 hours on ordinary small replaceable internal batteries are now readily available.

A satellite navigation system has the great advantage that its signals are available 24 hours a day irrespective of darkness or cloud cover.

‘Automatic’ electronic navigation aids
Radio navigation systems which enable a dedicated receiver to give a continuous display of the receiver’s latitude and longitude can be conveniently broken down into two sections:

1) Systems that use terrestrial (land or sea) based radio transmitters, such as Loran.
2) Systems which receive their signals from satellite transmitters orbiting in space, such as GPS.

Loran C
Loran (from **Lo**ng **ra**nge **n**avigation) is a long range radio based navigation system which uses signals from up to 5 land based transmitters from which a dedicated Loran receiver can compute its position continuously. Loran C give acceptable accuracy as far as 1000 miles from the transmitter. Loran C was never available world-wide and is now essentially being wound down due to the introduction of GPS. It is no longer available in North America or Russia who were the main suppliers/users.

Enhanced Loran (eLoran) is however being adopted by some administrations as a backup system to GPS for position, navigation and timing in the event of GPS failure, deliberate intrusion or in the event of degrading the signals in the event of war. eLoran has a superior accuracy up to ± 8 meters, includes additional pulses which can transmit auxiliary data such as DGPS corrections

Satellite positioning systems
The ability to put radio transmitters into space made extremely accurate world-wide position fixing a reality. As many satellites as required could be put into orbit to ensure that signals would be available to receivers any where in the world, night and day and furthermore the signals would not have to pass over land, consequently a satellite based system has a higher degree of inherent accuracy than that achievable using land based transmitters. Satellites are however very expensive to make, launch and maintain.

Navsat (also known as Satnav used by commercial shipping and yachts), was the first satellite navigation system available to the small boat navigator was developed by the American Navy and was known as ‘Transit’. Transit offered position fixing with an accuracy as good as 100 m but fixes could only be updated when a satellite was ‘visible’ above the horizon; this could take anything from 1 to 3 hours. The precision of a Transit position fix for a moving boat also depended upon an accurate input of the vessel’s speed and direction.
Transit has now been superseded by the Navstar Global Positioning System.

GPS
The current state of the art satellite radio positioning system is called ‘Global Positioning System’ or GPS for short. GPS was developed by the Americans for the US Military and is intended to offer precise position and altitude, 24 hours a day, world-wide.

In addition to GPS, other systems are now in use or under development. The Russian GLObal Navigation Satellite System (GLONASS) was in use by only the Russian military, until it was made fully available to civilians in 2007. There are also the European Union Galileo positioning system, Chinese Compass navigation system, and Indian Regional Navigational Satellite System.

The GPS navigation system is composed of 29 active satellites in orbit around the earth together with a land based master station, based at Colorado and a receiver on board the vessel.

Each satellite knows its exact position and sends out an individual signal which is picked up by the receiver. The receiver measures how long it took for the signal to reach the receiver; using this information the receiver works out its distance from the satellite.

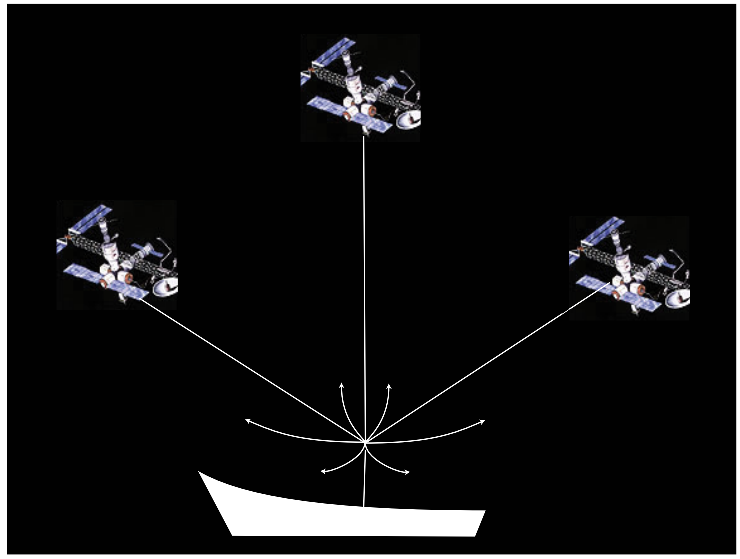


Figure 1

In other words the receiver has found a position circle centred on the satellite's known position. A second position circle from another satellite will give a position fix and a third position circle will confirm this fix with greater accuracy, Figure 1.

GPS accuracy

The GPS satellites actually transmit signals on two frequencies, one solely for military use and one for civilian use. The frequency available to civilians gives less precise accuracy than the military frequency because the U.S. military, reasonably enough, does not want the system used against them by their enemies in times of war. The design parameters for GPS were that it would provide an accuracy of 8 metres horizontally, 10 metres vertically, speed to 0.1 of a knot and time to a fraction of a micro second. Once operational GPS fulfilled these requirements, in fact the accuracy available on the civilian frequency was found to be too good, quite good enough to be used against the U.S. forces and their allies.

Selective Availability (SA)

In order to reduce the potential threat that the accuracy of the civilian signals allows, the U.S. introduced what is called Selective Availability. Quite simply the U.S. can, by introducing random errors, degrade the signal available on the civilian frequency as and when they wish. Selective availability is at present in operation giving an expected accuracy of between 100 and 150 meters 95% of the time. This is of course more than adequate for normal navigation. Remember, however, that this accuracy can, and will, be further degraded if and when required, nor will there necessarily be any prior warning to civilian users. The civilian frequency can also be switched off totally.

Differential GPS

DGPS has been introduced commercially in some parts of the world in order to cancel out the effect of selective availability. Differential Global Positioning System (DGPS) is an enhancement to GPS that provides improved location accuracy, to about 10 cm in case of the best implementations. DGPS uses a network of fixed, ground-based reference stations to broadcast the difference between the positions indicated by the satellite systems and the known fixed positions. Accuracy using DGPS is often quoted in terms of about 10 meters or 33' and sometimes figures of 5 meters are quoted, - BUT remember that in many cases charts are not produced to anything like this level of accuracy, indeed some charts are based on surveys carried out in the 1800's. See the warning from the British Admiralty at the end of this section.

Generally speaking it would seem to be most unwise to attempt to navigate in a fashion totally dependant upon quoted accuracies of these magnitudes.

GPS instruments

A GPS actually consists of a radio receiver tuned to receive the signals transmitted from the satellites and a computer which processes these signals to display the receiver's position in terms of latitude and longitude.

Many different models, either fixed or handheld (portable) are available but essentially they all do the same thing and give the user the same range of information. Fixed models generally use the boat's battery whereas handhelds use replaceable batteries or have a recharging facility.

Figure 2 shows a basic GPS receiver which might be about 100 mm x 150 mm (4½” x 6”) in size. The keypad of this GPS consists of a small number of multi function buttons, older models had a full numeric keypad. The instrument is connected to its external aerial by a cable and mounted where it can receive a clear and uninterrupted signal.

Figure 2. Basic GPS Unit

Figure 3. “Mushroom” type GPS Antenna

Using a GPS

When switched on a GPS set may take anything from a couple of minutes to as long as 15 minutes to work out its position which, when found, will be shown on the display in latitude and longitude. Once it has worked out its initial position it will continue to update this position every second or so until it is switched off; thus when the boat moves the latitude and longitude shown on the GPS display will change.

The art of navigation is based on being able to find your position at any moment in time because it is from your position that most other navigational information is derived. Now that the GPS knows its position it will also be able to give information such as speed, direction, estimated time of arrival and so on.

GPS Technology

With the rapid advances in electronics modern GPS systems include many different functions, even most of the less expensive models incorporate a Chart Plotter, see example on left (marine map showing the vessel’s position) and often a depth finder, right.

Commercial vessels and large yachts now have various options to integrate GPS into a complete navigation system, where the GPS connects to a dedicated chart plotter, overlays a chart onto the Radar and can control the Autopilot to steer the required course and to make planned course alterations.

It must be remembered that the vessels progress should be monitored and checked on charts and the electronics not relied on completely - all this equipment is an AID TO NAVIGATION only.

In addition to the basic GPS function of showing a vessel’s position, usually pictorially on a chart plotter, there are some other basic functions:

Speed and Distance

Speed is given as actual speed over the ground (SOG). That is to say that on a boat making 6 knots through the water against a 3 knot tide, the GPS will show a SOG of 3 knots, whereas on a boat making 6 knots through the water with a 3 knot tide the GPS will show a SOG of 9 knots. Likewise distance travelled is distance over the ground.

Track

The heading, or track, shown on the GPS will be the vessels ground track rather than the actual course steered.

Distance and bearing to a place

The GPS will show the distance and direction from its present position to any other place, or destination, but you must tell it where the other place is by entering the latitude and longitude of that place in the GPS as what is called a 'waypoint'. As a GPS can often hold hundreds of waypoints in its memory, each waypoint is given a number and each can also be named to help identification , the first one entered being WPT 1, the second WPT 2 and so on.

MOB Button

One other use of Waypoints is the MOB function on all GPS units, this will record the exact position of a casualty over board when the button is activated, (essentially setting up a waypoint allowing the vessel to return to that point) and from then on continually shows the bearing and distance to the position when the button was pressed. Remember, however, that if there is a tide or current the man overboard will have drifted from the recorded MOB position.

Waypoint

A waypoint is simply any place or position you define. GPS receivers can store the geographical coordinates (latitude and longitude) of specific points, either the destination or intermediate route course changes etc.

It could for example, be the entrance to Dune Harbour, or a position 1 mile off the headland to the east of Seal Creek or a spot in the middle of the Pacific Ocean. The GPS will allow the operator to set up waypoints using a pointer, BUT the latitude and longitude of the position should also be checked directly from the chart and the proposed course reviewed to see if there are any dangers etc to be avoided.

It must always be remembered that a GPS will simply find the direction and distance from its position to your waypoint, it does not allow for the existence of land, rocks, shallows, or other possible hazards.

In Figure 3 the GPS has found that the course from Dune Harbour to Seal Creek (waypoint 1) is 034ºT and the distance is 5.8 miles but if you accepted this course without checking on the chart you are in for a nasty shock because the course passes through solid land. The course given may either be True or Magnetic, most GPS sets can automatically apply variation (but not deviation) for any place in the world.

The GPS display would show something like this:

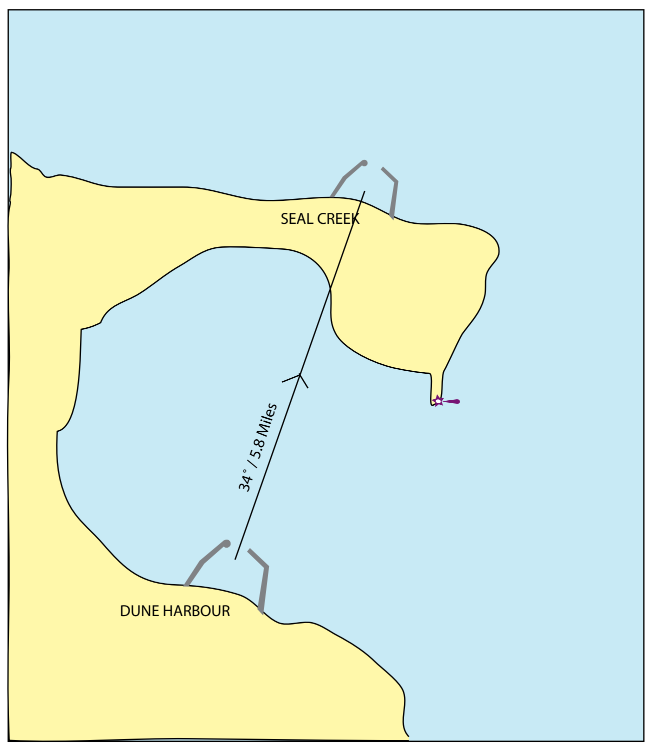


Figure 3

BRG	DST
034°	5.8M
WPT 1	SEALCRK

On passage with a GPS

Once underway not only will the GPS give a constant readout of the boat's position together with a plot on the chart display, but it will also carry out many other navigational functions as well. It will give the boat's speed over the ground and the course over the ground. It will record the average course steered and the total miles covered over the ground since the start of the trip. It will give the estimated time of arrival at the next waypoint based on the tidal and leeway conditions being experienced now; if these conditions change the ETA will also change.

Using waypoints

When using a GPS the procedure is to plot safe tracks on the chart, recording the latitude and longitude of each turning point and entering these as waypoints. Taking the same sketch of the trip from Seal Creek to Dune Harbour, Figure 4, the navigator has decide on three turning points and then finds, from the chart, the latitude and longitude of each waypoint.

All three waypoints are then entered into the memory of the GPS and, by pressing the correct button (or sequence of buttons) the display can be made to indicate the bearing and distance from Dune Harbour to waypoint 1, from waypoint 1 to waypoint 2 and so on. In practice the GPS will sound an alarm when the boat is within a specific (user defined) distance of the waypoint. This distance is usually set at about half a mile.

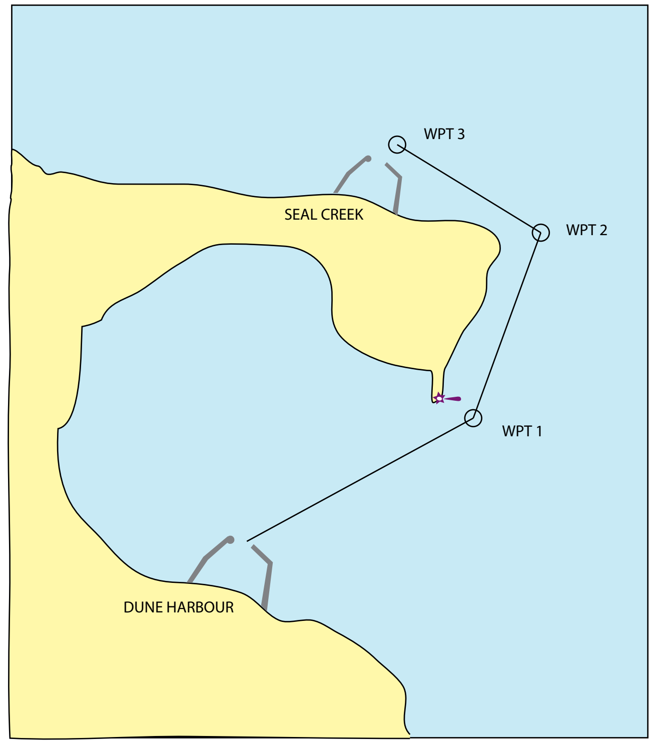
Waypoints can be joined together to give 'routes', the set will then automatically switch to the next waypoint as appropriate.

Cross Track Error

Cross track error (CTE or XTE) is the distance that the boat is to one side or other of the desired track at any moment in time. Knowing the magnitude of the cross track error enables you to decide whether a course change is necessary to get back onto your desired track and if so which way to turn.

The GPS will incorporate some sort of visual aid such as arrows pointing in the direction which you must steer in order to get back on the required track.

In figure 5 the boat has been allowed to move 1.25 miles off the desired ground track.



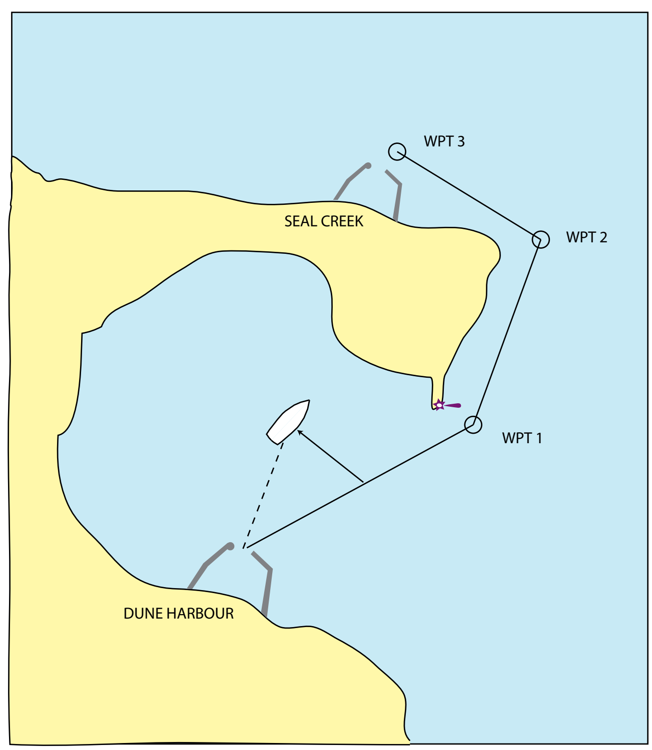


Figure 5

Modern GPS Systems will automatically compensate for cross track error by working with the Autopilot to update continuously the course being steered.

The GPS might display something like this:

```
WPT 1        >>>>>>> 1.25
DST.  2.75       ETA.  0028
```

This display in Figure 13.5 above tells you that

- the boat is 1.25 miles off the ground track to waypoint 1, the arrows indicate that the boat must be turned in the direction that the arrows point (to the right) to bring it back onto the correct track,
- the distance to waypoint number 1 is 2.75 miles and the esti mated time of arrival (ETA) under the current conditions of speed, tide and so on is in 28 minutes time.

Steering with regard to cross track error makes it relatively easy to keep to a defined course but it is also easy to become paranoid about being 0.01 miles off track and end up continuously correcting for tiny cross track errors. In reality you cannot steer to these precise figures, you will actually end up steering a snake like series of 's' bends. Usually you can let the cross track build up a bit before correcting. When steering to correct for cross track error don't do a huge course change as this will only waste time, rather do a gentle correction which will take you longer to get back on track but will result in less time wasted.

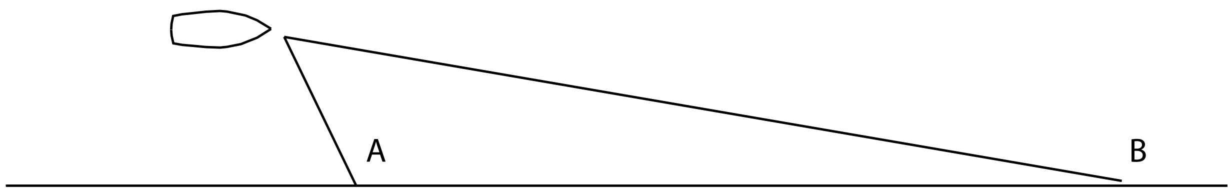


Figure 6

A gentle course change will result in less time wasted getting back to the required ground track.

By following the ground track with as little as possible cross track error the helmsman is automatically compensating for tidal drift and leeway; this method of navigation has obvious advantages in pilotage situations but remember that there is still an error in the absolute accuracy of the position due to Selective Accessibility. Remember the chart may be incorrect in areas where sand banks change, or coral has grown for example,.

You can use cross track error to check the accuracy of your course to steer calculations and plotting. Take the situation where the tide will first flood in one direction and then ebb in the opposite direction. Having worked up a single course to steer the boat will actually cover an 'S' like ground track to the destination, do not correct the course to cancel the cross track error but instead check the cross track error with your tidal predictions as the passage proceeds.

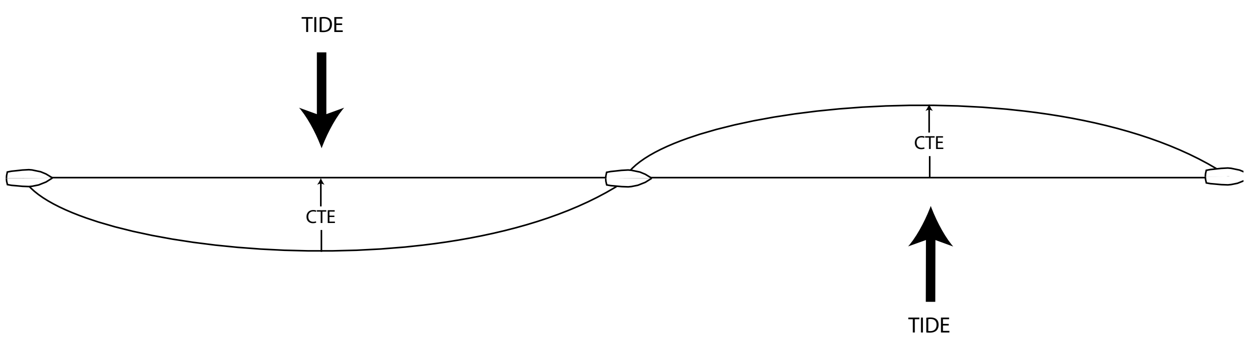


Figure 7

Many GPS sets show cross track error in pictorial form like a road or runway, as well as with figures. In figure 8, the display is meant to look like a road and you are off to the left of the track; therefore turn to the right to come back to the desired track. The display is also telling you that the bearing from the present position to the 'Seal Creek' waypoint is 270°, the course you are presently steering is 256°, the distance left to go is 20.1 miles and your current speed is 13 .4 knots. Down at the bottom of the display is the ETE (Estimated Time Enroute) of 1 hour 31 minutes and the amount of cross track error which is 0.8 mile.

VMG means the Velocity Made Good, that is the speed at which you are actually closing in on your destination. Much other information can be displayed depending on the set' capabilities and the 'page' selected. Different manufacturers use different displays as well as different words and abbreviations. Time will have to be spent with the handbook in order to avail of all the facilities and functions.

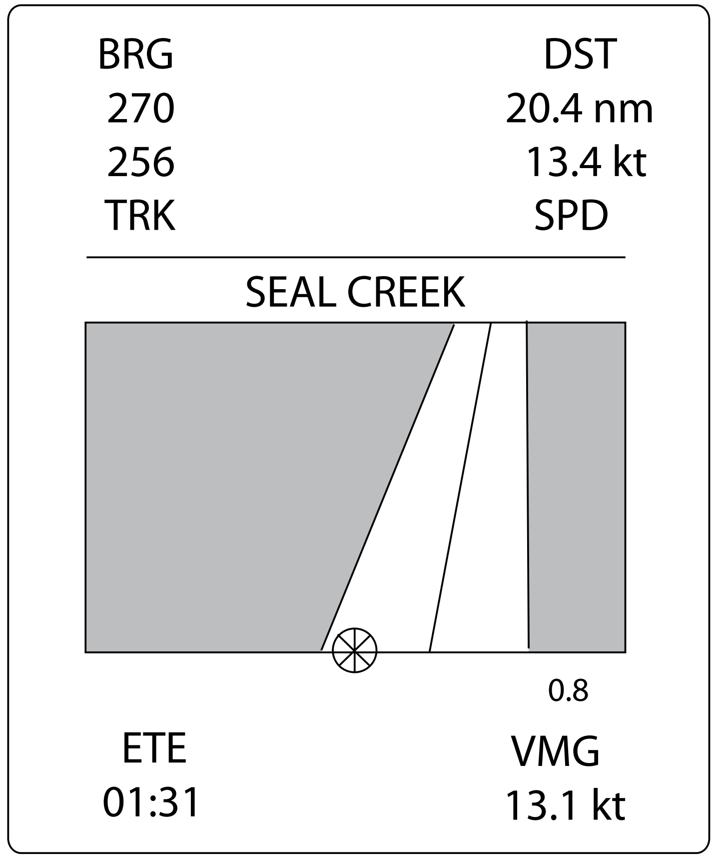


Figure 8

Map and Chart Datums

Maps and charts are drawn to different datums and you should check that the GPS is set to the correct datum by checking on the chart legend and then checking the GPS datum and changing it if required. Most UK charts are to OSGB36 (Ordnance Survey of Great Britain 1936).

As you will remember latitude and longitude are both angular measurements taken from the centre of the earth, but of course the world is not exactly round. Different charts around the world are drawn based on different 'centres' of the earth. Most GPS receivers are programmed to automatically select the WGS 84 datum (World Geodetic System 84) which gives reasonable results world wide. Using WGS 84 errors in position accuracy could be in the region of 150 metres in our local waters; this error can increase to displace the position by as much as a mile in the Pacific. 130 metres doesn't sound much but remember that this is in addition to the 150 metre inaccuracy introduced with Selective Availability.

Charts may have a heading 'satellite-derived positions' followed by instructions to correct the GPS position to comply with the chart.

The datum on which the chart was drawn can usually be found under the title in the section entitled 'Positions'. The user must check the datum of the chart in use. Usually there is a message under the title that states:

"Satellite-derived positions. Positions obtained from satellite navigation systems, such as the Global Positioning System (GPS), are normally referred to the World Geodetic System 1984 Datum. Such positions must be adjusted by … before plotting on the chart".

If there is no such message and the datum of the chart in use cannot be verified then the offset of the GPS derived position cannot be determined. In this case it is necessary to navigate with caution.

Errors and Inaccuracies in GPS - 'Dilution of Precision'
Position Dilution Of Precision is a fancy way of saying inaccuracy. The accuracy of the GPS position fix will depend, amongst other things, upon the angle of cut of the position lines from the satellites; too large or too fine an angle of cut will lead to a position error. The GPS will automatically pick the satellites which will give the best angle of cut but in some instances the aerial may not be able to 'see' all the satellites due to an obstruction such as a mountain or building for example. GPS sets will usually give an indication of the level of accuracy in numbers , low numbers being good and large numbers bad.

Other significant sources of error are: -

a) Multipath effects. The signal reaches the receiver by two different paths, possibly due to local reflections from structures close the aerial.
b) Ionospheric effects on the time delay.
c) Clock errors.

Interface Options
All modern quality sets and even most inexpensive models have an interface/s which allows information from the GPS to be transferred to compatible instruments such as an autopilot, Radar or chart plotter. The interface will also allow information to be fed to the GPS from compasses, logs and computers.

Installation
Installation of a fixed GPS should present no problems, the aerial does not need to be at the top of the mast but it should have a clear all round view of the sky and not be vulnerable to physical damage from ropes or crew.

Fast boats
GPS is especially suitable for navigating fast boats due to the speed with which a fix, and other information is available. With the interface to a chart plotter navigation on high speed craft can show the vessel's exact position at all times. (Using paper charts, for very fast boats it is a good idea to draw latitude and longitude lines across the chart every 5' or so depending on the scale of the chart. The boat's position can then be read from the GPS and quickly found on the chart by eye or if more accuracy is required the position can be plotted on the chart).

Tacking
Waypoints can be used to indicate when to tack on a windward passage. On a passage under sail when the destination is to windward it is customary to draw a line on the chart from the destination along the direction in which the wind is blowing. A 10° cone is then drawn on either side of this line, again starting from the destination, thus giving a cone of 20° total centred on the destination. The boat is then sailed as close to the wind as possible and she tacks when either side of the cone is reached. On a long passage the cone would become too wide and, in this case, a parallel sided 'corridor' is plotted as appropriate, changing to a 20° cone as the destination is approached.

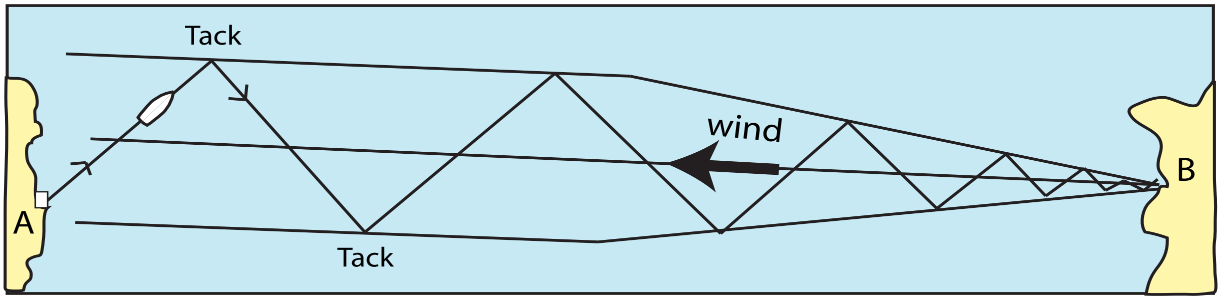


Figure 9

Setting up tacking parameters for a windward passage. The width of the corridor and length of the cone are decided by the navigator. In this example the width of the corridor is 5 miles and the cone entrance begins about 10 miles from the destination, B.

The GPS can be used in various ways to determine when to tack but perhaps the simplest is to deal with the parallel sided corridor first and then with the cone.
The latitude and longitude of the destination is first entered into the GPS as waypoint number 1 (WPT 1). Having decided which tack to start on the boat is sailed to make the best course to windward and, when the central line is crossed, (defined when the bearing to WPT 1, shown by the GPS, coincides with the bearing found from the chart) the position is entered as waypoint 2.
When to tack can now be easily determined by the cross track error reading between waypoint 2 and waypoint 1. The GPS alarm can also be set to warn when to tack.

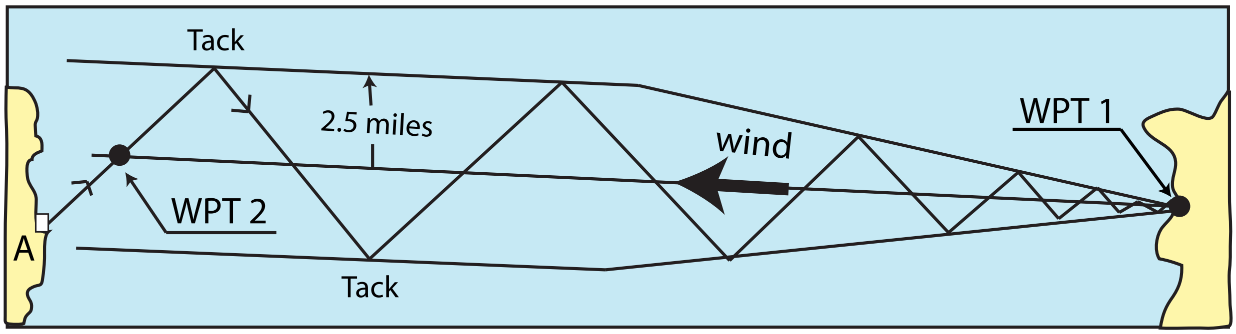


Figure 10

The destination has been entered into the GPS as waypoint number 1 (WPT 1). When the yacht crosses the central line its position is entered into the GPS as WPT 2. The GPS is now programmed to display the yacht's cross track error from WPT 2 to WPT 1. A corridor 5 miles wide has been decided on and drawn on the chart and the boat is therefore tacked as soon as the GPS display shows the cross track error to be 2.5 miles either side of the ground track. If required the GPS alarm can be set to warn when the cross track error is 2.5 miles.

When the beginning of the destination approach cone is reached the procedure must be changed. One method is to find, from the chart, the bearing to the destination along the two outside lines of the approach cone and the GPS is then adjusted to give a continuous read out of the bearing from the yacht's current position to WPT 1 ('bearing to waypoint'). The yacht is tacked when the bearing to WPT 1 reaches either of the two bearings found from the chart.
Tide and leeway will not effect when the yacht tacks but they will of course effect the yacht's position within the corridor or cone so a check must be kept on the yacht's position as usual.

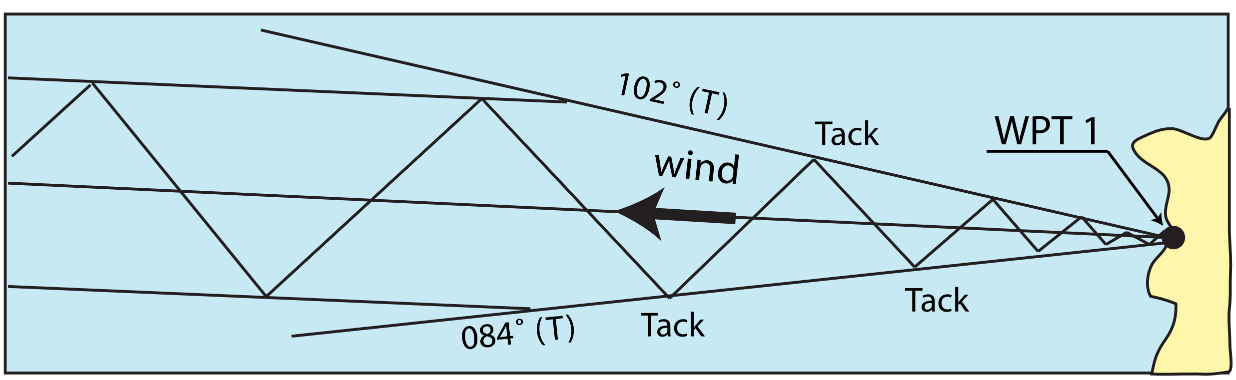


Figure 11

The bearing to the destination along the top of the cone is 102° (T) and along the bottom of the cone is 084° (T). As before the yacht is sailed on the best course to windward but is now tacked when the bearing to waypoint displayed by the GPS becomes 102° or 084°. The bearings shown in these figures are True bearings but as the GPS usually gives bearings in Magnetic apply variation to the bearings found from the chart so that they are also Magnetic.

Distance and bearing from a danger
GPS can be used in pilotage conditions to keep a check on the position of an unmarked or invisible hazard. If the hazard is entered into the GPS as a waypoint, the distance and bearing to the waypoint will not only tell you how far away you are from the hazard, but it will also tell you when you are safely past.
For example suppose you are sailing south in the dark past a river entrance to the West, with a shoal area 1/2 a mile off the entrance and you wanted to be certain not to come to close to the shoal area. By entering the shoal area as a waypoint the navigator can monitor the distance and bearing to the waypoint. By keeping the distance off the shoal greater than 1 mile the vessel will always be clear of the shoal. If the distance to the waypoint falls below this safety margin turn east until it returns to the safe value. Also by monitoring the bearing to the waypoint the navigator can see when the vessel is safely past the shoal. (Provided you found the correct figures from the chart and entered the correct figures into the GPS, and provided the shoal is still in the same place as it was when the area was surveyed!).

Other GPS functions
Many other functions such as satellite status, remaining battery life, self test functions, voltage display and so on are available. GPS sets are available which include tidal information for some standard ports or the time of sunrise and sunset for your latitude; GPS sets are also available combined with chart plotters and depth sounders. Most sets include an anchor watch alarm which, when set, will alert you if your anchored boat moves more than a user defined distance from a certain position, but do not forget to allow 300 metres or so for the inaccuracies introduced by SA.

Although most manufacturers try to make their sets easy to operate and their handbooks intelligible most of us will need to persevere for some time with the manufacturer's handbook in order to use the GPS effectively.

When navigating using GPS
- Always use the chart to check bearings and distances given by the GPS.
- Always plot positions on the chart, do not just write the lat and long in the log book.
- Always check carefully that you have entered the lat and long of waypoints correctly
- Always remember to include the 0" i.e. 53°06" not 53°6" or the GPS might read the latter as 5°36".
- Check that North or South, East or West are entered correctly as appropriate.
- Check that the GPS is set to the correct datum.
- Carry spare batteries for handheld units.
- Do not rely totally on GPS, or other electronics, as the sole method of navigation.

Chart plotters
Electronic 'charts' are now displayed on the screens of even the most inexpensive and simple GPS.

For more sophisticated needs there are a variety of plotters available which connect to a GPS (and often Radar) where the vessel's position is constantly displayed on the screen. As technology advances the quality of picture is improving all the time, and there are also options for waterproof screens for exposed wheel positions.

At the top of the range and for commercial use there is a sophisticated system of electronic chart plotters;
Electronic Chart Display and Information System (ECDIS) is a computer-based navigation information system that complies with International Maritime Organization (IMO) regulations and can be used as an alternative to paper nautical charts. (IMO refers to similar systems not meeting the regulations as Electronic Chart Systems (ECS)).
An ECDIS system displays the information from electronic navigational charts (ENC) or Digital Nautical Charts (DNC) and integrates position information from the GPS and other navigational sensors, such as radar and Automatic Identification Systems (AIS). It may also display additional navigation-related information, such as Sailing Directions and depth sounder.

In some cases a vessel may dispense with paper charts when there is an approved ECDIS system on board with totally independent back up system also.

There are two types of electronic charts:

Vector charts are the electronic chart databases comprising digital charts made up of multiple layers with standardized content, structure and format, issued for use with ECDIS on the authority of government authorized hydrographic offices. ENCs are vector charts that also conform to International Hydrographic Organization (IHO) specifications. ENCs contain all the chart information necessary for safe navigation, and may contain supplementary information in addition to that contained in the paper chart (e.g., Sailing Directions). These supplementary information may be considered necessary for safe navigation and can be displayed together as a seamless chart. ENCs are intelligent so that systems using them can be programmed to give warning of impending danger in relation to the vessel's position and movement.

Raster charts conform to IHO specifications for ECDIS and are produced by converting paper charts to digital image using a scanner. and which may be zoomed in for more detailed information. IMO permits ECDIS equipment to operate in a Raster Chart Display System (RCDS) mode in the absence of ENC.

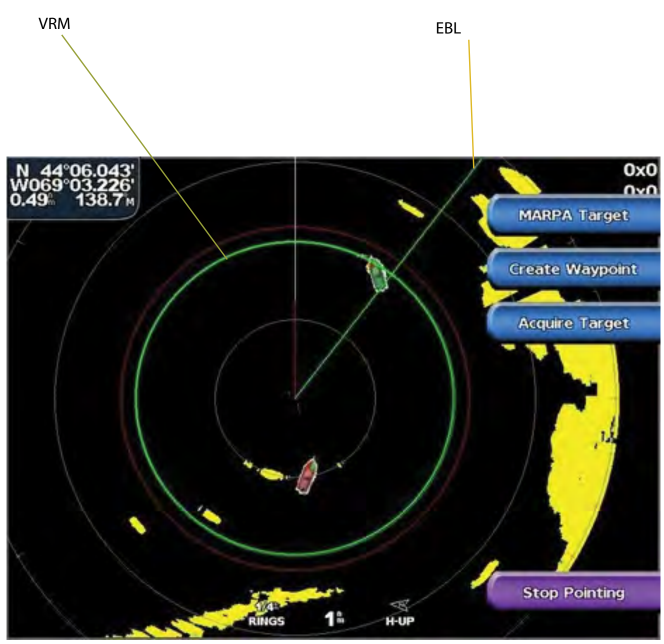
It must be remembered that plotters require electricity; electrical failure or fault will leave you with no chart if you rely solely on electronic charts. All electronic navigation equipment should be treated at all times as an AID TO NAVIGATION and not relied on without being checked by traditional methods.

Radar

Marine radar is a very useful navigation tool and is used to detect objects like buoys, other vessels, landmasses and weather systems, even when visibility conditions are poor. The screen will show their positions relative to the vessel's location. Radar works by sending out a radio signal, which when it hits an object, is reflected back to the radar unit calculating the bearing of the object and the distance from the vessel.

Collision Avoidance and Position Fixing

In addition to detecting vessels and land etc, for collision avoidance, and weather, the radar may be used to obtain a position line/s and fixes. When a vessel is within radar range of land or aids to navigation such as Racon Beacons and buoys, the navigator can measure distances and bearings to charted objects and use these to establish arcs of position and lines of position on a chart. A fix consisting of only radar information is called a radar fix. Radar fixing methods are "range and bearing to a single object," "two or more bearings to objects," "tangent bearings," and "two or more ranges."



Parallel indexing

Parallel index techniques can be useful when monitoring the ships progress in relation to the passage plan close to the coast or dangers etc. It does not fix the ship's position, but provides a method on the radar of verifying that the ship is maintaining a safe course and distance off to pass a fixed object, such as a headland.

In its simplest form the technique requires the range ring (Variable Range Marker, VRM) to be set to the required distance off the coast or a danger etc and the vessel will remain the set distance off the coast or danger purely if the course steered keeps the ring on the coast or danger point.

Parallel indexing does not replace the need to fix the ships position on the chart at regular intervals.

Guard Zone Alarm
Most marine radars allow you to set a guard zone around your boat. The safety distance is set and an alarm will sound as soon as any object is detected within the zone, such as a buoy, landmass or other obstacle. This can also be used at anchor to notify the anchor watch if another vessel approaches too close and enters the zone.

Radar Controls (Brief description)
The use of Radar and the multiple controls and functions require considerable explanation which is outside the remit of this course. Briefly the standard controls found and settings are:

a). Scanner/Antenna checked to be clear of obstructions (Personnel, halyards, snow etc.).

b). ALL operational controls turned down to minimum.
i.e. Brilliance, Gain, Contrast, Anti-Rain and Anti-Sea Clutter.
Switch off Auto-Clutter, Enhance. VRM, EBL, Trails, if fitted.

c). Main Power switched to standby the required waiting period varies with type of set. Maximum allowable is 4 minutes (IMO specifications).
Some radar require compass to be aligned in this standby mode.
Switch set from STANDBY to ON.

d). Range Scale set to recommended scale often 12 mile range.

e). Brilliance adjusted until sufficient brightness for the eye on displays

f). Contrast adjusted high enough to show clear contrast of Heading Marker/text etc.

Figure 12

Figure 12
Dual Screen Chart Plotter and Radar

g). Long pulse, normally selected when initially setting up the display.

h). Gain Control adjusted until lightly speckled background becomes visible.
Too little GAIN can lose echoes, while too much GAIN loses contrast.

i). Swept Gain/anti-sea clutter adjusted to reduce sea returns and **Differentiator/anti-rain clutter** adjusted to improve contrast within precipitation areas , Do NOT over apply or targets will also be suppressed

Anti Sea Clutter.....Swept Gain or Slow Time Constant (STC).
Anti Rain Clutter....Differentiator or Fast Time Constant (FTC).

j). Tune adjusted, check the setting by using the Performance Monitor, if fitted This will result in the maximum number of echoes being displayed.

Note: Make certain that the Performance Monitor is for both transmitter and receiver, often a Star or Sun pattern at the centre of rotation the radius of which can be measured to confirm they are both set correctly.

There are three main displays;

1. Relative Unstabilised.	or	Ship's Head up, Relative Motion.
2. Relative Stabilised.	or	North up or Course Up Relative Motion.
3. True Motion.		North up or Course Up, ground or sea stabilised.

Relative Motion
On Relative Motion Displays, the trace origin remains stationary at the screen centre, or sometimes off centre, and the targets move across the screen displaying their RELATIVE motion.

Unstabilised Relative motion or Ship's Head Up display has no compass interface and any swing of the ship head will result in the whole picture swinging round, making the picture difficult to understand and bearings very difficult to establish. The Heading Marker stays permanently up the screen with this display.

If a compass heading is introduced to the display this will make the display Relative Motion Compass Stabilised with North normally up the screen, similar the chart. Any change in own ships direction results in the heading marker changing direction, and not the whole picture.

The Course-Up compass stabilised display has the heading marker up the screen, similar to the Unstabilised mode, but when own vessel alters course, the heading marker responds to this change NOT the rest of the picture. The heading marker and picture orientation will require resetting back to be course-up at a convenient opportunity.

ALWAYS REMEMBER: RELATIVE MOTION trails are a combination of own ships course and speed AND the target vessels course and speed.

True Motion
The conventional True Motion display has the trace origin at a convenient position on the screen MOVING across the screen on a course from the gyro and at a speed dependant on the speed input. The result is that the targets also move with their own true course and speed, displaying their True Motion.

Ground and Sea Stabilised.
The motion of own vessel and the targets is dependent on the accuracy of the inputs of own ship's course and speed. If accurate course and speed through the water is fed into the radar, the output on the screen will be targets motion through the water. If the course and speed made good over the ground is entered, the output will also be with reference to the ground. If inaccurate information is entered then rubbish will be the result.

Electronic Navigation Aids

The advantages of electronic aids are:

- Accurate position fixing anywhere, regardless of conditions, 24 hours a day.
- Give a higher degree of accuracy than other methods of position fixing.
- World wide position fixing is possible including interface with chart plotters and radar etc.
- The position is instantaneous and continuous.

The disadvantages are

- Require complex radio receiving equipment which cannot be repaired on board.
- They rely on sophisticated electronic components which don't mix well with salt water.
- They require a constant supply of electricity.
- Not all sets give clear indication of a fault so the position displayed may not be correct.
- Aerials may be vulnerable to damage from people and ropes.
- They are under the control of governments and may be switched off without warning.
- Their accuracy or operation can be effected by thunderstorms, low voltage supply and sunspots, etc.
  Aerials can be shielded from satellite signals by metal objects or other aerials.
  A lightning strike will destroy delicate electronics.
- They are not aware of operator error so be very careful when using, for example entering the latitude and longitude of a waypoint, a small error may not be apparent so always use the chart to check a bearing and distance shown by the GPS.

DGPS Warning UK Hydrographic Office issued the following warning in mid 1998: Use of DGPS - Accuracy of Charts

1. With the imminent introduction of an unencrypted Differential Global Positioning System (DGPS) service by the General Lighthouse Authorities for the British Isles, and the introduction of DGPS services elsewhere in the world, mariners are warned against overreliance on the quoted accuracy of the DGPS system when using some large and medium-scale Admiralty charts particularly when closing the coast or approaching offlying dangers such as wrecks.

2. Whereas GPS produces a quoted accuracy in the order of 100 meters, DGPS has the potential to produce positions accurate to within a few meters referred to WGS 84 datum.

3. Admiralty charts are compiled from the best source data available (surveys, etc.), but these surveys are of varying age and scale. Also, in different parts of the world charts are referred to a variety of different horizontal datums. These factors may introduce apparent inaccuracies between the chart and the DGPS if the mariner relies solely on DGPS for navigation and attempts to navigate to the quoted DGPS accuracy.

Age (reliability) of Source Data

4. In many parts of the world, including some parts of the British Isles, the most recent data available may have been gathered when survey methods were less sophisticated than they are now and the sort of accuracy currently available with DGPS was not possible. In these cases the absolute accuracy of the positioning of this data to modern standards is doubtful. However, where recent survey data exists - e.g., in most significant ports and their approaches - and in other areas where modern surveys are indicated in the Source Diagram on the appropriate chart , this should be less of a problem. More information on the use of charts and the interpretation of source data is available in Chapter 2 of NP 100 The Mariner's Handbook.

Horizontal Datums

5. Local horizontal datums are usually unique to particular geographical areas and may have complex relationships with the WGS 84 datum. The available transformations and datum shifts, when applied to the DGPS position, may not in every case achieve agreement to the expected accuracy of DGPS. A detailed explanation, 'Horizontal Datums on Charts and Satellite-Derived Positions Notes' is given in Admiralty List of Radio Signals, Volume 8 - Satellite Navigation Systems.

19

Pilotage

Pilotage may be defined as navigating a vessel in inshore waters by using marks which can be seen at sea and on land as visual references. Pilotage is basically quite simple; it is the proximity to land and its dangers that makes pilotage so important. Pilotage is also one of the most enjoyable aspects of navigation as it usually implies the end of a successful passage together with the excitement of a new landfall.
In local waters pilotage is normally undertaken with very little conscious effort because you know your position by reference to well known buoys and landmarks; in other words pilotage by 'local knowledge'. However, in strange waters it will be important to work out a simple pilotage plan before arrival by collating all the information available from pilot books, charts and almanacs.
Pilotage will be easier if you can write this information in a clearly understood fashion. At all costs avoid writing an essay; rather try to assemble all the information in pictorial form which is readily understood, if you can.

Books and Charts
The secret of pilotage is planning ahead. You will need:

The relevant chart (s), corrected to date.
As many pilot books (also called sailing directions) as you can afford.
Cruising Guide/s - covers information for smaller vessels and non commercial ports
Tidal Information, Tide Tables, Tidal Stream Atlas
A nautical almanac for the current year.

All these supplement the information on the charts that would otherwise overwhelm the space. It may have some of the same information expanded, such as harbour entry details and charts of a large scale to help the navigator. It may have tidal information, weather to be expected in the area, dangers, marinas, fuel and waste outlets etc.

Pilot Books / Sailing Directions
Pilot books and sailing directions contain information which will enable you to decide, for example, which approach channel to use if there is more than one option. One channel may be preferable to another when the wind is from a certain direction or when the tide is setting in a particular direction. Not all channels are marked with buoys which are lit at night or have sufficient depth of water at low tide and some channels can only be used safely with local knowledge.

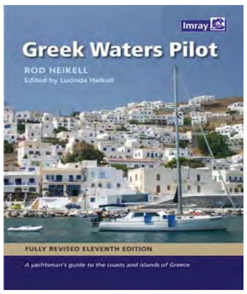
The British Admiralty Sailing Directions or Pilot Books have been produced to cover much of the world; BA Pilot Books were originally intended for use by commercial shipping but in recent years they have included much information of use to the small boat navigator. These books amplify charted detail and contain information necessary for safe navigation that is not available from the chart or other hydrographic publications. In particular, navigational advice is given for the area concerned, such as, weather details, tidal or current information, information on submarine and fishing activities etc. All of which assist the navigator in selecting suitable safe courses.

Sailing Directions are kept up to date by means of SUPPLEMENTS and corrections via Notices to Mariners (Weekly). A list of such notices is published in the weekly edition of Notice to Mariners.

US Pilot Books and Sailing Directions

NOS publishes a series of 9 excellent United States Coast Pilots covering U.S. coastal waters covering the **A**tlantic Coast, Pacific Coast and the Great Lakes

Also the Defense Mapping Agency publish Sailing Directions containing information on harbours, coasts, and waters of the world.
Sailing Directions (Enroute) include detailed information regarding port approaches and the general coastline, mostly in written form, with a small amount of sketches, chartlets and photographs.
Sailing Directions (Enroute) publication 147, for example, covers the Caribbean Sea and Bermuda.



Cruising Guides

Cruising guides are designed specifically with the small boat user in mind. They contain advice on navigation, weather, fuel and water, marinas and similar facilities.

There is a large choice for the most cruised areas, but if the plan is to cruise relatively remote areas then the choice will narrow to the BA Pilots or similar.

For example, Cruising guides for the Mediterranean are published by Imrays

Admiralty Notices to Mariners

Annual Summary: Contains important notices that are published each year and all TEMPORARY & PERMANENT notices affecting the Sailing Directions, which are in force at the end of the previous year. It also contains details of all of the I.M.O. adopted Traffic Separation Schemes.
Weekly Notice to Mariners: Contains corrections required to keep charts and other publications up to date

Nautical almanacs

There are many nautical almanacs available ranging from small, inexpensive, locally produced versions to a fully comprehensive volume covering a large area such as Reed's Nautical Almanac. The local ones usually contain tide tables and various brief items of general interest. Reed's contains many pages of valuable information and covers Atlantic coastal waters around the whole of the UK, Ireland, Channel Islands and the entire European coastline from the tip of Denmark right down to Gibraltar, Northern Morocco and the Azores. There are chartlets for many harbours together with all sorts of navigation and general information such as lights, marks, VHF radio channels used, telephone numbers, town facilities, availability of fuel and water and so on. There are tidal heights and current tables for reference ports together with subordinate station differences for for most areas covered by the almanac.

Almanacs must be replaced every year. Reed's issue corrections during the year which are mailed free of charge, on request.

Tidal Stream Atlas: This supplements the tidal information on the chart and covers the whole area in question rather than just the individual points at each tidal diamond.
These chartlets show the rate and direction every hour before and after high tide to enable accurate passage planning and position plotting.

Admiralty List of Lights: Gives the latest details of the lights and fog signals of any of light structures, light vessels, light floats etc. with their elevation.

Planning

Suppose you are planning the pilotage for entry to a harbour which has a channel marked with some buoys. Using the pilot books in conjunction with the chart (s) you can start to plan the pilotage.

- Decide on the best channel to use from the pilot books, if there is a choice.
- Decide on a definite starting point such as a cardinal mark or buoy at the start of the channel.
- Draw the planned track on the chart from the start through to the finish, this will consist of a number of different tracks rather than a single straight line.
- Try to draw the tracks so that any turning points are clearly defined by a buoy or similar mark.
- Make sure that you have pinpointed all the marks that could be useful.
- If you are passing through an area requiring pilotage without stopping at a port find some way, such as a buoy or bearing, of defining clearly when you have completed the pilotage plan.
- If tidal heights are a factor draw up the tidal curve beforehand; do the same for tidal streams.
- Bearings should have variation and deviation applied so they relate to the boat's compass.
- Plan for the worst scenario (i.e. night time) if you are not sure of your ETA at the pilotage area.
- Wherever possible use suitable transits/ranges rather than courses to steer; it is much easier to hold a boat on a precise heading by keeping two objects in line than by steering a compass course. A boat held on a transit/range is automatically compensating for tide, leeway, etc.
- If you are entering a harbour note any signals used by the harbour to regulate traffic and switch your VHF to dual watch Ch 16 and the channel the harbour or marina works on. Some of the busier ports require you to call them on VHF to obtain permission to enter; check in the almanac.

  Try to put all this information in an easily understood and quickly accessed pictorial form.

Pilotage in practice

- Stick to the pilotage plan, do not take short cuts. The area will often appear to be very different to the picture you have built up in your mind - this is why you drew up the pilotage plan.
- Start at the first mark and clearly identify it to be sure it is the right one.
- Check the identity of each mark as you pass it and mark it off on your pilotage plan.
- Do not assume that the mark ahead is the next one, check its bearing against your notes.
- As soon as you change course and are pointing at the next mark pick any fixed object, or shore light, directly in line with the mark to use as a transit/range to steer by. The object does not have to be on the chart, but it must be fixed.
- Keep a wary eye on the depth sounder, the depth may show any gross error in your pilotage.
- Set the depth sounder's shallow alarm, if it has one, to a sensible safety margin.
- It is usually best for someone other than you to helm, leaving you free to concentrate on the pilotage.
- Make sure that your instructions to the person on the helm are clear and unambiguous. Don't give vague orders like "steer for that light", rather pick a specific object and make sure that whoever is on the helm understands your wishes.

If things go wrong

- Slow down, or stop, and work things out. Don't just carry on trusting to luck. (If you are so lucky why are you lost out here?)
- Try to get back to the last mark or use any fixed object such as a lobster pot marker or buoy as a reference to ensure you are not being swept into further danger by the tide. Perhaps you can anchor if you are not in a shipping lane.
- Try to fix your position by any means available. Plot this position on the chart and draw a line from your position to the next (or last) mark. This will give you a bearing to either mark.
- If you are really lost at night, but in safe water, it may make sense to stay where you are until dawn, when it will be light enough find out where you are.
- It may be wise to run a sailing boat under power, particularly entering a harbour.
- Do not compromise the helmsman's night vision with lights from the chart table or torch. Smokers should remember not to cause a sudden unexpected flash with matches or lighter.
- Resist the temptation to make things fit what you want them to be. For example, don't ask the crew to look for "a green light flashing once every 5 seconds off the port bow". It is far better to ask them to look for a green flashing light ahead and, when it is seen, check its characteristics.
- The best way of identifying a mark is to come up to it and read its name or number. If this cannot be done for any reason take a bearing from your boat to the mark in question. Plot your position on the chart and

draw a line from your position along the bearing; this line should pass through the buoy you have taken the bearing of on the chart. Alternatively, get the mark you are unsure of in range with a charted mark and take the bearing along the range. Plot the bearing through the known mark on the chart and it should pass through the unknown mark.

- It can happen that a buoy has been removed, for repairs perhaps, and a similar mark but with a different name or number is temporarily in its place. If in doubt use the methods above to confirm the mark, or try calling the port authorities on the VHF.
- Occasionally marks go missing and lights go out. Navigation warnings on VHF should cover these in busy areas but in out of the way places it may be some time before they are replaced, repaired or reported.
- In some areas where the channels tend to change because of moving sand banks the buoyage route may be altered from time to time. The chart of the area may note if this is likely to occur and this is a good reason for keeping your charts up to date. If you suspect the channel has been moved read the buoys in the normal manner and proceed with caution and a wary eye on the echo sounder. Again, a call to the port authority might be worth considering.
- Inexperienced navigators and crew usually try to identify their destination as soon as land is sighted, long before it is necessary or even possible. Remember if you want to know where somewhere or something is first plot your position on the chart, then find the bearing from your position to the object from the chart and then look along this bearing using a hand bearing compass or turn the boat to the bearing. The object of interest is then ahead.
- Remember that when you see your destination it may be many hours before you actually reach it so avoid the temptation to steer directly towards the destination by eye unless it is very close. It is still necessary to plot courses to steer to compensate for tide and leeway.

Arriving at dawn
Before the days of electronic navigation aids it used to be common practice to plan passages so that you would arrive off your destination just before dawn. This meant that you could fix your position using lighthouses and lit marks and then make your way into harbour as daylight breaks.

Aiming off
If you are approaching land and are unsure of your exact position steer a course that will put you definitely on one side or other of your destination. In other words build in a definite offset so that when land is sighted you will know which way to turn to reach your destination. If possible pick the offset that will give you favourable wind and/or tide when you turn.

As an example suppose that you are approaching a harbour in foggy conditions under motor as there is now little or no wind. You only know your position to within about mile or two and therefore cannot plot a precise course to steer to the harbour. Suppose the tide is running towards the south. Plot a course to bring you, say, about 3 miles to the north (left) of the harbour. Steer this course until you reach a suitable depth contour or until land is sighted. You still don't necessarily know where you are but you do know that the harbour is to your right so turn to starboard and follow the depth contour or land (with due caution!) until you come to the harbour mouth.

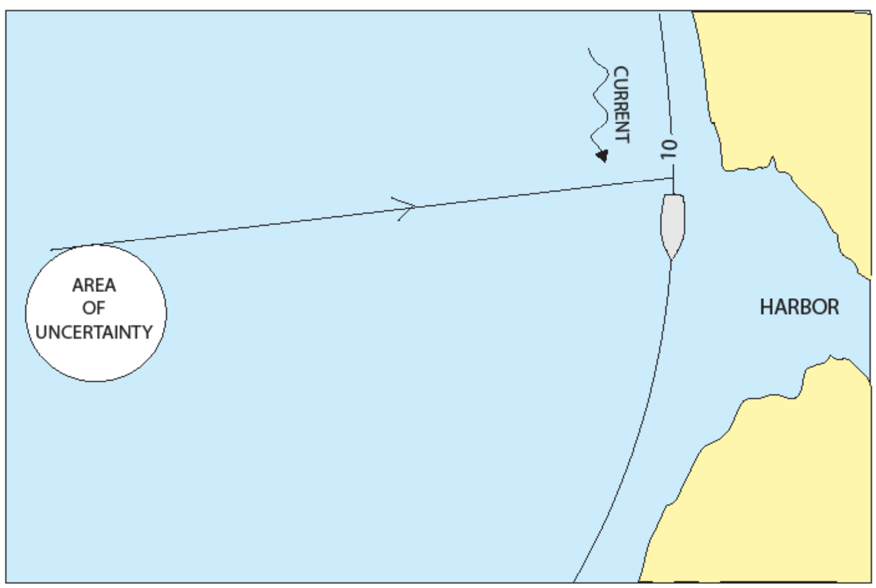


Fig. 1 The decision whether to head to the north or south of the harbour depends upon the direction of current and wind, if any.

Port control
When approaching a harbour switch your VHF to dual watch the port working channel and check whether it is obligatory to contact the port authority. If it is contact them and ask for their instructions or permission to enter.

Lock gates and marinas
If there are lock gates or a sill at the entrance to the harbour or marina check whether you can go directly in or will have to wait. If you must wait find out from the almanac where you can tie up, moor, or anchor. If a marina is your final stop call them on their working channel and arrange your berth together with directions if needed. At the same time ask the marina which side you should place your fenders in order to avoid having to change them all around at the last minute. If you need a hand to berth ask for assistance from the berthing master on the pontoon. Check in with the harbour master's office or marina office as soon as practicable to complete their forms.

Customs/ Immigration
Notify customs and/or immigration of your arrival if required.

Pilotage symbols
As was said earlier, try to avoid writing a lot of words when drawing up a pilotage plan, instead try to use sketches and symbols which are much easier to understand at a glance.

The symbols depicted here give an idea of a simple system which is generally accepted and is quick to use as well as being easy to understand at a glance.

It is not always necessary to go to great lengths to work out a complete pilotage plan but sometimes, in areas where the pilotage is very complex, great attention should be given to having all the work prepared beforehand.

If the pilotage is difficult you will not have time to keep going below to try and work out where you are and where you should be going.

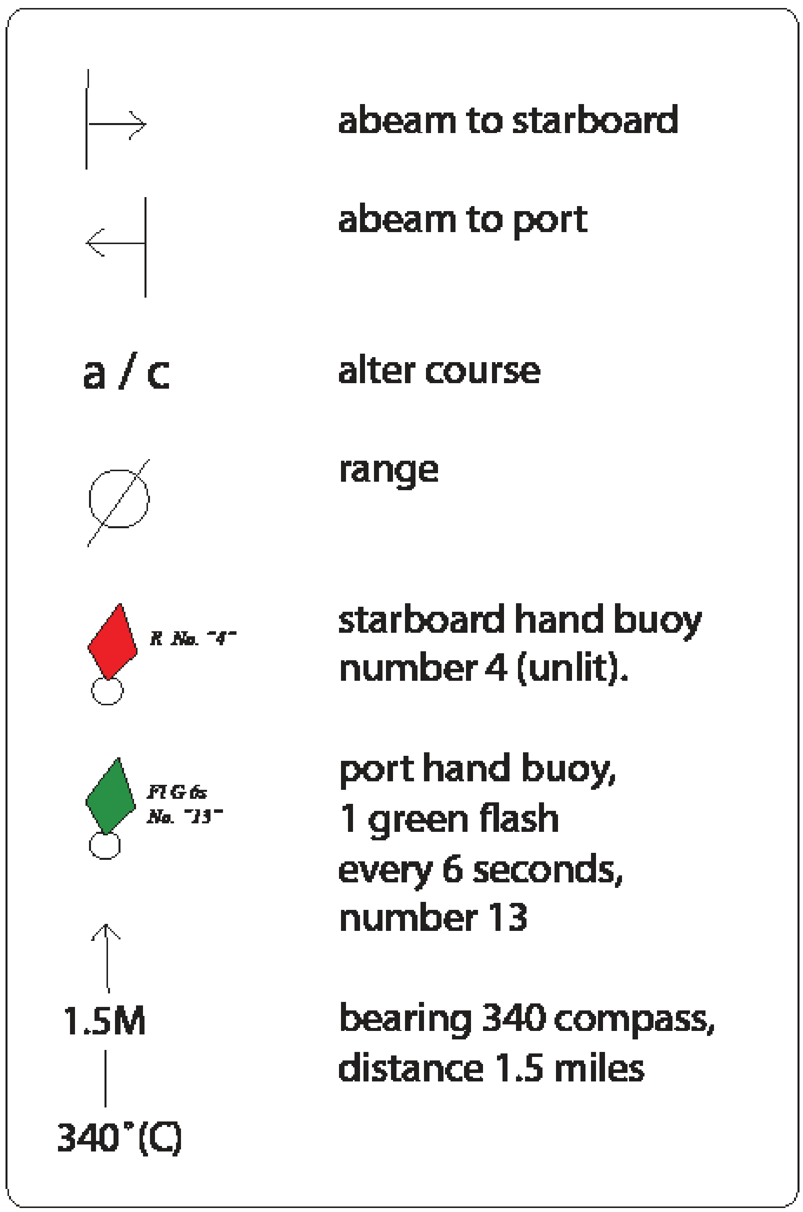


Figure 2
Suggested pilotage plan symbols

Example of pilotage notes for entry to Pogemahone for a boat approaching from the north east

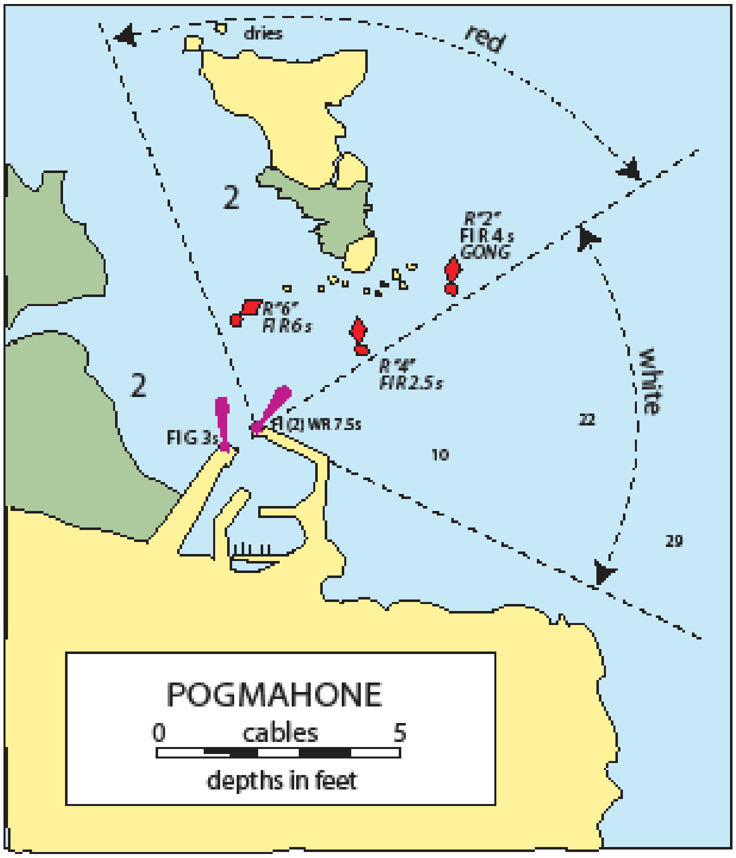


Fig. 3

A chartlet of (mythical) Pogemahon harbour, marina, and its approaches and is similar to what you might expect to find in a pilot book or nautical almanac. It does not have as much detail as you would find on the appropriate chart.

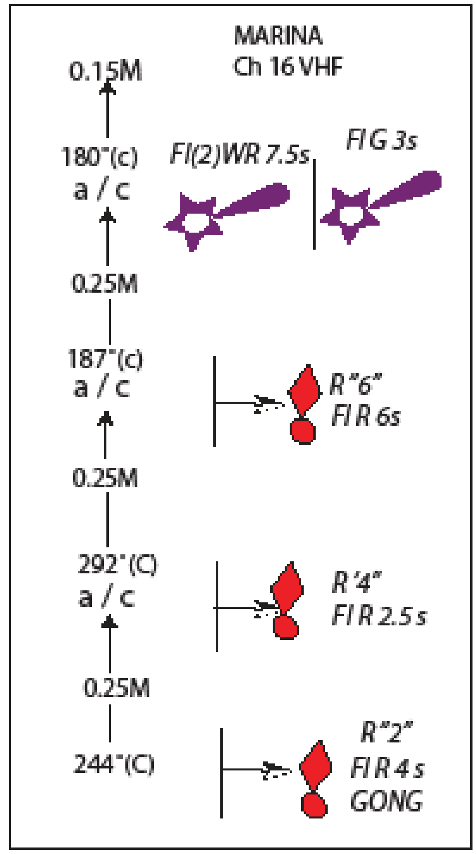


Fig. 4

Pilotage notes are usually drawn so that they are read from the bottom upwards. Note that all courses have been corrected for variation and (if required) deviation.

The pilotage notes shown in figure 4 above could also be written in text as follows:
"Pass the no "2" red buoy (Fl R 4s Gong) close on your starboard side, then steer 244° compass for 0.25 of a mile until you come to the red no "4" buoy which is lit,(Fl R 2.5s). Pass red No.4 buoy close to your starboard side and then alter course to 292° compass and hold this course for 0.25 of a mile until the red No "6" starboard hand buoy which is lit (Fl R 6s) is reached. Pass the No "6" close to on your starboard side and then alter course to 187° compass and hold this course for 0.25 of a mile until the harbour mouth is reached. Pass between the two lights on each of the breakwaters so that the Fl(2)WR7.5s light is on your port side and the Fl R Gs is on your starboard side. At the harbour mouth alter course to 180° compass and hold this course for 0.15 of a mile until the marina is reached. The marina monitors Channel 16 on the VHF radio".

The notes in diagram form, as in Fig. 4 above, are, for most people, much easier to follow than text.
The light on the end of the east pier, Fl(2)WR 7.5s, has red and white sectors. Approaching the harbour from the north east during darkness you should be in the white sector which will keep you clear of all dangers. If in doubt as to where you are within this white sector you could turn to starboard until the light just starts to turn red, you are then on a position line corresponding to the dotted line on the chart depicting where the white sector changes to red. Now turn a little to port and the light will turn back to white. If necessary you could continue on in this fashion until the R"2" Fl R 4s buoy becomes visible.

Following a line of soundings

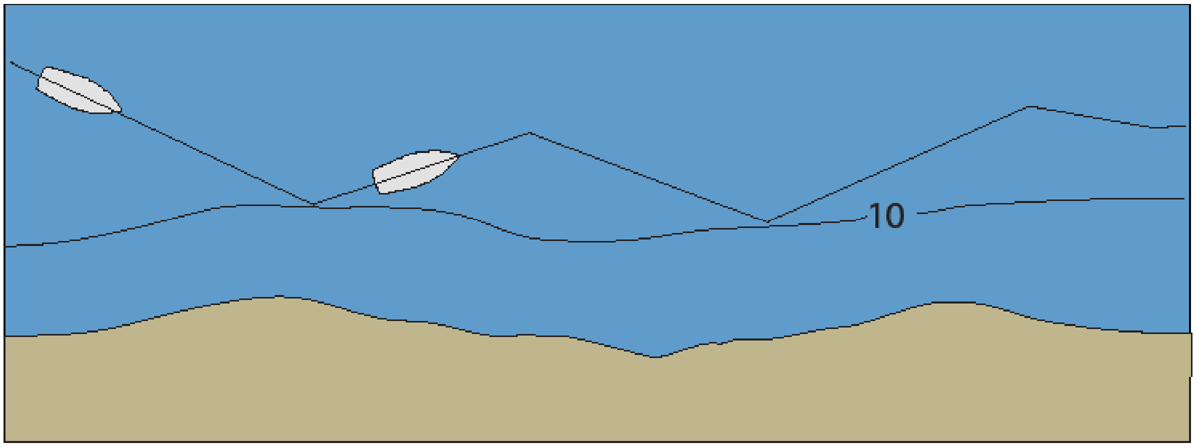


Fig. 5

It is usually impossible to try to follow a line of soundings, unless it happens to be a straight, line, which is most unlikely.

If you want to follow a line of soundings, provided the circumstances allow, try the method shown above in figure 5. Approach the shallower water until the sounding, allowing for height of tide if appropriate, is reached then move away from the sounding diagonally then back in again, a sort of touch and go method.

Identifying an unknown mark

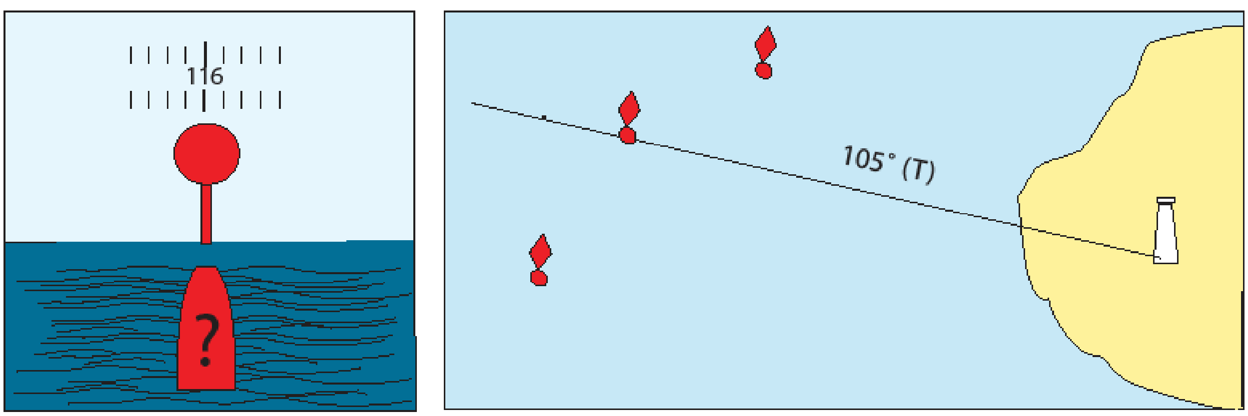


Fig. 6

If a mark is visible but you are not sure which one it is, perhaps because other similar marks are in the vicinity, try to bring the mark to make a range with a known landmark or sea mark. Take a bearing of the range and plot the bearing through the known mark on the chart. The line should pass through, or close to, the unknown mark.

This method, in reverse, can also be useful if you think that a buoy has moved (or been moved) and is not in its charted position. On the chart find the bearing through the buoy to a charted landmark then, when the two are visibly in a range with each other, take the bearing and compare it with the bearing from the chart.

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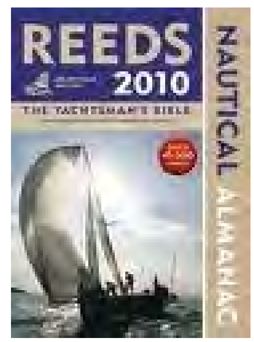
Passage Planning

Essentially passage planning consists of bringing together all of the general information required to complete the passage. The information needed will be gathered from various different sources such as pilot books, sailing directions, charts, almanacs and perhaps tourist guides and publications of the area. The destination area will have been decided prior to starting the passage planning. Usually the departure date is defined by circumstances such as holidays, weekends or owner's demands. As with pilotage keep the passage plan as brief and simple as possible.

Charts

A small scale passage planning chart will be required. Ideally this chart will cover all of the area involved as its purpose is to build up an overview of the whole passage; it will also be used to measure distances, to see what areas of interest might be visited and to pick out possible harbours of refuge along the proposed track.

Large scale charts will be required for any harbours or areas of particular interest which you may intend to visit. Use available chart catalogues when deciding on which charts are needed. Consider also charts of areas which you do not intend to visit but where you may have to seek shelter or assistance, i.e. 'harbours of refuge'.



Almanacs

An almanac such as Reed's for the current year will be needed, corrected to date, for its wealth of general information and harbour chartlets. This covers North Sea to Gibraltar

Pilot books and sailing directions

These have been mentioned before but remember that they should be up to date as possible; some pilot books may have correction sheets available from time to time.

Planning a passage

- Draw in the ground tracks from start to finish, avoiding dangers by a safe margin, and taking advantage of navigation marks and lights wherever possible. These tracks are not courses to steer, specific tidal work will usually be done just before the passage starts.
- From the distances and the expected average speed of the boat decide how long the passage will take and how much of the passage will be completed within your daily time schedule. Note harbours or anchorages which may suit for overnight stops.
- Circle clearly any hazards on the chart which are not easily noticed.
- Look for headlands or other areas which may have strong tides or overfalls, these may dictate that you pass at a specific time relative to high, or low, water.
- Note any harbours that may be used as harbours of refuge in an emergency. It may not be possible to en ter these harbours under all conditions so note carefully any shelter or tidal restrictions these harbours may have.
- If you are using GPS or Loran note the latitude and longitude of waypoints you intend to use. Check these carefully as it is only too easy to make mistakes when writing them out.
- Check whether the track passes through traffic separation schemes.
- If there is a tidal consideration, such as lock gates at your destination, it may be necessary to work backwards from this consideration in order to decide the time of departure. There is not much point in arriving 20 minutes after the lock gates have shut.
- Check which harbours have fuel and water available. The fuel consideration is of considerable importance to motor yachts. Always plan so that you have a reasonable amount of fuel in reserve and remember that adverse conditions may increase fuel, consumption dramatically. Check whether fuel, water, etc., is available on the dock.

- When deciding how long you will travel each day take into account the stamina and experience of the crew and the sea-worthiness of the boat. Remember that cruising is supposed to be relaxing and enjoyable, not a test of superhuman endurance.
- If a passage is expected to take longer than about 15 or 16 hours it is advisable to work out a suitable watch schedule.
- Decide the provisioning of basic food and water supplies.
- Most important of all try to maintain a flexible approach to the whole plan as conditions may be adverse on the day; trying to complete a passage against difficult conditions can spoil a holiday and put you and your crew under a lot of pressure.

Passage plan headings

DATES

Departure date.
Date by which passage must be completed.

CHARTS

Small scale passage chart (s),
Large scale detailed chart (s).

DISTANCES

Total passage.
Each leg of the passage, including courses and waypoints

BOAT SPEED

What you expect to be a reasonable average speed under average conditions.

PASSAGE TIME

Approximate time of the passage and/or each leg of the passage. To find how many hours a passage will take divide the distance in miles by the speed in knots.

TIDAL CONSIDERATIONS

Access and tidal restrictions (if any)
Tidal stream directions from the chart, Tidal Stream Atlas and Tide tables.
Areas effected by strong currents, overfalls, etc.
Times of low water and high water at the port of departure and the destination.

PORT INFORMATION

Access restrictions
Port signals, Radio reporting and radio channels
Berthing, provisioning and fuel facilities.

HARBOURS OF REFUGE

Access and tidal restrictions
Shelter
Facilities
VHF channel
Pilot book page number
Latitude and longitude

NAVIGATION MARKS EN ROUTE

Mark characteristics and light sequence.
Latitude and longitude

PROVISIONS

Sufficient food for 3 square meals a day plus snacks, tea, coffee, long life milk, etc.
Remember fuel for the cooker and a lighter or matches to light it.
Medical supplies; ensure that crew carry any medication they may require.
Note any special food requirements of the crew and any allergies to food.

FUEL AND WATER

Expected fuel consumption, and refuelling stops,
Reserve supplies of fuel and water
Availability of fuel and water at ports en route and at the destination.

DOCUMENTS

Check the requirements of any of the places you will, or may, visit. Personal items under this heading include passports, visas, inoculations, return tickets and so on. Ship's documents required may include registration papers, insurance documents, radio operator's certificate, ship's radio license (s), etc.

GUNS???

Whether or not to carry guns aboard becomes a difficult decision to make when cruising in some areas. Many authorities do not allow guns to remain onboard.

WATCH SCHEDULES

Try to have an experienced crew member on watch with one who has little experience.

The 'old' system used by ships gives 4 hours on watch and 4 hours off.

The crew are divided into two watches known as the port watch and the starboard watch, or for the sake of figure 1 lets call them Black Watch and White Watch. The Black and White watch are switched at 1800 so Black watch becomes White watch for the following 24 hours. This ensures that no one gets the unpopular middle watch from midnight until 0400 on two consecutive nights. The watch from 1600 to 1800 is known as the 'first dog' and from 1800 to 2000 as the 'second dog', the first watch being from 2000 to 0000.

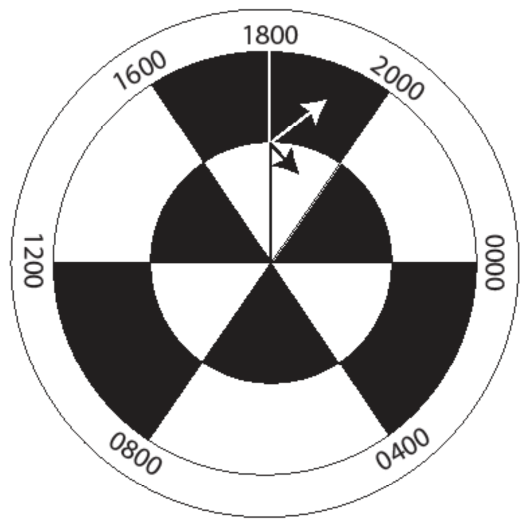


Figure 1

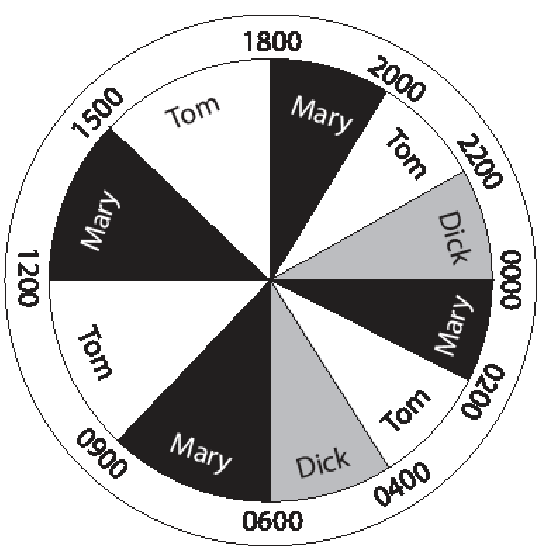


Figure 2

A Watch system with 3 people where one of them, by choice, does the cooking and house keeping on board.

The cook/housekeeper does his night watch but is excused watches during the day when he does the domestic chores and cooks the main meal (s), the other two share the daytime watches

Note that Dick enjoys the cooking and housekeeping, but the other two do not.

Figure 2

Figure 3 shows a system, when only two are available to keep watch; it gives 6 hours on watch and six hours off at night between 1800 and 0600. Three hours should not be too long on watch alone and six hours sleep during the night is not too bad either.

During the day a casual watch system allows the routine running of the boat and crew to continue and lost sleep can be caught up on when off watch.

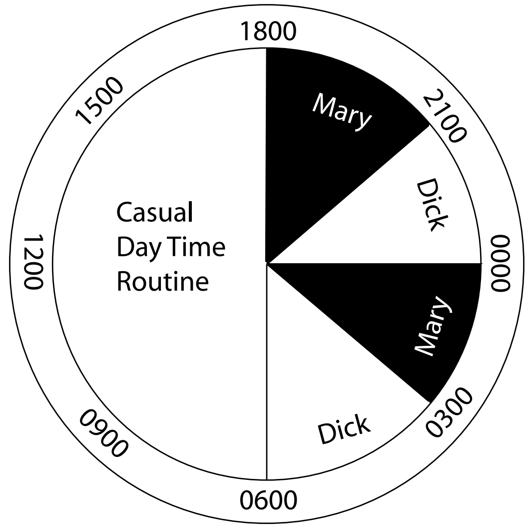


Figure 3

The system in figure 4 can work well when conditions are bad and tiring for the crew.

Each watch keeper gets 2 hours in the bunk, followed by an hour on standby, fully dressed and ready to come on deck immediately if required, followed by an hour on the helm.

HOURS	1	2	3	4	5	6	7	8	9	10	11	12
Mary			x	√			x	√			x	√
Tom		x	√			x	√			x	√	
Dick	x	√			x	√			x	√		
Harry	√			x	√			x	√			x

OFF	
STANDBY	x
ON WATCH	√

Figure 4

With 4 people this watch system gives each person 4 hours on watch but the first and last hours are shared with someone else.

Not only does this relieve the boredom but it means that one of the two on watch can make snacks and drinks, do the navigation and so on.

Using the system in figure 5 one person each day actually gets a luxurious 20 consecutive hours off watch; usually this person becomes responsible for preparing the evening meal.

Person	Day 1		Day 2		Day 3		Day 4
A	0600 to 1000	D	2100 to 0100	C	1200 to 1600	B	0300 to 0700
B	0900 to 1300	A	0000 TO 0400	D	1500 TO 1900	C	0200 TO 0600
C	1200 to 1600	B	0300 TO 0700	A	1800 TO 2200	D	0500 TO 0900
D	1500 to 1900	C	0600 TO 1000	B	2100 TO 0100	A	0800 TO 1200
A	1800 to 2200	D	0900 TO 1300	C	0000 TO 0400	B	1100 TO 1500

Figure 5

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Ropework, Knots, Bends & Splices

Knots, Bends, Splices, Hitches and Seizings are all ways of fastening one or more lines together or for attaching a line to an object such as a spar or ring. Bends and hitches are ways of fastening lines to one another or to an object. A splice is made by untwisting two rope ends, (or part of itself if a loop is required) and intertwining them together. A seizing is made by joining two spars, lines, or two parts of the same line by means of a smaller diameter seizing cord.

Selection of the right knot, bend, or hitch for the job is essential to prevent it undoing and also to take account of the type and size of rope. Consideration must be given to the construction and material of the rope. Simply, synthetic lines tend to have a smooth surfaces, some more so than others, and the holding power of knots and splices will be affected accordingly. It is also important to consider the 'lay' of the line; many knots and splices require some degree of twist, and laid line may resist this, buckling or kinking if forced. The line will cooperate much better if tension is taken out by a half twist in the knot making process or when coiling.

The ends of a line will unravel if not secure. Melting the exposed filaments of synthetic line will help but not for long if the line is in regular use. A more secure method is by use of a tight whipping using the correct thickness of whipping twine.

Rope Design

Ropework considers the construction of ropes and its correct usage. During the manufacturing process the word rope is used no matter what size or construction. When in use, rope is variously described as line, rope, cordage, small stuff, painters etc. depending upon its function. Normally rope is made as "right-laid" rope. Firstly the roping is twisted from left to right to spin the yarn. Next the yarns are twisted from right to left to form the strand, and finally the strands are twisted from left to right to lay the rope. Alternatively the process can be reversed, resulting in a "left-laid" rope. This method of construction using opposing twists gives a rope stability.

Inspection of wires and ropes

Wires, flexible steel wire ropes, are normally composed of strands of steel wire formed into strands laid, right handed, around rope core. The rope core forms a reservoir for the oil or wire rope dressing. The type of wire rope is identified by the number wires in each strand and the number of the strands. A 6 x 8 wire rope will have six wires in each of eight strands. Wire rope is generally galvanized to prevent corrosion and used in standing and running rigging. If a visual inspection of the wire rope reveals broken wires or excessive wear, the rope must not be used. If, in any length of ten diameters, the total number of ten broken wires exceeds five percent of the total number of wires, the wire must be taken out of use. No wire rope may be used if there is any knot in it or if strands are seriously deformed or kinked. Wire ropes should be cleaned to remove foreign materials such as sand which may stick to them and the correct wire rope dressing applied to keep them properly lubricated. Hand splicing of wire ropes is no longer acceptable and "Talurit" splices are used. These will have a serial number and safe working load (SWL) stamped onto them. All wires supplied to vessels should have a wire rope certificate. Lifting wires used in lifesaving appliances must be end for ended every thirty months and replaced every five years.

Care of Rope

The size of a rope is named for the circumference; the breaking strain is in tonnes .If the rope has been stored badly, it will be weakened and it will deteriorate in use. Misuse and incorrect handling will hasten this process. Man made fibre ropes are badly affected by ultra-violet radiation and require protection from direct tropical sunlight and contact with chemicals. Man made fibre ropes, especially nylon, can be very elastic and a length of nylon is often incorporated into towing springs, where extra elasticity is required.

Ropes should be inspected and condemned if there are obvious defects such as broken strands and kinks or signs of rot.

The effects of chemicals, water, salt, sand and sun on rope fibres all cause wear and tear, potentially reducing their strength. All ropes and lines should be protected from wear and tear and checked frequently. Ropes that are not used regularly should be uncoiled from time to time to prevent them from losing their flexibility. When storing ropes and cords, they should be hung in a dry place after coiling.

Of greater significance than breaking strain to the mariner is the Safe Working Load (SWL). This should be clearly marked on every` shackle, sheave, hook and wire splice. It is taken as being one sixth of the breaking strain.

Modern Rope Construction
There are three main groups of rope construction:

3 strand. Three strand is cheapest and easy to splice. It has resistance to sheave abrasion up to three times better than braided rope. A stranded line consists of fibres twisted in one direction to form a rope yarn which, when twisted again in the opposite direction, creates the strand. Three strands are then twisted again in the same direction as the fibres to create the final rope.

Braided. Easy on the hands braided rope is more flexible and less prone to kinks and twisting than 3 strand when used in a tackle. Should the braided cover become worn it can still be used without a very great loss of strength. A braided line comprises a core of braided or stranded threads covered with a sheath. The centre or core of the line gives it strength, and the sheath provides protection and ease of handling.

Plaited. Can be more easily and neatly spliced to chain, and as an advantage when used as anchor line, flakes well and does not kink easily.

Rope Types
Synthetic fibre ropes come in four main yarn groups. With the exception of nylon, generally the more expensive the fibre, the stronger the rope will be with less stretch.

1. Aramids such as SD3 (Spectra- Dyneema), Kevlar. These ropes are very expensive, are very strong and have very low stretch properties. They are a braided rope, used for Sail running rigging where lack of stretch is needed, but are sensitive to being nipped, difficult to make a strong splice and sometimes part with little warning under shock loads.

2. Polyester such as Dacron, Terylene. These are good all-round ropes. Strength can vary by 30% depending on construction but they can be pre-stretched to reduce stretch in use.

3. Polypropylene is an inexpensive rope with a lot less strength than Polyester, with more stretch and a slippery feel and that floats. Very prone to ultra-violet degradation

4. Nylon is stronger than similar polyester lay-up but has nearly twice the stretch. It is used for anchor warp and mooring lines.

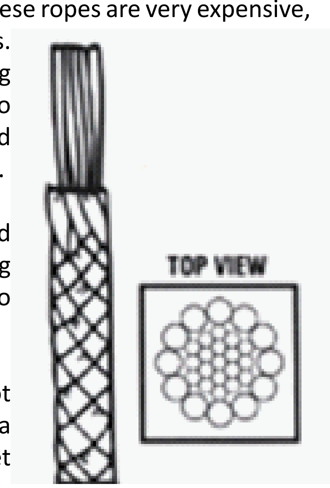


Figure 1
Braided

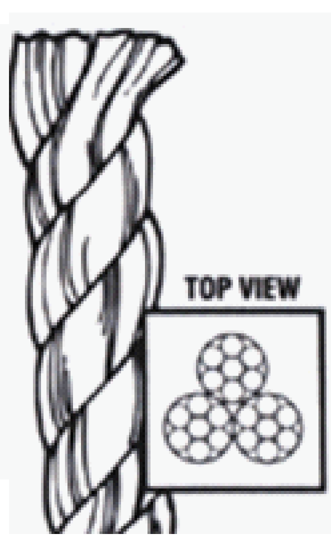


Figure 2
Stranded

Knots, splices, hitches etc.

Knots in the end of a single line
These knots are used in fastening a line upon itself or around some other object. Some of these are:
1. Overhand knot: Used in making other knots; never used alone.
2. Bowline: A temporary eye in the end of a line. It will not slip or jam.
3. Bowline on a bight: Used to sling a man over the side. It will not slip and constrict him.
4. Figure eight: Used to prevent the end of a line from unreeving through a block or eyebolt.
5. Blackwall hitch: Used to secure a line to a hook quickly.

Knots for bending two lines together
These knots are those that are used for joining two lines.
1. Square or reef: For tying reef points and bending lines together.
2. Granny knot: Usually a mistake for a square knot. It will slip under strain.
3. Sheet or becket bend (single): Used for bending line to becket and for bending lines of different sizes together.
4. Sheet or becket bend (double): Same uses as the sheet or becket bend (single).
5. Two bowlines: A safe and convenient way of bending two hawsers together.

Knots for securing a line to a ring or spar
These knots are called hitches or bends
1. Fisherman's bend: Used to secure a rope to a buoy or a hawser to the ring of an anchor.
2. Rolling hitch: Used to bend a line to a spar or to the standing part of another line.
3. Round turn and two half hitches: Used to secure the end of a line made around any object.
4. Half hitch or two half hitches: Used to secure a line temporarily around any object.
5. Clove or ratline hitch: Convenient for making a line fast to a spar, the standing part of another line, or a bollard.
6. Stopper on a line: Used to check a running line.
7. Catspaw: Used to secure a line to a hook.

Figure 3
Overhand Knot

Figure 4
Figure of Eight Knot

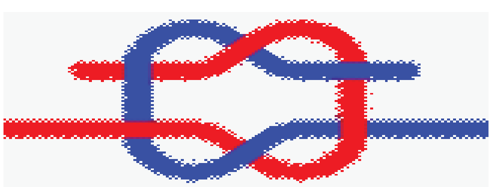


Figure 5
Granny Knot

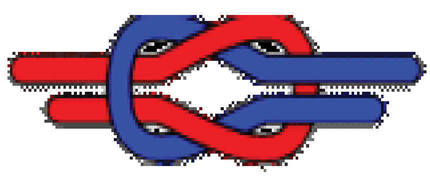


Figure 6
Reef or Square Knot

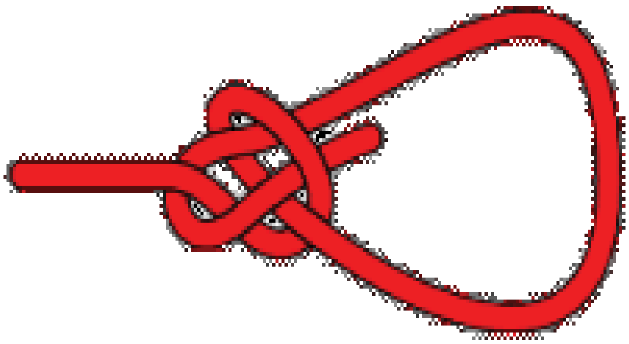
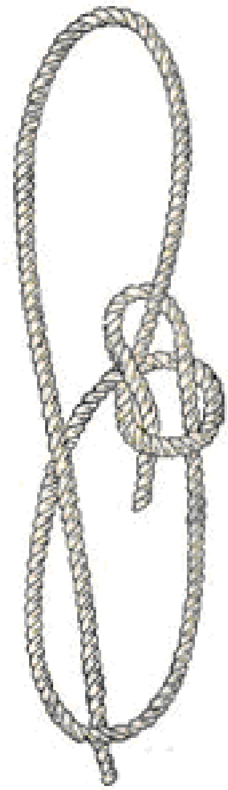


Figure 7
Bowline



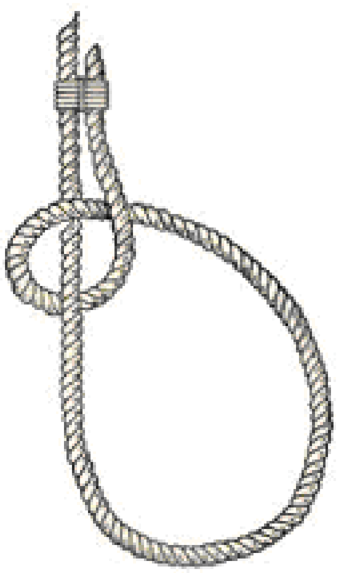


Figure 9
Half Hitch

Figure 8
Running Bowline

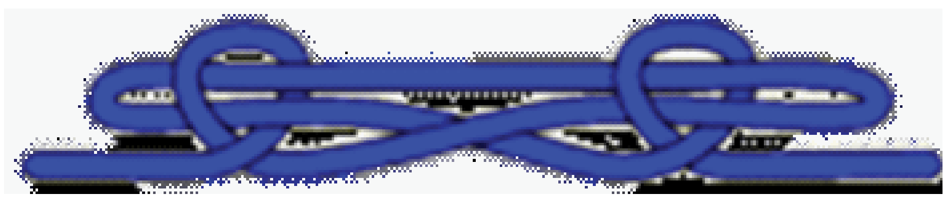


Figure 10
Sheep Shank

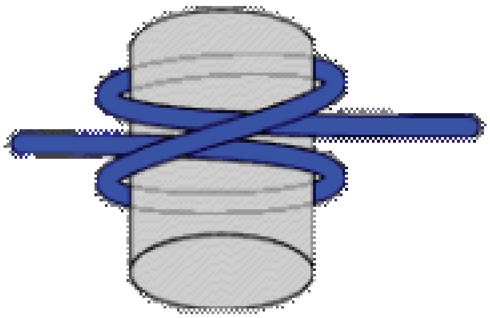


Figure 11
Clove Hitch

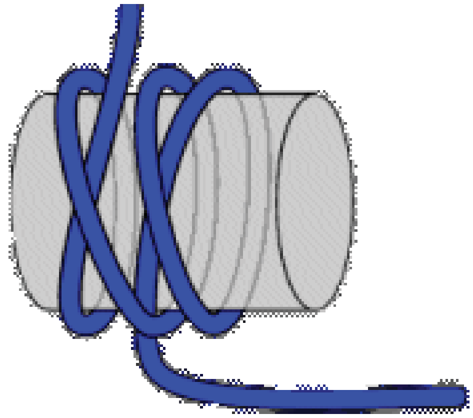


Figure 13
Rolling Hitch

Figure 14
Round Turn and 2 Half Hitches

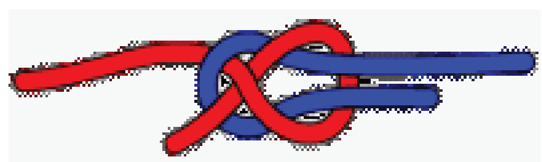


Figure 15
Sheet Bend

Figure 16
Double Sheet
Bend

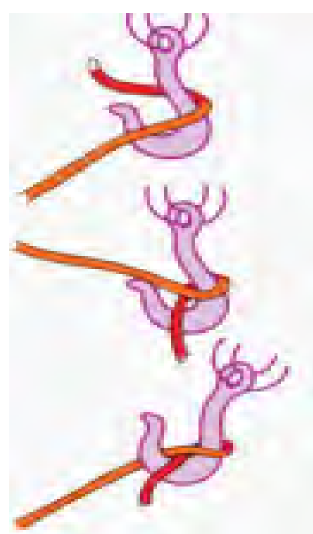


Figure 17
Blackwall Hitch

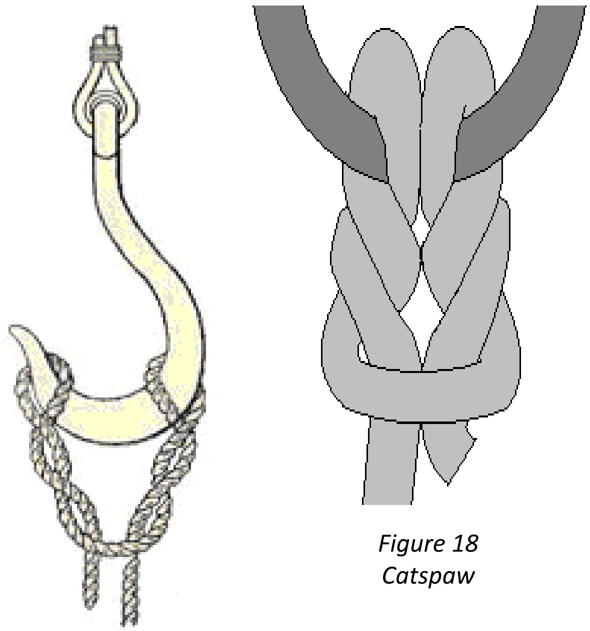


Figure 18
Catspaw

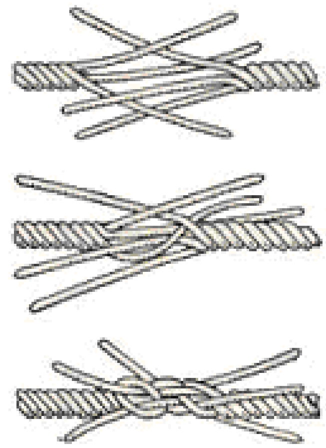


Figure 19
Short Splice

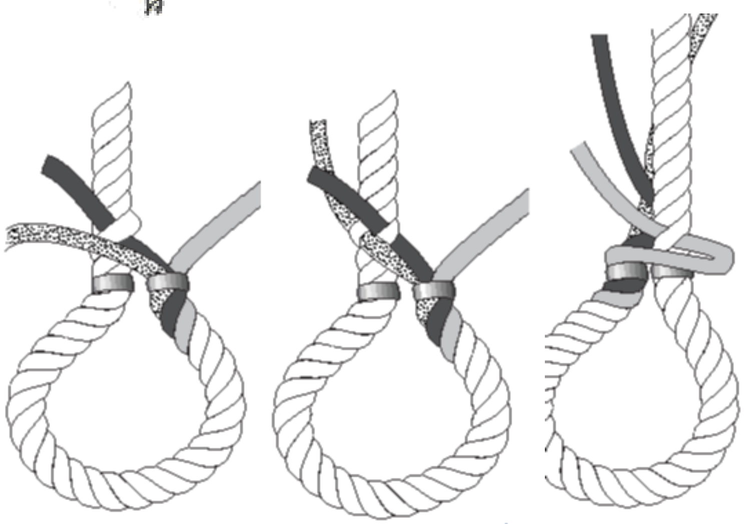


Figure 20
Eye Splice

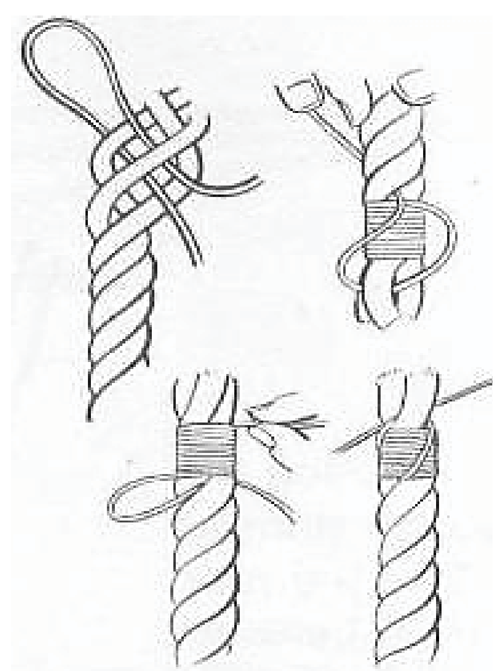


Figure 21
Sailmakers
Whipping

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Towing

The prime reason for towing is to clear a casualty from immediate danger or to get to it a safer point for repairs and to continue with its voyage. Whatever the situation, picking up a tow requires care and communication. A boat helping a casualty with a painter wrapped around its propeller is useless.

It should also be noted that insurance on any vessel is effective ONLY during normal navigation and customary operations which does include assisting and towing vessels or craft in distress. However this is not permission to undertake general commercial towage or salvage services. These activities entail putting the vessel to greater risk than that contemplated by the underwriters and would make the policy voidable.

Picking up a tow requires care and communication. Picking up the tow is usually best achieved by crossing ahead of the vessel to be towed depending on what proves most practical. Weather conditions, manpower and manoeuvrability of the boat will also dictate the manner of the transfer.

When towing, bear in mind that the tow will have little or no steerage, therefore all turns should be gentle. It is easy to turn inside the towed vessel, colliding with it or picking up the towline in the propeller. When bringing the towed craft alongside a rescue vessel, quay wall, etc remember that the tow cannot give a kick astern to stop, so use wind and tide to best effect.

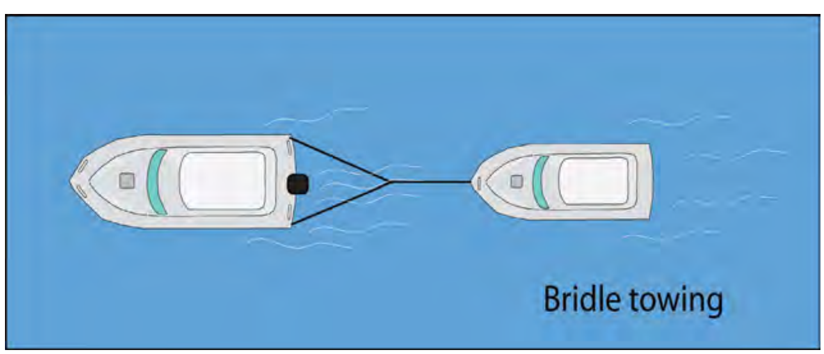
Towing general rules

1. Correct use of warnings to other craft, dayshapes, lights etc. (application of Colregs)
2. A rescue boat should use a bridle to spread the load and clear the towline from engines/propellers.
3. Tow to be attached to strong point on victim boat
4. The safety of personnel around the tow line and connected points is critical, to avoid injury to limbs and monitor potential chafe on the gear.
5. A system of communications is required during a casualty tow, preferably by radio, but if this is not possible then agreed hand signals work well. The coxswain must indicate the rescue boat intentions to the towed vessel.
6. Set scope of towline.- In enclosed waters, tow should be kept as short as possible. In open waters tow should be lengthened according to sea conditions.
7. Commence gently taking up the strain.
8. A dedicated member of the Crew watches tow at all times.
9. Towed vessel weight should be kept aft and steered if rudder is available.

There are two basic types of tow, astern and alongside.

Stern Tow

Picking up the tow is usually best achieved by crossing ahead of the vessel to be towed, the line can be passed from the rescue boat to the casualty.



Throwing a tow line, use of rescue quoits to aid throwing

When throwing a line to pass a towline, throw the line above the receiver to reduce the chance of injury and lessen chance of the line failing to reach the casualty.

A light line or a quoit can be used to achieve a throw of greater distance; the casualty can then haul in the line with the tow rope attached.

A towed boat should make the line fast on the painter attachment point, strong point, mast base or thwart.

Tow boat - tow line and Samson post

Generally speaking the towline should be attached to the rescue boat by means of a bridle or, in a dedicated tow boat, to a Samson post.

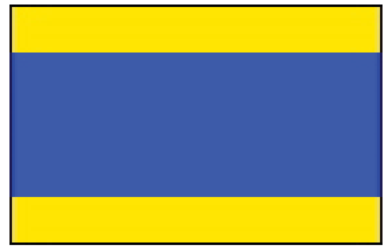
When towing, the tow line must not be too short, as this will result in "snatching" of the line, possibly causing damage to either craft and/or parting the tow.

Anti chafing gear should always be used to prevent the towline/s fraying.

Ideally the rescue boat and tow should be at the same stage in the wave trains; that is at the peak of the wave or in the trough at the same times. With the vessels out of step neither rides the crests or troughs at the same time. The result is snatching of the tow line causing potential damage to both of the vessels or parting of the tow line. In this case the tow line should be lengthened so that both ride the crests and troughs at the same time.

1. Attach towline to vessel to be towed.
2. Approach from downwind and cross ahead if possible, between 90 and 45 degrees, aim to pass the towline across to the bow of the vessel to be towed.
3. Tow line should be attached to a strong point on casualty. The towline should not be locked as it is important to to be able to get the line undone quickly if the rescue boat has to abandon the tow for any reason and also if the tow needs to be lengthened or shortened. A series of round turns and/or figures of eights on the towing post are normally used but it is important not to lock rope under each turn; everything tightens during a tow, bowlines, sheet bends should not be employed as they lock very easily
4. Estimate scope of towline.
5. In enclosed waters, tow should be kept as short as possible.
6. In open waters tow should be lengthened according to sea conditions; long enough to prevent the towed vessel slamming in to the stern of the rescue boat.
7. Catenary acts as shock absorber, it helps if there is a weight such as a length of chain in the line.
8. Commence the tow gently paying out the towline and then taking up the strain.
9. The engine revs need to be set at a speed that will allow control of the tow, taking care to minimise the chance of the towed vessel surfing the towing boat's wake; also not to put undue strain on the engines when towing a heavy casualty. Always allow for a speed reduction should the situation change.

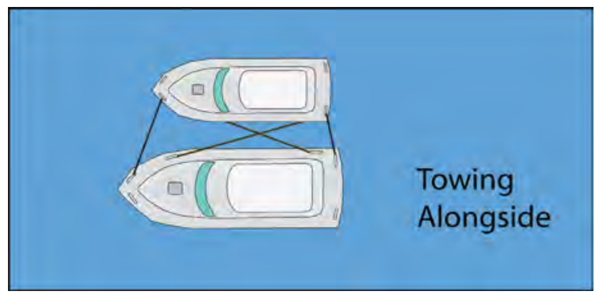
10. Crew must watch tow at all times.
11. Adjust trim of towed vessel; this should be trimmed aft and upright by the casualty crew.
12. On the casualty vessel, weight should be kept aft, centre board/daggerboard should be raised and steered if rudder is available.
13. Safe towing speeds will depend on the size and shape of the towboat and the size and shape of the towed vessel, the visibility and sea conditions.



During the day a code flag “D” (“I am manoeuvring with difficulty”) can be flown. At night the correct navigation lights should be displayed for towing operations.

Casting off the tow line and towed vessel needs to be done in a controlled and careful way to avoid ropes fouling the propellers and also that they are bought back on board quickly and efficiently, making sure the line is stowed and secured properly for next use.

Towing Alongside



The purpose of a side tow enables better manoeuvrability of the casualty in confined areas.

The ideal position for the Towing boat is to be well astern alongside of the casualty with the rudder or outboard is behind the casualty’s transom. The tow boat should be slightly toed in towards the casualty.

To protect both boats plenty of fenders should be used.

The two boats will require bow and stern lines to suitable strong points on both vessels, as well as 2 springs, fore and aft. All lines need to be tight to allow maximum manoeuvrability and control.

Manoeuvring with a Side Tow
A forward turn toward the casualty
Boats will pivot in place or describe a tight circle. Use this manoeuvre for tight turns in the direction of the tow and for bringing the bows to weather.

Forward turn away from the casualty
Boats will describe a large diameter turn away from the victim boat. Use this manoeuvre when you have plenty of room: do not use for bringing the bows to weather in tight quarters.

Backing toward the casualty
Boats will pivot in place or describe a tight circle. Use this manoeuvre for pivoting in place, aligning the bows in tight quarters or bringing the bows to weather away from the victim boat.

Backing away from the casualty
Boats will side slip backwards or side slip towards the victim boat (if it is heavy enough). Use this manoeuvre for backing when you have plenty of room; it is virtually useless for aligning the bows and cannot be used for bringing the bows to weather.

To bring a side tow to the dock
This requires an understanding of the manoeuvring characteristics and planning accordingly.
When docking boats of unequal size with a side tow, it is important to make sure that the boat on the outside does not damage the boat on the inside.
Putting the larger boat inboard will usually minimize this risk.

23

Anchors, Anchoring & Docking

There are a number of different types of anchor; each has its own advantages and disadvantages. The principle types are:

(a) Fisherman/Admiralty anchor
(b) CQR/Plough anchor
(c) Danforth anchor
(d) Bruce anchor
(e) Grapnel anchor .

Some manufacturers produce their own “improved “ versions based on these basic types.

Fisherman/Admiralty

The traditional type of anchor is sometimes known as an Admiralty Pattern anchor.

Advantages

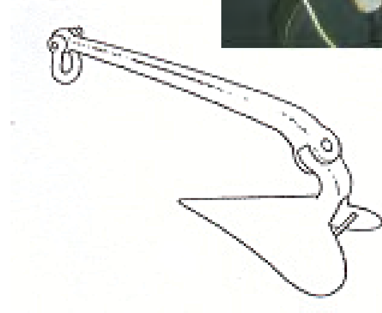
1. Good holding power in sand, mud, grass, or rubble.
2. Few moving parts to get fouled up.
3. Will hold in the widest variety of bottom types.

Disadvantages

1. A heavier anchor needed than some other types to give equal holding power.
2. It needs special consideration for stowing.
3. Because there is a vertical fluke when it is on the seabed, there is a possibility of the anchor chain or warp fouling this, or the boat settling on it.

CQR/Plough Type

The CQR is a proprietary type of anchor, sometimes also called a plough. Copying manufacturers’ versions are sometimes of inferior quality.



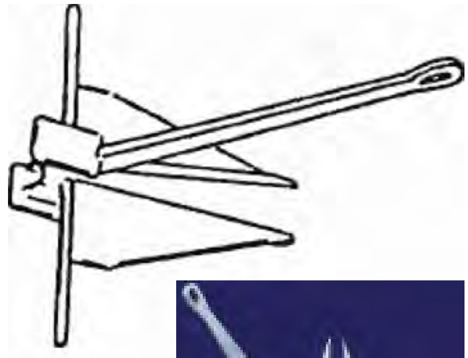
Advantages

1. Holds well in soft sand and mud.
2. Lighter anchor required than a Fisherman to give equal holding power.
3. Usually digs in well.

Disadvantages

1. There may be stowage difficulties, and special chocks are needed to secure it unless fitted over the bow roller.
2. Movable parts can become fouled and damage the fingers.
3. Can capsize (roll on it’s side after digging in).
4. Can be difficult to break out of mud unless a tripping line is used.
5. Does not hold too well in kelp, grass, or hard sand.

Danforth Anchor



The Danforth is a flat twin fluke anchor with the stock built into the head.

Advantages

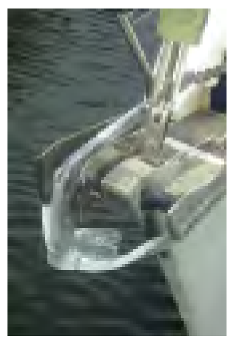
1. Good holding power in sand and mud.
2. Less weight needed to equal holding power compared with a Fisherman but about equal to a CQR.
3. Can be stowed flat.

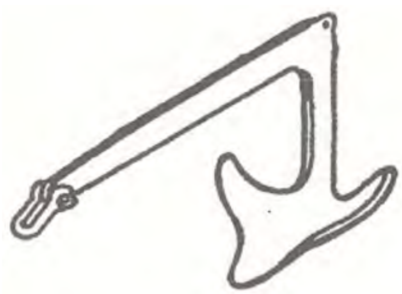
Disadvantages

1. Movable parts can become fouled and can damage fingers.
2. Not too good in rock, or heavy grass.
3. Can be difficult to break out of mud unless a tripping line is used.
4. Needs a length of chain to dig in well.

Bruce Anchor

Advantages



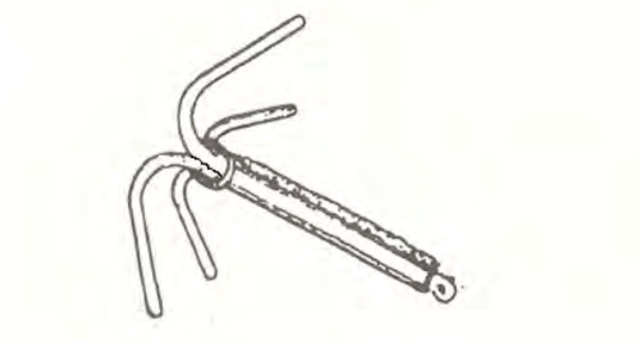


1. A much lighter anchor needed to equal the holding power of the other types.
2. No movable parts.
3. Digs well into the seabed however it lies, and quickly buries itself.
4. Good holding power in sand and mud.
5. Easy to break out.

Disadvantages

1. Difficult to stow without a special chock which, due to lack of space on the foredeck, cannot always be fitted. It can, however, be stowed over the bow roller if well secured.
2. Will not dig into heavy grass or kelp.
3. May continue to work it’s way very deep into the sea floor, making it difficult or impossible to retrieve.

Grapnel Anchor



A good anchor to hold on coral and rock and useful to use as a kedge.

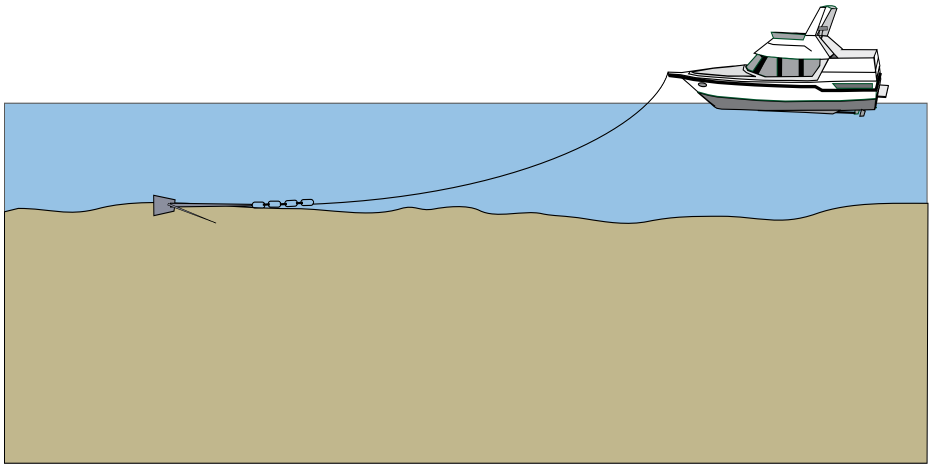
Kedge

A more portable smaller anchor of any appropriate type used for anchoring temporarily, for emergencies such as help to refloat after going aground, as a stern anchor or for assisting the main anchor.

Anchoring

Anchors hold best in soft bottoms such as sand and mud, but will hold in hard sand, shingle or pebbles. Smooth rock and weed are not good holding. The Fisherman is probably the best for holding in rock. It is best to carry two main anchors of different types, and a kedge.

Whichever type of anchor is used, to hold the vessel without dragging, a horizontal pull along the seabed must be created. This requires the correct amount of scope; at least 5 times the maximum depth of water for chain and at least 7 times the maximum depth for warp. Larger boats generally carry all chain while smaller boats are more likely to carry a short length of chain attached to a nylon warp.



The advantages and disadvantages of both are listed below:

Chain

Advantages:

1. The heavier weight gives better horizontal pull.
2. The weight of chain increases the catenary, which reduces the chances of snatching when anchored in rough seas.
3. Chain is not susceptible to chafe

Disadvantages:

1. All chain rode is very heavy.
2. Chain is harder to handle and needs a chain gypsy on the anchor windlass.
3. Weight at the bow of a smaller vessel may effect performance.
4. A snubber may have to be used to absorb shock.

Line

Advantages:

1. Absorbs shock
2. Lighter
3. Easier to handle than chain

Disadvantages:

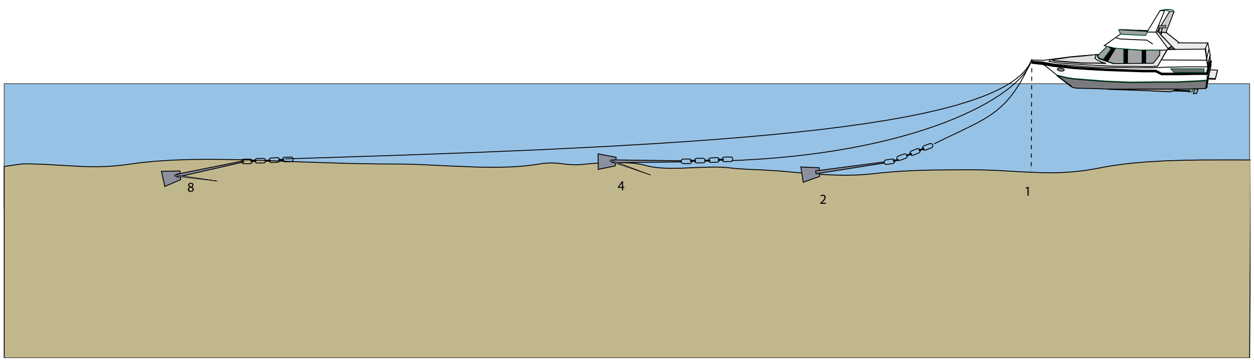
1. Susceptible to chafe
2. Susceptible to deterioration
3. More must be used than chain

Chain and warp

1. Even the short length of chain helps the horizontal pull on the anchor.
2. The elasticity of the nylon warp helps to reduce snatching when anchored in rough seas.
3. Chain and warp (line) is lighter.
4. Warp (line) is easier to handle.

Scope

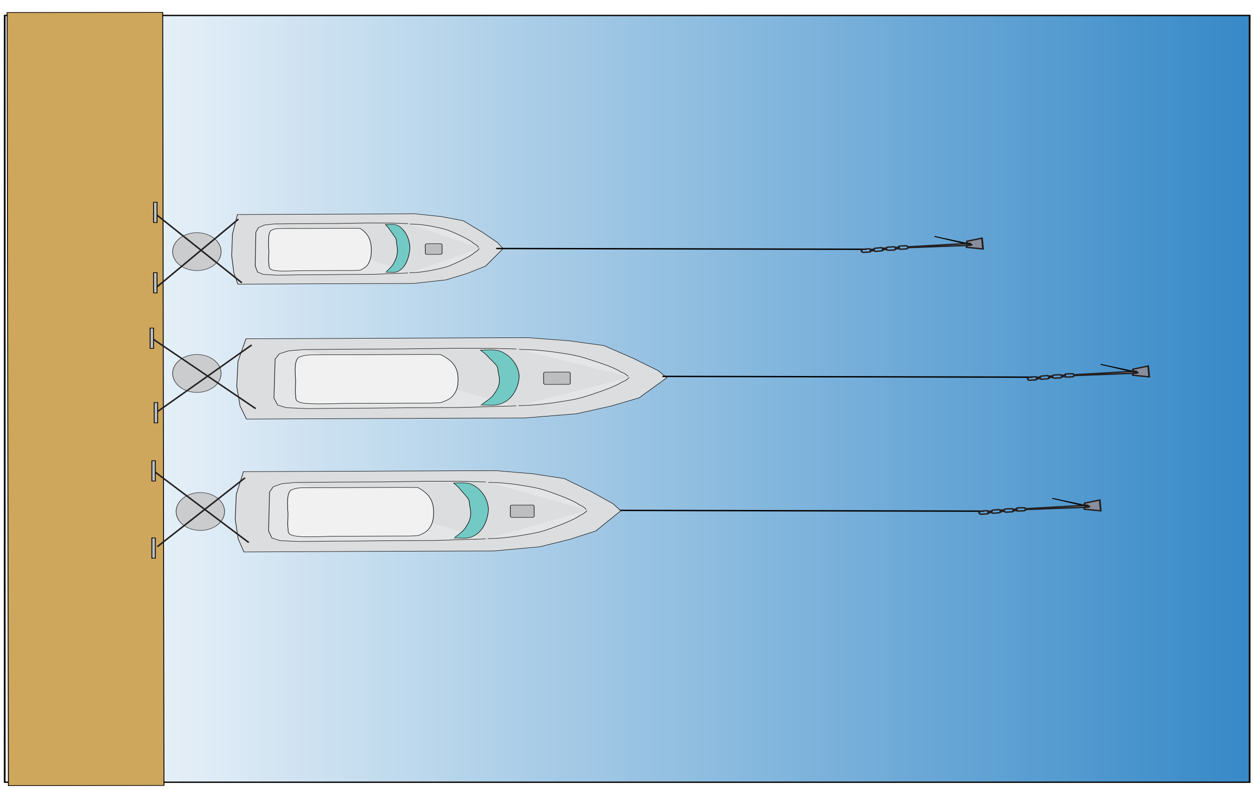
The scope of chain or warp will vary with conditions, the type of anchor and size and type of boat but, if the anchor is dragging, more should be let out. Whether chain or warp is used, both ends must be made fast securely. The inboard end should be lashed with a light line so that it can be quickly released, by cutting if necessary. At the anchor, shackles should be fastened with stainless steel wire (moused) to stop the pin turning. Warps should be attached either with a fisherman's bend or with a hard eye spliced in the line (around a metal thimble), fastened with a moused shackle.



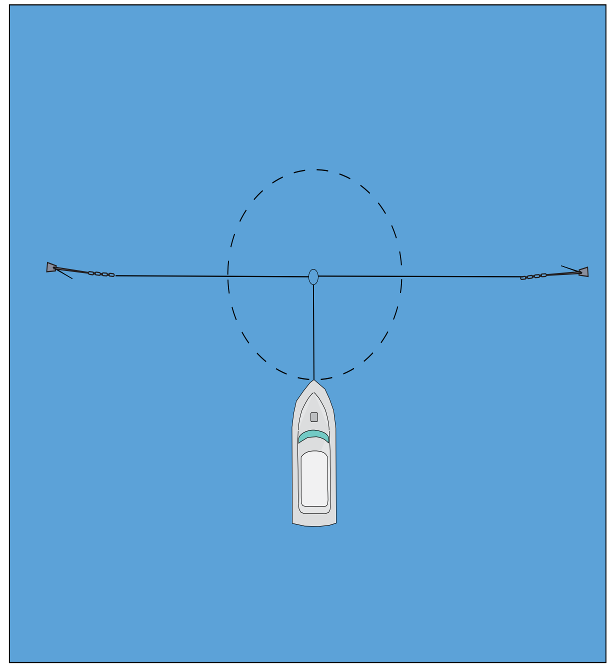
Fouled Anchor

If the seabed is covered with spoil and debris the anchor can become fouled. A trip line can save the ground tackle and before deployment it should be fastened to the anchor so that it can be pulled up by the crown. There is a hole or ring on most anchors for the attachment of such a line. The other end of the line may be attached to a small buoy (which has the advantage of marking the position of your anchor) or led back to the boat and secured on board (a longer line is required if the latter method is used, but it avoids the danger of the buoy becoming a hazard to other boats).

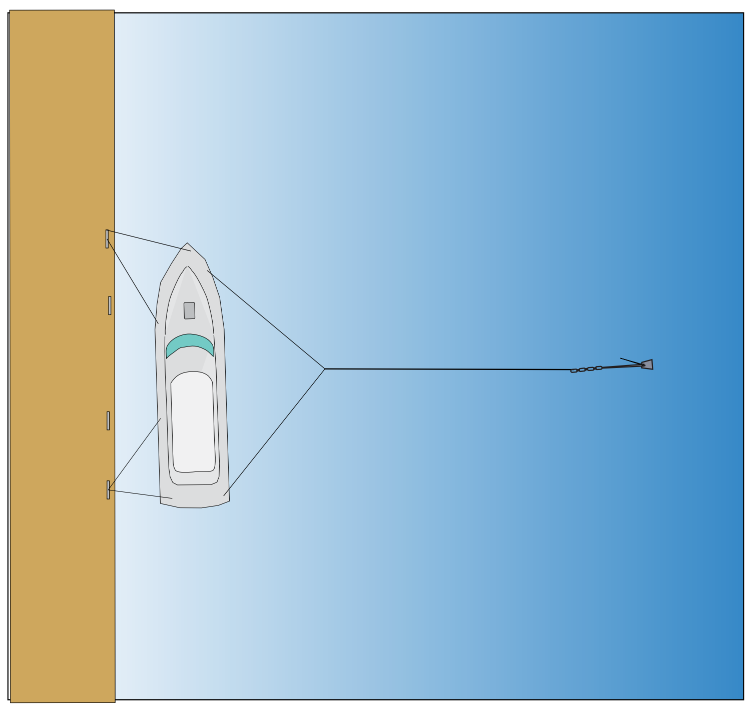
Mediterranean moor – Stern to dock with bow anchor to hold vessel off.



Bahamian Moor – use of two anchors meeting at a swivel, reduces swinging room.



Baltic Moor – alongside with an anchor laid out abeam midships to hold vessel off the dock.

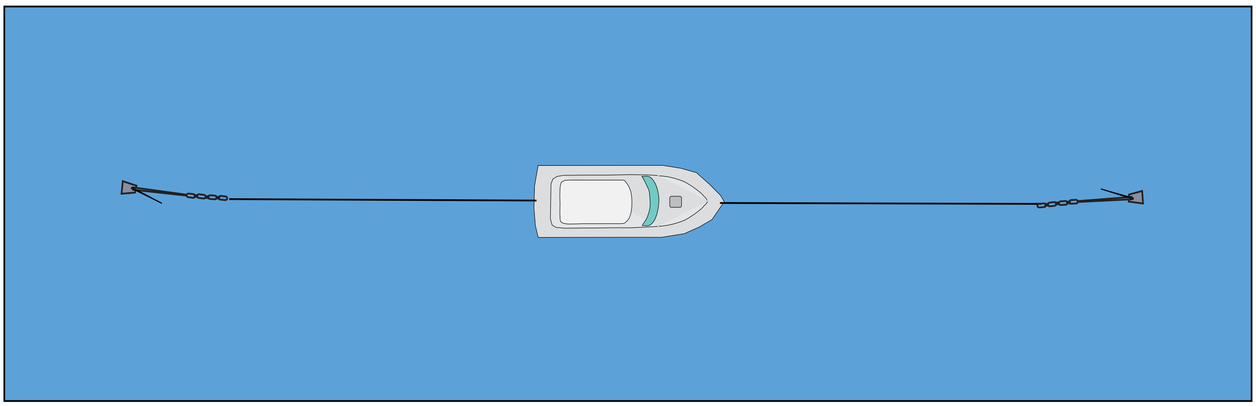


Laying A Second Anchor

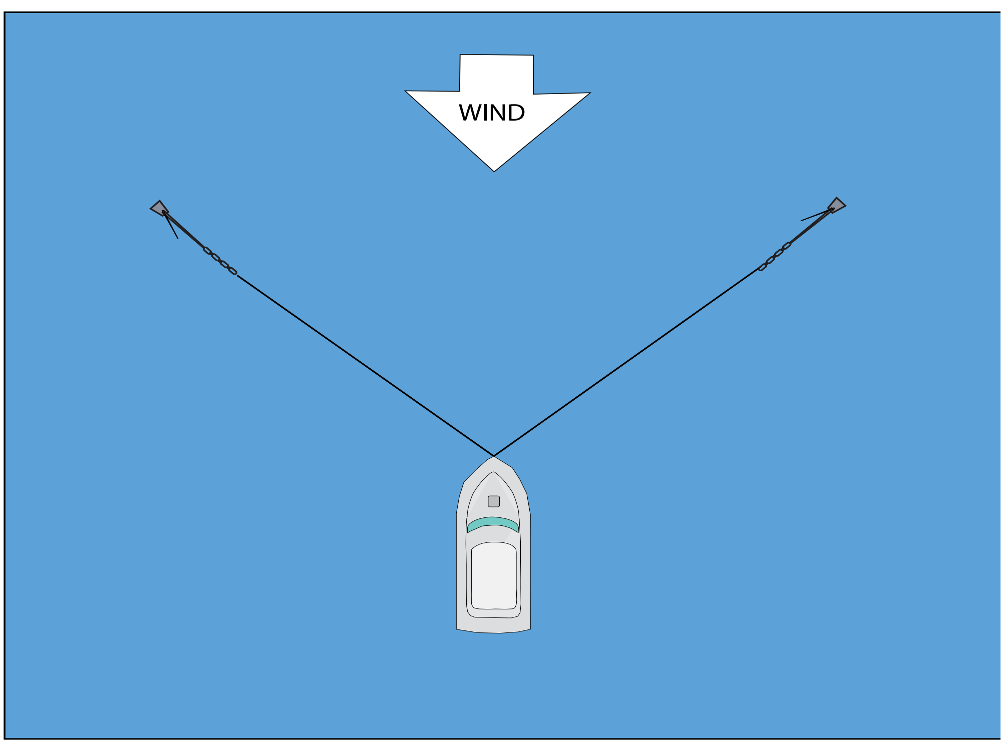
Sometimes it is necessary to lay a second anchor to reduce the swing or yaw of the boat due to tidal stream or strong wind, especially in a confined anchorage (the boat is then technically said to be moored). – See Bahamian Moor above.

Unfortunately not all boats, because of their different hull configurations, lie at the same angle in identical conditions. Some will lie more to wind and some more to tidal stream.

One method of laying two anchors is to lead one from the bows and once from the stern; the heaviest one in the direction of the strongest tidal stream and the other in the opposite direction. This method is only suitable for a strong tidal stream with little or no wind. If there is a crosswind, both anchors will drag. Anchoring fore and aft is not normally suitable for a small boat as it induces too much strain in a cross-tide or a strong cross wind.



Another way is to position the two anchors well forward from the bows, with not too wide an angle between them. This method is used when expecting strong winds.

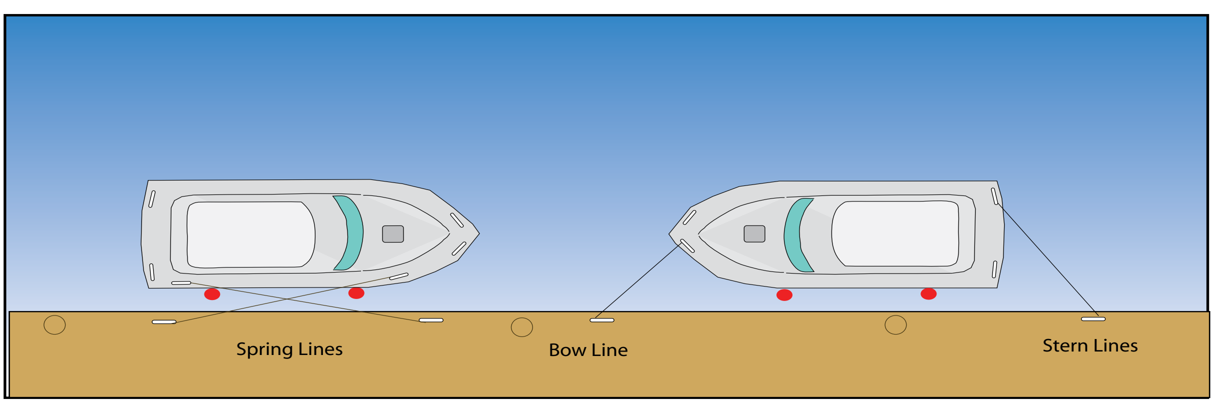


Choosing An Anchorage
Before reaching the proposed anchorage, estimate the direction the boat will lie and the length of chain or warp required. This should not be flaked down on deck because accidents can easily occur and the deck damaged. It should be marked at convenient intervals for depth identification.
When the boat has reached the anchorage and has stopped making way through the water, the anchor is lowered and, as the boat falls back, the chain or warp is paid out. An anchor ball or, if at night, an anchor light, should be displayed high in the forward part of the boat.

The inboard end of the chain or warp should be secured around a samson post or cleat. After the vessel has settled back on the anchor, bearings of objects abeam should be taken, or suitable transits noted, this allows the anchor watch to confirm that the anchor is not dragging. The maximum swinging circle should then be established to make sure that the vessel does not swing into shallow water or other vessels etc. after tidal stream changes or the wind shifts.

The following points should be taken into account when choosing an anchor berth.
1. The nature of the bottom and is it good holding ground suitable for the anchor that you carry.
2. The maximum and minimum depth of water, to determine the scope of rode to pay out and to ensure that you do not ground at low water.
3. Adequate shelter from all expected winds and other conditions for the duration of your stay.
4. Adequate swinging room at all states of tide.
5. Clear of channels and high traffic areas.
6. Take bearings and transits to confirm the vessel is stationary and not dragging.
7. Close to shore and to a safe landing point.

Docking
When docking in a new and unfamiliar area always check to see what the rise and fall of the tide will be and what state of the tide you are at now.
Allow for the rise and fall of the tide and use sufficiently long warps unless docking to a floating pontoon. As a general rule, you should allow at least three times the expected rise or fall of the tide. The lines to be used for docking will mainly depend upon the size and type of the boat and should take into account local conditions.
Suggested dimensions of mooring lines.
Diameter: 3 mm (1/8 inch for every 2.7 m of (9 feet) overall boat length.
Length: Bow & stern lines, two thirds of overall boat length, spring lines, one and a quarter times overall boat length.
The docking lines required to secure a vessel properly are:
1. Bow line. A line lead forward from the bows of the boat.
2. Stern line. A line lead aft from the stern of the boat.
3. Breast lines. Lines lead abreast of the boat from the bows and the stern. These keep the boat into the dock and they should be kept slightly slack.
4. Springs. One line lead from the bows of the vessel aft to the dock and one from the stern of the vessel lead forward to the dock. These stop the boat moving fore and aft and should be taut.



Adequate fenders both in size and quantity must be used to protect the hull and topsides. When alongside and where there are pilings proud of the dock a fender board will give the best protection.

When arriving at a new destination call ahead to the dockmaster to find where your dock is and which side you will need to come alongside. In coming alongside prepare in advance the necessary lines and fenders and clearly **brief the** crew on the duties and order in which things need to be done.

Do not jump ashore until the vessel is close enough to do it safely, and make sure arms, legs and other parts of the body do not get between the vessel and the dock or pilings.

On leaving make sure there are no lines in the water to foul the propellers and once clear of the dock untie and stow all lines, fenders and fender boards.

Etiquette Alongside

1. Always "Dip the Eye" (lead the eye of your dock line up through the eyes of other lines on the bollard). This will allow other vessels to cast their lines off first, should they choose to leave.
2. If lying alongside another boat for more than a short stop, lines from the bow and stern should be made fast directly ashore. It is preferable not to rely on the other vessels' lines and also it facilitates the inner boats' relieves the strain on the cleats of the innermost boat and will stabilize the raft.
3. Adequate fenders must be placed between boats or between the boat and the pontoon.
4. Spreaders should be staggered to avoid clashing in a swell.
5. When crossing another boat's deck, it should be done forward of the mast/deck house and not across the cockpit. Obviously cross as quietly as possible, taking care not to bring on dirt from shoes. If possible obtain permission first if there is someone aboard.
6. If on a sail boat rig frapping lines to prevent halyards slapping the mast.
7. Keep noise to a minimum.

Safety issues when handling Mooring lines and Anchors/Chains

Use of Personal Protective Equipment (PPE) should be mandatory,
Shoes should be worn, particularly when on the foredeck handling anchor chain
Gloves should be worn for rope and chain handling
Full briefing should be carried out well before the anchoring/docking manoeuvres

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Emergency Procedures

Emergency situations can be arise from a problem with the vessel such as fire, collision, stranding or foundering, or accidents to to a person or people on board, such as man overboard or a first aid emergency. Should an emergency situation arise the procedures that have been practised at musters and drills will come into play. A proper response to any emergency at sea depends on awareness of the crew, the safety equipment onboard the vessel and knowledge of the correct use of that equipment with maximum effect. In an emergency the safety or survival of each person depends on his own and his crewmates' foreknowledge and preparedness. It relies upon each persons' ability to remain calm and act quickly and effectively because panic ensures catastrophe.

Surviving the loss of a vessel at sea depends on split-second decision making and the more familiar the crewmember is with his survival equipment and how to use it, the better will be the response to the unique circumstances of an emergency. There must be adequate survival gear for every member of the crew; it must be properly maintained, properly stowed and accessible when an emergency strikes without warning.

All vessels must have a contingency plan for coping with all such emergencies and each crewmember must know how to carry out their required responsibilities. Survival equipment and safety gear carried aboard yachts varies greatly according to the size of the boat, its mode and area of operation, the size of its crew and its frequency of operation.

The **general emergency signal** is seven or more short blasts followed by one prolonged on the ships' whistle.
The order to abandon ship is given verbally by the Master, or senior surviving officer.

Situations Giving Rise To Emergencies At Sea

Correct assessments and responses to each of these situations will minimize loss and damage to property, crew and guests. Knowledge and familiarity with the equipment at your disposal together with regular training will enable all personnel to make an informed assessment and respond to any emergency which may arise.

Fire
Poor Housekeeping is the number one cause of fire! Some of the areas most vulnerable are:

- **Engine Room**
  Fuel/Diesel/Petrol . Insufficient ventilation/extractor fans. Faulty fuel lines, broken hoses, volatile fuels.
- **Galley**
  Explosions – forgetting to switch off propane. Propane locker must have overboard drainage and ventilation. Grease buildup in exhaust hood.
- **Smoking**
  Crew or guests fall asleep while smoking. Carpet and interior destruction. Smouldering ash getting blown back into the vessel's sails and igniting. Cigarettes should never be tossed into the water!!
- **Electrical**
  May occur anywhere on the vessel. Damp atmosphere causing short circuits. Wet electrical panel – over loading circuits. Lack of anti chafe
- **Exhaust Manifold**
  Extremely high temperatures. Wires, cloths, bulkheads or anything that will come into contact with it to cause ignition. Requires ventilation and shielding.
- Spontaneous combustion/ auto ignition due to poor housekeeping/stowage of materials.
- **Other**
  Hydrogen gas from charging batteries. Methane gas from holding tank.

Collision

- Distance to horizon is 1.34 x the square root of your height of eye above sea level. A ship travelling at 30 knots (with a height of eye of 9 ft) is on top of you in 7.5 minutes.
- Water tight bulkheads – if not closed at time of collision can cause boat to sink.
- Rapid flooding – can lead to death by hypothermia in cold water climates even if boat does not sink.
- Large or small-scale damage to boat – stern, bow, midships.
- Most collisions occur in fog or limited visibility.

Whales

- Whales are responsible for some of the small boat sinkings.
- Whales sleep on the surface at night, making them susceptible to collision.
- The hull of a sail boat underwater can be mistaken by a short sighted whale as being another whale. a whale can affectionately “brush” itself against the hull thus puncturing it beyond repair.

Containers

- Approximately 40,000 40 ft containers fall off ships every year worldwide.
- A container that doesn’t sink immediately will float right at the surface making it almost impossible to spot. It is probably the most dangerous obstacle for a small yacht to encounter due to its unknown location, re-enforced corners, steel construction and waterline puncture.
- Containers are almost completely invisible at night and can only be seen in daylight by maintaining an extremely alert visual watch. They are a very serious threat to shipping and are usually found floating with the currents that circle the oceans.

Heavy Weather

- Tropical Cyclones
- Risk of lee shore.
- Risk of reef or shoals.
- Pitch poling, turning turtle, knockdowns, capsizing, running aground, shallow water waves.
- Sea sickness, MOB, panic attack.
- Shifting objects.

Flooding

- Through hull fittings.
- Open hatches, portholes.
- Heavy weather.

Not Under Command N U C

- Loss of one or more engines.
- Loss of steering.

Stranding and Grounding

- Stranding in the event of flooding.
- Aground due to pilotage error.

Man Overboard

- Have a plan.
- Carry out regular practice drills.
- Allow all crew to experience each others roles in practice.

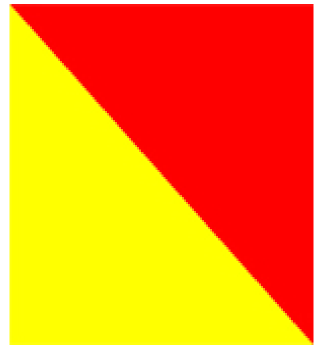
It should be noted that appropriate measures should always be taken to PREVENT MOB occurrence.

Personal protective equipment (harnesses) should always be worn whenever the weather might lead to in creased chances of MOB occurring.

Always use harnesses for any activity which might lead to MOB, ie working on exposed decks, and,

At night, in particular on sail boats, where work is required on deck and away from security of a cockpit

Man Overboard - There are 2 possible situations that could arise:



If person is seen to fall:

1. MOB Gear overboard. Mayday Call *
2. Alert crew/3 prolonged Blasts
   Crew to muster stations.
3. Appoint a spotter - DO not take eyes off victim!
4. Slow vessel.
5. Mark MOB position on GPS.
6. Appoint additional watchers.
   Radio Mayday or Pan pan

If a person is missing:

1. Alert crew. Mayday Call *
2. Slow vessel, mark position on GPS
3. Head count and search the vessel - find out when person was last seen, this gives a reference point to go back to.
4. Turn Vessel on reciprocal course.
5. Crew to muster stations.
6. Radio Mayday or Pan Pan.
7. Search.

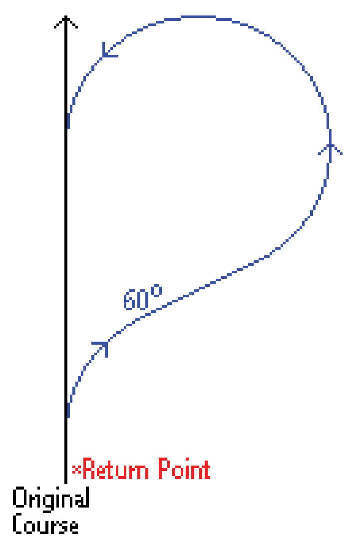
<u>In a MOB situation there are no right or wrong ways to return to the casualty; much will depend upon circumstances;</u> whether it is a power or sail boat, weather conditions, size of vessel, size and experience of crew, time of day or night, visibility, air and water temperature, proximity of other vessels and / or dangers, sail configuration in a sail boat, etc. Often the simplest method in good conditions is simply to stop the boat, power or sail, and motor back to the casualty. The following methods are outlined for general use and training as being the preferred method in most cases. Practice is important and using variations to improve these is to be encouraged. The most important thing to remember is to prevent the MOB occurring, but if it does that the casualty is recovered as quickly as possible and that during the process sight of the person in the water is not lost.

* Under International Radio Regulations 1982, the use of the word Mayday is strictly limited to situations where the ….ship, aircraft or other vehicle is threatened by grave and imminent danger...; there is no mention of a person. In order to include a person in the definition an International Conference on Safety of Life at Sea redefined Distress to include a person. Since 1991 it has been accepted practice to use Mayday in cases of man overboard.

MOB Recovery - Power - Williamson Turn

The Williamson Turn is most appropriate at night or in reduced visibility, or if the person has already has gone out of sight, but is still relatively near.

1. Put the rudder over full.
2. If in response to a man overboard, put the rudder toward the per son (e.g., if the person fell over the starboard side, put the rudder over full to starboard).
3. After deviating from the original course by about 60 degrees, shift the rudder full to the opposite side.
4. When heading about 20 degrees short of the reciprocal, put the rudder amidships so that vessel will turn onto the reciprocal course.
5. Bring the vessel upwind of the person, stop the vessel in the water with the person alongside, well forward of the propellers



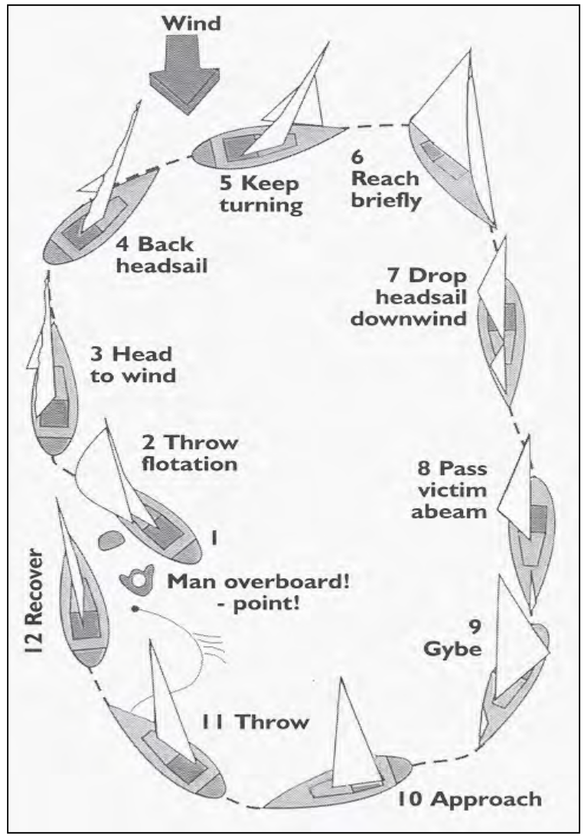
When dealing with a man overboard, always bring the vessel upwind of the person. Stop the vessel in the water with the person well forward of the propellers.

MOB Recovery - Sail

Quickstop Method

Safety authorities differ on what manoeuvre is best, so it is a good idea to learn all the techniques available. Practice will help determine the method that will work best for the situation, the conditions and the vessel

It is critical to stress here the importance of remaining as close to the MOB as possible.



There are 3 advantages of this method;

1. Can be carried out relatively easily with a small crew, even 1 person
2. The final approach is made on a fine reach enabling the sails to be either powered if needed or depowered to help slow or stop the boat.
3. It allows the vessel to approach either to windward of the MOB or to leeward depending on sea state and the condition of the MOB.

The Method

This method is best performed when close hauled or on a fine reach. It can be done from any point of sail in fact. Be prepared in some sea and wind conditions to trim the main as the boat rounds up to give enough boat speed or sail power to tack. With a shorthanded crew, trimming the main and steering at the same time may be difficult. Once the boat has tacked, continue to sail in a circle to windward of the MOB.

Once the boat is immediately upwind of the casualty, start to steer downwind past the casualty giving the boat room to head up and approach the casualty on a close reach.

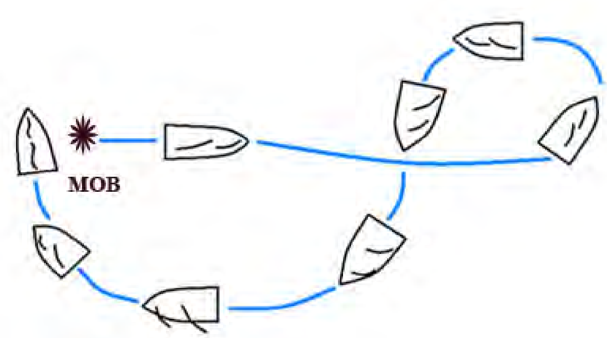
It helps to maintain a radius in the turn large enough to maintain steerage, making adjustments as necessary to reach the person.

Remember that on the downwind leg to get on a fine reach it will be necessary to gybe. Keep the boom in close to the centre line sheeted in to prevent a violent gybe.

Beam Reach or Figure 8 Method

The advantages of this method:

1. On a beam reach sail trim does not need to be carefully managed
2. The boat can be powered up or slowed by trimming the sails
3. It allows the vessel to approach on either side of the casualty depending on conditions.



The Method

This method will work from all points of sailing even downwind. (MOB under Spinnakers needs careful handling and practice)

It is essentially a figure eight and is executed as follows:

1. Change course to a beam reach and reach away for about 8 to 10 boat lengths, or 20 seconds
2. Tack the boat, leave the jib unsheeted
3. Veer off until the boat is at a broad reach, so that the victim is upwind about 3 or 4 boat lengths
4. Turn upwind until the vessel is pointing toward the casualty at this point the vessel should be on a fine reach.

5 Ease the mainsail sheets, controlling boat speed to bring the vessel to a stop with the victim in the windward side.

Recovery on Board
The sails will be flapping around at the pick up point, so if possible drop the sails.

With a conscious casualty and if the yacht has a “lifesling” this should be trailed so the casualty can reach it; Alternatively a line with a large bowline can be prepared so that the casualty can pass it around their body after being thrown over by heaving line.
Should the casualty not be able to help himself then the boat must be manoeuvred close enough to make contact and pickup from the deck. In large waves approach to leeward of the casualty to prevent the boat falling off a wave causing further injury to the person in the water.
Always be prepared for the boat to drift faster than the person in the water and have retrieval gear ready to deploy

Getting the casualty back onto the deck is another issue, some modern yachts have a boarding ladder on the “sugar scoop” at the stern which is easy in light weather, however in a heavy swell this could be dangerous as the yacht may rise and fall a substantial distance.

Do not put another person in the water unless absolutely necessary, ie, the first person is unconscious. The second person should be geared up in a survival suit and lifejacket / harness and be securely tethered to the boat.

Emergency Seamanship

There is often more than one solution to a problem but there will always be certain key factors that have to be taken into account.

Grounding and Refloating

Grounding

1. Fix the vessel’s Position because if the navigator knew the position then the boat would probably not have run aground. Consider holding the vessel in position with anchors.
2. Assess degree of damage, sound ALL bilges and tanks and arrange internal inspection of the hull. Taste water in bilge, you may have ruptured a fresh water tank!
3. Monitor the situation and make regular checks on all compartments.
4. Sound around the boat to determine the nature of the ground on which the she lies. How much of the of the hull is actually aground?
5. Assess the degree of risk and will depend on many factors, including the present weather and that forecast, the state of the tide and the amount of damage found. Divers may be required to make more a detailed inspection.
6. Arrange outside assistance, this may involve a Mayday, a Pan Pan or a call to arrange a tug.
7. Guests and crew may have to be taken off.

Refloating

1. Will she float and if so will she survive the tow to a safe port. Will extra pumps be needed? Is there enough crew?
2. If a tug is engaged to pull the vessel off, then good communications are essential between vessel and tug, together with an agreed plan of action.
3. In order to secure the tow, bearing in mind the strain on the towing gear in such an operation, it is worth considering using the heavy towing gear from the tug. Give thought how the line is to be secured aboard.
4. Passing the towline can present many problems and there are a variety of ways this can be done such as direct from the tug, by small boat or by line throwing equipment
5. It may be useful to lay out an anchor on a wire or rope to assist. Timing weather, the state of the tide and daylight will effect this.
6. Where is the nearest port that will have the necessary facilities to make repairs?

Heavy Weather Damage

It is important to take all possible steps to avoid damage especially to any windows as this will certainly disrupt the control systems of the boat. Should damage occur the points listed are some to consider.

1. Heave to with the bows into the sea and minimum speed. Make sure waves are unlikely to break aboard before crew is allowed on to exposed decks.
2. Ensure safety of personnel while inspecting damage. Consider life lines, harnesses and life jackets.
3. Assess the damage and make the best possible repair. If necessary wait for daylight or if there is risk of further damage stay hove to until weather conditions improve.

Collision Damage

1. Survival of the vessel, will she stay afloat?
2. Assistance is required either for own boat or the other one involved?
3. Inform shore authorities of the problem and your course of action, accident reports MUST be filed.
4. Remember that you must render assistance to the other vessel if required.
5. It is unlikely that any repairs can be done without outside assistance.

Flooding

1. Determine the source of the water. Is it salt or fresh water?
2. Actions should include closing watertight doors if fitted. Ensure crew is clear of compartments affected. Start all necessary bilge pumps.
3. Effect repairs if possible or make to nearest safe anchorage or harbour. Arrange shore assistance, extra labour, pumps and divers.

Assisting a Disabled Vessel

1. Assistance to a disabled vessel can take many forms depending on the circumstances.
2. On approaching a vessel in difficulty the first priority is to establish communication. Only then can the ex tent of the problem and the type of assistance be determined.
3. Usually all that will be required is 'moral support', just in case the situation deteriorates. The casualty may be able to get under way but require an escort to the nearest port.
4. Communications will be required.
5. It may be decided to transfer surplus personnel so preparations have to be made to receive extra people on board.
6. A tow may be requested, in which case either a towage fee should be agreed or Lloyd's Open Form used.
7. In the worst case the casualty will founder, and survivors will have to be recovered from the water. Actions will depend very much on the weather conditions.
8. The problem is then one of recovery of survivors from the water or life raft.
9. Read Annual Summary of Notices to Mariners No. 4 "Distress and Rescue at Sea -Ships and Aircraft". Sections 82 to the end.
10. Making a lee to recover survivors from the water. It has been found by experiment that the area of lee can be increased by a factor of 20 by slowly steaming round the raft or survivors. The vessel must move slowly otherwise a bow wave will build up and the circle must not be too large or waves will break in the centre of the turn. This manoeuvre may well give those extra minutes that are so vital in such an operation.

Beaching a Vessel

The main reason for beaching a vessel would be to stop her sinking as the result of uncontrollable flooding. Time the main consideration. Once it becomes clear that the water level cannot be controlled then she must be put ashore quickly, before the water reaches the engines.

It is unlikely that she will be able to move far as she will be getting lower in the water as time goes by. Therefore this operation is only possible close to the shore.

Successful beaching will help considerably in the subsequent salvage. The best position is a shelving flat sandy shore. Beaching a ship with any sort of sea running is going to involve considerable risk to personnel and will probably only be an option in good weather.

Heavy Weather Precautions

Weather information can be found in a Nautical Almanac or in the Admiralty List of Radio Signals Vol. 3. See also Annual Summary of Notices to Mariners No. 9. It is a vital part of good passage planning to obtain the latest weather information before setting out on a voyage.

Precautions for an expected period of heavy weather are very much a matter of common sense. However after a prolonged spell of good weather crews can become lulled into a false sense of security.

Some details that need to be attended to include:

External

Securing anchors.
Securing boats.
Storm shutters on exposed windows.
Loose gear around the decks.
Securing gangways.
Rigging Jackstays

Internal

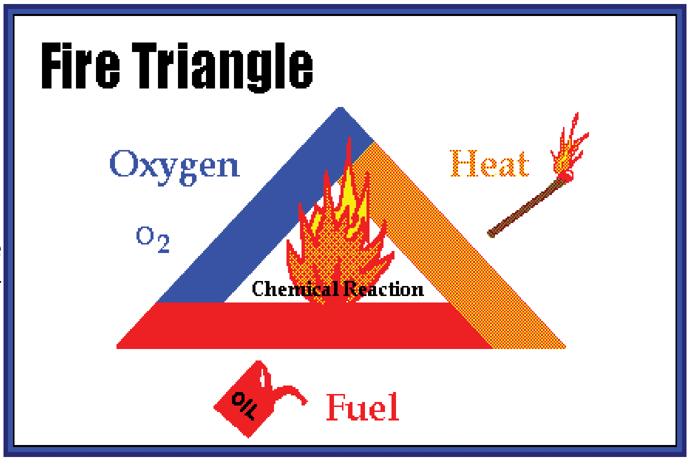
Around the galley with particular attention to bars on the stoves.
Passenger and crew cabins.
Store rooms
Ballast tanks, if fitted, should be either empty or pressed up.
In the steering gear compartment check and ensure nothing can fall and foul the steering.
Bilges should be empty, particularly those in the engine room. This should be normal practice, but in bad weather water can be thrown into machinery causing break downs.

Fire Prevention and Firefighting

Fire is the visible effect of combustion. Combustion is induced by the chemical combination of oxygen with one or more elements or with one or more constituents of a substance.

For a fire to exist, there must be three things:

FUEL	Something to burn.
HEAT	Something to raise the tempera ture of the fuel.
OXYGEN	Something for the fire to breathe.



A fire can only exist if the triangle is intact. Break the triangle by removing one side and the fire will be extinguished. This is the basic concept of firefighting.

a) Removing heat is called cooling.
b) Removing oxygen is called smothering.
c) Removing fuel is called starving.

Fire extinguishers can be used to remove one side of the fire triangle or the triangle of combustion and thus extinguishing the fire. They are generally sufficiently small and light in weight to be carried readily by hand and are then known as hand extinguishers. Larger extinguishers, usually foam or dry powder, mounted on trolley units may be found in machinery spaces.

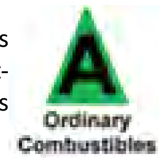
Basically extinguishers are divided into 2 groups:

1. Those that cool.
2. Those that smother.

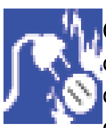
They are further sub-divided into the following groups as per selection chart types:

Fire Extinguisher Ratings

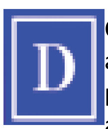
Class A Extinguishers will put out fires in ordinary combustibles that are not metals, such as wood, paper, cloth, trash, plastics. (Class **A** fires generally leave an **A**sh.). The numerical rating for this class of fire extinguisher refers to the amount of water the fire extinguisher holds and the amount of fire it will extinguish.



Class B Extinguishers should be used on fires involving flammable liquids, gasoline, oil, grease, acetone and any non-metal in a liquid state. This classification also includes flammable gases. (Class **B** fires generally involve materials that **B**oil or **B**ubble.), The numerical rating for this class of fire extinguisher states the approximate number of square feet of a flammable liquid fire that a non-expert person can expect to extinguish.



Class C Extinguishers are suitable for use on electrically energized equipment fires. This class of fire extinguishers does not have a numerical rating. The presence of the letter “C” indicates that the extinguishing agent is non-conductive. As long as it’s “plugged in,” it would be considered a class C fire. (Class **C** fires generally deal with electrical **C**urrent.)



Class D Extinguishers are designed for use on flammable metals like potassium, sodium, aluminum, magnesium and are often specific for the type of metal in question. There is no picture designator for Class D extinguishers. These extinguishers generally have no rating nor are they given a multi-purpose rating for use on other types of fires.

Using a fire extinguisher

It’s easy to remember how to use a fire extinguisher if you can remember the acronym PASS, which stands for Pull, Aim, Squeeze, and Sweep.

Pull the Pin

Aim at the base of the fire.

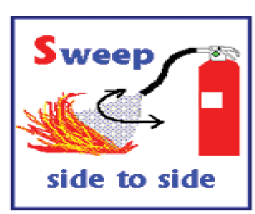
If you aim at the flames (which is frequently the temptation), the extinguishing agent will fly right through and do no good. You want to hit the fuel.

Squeeze the top handle or lever.

This depresses a button that releases the pressurized Extinguishing agent in the extinguisher.

Sweep from side to side

Until the fire is completely out. Start using the extinguisher from a safe distance away, then move forward. Once the fire is out, keep an eye on the area in case it re-ignites.



Fog and Low Visibility

In the event of being caught in an area of low visibility such as fog etc., immediate action should be to obtain a fix of position. If this is not possible the best known position should be worked out from the last available information. The logbook should be regularly updated with positions and courses.

Extra lookouts should be posted and engine/s ready for immediate manoeuvre. The VHF radio should be monitored and if in a shipping lane a “Securite” call made to advise all shipping of the vessel’s current position.

In dense fog when the coastline cannot be seen and normal bearings are not possible, there are a number of immediate dangers which are present:

1. Being run down by a larger boat which will probably be unaware of a small boat’s presence (radar on big ships does not always pick up the echo from a small boat).
2. To prevent going aground all available instruments that will help to fix the boat’s position should be used. For example, the depth sounder should be started if a line of soundings is possible or there is a danger of going aground. It is important to keep a steady course and speed, as constant changes make accurate navigation difficult or impossible; the speed should be slow enough to stop or alter course at the first signs of danger. Great care must be taken if another vessel is heard close at hand, and the following precautions should be taken to ensure the safety of the crew and the boat.
3. Inflated lifejackets must be worn; these can save lives in case of collision.
4. A good lookout should be posted in the bows to report to the helmsman everything, however trivial, ob served or heard, and a good listening watch should he maintained by every crew member for the fog signals of other boats or navigational marks. If in doubt, course should be altered away from the suspected danger.
5. The appropriate fog signal should be sounded.
6. Silence must he maintained by all the crew.
7. The radar reflector should be hoisted as high as possible.
8. All safety equipment must be checked over and made ready for immediate use. If a liferaft is not carried the dinghy should be fully inflated and towed astern.
9. Flares, especially white ones, should readily available.
10. If the engine is not already in use it should be turned over so that it is ready if needed.
11. If the engine is being used it may be turned off periodically to listen, but if this is done a careful check of how far the boat drifts in the time the engine is off must be kept.

Low Visibility Tactics

The tactics will be dictated by several factors including, the final destination, where the boat is at the time the visibility deteriorated, the expected time low visibility may last, the accuracy of the latest fix, the instruments available, and the ability and experience of the navigator. There are several courses of action:

1. If close to a marked channel hold position outside the channel and close to a buoy.
2. Go inshore at right angles to the coast, using the echo sounder, and try to pick up a contour line so that a course parallel to the shore can be maintained. The advantage of this action is that it keeps the boat in shallower water not used by larger boats, and so the chances of collision are minimized. Accurate and care ful navigation is needed to avoid grounding and inshore hazards. It may, however, be possible to see the coast close inshore and use the headlands for fixes.
3. If an acceptable anchorage can be found, the vessel can anchor and wait for visibility to improve. Unless it has a comparatively easy entry, it is much safer to wait for the fog to lift.
4. Standing offshore in deeper water may be better on an outward passage or if there are a lot of inshore hazards but, if there are deeper water channels and shipping staying inshore may be safer.
5. On no account stay in the shipping lanes. If the vessel finds herself in a shipping lane, the shortest route out should be found.
6. Do not attempt to cross a shipping lane or traffic separation scheme.

In all low visibility situations a constant and careful lookout is extremely more important.

Heavy Weather
If shipping forecasts have been studied and weather reports obtained regularly, there will usually be some warning of approaching bad Weather. If still in port and there is any doubt as to the ability of the crew, the seaworthiness of the boat or the severity of the threatening weather, the boat should not leave. Had this decision been made on some occasions, the rescue authorities would not have had to go out searching for survivors.

If at sea and there is no suitable port near at hand which can be safely entered in the worst expected conditions, preparations must be made to ensure the safety of the crew and the boat.

Sails
Sails should be reefed or changed down in good time. Being over canvassed when a severe storm hits the boat is the cause of much of the trouble encountered by the unwise sailor. It is too late and too dangerous to reef after the event, but should this have to be done, the minimum number of crew should be on the foredeck, and their safety harness clips should be securely fastened to a strong point.

A trysail, which is a small strong, loose-footed sail, can be used instead of the mainsail. This saves wear on the mainsail and enables the main boom to be lashed down, hut it may take some time to fit unless there is a special track on the mast, also the boat cannot sail as close to the wind as with a deeply reefed mainsail. Some long distance sailors keep such a sail permanently fitted on its own track ready to hoist quickly when needed.

Designer and sailmaker will decide the most effective size for storm and heavy weather sails. The purpose of these sails is to provide safe propulsion for the yacht in severe weather

it is strongly recommended that every storm sail should either be of highly-visible coloured material (eg dayglow pink, orange or yellow) or have a highly visible coloured patch added on each side; and also that a rotating wing mast used in lieu of a trysail Should have a highly-visible coloured patch on each side

Stowage
All gear must be stowed securely both above and below deck. Heavy objects hitting the hull of the boat can do much damage. See that all safety equipment is accessible and ready for immediate use. Turn the engine over to check that it will start if needed.

If there is danger of a rogue cross-wave, this effect starts at about 10 fathoms or 20 m, the boat will be safer offshore, especially if there is a danger of being blown onto a leeshore.

Lying a-hull
Some boats will lie quite well with no sails hoisted at all with the tiller to leeward (lying a-hull), however as the broadside of the boat will be presented to the weather she will roll badly. Many modern sailing boats lie with the bows away from the wind, and much damage can then be caused by breaking waves. If there is time, prepare food and hot soup in a vacuum flask, as this will be appreciated later when there is not much chance of anyone going below if conditions are severe. One of the contributory factors to seasickness is becoming cold through lack of food; hypothermia is then a risk.

Everyone must wear an efficient safety harness, which must be clipped on to a strong point if there is any danger of falling overboard. It is wise to clip on when leaving the cabin before climbing up on to the deck, as at this point most people are balanced on one foot and are unstable. Guardrails are not strongpoints.

Washboards and hatch covers must be in position and fixed so that they cannot accidentally come undone, and if there are storm boards, these should be put in place.

Heavy Weather Tactics

Drogues and Sea Anchors
These are different names for the same thing, which is a waterborne parachute. When the seas get too large to deal with the drogue is streamed from the bow to keep the vessel pointing into the swell. This is intended to keep the boat being knocked beam on to the sea and then knocked down.

Trailing Warps
Sometimes it is better to run before the wind with only a small amount of sail area if there is plenty of sea room, trailing long heavy warps behind to keep the boat steady. Shallow water causes otherwise fairly regular seas to become confused due to upsurge from the bottom, with

Heaving-to
If the boat can heave-to comfortably, and there is plenty of sea room, this can give breathing space to cope with an emergency, to reef, or to go below for a quick meal. The easiest way to heave-to is to tack, leaving the foresail cleated; when the foresail backs, the helm is brought to leeward and secured. The mainsail is adjusted according to the size of the foresail. This is thus an easy manoeuvre which results in a boat nearly stationary, with the foresail backed counteracting the forward drive of the mainsail. The boat's motion is steady and gives the opportunity in rough weather of a break for a rest. When hove-to the boat will make considerable leeway, but she can be tacked if there is a navigational hazard to leeward.

In the hove – to position, the helm is lashed to leeward and the foresail sheeted to windward. The drive of the mainsail is thus counteracted, and the boat should lie comfortably riding the seas making slow forward leeway.

Power Vessels
If the boat is a motorboat, it has to conserve fuel and attempt to gain a suitable port or shelter before this is exhausted. It may be necessary to motor gently into the weather to keep the bows into breaking waves.

Leeshore
In rough weather there is always the danger of a leeshore, one on to which the wind is blowing and the seas breaking. Particularly dangerous is a gradually shelving beach between two headlands. In strong winds a boat should keep well clear.

Frequently what appears to be a safe harbour requires an approach close to a leeshore. The prudence of such an approach must be carefully considered as it may well be safer to choose an alternative harbour, to remain at sea or to wait for high tide when the seas may be flatter. In the event of engine failure it can be difficult to get away from a leeshore, as it is quite likely that even the heaviest anchor, with all available chain let out, may drag in the heavy swell.

Emergency Signals
The general alarm signal is the signal for summoning the crew and passengers, if any, to their assembly/muster stations and for initiating the actions shown in the muster list. This signal consists of seven or more short blasts followed by one long sounded on the ships whistle or siren and on a bell, klaxon or similar warning system on ships required to be provided with such systems. Signals for incidents not requiring an assembly of the passengers or of the whole crew, or for dealing with a minor incident, are at the Masters discretion.

The means by which the order to abandon ship is given at the Master's discretion and may be by signal or by word of mouth, but arrangements should be such that everyone onboard including those in emergency parties in remote locations will receive it.

All signals must be described in the muster list, in the crew emergency instructions and as appropriate, in the emergency instructions for passengers.

The relevant signals mentioned in this section should be used when musters and drills are conducted. **All persons onboard should be informed that the drill/muster is an exercise only.**

Sources of information for emergency situations

There is a lot of information on board ship dealing with emergency situations. This ranges from the vessel's training manuals, dealing with everything from lifejackets through to lifeboat drills to full abandonment. The "Code of Safe Working Practices" also contains information on the conduct of drills and actions in event of a fire. The MCA also promulgates information in Merchant Shipping Notices "MSNs" and "Marine Guidance Notes". Refer also to the SOLAS training manual.

The most widely known is the "muster list". This must be conspicuously posted before the ship sails and must describe the allocated muster station, survival craft station, emergency duties and all emergency signals.

Muster List

This is a document that is unique to a particular vessel. It addresses individual crew member's duties and responsibilities in the event of an emergency. The muster list must be sited in a variety of locations to allow access to the information it contains.

It is the responsibility of each crew member to familiarize themselves with their duties and responsibilities in accordance with the muster list.

Crew's duties will include the preparation and the deployment of survival craft and other life saving appliances as well as fire fighting, first aid duties, lifeboat/rescue boat coxswain, the closing of watertight doors and other openings such as portholes and engine vents etc. Crew must also be allocated to assisting owners and guests to assemble, don lifejackets and checking to see if they are suitably dressed.

All crew members nominated to assist guests must have completed a course or had instruction in crowd management.

The muster list must contain:

- Details of the general emergency alarm and other emergency signals.
- The duties of each crew member in an emergency.
- Details of devolved command.
- The survival craft or launching station to which crew member is assigned.
- The name or rank of the officer who is responsible for the maintenance of lifesaving and fire fighting equip ment.
- On yachts, the point of assembly/muster for guests must be very clearly identified.
  In vessels with a significant number of non English speaking crew the muster list should include translation into the appropriate language or languages.

Emergency Instructions

Each crew member must be provided with clear instructions to be followed in the event of an emergency, showing;

- Assembly station.
- Emergency duty.
- Lifeboat/liferaft allocation.
- General emergency alarm signal.
- Any other emergency signal.
- The order to abandon ship.

25

Basic Stability & Drydocking

The Law of Flotation

Flotation
According to Archimedes Principle, for a body to float it must displace its own weight in a liquid. That is, for any vessel, the water that is displaced (pushed aside) must weigh the same as that vessel. The volume of water displaced (volume of displacement V) is the same as the underwater volume of the vessel. When this is multiplied by the density of the water, it gives the mass of the vessel that is, the displacement (Δ).

Mass = Volume x Density

The mass of the vessel, or its displacement Δ, must act vertically downwards through its centre of gravity G. The water surrounding the vessel presses back on the hull and with a force increasing with depth. This causes the force of buoyancy, which is equal and opposite to the force of gravity. The force of buoyancy can be considered to act vertically upwards at a point that is at the geometric centre of the underwater volume of the vessel. This point is called the centre of buoyancy B. For a vessel to float upright the force of buoyancy and the force of gravity must be equal, act in the opposite directions and be in the same vertical line.

A log of wood, when floating in water, would have a centre of gravity and centre of buoyancy as shown in diagram

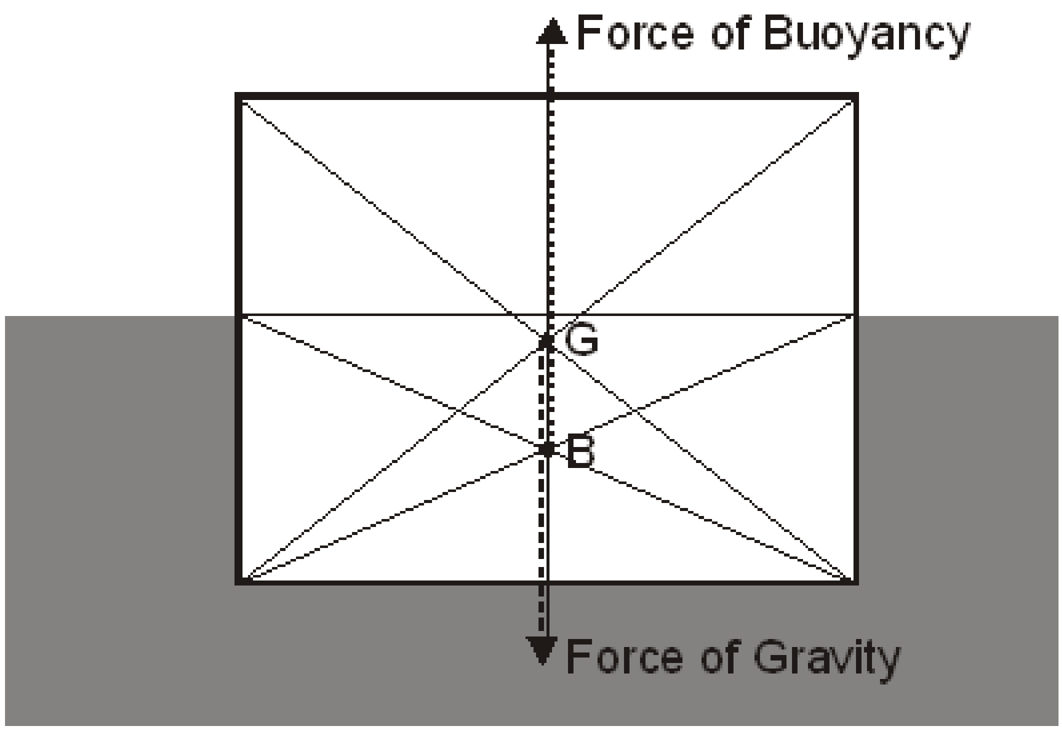


Figure 1

Displacement is the weight of the hull and superstructure with all its equipment plus engine room spares and with water in the boilers to working level.

Loaded Displacement is the total weight of the vessel when it is loaded down to its Summer Load Line.

Deadweight is the weight of cargo, fuel, stores, ballast etc. on board the vessel. It is the difference between the Light and Loaded Displacement.

Reserve Buoyancy is the volume of enclosed watertight space above the waterline. It is that volume which would be used as buoyancy if more weight were added to the vessel.

The concept of initial stability

At or near the upright, the initial stability of a vessel is calculated for small angles of list and heel, (usually up to approximately 10°) and is the ability of that vessel to return to the upright when inclined by an external force such as wind or waves.

Stability – The vessel's tendency to return to it's original position after an inclining force has been removed.

Positive stability – The vessel, if inclined (up to a certain point) will right itself.

Negative stability – The vessel inclined, will not return to an upright position

Neutral stability – An outside force will cause the vessel to assume a new position, but it neither falls over nor returns to the original upright position.

Stiff and tender vessels, their advantages and disadvantages.

A stiff vessel is difficult to incline, she develops large righting moments. In heavy weather she will have a short, sharp rolling motion liable to cause structural stress, shifting of cargo and injury to personnel.

A tender vessel will be easy to incline and develops small righting moments. She will have a long, slow, lazy roll at sea. Although this is more comfortable than a stiff vessel, the danger is that an unexpected reduction in stability will cause her to become initially unstable. Vessels that are tender at the start of a voyage may become initially unstable due to the absorption of water on deck and the use of fuel from below. If the vessel becomes initially unstable, it will possibly capsize.

Stable, neutral and unstable equilibrium

Stable equilibrium

When the weights within the vessel are low, and when heeled by an external force, the forces of buoyancy and gravity act in such a way as to bring the vessel back towards the upright condition. This is stable equilibrium.

Unstable equilibrium

When weights are loaded high in the vessel then , the centre of gravity of the vessel, will also be high. If this is so high that the forces of buoyancy and gravity and the lever between them cause the vessel to capsize, then she is said to be in unstable equilibrium.

Changes due to adding, removing and transferring weights

Fuel and water are usually stored at or near the bottom of the hull. When they are used during a voyage, this is the same as discharging a weight from low down and the vessel will become less stable. If sea water is retained on deck, as it may do in heavy weather, then the effect is the same.

The effect of free surface

This can affect basic stability.

The free liquid within a tank will move around as the vessel rolls and cause the roll to be greater than if there was no liquid present or if the tank was pressed full. This means that there is an apparent loss of stability, which can be substantial if the tank is large, even though the liquid may not be very deep.

This loss of stability or the reduced ability for the vessel to right itself, can result in the vessel capsizing

When any liquid within the hull is free to move, that is, a tank is not full or empty, then that liquid will cause the stability of the ship to decrease.

In the event of fighting a fire the vessels pumps should always be run while water is being used to reduce the Free surface effect.

Drydocking

When drydocking, the vessel should be trimmed by the stern so that when the stern first touches the keel blocks it can be used as a fulcrum to align the rest of the keel with the blocks. As soon as the stern touches, the buoyancy which was supplied by the water is transferred to the keel blocks and the vessel begins to lose stability. It is essential therefore that the vessel has adequate stability before entering the dock. The vessel should be trimmed by the stern but not too much, and upright. Make sure the vessel will float upright when refloating. Free surface effect should be at a minimum.

Side - Side shores cannot be set up until the vessel takes the blocks fore and aft, so it is vital that the vessel has adequate stability at this stage. Pumping will be stopped whilst the shores are being set up. These should be placed against frames and stringers or bulkheads.

Bilge blocks cannot be set up until the vessel is dried out.

When the vessel refloats it is important that she is in the same condition as when she took the blocks, soundings should be taken to ensure that if a tank has to be emptied, it can be refilled to the same level.

Tank plugs, if removed, must be stowed in a safe position and a careful check must be made that they are replaced before refloating.

Fire hoses must be rigged at all times. The drydock authority will need to know size and type of hose connections. Fire extinguishers must be at hand when welding or burning takes place. Ensure that both sides of a structure are watched.

The drydock authority will need a docking plan showing the position of underwater fittings, rudders, shafts and props, stabilisers, skin fittings, etc. and the vessel’s dimensions.

Check the condition and general standard of the dock beforehand. Make sure it is capable of taking your size of vessel safely. It is difficult to change your mind when you are dried out.

Check insurance.

Check the depth of water or height of tide in the dock if appropriate and confirm the time to enter the dock if it is tidal. If tugs are required, check that they are capable of handling your size of vessel.

Create a work schedule, drydock and repair specification. Is a Classification Society surveyor to be employed? Will any survey work be carried out?

Make sure the following are available:

Fresh water supply for refrigerator and air conditioning systems
Telephone available with emergency contact list
Illuminated gangway, with rails and safety nets
Correct and adequate warning notices and signs
Barriers if necessary
Gas free certificates if tanks are to be entered by personnel
Mooring and unmooring gangs in the drydock

26

Vessel Construction

Construction terminology

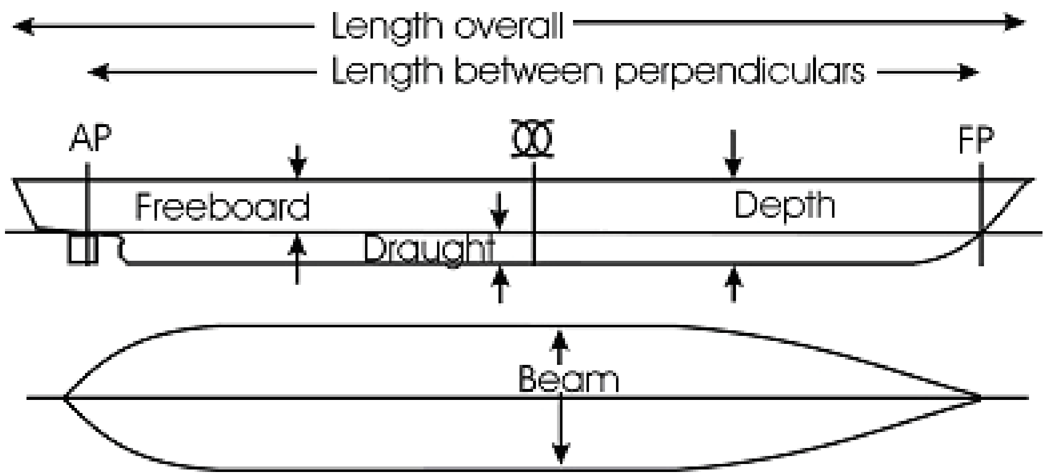


Figure 1

After Perpendicular (AP)– a perpendicular drawn to the waterline at the point where the aft side of the rudder post meets the summer load line. Where no rudder post is fitted it is taken as the centre line of the rudder stock.

Forward Perpendicular (FP) – a perpendicular drawn to the waterline at the point where the foreside of the stem meets the summer load line.

Length Between Perpendiculars (LBP or Lpp) - the horizontal distance between the after perpendicular and the forward perpendicular.

Length Overall (L) – the maximum length of the vessel

Midships (Or Amidships) the point midway between the forward and aft perpendiculars. The centre of the load line circle should indicate this position.

Beam – The distance across the ship a its widest point.

Depth – the distance from the top of the deck plating at the side of the vessel to the bottom of the keel.

Draft - the distance from the bottom of the keel to the waterline.

Freeboard - the distance from the waterline to the upper surface of the freeboard deck at the vessel's side.

Camber - the transverse downward curvature of the upper or weather deck.

Sheer - the fore and aft vertical curvature of the deck.

Flare – The outward curvature of the bow.

Rake – The departure from the vertical of vessel's profile, as in masts, stacks, etc.

Hull – The supporting body of the vessel, the "envelope". Inside are strengthening members to keep the body from collapsing.

Keel – The "Backbone". All other members used in constructing the hull are attached, directly or indirectly, to the keel.

Frames and Floors – Floors run outward from the keel, to the turn of the bilge, which then extend upwards to the main deck.

Longitudinal frames – run parallel to the keel. From the turn of the bilge, up the sides they are also known as stringers. The network of floors and longitudinal resembles a honeycomb which greatly strengthens the bottom of the ship. When the honeycomb is covered by plating, double bottoms or double hulls are formed.

Stem – Forward edge of the keel which extends upwards.

Sternpost – Aft end of the keel which extends upwards.

Bulkheads –Divide the interior of the vessel into compartments, running both transversely and longitudinally.

Strakes – Plates (steel) or planks (wood) which form the ship's hull, longitudinally. The keel forms the centre strake.

Garboard Strake – The strake alongside the keel.

Bilge Keel – Two protecting keels which run along the bottom near the turn of the bilge. They serve to reduce rolling. In areas of great tidal range, the vessel may come to rest on them.

Gunwales – The upper edged of the sides of the hull, where the sheer strakes join the main deck.

Bulwarks – A solid "wall" along the gunwale fitted with freeing ports to allow water drainage.

Scuppers – deck drains

Tonnage

Gross Tonnage a figure representing the total of all enclosed spaces within a vessel, arrived at by means of a formula which has as its basis the volume measured in cubic metres. Abbreviated to gt. The gross tonnage has replaced gross registered tonnage.

Net Tonnage a figure representing the total of all the enclosed spaces within a ship available for cargo, arrived at by means of a formula which has as its basis the volume measured in cubic metres. Abbreviated to nt. The net tonnage has replaced net registered tonnage.

Longitudinal, transverse and local stresses
Static and dynamic loading

A simple beam, such as an 'H' girder, that is supported at the ends and weighted in the middle will sag. The upper surface will suffer compressive stresses whilst the lower surface will suffer tensile stresses. Mid way between the upper and lower surfaces is the neutral axis that will suffer neither compressive nor tensile stresses. The greater the distance of the surfaces from the neutral axis, the greater will be the stresses imposed.
A ship can bend and suffer the same stresses as a simple beam.

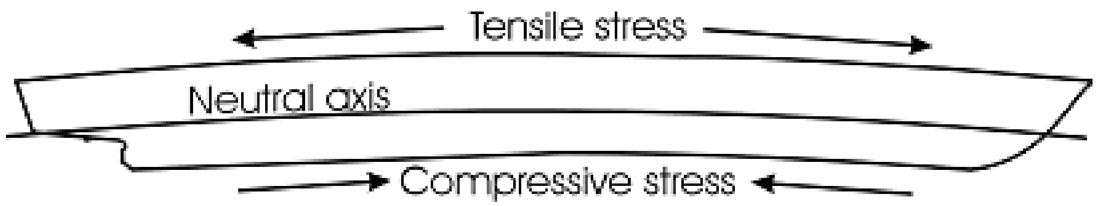


Figure 2

Longitudinal Stresses
The laws of flotation state that for a vessel to float in still water, the overall buoyancy must equal the overall weight. That is the upward forces of buoyancy must equal the downward forces due to the weight of the vessel and its contents. However, the weight and the buoyancy need not be equally distributed along the length of the vessel. The distribution of weight will depend on the position of the engines and stores whilst the buoyancy will depend upon the hull shape. For all vessels, the mid body will provide most of the buoyancy whilst the ends will provide much less.

Where the weight exceeds the buoyancy or vice versa, the excess will give rise to an overall bending of the hull. Excessive loading at the ends of the vessel will cause the vessel to hog. This bending in turn generates tensile and compressive forces in the decks and bottom plates. The effects of bending increase with distance from the neutral axis.

Excessive loading amidships will cause the hull to sag and the tensile and compressive forces will be reversed, but from a structural point of view, the problem is the same.

When a vessel goes to sea, it is subjected to the movement of the waves. This is most noticeable when the wave length of the prevailing swell is about the same as the length of the hull. The mid-body can be supported on the crest of a wave whilst the ends are in a trough. As the wave passes along the hull, the reverse will occur and the vessel will bend the other way, that is, it will sag. In this way, the hull will be subjected to a stress that is constantly changing.

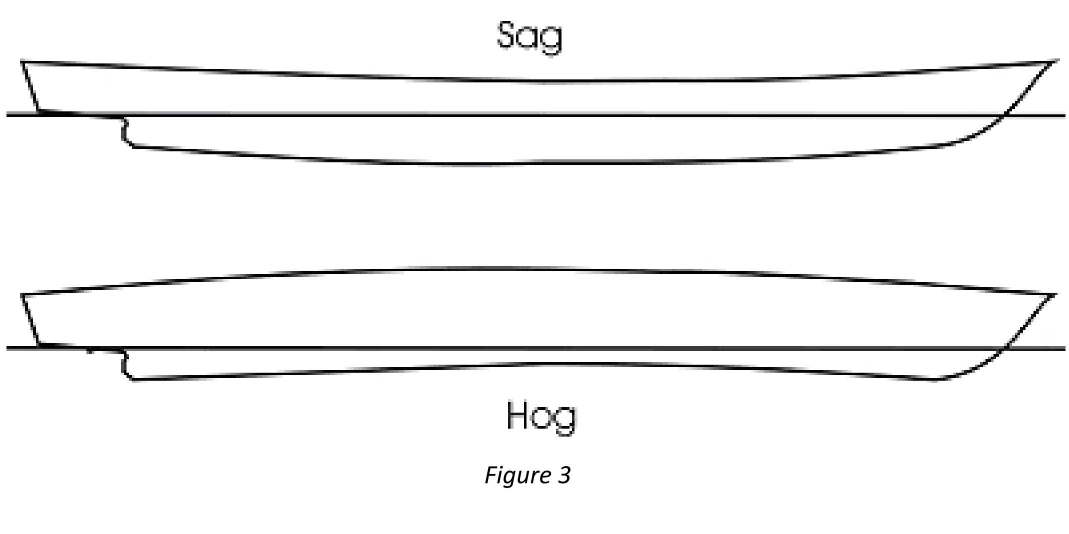


Figure 3

Transverse Stresses

When a vessel dry docks the keel blocks push upwards causing the bilges to sag downwards and the sides of the vessel to bulge outwards. When a vessel rolls in a seaway, the force of the waves acting on the hull can distort the box shape of the vessel's cross section. The rectangular shape of the cross section tends to be pushed into a parallelogram.

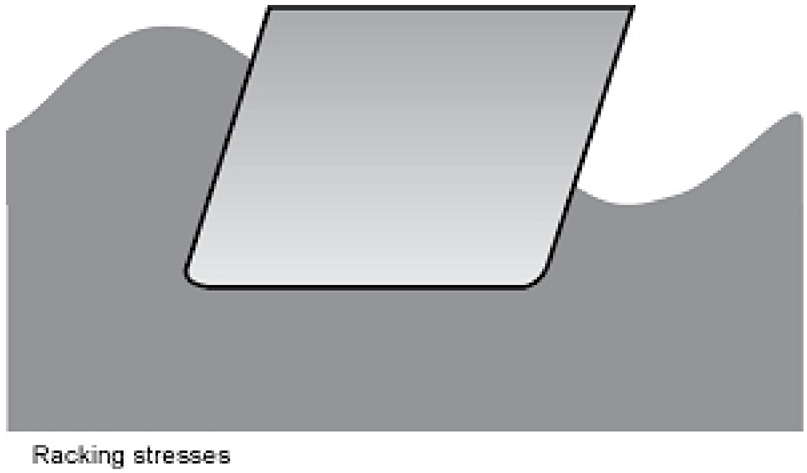


Figure 4

Panting, pounding and vibration

When a vessel heads into a big swell the bow starts rising and falling. This subjects the bow plates to a fluctuating hydrostatic pressure, causing the plates to move in and out. This stress is known as panting. It can also occur at the plates around the stern.

In very rough seas the bows may lift clear of the water and then slam down again on the next wave. This produces stress in the bottom plating and frames towards the bow. It is known as pounding.

Local loading stresses can be caused by heavy weights concentrated on small areas. This occurs in the under the main engine and also where heavy weight cargoes are concentrated along the central part of a hold. Local stresses can also be caused where longitudinal stress carrying members of the structure meet transverse members.

When a tensile stress is applied to a material with a sharp angle, then the stress is concentrated at that angle. This is known as a discontinuity. If a crack is spreading across a steel plate, then the way to arrest that crack is to drill a hole at the end of it.

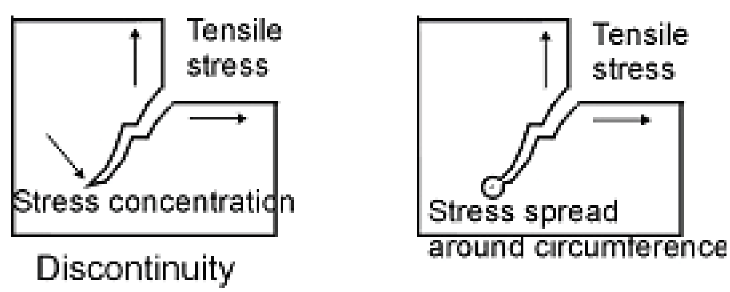


Figure 5

This will spread the load around the circumference of the crack, thus reducing the damaging concentration. Similarly, a sharp corner can be rounded to spread the load. Thus, the insides of hatch coamings are always rounded to avoid the stress concentration at the corners of the deck.

Vibration causes cyclic forces in steel usually resulting in tensile stresses. When repeated for a long period this will cause the structure to fail by cracking. This, in its turn, can cause corrosion in steel and weld fractures particularly in aluminium.

Dynamic Stresses - caused by a vessel working in a seaway. The forces producing these stresses are of two types: rotational and lateral.

Rotational

Rolling – movement about the longitudinal axis
Pitching – movement around the transverse axis
Yawing – movement around the vertical axis
Twisting or torsional-clockwise forward, counter clockwise aft, or vs. vs.

Lateral

Heaving – vertical movement
Surging – forward motion, as when picked up by following seas
Swaying – side to side movement about the horizontal axis

Methods of construction

The traditional method of vessel construction is to use transverse framing. The frames support the hull on bottom, sides and deck. Each frame could be thought of as a continuous band around the vessel, joined at the corners, such as the gunwale or turn of the bilge, by brackets or knees. The frame spacing can be over a meter on large vessels down to 0.3 of a meter at some parts of a small boat. The keel, side girders and stringers support the frames.
Large ships are constructed using a longitudinal system of framing. Longitudinal frames run the entire length of the vessel. They cover the insides of the bottom, sides and deck of the ship with a frame spacing of about one meter. The frames are not cut at the bulkheads but are continuous so that they are able to resist the stresses produced by hogging and sagging.

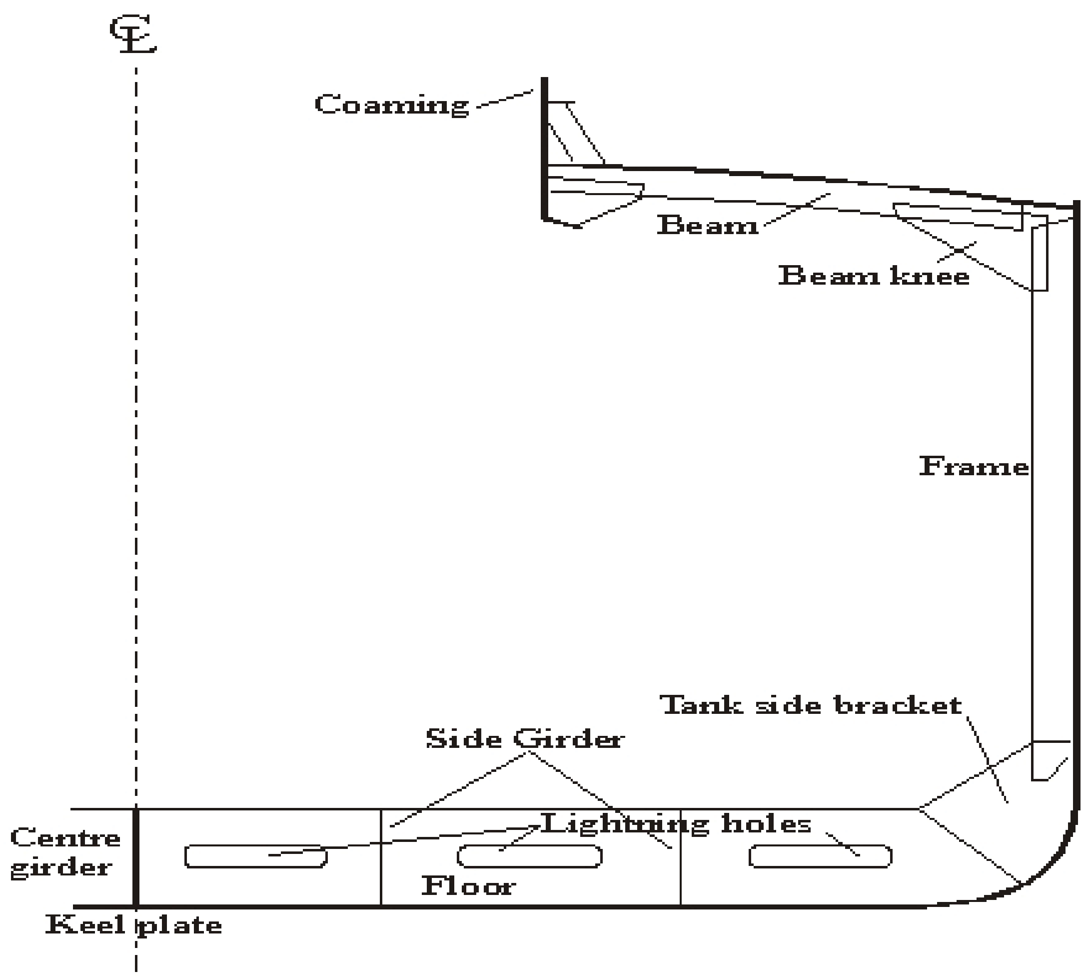


Figure 6

Some vessels combine transverse and longitudinal framing. The longitudinals are used on the bottom and the top of the hull with transverse frames supporting the sides.

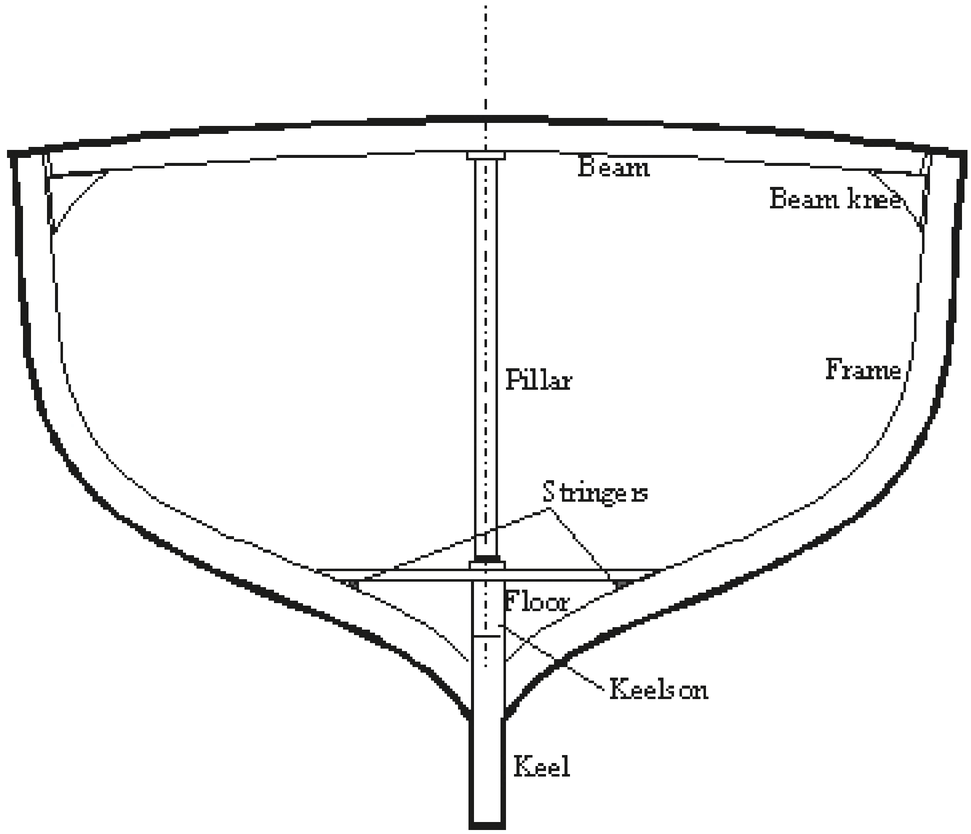


Figure 7

The bottom, side shell and upper deck structure are important strength members. The shell plating of any vessel binds the framing into a solid coherent structure that can resist the forces of the sea. The top and bottom plating is usually increased in thickness to resist the stresses caused by hog and sag as they are furthest from the neutral axis.

The center girder, with its associated plating above and below, makes up the keel which is the main longitudinal strength of the vessel.

Side girders are longitudinal members that support the double bottom.

Hatch coamings replace some of the strength lost by the removal of the deck to make the hatch. The corners of each hatch are usually reinforced with a doubling plate, as this is an area of discontinuity of strength.

Materials used in construction

There are advantages and disadvantages of wood, steel, aluminium alloy, and GRP and other composite systems used in construction.

Wood is the traditional material for building boats and is still used extensively today. Most of all it is a light material, after all it floats. Wood can be divided into two classes, namely hard woods and soft woods. Within the two classes are numerous types of timber each with its own special characteristics, all that can be mentioned here are their general qualities.

Hard woods tend to be denser, harder, heavier, stronger and rot resistant. They are also more expensive than soft woods but can look beautiful when properly finished. Hence, they are most often used for expensive, luxury yachts.

Soft woods, by comparison, are softer, lighter, weaker and cheaper. Having said that softwoods have a good strength to weight ratio, therefore they are often used to build fast vessels and racing craft.

Steel took over from wood in shipbuilding because of its superior strength and because it was relatively cheap and easy to produce. Mild steel has the elasticity and toughness to resist large tensile and compressive stresses. It is resistant to impact and fatigue. Corrosion is the biggest drawback of steel.

Aluminium used in boat building is not the pure metal but some form of alloy of aluminium. Size for size, aluminium weighs roughly one third but has about two-thirds the strength of steel. Aluminium is softer and dents more easily but it is more difficult to weld than steel. Aluminium does not corrode easily but when it does it can corrode with a dangerous rapidity.

The plastic in Glass Reinforced Plastic (GRP) is a resin of very complex chemistry beyond the scope of this work. These resins set hard and are reinforced with fibres that are often glass, hence, glass reinforced plastic (GRP). GRP is laid up in a mould to the required shape and size, it is therefore cheap and easy to manufacture, transport and handle. The glass fibres have a tensile strength many times that of steel.

The Functions of Classification Societies

Classification is a system designed to enable cargo shippers, marine underwriters and other interested parties to identify a ship that is fit to undertake a voyage from the point of view of structure, equipment and machinery. Ship Classification Societies provide a service to ship owners by classifying their ships according to published rules and regulations, enabling them to demonstrate that the ship meets a given standard.

The principle maritime nations all have established Classification Societies, for example:

United Kingdom	Lloyds Register of Shipping
USA	American Bureau of Shipping

A ship built in accordance with Lloyd's Register of Shipping rules will be assigned a class and listed in Lloyd's Register Book. The characters and symbols used in the book include: -

100	Considered suitable for seagoing service.
A	Built in accordance with Lloyd's class rules.
1	Anchor and mooring equipment comply with Lloyd's rules.
Maltese Cross	New ship built under supervision of a society surveyor.

Other characters are used for special ship types and machinery.

The Classification Societies carry out the following surveys;

Annual survey
Intermediate survey every 2 or 3 years
Special survey every 5 years
Docking survey twice within the 5-year period
Other surveys for special requirements

At an annual survey the general condition of the vessel and machinery is assessed. Other items included in the survey will be:

Closing appliances such as hatches, ventilators, and air pipes
Watertight doors and watertight bulkheads
Freeboard marks
Steering arrangements
The provision of structural fire protection is verified
Anchors and cables

At a Docking survey, the ship is to be examined is in dry dock where attention is paid to the underwater hull. Shell plating, rudder, stern frame, external fittings, and fittings which pass through the hull Areas liable to corrosion and any unfairness of the bottom plating.

Loadlines and Freeboard

The freeboard deck is the uppermost continuous deck that can be closed weather tight. The assigned freeboard is the distance from the top of the deck line to the top of the Summer load line.

Loadline/Plimsol Mark and Summer Zone

S is the mark on the Summer load line the top of which must not be submerged when in the Summer Zone.

F is the mark on the Fresh Water load line which must not be submerged when the ship is floating in fresh water in the Summer Zone.

FWA is the Fresh Water Allowance, that is the distance from the Summer load line to the Fresh Water load line.

Where the vessel is assigned a freeboard which is greater than the minimum Summer freeboard and lower than all other appropriate load lines, is known as an 'All Seasons Load Line'. The All Season Load Line may be just a single line (230 mm ´ 25 mm) without the vertical line used in other load lines.

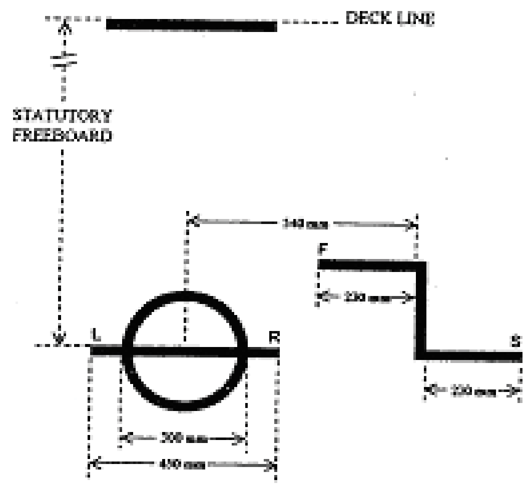


Figure 8

Reserve buoyancy

A vessel floats by virtue of the buoyancy produced by the hull. That part of the hull that is below the waterline displaces water, which displaced water presses back onto the hull so providing the buoyancy.

That part of the hull that remains above the waterline provides reserve buoyancy. The extra buoyancy may be required in an emergency, if an extra weight is placed on the vessel such as a heavy sea landing on deck or if a part of the hull is damaged and loses its buoyancy. In order to provide reserve buoyancy the hull must be watertight and be maintained so.

If the hull is open from one end to another and the hull is then holed the complete hull will fill with water, buoyancy will be lost and the craft will sink. A vessel should be subdivided with watertight bulkheads across the ship and at intervals along its length. If the hull is then damaged then only one or perhaps two compartments will fill with water. The hull settles in the water and some of the reserve buoyancy, in the compartments not filled with water, is converted into actual buoyancy, so allowing the vessel to remain afloat.

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Business and Maritme Law
Overview for the Master of Yachts
Contents

Introduction

NOTE: This module is based on UK law and its application to UK Yachts. It is the duty of all Masters and Officers on Yachts to know and understand the Laws and Procedures required by the Flag State when serving on vessels registered in that State. (Ignorance of the law is NO defence!).

In an international forum such as the Maritime Industry, the master of every vessel needs to understand the regulations which must be followed where ever in the world they are and the jurisdiction under which they fall.

It is expected therefore that every master will have an understanding of the law within the Maritime field as it affects the operations with regard to:

a. The legal responsibilities of a Captain/Master.
b. The Legally required documents/certificates to be carried on the vessel.
c. The National law with regard to the flag state of the vessel and if applicable, the location of the vessel at the time.
d. The International law dependant upon the location of the vessel at the time.
e. The compliance to IMO and other legal conventions including, MARPOL, COLREGS, STCW95 etc.
f. Employment law governed by the flag state including crew agreements, responsibilities of the Captain and the employer (vessel owner), employment contracts etc.
g. Charter operations, including charter contracts, the flag registry commercial requirements and if applicable, charter operation restrictions in an area.
h. Salvage law, including Lloyds Open Contract and the different types of salvage.
i. Insurance including the different types that may apply to the vessel, the crew and if applicable, for charter operations.

The objective of this section is to give prospective Captains of yachts up to 200 GT and Mates of yachts up to 500 GT, a basic understanding of maritime law and business law. The subjects covered are often complex and there are many details that cannot be covered here.

Legal Framework

All legal systems recognize dual functions of law; criminal law and civil law. The administration of criminal law is usually independent of civil law, and each has their own courts and distinct rules of law. Both criminal and civil law apply on all vessels.

There is a third aspect of law that is the need to ensure that certain key members of a vessels' crew have appropriate levels of skills and competence for the positions they hold, ie licensing. This is by the issuing of certificates of competency or licenses, ie "Licensing & Certification"; and enforced through the manning scales mandated by the Flag State in a "Safe Manning Document" which states the number and type of qualified crew that is required to safely operate the vessel.

Criminal Law

The function of Criminal Law (public law) is to enforce, on behalf of society, agreed minimum standards of behaviour for the protection of individuals and their property. It identifies unacceptable behaviour. If the individual responsible is convicted before a criminal court, a deterrent sanction, such as fines, or imprisonment, is inflicted. Such behaviour is designated as a "crime".

For yacht crew, failing to comply with detailed standards specified in statues or regulations would be designated as a "crime". For example not complying with the Load Line requirements, if the individual responsible is convicted before a criminal court, a deterrent, such as fines or imprisonment may be imposed.

Another example would be a crew member assaulting another crew member, this would be considered to be unacceptable behaviour; and if convicted in a court of law, would be designated as a "crime".

Civil Law
The function of Civil Law (private law) is to provide the rules and court machinery for the settlement of private disputes, between individuals in society, in an orderly and peaceful manner. The consequence of civilly wrongful conduct which causes injury and/or property damage is that the wrongdoer must pay compensation for the losses sustained.

Each individual is personally liable for the damage he causes acting in breach of his civil law duties and obligations. Thus the OOW or mate of a yacht, in charge of the navigational watch, is personally liable for any damage caused by his negligent navigation. The Master (and owner) may also be held responsible for the actions of his crew.

In the context of marine operations the following are those most frequently relied upon,

a. **The Law of Contract** - provides the rules for agreements, promises and claims for compensation when promises and agreements have not been honoured. An example would be failure to pay crew wages, or conversely if crew do not do the job satisfactorily that they were hired for.

b. **The Law of Tort** - a tort can be defined as civilly unlawful conduct which causes damage. There are many different torts, the most applicable to the marine industry is:-

c. **The Tort of Negligence** - occurs when a person's behaviour falls below the standard of care fixed by law i.e. to take that care which it is presumed that a "reasonable person" in that position would take to guard against the harmful effects of reasonably foreseeable dangers - Negligence is committed if a person who owes a legal duty of care to someone else breaches that duty and which results in physical or financial damage of some kind to that other person. An example would be not providing safe access for crew and others to a yacht that is out of the water, and someone falls resulting in physical damage.

d. **Duty of Care** - No legal definition of Duty of Care exists, however it has been held to mean failure to take that degree of care which it is presumed that a "reasonable person" in that position would take to guard against the harmful effects of reasonably foreseeable dangers.
A Yacht captain for example owes a duty of care to, amongst others, the owner for the care of the yacht, the crew for their health and safety, the guests for their safety and, protection of the environment.

e. **Vicarious Liability** - is the legal liability imposed on an individual for a crime or tort committed by another person. The idea of the doctrine is to ensure employers are liable and responsible for the damages caused by their operations in business. As a rule an employer (the owner or yacht manager) is usually liable for the torts committed by his employees, the captain and crew.
Thus a yacht owner or Yacht manager (generally they are employed as an agent of the owner and thus their liability is in addition to that of the owner) may be liable for the crimes and torts committed by the captain and crew of the yacht.

Licensing/Certificates of Competency
The law of most maritime states recognises that a minimum number of crew on every vessel need to have appropriate levels of skills, training and competence. The administrative machinery and rules for the issue and suspension or withdrawal/cancellation of certificates of competence/licenses vary with each flag administration. However all administrations will act against crew if they are found to be:
Unfit to discharge their duties because of incompetence, misconduct or other reason;
has been seriously negligent in discharging their duties, or
has failed to render assistance and exchange information after a collision.

Usually license and conduct issues are dealt with independent of and separate from the criminal and civil courts.

International Conventions
Ships operating in an international arena have to comply with the changing and sometimes conflicting regulatory standards to satisfy the laws of the countries visited. To avoid this dilemma states have had to agree to minimum standards relating to safe ship operations, using International Conventions.

A Convention is a multilateral agreement between participating sovereign states. It becomes international law and regulates the relationship between those states. There is no international law enforcement agency and international law can only be enforced by individual sovereign states concerned in the matter and then only when the matter has been embodied in the national law of that state. Conventions covering maritime affairs derive from the International Maritime Organisation, IMO, a specialist agency of the United Nations. The IMO has about 167 member states as well as 3 Associate Members. It has its HQ in London.

The process whereby a Convention comes into being requires the representatives of the participating states to negotiate the text of the draft instrument at the International Maritime Organisation. The text is then adopted by the governments of the negotiating states and the text incorporated into each state's law.

Other states do not escape its provisions merely by not agreeing to be bound by it, as their ships may be required to comply with the Convention when visiting a state party to the Convention. Those states which are party to the Convention, if they are numerous enough or powerful enough, can always turn around to the non-complying state and say that the Convention is now "customary international law", and must be obeyed as a condition of access to the internal waters of those states.

International law is concerned with the regulation of relationships between states and as such cannot be enforced directly against individual ships or persons. It is given effect through national laws. By accepting the duty to create national law, each state will enforce compliance of the Convention by all ships and individuals within its jurisdiction and in particular its own flag ships, wherever they are.

Some Conventions merely outline policy leaving to individual states the task of creating detailed laws to implement that policy. The resulting laws can differ considerably from state to state. Visiting a particular state a ship is bound to comply with laws of that state, fortunately, even where there are differences most states do not take action against a ship if it complies with its own state laws in the matter, and as a general rule coastal states accept the certificates and documents issued by the flag state as sufficient evidence that a ship complies with Convention requirements.

Enforcing compliance of a Convention on the High Seas is within the exclusive jurisdiction of a ship's flag state. It owes other states a duty to enforce compliance. If a coastal state detects a ship in breach of a convention whilst navigating within its jurisdiction, not only may it take action against the ship under its own laws, but it may report the ship to its allocating state. That state is then bound by the Convention to take corrective action against the ship.

Maritime Conventions include:

SOLAS	International Convention for the Safety of Life at Sea
GMDSS	Global Maritime Distress and Safety System
MARPOL	International Convention for the Prevention of Pollution from Ships /modified by the Protocol of 1978 (MARPOL 73/78)
ILC	International Load line Convention
STCW 78/95	International Convention on Standards of Training, Certification and Watchkeeping for Seafarers
UNCLOS	United Nations Convention Law of the Sea
ILO	International Labour Organisation Convention
ICS	International Convention on Salvage

Yachts Defined by International Convention

A yacht is defined as a vessel that carries no more than 12 guests and is less than 3000 gt. (Once these numbers are exceeded then it is a passenger ship). Engaging in trade in this context means a yacht used in any form of commercial enterprise such as chartering or carrying "paying passengers"; that is chartering for payment chartering for payment. Payment is any form of compensation including contribution for fuel and other provisions.

Passenger Vessel is a ship carrying more than 12 guests/ passengers.

Pleasure Vessel is any vessel of whatever size used by the owner for his or his immediate families sport or pleasure on a voyage or excursion for which the owner does not receive money for or in connection with the operating of the vessel or carrying persons. In the case of a vessel owned by a corporate body, employees of the company and their immediate families can use the vessel for their sport or pleasure, subject to the above conditions, without affecting its status as a pleasure vessel.

Passenger means any person carried in a ship except:
(a) a person employed or engaged in any capacity on board the ship on the business of the ship
(b) a person on board the ship who has been shipwrecked, distressed or other persons or any reason that the master could not have prevented.
(c) a child under one year of age

Crew means any person signed on board the crew list who is part of the daily operations of the ship, registered, employed or engaged in any capacity on board.

Trainee means apprentice or cadet in a training capacity on board a ship. He is generally (due to his lack of experience) not included in a safe manning certificate.

National law, international law
A ship registered in a particular country assumes the nationality of that country and is subject to its control and jurisdiction wherever the ship is located. Vessels operating on International voyages move from the control and jurisdiction of one country's legal system to the control and jurisdiction of another country's legal system. In doing so the ship may navigate in high sea areas where all countries have only a very limited jurisdiction. Owners/operators and individual crew members are at all times subject to the laws of the flag state. It is essential that operators and masters can identify the legal system and laws which regulate the operation of the ship at any given time.

Jurisdiction is defined as an area over which authority extends.

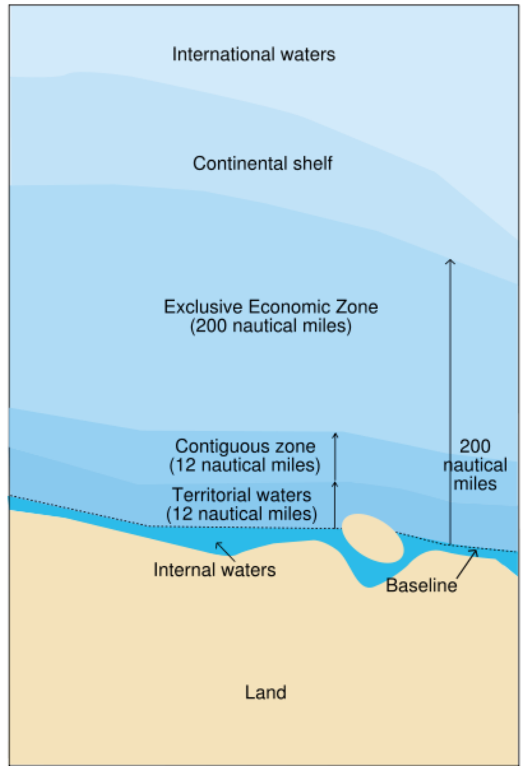
The country whose laws a yacht operator and it's crew must comply with at any one time depends upon either one or both of the following factors:
The geographical position of the yacht - Coastal State
The nationality of the yacht - Flag State

Nationality of Ships - Flag State Registration
The nationality of a vessel is a crucial factor when deciding which state has jurisdiction over the ship; that is the right to prescribe and enforce laws governing its operation.

The conditions for the granting of its nationality to vessels vary from state to state. There must be a genuine link between the State and the vessel. Every State is required issue to vessels granted the right to fly its flag documents to that effect. Each state has the exclusive right to determine the conditions under which it is prepared to allocate its nationality to a vessel.

1. Ships have the nationality of the State whose flag they are entitled to fly.
2. Ships shall sail under the flag of one State only.
3. No ships shall be entered in the registers of two or more States at a time.
4. A ship may not change its flag during a voyage or while in a port of call,

Geographical Position
The United Nations Convention Law of the Sea, UNCLOS, establishes a comprehensive legal framework to regulate all ocean space, its uses and resources.



Internal Waters of a State
Internal waters are all waters lying to the landward side of the baseline from which territorial waters are measured and includes all port and harbour areas. International law recognizes the absolute right of coastal state to complete jurisdiction over internal waters; in the same legal position as the land area of the state. This includes the right to deny access, unless through reasons of force majeure or distress.

In internal waters the jurisdiction of a coastal state takes precedence over, but does not erase a ship's flag state jurisdiction. Coastal states usually limit their action to things that affect the peace, good order and security of the coastal state.

Base Line
The Convention also provisions for determining the base-line, which is, **the low water mark shown on large scale charts recognized by the coastal state concerned.**

The Territorial Seas of a State
A maximum limit to the width of the territorial sea is 12 nautical miles. Every coastal state has full jurisdiction over its territorial sea and thus the right to regulate ships of any nationality whilst they are within that area, subject to the right of all ships to innocent passage through territorial seas. **In practice states normally limit their effective jurisdiction in the territorial sea to making regulations which are necessary for the peace, good order and security.**

Archipelagic States
Where a sovereign state is made up of a collection or group of closely related islands, straight lines may be drawn joining the outer-most points of the outer islands. The main islands must be included within those base-lines and the area ratio of water to land does not exceed 9:1.

The territorial sea may then be measured from these base-lines. All the waters within these base-lines have similar status to "internal waters", but are known as archipelagic waters. The ships of all states enjoy the right of innocent passage through these archipelagic waters subject to the archipelagic state's right to designate sea lanes. **Sea lanes** are to be designated by axis lines and ships on innocent passage must not deviate more than 25 nautical miles, if navigable water exists, either side of the axis line.

Meaning of innocent passage
Passage means navigation through the territorial sea and must be continuous and expeditious. However, passage includes stopping and anchoring, or force majeure which is when a vessel has problems outside of her control, such as breakdowns, but only in so far as the same are incidental to ordinary navigation or necessary by force majeure or distress or for the purpose of rendering assistance to persons, ships or aircraft in danger or distress. Passage is innocent so long as it is not prejudicial to the peace, good order or security of the coastal state. This excludes such actions as: Any threat or use of force against the sovereignty, territorial integrity or political independence of the coastal state, exercise or practice with weapons of any kind, spying, eavesdropping, landing or removing money, antiquities, people etc., pollution, fishing and research.

The Contiguous Zone
The jurisdiction allowed is to exercise enforcement to prevent infringement of the coastal state's Customs, fiscal, immigration, and sanitary regulations. It limits the extent of the contiguous zone to a maximum of 24 nautical miles from the territorial sea base-line.

The Exclusive Economic Zone of a State
In the EEZ the coastal state is granted sovereign rights for the purpose of exploring and exploiting, conserving and managing the natural resources of the zone. The right of freedom of navigation of other states through these zones is expressly preserved. An Exclusive Economic Zone must not extend more than 200 nautical miles from the base-line from which the territorial sea is measured.

Rights, jurisdiction and duties of the coastal State in the exclusive economic zone include sovereign rights for the purpose of exploring and exploiting, conserving and managing the natural resources, whether living or non-living, of the waters super adjacent to the sea bed and of the sea-bed and its subsoil, and with regard to other activities for the economic exploitation and exploration of the zone, such as the production of energy from the water, currents and winds, marine scientific research and the protection and preservation of the marine environment

Fishing Zone
The FZ and the EEZ differ in that, while the FZ relates only to the use or protection of fisheries, the EEZ relates to all types of resources in the zone (eg. fish, oil, gas, minerals, etc.)

The Continental Shelf
The continental shelf of a coastal state comprises the seabed and subsoil:

1. The area beyond the territorial sea extending to the outer edge of the continental margin, or to a distance of 100 nautical miles where the edge does not extend this far.
2. In no case shall the continental shelf extend more than 350 nautical miles from the base-line from which the territorial sea is measured
3. Nor exceed 100 nautical miles from the 2500 metre depth contour.

The rights of coastal State over continental shelf are for the purpose of exploring and exploiting its natural resources; the mineral and other non-living resources of the sea-bed and subsoil together with living organisms belonging to sedentary species, that is to say, organisms which, at the harvestable stage, either are immobile on or under the sea-bed or are unable to move except in constant physical contact with the sea-bed or the sub-soil.

The High Seas
The High Seas include all Seas NOT included in the EEZ, Territorial Seas, Internal or Archipelagic Waters of a State. If no EEZ is claimed the High Seas start after the Territorial Seas. The High Seas are reserved for peaceful purposes but any state may take action on the High Seas against ships of any nationality suspected of:

1. Drug running
2. Illegal broadcasting
3. Piracy
4. Slavery.

Freedom of the high seas
The high seas are open to all States, whether coastal or land locked.

Jurisdiction under which all crew will fall:
When a seafarer/crew member joins a vessel, no matter which nationality they hold, they will come under the legal jurisdiction of the vessel's flag; however if that vessel is in a country's (or states/regional) territorial waters or their ports, they will also come under the country's laws (or states/regional law if applicable).

For example; a Cayman Islands flag registered yacht is berthed in Monaco; therefore the crew on board will be subjected to the laws of the Cayman Islands as well as the laws of Monaco.

The laws that the seafarer/crew are subjected to by the jurisdiction area are:
Vessel in their Flag State Territorial Seas and Internal Waters: the laws of the flag state.
Vessel on the High Seas: the laws of the flag state.
Vessel in Territorial Seas/ Internal Waters of another country/state: the laws of the flag state &the laws of the country/state.
Vessel in the port/harbour of another country/state: the laws of the flag state & laws of the country /state.

Customs and Immigration

Immigration
It is very important to make sure all crew have appropriate and valid visas for the countries to be visited. Also it is the Captain's and Owner's responsibility for repatriation in the event a crew member has to leave the vessel for whatever reason. Restrictions in some popular Yachting destinations are increasing so research during the passage planning process is required.

Customs
The customs officers are very important in the paperwork process. They can demand any and all vessels documents at any time. They are also usually responsible for clearing out procedures, and in many parts of the world clearance out papers are needed at the next port of arrival.

Also customs are involved in the import and export of personal items and souvenirs. In many parts of the world antiquities are controlled as well as obvious items such as drugs, tobacco and alcohol, weapons and pornographic subject matter. Remember that the result of transporting illegal items through customs can result in a yacht being impounded as well as crew.

Dealing with Drugs found on board
If any illegal substances are found the response will depend on the Drug Policy in place but:
1. If a person employed on board a vessel is found to be in possession of drugs (small amounts for personal use, like marijuana then the master would use his discretion as how to deal with it. This would usually be instant dismissal and maybe inform the owners; remember to log every action taken). HOWEVER the flag state laws if in another country have to be followed and therefore it may be a requirement to report.
2. If the amount is substantial and appears to be more of a 'commercial venture' then the master must report it to the authorities ashore as well as his owners.

Obviously in either case the drugs would be confiscated and held as proof and placed in a secured location until the vessel reaches home port or another port of call, at which time the offense should be reported, and the drugs turned over to the appropriate authorities for action.
Log all actions taken and with a witness record what was found and where found and what action was taken and photograph extensively.
Notify owner, agent and Insurance Company.
Enter all this in the Official Log Book, OLB - see later section.
Notify owners' agent and authorities in next port of call.
The master is obliged to inform the proper authorities, eg.in the UK, the Customs and Revenue officers.

Documents (Ships Certificates, Official Log Book)

It is the responsibility of the master to be aware of the documents that are required to be carried by vessels and to be able to identify those required for his own vessel in particular. There is an increasingly complex number of certificates and documents which must be carried and produced to the appropriate authorities in countries and ports visited. Any failure to produce the appropriate documentation not only may result in delays and inconvenience, but also the ship may be detained and the master may face prosecution.

The list of certificates that a yacht is required to carry is long. The period of their validity and need for annual and periodic surveys together with the method of issue and authority issuing them is varied. The documents may be divided into SOLAS Certificates, and other Convention Compliance Certificates, all relating to the vessel, Crew Certificates of Competency and compliance, as well as Insurance and Class Society Documents and Equipment Licenses.

It must be noted that when the Registry/Flag is changed, all certificates cease to be valid. Complete renewal surveys are required to check compliance with all IMO conventions and all new flag state requirements. Similarly when a class is cancelled all statutory certificates become invalid.

Certificates Required For Yachts
The list is not complete and may vary according to vessel size; it should be used as a guide only.

Certificate of Registry **Valid 5 years**

Codes of Practice Certificates of Compliance
A certificate to the effect that the vessel complies with the requirement of the Code of Practice

SOLAS Safety Certificates - for vessels over 500 gt
Convention for the Safety of Life at Sea establishes minimum standards for the construction and equipment of ships.
SOLAS excludes compliance for any ship, other than a passenger ship, which is under 500 gt, Sailing vessels, fishing vessels and pleasure yachts not engaged in trade.
A Safety Radio Certificate is required for vessels over 300gt, in line with the GMDSS convention

SOLAS Safety Radio Certificate - Cargo Ship Radio Installations, valid 5 years
GMDSS Log Book
All yachts fitted with GMDSS equipment are required to carry a GMDSS Log Book

SOLAS Safety Equipment Certificate and Safety Construction Certificate valid 5 years

SOLAS Safe Manning Document
Any ship of 500 gt or over must carry a Safe Manning Document issued by the flag state. Pleasure yachts and fishing vessels are exempt from this requirement but not yachts operated commercially.

Although a particular vessel may not be obliged to carry a Safe Manning Document, by obtaining such a certificate owners/operators benefit from the expertise of flag state authorities as to what constitutes proper manning for their vessels. Compliance with manning levels dictated by such a certificate is evidence of seaworthiness as regards adequacy of the manning.

In addition the STCW 95 Convention requires flag states to establish and enforce minimum standards of training and certification required by seaman and watchkeeping requirements on vessels.

ISM Certificates Safety Management Certificate/Document of Compliance **Valid 5 years**
The certificates are authorized by the flag state administration and delegated to the recognized Class Societies.

ISPS
The ISPS Code is an internationally agreed protective security regime for the maritime sector and was adopted in a resolution on 12 December 2002 by a Diplomatic Conference of Contracting Governments to the International Convention for the Safety of Life at Sea (SOLAS) 1974. Another resolution was adopted which made necessary amendments to SOLAS Chapter V and the new Chapter XI-2 of SOLAS by which compliance with the ISPS Code became mandatory on 1 July 2004. It contains measures aimed at improving the security of ships and port facilities by placing obligations on governments and the maritime industry, including the appointment of security officers, the preparation of security assessments, the implementation of security plans, the issue of mutually recognised security certificates and the setting of security levels.

International Ship Security Certificate Valid 5 years
Covers the security system and any associated security equipment of the vessel has been verified in accordance the ISPS Code and that the ship complies with the applicable requirements of chapter XI-2 of the Convention and has on board an approved ship security plan.

Continuous Synopsis Record (CSR)
The primary purpose of the CSR is to provide a history of the ship from build onwards which can be inspected by appropriate officials.

Load Line Convention Valid 5 years
International Load Line Certificate

IMO FAL: International Maritime Organization Facilitation Convention (FAL)
Certificate of Registry

Tonnage Convention
International Tonnage Certificate Valid 5 years
Suez Canal/Panama Canal Tonnage Certificates
A separate survey is required because the canal authority requirements differ from the International system.

MARPOL the requirements for complete compliance covers all vessels over 400 gt
Annex I Oil
International Oil Pollution Prevention Certificate IOPP Cert Valid 5 years
Oil Record Book -The following must be recorded in Part I of the Oil Record Book
1. Ballasting or cleaning oil fuel tanks
2. Discharge of ballast or cleaning water from oil fuel tanks
3. Disposal of oily residue (sludge)
4. Discharge overboard of bilge water

Ports are now required to provide reception facilities for all oil residues. In all cases a receipt should be obtained from the reception facilities operator. The entry must be made as soon as possible, signed by the officer and the master must sign each completed page.

Shipboard Oil Pollution Prevention Plan - SOPEP
MARPOL requires all vessels to carry a SOPEP, which is a plan to set in motion the necessary actions to stop or minimize discharges and reduce their effect on the marine environment. Each state approves the form a SOPEP will take. In the US a Vessel Response Plan (VRP) is required.

Annex IV Sewage Sewage Certificate valid 5 years
Requires one of three approved sewage systems installed and prohibits the discharge of sewage into the sea, except when the sewage has been treated
1. Within 4 miles of land, no discharge except from an approved sewage treatment plant (or holding tank – no discharge).
2. Between 4 and 12 miles from land, no discharge except from an approved system for comminuting and disinfecting sewage or (an approved sewage treatment plant, or holding tank – no discharge).
3. More than 12 miles from land, untreated discharges (direct or from holding tank) if the vessel is proceeding at more than 4 knots at the flag state approved rate of discharge or (from an approved sewage treatment plant or an approved system for comminuting and disinfecting sewage).

Annex V Garbage
Garbage Record Book/Garbage Management Plan
Every vessel over 12 meters must display a sign/placard outlining the garbage regulations.
All vessels over 400 gt or carrying 15 persons or more must carry a GMP, which is to provide procedures for collecting, storing, processing and disposing of garbage and the use of equipment. There must be nominated a person in charge of the plan. The plan must follow IMO guidelines.

Disposal of Garbage
Outside of Special Areas
1. No disposal of plastics of any kind, anywhere.
2. Within 3 miles off the nearest land, no disposal
3. More than 3 miles off the nearest land, all Food Waste, Rags, Glass, Crockery, Metals and Paper can be disposed of provided it is comminuted or ground so that it can be passed through a mesh screen with openings no greater than 25 mm, "required standard"
4. More than 12 miles off the nearest land, all Food Waste, Rags, Glass, Crockery, Metals and Paper may be disposed of.
5. More than 25 miles off the nearest land, dunnage, lining, cardboard and packing materials to be disposed of

Disposal of Garbage - Inside Special Areas
1. No garbage other than food waste may be disposed of
2. More than 12 miles off the nearest land only Food Waste can be disposed of , in the Wider Caribbean Region there is a relaxation of this requirement where food waste can be disposed of more than 3 miles off the nearest land provided it is ground

Annex VI Air Various Documents issued for engines etc.

Special Areas
Special Areas are identified in MARPOL as areas where for ecological reasons the IMO has recognized the need for special measures to reduce or restrict disposal of the various Annex substances because:
a. The area is environmentally sensitive
b. There is a lack of movement of water
c. High traffic volume and or an area of dense population.

STCW 95 as amended
Covers the requirements for the issue of Certificates of Competency for Masters, Officers and ratings as well as Medical Certificates

WHO International Health Regulations (FAL) All vessels fall under this
Ship Sanitation Control Exemption Certificate
Ship Sanitation Control Certificate

International Labour Organization - ILO
Maritime Labour Certificate
Declaration of Maritime Labour Compliance

Yacht Codes
Code of Practice Compliance Certificate

Sundry Other Certificates
Compass Certificate
D/F Certificate
Liferaft Test Certificate
Anchor Test Certificate
Chain Test Certificate
Type Approval Certificates Lifejackets, davits, etc. see M1 440

Equipment Licenses
Ships Radio License etc.

Certificate of Registry

Class Societies authorized - Certificate of Class

Class Society compliance may not be compulsory but is required for insurance purposes and if a vessel is commercially employed. It lays down the standards for construction, safety equipment and maintenance of vessels. To comply with the Society's standards ensures continuance in Class. If the vessel has the class suspended or withdrawn, it will normally lose its Safety Certificates, and also insurance cover.

To maintain the vessel in class the owner is required to have regular surveys and repairs carried out on the hull, machinery and equipment by the Class Society surveyors. The period of time between surveys will depend on particular class rules. The Society will issue a Certificate of Class.

All commercial vessels are required to be classed by a Classification Society that is recognized by the Administration. The following are currently recognized by the MCA:

Lloyd's Register of Shipping (LR)
And the British Committees of,
Bureau Veritas (BV)
Det Norske Veritias (DNV)
Germanische Lloyd (GL)
American Bureau of Shipping (ABS)
Registro Italiano Navale (RINA)

Insurance Documents
P&I Club Documents
Fire Arms Certificates
Deck Log Book
Engine Room Log Book
GMDSS Log

ILO Convention inspection of seafarer's working and living conditions

For vessels over 200 gt
The ILO Convention 178 and Recommendation 185 require inspection of seafarer's working and living conditions within specified time intervals.
They will be inspected initially at first ISM audit (following registration) and at intervals not exceeding 3 years afterwards. This will usually be carried out during an ISM or ISPS audit.

The ILO 178 inspection will generally cover areas such as:

- Standards of maintenance and cleanliness of the ship's living and working areas.
- Minimum age of seafarers.
- Articles of Agreement (crew agreements).
- Food, catering and the standards and cleanliness of food and provisions arrangements.
- Crew accommodation arrangements.
- Manning, medical examination of seafarers, medical provisions on board and the qualifications and training of crew members.
- Hours of work and rest periods and the records kept.
- Arrangements on board for the prevention of occupational accidents and for reporting and investigation of accidents, and
- Articles of Agreement, contracts of employment and/or any collective bargaining agreements in place relating to the terms and conditions of employment on board.

Issue of Load Line Certificates valid 5 years

Application for a load line certificate must be made to the Assigning Authority approved by the flag state. The ship is surveyed in accordance with flag state requirements by the Assigning Authority. Freeboard will then be calculated and when the ship has been marked with the resulting load lines the certificate will be issued.

A vessel must be kept marked in accordance with load line requirements, concealing, removing or defacing the marks all constitute criminal offences. It must not be loaded so that the load line on each or either side is submerged, if in salt water with the ship upright, or in any other case, it would be submerged if in salt water, with the ship upright.

If loaded in contravention of the above, the owner and master are guilty of an offence.

Certificate no: HAM0730019
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Lloyd's Register International Load Line Certificate

Issued under the provisions of the International Convention on Load Lines, 1966, in accordance with Assembly resolution A.883(21) relating to the global implementation of the harmonized system of survey and certification, under the authority of the Government of the United Kingdom of Great Britain and Northern Ireland by Lloyd's Register EMEA.

Particulars of Ship

Name of ship	STENA BRITANNICA
Distinctive number or letters	2YUJ5
Port of registry	HARWICH
IMO number	9235517
Freeboard assigned as	A new ship
Type of ship	Type B

Official Log Book – OLB - the OLB is the record of the legal life on board the vessel

The Official logbook is required under UK legislation for maintaining a record of all the events on board a vessel. It is started when the Crew Agreement is opened, and it is closed when the Crew Agreement is terminated. Together with the Crew Agreement and the Radio Log, which technically is a part of the Official Log Book it is forwarded to the Registrar of Seamen and Shipping at Cardiff.

On Yachts the OLB is opened at the same time as the Crew Agreement (MGN 149) and both are closed at the same time, both remain open for 12 months.

Every UK registered vessel is required to keep an OLB in the statutory format, but not if they are

1. Vessels of less than 25 gross tons
2. Pleasure yachts
3. Ships belonging to the General Lighthouse Authority

Once the OLB has been lodged at Cardiff it forms part of the Public Records. It is available to parties in litigation as evidence to support their case. It is an offence for the master to fail to record anything required by the regulations; on the other hand, the master is not restricted as to what else he enters in the OLB.
There are statutory entries required to be made, ie Change in Command, Accidents, Deaths, etc

Command Duties

Duties On taking over command

1. Inspect the vessel, condition, safety gear etc.
2. Check the Continuous Synopsis Record, CSR
3. Check all ships documents, the hand over notes, manning levels against the Safe Manning Document, the crew certificates of competency and training, including revalidations, crew Medical Fitness Certificates. Enter master on Crew list cover, enter name and Certificate number on OLB cover, enter name rank and reference number inside front cover of OLB, enter in the narrative section, note change in command and receipt of all documents.

Standing Orders

Standing orders and yacht Operational Procedures Manuals form the basis of command and Control on board. Masters Standing Orders will be reflected in the size of vessel and crew, area of operation and the experience of the watchkeepers. The orders must be consistent with the vessel's safety management system. All officers must read the Standing Orders and sign to that effect and a copy available for reference at all times. Additional Instructions must be written in the Bridge Order Book, such as night instructions of a special nature. Refer to the Bridge Procedures Guide.

Duty to Carry Navigational and Safety Publications

In addition to the documents required to be carried as above, and in response to the SOLAS requirements that all vessels carry appropriate charts and navigational data, UK legislation requires all ships of 12 metres or more in length, when going to sea from a port in the United Kingdom, to carry corrected Admiralty charts (or corrected alternative) of an appropriate scale for all areas in which they intend to navigate. That is of a scale to show all navigation marks, dangers and routing/reporting requirements. If non admiralty charts are carried then they must be corrected.

In addition, if going beyond a distance of 5 nm from land, one copy of each of the following publications:

- Official Log Book (MCA)
- Crew Agreement forms (MCA)
- Code of Safe Working Practices (MCA) - The following numbers are required to be carried:
  - 5 crew or less - 1 copy
  - More than 5 crew but less than 20 - 4 copies
  - More than 20 crew - 6 plus
- International Code of Signals (IMO)
- Mariners' Handbook (UKHO)
- Merchant Shipping Notices, Marine Guidance Notes and Marine Information Notes (MCA) [Only (M) and (M+F) designated notices are required for Merchant ships]
- Notices to Mariners (UKHO)
- Notices to Mariners – Annual Summary (UKHO)
- Lists of Radio Signals (UKHO)
- Lists of Lights (UKHO)
- Sailing Directions (UKHO)
- Nautical Almanac (UKHO)
- Navigational Tables
- Tide Tables
- Tidal Stream Atlases
- Operating and Maintenance Instructions for Navigational Aids Carried by the Ship
- MCA Ship Captains Medical Guide
- It is recommended that a copy of the Bridge Procedures Guide is carried

Shipping Accidents - Investigation and Reporting

The Safety of Life at Sea Convention (SOLAS) requires all flag states to investigate every shipping accident occurring within their jurisdiction, that is, accidents involving ships registered in that state, wherever they occur, and accidents involving any ship within the state's territorial jurisdiction. The rules and the manner in which a particular flag state complies with this requirement is a matter for that state to determine.

The UK government through its executive arm, the Department of the Environment, Transport and the Regions, (DFT) is responsible for all matters relating to maritime affairs. The enforcement of the provisions of International Conventions have been delegated to the two main executive agencies the MCA and the Marine Accident Investigation Branch (MAIB). These two agencies are separate and report independently.

The UK regulations require the Master of a United Kingdom registered vessel, or any vessel within the territorial jurisdiction to report to the Chief Inspector of the MAIB, all accidents, including major injuries, within 24 hours by the quickest possible means. This is so they can be investigated immediately, before vital evidence decays, is removed or is lost. Accidents should be reported in writing to the Marine Accident Investigation Branch with copies kept on board.
Reports also have to be made to the Flag State authorities under whose jurisdiction the vessel falls at the time of the accident.

Duty to Report Dangers to Navigation
The master must report via radio any dangers to navigation: Includes

1. Dangerous ice
2. Dangerous derelict
3. Tropical storm
4. Air temperatures below freezing with gale force winds causing severe ice accretion
5. Winds of force 10 or above for which no storm warning has been received
6. Any other direct danger to navigation, logs, containers, etc.

The information is to be communicated by all means. The message sent by radio is a "securite" call.

Seaworthiness
Owners and the master have both a criminal and civil law duty to take reasonable care to ensure that at the commencement of a voyage, the ship is seaworthy. This duty is owed to charterers, passengers and crew members. The seaworthiness of the ship is also a requirement of marine insurance contracts and underwriters may avoid liability for any loss or damage attributable to such unseaworthiness.

Safe Manning
Minimum levels of manning are set by all maritime states and they will vary by vessel size and state regulations. If any vessel proceeds to sea in breach of their requirements, the owner, managers and/or master are liable to criminal prosecution and substantial penalties.

Employment Law and Code of Conduct

Every administration has its own laws and regulations concerning employment law and protections of employment. The master of every vessel should make him/her self aware of these regulations and comply.

Generally there are requirements for equal opportunities and also for fair treatment of employees the failure to comply can lead to criminal and civil action against not only the master but also the owner and manager.

In the UK Employment protection legislation provides that certain employees have a right not to be dismissed in an unfair manner or for an unfair reason and if they feel that they have been unfairly dismissed they may complain to an Industrial Tribunal for a ruling. Such a complaint must be made by the individual who was dismissed, (usually with the support of a trade union), or a personal representative if deceased.

Any employee, that is anyone employed under a contract of employment, is protected under UK Employment protection legislation. All crew on UK vessels are employed either under an MCA Crew Agreement or in the case of the master, a Master's Contract (not being a seaman under the Crew Agreement and is exempt from signing it). A contract of employment is a contract of service or apprenticeship. Its terms may be expressed in writing or orally, or may be implied.

In addition to the legal requirements under the criminal code there will also be civil/contract requirements to fulfil. Mostly this will be crew contracts which are a civil agreement between the owner (Or master/management company acting as agent for the owner) and each crew member. This will be in the form of a contract.

An employment contract for a job on a yacht will be similar to that of any other employment contract. However there may be additional clauses that are specific to the industry, for example Confidentiality, Dress code, etc.

An employment contract need not be in writing. It makes it no less enforceable if it is in writing. Yacht Management companies will always have a written contract and most Captains who act as the employer for an owner will too.

Failure to comply with the terms by either party can lead to the contract being voided, and then there is no contract, or by civil action for damages. Either may well be expensive to file.

The Code of Conduct for the Merchant Navy - outlines the procedures to be followed for disciplinary lapses.

It is the basis on which discipline is maintained and some Yacht management companies have developed their own MCA approved Crew Agreements which incorporate the MN Code of Conduct. The way it works is based on the premise that the most effective form of discipline is self-discipline, which develops with a responsible attitude to the job, and concern for the efficient operation of the vessel and for the comfort and convenience of fellow crew members.

The Code lists those types of conduct which constitute a breach of the code and outlines the remedies, categorizing them into:
Conduct in emergencies (Paragraph 5)
Serious breaches (Paragraph 9)
Less serious breaches (Paragraph 11)

Conduct in Emergencies (Paragraph 5)
In any emergency or other situation in which the safety of the vessel or person on board, whether crew or guests, is at stake the Master and Officers are entitled to look for immediate and unquestioning obedience of orders. Failure to comply will be treated as the most serious breach and will be liable to lead to dismissal from the yacht at the first opportunity. It may also warrant criminal prosecution.

Serious Breaches (Paragraph 9)
Include:

1. Assault
2. Wilful damage to ship or any property on board
3. Theft or possession of stolen property
4. Possession of offensive weapons
5. Persistent or wilful failure to perform duty
6. Unlawful possession or distribution of drugs
7. Conduct endangering the ship or persons on board
8. Combination with others at sea to impede the progress of the voyage or navigation of the ship
9. Disobedience of orders relating to safety of the ship or any person on board
10. To be asleep on duty or fail to remain on duty if such conduct would prejudice the safety of the ship or any person on board
11. Incapacity through the influence of drink or drugs to carry out duty to the prejudice of the safety of the ship or of any person on board
12. To smoke, use a naked light or an unapproved electric torch/flashlight in any part of a ship carrying dangerous cargo or stores where smoking or the use of naked lights or unapproved torches/flashlights is prohibited
13. Intimidation, coercion and/or interference with the work of other employees
14. Behaviour which seriously detracts from the safe and/or efficient working of the ship
15. Conduct of a sexual nature, or other conduct based on sex affecting the dignity of women and men at work which is unwanted, unreasonable and offensive to the recipient.
16. Behaviour which seriously DFT acts from the social well-being of any other person on board.
17. Causing or permitting unauthorized persons to be on board whilst it is at sea
18. Repeated commission of breaches of a lesser degree listed in Paragraph 11, after warnings have been given in accordance with the procedures in Paragraph 10.

Remedies
The Code specifies industrially fair procedures are employed and a hearing by the captain with the "accused" given the chance to be represented (usually by an officer) but the master must only be reasonably satisfied that an appropriate breach of the Code has occurred. He then has 3 choices,
If he finds the seafarer did commit the alleged breech, he will impose a penalty which he considers to be reasonable in all the circumstances, taking into account the seafarer's record on the ship and any other relevant factors. He may announce,

1. That he is giving a warning
2. That he is giving a written reprimand
3. That the seafarer will be dismissed from the ship. at the next port of call for repatriation

The Master will enter details of the breach and the action taken in the official log. The seafarer is to be given a copy of all entries made in the logbook relating to his breach

Occupational Health and Safety

Occupational health and safety is concerned with protecting the safety, health and welfare of people engaged in all forms of work. As a secondary effect, it may also protect co-workers, family members, employers, customers, suppliers, nearby communities, and other members of the public who are impacted by the workplace environment.

The UK regulations ensure that:

1. Employers have a duty to ensure the health and safety of workers. This includes the provision and maintenance of safe plant and equipment.
2. The safety of the working environment on board receives proper consideration at all levels of management.
3. Employers have a duty for the provision of safety information, training and supervision.
4. Both management and individual employees are involved in managing the safety of the working environment. This includes therefore the Safety Officers, Safety Representatives and Safety Committees. (The employer through the Master must appoint a safety Officer, the officers and crew elect safety representatives and then the master appoints a safety committee)
5. Employers have a duty to produce a Safety policy and annual review

Duties of the employee

1. To take reasonable care for his own and his co workers health and safety on board.
2. To cooperate with the employer and allothers to enable all health and safety duties are carried out.
3. Not to intentionally act recklessly or interfere with anything provided in the interests of health and safety.

Chartering Yachts

The word 'Charter' is used to identify a contract, the objective of which is to let/hire the use of a vessel for a specific purpose (voyage charter) or for a specified period of time (time charter). Each party to the agreement (Charter Party) must carry out their promises or be liable to pay compensation for any loss or damage caused by their failure to do so. It is irrelevant that any such failure was due to circumstances beyond the control of the party concerned unless such circumstances were allowed for in the terms of the contract.

The country whose law will determine disputes arising out of a charter is a matter for agreement between the parties, usually at the time of contracting, when it becomes a term of the charter, or if not in the charter agreement when the dispute arises.

Under UK Contract law, it is not necessary for charters to be in writing to be enforceable in law, but because they are of a complex nature it is usual for such agreements to be in writing so as to avoid misunderstanding and provide clear evidence of the terms of the contract. Various standard forms of agreement are available, which the parties use, modifying them as necessary to suit their particular arrangements. It is, however, important to remember that the terms of any such written agreement can subsequently be varied by the conduct of the parties.

It should be noted that any failure to perform any part of any promise contained in a charter gives the injured party a claim in law for compensation. There are, however some promises in a charter which are viewed in law as being so fundamental to the performance of the agreement as a whole, that if they are broken the injured party can refute the whole agreement as well as claiming damages, for example failure to provide the yacht contracted for by the time specified in the contract.

Voyage and Time Charters
There are the main types of charter:

Voyage Charter - The charterer hires the vessel for a single voyage to make a specific trip between identified terminal ports, carrying cargo and /or passengers for and on behalf of the charterer. The charterer pays for the use of the ship either on the basis of a lump sum or, in the case of cargo, a "freight rate" (so much per ton carried and delivered). This form of charter for hiring the use of commercially operated yachts would be unusual. The owner and his crew manage the vessel.

Time Charter is a contract for the hire of the use of a ship for a specified period of time and can take on one of two basic forms. The difference between the two is who has Operational Control of the vessel and crew.

Basic Time Charter - This is an agreement between the owner of a ship and a charterer who wishes to use the ship for his own purposes without being responsible for the operation of the ship nor its day to day management. The owner still manages the vessel but the charterer selects the ports of destination. Throughout the period of charter the owners/operators must maintain the ship in a thoroughly efficient state ready in all respects to do as the charterer requires, provided it is in accordance with the terms of the charter. The charterer must pay the agreed hire and is responsible for any damage or loss directly attributable to his use of the ship. It is a more permanent arrangement than the voyage charter and more representations are made about the ship to the charterer.
It may be considered similar to the hire of a chauffeur driven car.

Demise or Bareboat Charters - This is an agreement between the owner of the ship and a charterer, sometimes referred to as the disponent owner, whereby in exchange for the payment of hire the charterer obtains full possession and control over the use of the "bare" ship for the period of time agreed, subject only to any restrictions imposed by the owner and written in the agreement. This arrangement is completely different from the previous two. The charterer takes full control of the vessel along with the legal and financial responsibility for it. The demise shifts the control and possession of the vessel from the owner to the charterer.

The master and crew are the servants of the charterer and the charterer must return the ship in the same condition as it was received, fair wear and tear excepted, at the end of the charter period.
The charterer is responsible in law for the safe operation of the ship and is liable in law for any infringement of regulations and/or damage caused by the operation of the ship.
It may be considered similar to a vehicle leasing contract.

Salvage & Wreck Law

Common law salvage means a salvage service performed by someone without a contract who relies on the law of salvage to ensure he is paid for his services. There are very few common law Salvage Claims as there is now an international Convention and the general use of Lloyds Open Form.

Salvage was defined as a voluntary service which successfully saves, or assists in saving, Maritime property in danger at sea.

The person in possession and control of the property has the right in law to decide which of the persons offering should render the salvage service. He has the right to dispense with the services of salvers and to have additional salvers if necessary. Any salver who unjustifiably interferes with this right puts his own salvage award in jeopardy, and if this interference results in greater damage, he could be sued for the loss.

The right of the person in possession to control the salvage service is qualified by three things,

1. Unless he is the owner of that property his action must always be in the best interests of saving the property
2. Once engaged, a salver has the right to a fair opportunity to earn his award. If his services are dispensed with in favour of another, then he must be compensated as well as the new salver

3. In the case of a loaded tanker which threatens serious pollution the coastal state concerned has the power to intervene and override the wishes of the master, owner and salver

Duties of the salver

The salver shall owe a duty to the owner of the vessel or other property in danger

1. To carry out the salvage operations with due care;
2. In performing the duty specified in subparagraph (a), to exercise due care to prevent or minimize damage to the environment;
3. Whenever circumstances reasonably require, to seek assistance from other salvers;
4. To accept the intervention of other salvers when reasonably requested to do so by the owner or master of the vessel or their property in danger; provided however that the amount of his reward shall not be prejudiced should it be found that such a request was unreasonable.

Duties of the owner and master

The owner and master of the vessel or the owner of other property in danger shall owe a duty to the salver-

i. To co-operate fully with him during the course of the salvage operations;
ii. In so doing, to exercise due care to prevent or minimize damage to the environment;
iii. When the vessel or other property has been brought to a place of safety, to accept redelivery when reasonably requested by the salver to do so.

Criteria for fixing the reward -Article 13

1. The reward shall be fixed with a view to encouraging salvage operations, taking into account the following criteria without regard to the order in which they are presented below:

(a) The salved value of the vessel and other property;
(b) The skill and efforts of the salvers in preventing or minimizing damage to the environment;
(c) The measure of success obtained by the salver;
(d) The nature and degree of the danger
(e) The skill and efforts of the salvers in salving the vessel, other property and life;
(f) The time used and expenses and losses incurred by the salvers;
(g) The risk of liability and other risks run by the salvers or their equipment
(h) The promptness of the services rendered;
(i) The availability and use of vessels or other equipment intended for salvage operations;
(j) The state of readiness and efficiency of the salver's equipment and the value thereof

2. Payment of a reward fixed according to paragraph 1 shall be made by all of the vessel and other property interests in proportion to their respective salve values. However, a State Party may in international law provide that the payment of a reward has to be made by one of these interests, subject to a right of recourse of this interest against the other interests for their respective shares. Nothing in this article shall prevent any right of defence.
3. The reward, exclusive of any interest and recoverable legal costs that may be payable thereon, shall not exceed the salved value of the vessel and other property.

Special compensation - Article 14

The Salvage Convention provides in Article 14 that whenever there was a threat of damage to the environment, the salvor should receive as a minimum:-

a) His expenses – even if unsuccessful

and

b) Plus, if successful in minimising or preventing damage to the environment, an uplift of those expenses of up to 100%.

Salvage - Practical Aspects

A salvage service implies that there is some degree of danger or some need of extraordinary assistance to the vessel which characterizes a salvage service. Although a marine peril to the salved property is a necessary ingredient of a valid salvage claim, that peril does not need to be one that is necessarily imminent or an absolute danger. It is sufficient if the property is in danger, either presently or reasonably to be so in the near future.

Simple towage, on the other hand, is a service that is based on the employment of one vessel to expedite the voyage of another when nothing more is required than the acceleration of her progress. Simple towage is regarded as having taken place when a tow is called for or taken by a sound vessel as a mere means of saving time, or for considerations of convenience. The hallmark of towage is the absence of peril. The motivation for the towing service is convenience not safety. An example would be where a sailboat, proceeding under sail in light airs without difficulty, requests a tow from a power vessel to expedite the vessel's return to her mooring.

The need for the master to immediately assess the threat and decide urgently whether and what assistance is needed. The master should always overreact on the side of safety and pollution prevention rather than delay in the hope of improving circumstances.

Masters' Actions should include:

1. If time permits request advice form owners, insurers and P&I club.
2. Call for assistance immediately in the event of safety of vessel, crew and passengers.
3. Accept the most reasonable assistance and the one that is most equipped to achieve the best result.
4. Try to obtain agreement, LOF before accepting services.

If immediate assistance is not required, arrange for appropriate services through owner on a contractual basis for towage or a fixed price. This should not be done if the vessel, life or environment is threatened.
Once a vessel/s responds, request immediate action, and never delay for negotiations of contract terms and accept any form offered to get the salvage operation underway. If LOF is declined agree other terms, and if these are onerous then protest and record in the log.
The master still retains command of the vessel and can dispense with the services at any time.

Lloyds Open Form
If the ship is in trouble, the master will have to decide whether the service he wants is towage or salvage. If there is danger, then his decision is likely to be salvage. Because of the many disputes which arise in salvage cases, and because of the fact that increasing danger on the one hand may make the outcome more lucrative for the salver on the other hand, it is to the advantage of both parties to use some form of salvage agreement. Additionally, due to the circumstances outlined above, salvage agreements have always been subject to the special jurisdiction of the courts which have the power to re-open salvage agreements and to adjust the awards.

Lloyd's Form of Salvage Agreement, or Lloyd's Open Form as it is usually referred to, has been revised and the new form, known as LOF provides the mechanism for deciding the amount of remuneration to be paid to salvage companies following the successful salvage of maritime property of any description at sea. LOF is the most widely used international salvage agreement of its kind. Virtually every professional salvor in the world carries out salvage services under the terms and conditions of Lloyd's Form at some time and it is universally accepted as a means of determining salvage rewards.

Special Compensation P&I Clause (SCOPIC)
LOF90 incorporated the Salvage Convention which included the provision for Special Compensation under Article 14. As a result of LOF90, there were a substantial number of Article 14 (Special Compensation) claims in the ensuing years. However it was discovered that the interpretation of Article 14 was not as easy as originally hoped. The difficulties of interpreting the precise meaning of Article 14 was defeating the purpose to encourage salvors to proceed to the assistance of seriously damaged ships of low value which threatened damage to the environment.

To correct the situation, all sides of the industry got together and developed a new concept, the SCOPIC Clause (Special Compensation P&I Clause), which was specifically designed to replace the Article 14 provision of the Salvage Convention and make the assessment of the amount due to the contractor that much easier. When LOF was revised, LOF2000 specifically made provision for the use of the SCOPIC clause should the contracting parties so wish.

Marine Insurance
It is important for the master to make sure that there is an insurance policy in place that covers the Vessel, the captain and crew and third party liability.

The policy should also cover the area in which it is planned to operate. This may also include a clause that requires the vessel NOT to be in certain areas at certain times of the year, for example in the Caribbean or Florida during the hurricane season.

The principle of insurance is that where a venture involves risk and therefore the possibility of loss or damage to some sort of property, the insurer accepts the financial liability resulting from the loss in return for the payment of a premium by someone with an interest in the property, that is, the assured. The insurer calculates the premium on the basis of the maximum sum he may have to pay out, together with the probability and degree of likely loss. The insurer intends to make a profit by carefully setting the premiums at such a level so that at the end of the accounting period, the premiums collected exceed the amount paid out in losses. The terms and conditions of a contract of insurance are set out in a document called a policy.

Policies on yachts may be underwritten by a marine insurer likely providing property and liability insurance in one policy.
Builder's risk insurance is available to cover damage to a vessel under construction.
Insurance policies are written based on 3 principles, insurable interest, indemnity and utmost good faith.
Insurable interest, the insured has to have something of value to loose, usually the yacht

Indemnity, the Insurer undertakes to indemnify the assured for loss or damage arising from loss suffered, by means of financial compensation based on the agreed value. A principle of indemnity is where the assured cannot claim more than once on the same risk. Therefore if the assured has policies covering the same risk with 2 insurers (double insurance), each will make a pro rata contribution to the settlement. Double insurance is not the same as spreading the risk between several insurers.

Utmost good faith, which means that the assured must disclose to the insurer before the contract is concluded, every material circumstance which is known to the assured. Material in this context means anything that will influence the insurer's judgement in fixing the premium or even determining whether or not to accept the risk. If this is not observed, the contract may be avoided by the other party.

All marine insurance policies have warranties. A warranty may be express or implied; express is written into the policy whereas implied warranties are implied by law to form part of the contract. Both must be strictly complied with.
There are 3 major implied warranties, seaworthiness, legality, and also neutrality:.

Legality
It is implied that the adventure insured is a legal enterprise and will be carried out in a lawful manner. If the adventure is illegal at the time the policy is written, it will render the policy void.

Seaworthiness
It is implied that the vessel must be seaworthy at the commencement of the voyage. If the assured sends a vessel to sea unseaworthy, the insurer is not liable for any loss arising out of that unseaworthiness. To be seaworthy, the ship must be reasonably fit in all respects to encounter the ordinary perils of the seas of the adventure insured.

Neutrality
It is assumed that the vessel is neutral.

The types of express warranties:
Operation limits clause
Carrying of passengers for payment
Not to tow or be towed