2021

YACHTMASTER OFFSHORE RECREATIONAL

Recreational Certificate of Competency <24 Meters Power & Sail
(includes Maritime Business & Law)

Canadian General Standards
Board Approved:
ISO 9001:2015
Quality Management System

International
Yacht
Training
WORLDWIDE

Updated January 27, 2021

LIST OF IYT COURSES

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Dinghy Sailing – Silver Level – Safe Sailing
Dinghy Sailing – Gold Level - Independent Sailing
Dinghy Sailing – Platinum Level – Perfected Sailing
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IYT Day Skipper / Crew
Introductory Sailing Skills
Try Sailing
Introduction to Yachting
International Crew Power or Sail
International Flotilla Skipper Power or Sail
International Bareboat Skipper Power or Sail
International Bareboat Skipper Sail Catamaran
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Personal Watercraft Operator (PWC)
Small Powerboat & RIB Master (MCA Approved)
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Navigation Master
Weather Master
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International Certificate of Competency <10m Power Coastal & Inland
International Certificate of Competency <24m Power Coastal
International Certificate of Competency <24m Power Coastal & Inland
International Certificate of Competency <24m Sail & <10m Power Coastal
International Certificate of Competency <24m Sail & <10m Power Coastal & Inland
International Certificate of Competency PWC Coastal
International Certificate of Competency PWC Coastal & Inland
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STCW Personal Survival Techniques
STCW Personal Safety & Social Responsibilities
Master of Yachts Coastal/Mate 200 Tons

Master of Yachts Limited
Master of Yachts Unlimited
Master of Yachts Inshore < 80gt.
IYT Boat Master Level 1 & 2 Marine Engineering

We also offer instructor courses for all levels of training.

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PREFACE

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 Gross Tons.

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
- Maritime 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.

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.

Amendments

Amendments and updates to the Publication will be published as and when necessary.

Any comments or suggestions for this document should be directed to International Yacht Training. Please e-mail: **support@IYTworld.com** or telephone Canada +1 778-477-5668.

Publication information

This publication is for purposes of guidance and training. While every effort has been made to ensure accuracy, International Yacht Training Worldwide is not liable for the consequence of implementing or attempting to implement any instructions or advice contained within these notes.

Publication Authority

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CANADA

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Chapter 1 INTERNATIONAL REGULATIONS FOR PREVENTING COLLISIONS AT SEA

1.1 Key Objectives

THE OBJECTIVE OF THIS MODULE IS TO PROVIDE A COMPLETE UNDERSTANDING OF THE INTERNATIONAL REGULATIONS FOR PREVENTING COLLISIONS AT SEA, BETTER KNOWN AS ***"COLREGS"***

1.2 General Information – History of "Colregs"

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.

1.3 Buoys & 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:

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.

FIGURE 1 - IALA MARITIME BUOYAGE SYSTEM – BUOYAGE REGIONS A & B

Marks can either be a buoy floating in the water or a pole set into the rocks or seabed 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.

Buoys & Marks 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.

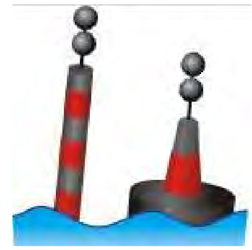


FIGURE 2 - ISOLATED DANGER MARK

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 ***<u>Fairway Buoy</u>***, 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].

FIGURE 3 – SAFE WATER MARK

Because the buoy has several meanings It is therefore important to consult an appropriate chart to determine the exact meaning in each case. ***<u>The marker is also sometimes known as a Fairway Buoy.</u>***

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.

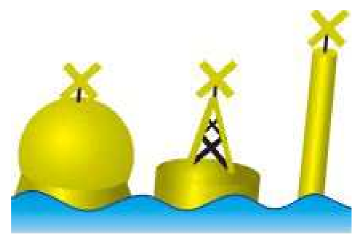


FIGURE 4 - SPECIAL MARK

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.

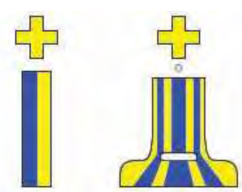


FIGURE 5 - WRECK BUOY

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

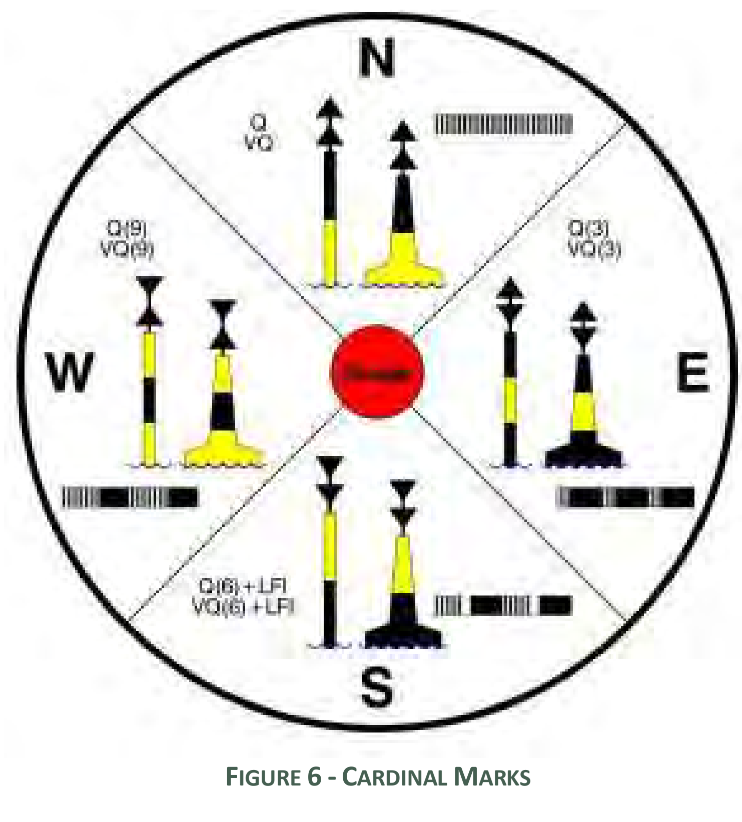


FIGURE 6 - CARDINAL MARKS

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).

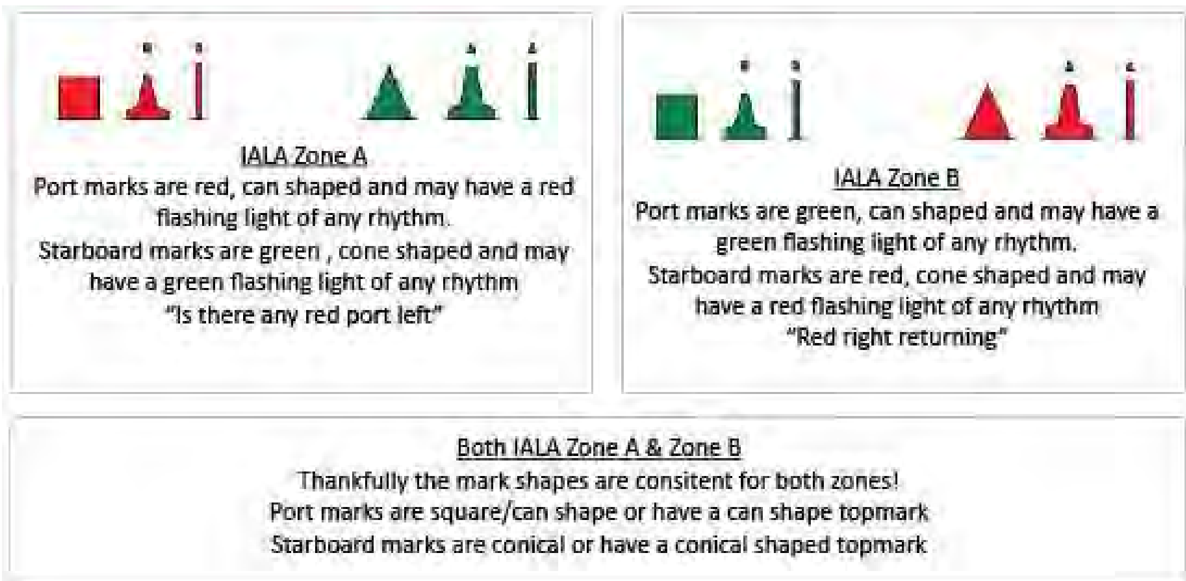
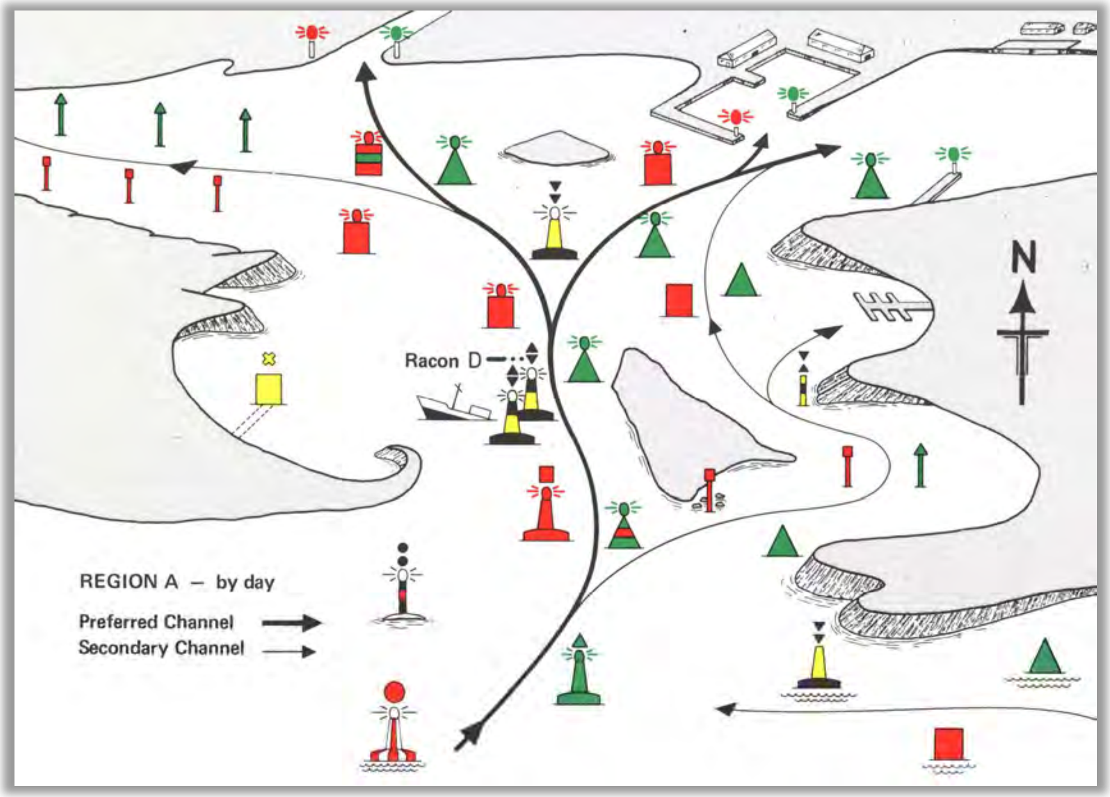
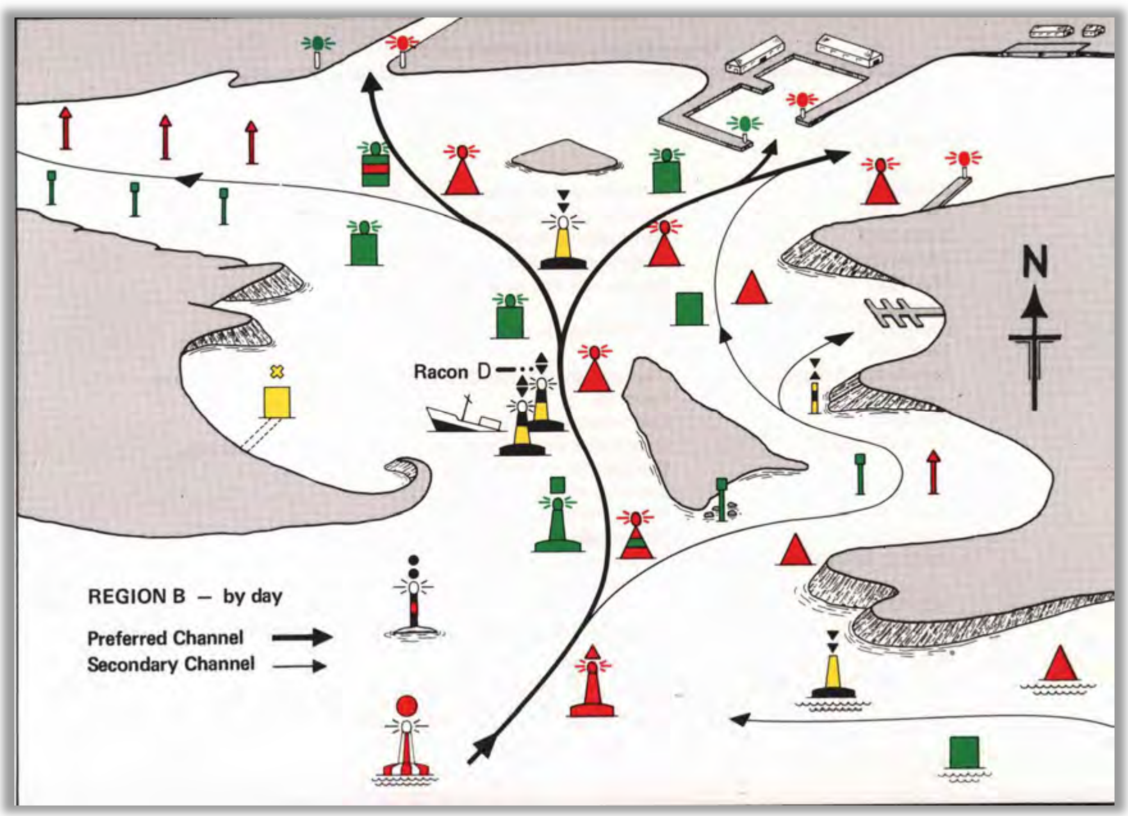


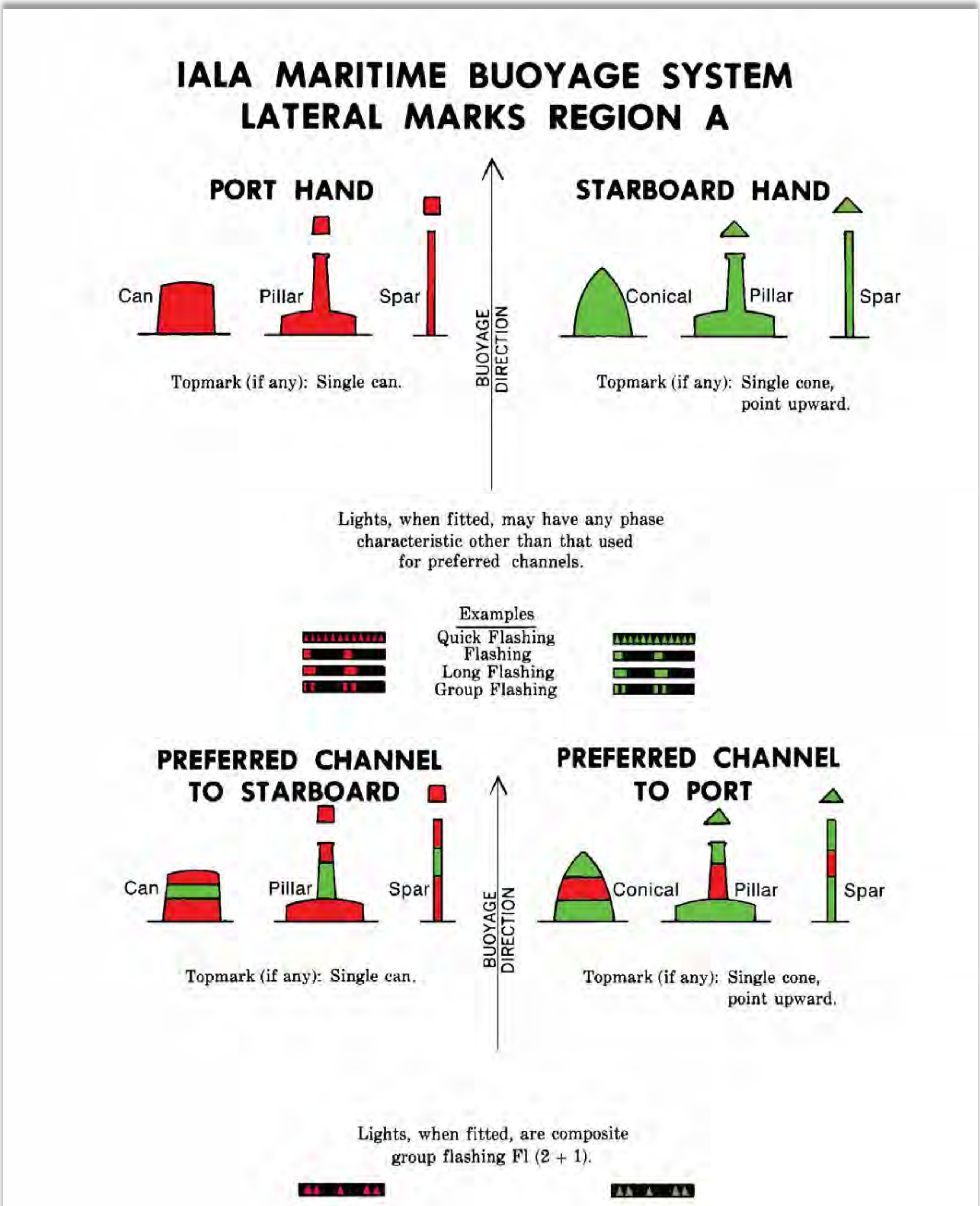
FIGURE 7 - LATERAL MARKS

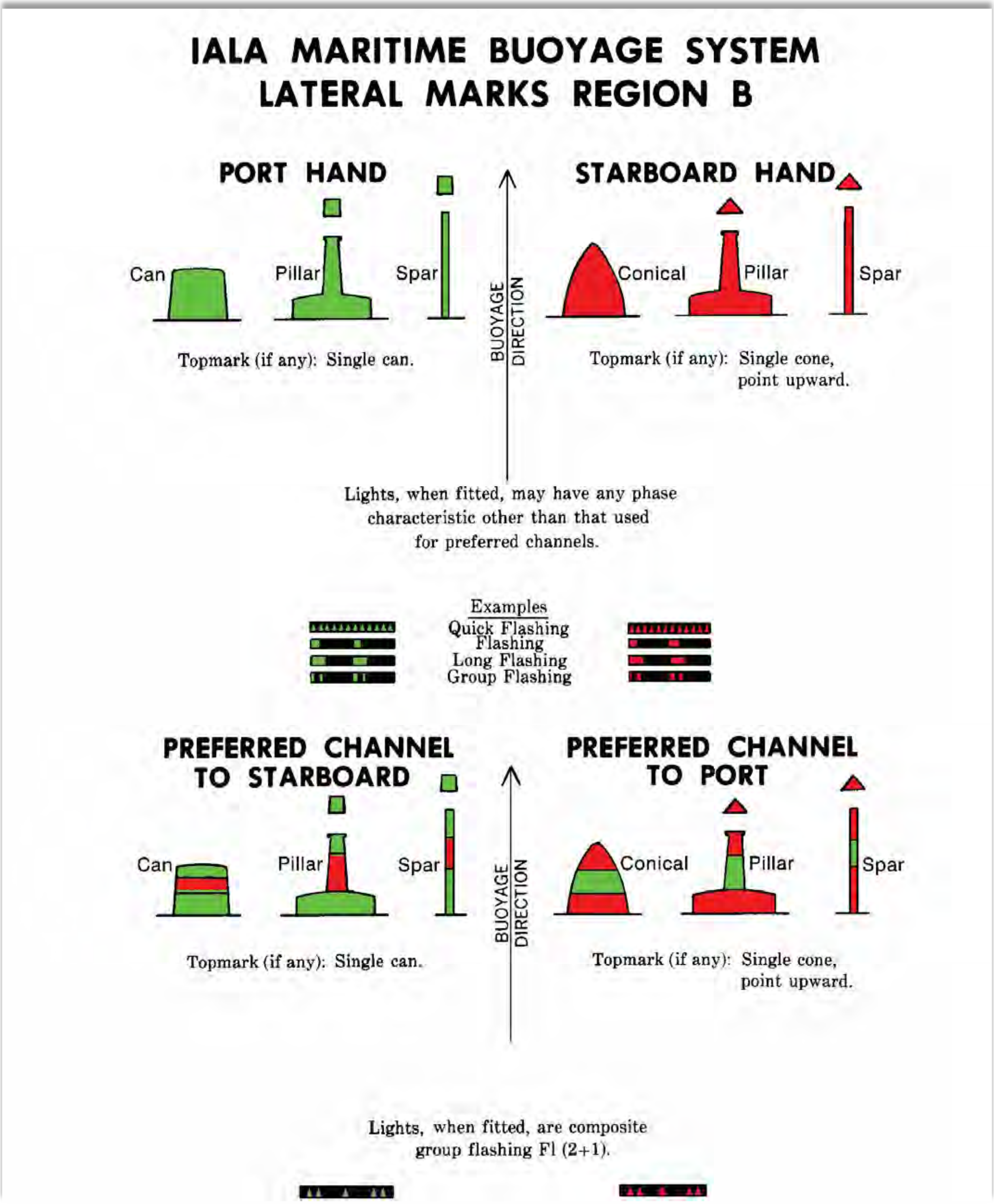
Bifurcation/Preferred Channel Mark

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.


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


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


IALA MARITIME BUOYAGE SYSTEM
LATERAL MARKS REGION A
PORT HAND
Can
Pillar
Spar
Topmark (if any): Single can.
BUOYAGE DIRECTION
STARBOARD HAND
Conical
Pillar
Spar
Topmark (if any): Single cone, point upward.
Lights, when fitted, may have any phase characteristic other than that used for preferred channels.
Examples
Quick Flashing
Flashing
Long Flashing
Group Flashing
PREFERRED CHANNEL TO STARBOARD
Can
Pillar
Spar
Topmark (if any): Single can.
BUOYAGE DIRECTION
PREFERRED CHANNEL TO PORT
Conical
Pillar
Spar
Topmark (if any): Single cone, point upward.
Lights, when fitted, are composite group flashing Fl (2 + 1).


IALA MARITIME BUOYAGE SYSTEM
LATERAL MARKS REGION B
PORT HAND
Can
Pillar
Spar
Topmark (if any): Single can.
BUOYAGE DIRECTION
STARBOARD HAND
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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

1.4 [1]INTERNATIONAL REGULATIONS FOR PREVENTING COLLISIONS AT SEA, 1972

(as amended by Resolutions A464(XII), A626(15), A678(16), A736(18) and A.910(22))

PART A- GENERAL

Rule 1: Application

- (a) These Rules shall apply to all vessels upon the high seas and in all waters connected therewith navigable by seagoing vessels.
- (b) Nothing in these Rules shall interfere with the operation of special rules made by an appropriate authority for roadsteads, harbours, rivers, lakes or inland waterways connected with the high seas and navigable by seagoing vessels. Such special rules shall conform as closely as possible to these Rules.
- (c) Nothing in these Rules shall interfere with the operation of any special rules made by the Government of any State with respect to additional station or signal lights, shapes or whistle signals for ships of war and vessels proceeding under convoy, or with respect to additional station or signal lights or shapes for fishing vessels engaged in fishing as a fleet. These additional station or signal lights, shapes or whistle signals shall, so far as possible, be such that they cannot be mistaken for any light, shape or signal authorised elsewhere under these Rules.
- (d) Traffic separation schemes may be adopted by the Organization for the purpose of these Rules.
- (e) Whenever the Government concerned shall have determined that a vessel of any special construction or purpose cannot comply with the provisions of any of these Rules with respect to the number, position, range or arc of visibility of lights or shapes, as well as to the disposition and characteristics of sound-signalling appliances, such vessel shall comply with such other provisions in regard to the number, position, range or arc of visibility of lights or shapes, as well as to the

[1] https://en.wikisource.org/wiki/International_Regulations_for_Preventing_Collisions_at_Sea

disposition and characteristics of sound-signalling appliances, as her Government shall have determined to be the closest possible compliance with these Rules in respect of that vessel.

Rule 2: Responsibility

- (a) Nothing in these Rules shall exonerate any vessel, or the owner, master or crew thereof, from the consequences of any neglect to comply with these Rules or of the neglect of any precaution which may be required by the ordinary practice of seamen, or by the special circumstances of the case.
- (b) In construing and complying with these Rules due regard shall be had to all dangers of navigation and collision and to any special circumstances, including the limitations of the vessels involved, which may make a departure from these Rules necessary to avoid immediate danger.

Rule 3: General definitions

For the purpose of these Rules, except where the context otherwise requires:

- (a) The word “vessel” includes every description of watercraft, including non-displacement craft, WIG craft and seaplanes, used or capable of being used as a means of transportation on water.
- (b) The term “power-driven vessel” means any vessel propelled by machinery.
- (c) The term “sailing vessel” means any vessel under sail provided that propelling machinery, if fitted, is not being used.
- (d) The term “vessel engaged in fishing” means any vessel fishing with nets, lines, trawls or other fishing apparatus which restrict manoeuvrability, but does not include a vessel fishing with trolling lines or other fishing apparatus which do not restrict manoeuvrability.
- (e) The word “seaplane” includes any aircraft designed to manoeuvre on the water.
- (f) The term “vessel not under command” means a vessel which through some exceptional circumstance is unable to manoeuvre as required by these Rules and is therefore unable to keep out of the way of another vessel.
- (g) The term “vessel restricted in her ability to manoeuvre” means a vessel which from the nature of her work is restricted in her ability to manoeuvre as required by these Rules and is therefore unable to keep out of the way of another vessel. The term “vessels restricted in their ability to manoeuvre” shall include but not be limited to:
  - (i) a vessel engaged in laying, servicing or picking up a navigation mark, submarine cable or pipeline;
  - (ii) a vessel engaged in dredging, surveying or underwater operations;

  - (iii) a vessel engaged in replenishment or transferring persons, provisions or cargo while underway;
  - (iv) a vessel engaged in the launching or recovery of aircraft;
  - (v) a vessel engaged in mine clearance operations;
  - (vi) a vessel engaged in a towing operation such as severely restricts the towing vessel and her tow in their ability to deviate from their course.
- (h) The term “vessel constrained by her draught” means a power-driven vessel which, because of her draught in relation to the available depth and width of navigable water, is severely restricted in her ability to deviate from the course she is following.
- (i) The word “underway” means that a vessel is not at anchor, or made fast to the shore, or aground.
- (j) The words “length” and “breadth” of a vessel mean her length overall and greatest breadth.
- (k) Vessels shall be deemed to be in sight of one another only when one can be observed visually from the other.
- (l) The term “restricted visibility” means any condition in which visibility is restricted by fog, mist, falling snow, heavy rainstorms, sandstorms or any other similar causes.
- (m) The term “Wing-in-Ground (WIG) craft” means a multimodal craft which, in its main operational mode, flies in close proximity to the surface by utilizing surface-effect action.

PART B - STEERING AND SAILING RULES

Section I - Conduct of vessels in any condition of visibility

Rule 4: Application

Rules in this Section apply in any condition of visibility.

Rule 5: Look-out

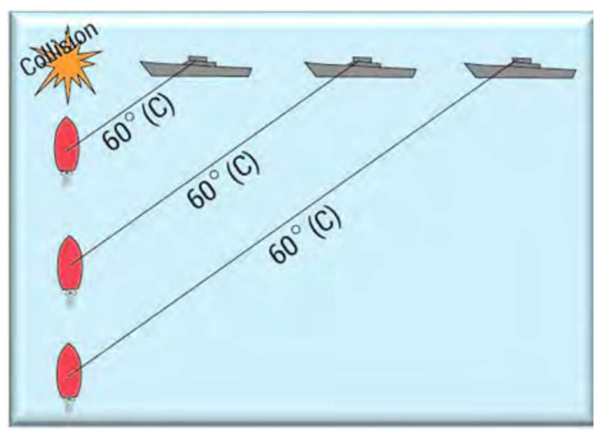
Every vessel shall at all times maintain a proper look-out by sight and hearing as well as by all available means appropriate in the prevailing circumstances and conditions so as to make a full appraisal of the situation and of the risk of collision.

Rule 6: Safe speed

Every vessel shall at all times proceed at a safe speed so that she can take proper and effective action to avoid collision and be stopped within a distance appropriate to the prevailing circumstances and conditions. In determining a safe speed the following factors shall be among those taken into account:

- (a) By all vessels:
    - (i) the state of visibility;
    - (ii) the traffic density including concentrations of fishing vessels or any other vessels;
    - (iii) the manoeuvrability of the vessel with special reference to stopping distance and turning ability in the prevailing conditions;
    - (iv) at night the presence of background light such as from shore lights or from back scatter of her own lights;
    - (v) the state of wind, sea and current, and the proximity of navigational hazards;
    - (vi) the draught in relation to the available depth of water.
- (b) Additionally, by vessels with operational radar:
    - (i) the characteristics, efficiency and limitations of the radar equipment;
    - (ii) any constraints imposed by the radar range scale in use;
    - (iii) the effect on radar detection of the sea state, weather and other sources of interference;
    - (iv) the possibility that small vessels, ice and other floating objects may not be detected by radar at an adequate range;
    - (v) the number, location and movement of vessels detected by radar;
    - (vi) the more exact assessment of the visibility that may be possible when radar is used to determine the range of vessels or other objects in the vicinity.

Rule 7: Risk of collision



- (a) Every vessel shall use all available means appropriate to the prevailing circumstances and conditions to determine if risk of collision exists. If there is any doubt such risk shall be deemed to exist.
- (b) Proper use shall be made of radar equipment if fitted and operational, including long-range scanning to obtain early warning of risk of collision and radar plotting or equivalent systematic observation of detected objects.
- (c) Assumptions shall not be made on the basis of scanty information, especially scanty radar information.
- (d) In determining if risk of collision exists the following considerations shall be among those taken into account:
    - (i) such risk shall be deemed to exist if the compass bearing of an approaching vessel does not appreciably change;

  - (ii) such risk may sometimes exist even when an appreciable bearing change is evident, particularly when approaching a very large vessel or a tow or when approaching a vessel at close range.

Rule 8: Action to avoid collision

- (a) Any action taken to avoid collision shall be taken in accordance with the Rules of this Part and shall, if the circumstances of the case admit, be positive, made in ample time and with due regard to the observance of good seamanship.
- (b) Any alteration of course and/or speed to avoid collision shall, if the circumstances of the case admit, be large enough to be readily apparent to another vessel observing visually or by radar; a succession of small alterations of course and/or speed should be avoided.
- (c) If there is sufficient sea-room, alteration of course alone may be the most effective action to avoid a close-quarters situation provided that it is made in good time, is substantial and does not result in another close-quarters situation.
- (d) Action taken to avoid collision with another vessel shall be such as to result in passing at a safe distance. The effectiveness of the action shall be carefully checked until the other vessel is finally past and clear.
- (e) If necessary, to avoid collision or allow more time to assess the situation, a vessel shall slacken her speed or take all way off by stopping or reversing her means of propulsion.
- (f)
  - (i) A vessel which, by any of these Rules, is required not to impede the passage or safe passage of another vessel shall, when required by the circumstances of the case, take early action to allow sufficient sea-room for the safe passage of the other vessel.
  - (ii) A vessel required not to impede the passage or safe passage of another vessel is not relieved of this obligation if approaching the other vessel so as to involve risk of collision and shall, when taking action, have full regard to the action which may be required by the Rules of this Part.
  - (iii) A vessel the passage of which is not to be impeded remains fully obliged to comply with the Rules of this Part when the two vessels are approaching one another so as to involve risk of collision.

Rule 9: Narrow channels

- (a) A vessel proceeding along the course of a narrow channel or fairway shall keep as near to the outer limit of the channel or fairway which lies on her starboard side as is safe and practicable.
- (b) A vessel of less than 20 metres in length or a sailing vessel shall not impede the passage of a vessel which can safely navigate only within a narrow channel or fairway.

- (c) A vessel engaged in fishing shall not impede the passage of any other vessel navigating within a narrow channel or fairway.
- (d) A vessel shall not cross a narrow channel or fairway if such crossing impedes the passage of a vessel which can safely navigate only within such channel or fairway. The latter vessel may use the sound signal prescribed in Rule 34(d) if in doubt as to the intention of the crossing vessel.
- (e)
    - (i) In a narrow channel or fairway when overtaking can take place only if the vessel to be overtaken has to take action to permit safe passing, the vessel intending to overtake shall indicate her intention by sounding the appropriate signal prescribed in Rule 34(c)(i). The vessel to be overtaken shall, if in agreement, sound the appropriate signal prescribed in Rule 34(c)(ii) and take steps to permit safe passing. If in doubt she may sound the signals prescribed in Rule 34(d).
    - (ii) This Rule does not relieve the overtaking vessel of her obligation under Rule 13.
- (f) A vessel nearing a bend or an area of a narrow channel or fairway where other vessels may be obscured by an intervening obstruction shall navigate with particular alertness and caution and shall sound the appropriate signal prescribed in Rule 34(e).
- (g) Any vessel shall, if the circumstances of the case admit, avoid anchoring in a narrow channel.

Rule 10: Traffic separation schemes

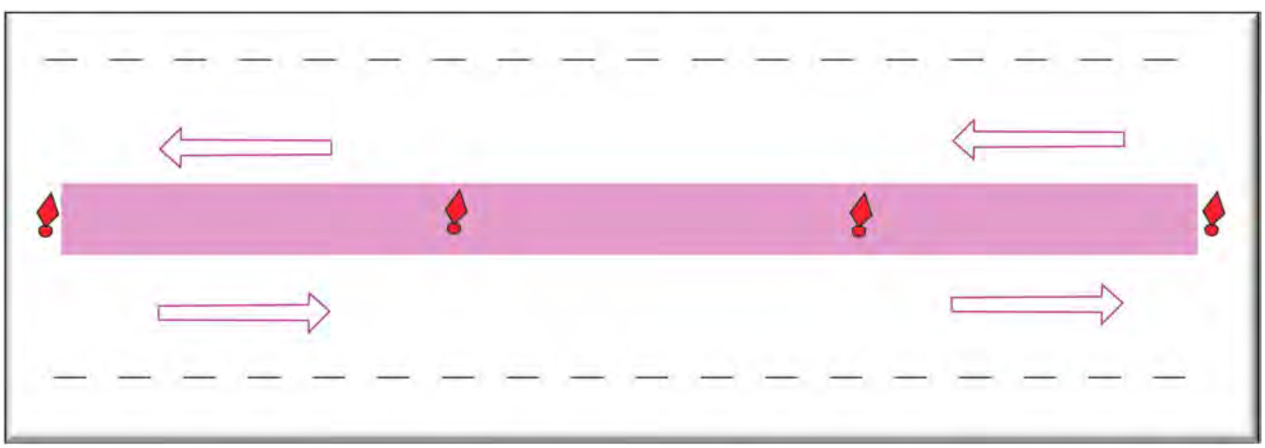


FIGURE 8 TRAFFIC SEPARATION SCHEME. THE ARROWS SHOWS THE DIRECTION OF TRAVEL. THE SEPARATION ZONE IS NOT ALWAYS MARKED WITH BUOYS AS IS SHOWN N THIS EXAMPLE

- (a) This Rule applies to traffic separation schemes adopted by the Organization and does not relieve any vessel of her obligation under any other Rule.
- (b) A vessel using a traffic separation scheme shall:
    - (i) proceed in the appropriate traffic lane in the general direction of traffic flow for that lane.

  - (ii) so far as practicable keep clear of a traffic separation line or separation zone.
  - (iii) normally join or leave a traffic lane at the termination of the lane, but when joining or leaving from either side shall do so at as small an angle to the general direction of traffic flow as practicable.
- (c) A vessel shall, so far as practicable, avoid crossing traffic lanes but if obliged to do so shall cross on a heading as nearly as practicable at right angles to the general direction of traffic flow.
- (d)
  - (i) A vessel shall not use an inshore traffic zone when she can safely use the appropriate traffic lane within the adjacent traffic separation scheme. However, vessels of less than 20 metres in length, sailing vessels and vessels engaged in fishing may use the inshore traffic zone.
  - (ii) Notwithstanding sub-paragraph (d) (i), a vessel may use an inshore traffic zone when en route to or from a port, offshore installation or structure, pilot station or any other place situated within the inshore traffic zone, or to avoid immediate danger.
- (e) A vessel other than a crossing vessel or a vessel joining or leaving a lane shall not normally enter a separation zone or cross a separation line except:
  - (i) in cases of emergency to avoid immediate danger.
  - (ii) to engage in fishing within a separation zone.
- (f) A vessel navigating in areas near the terminations of traffic separation schemes shall do so with particular caution.
- (g) A vessel shall so far as practicable avoid anchoring in a traffic separation scheme or in areas near its terminations.
- (h) A vessel not using a traffic separation scheme shall avoid it by as wide a margin as is practicable.
- (i) A vessel engaged in fishing shall not impede the passage of any vessel following a traffic lane.
- (j) A vessel of less than 20 metres in length or a sailing vessel shall not impede the safe passage of a power-driven vessel following a traffic lane.
- (k) A vessel restricted in her ability to manoeuvre when engaged in an operation for the maintenance of safety of navigation in a traffic separation scheme is exempted from complying with this Rule to the extent necessary to carry out the operation.
- (l) A vessel restricted in her ability to manoeuvre when engaged in an operation for the laying, servicing or picking up of a submarine cable, within a traffic separation scheme, is exempted from complying with this Rule to the extent necessary to carry out the operation.

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.

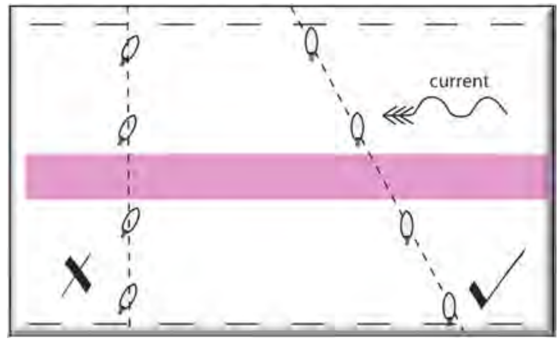


FIGURE 9 CROSS A TSS ON A HEADING OF 90°

Section II - Conduct of vessels in sight of one another

Rule 11: Application

Rules in this Section apply to vessels in sight of one another.

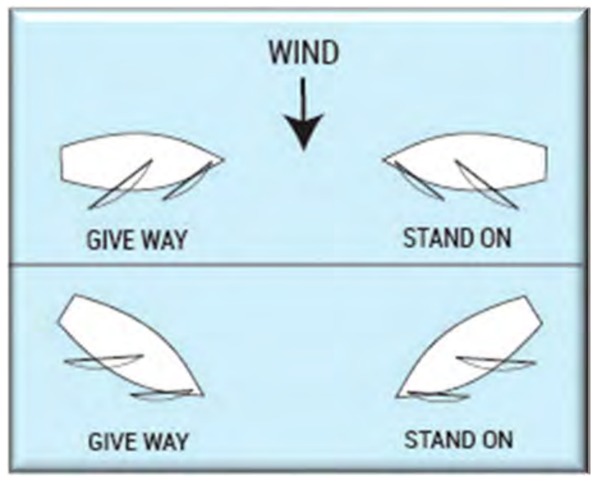


FIGURE 10
PORT TACK GIVES WAY, STARBOARD TACK STANDS ON

Rule 12: Sailing Vessels

- (a) When two sailing vessels are approaching one another, so as to involve risk of collision, one of them shall keep out of the way of the other as follows:
  - (i) when each has the wind on a different side, the vessel which has the wind on the port side shall keep out of the way of the other;
  - (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;
  - (iii) if a vessel with the wind on the port side sees a vessel to windward and cannot determine with certainty

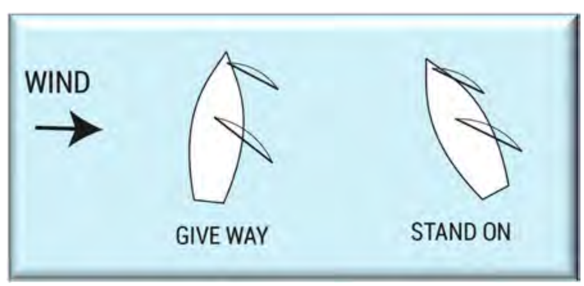


FIGURE 11 - SAME TACK: WINDWARD BOAT GIVES WAY

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.

- (b) For the purposes of this Rule the windward side shall be deemed to be the side opposite to that on which the mainsail is carried or, in the case of a square-rigged vessel, the side opposite to that on which the largest fore-and-aft sail is carried.

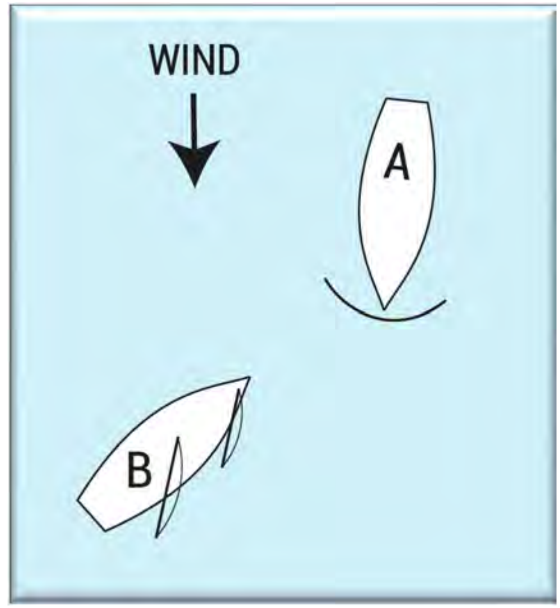


FIGURE 12 - IF IN DOUBT PORT TACK, B, GIVES WAY

Rule 13: Overtaking

- (a) Notwithstanding anything contained in the Rules of Part B, Sections I and II, any vessel overtaking any other shall keep out of the way of the vessel being overtaken.
- (b) A vessel shall be deemed to be overtaking when coming up with another vessel from a direction more than 22.5 degrees abaft her beam, that is, in such a position with reference to the vessel she is overtaking, that at night she would be able to see only the stern light of that vessel but neither of her sidelights.
- (c) When a vessel is in any doubt as to whether she is overtaking another, she shall assume that this is the case and act accordingly.
- (d) Any subsequent alteration of the bearing between the two vessels shall not make the overtaking vessel a crossing vessel within the meaning of these Rules or relieve her of the duty of keeping clear of the overtaken vessel until she is finally past and clear.

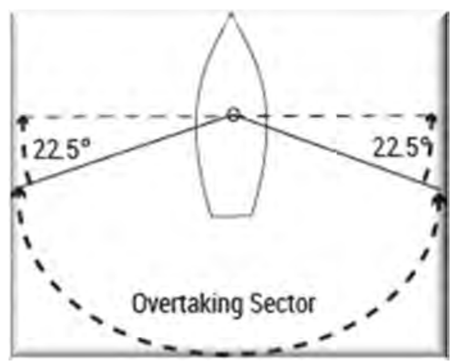


FIGURE 13 – OVERTAKING SECTOR

Rule 14: Head-on situation

- (a) When two power-driven vessels are meeting on reciprocal or nearly reciprocal courses so as to involve risk of collision each shall alter her course to starboard so that each shall pass on the port side of the other.

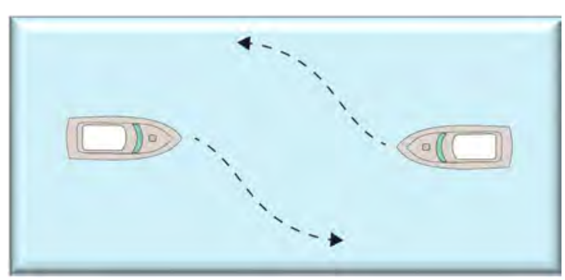


FIGURE 14 - POWER VESSELS MEETING HEAD ON - BOTH TUN TO STARBOARD

- (b) Such a situation shall be deemed to exist when a vessel sees the other ahead or nearly ahead and by night she would see the mast head lights of the other in a line or nearly in a line and or both sidelights and by day she observes the corresponding aspect of the other vessel.
- (c) When a vessel is in any doubt as to whether such a situation exists, she shall assume that it does exist and act accordingly.

Rule 15: Crossing situation

When two power-driven vessels are crossing so as to involve risk of collision, the vessel which has the other on her own starboard side shall keep out of the way and shall, if the circumstances of the case admit, avoid crossing ahead of the other vessel.

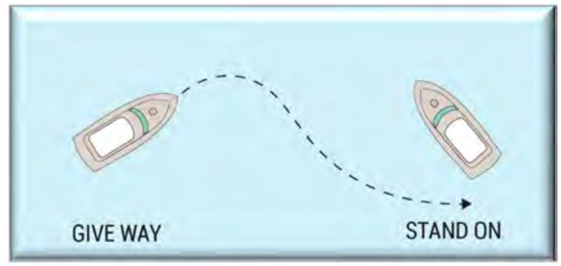


FIGURE 15 - POWER VESSELS CROSSING OR CONVERGING: GIVE WAY TO VESSEL ON YOUR STARBOARD SIDE, STAND ON FOR VESSEL ON YOUR PORT SIDE.

Rule 16: Action by give-way vessel

Every vessel which is directed to keep out of the way of another vessel shall, so far as possible, take early and substantial action to keep well clear.

Rule 17: Action by stand-on vessel

- (a)
  - (i) Where one of two vessels is to keep out of the way the other shall keep her course and speed.
  - (ii) The latter 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.
- (b) 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.
- (c) A power-driven vessel which takes action in a crossing situation in accordance with sub-paragraph (a)(ii) of this Rule to avoid collision with another power-driven vessel shall, if the circumstances of the case admit, not alter course to port for a vessel on her own port side.
- (d) This Rule does not relieve the give-way vessel of her obligation to keep out of the way.

Rule 18: Responsibilities between vessels

Except where Rules 9,10 and 13 otherwise require:

- (a) A power-driven vessel underway shall keep out of the way of:
  - (i) a vessel not under command;
  - (ii) a vessel restricted in her ability to manoeuvre;
  - (iii) a vessel engaged in fishing;
  - (iv) a sailing vessel.
- (b) A sailing vessel underway shall keep out of the way of:
  - (i) a vessel not under command;
  - (ii) a vessel restricted in her ability to manoeuvre;
  - (iii) a vessel engaged in fishing.
- (c) A vessel engaged in fishing when underway shall, so far as possible, keep out of the way of:
  - (i) a vessel not under command;
  - (ii) a vessel restricted in her ability to manoeuvre.
- (d)
  - (i) 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 draught, exhibiting the signals in Rule 28.
  - (ii) A vessel constrained by her draught shall navigate with particular caution having full regard to her special condition.
- (e) A seaplane on the water shall, in general, keep well clear of all vessels and avoid impeding their navigation. In circumstances, however, where risk of collision exists, she shall comply with the Rules of this Part.
- (f)
  - (i) A WIG craft shall, when taking off, landing and in flight near the surface, keep well clear of all other vessels and avoid impeding their navigation;
  - (ii) A WIG craft operating on the water surface shall comply with the Rules of this Part as a power-driven vessel.

Section III - Conduct of vessels in restricted visibility

Rule 19: Conduct of vessels in restricted visibility

- (a) This Rule applies to vessels not in sight of one another when navigating in or near an area of restricted visibility.
- (b) Every vessel shall proceed at a safe speed adapted to the prevailing circumstances and conditions of restricted visibility. A power-driven vessel shall have her engines ready for immediate manoeuvre.

- (c) Every vessel shall have due regard to the prevailing circumstances and conditions of restricted visibility when complying with the Rules of Section I of this Part.
- (d) A vessel which detects by radar alone the presence of another vessel shall determine if a close-quarters situation is developing and/or risk of collision exists. If so, she shall take avoiding action in ample time, provided that when such action consists of an alteration of course, so far as possible, the following shall be avoided:
    - (i) an alteration of course to port for a vessel forward of the beam, other than for a vessel being overtaken;
    - (ii) an alteration of course towards a vessel abeam or abaft the beam.
- (e) Except where it has been determined that a risk of collision does not exist, every vessel which hears apparently forward of her beam the fog signal of another vessel, or which cannot avoid a close-quarters situation with another vessel forward of her beam, shall reduce her speed to the minimum at which she can be kept on her course. She shall if necessary, take all her way off and in any event navigate with extreme caution until danger of collision is over.

PART C - LIGHTS AND SHAPES

Rule 20: Application

- (a) Rules in this Part shall be complied with in all weathers.
- (b) The Rules concerning lights shall be complied with from sunset to sunrise and during such times no other lights shall be exhibited, except such lights as cannot be mistaken for the lights specified in these Rules or do not impair their visibility or distinctive character, or interfere with the keeping of a proper look-out.
- (c) The lights prescribed by these Rules shall, if carried, also be exhibited from sunrise to sunset in restricted visibility and may be exhibited in all other circumstances when it is deemed necessary.
- (d) The Rules concerning shapes shall be complied with by day.
- (e) The lights and shapes specified in these Rules shall comply with the provisions of Annex I to these Regulations.

Rule 21: Definitions

- (a) “Masthead light” means a white light placed over the fore and aft centreline of the vessel showing an unbroken light over an arc of the horizon of 225 degrees and so fixed as to show the light from right ahead to 22.5 degrees abaft the beam on either side of the vessel.
- (b) “Sidelights” means a green light on the starboard side and a red light on the port side each showing an unbroken light over an arc of the horizon of 112.5 degrees and so fixed as to show the light from the right ahead to 22.5 degrees abaft the beam on its respective side. In a vessel of less than 20 metres in length the sidelights may be combined in one lantern carried on the fore and aft centreline of the vessel.

- (c) “Sternlight” means a white light placed as nearly as practicable at the stern showing an unbroken light over an arc of the horizon of 135 degrees and so fixed as to show the light 67.5 degrees from right aft on each side of the vessel.
- (d) “Towing light” means a yellow light having the same characteristics as the “sternlight” defined in paragraph (c) of this Rule.
- (e) “All-round light” means a light showing an unbroken light over an arc of the horizon of 360 degrees.
- (f) “Flashing light” means a light flashing at regular intervals at a frequency of 120 flashes or more per minute.

Rule 22: Visibility of lights

The lights prescribed in these Rules shall have an intensity as specified in Section 8 of Annex I to these Regulations so as to be visible at the following minimum ranges:

- (a) In vessels of 50 metres or more in length:
    - a masthead light, 6 miles;
    - a sidelight, 3 miles;
    - a stern light, 3 miles;
    - a towing light, 3 miles;
    - a white, red, green or yellow all-round light, 3 miles.
- (b) In vessels of 12 metres or more in length but less than 50 metres in length:
    - a masthead light, 5 miles; except that where the length of the vessel is less than 20 metres, 3 miles;
    - a sidelight, 2 miles;
    - a sternlight, 2 miles;
    - a towing light, 2 miles;
    - a white, red, green or yellow all-round light, 2 miles.
- (c) In vessels of less than 12 metres in length:
    - a masthead light, 2 miles;
    - a sidelight, 1 mile;
    - a sternlight, 2 miles;
    - a towing light, 2 miles
    - a white, red, green or yellow all-round light, 2 miles.
- (d) In inconspicuous, partly submerged vessels or objects being towed:
    - a white all-round light, 3 miles.

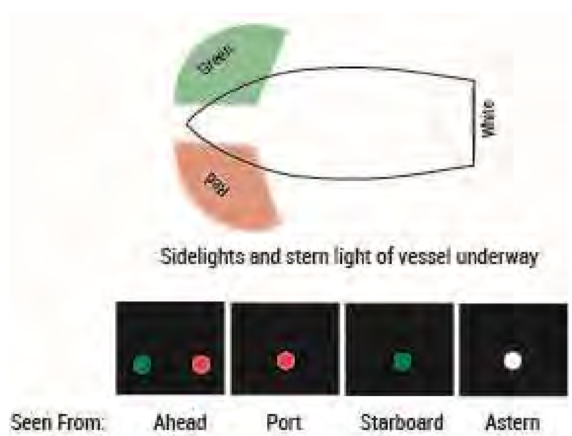


FIGURE 16

Rule 23: Power-driven vessels underway

- (a) A power-driven vessel underway shall exhibit:
  - (i) a masthead light forward;
  - (ii) a second masthead light abaft of and higher than the forward one; except that a vessel of less than 50 metres in length shall not be obliged to exhibit such light but may do so;
  - (iii) sidelights;
  - (iv) a sternlight.

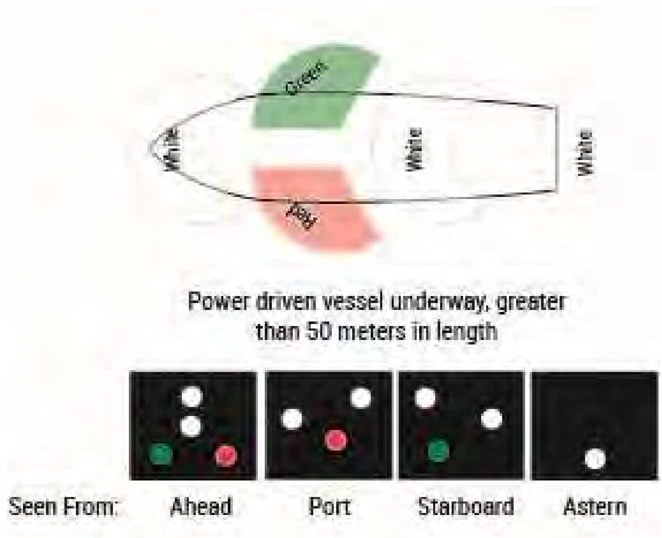


FIGURE 18

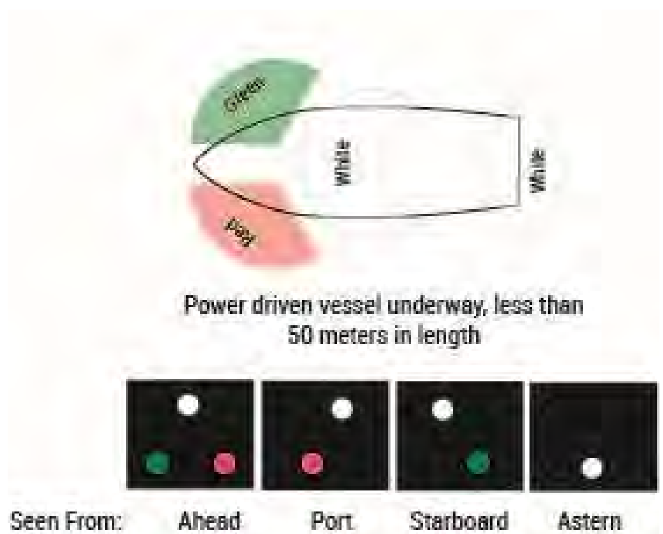


FIGURE 17

(b) An air-cushion vessel when operating in the non-displacement mode shall, in addition to the lights prescribed in paragraph (a) of this Rule, exhibit an all-round flashing yellow light.

- (c) A WIG craft only when taking off, landing and in flight near the surface shall, in addition to the lights prescribed in paragraph (a) of this Rule, exhibit a high intensity all-round flashing red light.
- (d)
    - (i) A power-driven vessel of less than 12 metres in length may in lieu of the lights prescribed in paragraph (a) of this Rule exhibit an all-round white light and sidelights;
    - (ii) a power-driven vessel of less than 7 metres in length whose maximum speed does not exceed 7 knots may in lieu of the lights prescribed in paragraph (a) of this Rule exhibit an all-round white light and shall, if practicable, also exhibit sidelights;
    - (iii) the masthead light or all-round white light on a power-driven vessel of less than 12 metres in length may be displaced from the fore and aft centre line of the vessel if centreline fitting is not practicable, provided that the sidelights are combined in one lantern which shall be carried on the fore and aft centre line of the vessel or located as nearly as practicable in the same fore and aft line as the masthead light or the all-round white light.

Rule 24: Towing and pushing

- (a) A power-driven vessel when towing shall exhibit:
    - (i) instead of the light prescribed in Rule 23(a)(i) or (a)(ii), two masthead lights in a vertical line. When the length of the tow, measuring from the stern of the towing vessel to the after end of the tow exceeds 200 metres, three such lights in a vertical line;
    - (ii) sidelights;
    - (iii) a sternlight;
    - (iv) a towing light in a vertical line above the sternlight;
    - (v) when the length of the tow exceeds 200 metres, a diamond shape where it can best be seen.
- (b) When a pushing vessel and a vessel being pushed ahead are rigidly connected in a composite unit they shall be regarded as a power-driven vessel and exhibit the lights prescribed in Rule 23.
- (c) A power-driven vessel when pushing ahead or towing alongside, except in the case of a composite unit, shall exhibit:
    - (i) instead of the light prescribed in Rule 23(a)(i) or (a)(ii), two masthead lights in a vertical line;
    - (ii) sidelights;
    - (iii) a sternlight.
- (d) A power-driven vessel to which paragraph (a) or (c) of this Rule applies shall also comply with Rule 23(a) (ii).

- (e) A vessel or object being towed, other than those mentioned in paragraph (g) of this Rule, shall exhibit:
    - (i) sidelights;
    - (ii) a sternlight;
    - (iii) when the length of the tow exceeds 200 metres, a diamond shape where it can best be seen.
- (f) Provided that any number of vessels being towed alongside or pushed in a group shall be lighted as one vessel,
    - (i) a vessel being pushed ahead, not being part of a composite unit, shall exhibit at the forward end sidelights;
    - (ii) a vessel being towed alongside shall exhibit a sternlight and at the forward end, sidelights.
- (g) An inconspicuous, partly submerged vessel or object, or combination of such vessels or objects being towed, shall exhibit:
    - (i) if it is less than 25 metres in breadth, one all-round white light at or near the forward end and one at or near the after end except that dracones need not exhibit a light at or near the forward end;
    - (ii) if it is 25 metres or more in breadth, two additional all-round white lights at or near the extremities of its breadth;
    - (iii) if it exceeds 100 metres in length, additional all-round white lights between the lights prescribed in sub-paragraphs (i) and (ii) so that the distance between the lights shall not exceed 100 metres;
    - (iv) a diamond shape at or near the aftermost extremity of the last vessel or object being towed and if the length of the tow exceeds 200 metres an additional diamond shape where it can best be seen and located as far forward as is practicable.
- (h) Where from any sufficient cause it is impracticable for a vessel or object being towed to exhibit the lights or shapes prescribed in paragraph (e) or (g) of this Rule, all possible measures shall be taken to light the vessel or object towed or at least to indicate the presence of such vessel or object.
- (i) Where from any sufficient cause it is impracticable for a vessel not normally engaged in towing operations to display the lights prescribed in paragraph (a) or (c) of this Rule, such vessel shall not be required to exhibit those lights when engaged in towing another vessel in distress or otherwise in need of assistance. All possible measures shall be taken to indicate the nature of the relationship between the towing vessel and the vessel being towed as authorized by Rule 36, in particular by illuminating the towline.

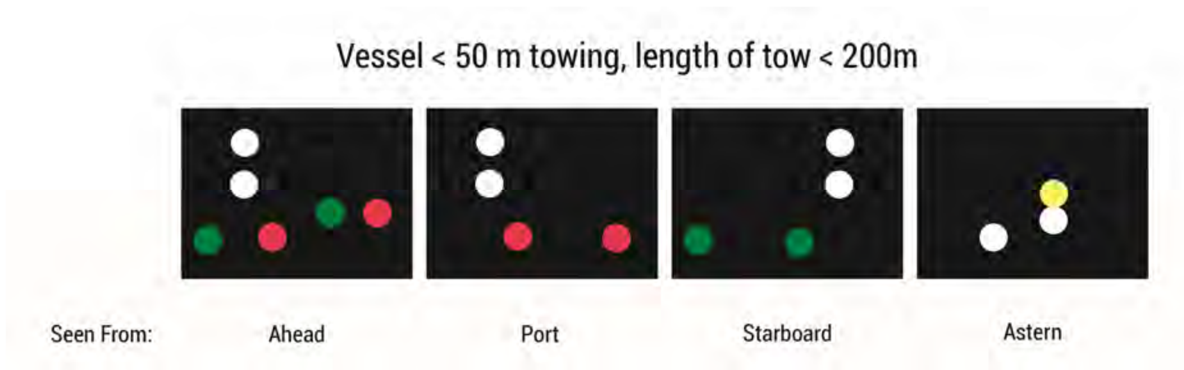


FIGURE 20

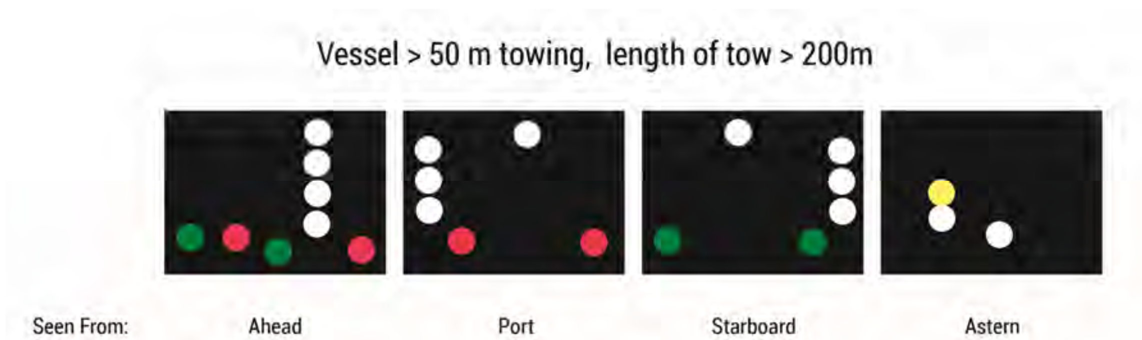


FIGURE 19

Rule 25: Sailing vessels underway and vessels under oars

- (a) A sailing vessel underway shall exhibit:
    - (i) sidelights;
    - (ii) a sternlight.
- (b) In a sailing vessel of less than 20 metres in length the lights prescribed in paragraph (a) of this Rule may be combined in one lantern carried at or near the top of the mast where it can best be seen.
- (c) A sailing vessel underway may, in addition to the lights prescribed in paragraph (a) of this Rule, exhibit at or near the top of the mast, where they can best be seen, two all-round lights in a vertical line, the upper being red and the lower green, but these lights shall not be exhibited in conjunction with the combined lantern permitted by paragraph (b) of this Rule.
- (d)
    - (i) A sailing vessel of less than 7 metres in length shall, if practicable, exhibit the lights prescribed in paragraph (a) or (b) of this Rule, but if she does not, she shall have ready at hand an electric torch or lighted lantern showing a white light which shall be exhibited in sufficient time to prevent collision.

- (ii) A vessel under oars may exhibit the lights prescribed in this Rule for sailing vessels, but if she does not, she shall have ready at hand an electric torch or lighted lantern showing a white light which shall be exhibited in sufficient time to prevent collision.

- (e) A vessel proceeding under sail when also being propelled by machinery shall exhibit forward where it can best be seen a conical shape, apex downwards.

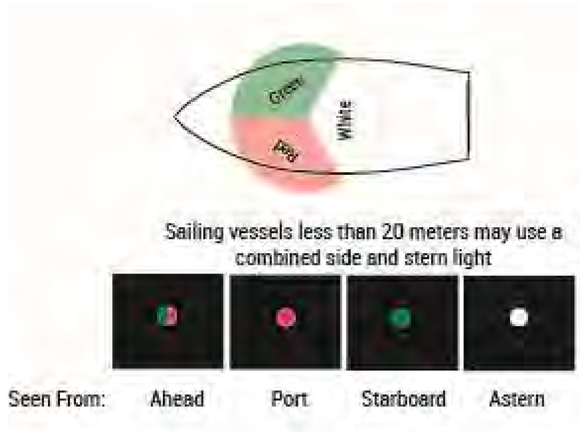


FIGURE 21

Rule 26: Fishing Vessels

- (a) A vessel engaged in fishing, whether underway or at anchor, shall exhibit only the lights and shapes prescribed in this Rule.
- (b) A vessel when engaged in trawling, by which is meant the dragging through the water of a dredge net or other apparatus used as a fishing appliance, shall exhibit:
    - (i) two all-round lights in a vertical line, the upper being green and the lower white, or a shape consisting of two cones with their apexes together in a vertical line one above the other;
    - (ii) a masthead light abaft of and higher than the all-round green light; a vessel of less than 50 metres in length shall not be obliged to exhibit such a light but may do so;
    - (iii) when making way through the water, in addition to the lights prescribed in this paragraph, sidelights and a stern light.
- (c) A vessel engaged in fishing, other than trawling, shall exhibit:
    - (i) two all-round lights in a vertical line, the upper being red and the lower white, or a shape consisting of two cones with apexes together in a vertical line one above the other;
    - (ii) when there is outlying gear extending more than 150 metres horizontally from the vessel, an all- round white light or a cone apex upwards in the direction of the gear;
    - (iii) when making way through the water, in addition to the lights prescribed in this paragraph, sidelights and a sternlight.

- (d) The additional signals described in Annex II to these Regulations apply to a vessel engaged in fishing in close proximity to other vessels engaged in fishing.
- (e) A vessel when not engaged in fishing shall not exhibit the lights or shapes prescribed in this Rule, but only those prescribed for a vessel of her length.

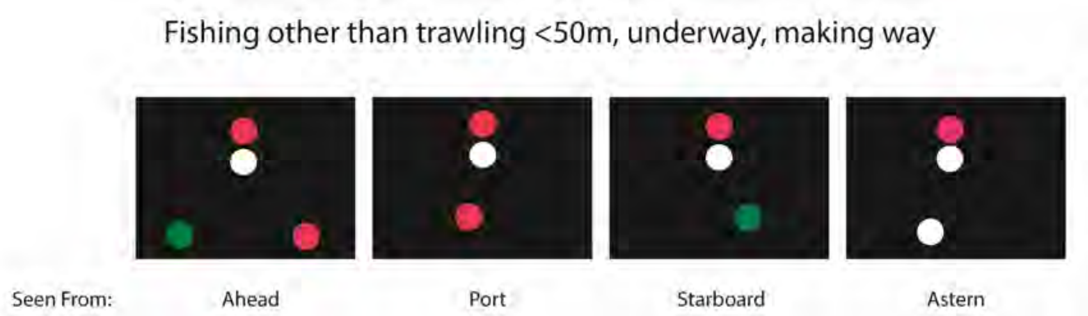


Figure 22

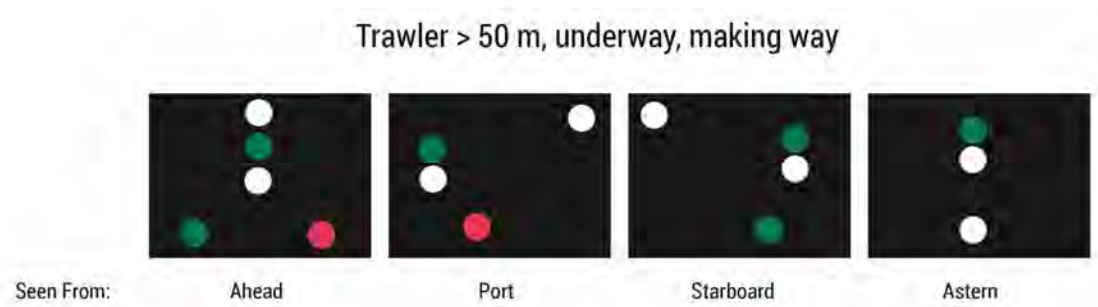


Figure 23

Rule 27: Vessels not under command or restricted in their ability to manoeuvre

- (a) A vessel not under command shall exhibit:
  - (i) two all-round red lights in a vertical line where they can best be seen;
  - (ii) two balls or similar shapes in a vertical line where they can best be seen;
  - (iii) when making way through the water, in addition to the lights prescribed in this paragraph, sidelights and a stern light.
- (b) A vessel restricted in her ability to manoeuvre, except a vessel engaged in mine-clearance operations, shall exhibit:
  - (i) three all-round lights in a vertical line where they can best be seen. The highest and lowest of these lights shall be red and the middle light shall be white;

- (ii) three shapes in a vertical line where they can best be seen. The highest and lowest of these shapes shall be balls and the middle one a diamond;
- (iii) when making way through the water, a masthead light or lights, sidelights and a sternlight, in addition to the lights prescribed in sub-paragraph (i);
- (iv) when at anchor, in addition to the lights or shapes prescribed in sub-paragraphs (i) and (ii), the light, lights or shape prescribed in Rule 30.

- (c) A power-driven vessel engaged in a towing operation such as severely restricts the towing vessel and her tow in their ability to deviate from their course shall, in addition to the lights or shapes prescribed in Rule 24(a), exhibit the lights or shapes prescribed in sub-paragraphs (b)(i) and (ii) of this Rule.
- (d) A vessel engaged in dredging or underwater operations, when restricted in her ability to manoeuvre, shall exhibit the lights and shapes prescribed in sub-paragraphs (b) (i), (ii) and (iii) of this Rule and shall in addition, when an obstruction exists, exhibit:
  - (i) two all-round red lights or two balls in a vertical line to indicate the side on which the obstruction exists;
  - (ii) two all-round green lights or two diamonds in a vertical line to indicate the side on which another vessel may pass;
  - (iii) when at anchor, the lights or shapes prescribed in this paragraph instead

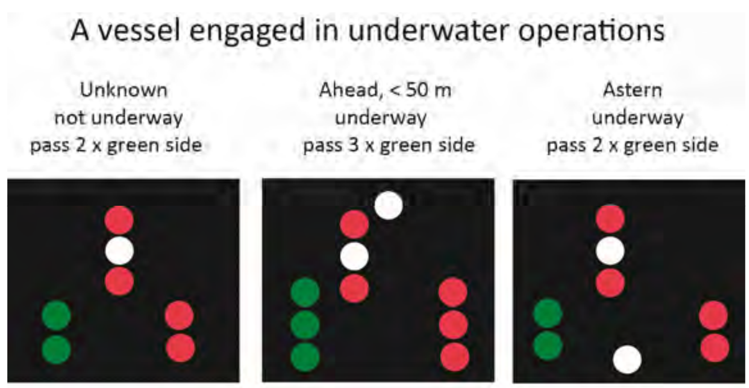


FIGURE 24

of the lights or shape prescribed in Rule 30.

- (e) Whenever the size of a vessel engaged in diving operations makes it impracticable to exhibit all lights and shapes prescribed in paragraph (d) of this Rule, the following shall be exhibited:
  - (i) three all-round lights in a vertical line where they can best be seen. The highest and lowest of these lights shall be red and the middle light shall be white;
  - (ii) a rigid replica of the International Code flag "A" not less than 1 metre in height. Measures shall be taken to ensure its all-round visibility.
- (f) A vessel engaged in mine-clearance operations shall in addition to the lights prescribed for a power-driven vessel in Rule 23 or to the lights or shape prescribed

for a vessel at anchor in Rule 30 as appropriate, exhibit three all-round green lights or three balls. One of these lights or shapes shall be exhibited near the foremast head and one at each end of the fore yard. These lights or shapes indicate that it is dangerous for another vessel to approach within 1000 metres of the mine clearance vessel.

- (g) Vessels of less than 12 metres in length, except those engaged in diving operations, shall not be required to exhibit the lights and shapes prescribed in this Rule.
- (h) The signals prescribed in this Rule are not signals of vessels in distress and requiring assistance. Such signals are contained in Annex IV to these Regulations.

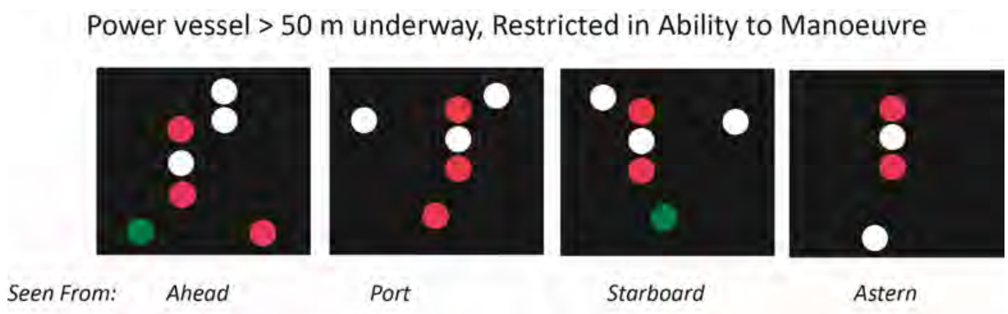


FIGURE 25

Rule 28: Vessels constrained by their draught

A vessel constrained by her draught may, in addition to the lights prescribed for power-driven vessels in Rule 23, exhibit where they can best be seen three all-round red lights in a vertical line, or a cylinder.

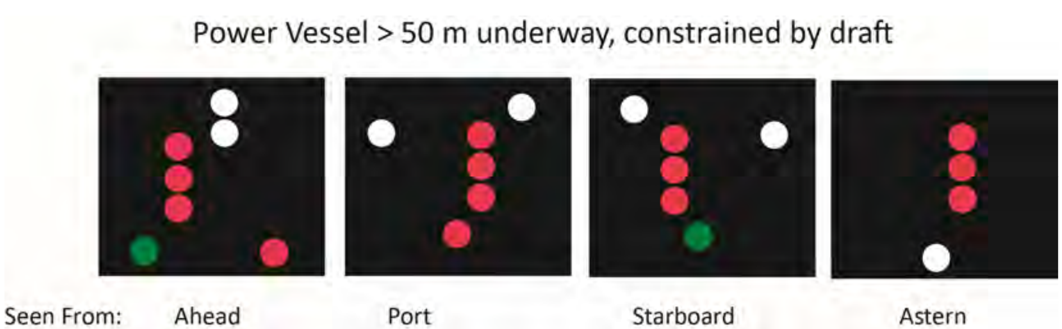


FIGURE 26

Rule 29: Pilot vessels

- (a) A vessel engaged on pilotage duty shall exhibit:
  - (i) at or near the masthead, two all-round lights in a vertical line, the upper being white and the lower red;
  - (ii) when underway, in addition, sidelights and a sternlight;

- (iii) when at anchor, in addition to the lights prescribed in sub-paragraph (i), the light, lights or shape prescribed in Rule 30 for vessels at anchor.
- (b) A pilot vessel when not engaged on pilotage duty shall exhibit the lights or shapes prescribed for a similar vessel of her length.

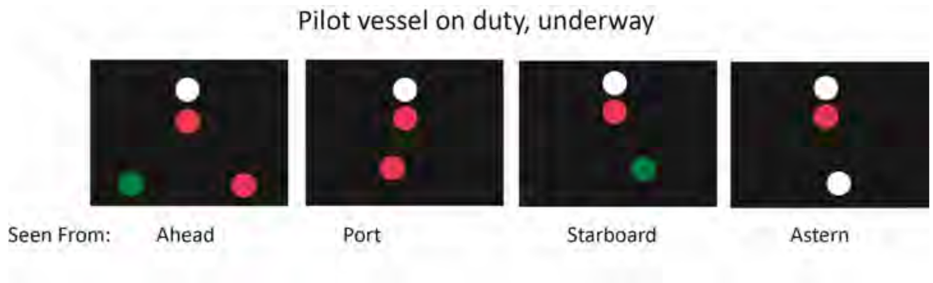


FIGURE 27

Rule 30: Anchored vessels and vessels aground

- (a) A vessel at anchor shall exhibit where it can best be seen:
  - (i) in the fore part, an all-round white light or one ball;
  - (ii) at or near the stern and at a lower level than the light prescribed in sub-paragraph (i), an all-round white light.
- (b) A vessel of less than 50 metres in length may exhibit an all-round white light where it can best be seen instead of the lights prescribed in paragraph (a) of this Rule.
- (c) A vessel at anchor may, and a vessel of 100 metres and more in length shall, also use the available working or equivalent lights to illuminate her decks.
- (d) A vessel aground shall exhibit the lights prescribed in paragraph (a) or (b) of this Rule and in addition, where they can best be seen:
  - (i) two all-round red lights in a vertical line;
  - (ii) three balls in a vertical line.
- (e) A vessel of less than 7 metres in length, when at anchor, not in or near a narrow channel, fairway or anchorage, or where other vessels normally navigate, shall not be required to exhibit the lights or shape prescribed in paragraphs (a) and (b) of this Rule.

- (f) A vessel of less than 12 metres in length, when aground, shall not be required to exhibit the lights or shapes prescribed in sub-paragraphs (d) (i) and (ii) of this Rule.

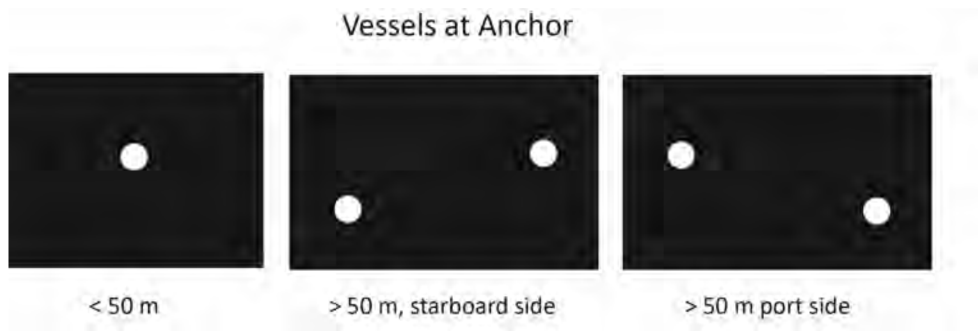


FIGURE 30

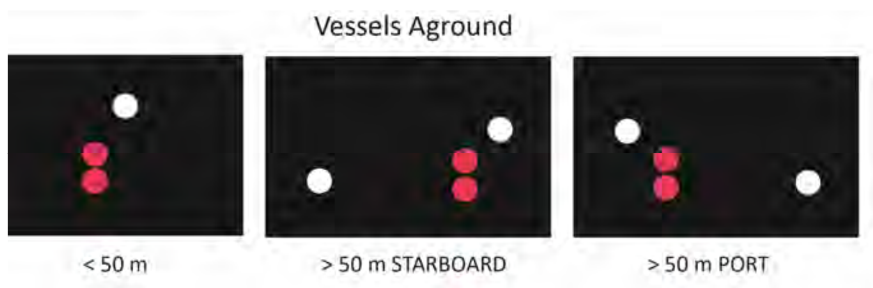


FIGURE 29

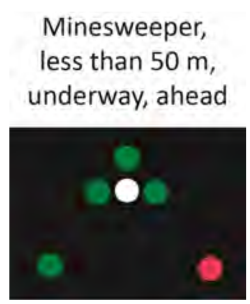


FIGURE 28

Rule 31: Seaplanes

Where it is impracticable for a seaplane or a WIG craft to exhibit lights and shapes of the characteristics or in the positions prescribed in the Rules of this Part, she shall exhibit lights and shapes as closely similar in characteristics and position as is possible.

PART D - SOUND AND LIGHT SIGNALS

Rule 32: Definitions

- (a) The word "whistle" means any sound signalling appliance capable of producing the prescribed blasts and which complies with the specifications in Annex III to these Regulations.
- (b) The term "short blast" means a blast of about one second's duration.
- (c) The term "prolonged blast" means a blast of from four to six seconds' duration.

Rule 33: Equipment for sound signals

- (a) A vessel of 12 metres or more in length shall be provided with a whistle, a vessel of 20 metres or more in length shall be provided with a bell in addition to a whistle, and a vessel of 100 metres or more in length shall, in addition, be provided with a gong, the tone and sound of which cannot be confused with that of the bell. The whistle, bell and gong shall comply with the specifications in Annex III to these Regulations. The bell or gong or both may be replaced by other equipment having the same respective sound characteristics, provided that manual sounding of the prescribed signals shall always be possible.
- (b) A vessel of less than 12 metres in length shall not be obliged to carry the sound signalling appliances prescribed in paragraph (a) of this Rule but if she does not, she shall be provided with some other means of making an efficient sound signal.

Rule 34: Manoeuvring and warning signals

- (a) When vessels are in sight of one another, a power-driven vessel underway, when manoeuvring as authorized or required by these Rules, shall indicate that manoeuvre by the following signals on her whistle:
  - one short blast to mean "I am altering my course to starboard";
  - two short blasts to mean "I am altering my course to port";
  - three short blasts to mean "I am operating astern propulsion".
- (b) Any vessel may supplement the whistle signals prescribed in paragraph (a) of this Rule by light signals, repeated as appropriate, whilst the manoeuvre is being carried out:
  - (i) these light signals shall have the following significance
    - one flash to mean "I am altering my course to starboard";
    - two flashes to mean "I am altering my course to port";
    - three flashes to mean "I am operating astern propulsion";
  - (ii) the duration of each flash shall be about one second, the interval between flashes shall be about one second, and the interval between successive signals shall be not less than ten seconds;

    - (iii) the light used for this signal shall, if fitted, be an all-round white light, visible at a minimum range of 5 miles, and shall comply with the provisions of Annex I to these Regulations.
- (c) When in sight of one another in a narrow channel or fairway:
    - (i) a vessel intending to overtake another shall in compliance with Rule 9(e)(i) indicate her intention by the following signals on her whistle:
        - two prolonged blasts followed by one short blast to mean "I intend to overtake you on your starboard side";
        - two prolonged blasts followed by two short blasts to mean "I intend to overtake you on your port side".
    - (ii) the vessel about to be overtaken when acting in accordance with Rule 9(e)(i) shall indicate her agreement by the following signal on her whistle:
        - one prolonged, one short, one prolonged and one short blast, in that order.
- (d) When vessels in sight of one another are approaching each other and from any cause either vessel fails to understand the intentions or actions of the other, or is in doubt whether sufficient action is being taken by the other to avoid collision, the vessel in doubt shall immediately indicate such doubt by giving at least five short and rapid blasts on the whistle. Such signal may be supplemented by a light signal of at least five short and rapid flashes.
- (e) A vessel nearing a bend or an area of a channel or fairway where other vessels may be obscured by an intervening obstruction shall sound one prolonged blast. Such signal shall be answered with a prolonged blast by any approaching vessel that may be within hearing around the bend or behind the intervening obstruction.
- (f) If whistles are fitted on a vessel at a distance apart of more than 100 metres, one whistle only shall be used for giving manoeuvring and warning signals.

See next page for visual diagram of signals

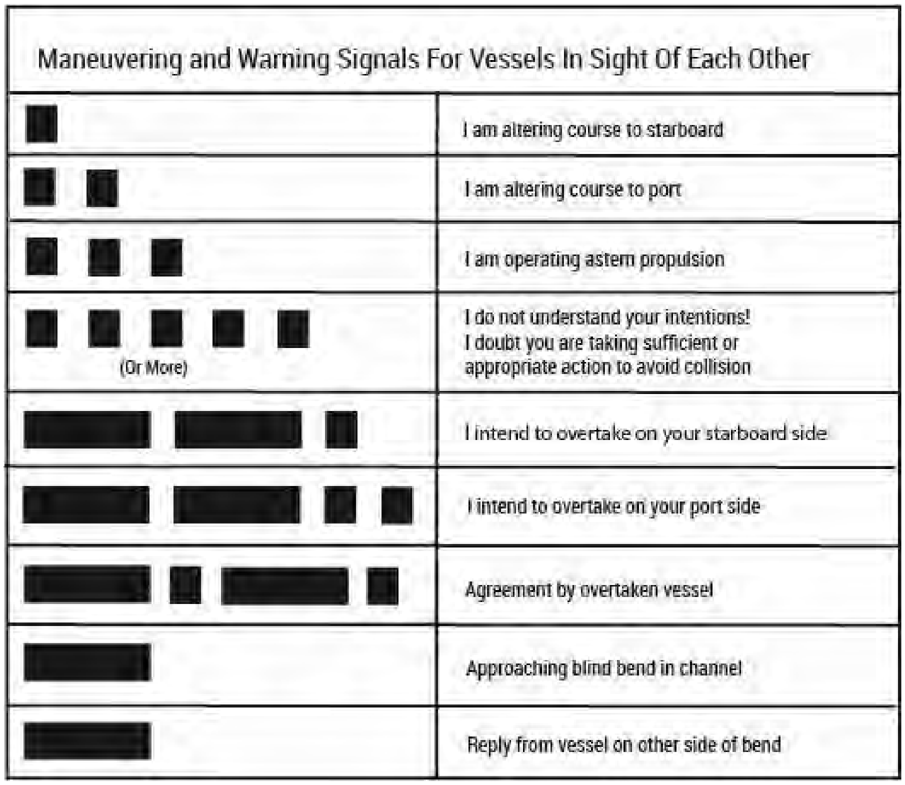


FIGURE 31

Rule 35: Sound signals in restricted visibility

In or near an area of restricted visibility, whether by day or night, the signals prescribed in this Rule shall be used as follows:

- (a) A power-driven vessel making way through the water shall sound at intervals of not more than 2 minutes one prolonged blast.
- (b) A power-driven vessel underway but stopped and making no way through the water shall sound at intervals of not more than 2 minutes two prolonged blasts in succession with an interval of about 2 seconds between them.
- (c) A vessel not under command, a vessel restricted in her ability to manoeuvre, a vessel constrained by her draught, a sailing vessel, a vessel engaged in fishing and a vessel engaged in towing or pushing another vessel shall, instead of the signals prescribed in paragraphs (a) or (b) of this Rule, sound at intervals of not more than 2 minutes three blasts in succession, namely one prolonged followed by two short blasts.
- (d) A vessel engaged in fishing, when at anchor, and a vessel restricted in her ability to manoeuvre when carrying out her work at anchor, shall instead of the signals

prescribed in paragraph (g) of this Rule sound the signal prescribed in paragraph (c) of this Rule.

- (e) A vessel towed or if more than one vessel is towed the last vessel of the tow, if manned, shall at intervals of not more than 2 minutes sound four blasts in succession, namely one prolonged followed by three short blasts. When practicable, this signal shall be made immediately after the signal made by the towing vessel.
- (f) When a pushing vessel and a vessel being pushed ahead are rigidly connected in a composite unit they shall be regarded as a power-driven vessel and shall give the signals prescribed in paragraphs (a) or (b) of this Rule.
- (g) A vessel at anchor shall at intervals of not more than one minute ring the bell rapidly for about 5 seconds. In a vessel of 100 metres or more in length the bell shall be sounded in the forepart of the vessel and immediately after the ringing of the bell the gong shall be sounded rapidly for about 5 seconds in the after part of the vessel. A vessel at anchor may in addition sound three blasts in succession, namely one short, one prolonged and one short blast, to give warning of her position and of the possibility of collision to an approaching vessel.
- (h) A vessel aground shall give the bell signal and if required the gong signal prescribed in paragraph (g) of this Rule and shall, in addition, give three separate and distinct strokes on the bell immediately before and after the rapid ringing of the bell. A vessel aground may in addition sound an appropriate whistle signal.
- (i) A vessel of 12 metres or more but less than 20 metres in length shall not be obliged to give the bell signals prescribed in paragraphs (g) and (h) of this Rule. However, if she does not, she shall make some other efficient sound signal at intervals of not more than 2 minutes.
- (j) A vessel of less than 12 metres in length shall not be obliged to give the above-mentioned signals but, if she does not, shall make some other efficient sound signal at intervals of not more than 2 minutes.
- (k) A pilot vessel when engaged on pilotage duty may in addition to the signals prescribed in paragraphs (a),(b) or (g) of this Rule sound an identity signal consisting of four short blasts.

See next page for visual diagram of signals

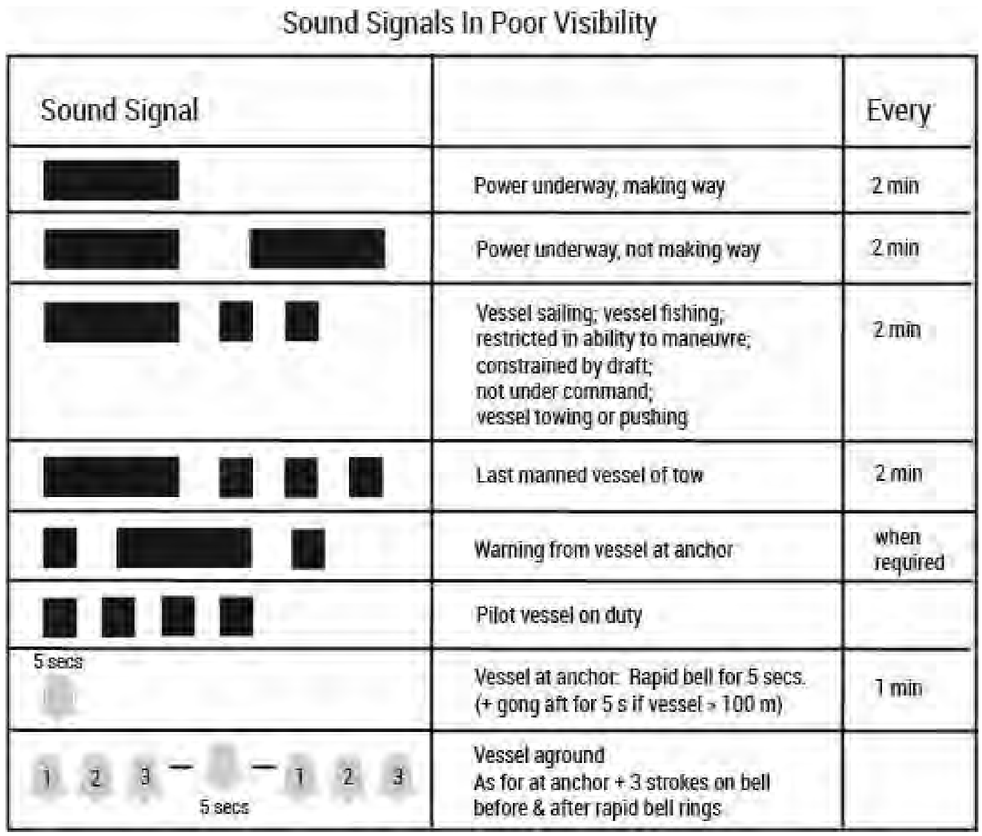


FIGURE 32

Rule 36: Signals to attract attention

If necessary to attract the attention of another vessel any vessel may make light or sound signals that cannot be mistaken for any signal authorised elsewhere in these Rules, or may direct the beam of her searchlight in the direction of the danger, in such a way as not to embarrass any vessel. Any light to attract the attention of another vessel shall be such that it cannot be mistaken for any aid to navigation. For the purpose of this Rule the use of high intensity intermittent or revolving lights, such as strobe lights, shall be avoided.

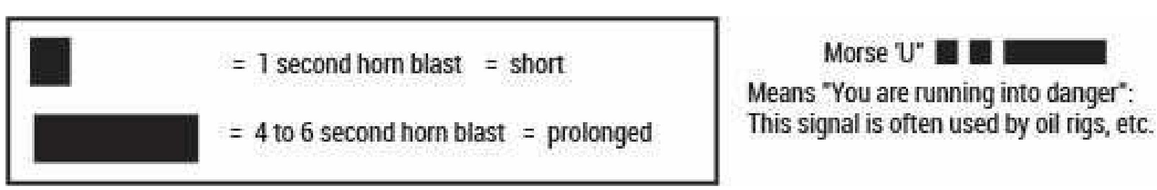


FIGURE 33

Rule 37: Distress signals

When a vessel is in distress and requires assistance, she shall use or exhibit the signals described in Annex IV to these Regulations.

PART E - EXEMPTIONS

Rule 38: Exemptions

Any vessel (or class of vessels) provided that she complies with the requirements of the International Regulations for Preventing Collisions at Sea, 1960 (a), the keel of which is laid or which is at a corresponding stage of construction before the entry into force of these Regulations may be exempted from compliance therewith as follows:

- (a) The installation of lights with ranges prescribed in Rule 22, until 4 years after the date of entry into force of these Regulations.
- (b) The installation of lights with colour specifications as prescribed in Section 7 of Annex I to these Regulations, until 4 years after the date of entry into force of these Regulations.
- (c) The repositioning of lights as a result of conversion from Imperial to metric units and rounding off measurement figures, permanent exemption.
- (d)
    - (i) The repositioning of masthead lights on vessels of less than 150 metres in length, resulting from the prescriptions of Section 3(a) of Annex I to these Regulations, permanent exemption.
    - (ii) The repositioning of masthead lights on vessels of 150 metres or more in length, resulting from the prescriptions of Section 3(a) of Annex I to these Regulations, until 9 years after the date of entry into force of these Regulations.

- (a) See Cmnd.2956 and Schedule 1 to the Collision Regulations (Ships and Seaplanes on the Water) and Signals of Distress (Ships) Order 1965 (S.I. 1965/1525)
- (e) The repositioning of masthead lights resulting from the prescriptions of Section 2(b) of Annex I to these Regulations, until 9 years after the date of entry into force of these Regulations.
- (f) The repositioning of sidelights resulting from the prescriptions of Sections 2(g) and 3(b) of Annex I to these Regulations, until 9 years after the date of entry into force of these Regulations.
- (g) The requirements for sound signal appliances prescribed in Annex III to these Regulations, until 9 years after the date of entry into force of these Regulations.
- (h) The repositioning of all-round lights resulting from the prescription of Section 9(b) of Annex I to these Regulations, permanent exemption.

ANNEX I: Positioning and technical details of lights and shapes

1. Definition

The term “height above the hull” means height above the uppermost continuous deck. This height shall be measured from the position vertically beneath the location of the light.

2. Vertical positioning and spacing of lights

- (a) On a power-driven vessel of 20 metres or more in length the masthead lights shall be placed as follows:
  - (i) the forward masthead light, or if only one masthead light is carried, then that light, at a height above the hull of not less than 6 metres, and, if the breadth of the vessel exceeds 6 metres, then at a height above the hull not less than such breadth, so however that the light need not be placed at a greater height above the hull than 12 metres;
  - (ii) when two masthead lights are carried the after one shall be at least 4.5 metres vertically higher than the forward one.
- (b) The vertical separation of masthead lights of power-driven vessels shall be such that in all normal conditions of trim the after light will be seen over and separate from the forward light at a distance of 1,000 metres from the stem when viewed from sea-level.
- (c) The masthead light of a power-driven vessel of 12 metres but less than 20 metres in length shall be placed at a height above the gunwale of not less than 2.5 metres.
- (d) A power-driven vessel of less than 12 metres in length may carry the uppermost light at a height of less than 2.5 metres above the gunwale. When however a masthead light is carried in addition to sidelights and a sternlight or the all-round light prescribed in Rule 23(c)(i) is carried in addition to sidelights, then such masthead light or all-round light shall be carried at least 1 metre higher than the sidelights.
- (e) One of the two or three masthead lights prescribed for a power-driven vessel when engaged in towing or pushing another vessel shall be placed in the same position as either the forward masthead light or the after masthead light; provided that, if carried on the aftermast, the lowest after masthead light shall be at least 4.5 metres vertically higher than the forward masthead light.
- (f)
  - (i) The masthead light or lights prescribed in Rule 23(a) shall be so placed as to be above and clear of all other lights and obstructions except as described in sub-paragraph (ii).
  - (ii) When it is impracticable to carry the all-round lights prescribed by Rule 27(b)(i) or Rule 28 below the masthead lights, they may be carried above the after masthead light(s) or vertically in between the forward masthead light(s) and the after masthead light(s) provided that in the latter case the requirement of Section 3(c) of this Annex shall be complied with.
- (g) The sidelights of a power-driven vessel shall be placed at a height above the hull not greater than three-quarters of that of the forward masthead light. They shall not be so low as to be interfered with by deck lights.
- (h) The sidelights, if in a combined lantern and carried on a power-driven vessel of less than 20 metres in length, shall be placed not less than 1 metre below the masthead light.

- (i) When the Rules prescribe two or three lights to be carried in a vertical line, they shall be spaced as follows:
  - (i) on a vessel of 20 metres in length or more such lights shall be spaced not less than 2 metres apart, and the lowest of these lights shall, except where a towing light is required, be placed at a height of not less than 4 metres above the hull;
  - (ii) on a vessel of less than 20 metres in length such lights shall be spaced not less than 1 metre apart and the lowest of these lights shall, except where a towing light is required, be placed at a height of not less than 2 metres above the gunwale;
  - (iii) when three lights are carried, they shall be equally spaced.
- (j) The lower of the two all-round lights prescribed for a vessel when engaged in fishing shall be at a height above the sidelights not less than twice the distance between the two vertical lights.
- (k) The forward anchor light prescribed in Rule 30(a)(i), when two are carried, shall not be less than 4.5 metres above the after one. On a vessel of 50 metres or more in length this forward anchor light shall be placed at a height of not less than 6 metres above the hull.

3. Horizontal positioning and spacing of lights

- (a) When two masthead lights are prescribed for a power-driven vessel, the horizontal distance between them shall not be less than one-half of the length of the vessel but need not be more than 100 metres. The forward light shall be placed not more than one-quarter of the length of the vessel from the stem.
- (b) On a power-driven vessel of 20 metres or more in length the sidelights shall not be placed in front of the forward masthead lights. They shall be placed at or near the side of the vessel.
- (c) When the lights prescribed in Rule 27(b)(i) or Rule 28 are placed vertically between the forward masthead light(s) and the after masthead light(s) these all-round lights shall be placed at a horizontal distance of not less than 2 metres from the fore and aft centreline of the vessels in the athwartship direction.
- (d) When only one masthead light is prescribed for a power-driven vessel, this light shall be exhibited forward of amidships; except that a vessel of less than 20 metres in length need not exhibit this light forward of amidships but shall exhibit it as far forward as is practicable.

4. Details of location of direction-indicating lights for fishing vessels, dredgers and vessels engaged in underwater operations

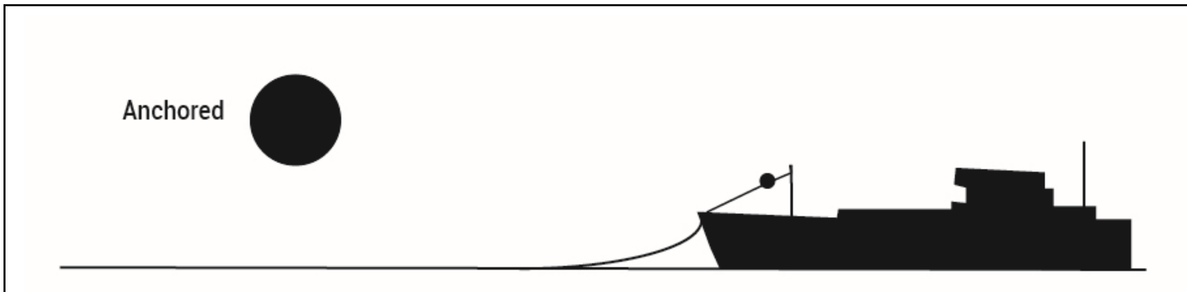
- (a) The light indicating the direction of the outlying gear from a vessel engaged in fishing as prescribed in Rule 26(c)(ii). shall be placed at a horizontal distance of not less than 2 metres and not more than 6 metres away from the two all-round red and white lights. This light shall be placed not higher than the all-round white light prescribed in Rule 26(c)(i) and not lower than the sidelights.
- (b) The lights and shapes on a vessel engaged in dredging or underwater operations to indicate the obstructed side and or the side on which it is safe to pass, as prescribed in Rule 27(d)(i) and (ii), shall be placed at the maximum practical horizontal distance, but in no case less than 2 metres, from the lights or shapes prescribed in Rule 27(b)(i) and (ii). In no case shall the upper of these lights or shapes be at a greater height than the lower of the three lights or shapes prescribed in Rule 27(b)(i) and (ii).

5. Screens for sidelights

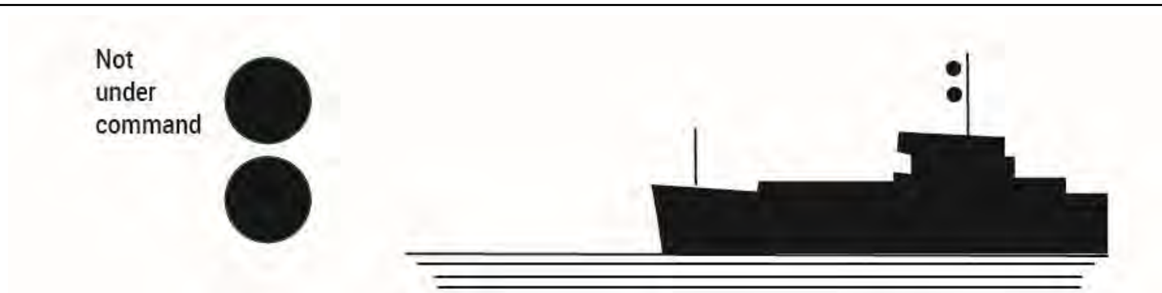
The sidelights of vessels of 20 metres or more in length shall be fitted with inboard screens painted matt black and meeting the requirements of Section 9 of this Annex. On vessels of less than 20 metres in length the sidelights, if necessary, to meet the requirements of Section 9 of this Annex, shall be fitted with inboard matt black screens. With a combined lantern, using a single vertical filament and a very narrow division between the green and red sections, external screens need not be fitted.

6. Shapes

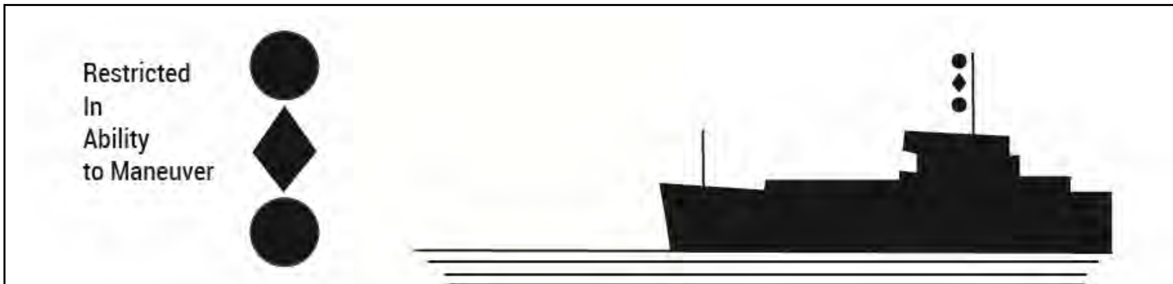
- (a) Shapes shall be black and of the following sizes:
  - (i) a ball shall have a diameter of not less than 0.6 metre;
  - (ii) a cone shall have a base diameter of not less than 0.6 metre and a height equal to its diameter;
  - (iii) a cylinder shall have a diameter of at least 0.6 metre and a height of twice its diameter
  - (iv) a diamond shape shall consist of two cones as defined in (ii) above having a common base.
- (b) The vertical distance between shapes shall be at least 1.5 metres.
- (c) In a vessel of less than 20 metres in length shapes of lesser dimensions but commensurate with the size of the vessel may be used and the distance apart may be correspondingly reduced.



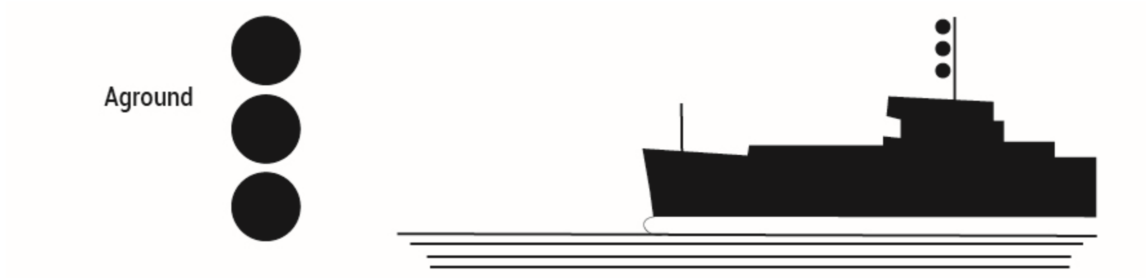
ANCHORED



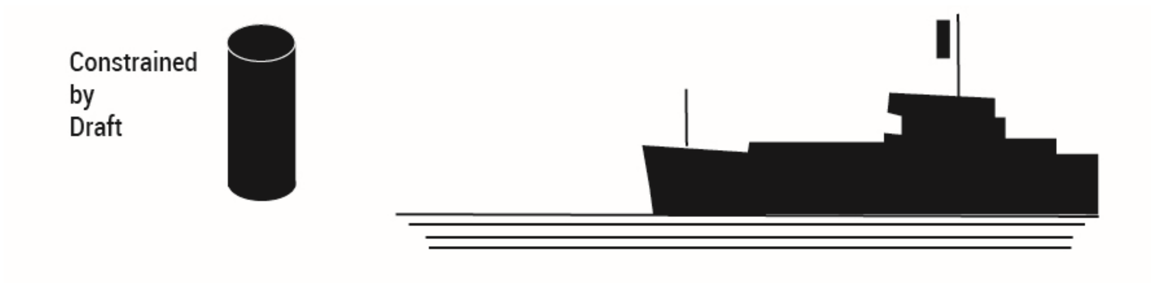
NOT UNDER COMMAND



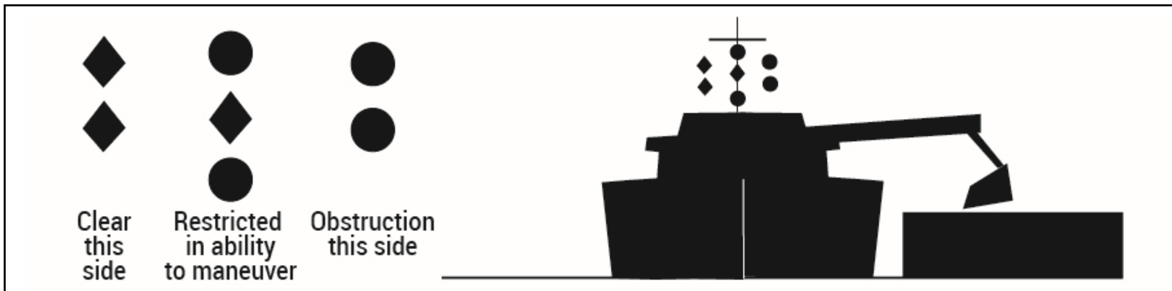
RESTRICTED IN ABILITY TO MANOEUVRE



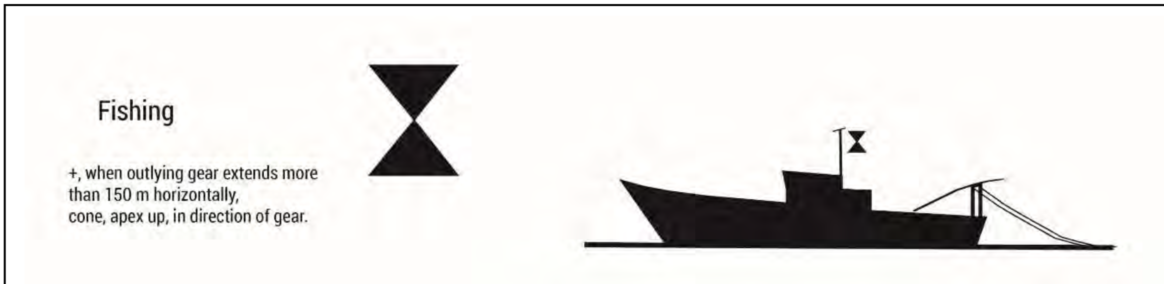
AGROUND



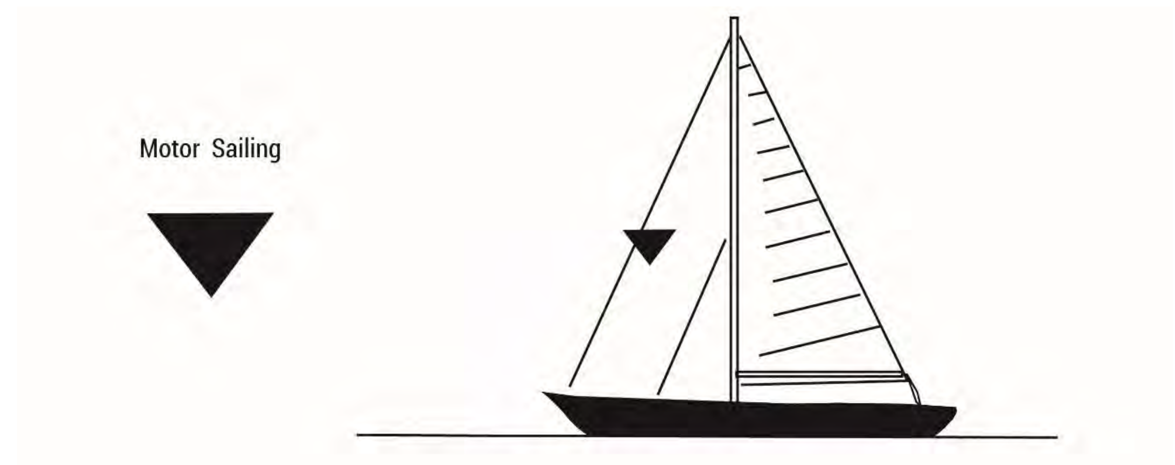
CONSTRAINED BY DRAFT



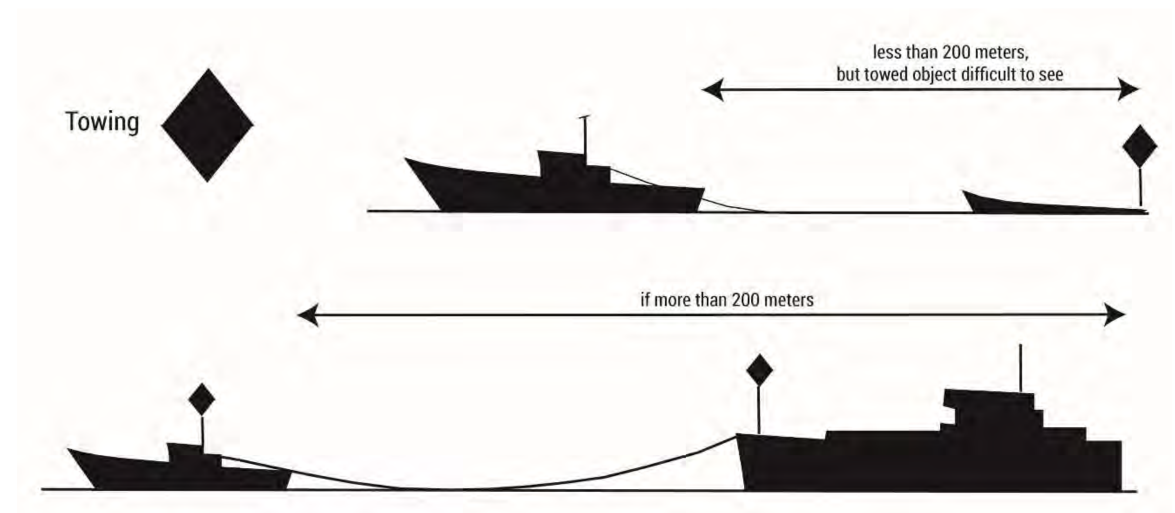
VARIOUS



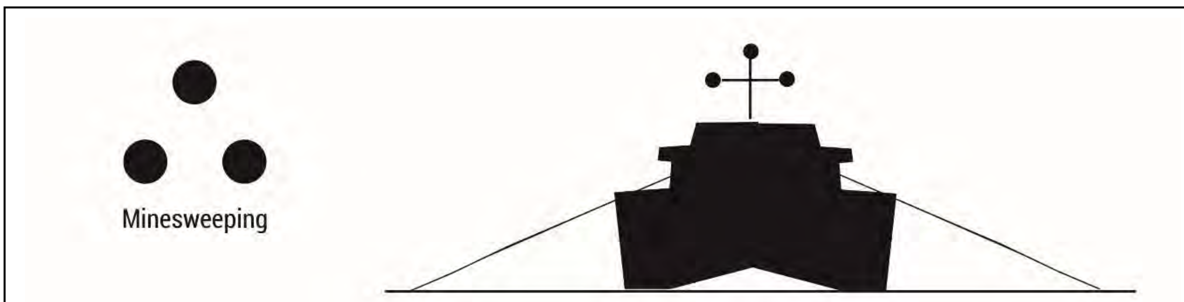
FISHING



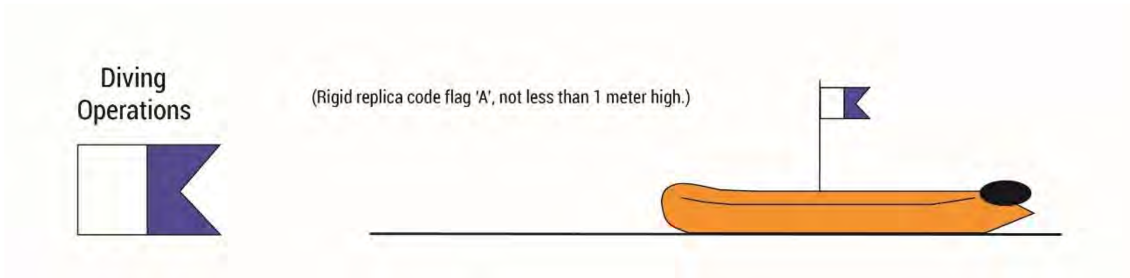
MOTOR SAILING



TOWING



MINESWEEPING



DIVING OPERATIONS

7. Colour specification of lights

The chromaticity of all navigation lights shall conform to the following standards, which lie within the boundaries of the area of the diagram specified for each colour by the International Commission on Illumination (CIE).

The boundaries of the area for each colour are given by indicating the corner co-ordinates, which are as follows:

- (i) White

x 0.525 0.525 0.452 0.310 0.310 0.443 y 0.382 0.440 0.440 0.348 0.283 0.382 29

- (ii) Green

x 0.028 0.009 0.300 0.203 y 0.385 0.723 0.511 0.356

- (iii) Red

x 0.680 0.660 0.735 0.721 y 0.320 0.320 0.265 0.259

- (iv) Yellow

x 0.612 0.618 0.575 0.575 y 0.382 0.382 0.425 0.406

8. Intensity of lights

- (a) The minimum luminous intensity of lights shall be calculated by using

I = 3.43 x 106 x T x D2 x K–D where I is luminous intensity in candelas under service conditions, T is threshold factor 2 x 10-7 lux, D is range of visibility (luminous range) of the light in nautical miles, K is atmospheric transmissivity. For prescribed lights the value of K shall be 0.8, corresponding to a meteorological visibility of approximately 13 nautical miles.

- (b) A selection of figures derived from the formula is given in the following table:

Range of visibility Luminous intensity of

- (luminous range) of light in candelas for

light in nautical K=0.8 miles D I 1 0.9 2 4.3 3 12 4 27 5 52 6 94

Note: The maximum luminous intensity of navigation lights should be limited to avoid undue glare. This shall not be achieved by a variable control of the luminous intensity.

9. Horizontal sectors

- (a)
  - (i) In the forward direction, sidelights as fitted on the vessel shall show the minimum required intensities. The intensities shall decrease to reach practical cut-off between 1 degree and 3 degrees outside the prescribed sectors.
  - (ii) For stern lights and masthead lights at 22.5 degrees abaft the beam for sidelights, the minimum required intensities shall be maintained over the arc of the horizon up to 5 degrees within the limits of the sectors prescribed in Rule 21. From 5 degrees within the prescribed sectors the intensity may decrease by 50 per cent up to the prescribed limits: it shall decrease steadily to reach practical cut-off at not more than 5 degrees outside the prescribed sectors.
- (b)
  - (i) All-round lights shall be so located as not to be obscured by masts, topmasts or structures within angular sectors of more than 6 degrees, except anchor lights prescribed in Rule 30, which need not be placed at an impracticable height above the hull.
  - (ii) If it is impracticable to comply with paragraph (b) (i) of this section by exhibiting only one all-round light, two all-round lights shall be used suitably positioned or screened so that they appear, as far as practicable, as one light at a distance of one mile.

10. Vertical sectors

- (a) The vertical sectors of electric lights as fitted, with the exception of lights on sailing vessels underway shall ensure that:
  - (i) at least the required minimum intensity is maintained at all angles from 5 degrees above to 5 degrees below the horizontal;

  - (ii) at least 60 per cent of the required minimum intensity is maintained from 7.5 degrees above to 7.5 degrees below the horizontal.
- (b) In the case of sailing vessels underway the vertical sectors of electric lights as fitted shall ensure that:
  - (i) at least the required minimum intensity is maintained at all angles from 5 degrees above to 5 degrees below the horizontal;
  - (ii) at least 50 per cent of the required minimum intensity is maintained from 25 degrees above to 25 degrees below the horizontal.
- (c) In the case of lights other than electric these specifications shall be met as closely as possible.

11. Intensity of non-electric lights

Non-electric lights shall so far as practicable comply with the minimum intensities, as specified in the table given in Section 8 of this Annex.

12. Manoeuvring light

Notwithstanding the provisions of paragraph 2(f) of this Annex the manoeuvring light described in Rule 34(b) shall be placed in the same fore and aft vertical plane as the masthead light or lights and, where practicable, at a minimum height of 2 metres vertically above the forward masthead light, provided that it shall be carried not less than 2 metres vertically above or below the after masthead light. On a vessel where only one masthead light is carried the manoeuvring light, if fitted, shall be carried where it can best be seen, not less than 2 metres vertically apart from the masthead light.

13. High Speed Craft*

- (a) The masthead light of high-speed craft may be placed at a height related to the breadth of the lower than that prescribed in paragraph 2(a)(i) of this annex, provided that the base angle of the isosceles triangles formed by the sidelights and masthead light, when seen in end elevation, is not less than 27o.
- (b) On high-speed craft of 50 metres or more in length, the vertical separation between foremast and mainmast light of 4.5 metres required by paragraph 2(a)(ii) of this annex may be modified provided that such distance shall not be less than the value determined by the following formula:

Where: y is the height of the mainmast light above the foremast light in metres; Ais the height of the foremast light above the water surface in service condition in metres; Cis the trim in service condition in degrees; Cis the horizontal separation of masthead lights in metres.

- Refer to the International Code of Safety for High-Speed Craft, 1994 and the International Code of Safety for High-Speed Craft, 2000.

14. Approval

The construction of lights and shapes and the installation of lights on board the vessel shall be to the satisfaction of the appropriate authority of the State whose flag the vessel is entitled to fly. Y= 32

ANNEX II: Additional signals for fishing vessels fishing in close proximity

1. General

The lights mentioned herein shall, if exhibited in pursuance of Rule 26(d), be placed where they can best be seen. They shall be at least 0.9 metre apart but at a lower level than lights prescribed in Rule 26(b)(i) and (c)(i). The lights shall be visible all round the horizon at a distance of at least 1 mile but at a lesser distance than the lights prescribed by these Rules for fishing vessels.

2. Signals for trawlers

- (a) Vessels of 20 metres or more in length when engaged in trawling, whether using demersal or pelagic gear, shall exhibit:
  - (i) when shooting their nets, two white lights in a vertical line;
  - (ii) when hauling their nets, one white light over one red light in a vertical line;
  - (iii) when the net has come fast upon an obstruction, two red lights in a vertical line.
- (b) Each vessel of 20 metres or more in length engaged in pair trawling shall exhibit:
  - (i) by night, a searchlight directed forward and in the direction of the other vessel of the pair;
  - (ii) when shooting or hauling their nets or when the nets have come fast upon an obstruction, the lights prescribed in 2(a) above.
- (c) A vessel of less than 20 metres in length engaged in trawling, whether using demersal or pelagic gear or engaged in pair trawling, may exhibit the lights prescribed in paragraphs
- (a) or (b) of this Section, as appropriate.

3. Signals for purse seiners

Vessels engaged in fishing with purse seine gear may exhibit two yellow lights in a vertical line. These lights shall flash alternately every second and with equal light and occultation duration. These lights may be exhibited only when the vessel is hampered by its fishing gear.

ANNEX III: Technical details of sound signal appliances

1. Whistles

- (a) Frequencies and range of audibility

The fundamental frequency of the signal shall lie within the range 70 - 700 Hz. The range of audibility of the signal from a whistle shall be determined by those frequencies, which may include the fundamental and/or one or more higher frequencies, which lie within the range 180 - 700 Hz (+/-1%) for a vessel of 20 metres or more in length, or 180-2100Hz (+/-1%) for a vessel of less than 20 metres in length and which provide the sound pressure levels specified in paragraph l(c) below.

- (b) Limits of fundamental frequencies

To ensure a wide variety of whistle characteristics, the fundamental frequency of a whistle shall be between the following limits:

-
    - (i) 70 - 200 Hz, for a vessel 200 metres or more in length;
    - (ii) 130 - 350 Hz, for a vessel 75 metres but less than 200 metres in length;
    - (iii) 250 - 700 Hz, for a vessel less than 75 metres in length.

- (c) Sound signal intensity and range of audibility

A whistle fitted in a vessel shall provide, in the direction of maximum intensity of the whistle and at a distance of 1 metre from it, a sound pressure level in at least one 1/3rd-octave band within the range of frequencies 180 - 700 Hz (+/-1%) for a vessel of 20 metres or more in length, or 180-2100Hz (+/-1%) for a vessel of less than 20 metres in length, of not less than the appropriate figure given in the table below. The range of audibility in the table above is for information and is approximately the range at which a whistle may be heard on its forward axis with 90 per cent probability in conditions of still air on board a vessel having average background noise level at the listening posts (taken to be 68 dB in the octave band centered on 250 Hz and 63 dB in the octave band centered on 500Hz. In practice the range at which a whistle may be heard is extremely variable and depends critically on weather conditions; the values given can be regarded as typical but under conditions of strong wind or high ambient noise level at the listening post the range may be much reduced.

- (d) Directional Properties

The sound pressure level of a directional whistle shall be not more than 4 dB below the prescribed sound pressure level on the axis at any direction in the horizontal plane within ±45 degrees of the axis. The sound pressure level at any other direction in the horizontal plane shall be not more than 10 dB below the prescribed sound pressure level on the axis, so that the range in any direction will be at least half the range on the forward axis. The sound pressure level shall be measured in that 1/3rd-octave band which determines the audibility range.

Length of vessel in metres 1/3rd-octave band level at Audibility range in 1 metre in dB referred to nautical miles 2x10-5N/m2 200 or more 143 2 75 but less than 200 138 1.5 20 but less than 75 130 1 120 * Less than 20 115 † 0.5 111 ‡

- When the measured frequencies lie within the range 180-450Hz

† When the measured frequencies lie within the range 450-800Hz ‡ When the measured frequencies lie within the range 800-2100Hz

- (e) Positioning of whistles

When a directional whistle is to be used as the only whistle on a vessel, it shall be installed with its maximum intensity directed straight ahead. A whistle shall be placed as high as practicable on a vessel, in order to reduce interception of the emitted sound by obstructions and also to minimize hearing damage risk to personnel. The sound pressure level of the vessel's own signal at listening posts shall not exceed 110 dB (A) and so far as practicable should not exceed 100 dB (A).

- (f) Fitting of more than one whistle

If whistles are fitted at a distance apart of more than 100 metres, it shall be so arranged that they are not sounded simultaneously.

- (g) Combined whistle systems

If due to the presence of obstructions the sound field of a single whistle or one of the whistles referred to in paragraph l(f) above is likely to have a zone of greatly reduced signal level, it is recommended that a combined whistle system be fitted so as to overcome this reduction. For the purposes of the Rules a combined whistle system is to be regarded as a single whistle. The whistles of a combined system shall be located at a distance apart of not more than 100 metres and arranged to be sounded simultaneously. The frequency of any one whistle shall differ from those of the others by at least 10 Hz.

2. Bell or gong

- (a) Intensity of signal

A bell or gong, or other device having similar sound characteristics shall produce a sound pressure level of not less than 110 dB at a distance of 1 metre from it.

- (b) Construction

Bells and gongs shall be made of corrosion-resistant material and designed to give a clear tone. The diameter of the mouth of the bell shall be not less than 300 mm for vessels of 20 metres or more in length. Where practicable, a power-driven bell striker is recommended to ensure constant force, but manual operation shall be possible. The mass of the striker shall be not less than 3 per cent of the mass of the bell.

3. Approval

The construction of sound signal appliances, their performance and their installation on board the vessel shall be to the satisfaction of the appropriate authority of the State whose flag the vessel is entitled to fly.

ANNEX IV: Distress signals

1. The following signals, used or exhibited either together or separately, indicate distress and need of assistance:

- (a) a gun or other explosive signal fired at intervals of about a minute;
- (b) a continuous sounding with any fog-signalling apparatus;
- (c) rockets or shells, throwing red stars fired one at a time at short intervals;
- (d) a signal made by radiotelegraphy or by any other signalling method consisting of the group • • • — — — • • • (SOS) in the Morse Code;
- (e) a signal sent by radiotelephony consisting of the spoken word "Mayday";
- (f) the International Code Signal of distress indicated by N.C.;
- (g) a signal consisting of a square flag having above or below it a ball anything resembling a ball;
- (h) flames on the vessel (as from a burning tar barrel, oil barrel, etc.);
- (i) a rocket parachute flare or a hand flare showing a red light;
- (j) a smoke signal giving off orange-coloured smoke;
- (k) slowly and repeatedly raising and lowering arms outstretched to each side;
- (l) a distress alert by means of digital selective calling (DSC) transmitted on
  - (i) VHF channel 70, or
  - (ii) MF/HF on the frequencies 2187.5 kHz, 8414.5 kHz, 4207.5 kHz, 6312 kHz, 12577 kHz or 16804.5 kHz;
- (m) a ship-to-shore distress alert transmitted by the ship’s Inmarsat or other mobile satellite service provider ship earth station;
- (n) signals transmitted by emergency position-indicating radio beacons;
- (o) approved signals transmitted by radiocommunication systems, including survival craft radar transponders.

2. The use or exhibition of any of the foregoing signals except for the purpose of indicating distress and need of assistance and the use of other signals which may be confused with any of the above signals is prohibited.

3. Attention is drawn to the relevant sections of the International Code of Signals, the Merchant Ship Search and Rescue Manual, Annex III and the following signals:

- (a) a piece of orange-coloured canvas with either a black square and circle or other appropriate symbol (for identification from the air);
- (b) a dye marker.

Chapter 2 METEOROLOGY

2.1 Key Objectives

THE OBJECTIVE OF THIS MODULE IS TO PROVIDE BASIC UNDERSTANDING OF ATMOSPHERIC CONDITIONS AND HOW THEY INTERACT WHICH WILL HELP IMMENSELY WHEN TRYING TO DECIDE HOW THE ACTUAL WEATHER AND SEA CONDITIONS WILL DEVELOP IN A SPECIFIC AREA.

2.2 General

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, airplanes, 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 from the point of view of safety and of enjoyment.

Today we are lucky to have easy access to many 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 sulfur 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.

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 tire is pumped up to a high pressure; if the tire is punctured the air will flow out of the tire (high pressure area) into the surrounding air (low pressure area) until the pressure in the tire and the surrounding area are the same. The higher the initial pressure in the tire 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.

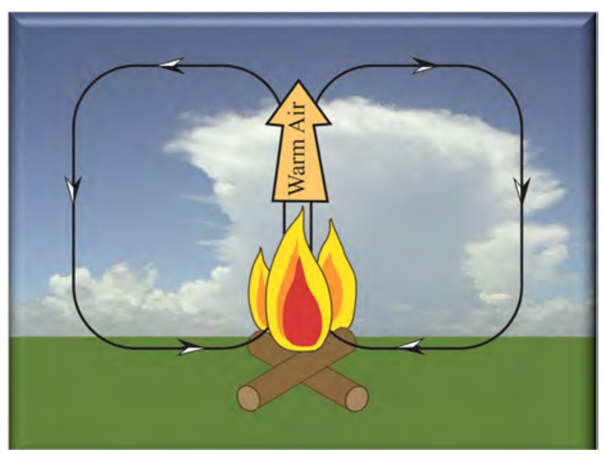
Air Circulation

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.



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.

This figure below 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 which have a great effect on the general weather patterns of the world.

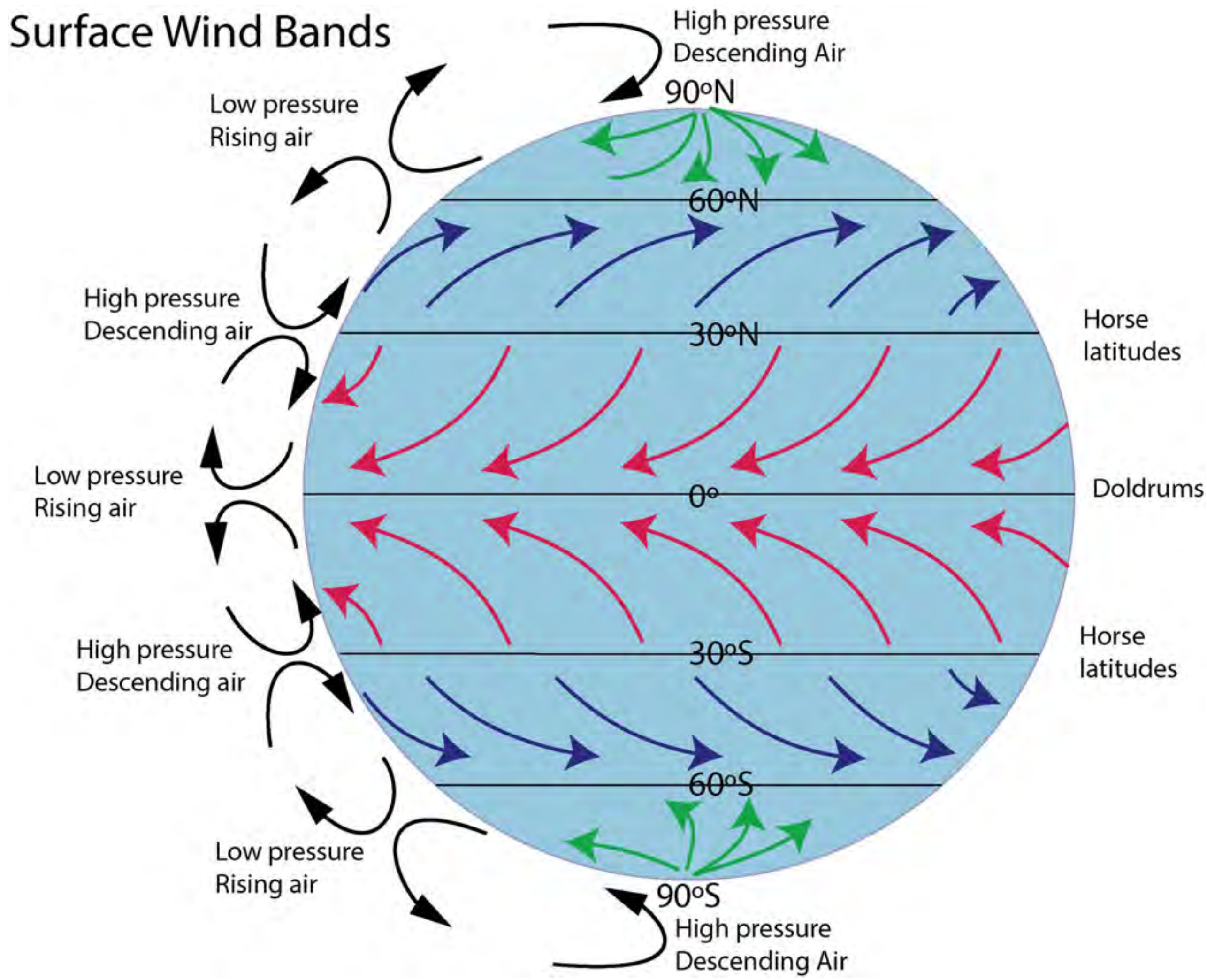


FIGURE 34 - THEORY OF THE WORLD'S AIR CIRCULATION

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 affected 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 35 - Coriolis Force – General Direction of the Trade Winds & Prevailing Winds of the World, 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.

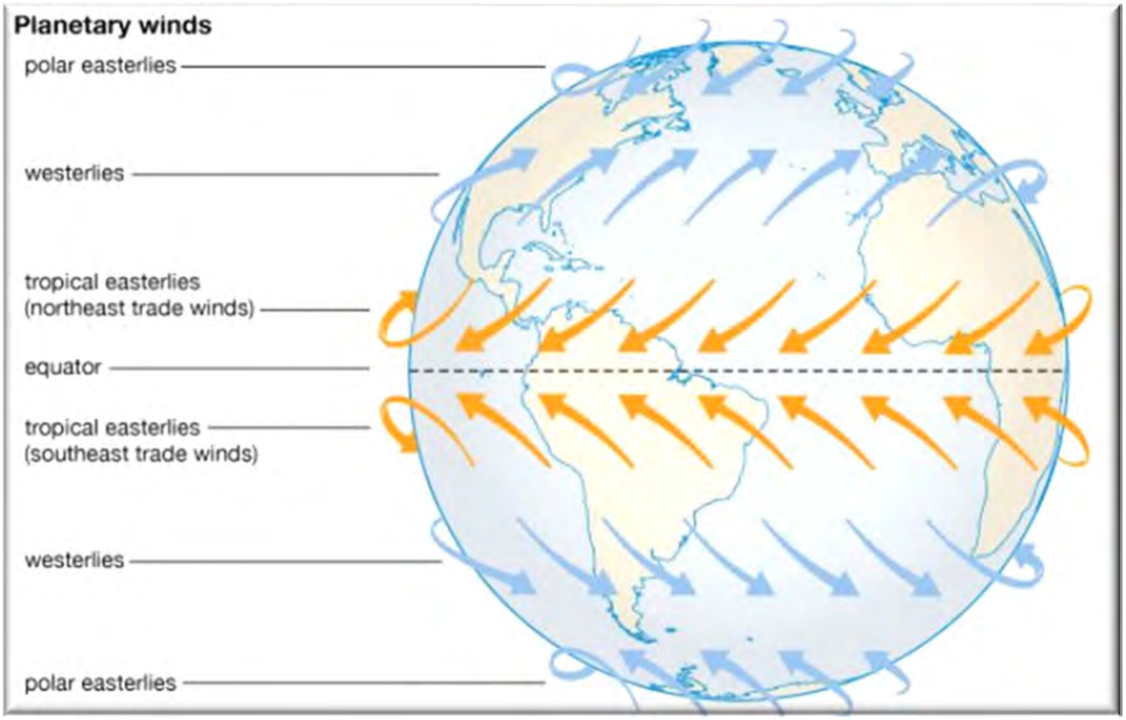


FIGURE 35 - CORIOLIS FORCE – GENERAL DIRECTION OF THE TRADE WINDS & PREVAILING WINDS OF THE WORLD

The wind blowing from the high pressure belt at 30N° 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 30N° 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.

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.

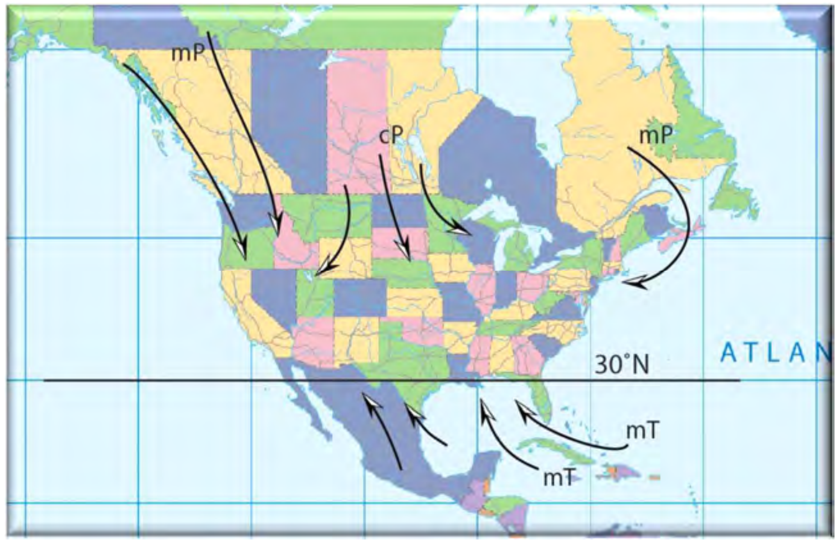
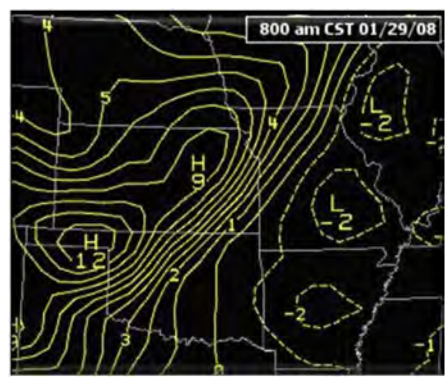


FIGURE 36 - THE DIFFERENT AIR MASSES THAT EFFECT THE US IN SUMMER

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.



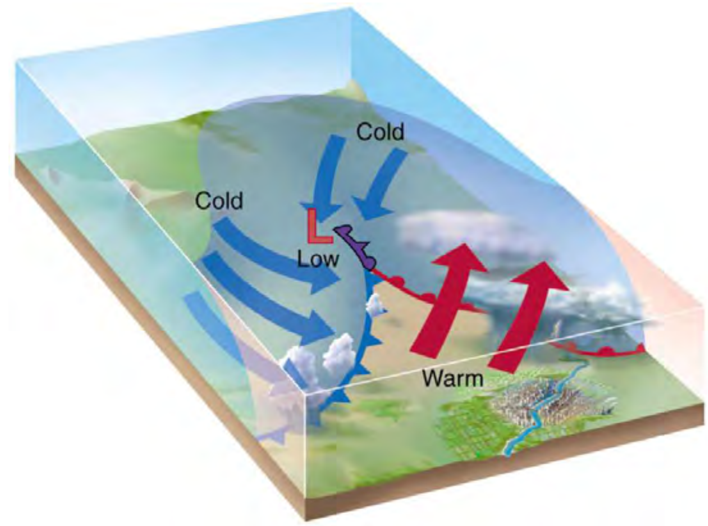
Depression

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 a counter-clockwise, or cyclonic, direction around the center 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

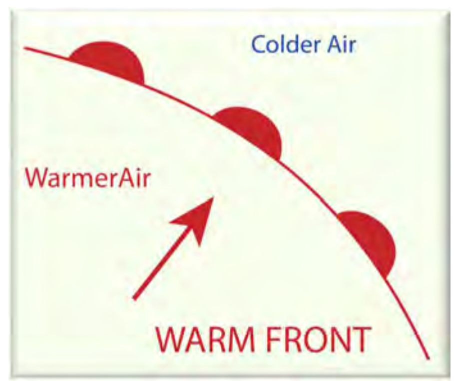


A region of closed isobars with high pressure on the inside; also called a 'high'. The wind circulates in a clockwise direction around the center of high pressure in the northern hemisphere, due to the Coriolis effect.

Warm Sector

The area of relatively warm air within a depression.

Cold Sector



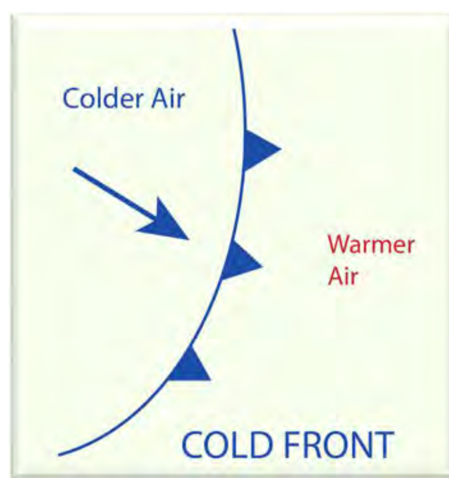
The part of a depression which is distinguished by relatively cold air.

Front

A line of separation between cold and warm air masses.

Warm Front

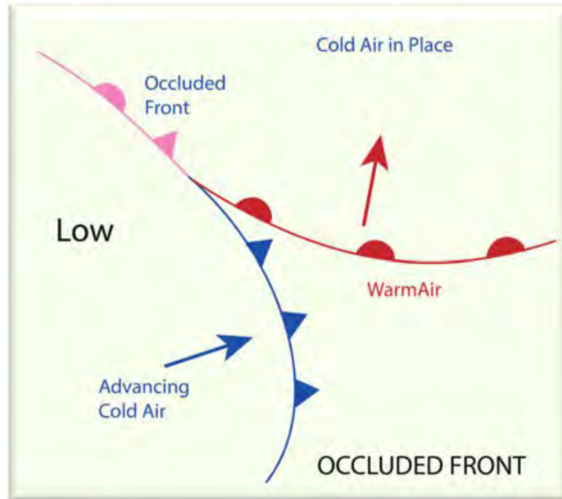
The boundary line between the warm air of a warm sector and the cold air in front of it. In other words, there is warm air behind a warm front.



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 this word 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.

High and Low Pressure Systems / Wind Direction

As was explained earlier wind blows from a high-pressure area towards a low-pressure area. High pressure systems can also be known as anti-cyclones.

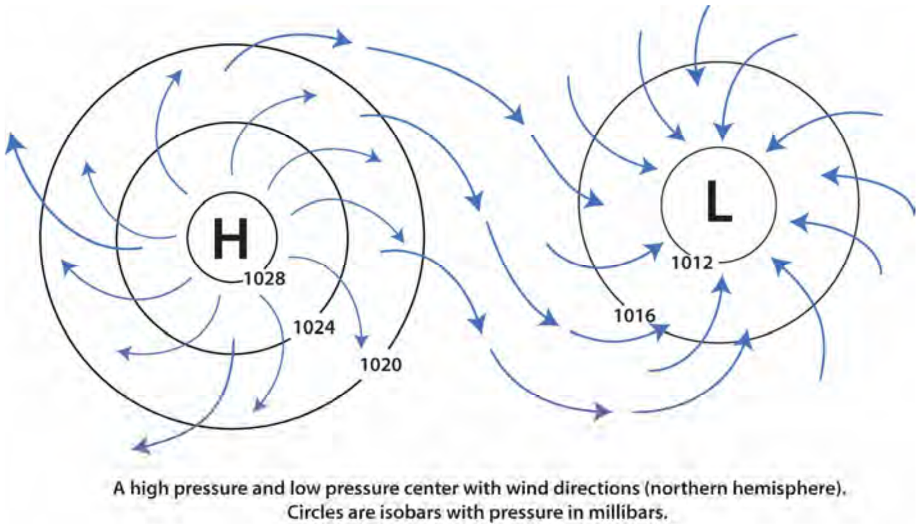


FIGURE 37 – WIND DIRECTION HIGH & LOW – NORTHERN HEMISPHERE

High-Pressure System

Coriolis force deflects the wind to the right of its path in the northern hemisphere and so wind blowing outward (diverging) from the center 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 center of high pressure. The isobars in the figure are drawn as concentric circles to make the drawing as clear as possible, in reality the isobars would be much less uniform in appearance.

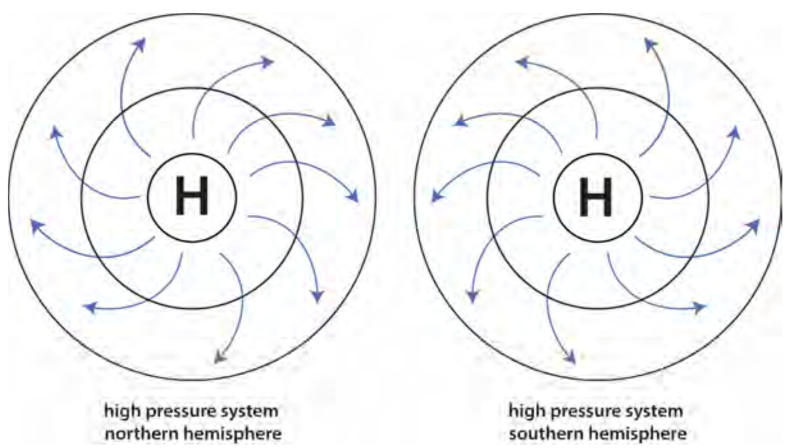


FIGURE 38 – WIND DIRECTION IN A HIGH-PRESSURE SYSTEM

Low-Pressure System

The wind in a low-pressure system will be blowing inwards towards the center 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 inward towards the center 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.

Low pressure systems can also be known as ***depressions*** or ***cyclones***.

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.

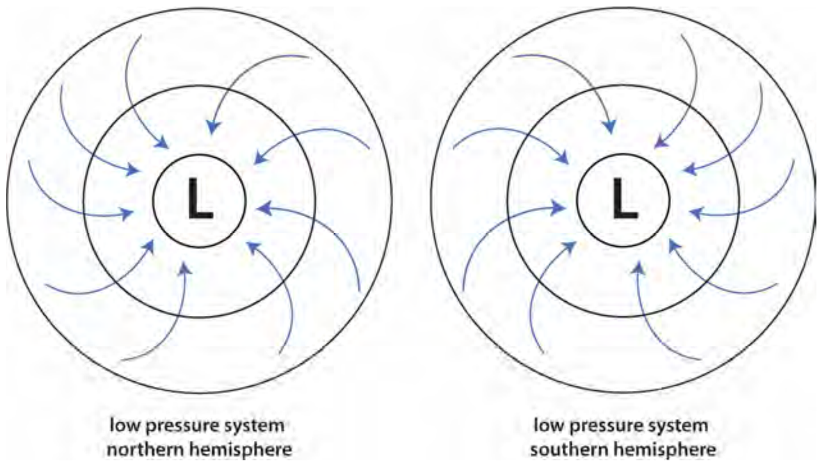
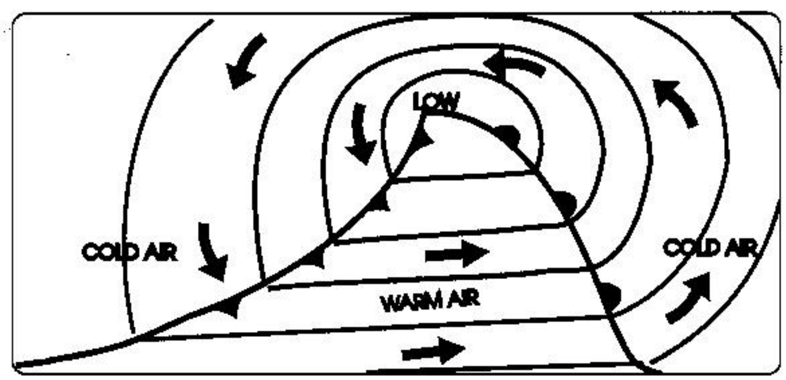


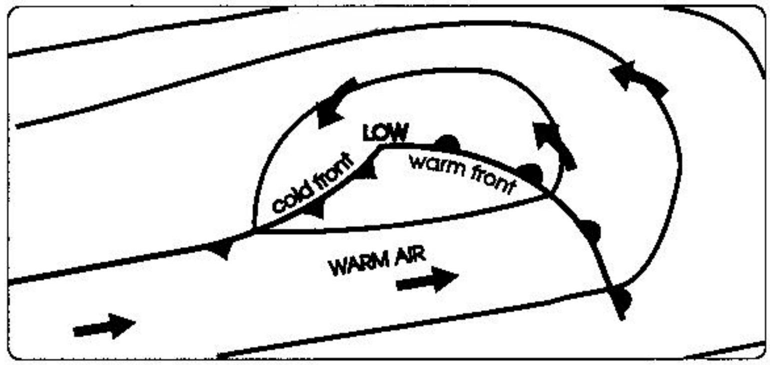
FIGURE 39 – WIND DIRECTION IN A LOW-PRESSURE SYSTEM

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.



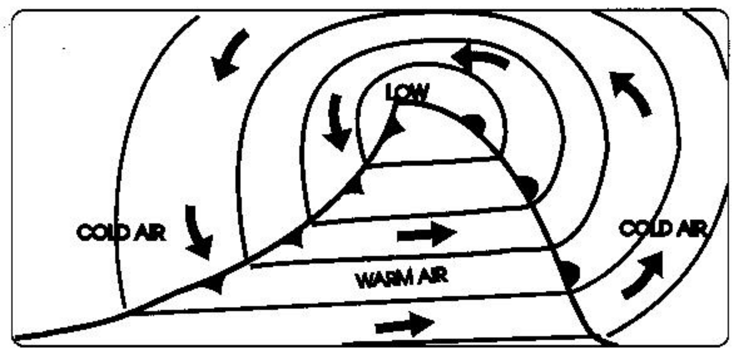
The pressure starts to drop at the bulge because warm unstable air is replacing the cold stable air. As the warm air in the wave rises up it is replaced by more warm air rushing in behind it, and Coriolis force deflects this wind to the right of its path setting up a cyclonic (counter clockwise) wind 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.

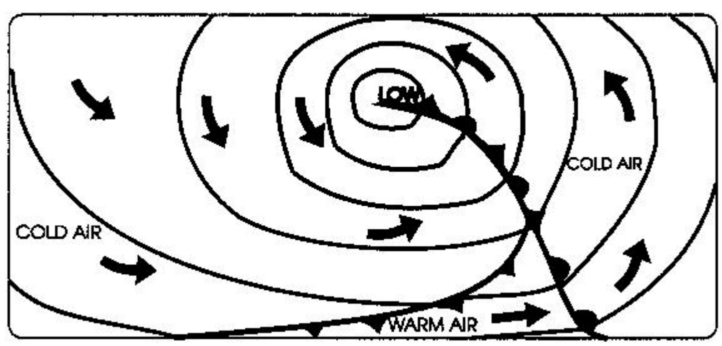
Mid Life

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 by now caught up with the warm front over some of its length. Because cold air is heavier than warm air 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.***

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:

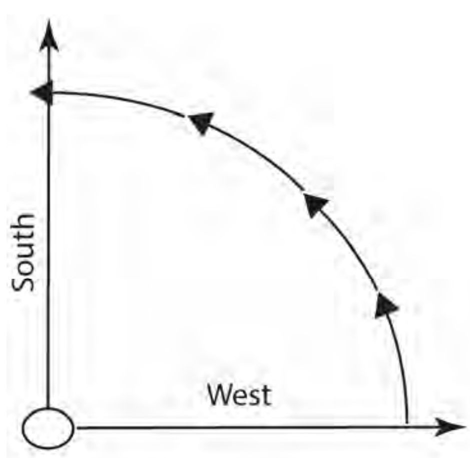
- Polar lows: cold air warmed when a cold air mass moves over warm seas.
- Heat lows: air being heated by hot land masses.
- Lee lows: a low-pressure area can form in the lee of a mountain subjected to a flow of air.

Backing

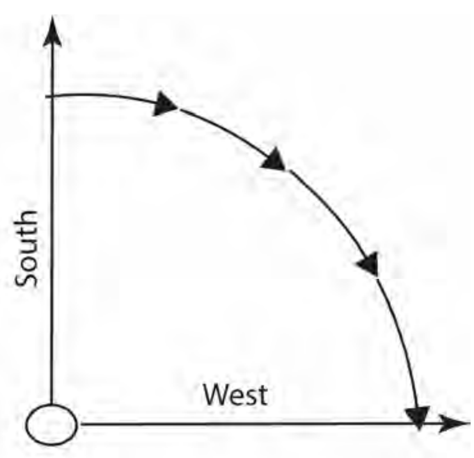
A wind which is changing in a counter-clockwise direction (e.g. W-S-E-N) is said to be backing.

Veering

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



West wind backing southerly



South wind veering westerly

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.

2.3 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.

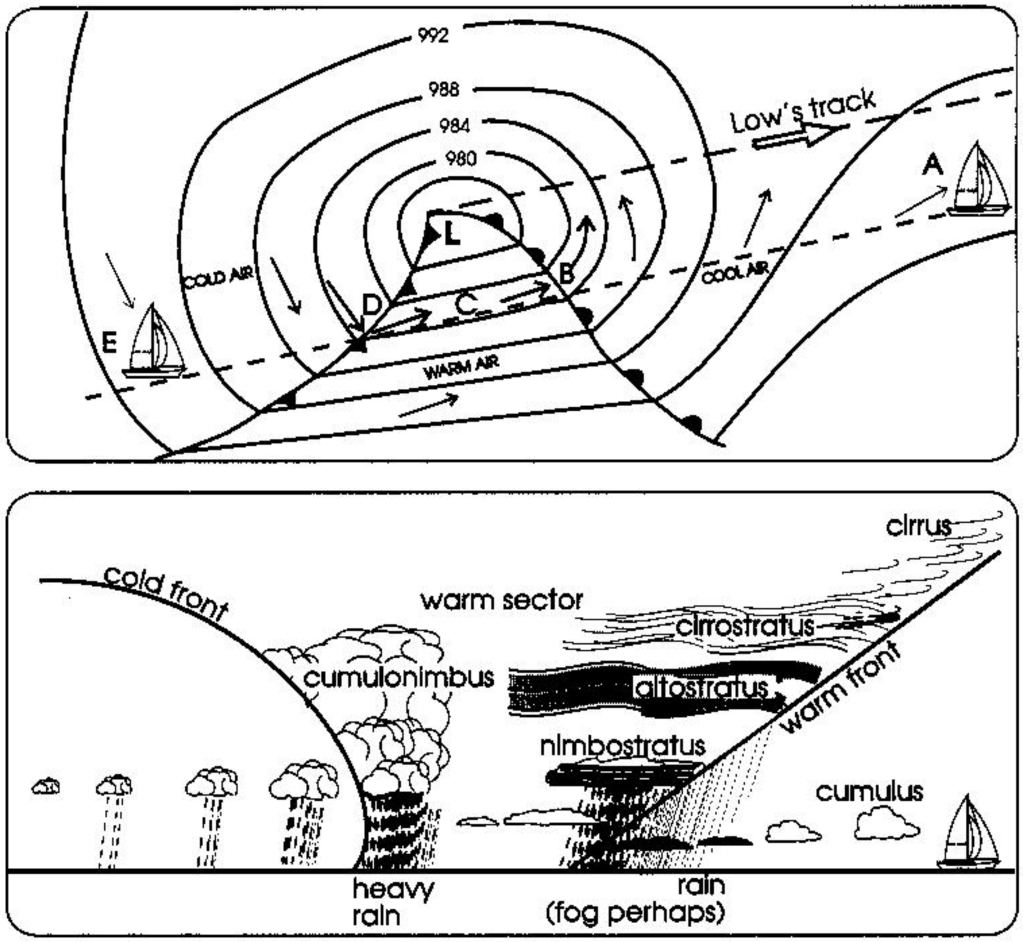
Cirrus	**Cirrus means 'hair', cirrus clouds are thin wispy, or feathery clouds, at a very high altitude. The word 'cirro' is used as a prefix to denote high altitude clouds.**
Cumulus	**Cumulus means a 'heap', cumulus clouds are clearly outlined heaped up clouds.**
Stratus	**Stratus means a 'layer' and 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.

The figure below shows two views of a depression; the figure is in two parts, the top drawing 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.

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 you.

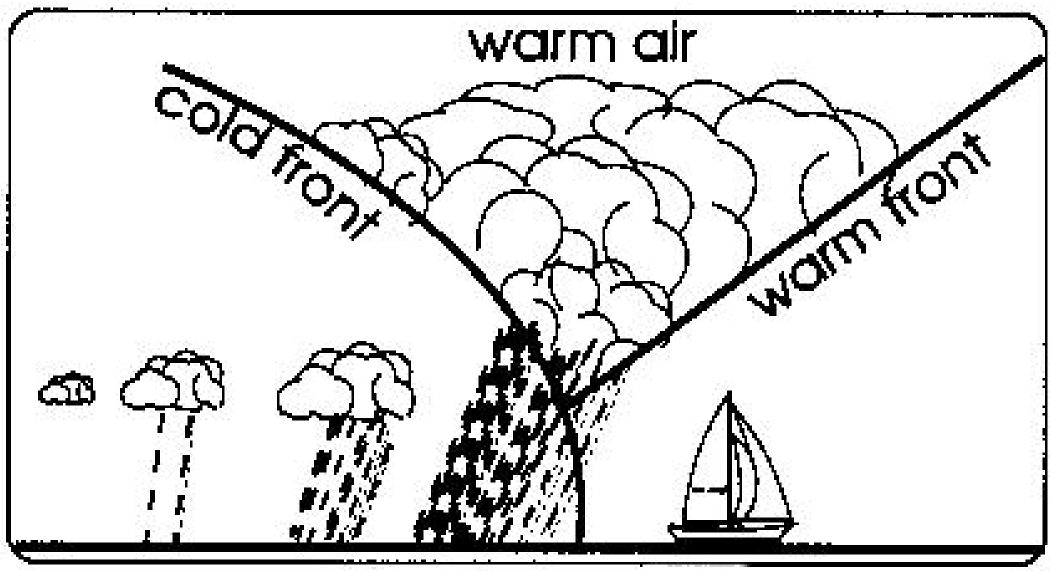
Changes in conditions when a depression passes to the south of your position

	APPROACH OF WARM FRONT	AT WARM FRONT	IN THE WARM SECTOR	AT THE COLD FRONT	WHEN COLD FRONT IS PAST
WIND DIRECTION AND STRENGTH	Veers to S.W., 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

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.

2.4 Occlusions

Looking at the section through the depression in this figure, 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.



2.5 Buys-Ballots Law

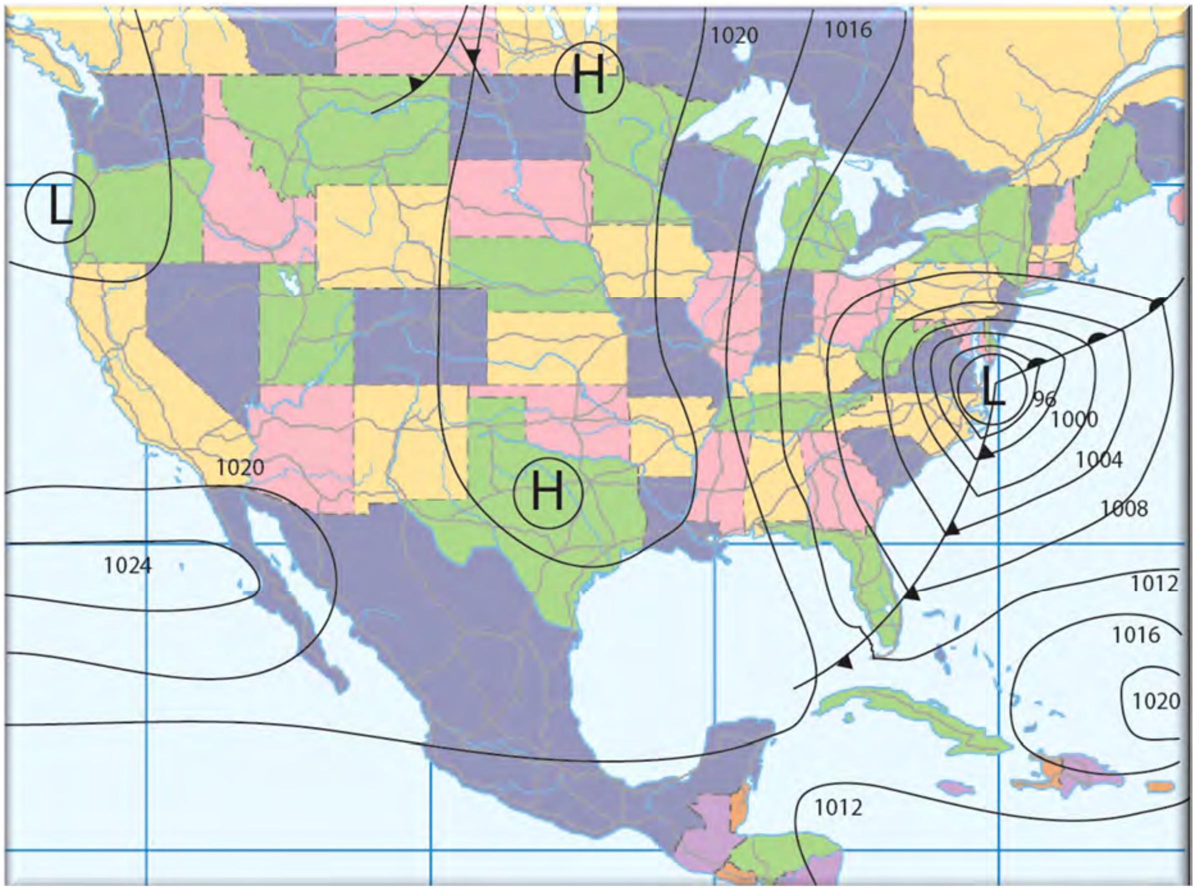
A Dutch professor, gave us this simple rule to locate the centre of a depression:

> *"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.

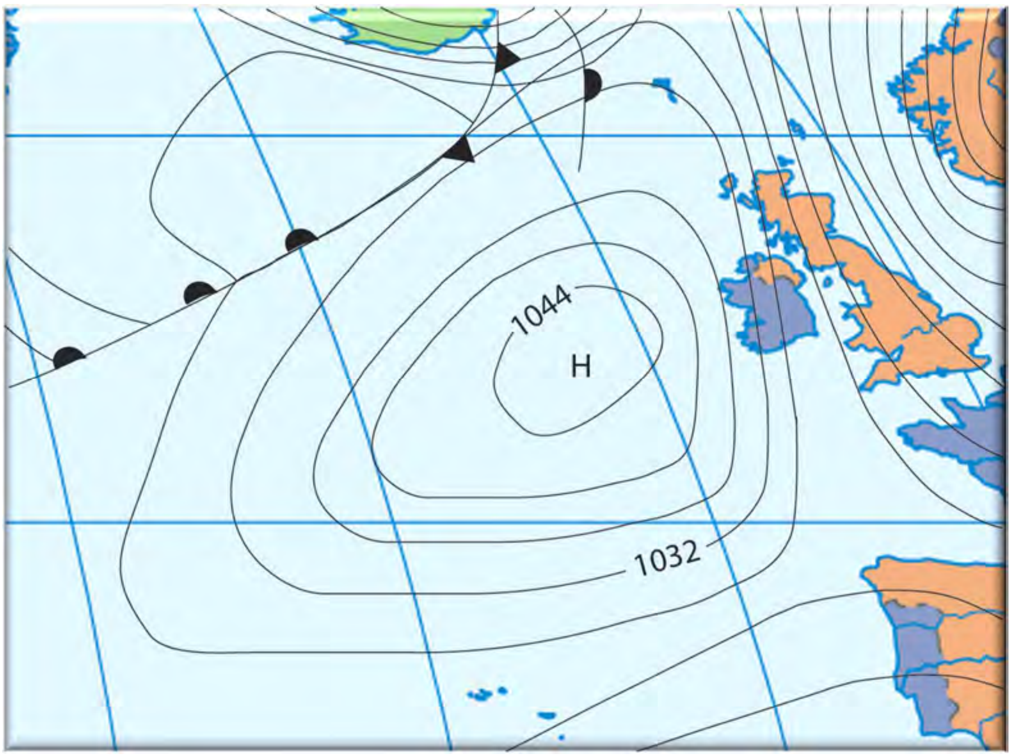
2.6 High Pressure Systems

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.



Above: A frontal depression centered 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 center 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 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.

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.



An anticyclone (high pressure system therefore the wind blows in a clockwise direction around the center 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.

2.7 Sea Breeze

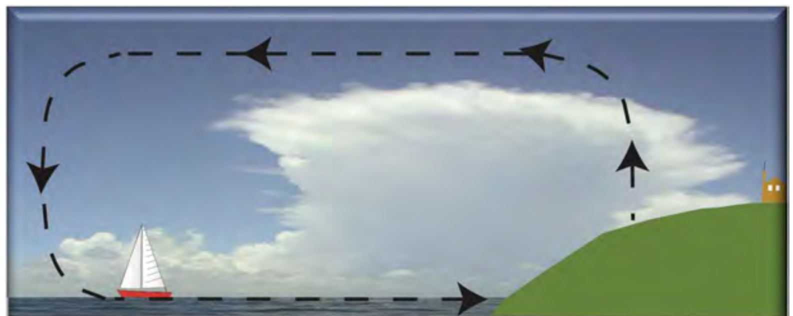
A sea breeze is a wind which blows locally from the sea towards the land during the daytime.

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.

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.



How a sea breeze is generated during the day

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.

2.8 Land Breeze

How a land breeze is generated at night

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.

2.9 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.

2.10 Hail

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

2.11 Snow

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

2.12 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 lose 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.

2.13 Fog

Fog is defined by meteorologists as <1 kilometer of visibility. Fog is composed of droplets of water and is formed when air is cooled to its 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 that occurs during cold clear nights when the land radiates the heat it absorbed during the day. The warm land 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 vapor 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.

2.14 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.

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.

Examples:

- 10 m/sec = 20 knots
- 5 m/sec = 10 knots

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	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
11	Violent Storm	Exceptionally high waves, foam patches cover sea, visibility very reduced	56 - 63 kn	30 - 45 ft
12	Hurricane	Air filled with foam, sea completely white with driving spray, visibility greatly reduced	64 + kn	over 45 ft

FIGURE 40 - THE BEAUFORT SCALE

2.15 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.

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.

2.16 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 logbook. A barograph is an instrument which records the pressure either on paper charts or electronically.

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 squallier than gales with a falling barometer.

2.17 Weather Forecasts

Weather forecasts for the coastal waters of USA are available from various different sources but NOAA weather on VHF radio WX channels are of a very high quality. For cruising away from U.S. coastal waters, an SSB MF/ HF radio receiver is required. Sometimes it can be difficult to catch all the forecast information – a small handheld tape recorder is a great help in this case.

The National Weather Service publishes a book entitled *Selected 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 radio facsimile 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. Those who expect to sail outside of the areas covered by VHF transmissions should consult this book to determine what radio weather information will be available to them.

Forecast Format

In the UK and Irish Sea there is a specific format for a weather forecast known as the ***"The Shipping Forecast".*** The Shipping Forecast is a BBC Radio broadcast of weather reports and forecasts for the seas around the coasts of the British Isles. It is produced by the Met Office and broadcast by BBC Radio 4 on behalf of the Maritime and Coastguard Agency.

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 therefore it could 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 affect 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.

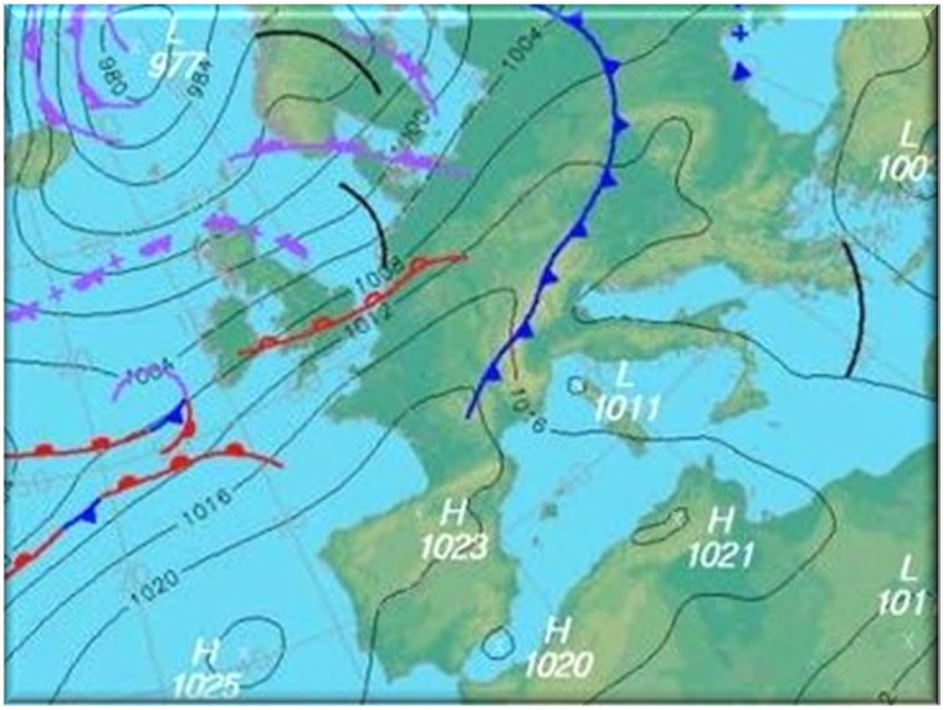


FIGURE 41 SYNOPSIS CHART

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 seriously affected. Probable wave height 45 feet".

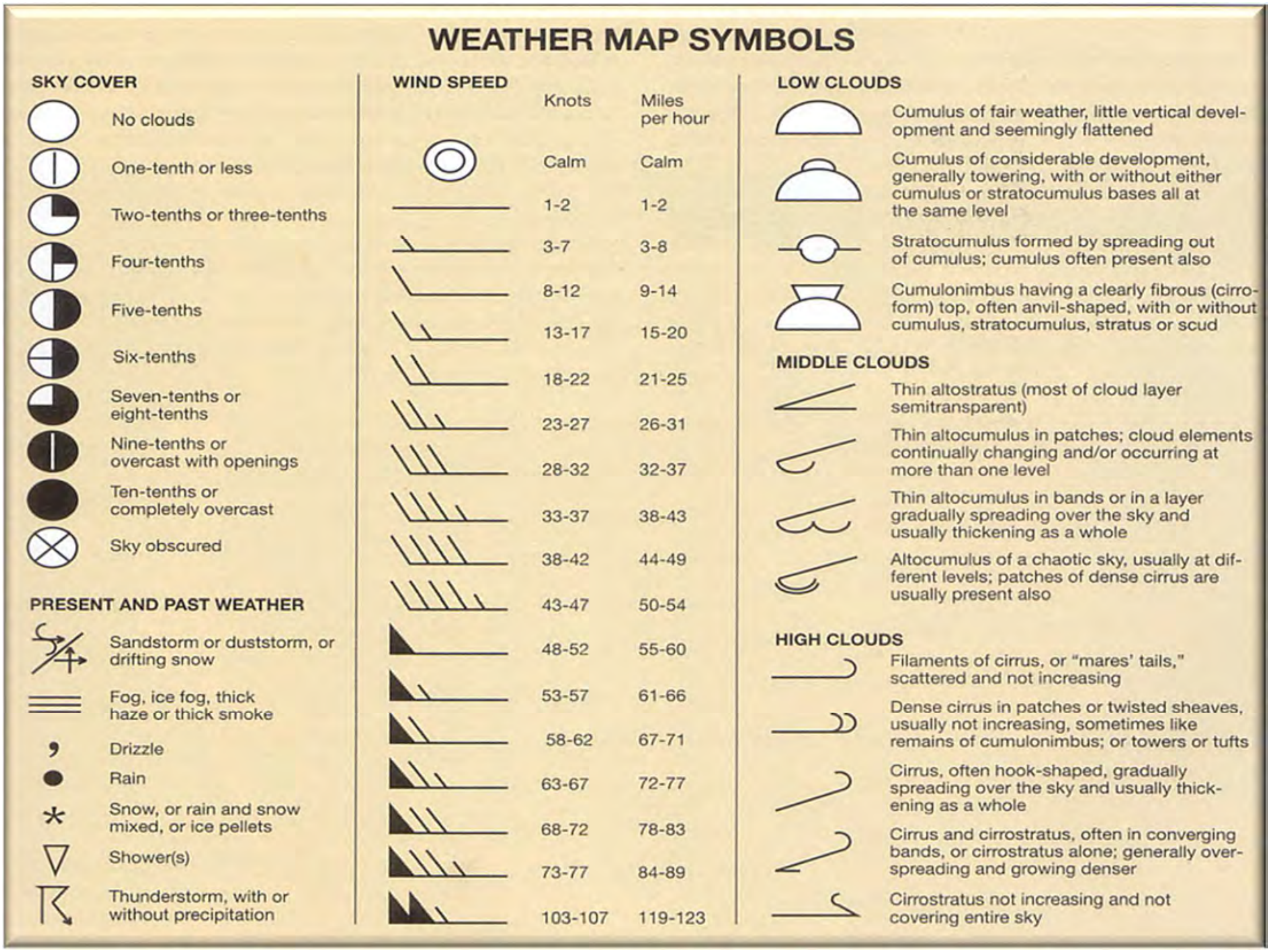


FIGURE 42 - INTERNATIONAL WEATHER PLOTTING SYMBOLS

2.18 Tropical Revolving Storms

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.

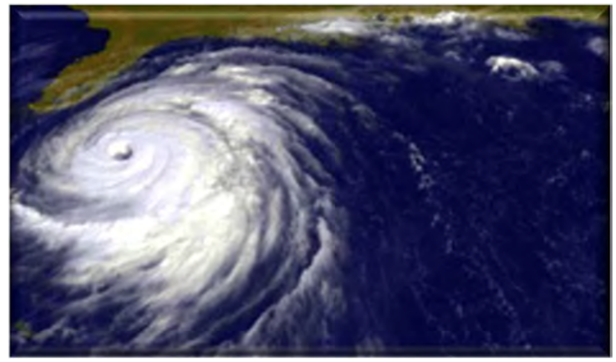


FIGURE 43 - HURRICANE FLOYD

These revolving storms can cause serious damage. 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 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 may not cover use in hurricane prone areas during the hurricane season. Some marinas will dig keel holes ashore into which the boat is craned and left until the hurricane season is over.

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 extracts:

1. "In December 1944, vessels of the United States Pacific Fleet, operating to the east of the Philippines, were caught near the center of a typhoon of extreme violence. Three destroyers capsized and went down with practically all hands. Serious damage was sustained by a light cruiser, three small carriers, three escort carriers and three destroyers. About 750 officers and men were lost or killed." (Admiralty Manual of Navigation, Vol. 1).

2. "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. During the Labor Day Hurricane of 1935, winds surpassed 200 miles an hour and people caught outside were sandblasted to death. Rescue workers found nothing but their shoes and belt buckles. So much rain can fall during a hurricane - up to 5inches an hour - that the soil liquefies. .... 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 vapor. 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 vapor rises and is cooled. The water vapor condenses back into water and the latent heat, or energy, contained by the vapor is released.

Tropical cyclones obtain their terrific energy by evaporating water from the sea surface and releasing this energy when the moisture vapor 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 center 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 center 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 second requirement for a tropical cyclone to develop is the existence of Coriolis force which will set up a counter clockwise spinning motion in the northern hemisphere or clockwise in the southern hemisphere. Coriolis 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 which move off the west coast of Africa. They move from east to west, carried along by the circulation around the Azores, or Bermuda High. 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 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 name such as TD2 (i.e. Tropical Depression no. 2).

Tropical Revolving 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 center 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, center 'eye' of the storm is formed. At this stage the storm will be given a name, female and male names being used alternately, i.e. Hurricane Charlie, Hurricane Camille, etc., in areas such as the Caribbean covered by the US weather service.

Hurricane

When the maximum sustained surface wind speed of the TRS exceeds 64 knots the TRSis 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 shown in the table below:

Saffir–Simpson scale

Category	Wind speeds (for 1-minute maximum sustained winds)			
	m/s	knots (kn)	mph	km/h
Five	≥ 70 m/s	≥ 137 kn	≥ 157 mph	≥ 252 km/h
Four	58–70 m/s	113–136 kn	130–156 mph	209–251 km/h
Three	50–58 m/s	96–112 kn	111–129 mph	178–208 km/h
Two	43–49 m/s	83–95 kn	96–110 mph	154–177 km/h
One	33–42 m/s	64–82 kn	74–95 mph	119–153 km/h

Note that there are different classification systems for different regions of the world.

Areas TRS Prone

FIGURE 44

The figures in brackets indicate the average number of severe tropical storms recorded over 10 years. These figures are from the BA Admiralty Manual of Navigation and were obtained prior to 1960. Remember that some storms may not have been recorded or the observers may not have survived to report them.

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)

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.

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!

Eyewall

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

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.

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 6 feet were forecast the average wave height would be about 3.6 feet, the height of the highest 10% of the waves would be about 7.8 feet and one wave in 1,175 could reach 11.4 feet.

In passing it is worth defining the difference between the terms wave 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 10sec 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 may be available in some areas. Local radio stations, television stations, newspapers, weather fax machines, etc., if available, will also give warnings and advice. Details of the radio frequencies and times of warning broadcasts are in 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 course 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.

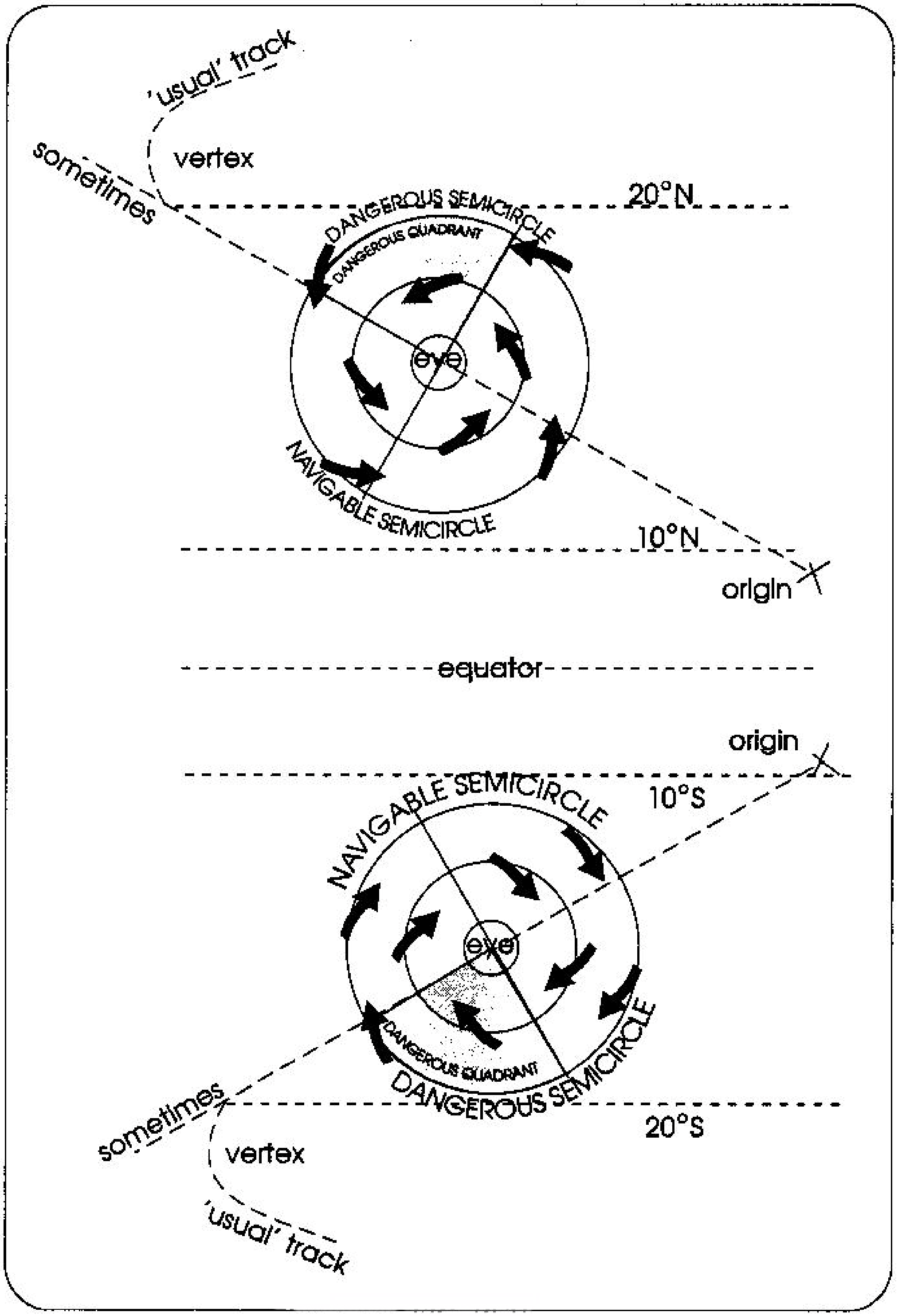


FIGURE 45
TROPICAL REVOLVING STORMS, NORTHERN AND SOUTHERN HEMISPHERE.
THE ARROWS INDICATE THE WIND DIRECTIONS.

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 center.

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

A very rapid fall indicates the observer is from 60 to 10 miles from the storm's center. The barometer may fall as much as 70 mb at the storm center. (In 1975 a pressure of 870 mb was recorded at the center 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 center and will certainly be felt 500 to 600 miles from the center. Higher and faster than usual swell should be taken as warning sign. As swell extends outward in concentric circle from the storm center 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 center of a TRS, but this will depend upon the radar range and proximity of the center 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 denser, 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 its 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 its 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.

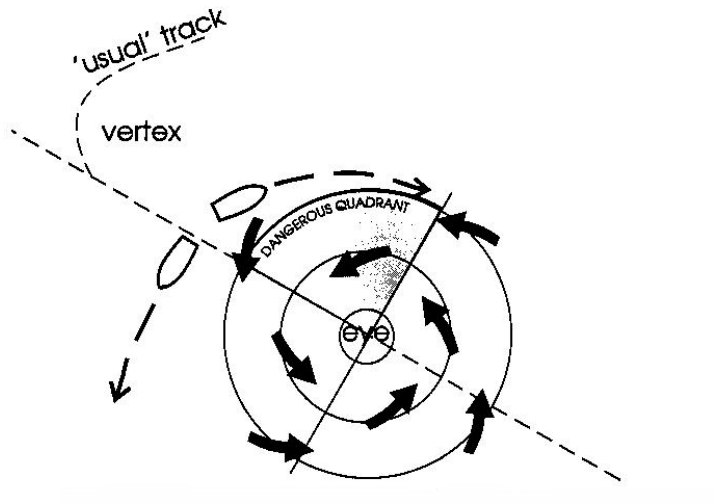


FIGURE 46 - AVOIDING ACTION IF A TRS IS APPROACHING IN THE NORTHERN HEMISPHERE.

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

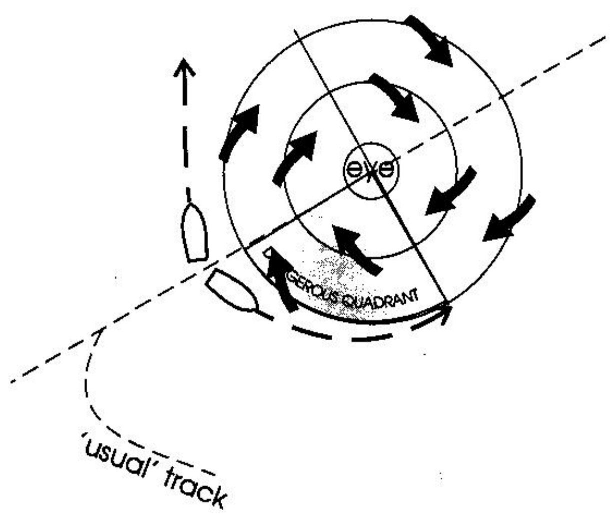


FIGURE 47 - AVOIDING ACTION IF A TRS IS APPROACHING IN THE SOUTHERN HEMISPHERE.

Radio Warnings

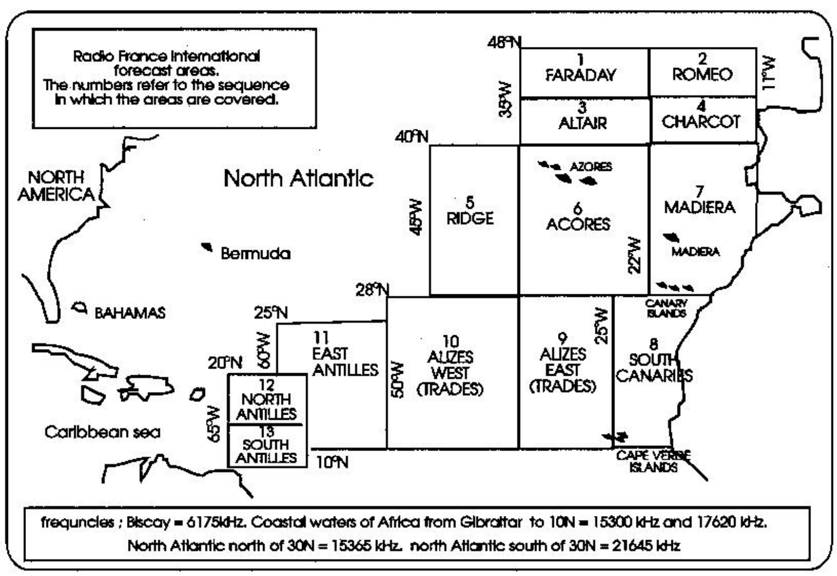
Radio, internet and navtes/INMARSAT warnings of the existence of a TRS and forecasts of its track in English are available from a considerable number of sources around the world. (See section above regarding forecasting sources)

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 trade winds route from the Canaries to the Caribbean, are covered by forecasts in French transmitted by Radio France International (RFI) at 1138 UT. See the figure below. Non-French speakers can use a tape recorder and dictionary to translate the basics easily enough. Trudy's maritime mobile Ham net relays an English translation at around 1300 UT on 14.300 MHz.



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 supplemented by access to the websites and forecasting services, the examples of which are listed above under the Forecasting 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.

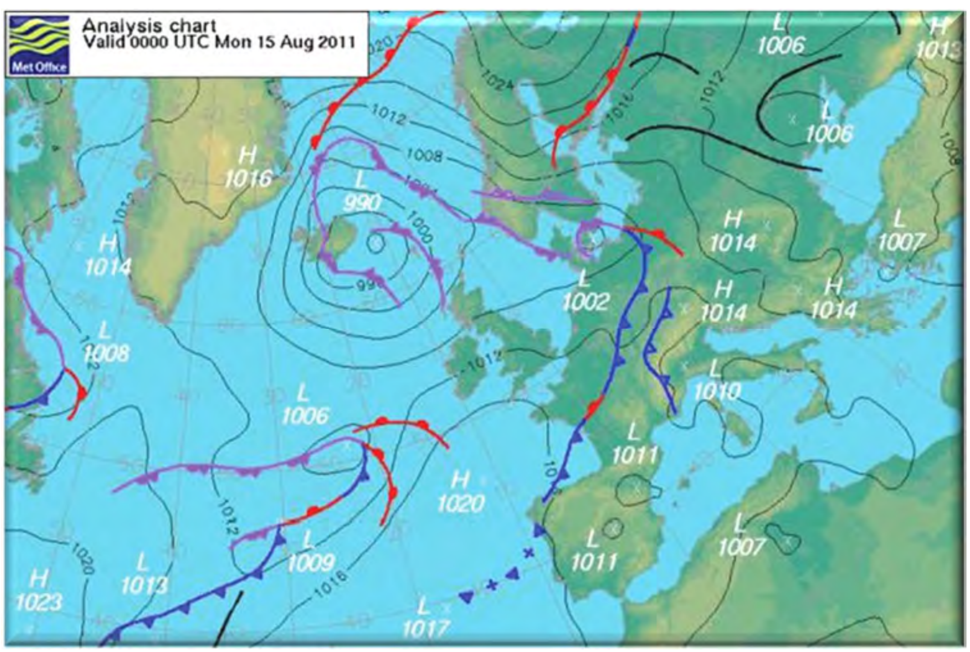


FIGURE 48 0000 UTC SURFACE ANALYSIS

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

The Met Office initiates warnings and prepares routine forecasts for dissemination on behalf of the MCA. http://www.metoffice.gov.uk/weather/marine/

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:

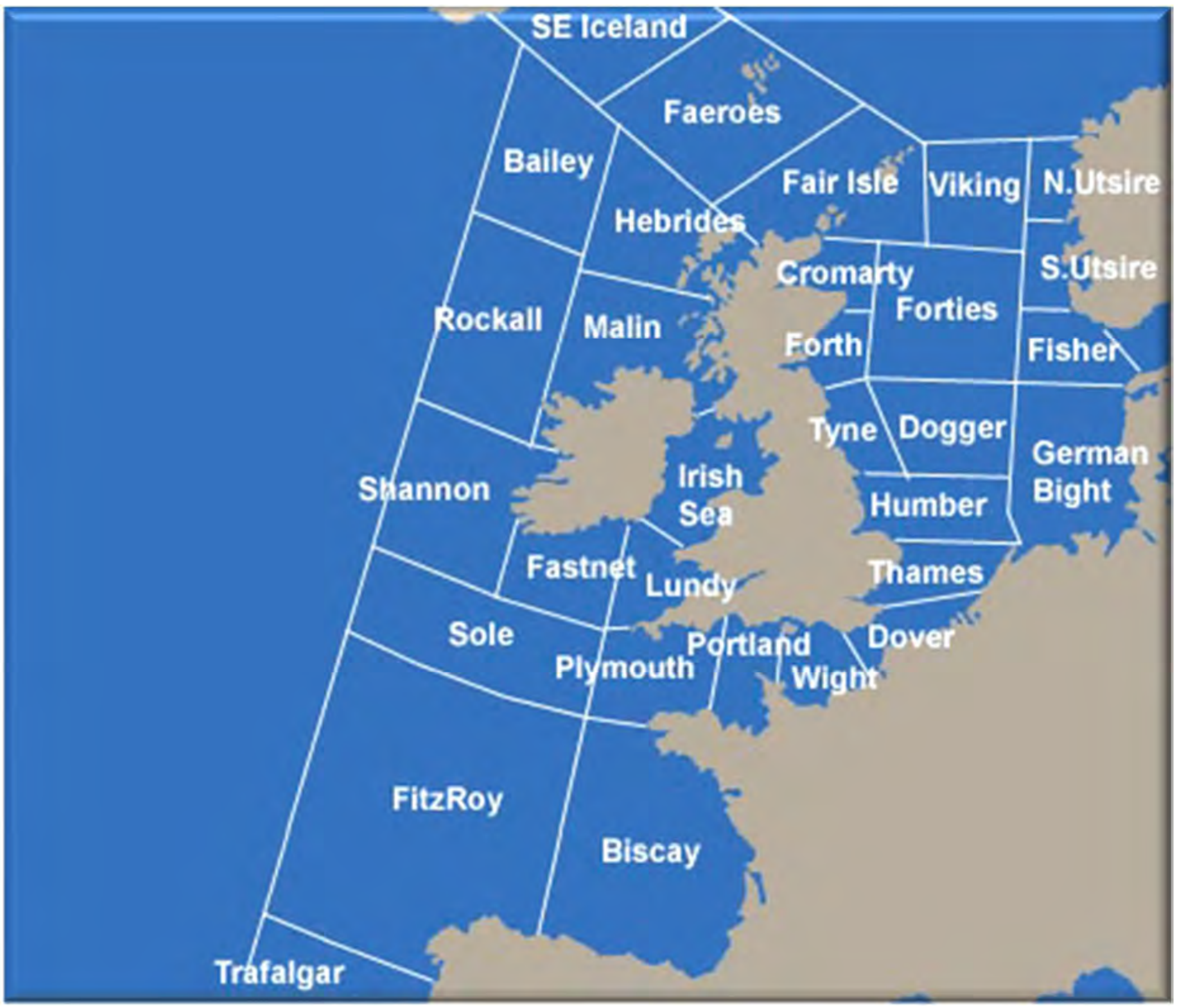


FIGURE 49 - SHIPPING FORECAST SEA AREAS

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.

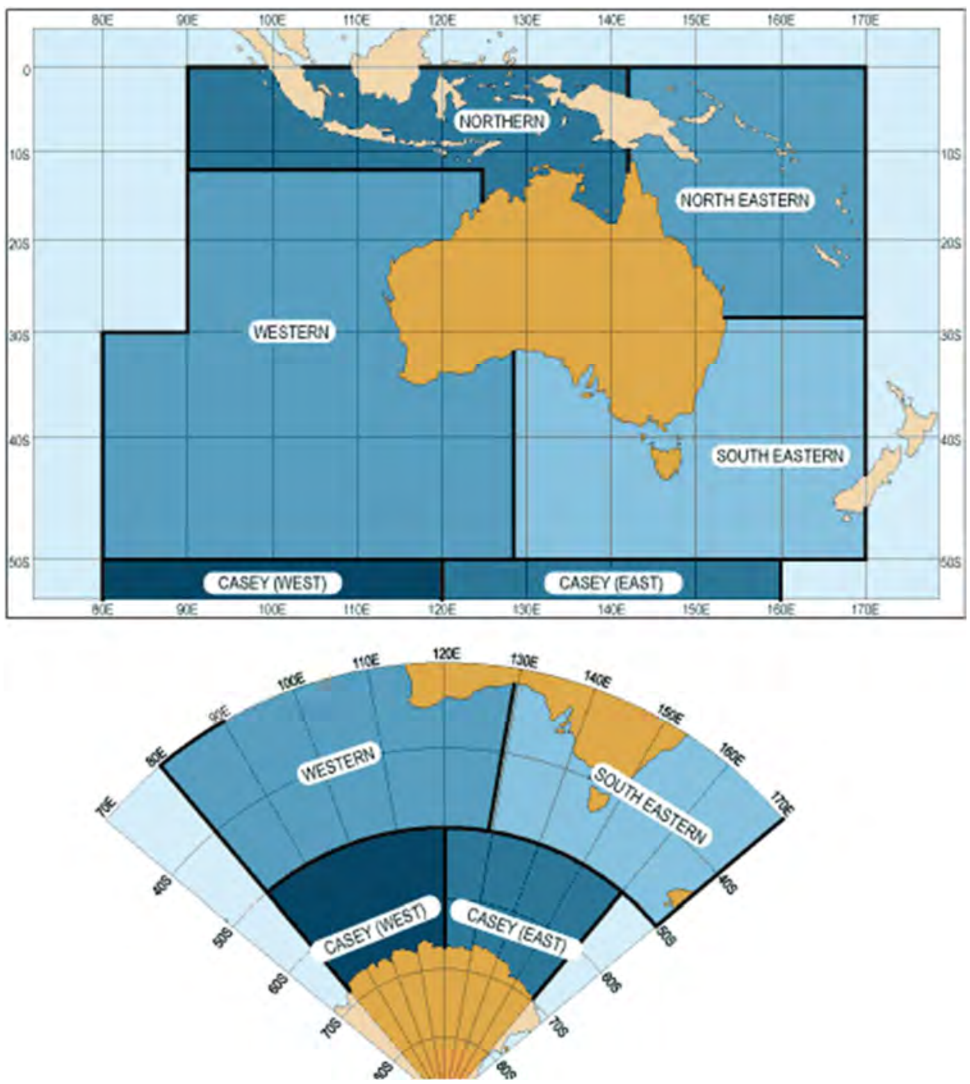


FIGURE 50 - AUSTRALIAN SHIPPING FORECAST SEA AREAS

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.

Chapter 3 CHARTWORK INSTRUMENTS

3.1 Key Objectives

THE OBJECTIVE OF THIS MODULE IS TO REVIEW CHARTWORK INSTRUMENTS

3.2 Chartwork Instruments and Information

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.

The practical navigator does not require expensive equipment to work effectively. The basic needs are as follows:

Pencils - 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.

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.

PARALLEL RULES

Parallel Rules - Used to measure courses, bearings, lines of position etc. by reference to a compass rose printed on a chart. Worked by walking or rolling (depending on type) the rule across the chart to/from compass rose. These are not very accurate in a rolling sea or in bad weather – **(not recommended due to inaccuracy)**

DIVIDERS

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.

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.

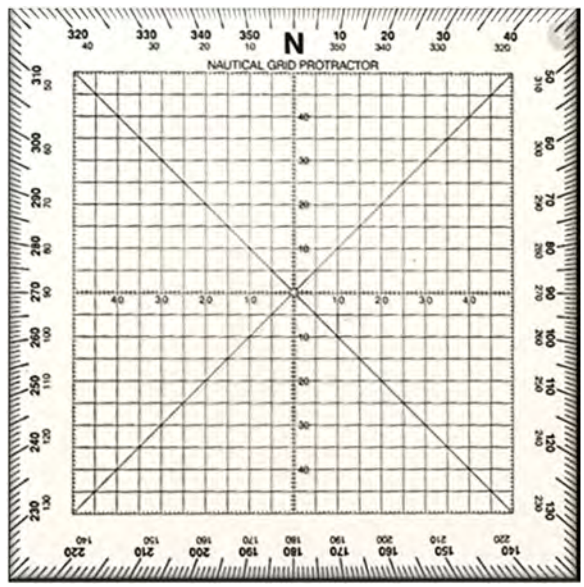


FIGURE 51 - SQUARE OR DOUGLAS PROTRACTOR

The Douglas protractor is inexpensive and virtually indestructible when made of impact resistant plastic and has no moving parts.

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.

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.

FIGURE 52 - BRETON PLOTTER

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.

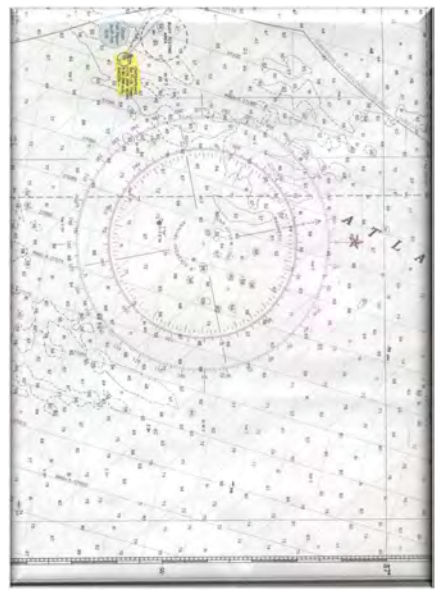
Weems and Plath make a similar plotting instrument called 'bi-rola chart protractor'.

Chapter 4 CHARTS, CHART PROJECTIONS & PUBLICATIONS, LAT & LONG

4.1 Key Objectives

THE OBJECTIVE OF THIS MODULE IS TO REVIEW CHARTS, CHART PROJECTIONS AND PUBLICATIONS TO ENSURE CANDIDATES FULLY UNDERSTAND ALL THE INFORMATION PRESENTED, THE SIGNIFICANCE OF THE ABBREVIATIONS AND SYMBOLS AT A GLANCE.

4.2 General



Charts are maps of the seabed 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.

4.3 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.

USA - National Oceanic and Atmospheric Administration (NOAA) charts

U.S. charts are published in 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,
- National Geospatial-Intelligence Agency 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.

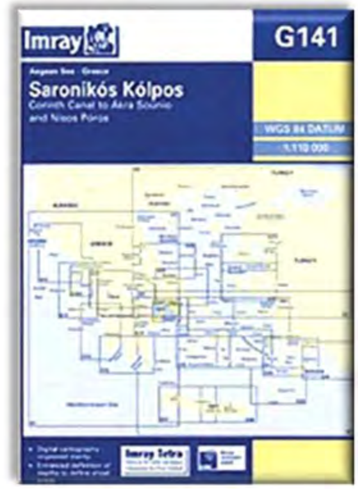
Other Chart Agencies

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

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

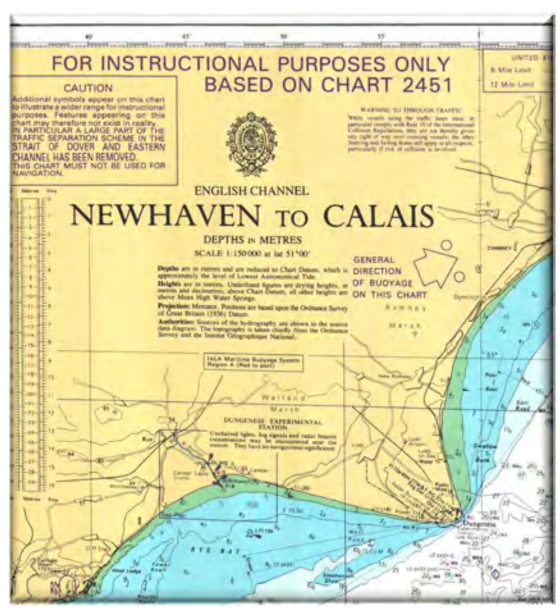
Charts are available from chart agents and nautical bookstores; most chandlers shops can supply yacht charts for the immediate area at least. Suppliers such as chart agents also stock Notices to Mariners which update ever changing navigation information usually weekly. Many are also approved to provide 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 is used as an example.

Training Chart 12221 is also shown as an example which covers Chesapeake Bay Entrance.

Note: TRAINING CHARTS ARE NOT TO BE USED FOR NAVIGATION.



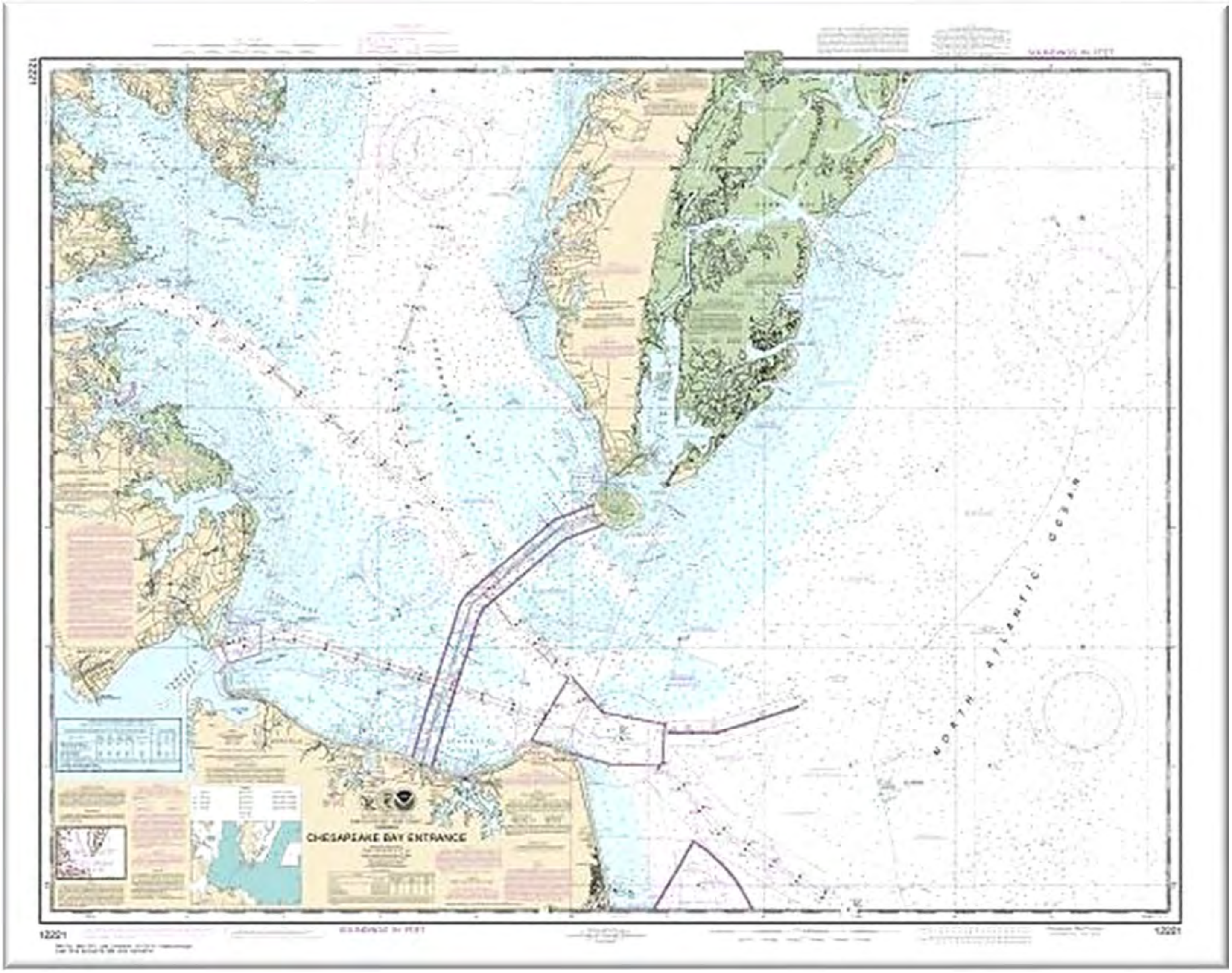


FIGURE 53 - CHART 12221

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

Title: the area covered by the chart – “Newhaven to Calais” and “Chesapeake Bay Entrance”

Number: each chart has a unique number. Adjoining chart numbers are given in the top, bottom and left margins.

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. ***There are no corrections noted on training charts.***

Projection: i.e. Mercator projection or gnomonic or other projection.

Large Scale Charts

The large-scale charts which are available within the area covered by the smaller scale chart in use may be shown in a box which is usually printed somewhere on the land area. The sea areas within this box are colored white and magenta colored rectangular boxes show the area covered by a particular large-scale chart together with the respective chart number. For example, it can be seen from the box in the left-hand bottom corner of chart 12221 that large scale chart number 12241 will cover the entry to York River in greater detail.

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.

Charts, Detailed Information

Details of all the abbreviations, colors and chart symbols used on U.S. charts can be found in Chart No. 1, United States of America, Nautical Chart Symbols and Abbreviations, the latest edition of which should be aboard every boat.

- Printed on the bottom left hand corner of NOAA charts are the edition number and its date. The reference numbers and date of any corrections made to the chart since it was printed should be entered here. When using, or buying, any chart always check to see how old the edition is.

- A NOS chart shows land that is not covered with water in a yellow/gold color. 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 MHW beside it.

- 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 center. 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 MHW may also be included: ⊙ R TR 416ft

- 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 center. The uppercase letters PA (position approximate) may also be included.

  ○ Sign PA, ○ Tr, ○ Chy 135ft

- Other pictorial symbols may be used, a church spire for example could be depicted by a cross ✠ Windmills ⊗ as well as by ⊙

<u>The type of lettering used on the chart is significant.</u>

Details of features that are floating or submerged at HW are in italics, thus:

Willoughby Bank, G "9" Fl G 4s, Obstr, Subm Stake, Wreck

Features that remain above water at HW are given in upright letters, thus:

Willoughby spit Fl 4s 8M (in upright figures).

Note that care is needed when the letters are written at an angle to the horizontal, it is possible to mistake upright letters for italics; see the two lights at Rudee Inlet on chart 12221 at approx. 36°50'N 75°58'W.

Land is colored a buff or yellow/gold color on NOS charts and grey on NGA (Formerly DMA, NIMA) charts. Other chart publishers may use different colors for land and drying areas.

Areas which are covered and uncovered by the tide are colored green and may have underlined numbers printed on them indicating how high the area dries above water level at Chart Datum. A figure of 22 on a chart with soundings in fathoms would indicate that this place dries to a height of 2 fathoms 2 feet above chart datum.

The nature of the foreshore may also be given in writing, for example Little Inlet on Smith Island (37°10'N 75°50'W) is 'Marsh'. Other descriptions which may be used are self explanatory such as 'Mud', 'Sand', 'Coral' and so on.

The sea below Chart Datum is shown as white with shallow areas highlighted in blue, the density of the blue shading may change at various depth contours, the density of the blue increasing as the depth decreases.

The terms shallow and deep are of course relative to the scale of the chart.

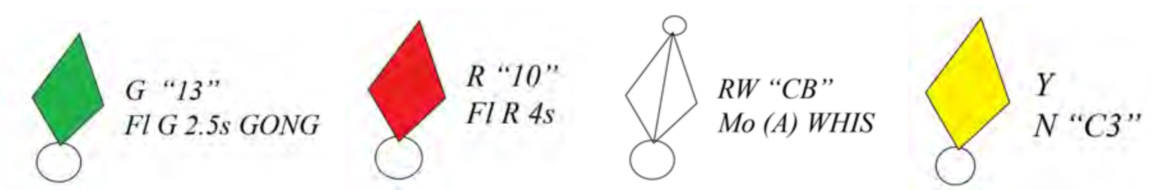
On practice chart 12221 depth contour lines are shown by dotted lines at depths of 60, 36, 30, 24, 18, 12 and 6 feet. Areas with depths greater than 30 ft are left white; areas inside the 30 ft contour have depths less than 30 ft and these areas are colored pale blue to make it noticeable; areas inside the 24 ft contour line have depths less than 24 ft and this area is filled with a darker blue to further draw attention to the shallower water. Small scale charts of, say, 1:500,000 with ocean boundaries might have contour lines at 400, 300, 200, and 100 fathoms.

The depth along a contour line can normally be decided quickly by inspection on either side of the contour but present-day charts usually have contour lines in continuous lines with the contour value inserted at intervals.

Navigational buoys are shown in shapes and colors indicating the way they should be used for pilotage. North America uses the IALA B system, with which, on entering a channel from seaward red buoys (even numbers,) are passed on your starboard side and green buoys (uneven numbers) are passed on your port side. Port hand buoys used to be black but have mostly been replaced with green to conform to IALA B standards. (Europe, Africa and Asia use IALA A in which the colors of the buoys are reversed, i.e. red buoys are passed to port, green to starboard.)

If buoys have a sound signal, a bell usually indicates the starboard side of the channel and a gong marks the port side but check the sound signal and buoy on the chart. Buoys which are unlit and have no sound signal are 'nun' buoys (shaped like a cone with the top cut off) on the right-hand side of the channel and can buoys on the left.

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, and so on. A red starboard hand buoy will have a red diamond, a green port hand buoy will have a green diamond and a yellow or red/white buoy will have an uncolored diamond. If the buoy is lit its light signature will be shown beside it in abbreviated form. The color 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.

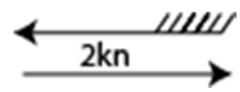


The R/W Mid Channel Aid above is spherical in shape with red and white vertical stripes and its light signature is Morse A (— ——). The yellow buoy is unlit and is a Nun buoy.

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 center of the star.

Details of a light are given in abbreviated form, for example Chesapeake light house above "Gp Fl (2) 15s 117ft 24M Horn" means the light gives a Group of 2 Flashes together repeated every 15 seconds, the light is 117 feet high, has a nominal range of 24 Miles, the light also has a fog signal in the form of a Horn. The color of the light is only given if it is other than white, if the light in the example were green it would read "Gp Fl (2) G 15s......".

The general direction of the tidal current may sometimes be shown by arrows, the arrow with the feathers on the end represents 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.



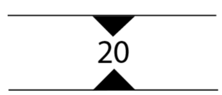
Tide rips and overfalls are areas where sea conditions can become rough, particularly when the wind and tide are going in opposite directions, called 'wind against tide'. Caused by headlands, shoal banks and rough sea beds in areas where the tide runs strongly these areas are shown on the chart by squiggles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

Wrecks are shown as a depth inside a dotted circle with the letters Wk, or Wreck beside them.

The vertical clearance beneath an overhead obstruction such as a bridge, powerline, etc., is measured from the underneath of the obstruction to the sea surface at MHW (Mean High Water) and may be written as:

FIXED BRIDGE HOR CL 84 FT VERT CL 35 FT

OVHD PWR CBL AUTH CL 68 FEET

or may be shown thus: 

, indicating a clearance of 20 feet at MHW.

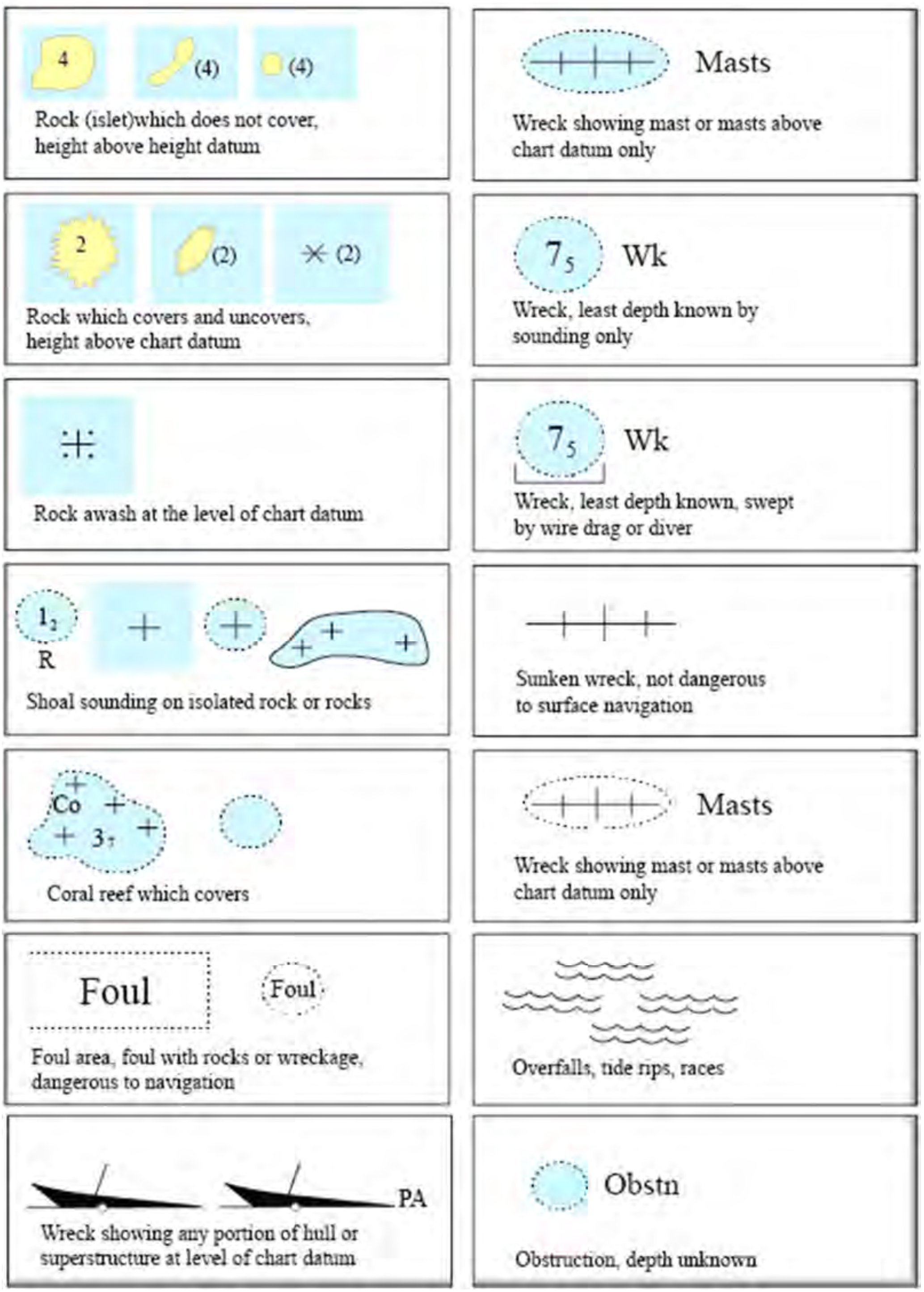
Be very careful to allow sufficient clearance when passing under powerlines.

The figures for clearances beneath bridges are supplied by the U.S. Coast Guard and the Army Corps of Engineers supply the clearances for cables. A clearance may be 'as-built' meaning that the clearance has been physically checked, or 'authorized' meaning the clearance has been taken from the plans upon which issue of the construction permit was based. The significance is that a bridge or cable marked 'AUTH CL 68 ft' on the chart may not have exactly 68 ft clearance at MHW, there could well be less.

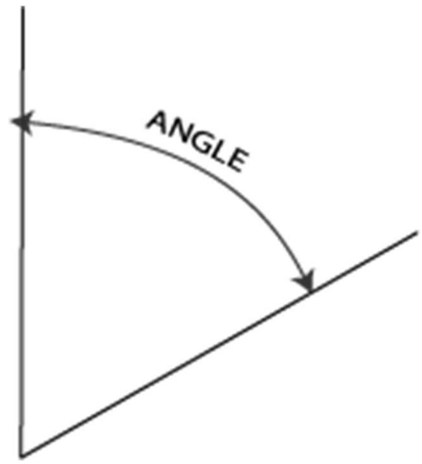
- The height of a lighthouse is given from the sea surface at MHW to the centre of the actual light source. The height of all land-based objects is given from MHW.

Nautical Chart Symbols and Abbreviations

A booklet called 'Chart No. 1, Nautical Chart Symbols and Abbreviations' is available from chart agents and one should be aboard every cruising boat. It details and shows in color all the symbols and abbreviations used on U.S. charts.



Angles

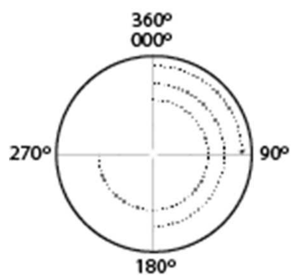


As chart work and navigation involves working with angles a brief explanation of what an angle is might help here. An angle is the space between two lines which meet at one end.

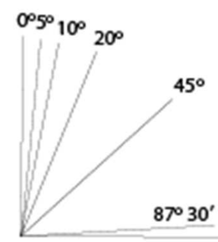
Everyone is used to measuring distances in terms of inches, meters, miles, kilometres and so on, angles are the measurement of the distance between two meeting lines. The angle remains the same no matter how far the lines forming the angle are extended. Angles are measured in degrees, minutes and decimals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

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 ‘ , therefore 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 360° in a full circle, 180° in a half circle and so on.



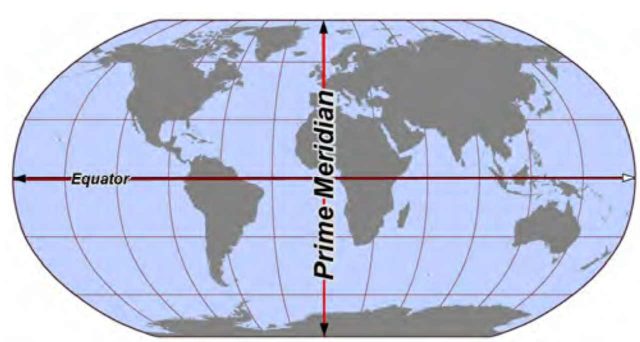
There are 60 minutes in one degree and so 87 1/2 degrees is 87° 30′

87 degrees 30 point 5 minutes is therefore written as 87° 30’.5. Note that in navigation the decimal point is placed after the minute sign.

Latitude and Longitude

It is easy to define a position by reference to known objects as for example Cape Henry or Chesapeake light house. 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.



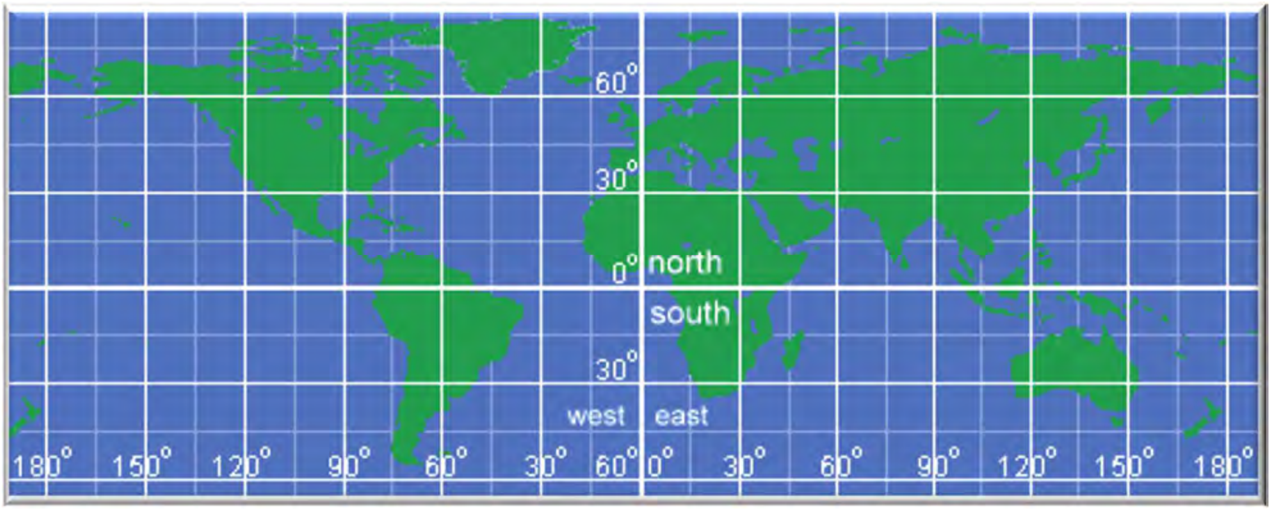
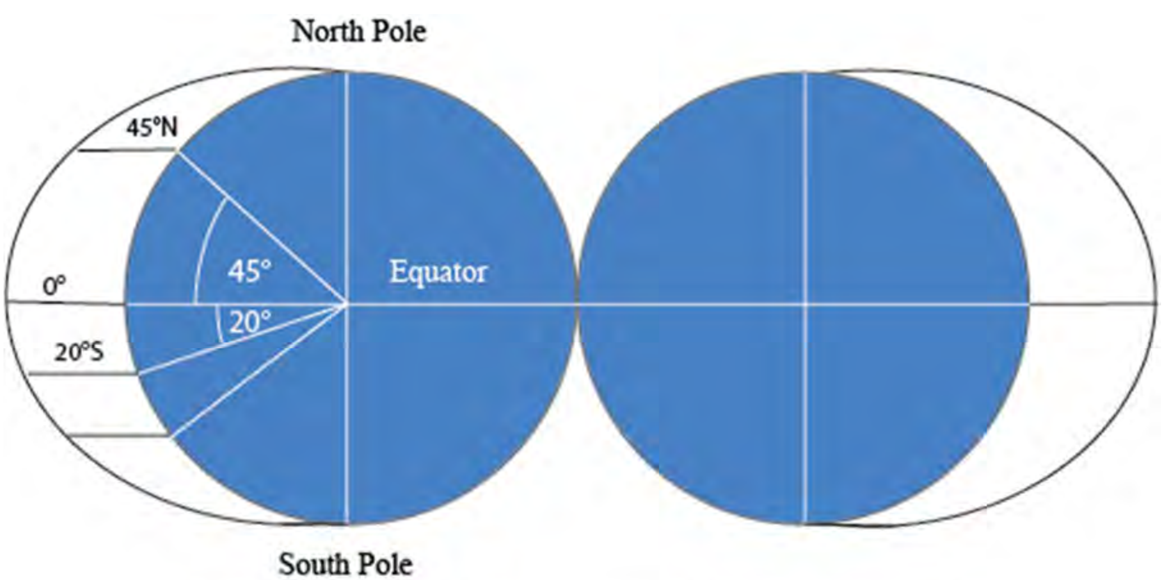


FIGURE 54 LAT AND LONG GRID

Latitude

Latitude is the angular distance measured from the center 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 center 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.

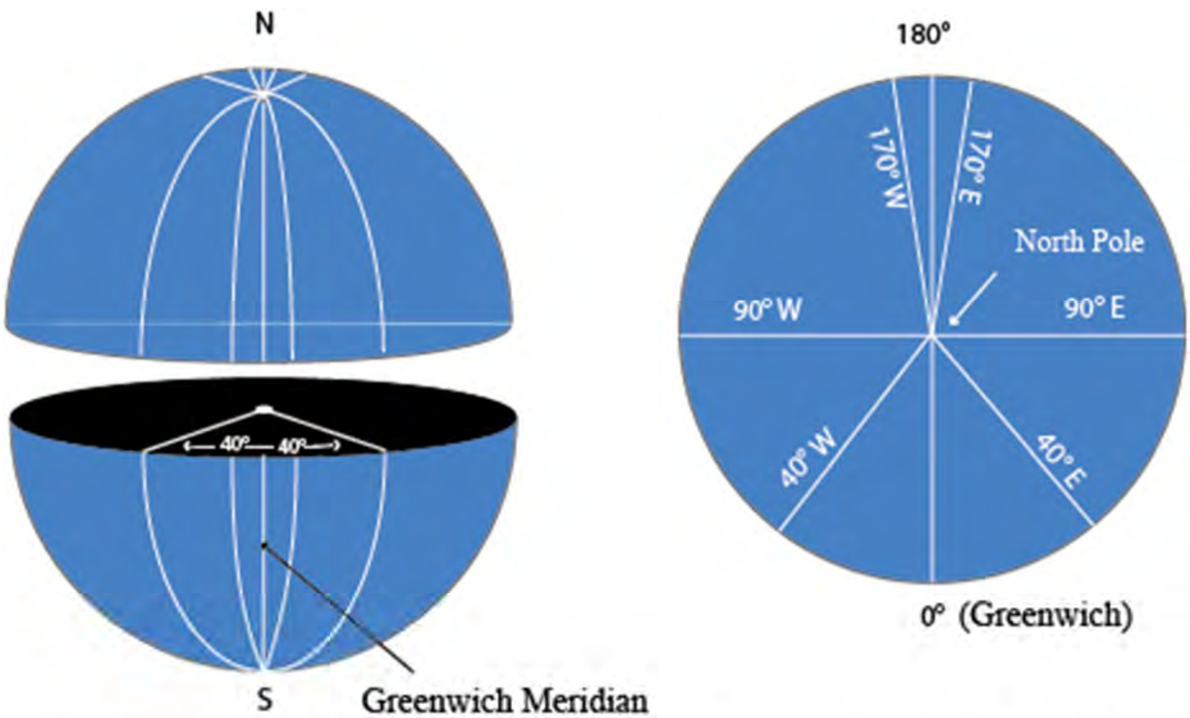


Latitude is angular distance, measured from the center of the earth, North or South of the equator

Longitude

Longitude is the angular distance measured from the center 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. 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.



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

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

Defining a position by latitude and longitude

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 37°N and at 10' intervals above and below. Note that the parallel 10' below 37°N is 36°50'N.

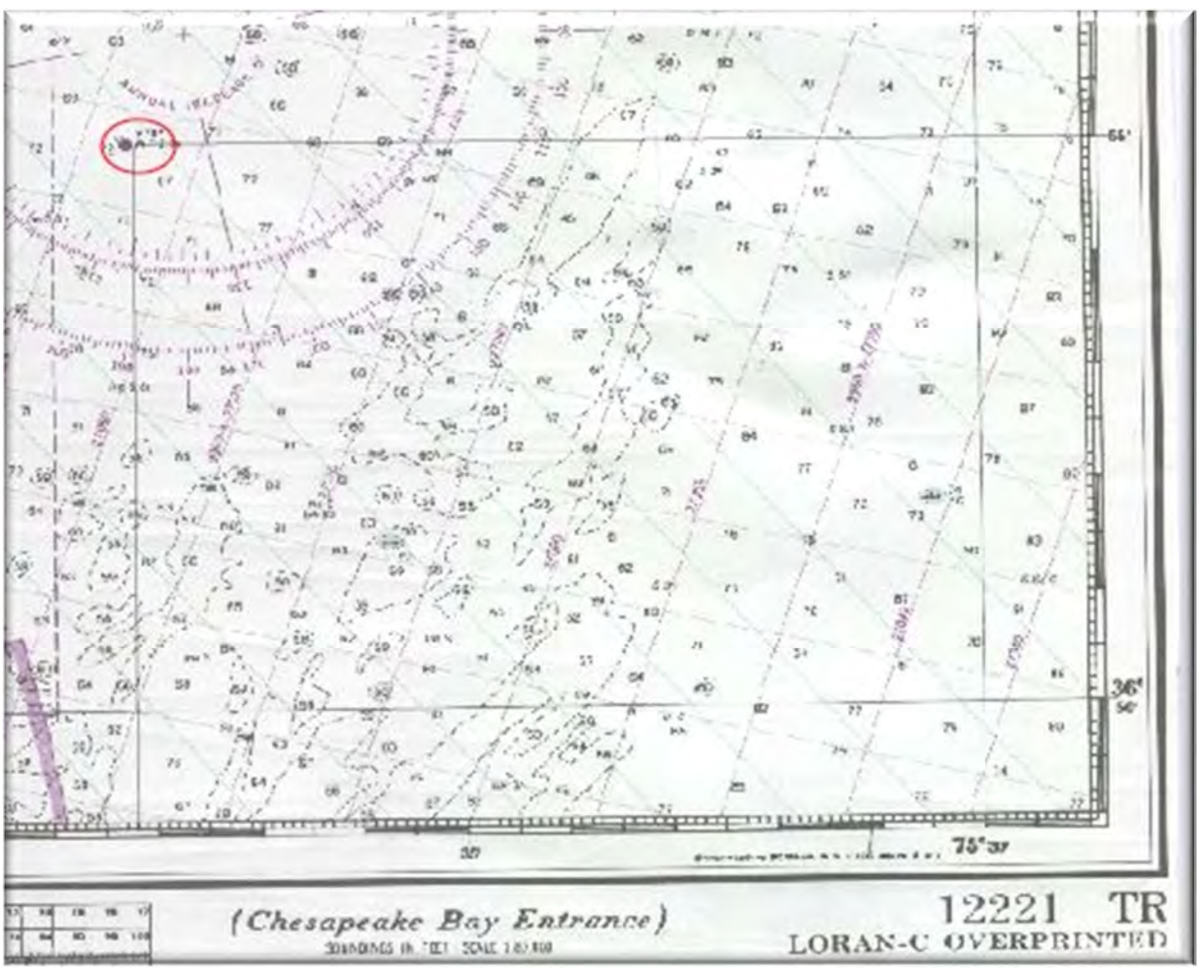
The space between 37°00' and 37°10' is divided into 10 equal spaces each space therefore represents 1' of latitude; these spaces are alternately colored light and dark to make them easy to see. The 1' spaces are further subdivided into 10 equal spaces each space therefore represents 1/10 th of a minute or 0.1'.

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 76° with further meridians at 10' on either side. There is no printed indication as to whether this is East or West longitude, but it is obvious, by inspection, that the longitude is West of Greenwich because the minutes of longitude are increasing moving in a westward direction. If the minutes were decreasing moving in a westward direction the longitude would be East.

With longitudes as large as 75°W this should not give rise to difficulties, but it is important to be aware of the change in longitude notation when using a chart close to, or centered on, 0° longitude such as when in the English channel for example. It is very easy to misread minutes of longitude under these conditions.

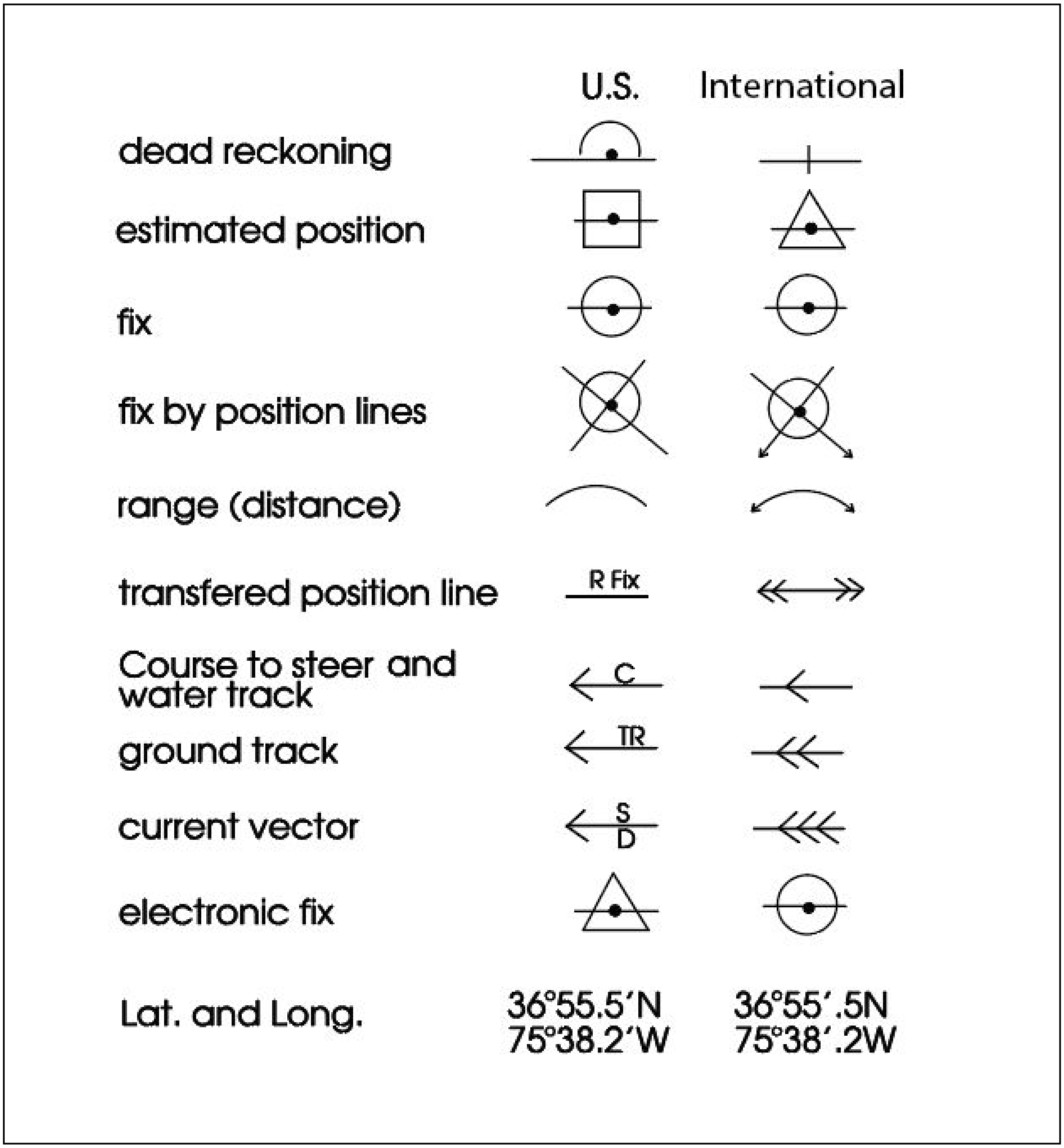
The position of the yellow buoy "A" to the north east of Chesapeake light on chart 12221 is 36°55'.0N 75°38'.2W.

Note that the convention is to give latitude first followed by longitude.

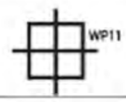
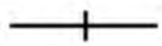
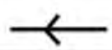


Chartwork Conventions

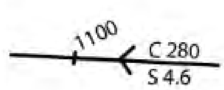
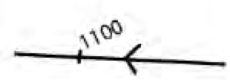
Symbols used in chartwork convey meanings of themselves. Different symbols are used in the U.S. and Internationally.



<u>Basic plotting symbols used for this course:</u>

	Fix
	Estimated position
	Waypoint (with optional naming)
	Dead Reckoning Position (DR)
	Visual Line of Position Arrow head points away from object
	Transferred (Advanced or Retarded) Line of Position
	Circle of Position
	Transferred (Advanced or Retarded) Circle of Position
	Course
	Course Made good or Intended Course (or Rhumb Line)
	Current

<u>Plotting Symbol Examples with Label – Lines of Motion Scale</u>

Plotting standard with optional labels and values	Description	Plotting Standard to be used in conjunction with log entry details
	Course to steer showing course and speed in knots to one decimal place. Arrow head indicates direction of travel. DR indicated by short vertical line and time at an angle.	
	Course made Good and Speed made good. Arrow heads indicate direction of travel.	
	Current Set and Drift. Arrow heads indicate direction of Set.	

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.

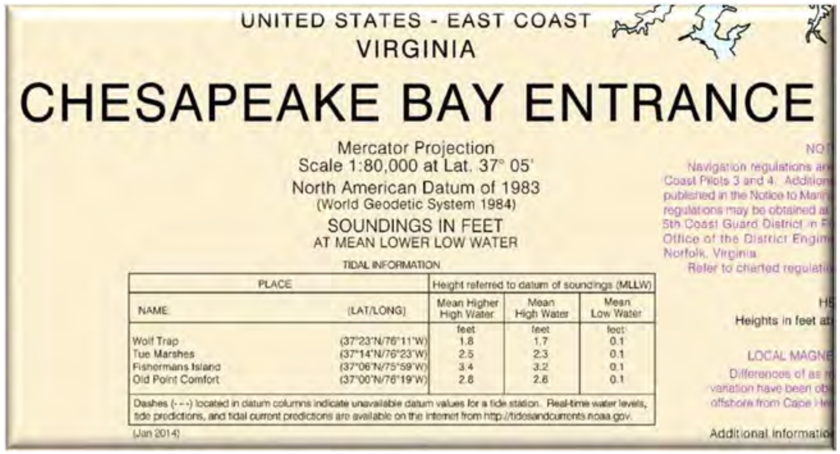


Chart 12221 Scale is 1:80,000 which means that one unit (a foot) of measurement on the chart represents 80,000 units on the surface of the earth.

Units of Measurement

Most NOS charts use either fathoms or feet for soundings or measurement of depths on the chart (1 fathom = 6 feet). Heights of objects above water such as lighthouses, bridges and overhead obstructions are then also given in feet.

The soundings on chart 12221 are in feet; therefore, a figure of, say, 23 on the chart means that there are 23 feet of water from the sea surface to the seabed at this place on the chart. When the soundings are in fathoms depths of less than 1 fathom may be given as fractions of a fathom, thus: 1¼ (= 7'6") ½ (= 3') ¾ (= 4'6") or as fathoms and feet, thus 32 (=3 fathoms 2 feet) but heights above sea level of lights and obstructions will still be in feet.

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

Be extra careful when changing from a small-scale passage chart with soundings in fathoms to a large scale inshore chart with soundings in feet - there is a serious difference between 2 fathoms and 2 feet as there is between 2 meters and 2 feet.

NGA (Formerly DMA, NIMA) nautical charts, European charts and US charts based on foreign surveys for the most part use the metric unit of meters and tenths of a meter for both depths and heights. NGA metric charts will carry the words SOUNDINGS IN METRES in purple print on the upper and lower margins as well as in the title.
1 meter = 3 feet 3 inches or, as a rough guide, 2 meters = 1 fathom.

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

Chart Number

The reference number of the chart, e.g. 12221 on the Chesapeake Bay practice chart. These reference numbers are not always consecutive for adjoining charts.

In the U.S. the chart numbers convey certain information. 5-digit chart numbers are used for charts which have a scale of 1:2,000,000 or larger. This includes most charts used in yacht navigation. The first digit indicates that the chart is in one of 9 regions of the world; region 1 includes most of the U.S. and Canada. Region 3 covers Greenland, Iceland and some of Europe including the British Isles, Ireland, Holland, Belgium and the Atlantic coasts of France and northern Spain. The next digit further narrows down the area of the chart to a sub region. For example, the practice chart of Chesapeake Bay is numbered 12 221 indicating that the chart is in world area 1 (U.S.) and in the sub region, 2, on the part of the east coast that includes Chesapeake Bay. The final three digits, 221, are used to number, in an anti-clockwise direction, each of the charts of the sub region. The numbers are not necessarily consecutive as numbers have been left unallocated to allow the insertion of new charts at a latter date.

Adjoining chart numbers are given in the top, bottom and left margins; i.e. chart no. 12207 is the next chart to the south of 12221.

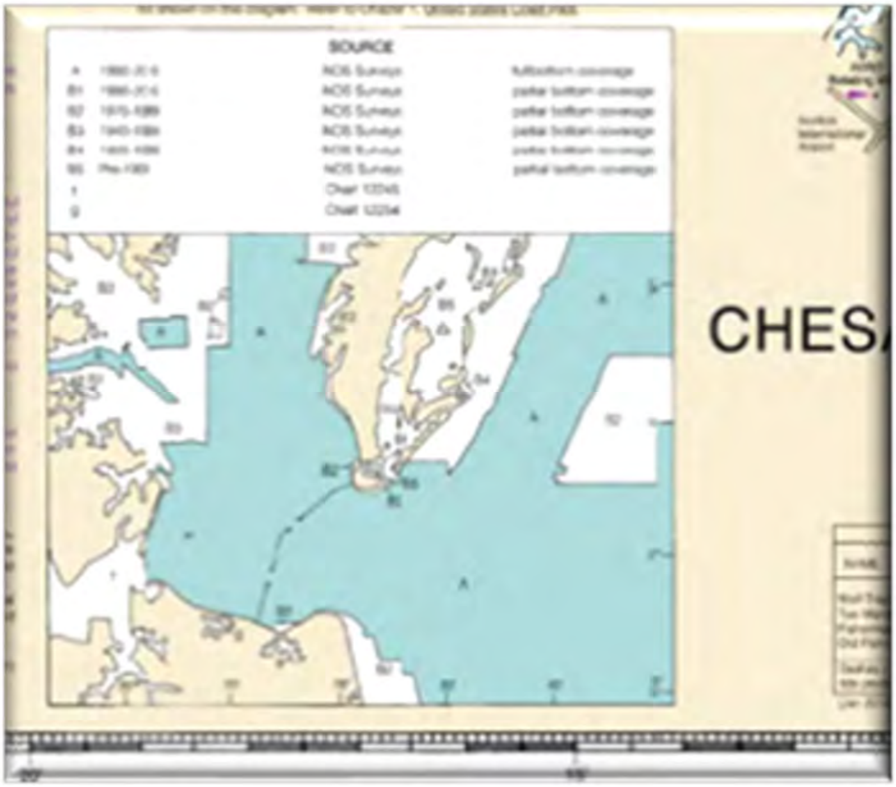
Source Diagram

Some charts may have a source 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. The white 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.

The source diagram on NOS chart No. 11470 of Fort Lauderdale, for example, shows that the surveys on which the chart is based were carried out by NOS, the Corps of Engineers and miscellaneous surveys between 1928 and 1995. The practice chart 12221 does not have a source diagram.

In general, it is reasonable to presume that areas which experience heavy concentrations of commercial shipping and yachting are unlikely to have any undiscovered hazards. 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.

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....".



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 a later section.

Horizontal Geodetic Datum

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.

On practice chart 12221 the datum is given as North American Datum of 1983 (NAD 83) with World Geodetic System 1984 in brackets. 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.

<u>But remember that practice charts must not be used for navigation.</u>

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).

Datum of Sounding

Mean Lower Low Water (MLLW)

In areas effected by tides the actual depth of water at any place must 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.

The Datum used on chart 12221 is given as MEAN LOWER LOW WATER (MLLW).
'Mean' in this context means 'average', so MLLW is the average of the lower of the two daily tides of each day.

The tide tables for a locality use the same plane of reference as the largest scale chart available for that area. This datum (MLLW) is used for NOS tide tables and Reed's Nautical Almanac tide tables headed U.S. DATUM. Therefore, 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 tide table to the sounding on the chart for the area in question.

Therefore:
if the chart shows a sounding of 10 feet and the tide table gives 3.1 feet at that time the actual depth should be 10 + 3.1 = 13.1 feet,
if the chart shows a sounding of 10 feet and the tide table gives - 0.6 ft at that time
the actual depth should be 10 - 0.6 = 9.4 feet.

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

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.

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, powerlines, bridges and so on must also be measured from a suitable datum. If 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.

TIDAL INFORMATION

PLACE		Height referred to datum of soundings (MLLW)		
NAME	(LAT/LONG)	Mean Higher High Water	Mean High Water	Mean Low Water
		feet	feet	feet
Wolf Trap	(37°23'N/76°11'W)	1.8	1.7	0.1
Tue Marshes	(37°14'N/76°23'W)	2.5	2.3	0.1
Fishermans Island	(37°06'N/75°59'W)	3.4	3.2	0.1
Old Point Comfort	(37°00'N/76°19'W)	2.8	2.6	0.1

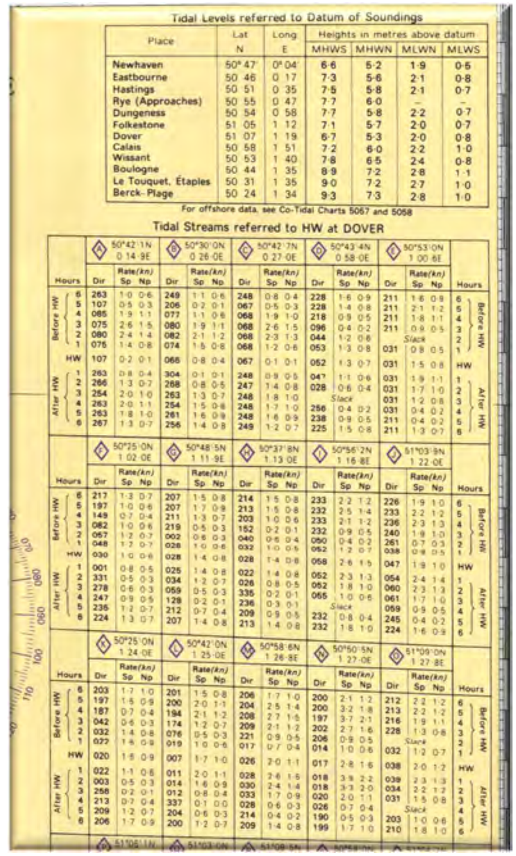
Dashes (- - -) located in datum columns indicate unavailable datum values for a tide station. Real-time water levels, tide predictions, and tidal current predictions are available on the Internet from http://tidesandcurrents.noaa.gov.

(Jan 2014)

The height of objects above sea level is taken from a datum referenced to High Water levels thus ensuring that there will usually (but not always) be at least the charted height shown beneath the obstruction. The datum for heights on U.S. charts is taken as being Mean High Water (MHW), unless noted otherwise. A box headed TIDAL INFORMATION, such as the one on practice chart 12221 just beneath the chart name, will indicate the height of MHW above chart datum.

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.

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

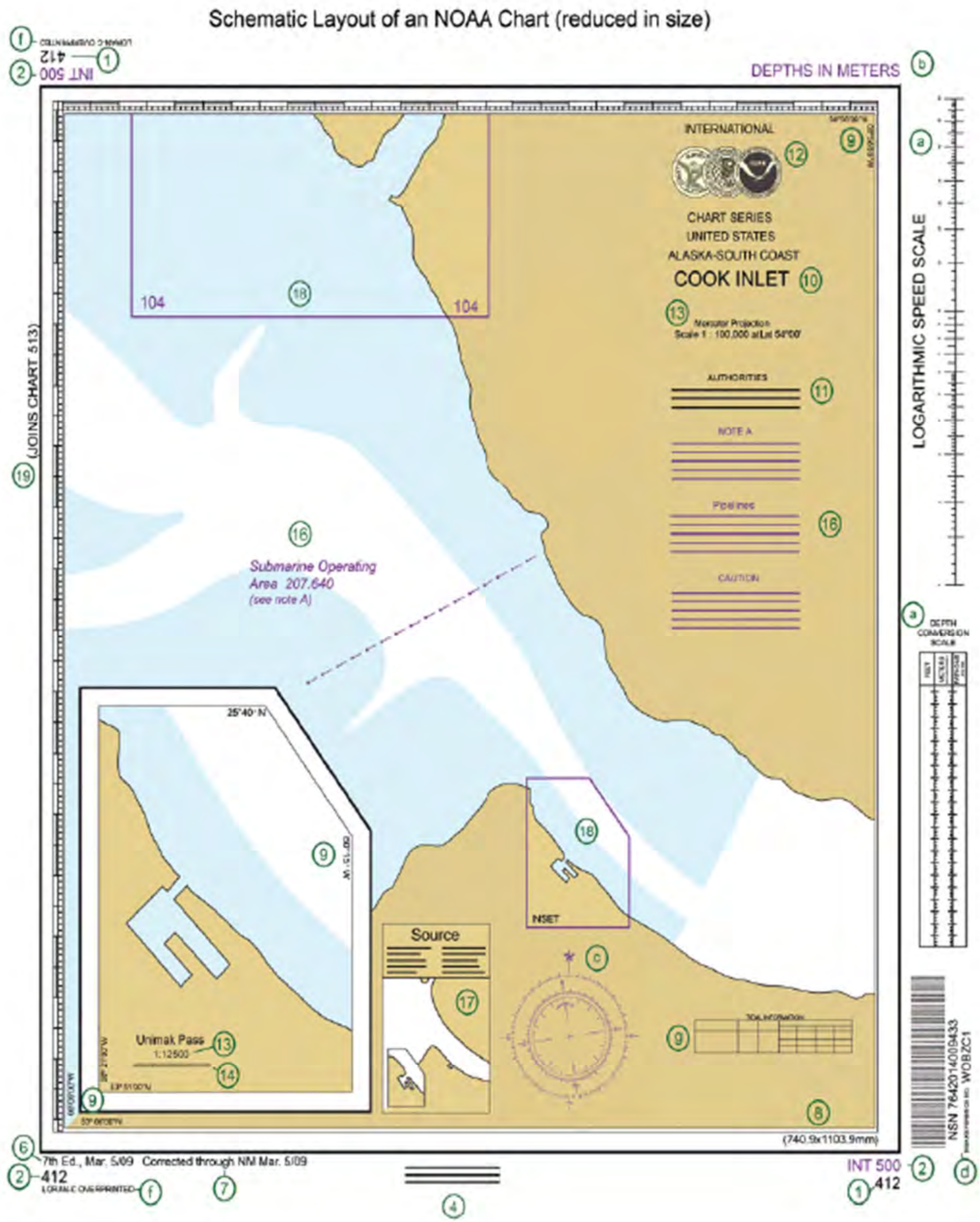
Admiralty Sailing Directions:

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)
DEPTHS IN METERS
INTERNATIONAL
CHART SERIES
UNITED STATES
ALASKA-SOUTH COAST
COOK INLET
Mercator Projection
Scale 1 : 100,000 at Lat 54°00'
AUTHORITIES
NOTE A
Pipelines
CAUTION
LOGARITHMIC SPEED SCALE
DEPTH CONVERSION SCALE
(JOINS CHART 513)
104
Submarine Operating Area 207.640
(see note A)
25°40' N
Unimak Pass
1:12500
INSET
Source
7th Ed., Mar. 5/09 Corrected through NM Mar. 5/09
412
INT 500
(740.9x1103.9mm)
NSN 7642014009433
WOBZC1

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 notes
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 durations 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.

Chapter 5 DISTANCE, SPEED, TIME AND DIRECTION

5.1 Key Objectives

THE OBJECTIVE OF THIS MODULE IS TO REVIEW SPEED, TIME AND DIRECTION AND HOW TO DEFINE A POSITION ON A CHART.

5.2 Distances

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, so 23.2’ of latitude is 23.2 miles.
- A ‘cable’ is a term still used sometimes in pilot books; a cable is 1/10 th of a mile, 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..

5.3 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.

5.4 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 EST (Eastern Standard Time).

If Daylight Saving Time, or summertime, has been applied this should be stated 2120 EDT (Eastern Daylight Time).

5.5 Distance – Speed – Time

The unit of speed is the "knot" which is one nautical mile (M) per hour. Hence if a yacht covers a distance of 5M in one hour she has been travelling at an average speed of 5 knots. Speed, time and distance are connected by the following formulae:

$$S = \frac{D}{T} \qquad T = \frac{D}{S} \qquad D = S \times T$$

<u>The application of each of these is illustrated by the following examples.</u>

1. A yacht's log indicates a distance of 10.3M travelled in 2 hours 30 minutes. What was her average speed through the water?

   You must always convert minutes of an hour into tenths or decimals of an hour by dividing the minutes by 60

   ANS: Convert 30 minutes to a decimal of an hour = $\frac{30}{60} = 0.5$

   Therefore time (T) = 2.5 hours.

   $S = \frac{D}{T} = \frac{10.3}{2.5} = 4.1$ Knots

2. A yacht's log indicates that she is maintaining an average speed of 6.5 knots. How long will it take her to travel a distance through the water of 15 M?

   ANS: $T = \frac{D}{S} = \frac{15}{6.5} = 2.3$ hours = 2 hours 18 minutes

Note: To change tenths of an hour into minutes you multiply by 60. In this case .3 x 60 = 18 minutes

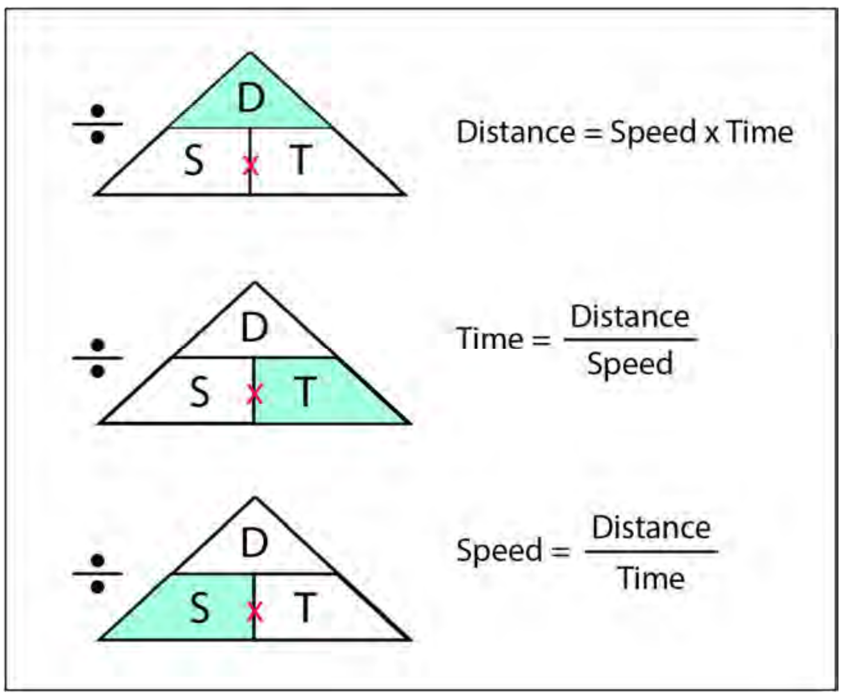
3. A yacht maintains an average speed of 7.5 knots for 3 hours 20 minutes. What distance through the water will she have covered?

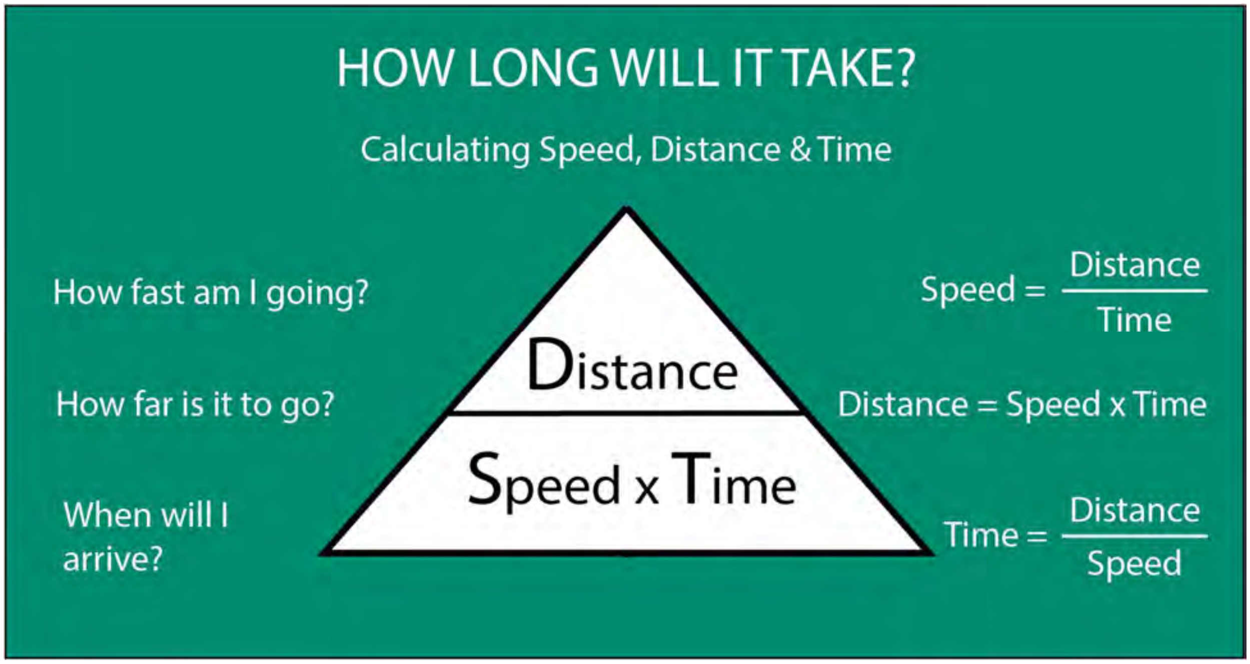
   First convert 20 minutes into a decimal of an hour 20 ÷ 60 = 33

   ANS: D = S x T = 7.5 x 3.33 = 25 M.

<u>Hot Tip.</u> *Want to know how long it will take to travel one nautical mile? Divide the number 60 by your sailing speed. Sailing at 4 knots? You'll cover one mile in 15 minutes (60 ÷ 4). Going 5 knots? It'll take just 12 minutes to sail one mile (60 ÷ 5).*

This triangle will help you remember Navigation Formulae for Speed, Time and Distance.





5.6 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, 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.

5.7 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, in the figure below the position at the yellow buoy, "A", is:

36° 55'.0 N 75° 38'.25W;
the position can also be defined as 079° (T) / 3.75 Miles from Chesapeake Light.

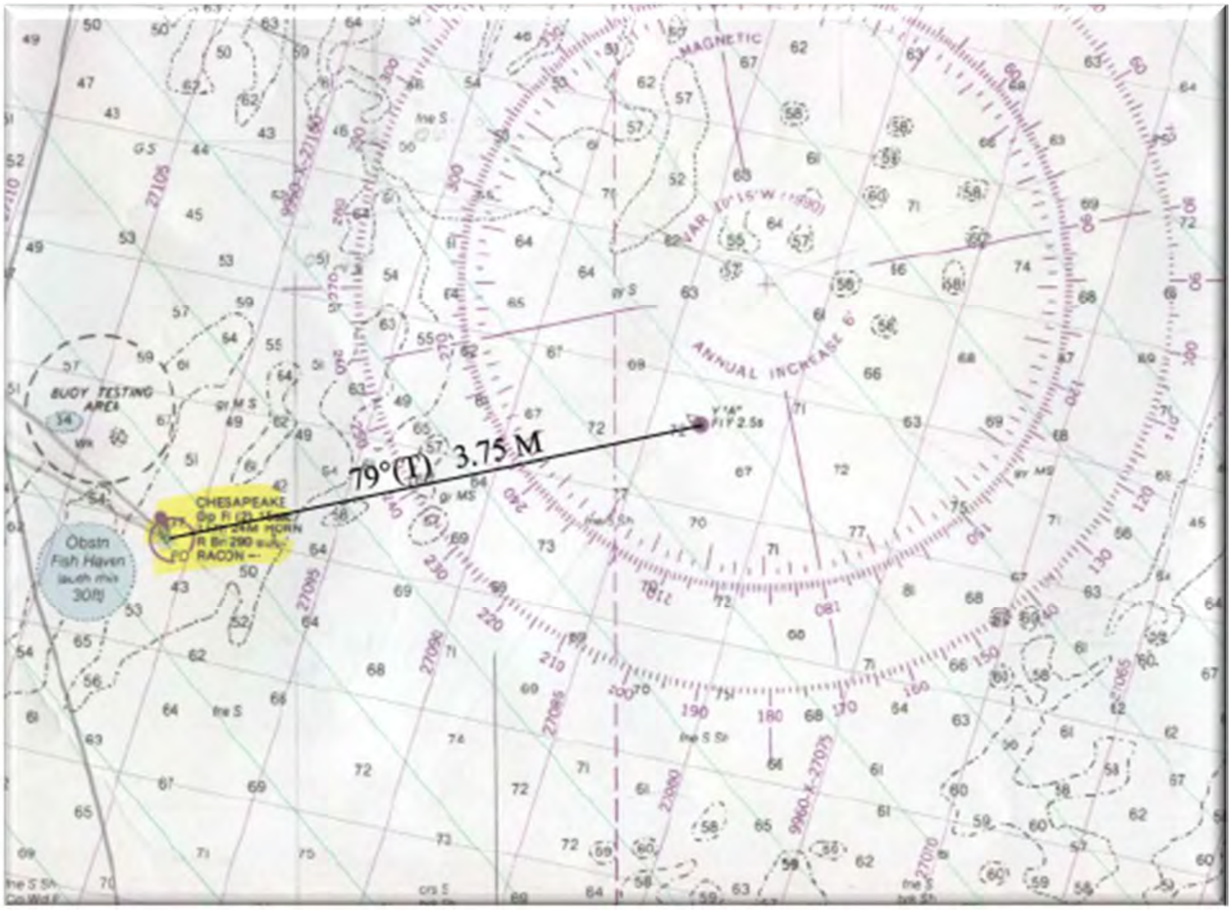


FIGURE 55 - POSITION BY BEARING & DISTANCE

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.

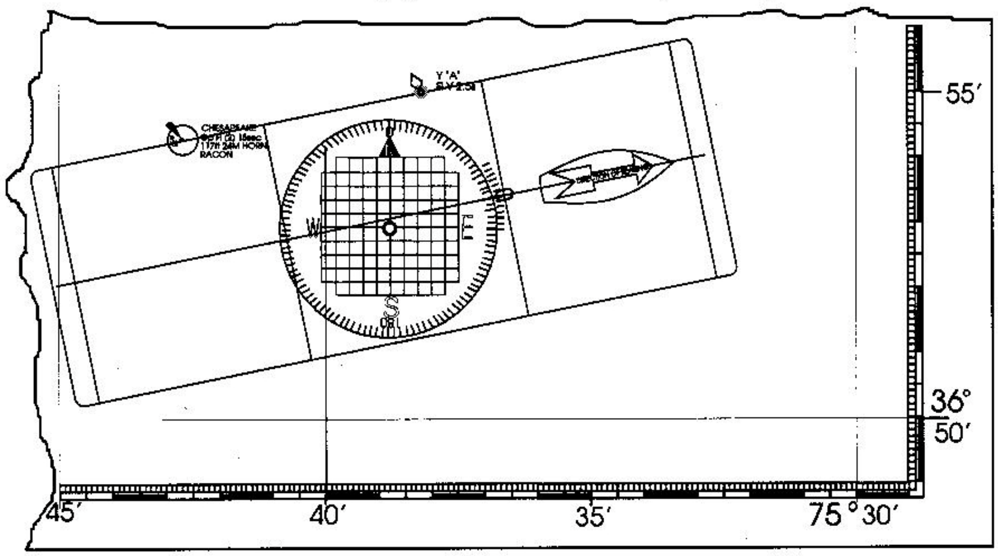


FIGURE 56

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.
Here the bearing from Chesapeake to buoy 'A' is 79° True.

5.8 ETA (Estimated Time of Arrival)

To estimate the time of arrival, use the following formula. Speed x Time = Distance. Therefore, Distance / Speed = Time and Distance / Time = Speed.

Examples:

Chapter 6 THE MAGNETIC COMPASS, VARIATION & DEVIATION

6.1 Key Objectives

THE OBJECTIVE OF THIS CHAPTER IS TO REVIEW THE MAGNETIC COMPASS AND HOW TO APPLY 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.

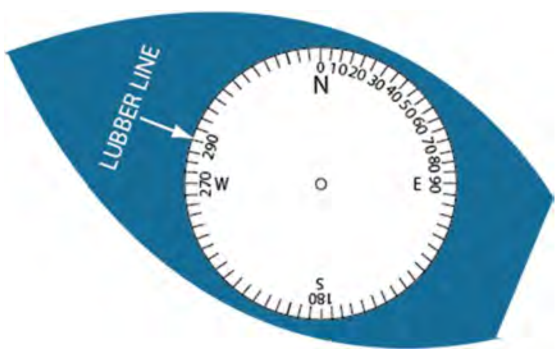


FIGURE 58
THE BOAT IS TURNED UNTIL THE LUBBER LINE (WHICH TURNS WITH THE BOAT) POINTS TO THE REQUIRED COURSE.

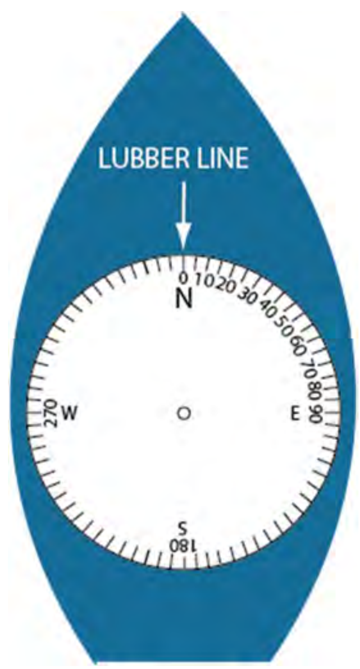


FIGURE 57
THE COMPASS ALWAYS POINTS TO NORTH

6.2 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.

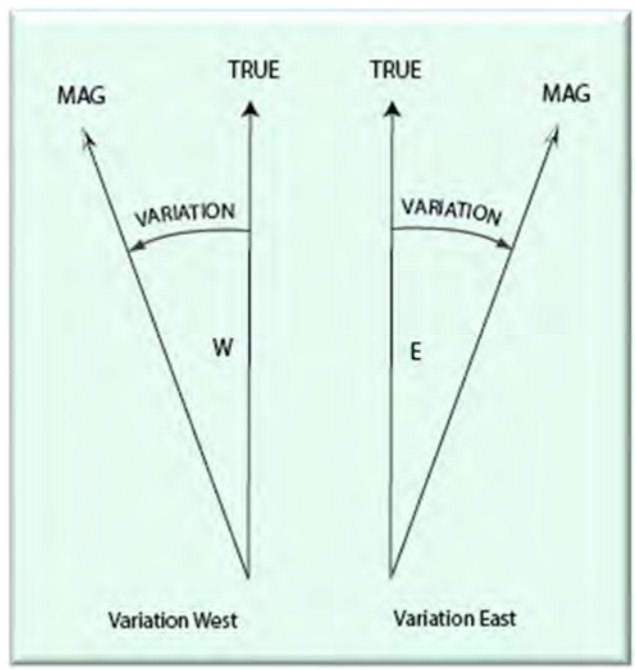
If you wished to get from Chesapeake Light to buoy 'A' the course to steer would be 79°(T). The boat is turned until the compass indicates that the boat is pointing 79°(T) and is held on this course until buoy A is reached.

6.3 Bearings

A compass can also be used to determine your position by taking bearings of visible charted objects. To do this a handheld, 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.

6.4 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. At present magnetic north is off to the west of True North when measured from much of the east coast of America. 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.

6.5 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 in use is shown on the chart. If you look at the compass rose (which looks like a protractor printed in magenta ink) centred about 4½ miles north east of Chesapeake light on the practice chart you will see 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 magnetic rose note the arrow drawn through it representing the direction of magnetic north, printed over this arrow is “VAR 10°15’W (1990) ANNUAL INCREASE 6’ ”. The first part means that the variation in 1990 for this area was 10°15’W. ANNUAL INCREASE 6’ means that the variation in this area is increasing by 6’ each year, that is to say the variation is changing 6’ in a westward direction annually.

From this information it is possible to work out the variation for any year. For example, suppose you wished to find the variation near Chesapeake Light for 2000:

 2000
-1990
= 10 Years 10 x 6’ = 60’ increase in variation
 10°15’W
 + 60’W
 11°15’W

This means that on this area of the chart the variation during 2000 is 11°W, to the nearest whole degree.

From the diagram you can see that if you wished to sail true north (000°T) when in the area covered by chart 12221 you would actually have to steer a magnetic course of 011°, written as 011°(M), the capital M in brackets indicating that this is a magnetic bearing.

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.

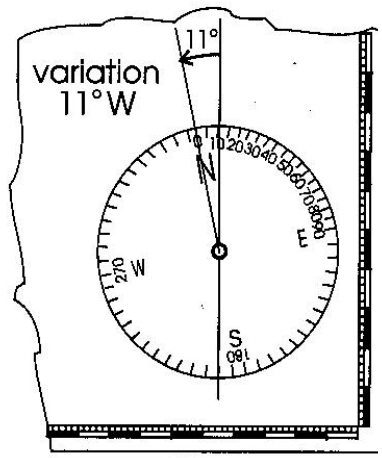
When to Apply Variation

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.

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'

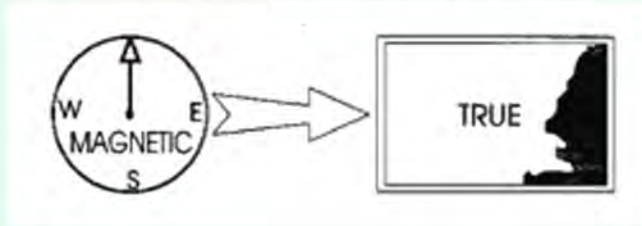
'Best' here means biggest or larger number, least means a lesser or smaller number. What the rhyme is saying is 'if the variation is west then the compass reading will be larger than the true reading, or, if the variation is east then the compass reading will be smaller than the true reading'.

Examples of correcting True bearings to Magnetic bearings:

Correcting True Bearings to Magnetic

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;



Correcting Magnetic Bearings to True

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

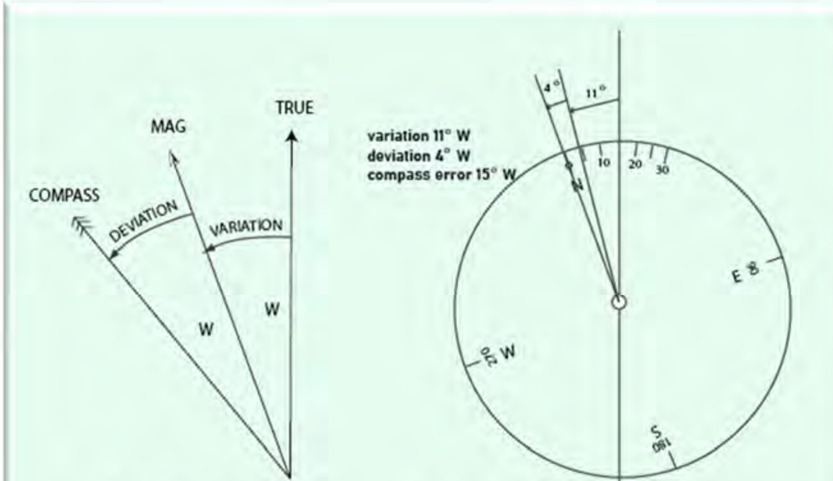
The True course to steer from Chesapeake Light to buoy 'A', from the chart, is 79°(T) but if you steered 79° by the compass you would not be going in the right direction.

T	V	M
79°	+11°W	=90°

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.



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)

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).

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 affected 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. Motorboats 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, at the beginning of the season and whenever any new equipment has been fitted which might cause deviation. Deviation should also be checked on a new, chartered, or borrowed boat.

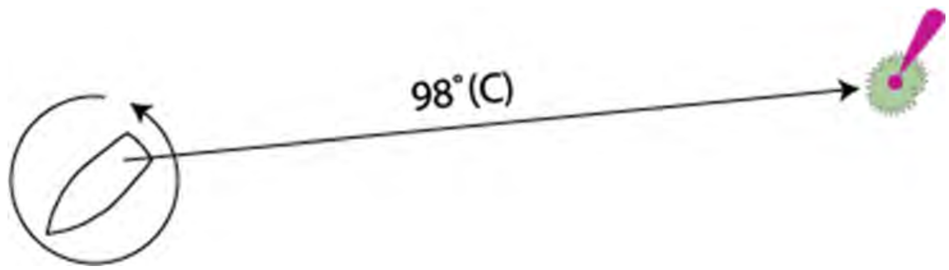
Using A Hand Bearing Compass to Check for Deviation

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 affected by deviation.
- If the bearing to the object changes as the boat turns the compass is being affected by magnetic influences on the boat, try another site and repeat the process.



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 range, ahead or astern. The true bearing of the range 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.
To check for deviation using a range:

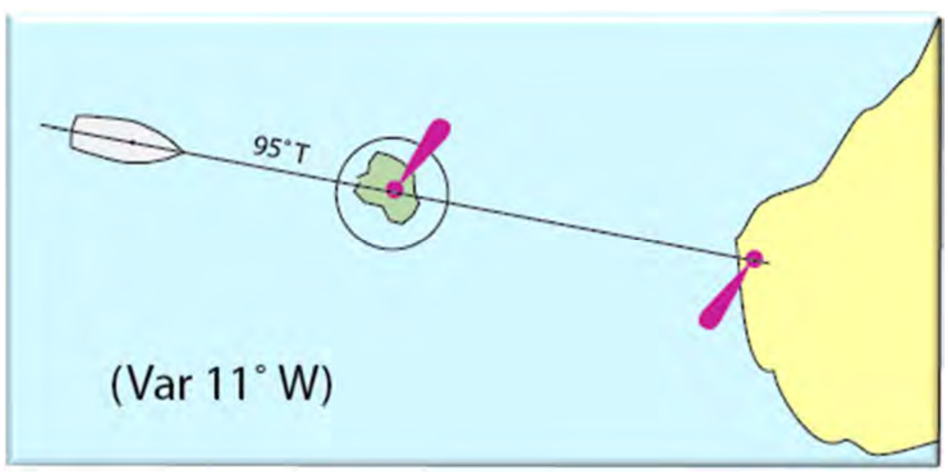


FIGURE 59

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 range is found from the chart.

If the steering compass has deviation, there are various options.

- 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 ships headings and draw them up in the form of a graph (called a deviation card) which is kept onboard so that deviation can be found quickly for any heading. This process is known as swinging the compass, on commercial vessels the steering compass has to be check by an approved compass adjuster. The time frame for this process will be found in the survey documents for the vessel.
- A note of interest, STCW'95 convention requires owners and masters each have responsibilities for ensuring that magnetic compasses are maintained in good working order.
- The performance of the compass should be monitored and, for a vessel more than 100GT, deviations recorded in a compass deviation book at regular intervals, ***ideally at least once every watch and also shortly after a large alteration of course, standard and gyro compasses are frequently compared, and repeaters are synchronised with the master compass.***

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:

Chesapeake Light to A	79°(T)
Variation 11°W	11°(W)
Magnetic	90°(M)
Deviation 4°E	4°(E)
Course to Steer (Compass)	86°(C)

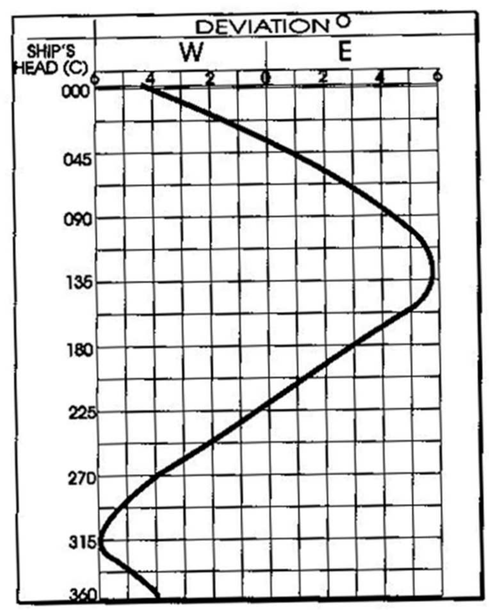


FIGURE 60 - TYPICAL DEVIATION CARD

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, take the figures from Figure 55 - Position by Bearing & Distance and deviation from the deviation card in Figure 60 - typical deviation card.

- The true course, 79°(T), from Chesapeake Light to buoy "A" is found from the chart and entered under True.
- The variation, 11°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 79° + 11° = 90°.
- The deviation from the deviation card is approximately 4°E (compass least).
- Therefore, compass course is 90° - 4° = 86°(C).

True	Var	Mag	Dev	Compass
79°	+11°W	=90°	4°E	=86°

Long Passages

Note that deviation, if it exists, will change during a long passage.

Examples of Corrections for Variation and Deviation

Try to determine answers				
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°	4W°			
004°	4°E			
182°	15°W			
098°	7°E			
359°	6°W			
B) Correcting from magnetic to true				
MAG	**VAR**	**TRUE**		
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.				
TRUE	**VAR**	**MAG**		
075°	4°W	079°		
039°		036°		
246°		235°		
137°		149°		
200°		202°		
359°		004°		
Answer key at end of course; please try to work these out without referring to the answer key				

Try to determine answers				
D) Try these				
T	**V**	**M**	**D**	**C**
256	5W		6W	
096	7W			098
061		064		060
	3E	307	9W	
	5E	022		019
	7W	359	0	359
Answer key at end of course; please try to work these out without referring to the answer key				

Chapter 7 POSITION LINES AND POSITION FIXES

7.1 Key Objectives

THE OBJECTIVE OF THIS CHAPTER IS TO EXPLAIN THE VARIOUS WAYS OF OBTAINING YOUR POSITION AT SEA EVEN WHEN MODERN DAY ELECTRONIC POSITION FIXING EQUIPMENT IS BEING USED.

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 Loran or 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.

7.2 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 manmade 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.

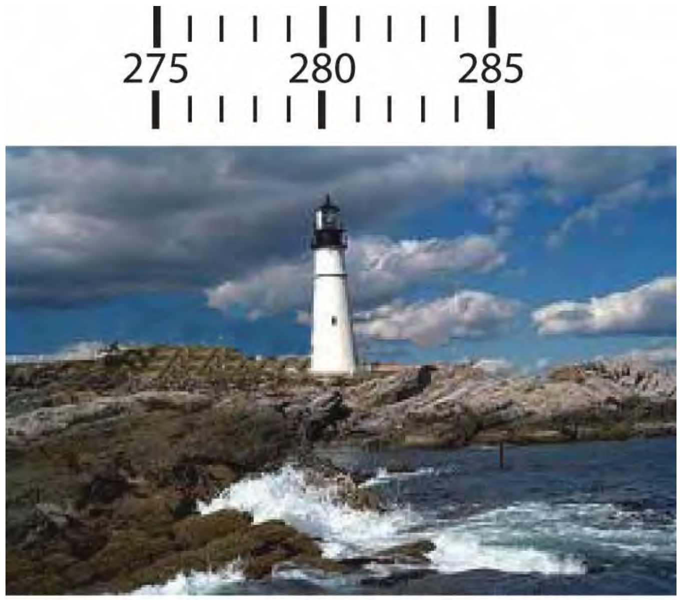
7.3 Visual Position Lines

A position line can be obtained by taking a bearing of an object with a hand bearing compass.

FIGURE 61
HAND BEARING COMPASS

Other types of handheld compass are available including an electronic type which shows the magnetic bearing in digital form on a small 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 hand bearing compass was used from a deviation free position on the boat.



Take a bearing of a light house using a hand bearing compass. In the picture the bearing to the light house from your position on the boat is 280° (C).

Using the Breton plotter to plot the bearing on the chart.

First correct the compass bearing to true:

True	Var	Mag	Dev	Compass
269°	11° W	280°	0°E	280°

The true bearing is therefore 269°(T).

1. Turn the protractor until 269° is opposite the 0-mark engraved on the plotter body and from now on do not move the protractor disc from this position.

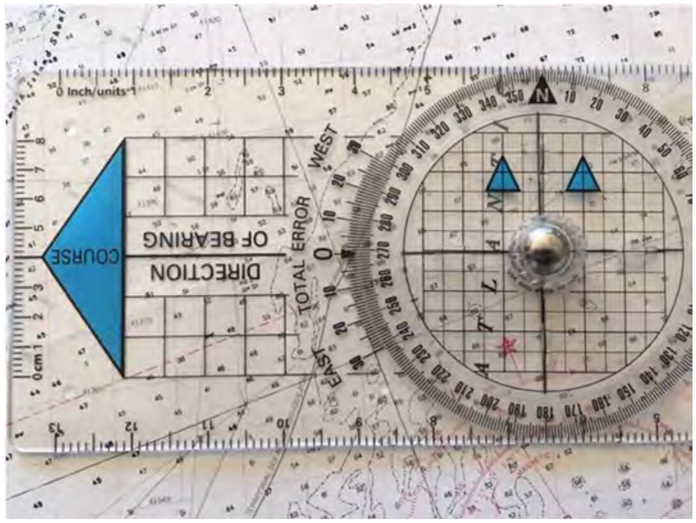


FIGURE 62 - PROTRACTOR DISC SET TO 269°

Put the plotter on the chart so that one edge is on the object from which you obtained the bearing - Chesapeake light in this case.

2. 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.
3. To ensure the plotter is pointing exactly north move the whole plotter until any one of the engraved gridlines is parallel to any convenient line of latitude or longitude printed on the chart.

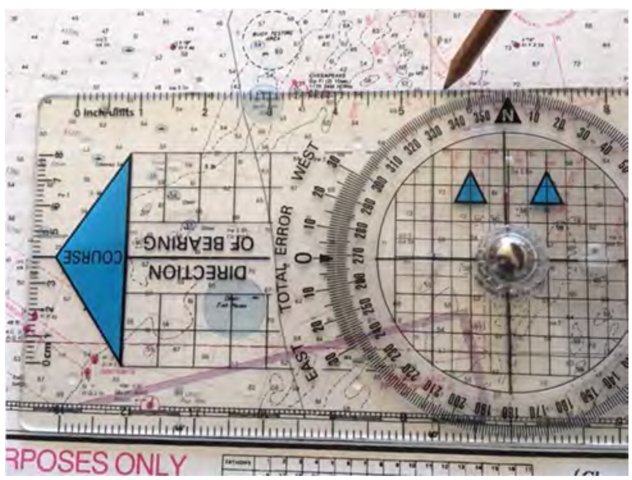


FIGURE 63

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.

7.4 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 Chesapeake Light you also found that the bearing from your position to the yellow buoy "A" was 005°(C).
Correct 005°(C) to True (365°- 11°W) = 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.

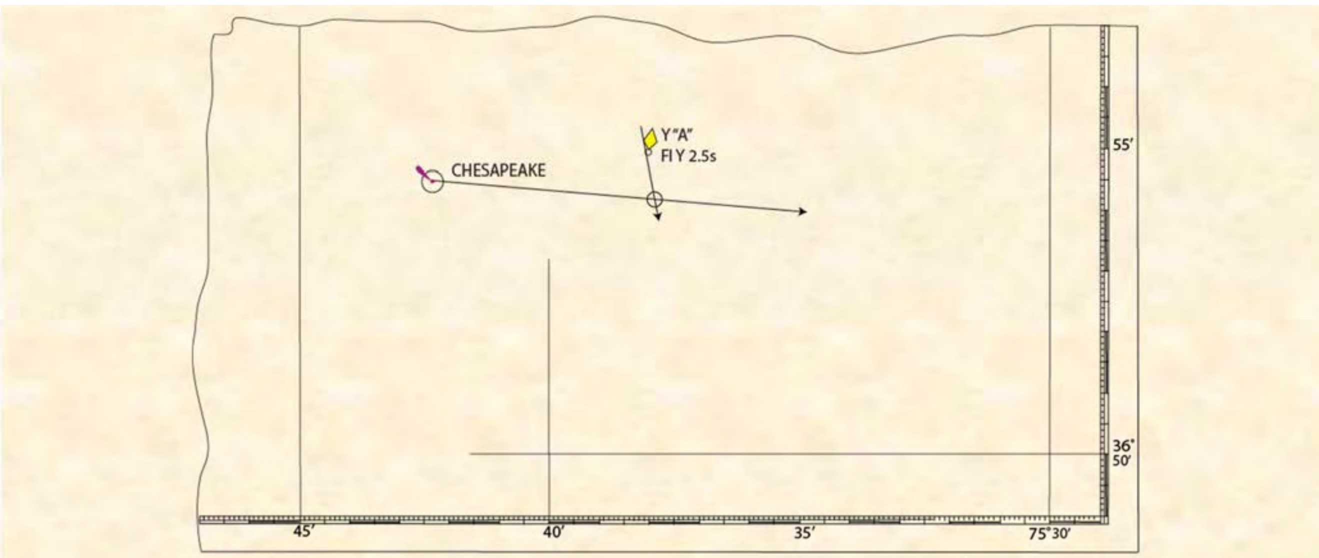
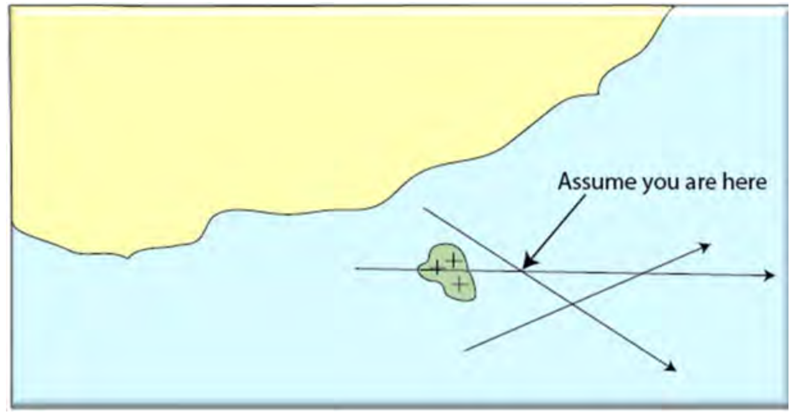


FIGURE 64 THE BOAT'S POSITION IS WHERE THE TWO POSITION LINES CROSS. THESE POSITION LINES HAVE AN ARROW DRAWN AT THE END TO INDICATE THAT THEY ARE POSITION LINES. THE POSITION FIX IS SHOWN ON THE CHART BY THE CIRCLE.

Whenever possible try to get a third position line as this will confirm your position or alternatively alert you to a possible error.

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.



7.5 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.

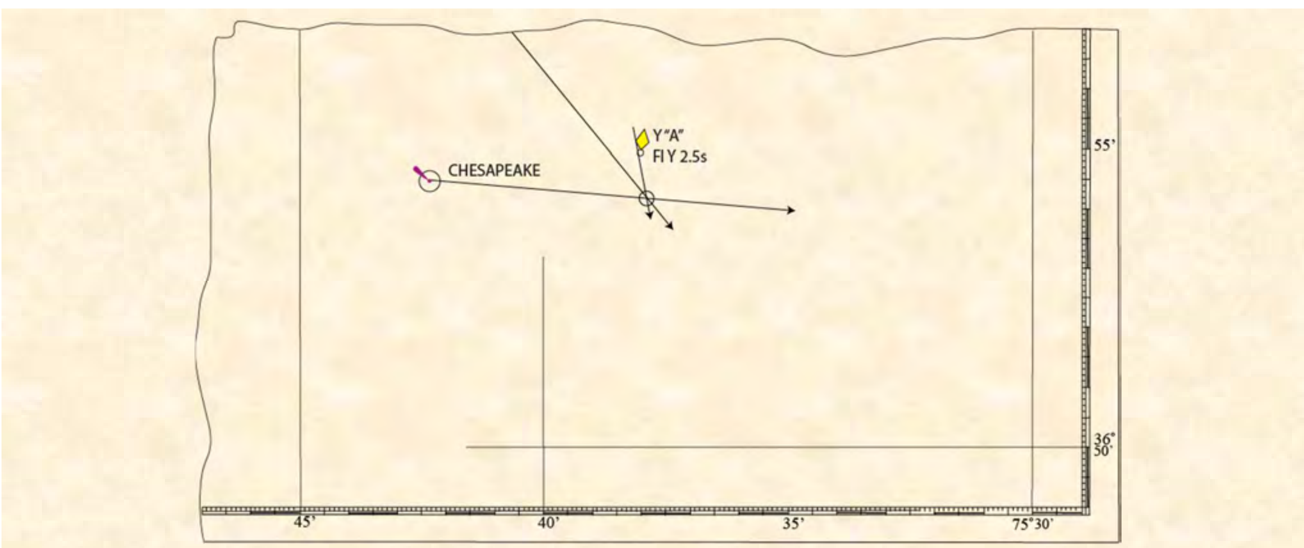


FIGURE 65 - THREE POSITION LINE FIX

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 ship'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.

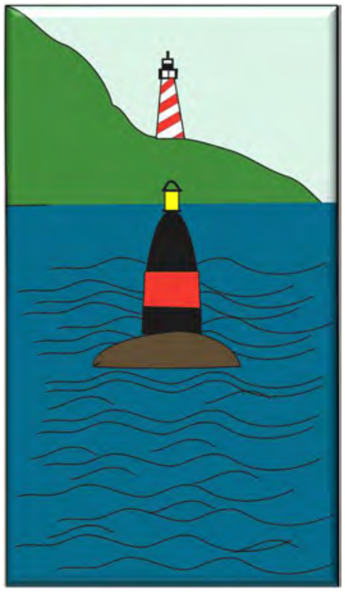
Sources of Bearings

- 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

7.6 Range / Transit

A range or transit occurs when two charted objects are seen by eye to be directly in line. A range can 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 range 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 range occurs, you will have a fix. This is easier with two people; one to watch for the range and the other to take the bearing of the third object when told to.



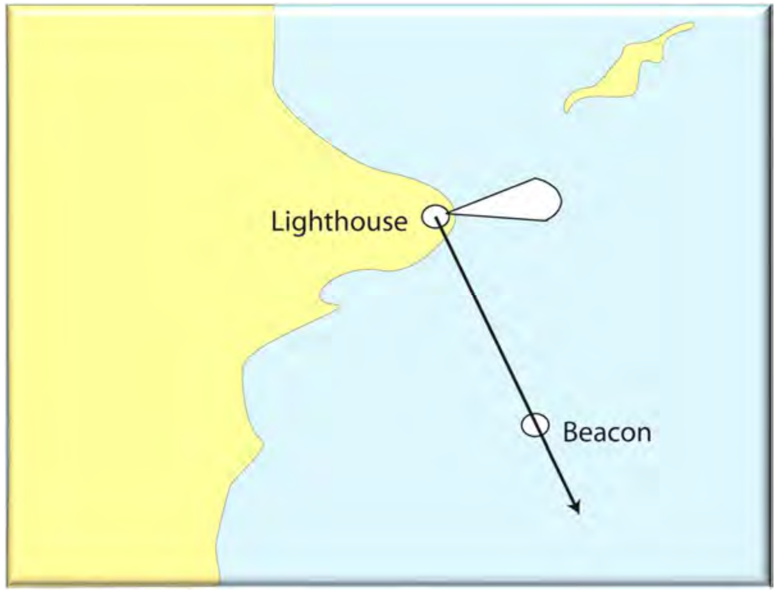


FIGURE 66 - A RANGE

AS IT IS SEEN FROM THE BOAT AS IT IS PLOTTED ON THE CHART

Fix by Range and Bearing

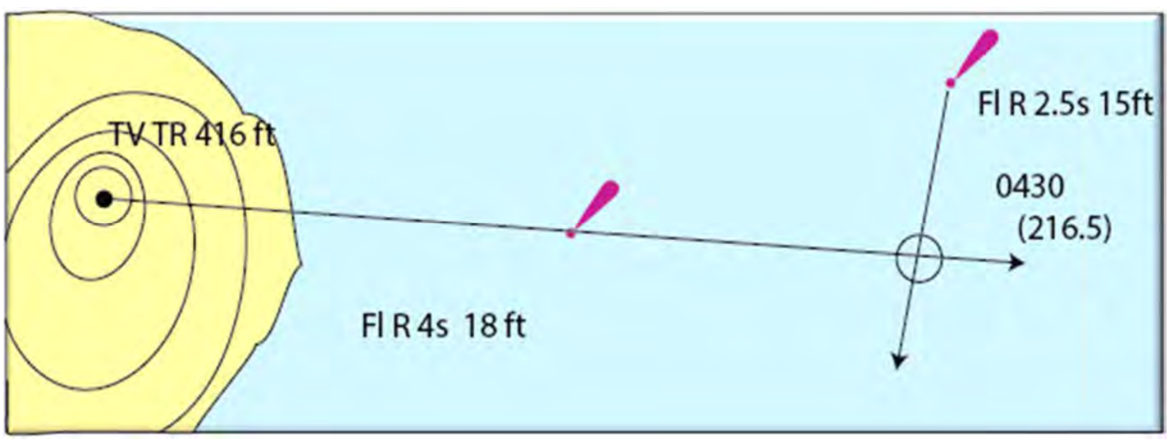


FIGURE 67 - A FIX BY RANGE AND SIMULTANEOUS BEARING OF LIGHT STRUCTURE. NOTE THAT A FIX SHOULD ALWAYS INCLUDE THE TIME AND DISTANCE LOG READING AT THE TIME OF THE FIX. TO AVOID CONFUSION THE LOG READING IS IN BRACKETS.

Sectored light

Some light houses have sectored lights. The light changing color 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 color does not necessarily signify danger - check on the chart.

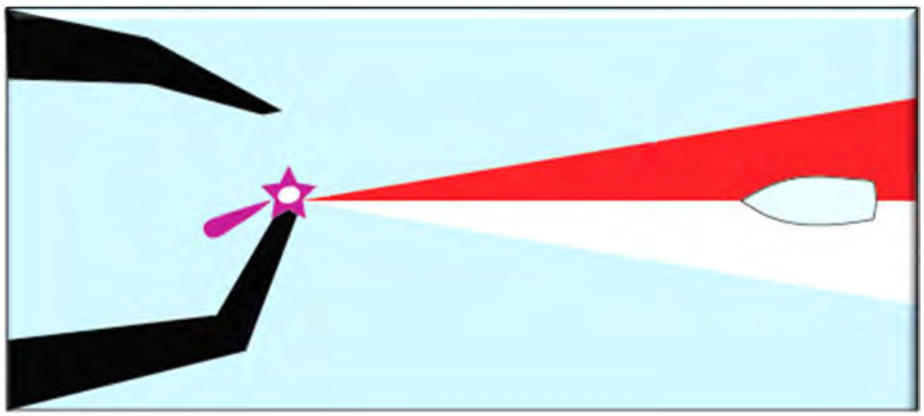


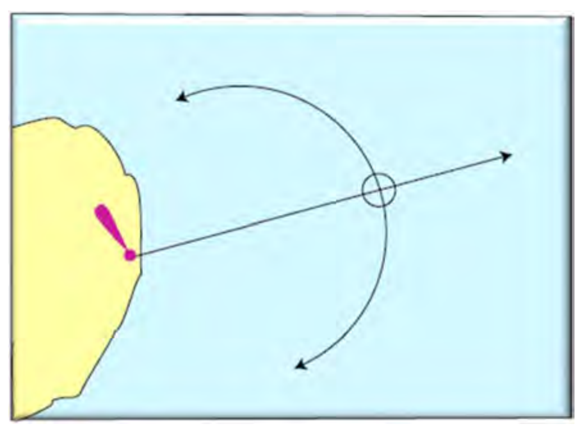
FIGURE 68 - POSITION LINE FROM SECTORED LIGHT

Clearly Defined Depth Contour

If the seabed shelves rapidly it may be possible to use a depth contour as a position line. The Great Machipongo Inlet is a possible example as the sea bed has definite contours. 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 centered 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 such as Reeds Nautical Companion. 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.

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

FIGURE 69

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 (usually Mean High Water) 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 ($\sqrt{\text{ht of light}}$ + $\sqrt{\text{ht of eye}}$) , when the heights and answer are in feet, or
2.072 x ($\sqrt{\text{ht of light}}$ + $\sqrt{\text{ht of eye}}$) , when the heights and answer are in meters.

A fix may be possible if a bearing to the object can be found using a hand bearing compass. A fix may also be possible 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, however, radar will measure distances accurately. Use radar bearings with great caution; compass bearings are usually preferable.

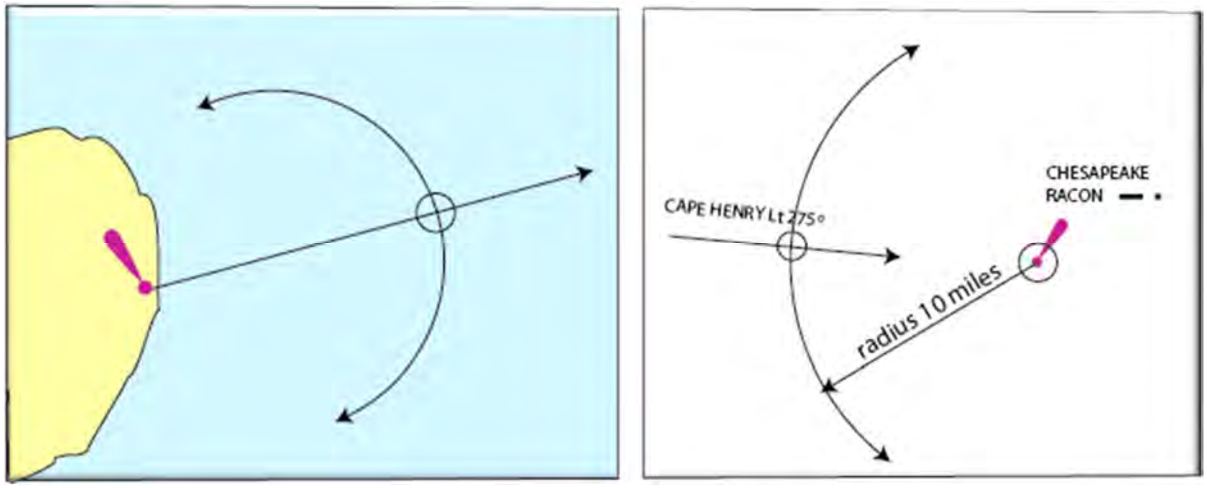
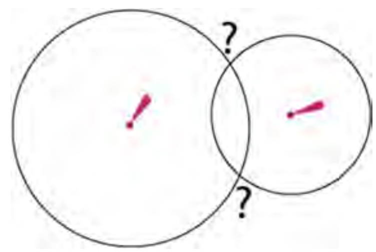


FIGURE 70 - FIX BY DISTANCE AND BEARING

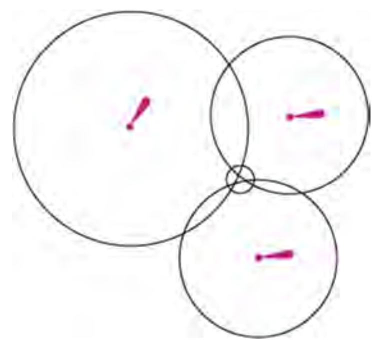
OF SAME OBJECT **FROM ONE OBJECT AND BEARING FROM ANOTHER**

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.

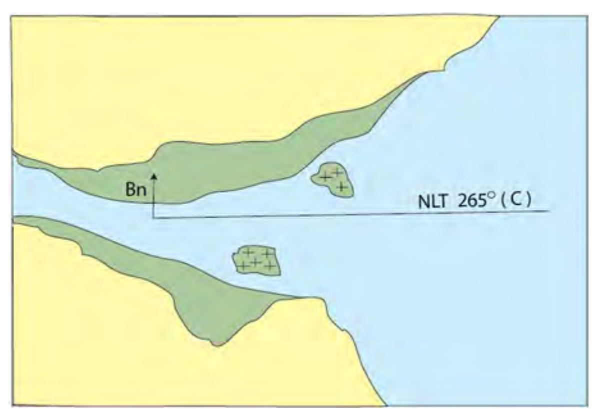
Using Three Position Circles



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.

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 harbor 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 range. 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; this is no time to be muttering about True Virgins.

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.

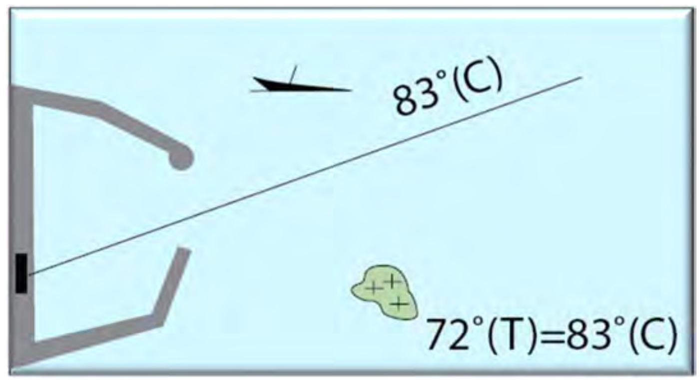


FIGURE 71
HERE A BACK BEARING OF THE END OF CONSPICUOUS BUILDING IS BEING USED TO AVOID HIDDEN DANGERS WHEN LEAVING A HARBOUR

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 NL or NM bearing.

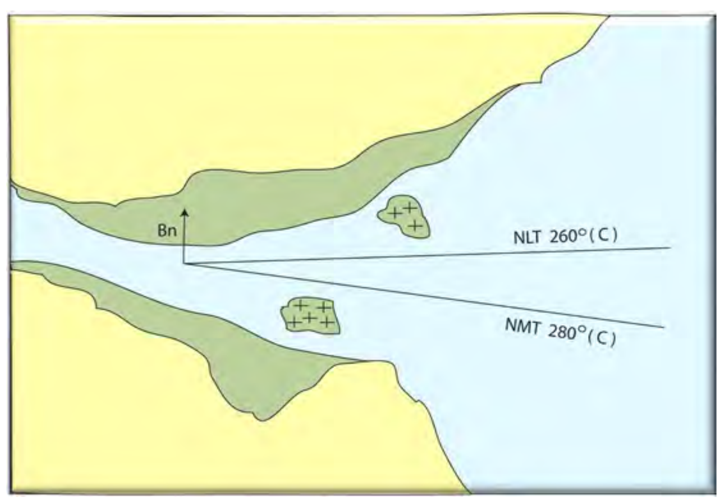


FIGURE 72
NOT LESS THAN 260° (C), NOT MORE THAN 280° (C)

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		Cape Charles lt.ho. 245° (T)
1000	50	185	Cape Charles lt.ho. 300° (T), current 0900 – 1000 = 215° (T) / 1knt

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) / 1Miles. (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.

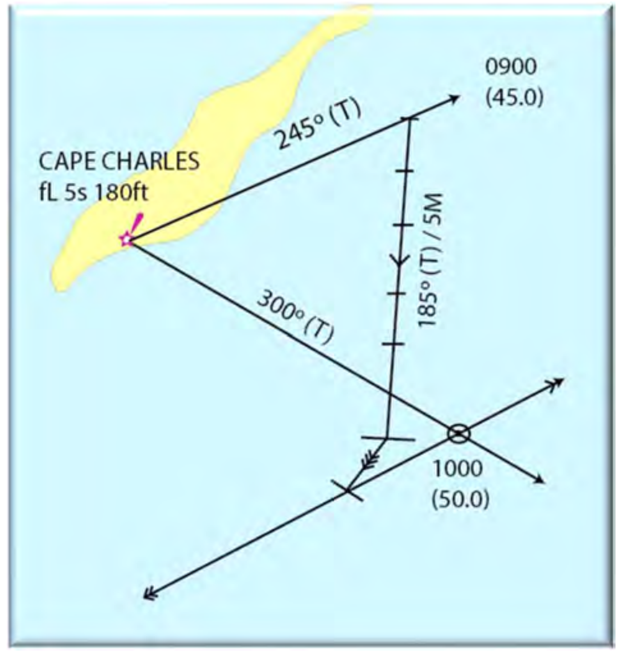
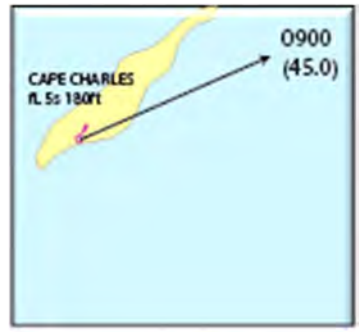


FIGURE 73 - POSITION AT 1000 FROM A FUNNING FIX

The running fix, step by step

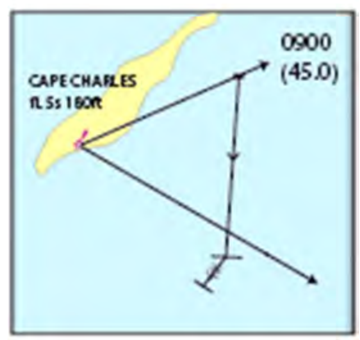
TIME	LOG	COURSE °T	REMARKS
0900	45		Cape Charles lt.ho. 245° (T)
1000	50	185	Cape Charles lt.ho. 300° (T), current 0900 – 1000 = 215° (T) / 1knt

1. Plot the first position line, 245°T to the light house



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

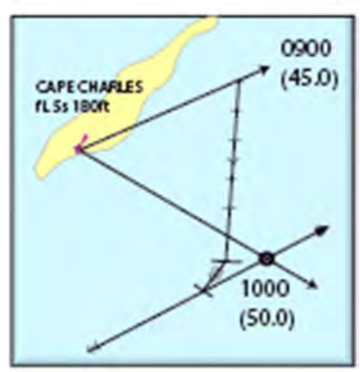


4. Plot the current vector 215°(T) / 1M. (Assumed for the sake of this example)

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			Cape Charles Lt. 245° (T) Poor visibility!
2200	150	185°	nil	Tank, Fishermans Island 295° (T), current 2100 - 2200 + 215° /1 knot

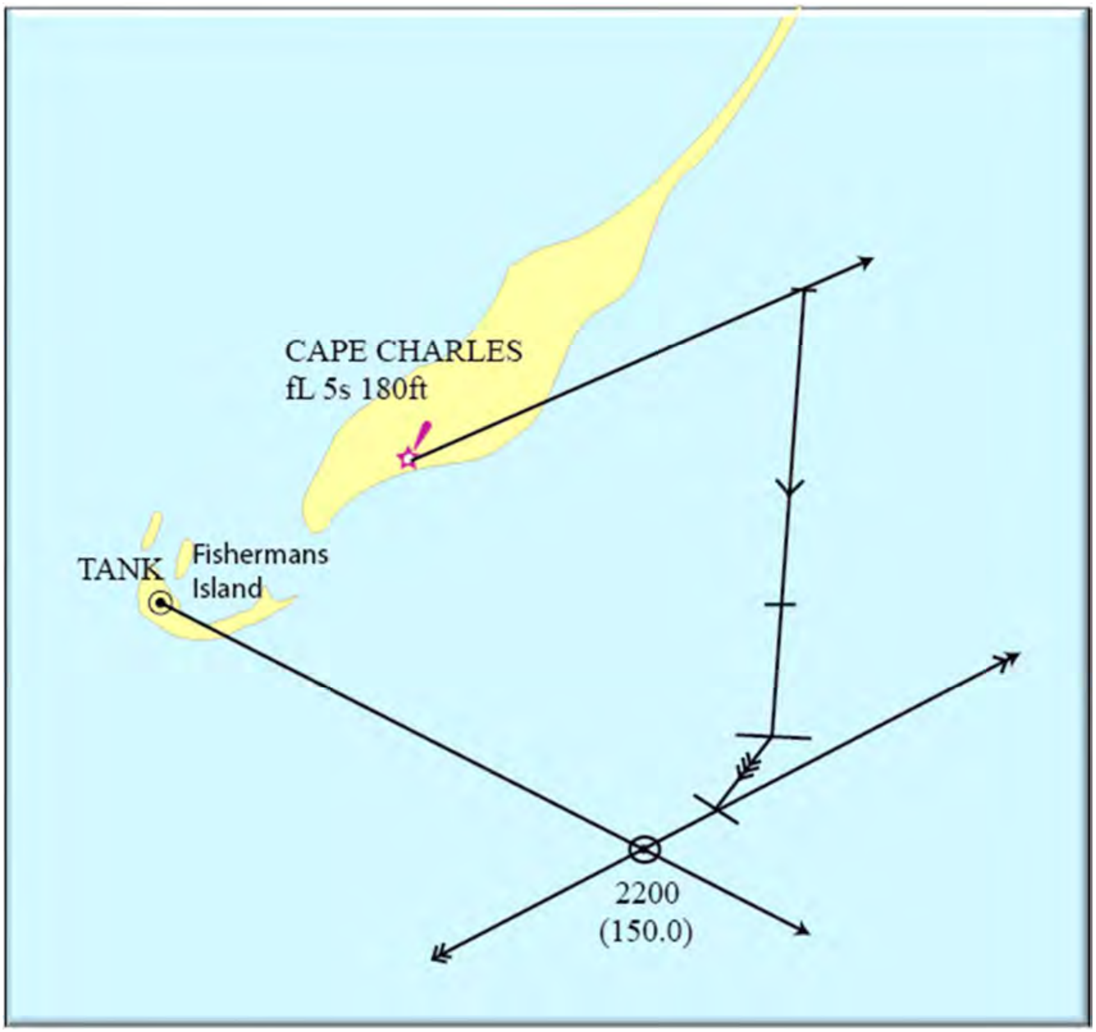


FIGURE 74

RUNNING FIX DERIVED FROM TWO DIFFERENT SOURCES: THE FIRST POSITION LINE IS FROM THE CAPE CHARLES LIGHT, THE SECOND IS FROM THE TANK ON FISHERMAN'S ISLAND

Chapter 8 DEAD RECKONING AND ESTIMATED POSITIONS

8.1 Key Objectives

THE OBJECTIVE OF THIS CHAPTER IS TO ENSURE CANDIDATES FULLY UNDERSTAND DEAD RECKONING, ESTIMATED POSITION, AND HOW TO DETERMINE ESTIMATED POSITION.

Dead reckoning (DR) comes from the term deduced reckoning which, in days gone by, used to be written as “ded. reckoning” in the ship’s logbook. 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.

8.2 Dead Reckoning Position (DR)

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 logbook. The distance travelled will be found from the ship’s distance log and should also be entered in the logbook. 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 logbook:

TIME	POSITION	LOG	COURSE° (C)	WIND
1300	36°54’.3.N 75°42’.8W	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.

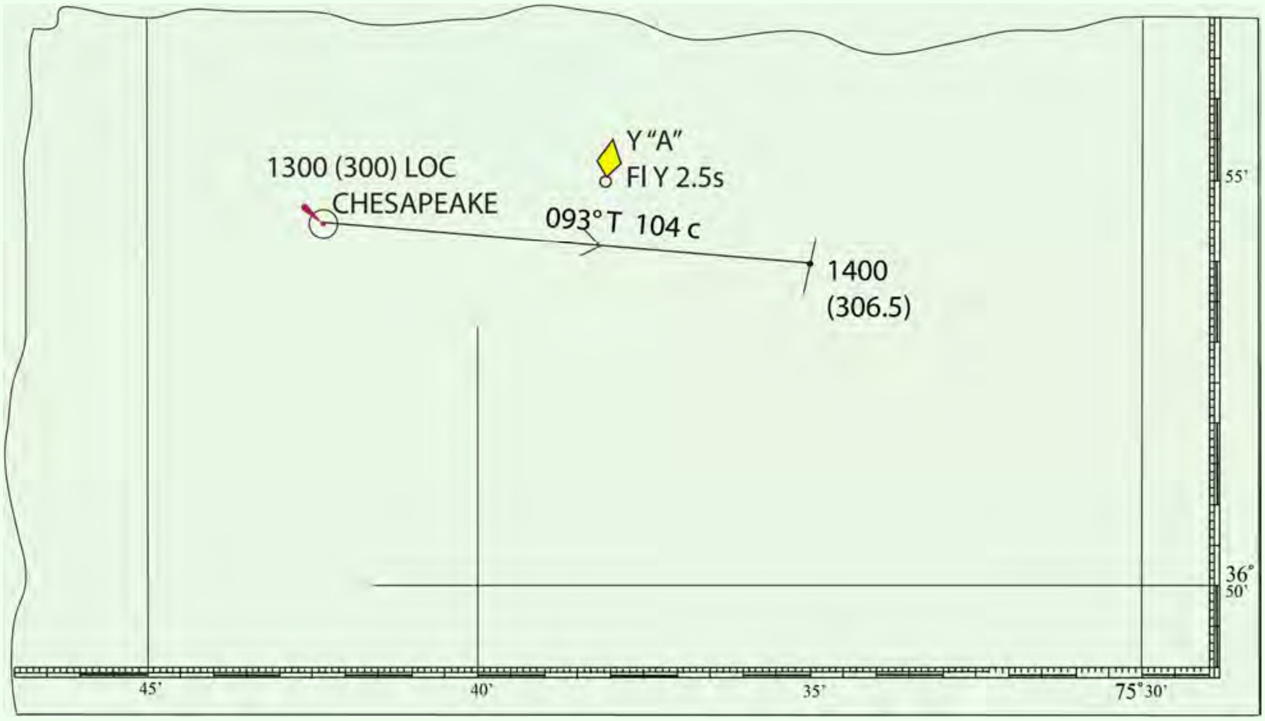


FIGURE 75 THE DR IS PLOTTED AND THE TIME AND LOG READING WRITTEN ON THE CHART

A position derived from dead reckoning is only really valid if:

- there is no current 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 a liar.

8.3 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. Current set and drift is the direction and distance the current has moved the water and hence the boat during the time involved in the EP. Current set and drift is found from Reed's Nautical Almanac or from current atlases if available. 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. Motorboats 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.

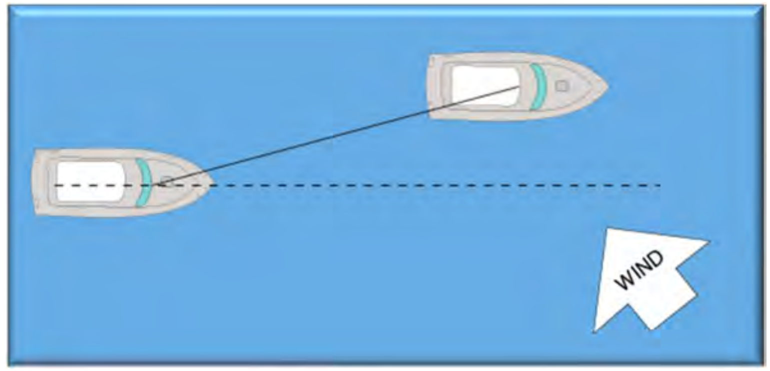


FIGURE 76 - LEEWAY

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 current vector (a vector is a line which has both direction and length) is drawn in the same direction as the current was moving and its length is the distance in miles the current 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 current was flowing 182°(T) at rate of 1.2 knots. This means that in 1 hour the current 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 logbook:

TIME	POSITION	LOG	COURSE° (C)	WIND	LEEWAY	CURRENT
1300	36°54'.3N 75°42'.8W	300	165°	NE 18	nil°	
1400		306.5	100°	NE 18	10°	182°/1.2M

Plot the yacht's position at 1400.

Do all the 'math' 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

Now, from the position at 1300

1. plot a vector 103°(T) / 6.5M, and then, from the end of this vector,
2. plot the current vector 182° / 1.2M.

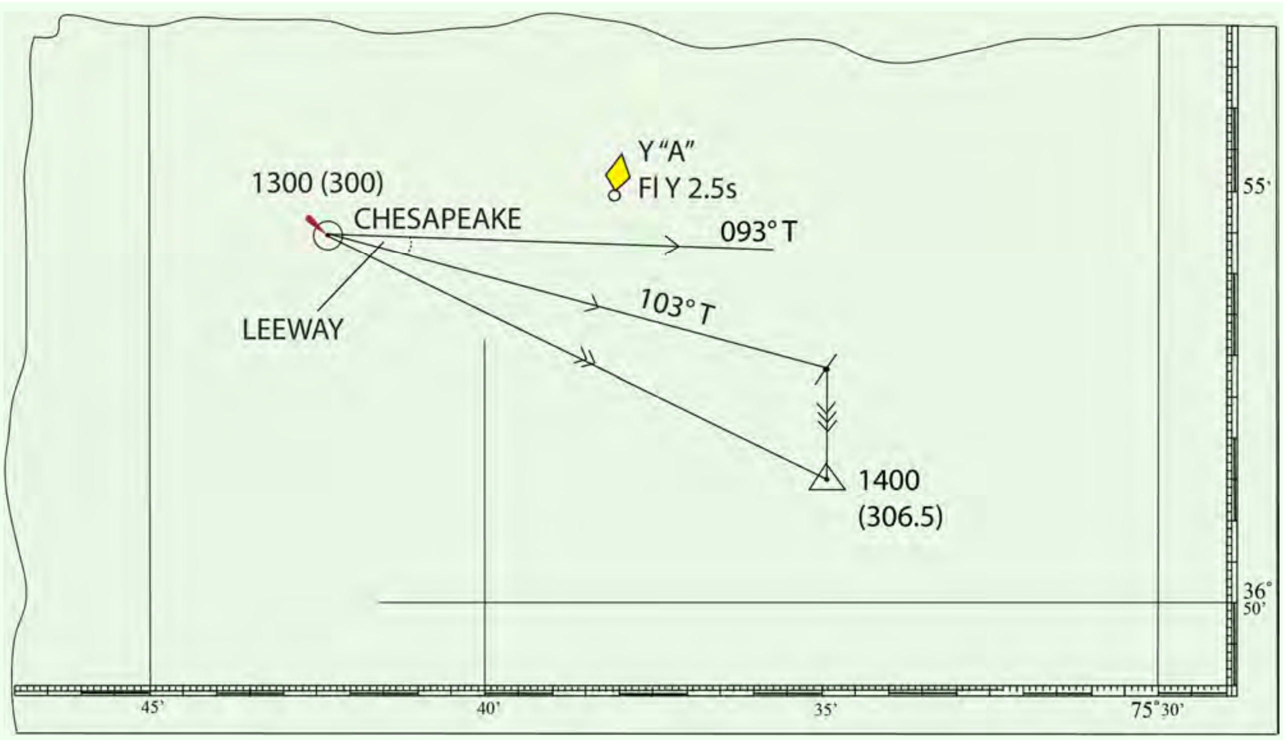


FIGURE 77 NOTE THAT THE WATER TRACK IS MARKED WITH ONE ARROW, THE GROUND TRACK WITH TWO ARROWS AND THE TIDAL VECTOR IS MARKED WITH THREE ARROWS. THE ESTIMATED POSITION IS SHOWN BY A TRIANGLE WITH A DOT IN THE CENTRE AT THE BOATS' POSITION. USUALLY WITH AN EP THE ONLY REQUIREMENT IS TO FIND THE ESTIMATED POSITION SO THE GROUND TRACK AND COURSE STEERED WOULD NOT NORMALLY BE PLOTTED.

So far, the examples have been for periods of one hour which require only one current vector to be drawn representing the set and drift of the current. 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 current streams changes can be worked up in one of two ways. The first way is to plot the course, distance and current stream separately for each individual hour and the second way is to plot all the courses and distances first and then plot all the current 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 'logbook' extract.

TIME	LOG	COURSE° (M)	WIND	LEEWAY	POSITION
1300	307.0	061°	W2	0°	Fix 36°54'.3N 75°42'.8W
1400	309.8	061°	W2	0°	a/c to 141°(M)
1500	313.8	141°	W2	0°	a/c to 061°(M)
1600	318.0	061°	W2	0°	EP at 1600?

The vectors which must be plotted to find the EP are: From 1300 to 1400: water track = 050°(T)/2.8M; current = 174°/1.0knFrom 1400 to 1500: water track = 130°(T)/4.0M; current = 164°/0.9knFrom 1500 to 1600: water track = 050°(T)/4.2M; current = 172°/0.8kn(The current direction and rate given are just for the sake of this example.)

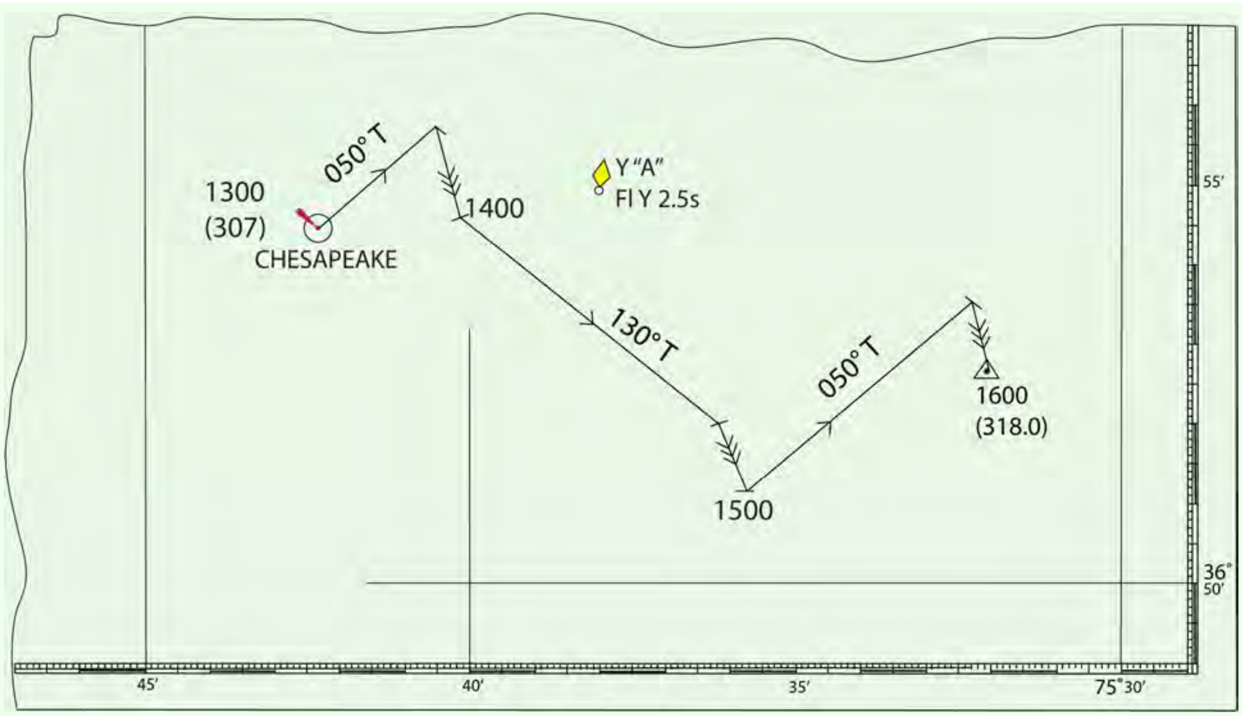


FIGURE 78 WATER TRACK AND CURRENT VECTOR PLOTTED FOR EACH INDIVIDUAL HOUR

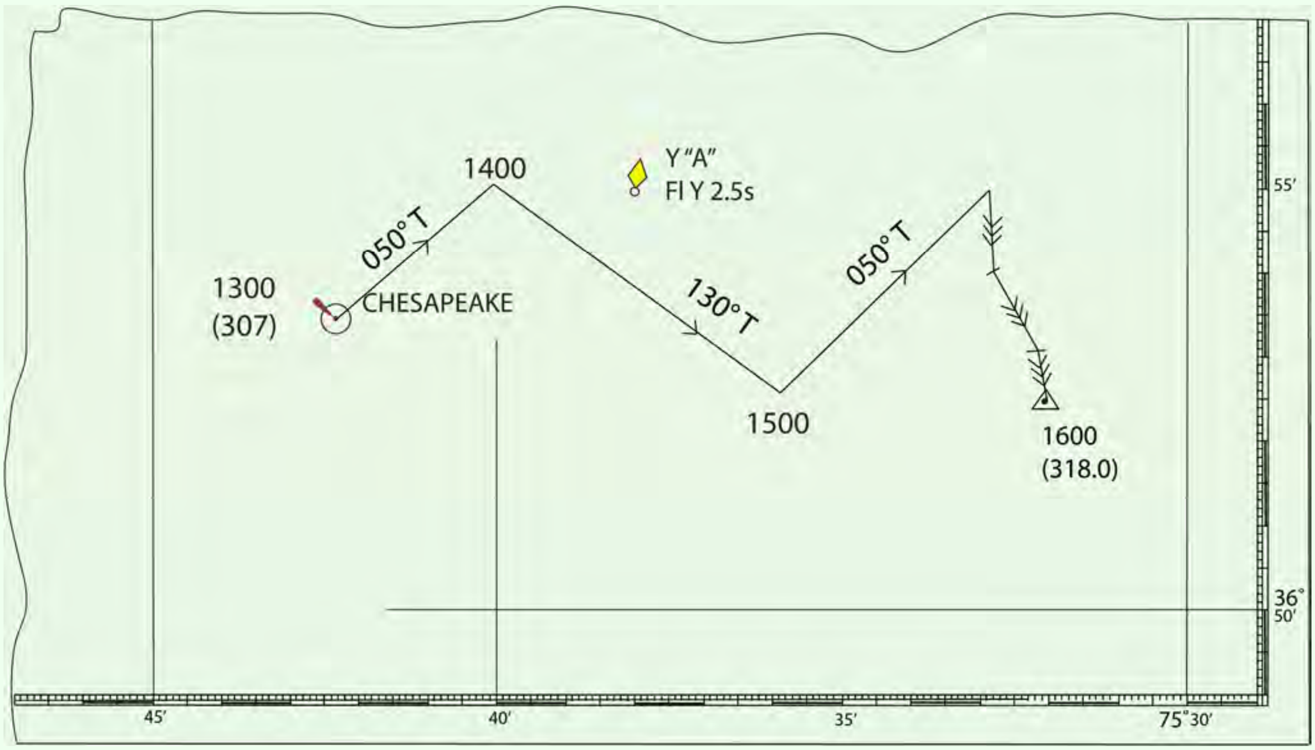


FIGURE 79 WATER TRACKS PLOTTED FIRST, THEN ALL THE CURRENT VECTORS.
THE EP POSITION IS THE SAME AS THAT IN THE FIGURE BEFORE

8.4 The Logbook

A small boat's logbook, 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 logbook.

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.

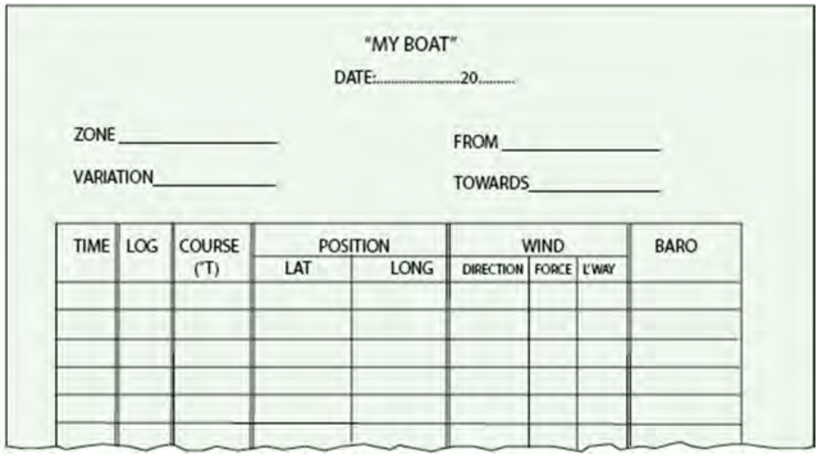
Logbook Headings

Logbooks 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


"MY BOAT"

DATE:.....................20.........

ZONE ______________ FROM ______________

VARIATION____________ TOWARDS____________

TIME	LOG	COURSE (°T)	POSITION		WIND			BARO
			LAT	LONG	DIRECTION	FORCE	L'WAY	

FIGURE 80 EXAMPLE OF SHIP'S LOGBOOK LAYOUT

The time of the entry is entered in the time column and then the reading from the boat's distance log. 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. "Chesapeake light abeam, 200 feet". 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.

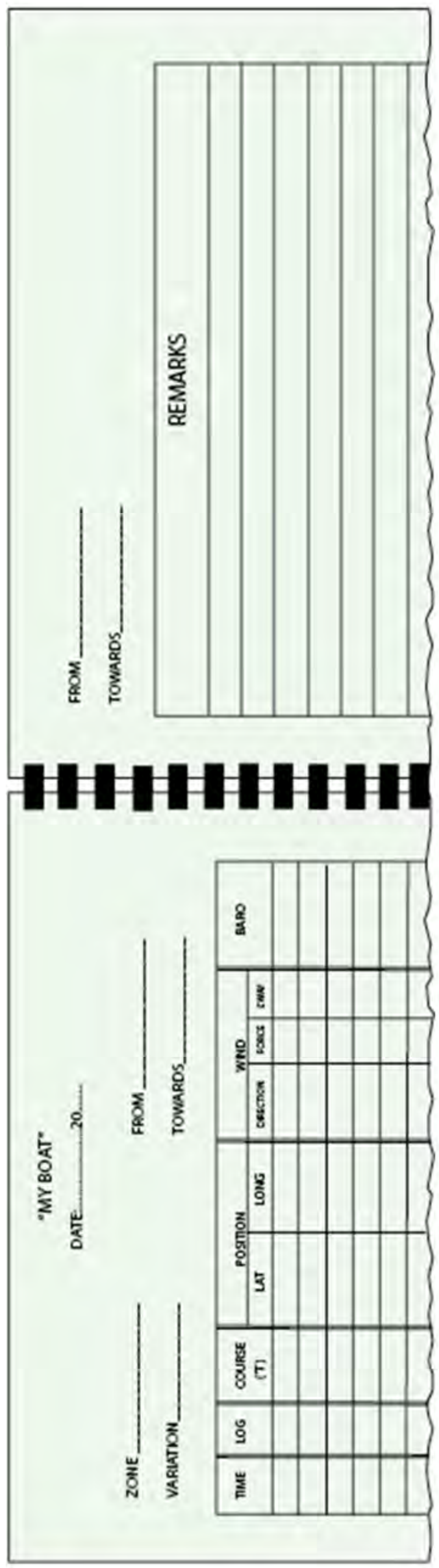
The wind direction is usually recorded in general terms such as W (west), NW (north west), etc. and the wind strength is usually entered using either knots or Beaufort Force numbers, thus an entry for a force 5 wind from the north east would be "NE 5". The wind direction and strength entered are once again since the last entry in the logbook 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 logbook 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 motorboat 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 motorboat 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.


"MY BOAT"
DATE 20
ZONE
VARIATION
FROM
TOWARDS
TIME
LOG
COURSE (T)
POSITION
LAT
LONG
WIND
BARO
FROM
TOWARDS
REMARKS

Chapter 9 TIDES

9.1 Key Objectives

THE OBJECTIVE OF THIS CHAPTER IS TO ENSURE CANDIDATES FULLY UNDERSTAND THE CAUSE OF TIDES, SPRING & NEAP TIDES, TIDAL HEIGHTS AND HOW TO USE TIDE TABLES IN ORDER TO SAFELY NAVIGATE.

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 currents.

Most, but not all, places experience two high tides and two low tides each day; this tidal regime being called semidiurnal (i.e. “half daily”). The coastal waters of the Atlantic coast of the United States 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.

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

9.2 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 the effect of gravity it can 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 'barycenter', 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.

FIGURE 81

HOW THE GRAVITATIONAL PULL OF THE MOON ON THE SEA CAUSES TWO DEEP POINTS AND TWO SHALLOW POINTS TO DEVELOP. *THIS 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.

This figure 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.

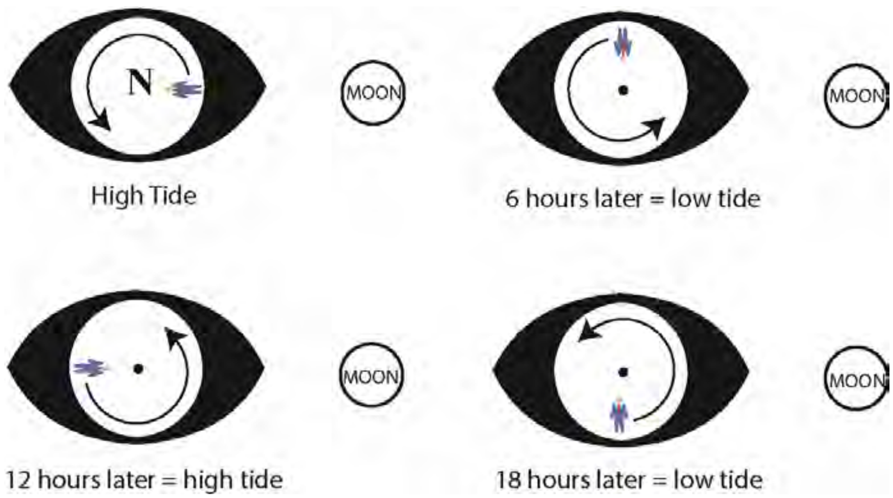


FIGURE 82 - VIEW THESE FIGURES AS IF LOOKING DOWN ON THE NORTH POLE FROM A GREAT HEIGHT.

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
- 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 from earth whereas the sun is about 93,000,000 miles 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.

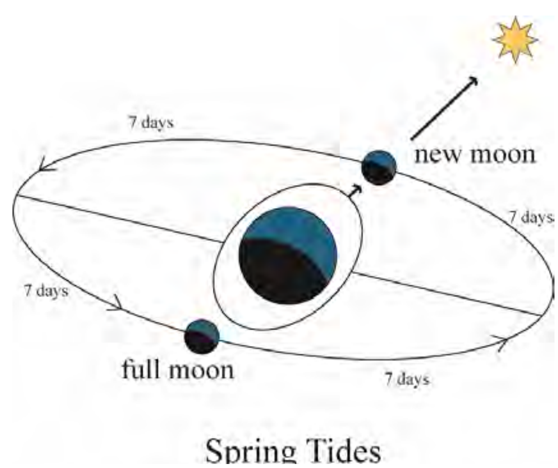
When the attraction from the sun and moon combine together the range of the tide is great, high tides being higher than normal and low tides being lower than normal. These tides are called spring tides.

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.

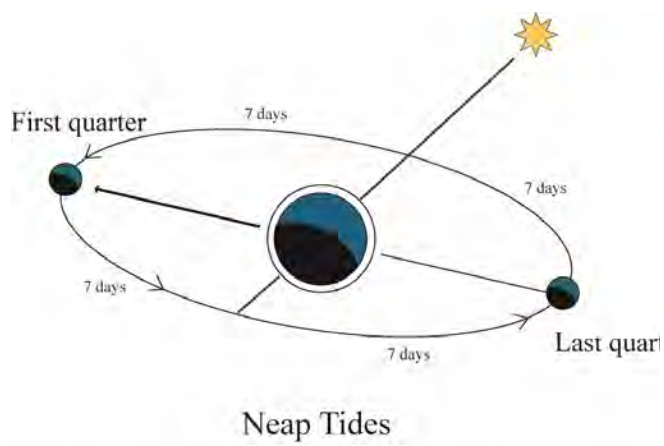
The greatest spring tides of the year take place near the equinoxes during March and September at new and full moon.



Neap Tides

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.

9.3 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 a foot (0.3m) or so would not be noticeable but in coastal waters tides can cause the depth to change by as much as 40 feet or more. The average range of spring tides at Burntcoat Head in the Bay of Fundy is 52.6 feet, (15.8 metres) whereas, at the other extreme, the spring range at San Salvador in the Bahamas is 2.9 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 seabed 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 seabed 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 from 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 and currents 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 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 3 inches (0.08m).

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 seabed, 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, Seiches & Strong Winds

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 seabed. 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 seabed, the wave heights can increase to 20 metres or more with devastating results on low lying areas.

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 0.3m (1 foot). A storm surge in January of 1953 raised the sea level in the southern part of the North Sea by 10 feet (3 m).

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

Seiches is a standing wave in an enclosed or partially enclosed body of water. The key requirement for formation of a seiche is that the body of water be at least partially bounded, allowing the formation of the standing wave. They 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.

9.4 Tidal Height Definitions

The following terms used to define tidal heights and depths should be clearly understood to avoid confusion.

Chart Datum

Chart datum, or Sounding Datum, is a fixed reference level from which all depths and drying heights are measured on a chart. NOS charts of US waters generally use Mean Lower Low water (MLLW). British Admiralty metric charts use Lowest Astronomical Tide (LAT).

Charted Depth

The distance from chart datum to the seabed or the depth of water at MLLW. Charted depths are often referred to as soundings.

Drying Height

The height above chart datum of features that cover and uncover with the tide.

High Water

The highest point reached by any one tide.

Low Water

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 interval between high water 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 in conjunction with correction tables.

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.

Spring Tides

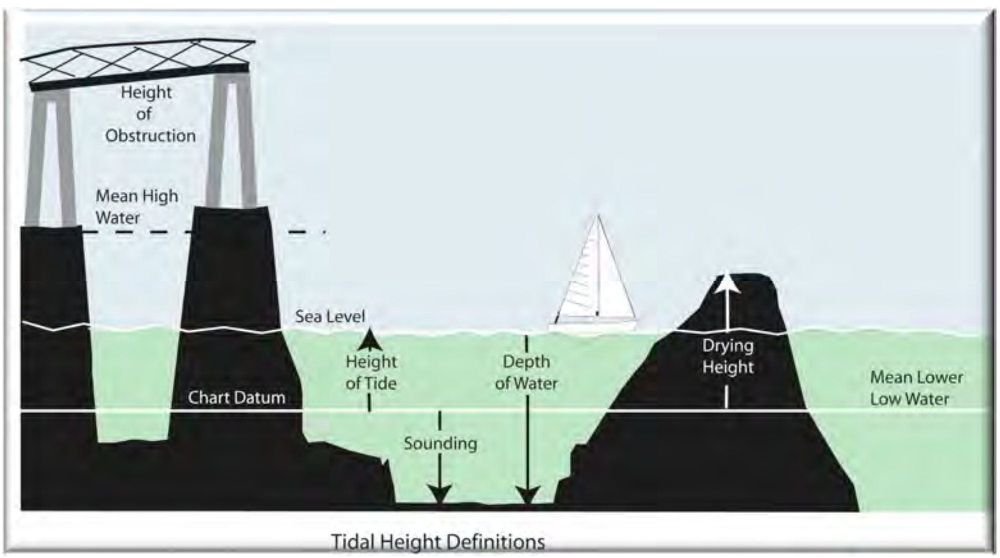
A spring tide has a higher high water and a lower low water than the average tide for the area, therefore a spring tide has a big range. Spring tides occur at about the time of new and full moon.

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.

Mean High Water (MHW)
"Mean" refers to average. MHW is the average height of all high waters for a particular place; the average is worked out over a 19 year period. Its significance is that this is the datum from which the heights of lighthouses, landmarks and the clearances beneath overhead obstructions such as bridges, powerlines and overhead cables are usually measured.

Mean Lower Low Water (MLLW)
The average of the lower of the low waters of each tidal day.

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.



Tidal Height Definitions

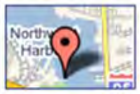
9.5 Sources of Tide Tables

Predictions of the heights of high and low water can be easily found online. Below is a screenshot from NOAA https://tidesandcurrents.noaa.gov/tide_predictions.html showing tide predictions for California.

NOAA Tide Predictions

About NOAA Tide Predictio

Choose a station using our Tides and Currents Map, click on a state below, or search by station name, ID, or latitude/longitude.



Or search: [ ] Go search help

California

Name	Id	Lat	Lon	Predictions
Baja California				
San Carlos	TWC0399	+24.7833	-112.1167	Subordinate
Isla Guadalupe	TWC0401	+28.8833	-116.3000	Subordinate
Ensenada, Todos Santos Bay	TWC0403	+31.8500	-116.6333	Subordinate
Southern California				
Imperial Beach	9410120	+32.5783	-117.1350	Subordinate
Point Loma	TWC0405	+32.6667	-117.2333	Subordinate
San Diego, Quarantine Station	9410166	+32.7033	-117.2350	Subordinate
SAN DIEGO (Broadway)	9410170	+32.7142	-117.1736	**Harmonic**

Reference or Harmonic stations

Reference stations (also referred to as ***Harmonic***) are basically ports which have sufficient traffic to make the work and expense involved in publishing dedicated tide tables worthwhile. For example, San Diego, Eastport, Cape Hatteras and St. Petersburg are standard ports.

Reference or Harmonic stations are stations with tidal harmonic constants and tidal datums. Tide predictions for harmonic stations are generated directly from the harmonic constants. Harmonic stations have the greatest capabilities for providing predictions with different data intervals and relative to different tidal datums.

Subordinate Stations

Subordinate stations are historic stations which do not have tidal harmonic constants available. Tide predictions for subordinate stations are generated by first generating high/low tide predictions for a designated harmonic station, called the "reference station"; then time and height adjustments are applied to correct the high/low predictions to the tidal conditions at the subordinate station. Subordinate stations only allow for the generation of high/low tide predictions, and heights will be relative to Mean Lower Low Water (MLLW)

9.6 Tide Table Layout

- Make sure you are using the correct tide table, check the name of the port at the top.
- Always check carefully that you are using the correct month, day and date.
- Times are in 24 hour clock notation, i.e. 1518 means 1500 hours and 18 minutes.
- Check carefully whether the times in the tables have been corrected for Daylight Saving Time. Reed's North American east coast tide tables have the hour added, other predictions may not.
- The predicted height of tide is given in feet and decimals (tenths) of a foot.
- The height of tide given is the height above Chart Datum.
- The datum used will be given, e.g. U.S. Datum.
- The tables do not say low or high water, the heights given will show which is which.
- Underneath the date are printed the first few letters of the day, i.e. Tu = Tuesday
- The time zone will be shown, e.g. Eastern Time (75° W).
- The date of new moon and full moon is shown by symbols

BOSTON, MA

HIGH AND LOW WATER 199X — US DATUM — 42°21' N 71°03' W

Eastern Time (75°W) — Corrected for Daylight Saving Time: April 5 - October 24

MAY

	Time	ft		Time	ft
1	0033	11.1	**16**	0259	10.2
	0956	-0.7		0925	0.1
F	1616	9.8	Sa	1539	9.2
	2213	0.6		2139	1.2
2	0429	10.5	**17**	0346	10.1
	1053	0.0		1013	1.0
Sa	1715	9.4	**Su**	1628	9.2
	2311	1.2		2231	1.2
3	0529	9.9	**18**	0438	10.0
	1151	0.5		1105	0.2
	1815	9.1		1721	9.4
Su			M	2327	1.1

JUNE

	Time	ft		Time	ft
1	0458	9.8	**16**	0419	10.4
	1117	0.5		1042	-0.3
M	1740	9.2	Tu	1659	10.0
	2340	1.5		2307	0.6
2	0554	9.4	**17**	0515	10.2
	1211	1.0		1136	-0.2
Tu	1835	9.1	**W**	1754	10.2
3	0038	1.7	**18**	0006	0.5
	0652	9.1		0615	10.1
	1305	1.2	Th	1233	-0.1
W	1928	9.2		1850	10.5

JULY

	Time	ft		Time	ft
1	0515	9.3	**16**	0458	10.4
	1129	1.0		1114	-0.4
W	1750	9.2	Th	1731	10.6
	2357	1.6		2347	0.0
2	0609	8.9	**17**	0558	10.0
	1219	1.3		1210	-0.1
Th	1841	9.2	**F**	1829	10.7
3	0052	1.6	**18**	0049	
	0704	8.7		0700	
	1310	1.5	F	1308	
F	1931	9.3			

AUGUST

	Time	ft		Time	ft
1	0009	1.5	**16**	0031	-0.1
	0621	8.5		0646	9.5
Sa	1225	1.6	Su	1250	0.5
	1844	9.2		1910	10.6
2	0104	1.5	**17**	0135	0.0
	0716	8.4		0752	9.3
Su	1317	1.7	**M**	1351	0.7
	1936	9.3		2013	10.6

FIGURE 83 - EXTRACT FROM THE TIDE TABLES FOR BOSTON, MA, U.S.A.

9.7 Using the Tide Tables

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.

Find the times and heights of HW and LW at Boston, MA on Monday the 1st of June.

HW	0458 EDT	9.8 ft
LW	1117 EDT	0.5 ft
HW	1740 EDT	9.2 ft
LW	2340 EDT	1.5 ft

Find the times and heights of HW, LW and the range of tide on the evening of May 2nd:

HW	1715 EDT	9.4 ft
LW	2311 EDT	1.2 ft
	Range	8.2 ft

What information found in the last example actually means is that high tide will be at 1715 by your watch and at that time there will be 9.4 ft in addition to the depths shown on the chart of the area. Low tide will occur at 2311 when there will be 1.2 ft in addition to the depths shown on the chart for the area.
The range of this tide is from 9.4 ft to 1.2 ft = 8.2 ft.

Note that the first time shown is not necessarily the time of high water, look at Boston tide tables for the 1st. of August:

0009 EDT	1.5
1621 EDT	8.5

Find the times and heights of HW, LW and the range of tide on the morning of June 17:

HW	0515 EDT	10.2 ft
LW	1136 EDT	- 0.2 ft
	Range	10.4 ft

In this instance the height of tide at low water is preceded by a minus sign meaning that at low water the sea level will be 0.2 ft below chart datum. There will therefore be 0.2 ft less depth than that which is shown on the chart of the area at 1136 EDT.

Sometimes there are only three times instead of four given for a particular day.
Find the times and heights of HW, LW and range of tide on May 3 in the early morning:

2311	1.2 (May 2)
0529	9.9 May 3
Range	8.7

9.8 Subordinate station

Immediately following the tide tables for the primary reference ports are tables that permit the calculation of height and time differences allowing the calculation of tidal data for many secondary, or subordinate, places. These tables are called Tide Difference Tables.

Tide Difference tables

To Use the Tide Difference Tables:

- find the page for the station, or place, required.

- note the name of the primary reference station in bold print at the top of the section
- the position of the station is given in lat and long
- note the time differences which must be added to (+), or subtracted from (-), the times of high and low water at the primary reference station; the first column is for high tide the second column is for low tide
- note the height differences which must be applied to the high and low waters at the primary reference station. These height differences are applied in a variety of ways:

  add when the difference is preceded by a + sign.

  subtract when the difference is preceded by a - sign.

  multiply when the difference is preceded by an asterisk *

  if the differences are enclosed in parentheses the tide height from the primary station is multiplied by the first figure and the second figure is then added or subtracted according to the + or - sign.

Tide Differences Table

PLACE	POSITION		DIFFERENCES				RANGE
	north latitude	west longitude	Time high h m	Time low h m	Height high ft	Height low ft	spring ft
			on BOSTON, P. T 27				
Chatham, outer coast	41°40’	69°56’	+0:32	+0:26	*0.70	*0.70	7.8
Chatham inside	41°41’	69°57’	+1:56	+2:26	*0.38	*0.38	4.2
Georges Shoal	41°42’	67°46’	-0:47	-0:43	*0.44	*0.44	4.8
Davis Bank	41°08’	69°39’	+0:06	-0:25	*0.14	*0.14	1.5

FIGURE 84 - EXTRACT FROM TIDE DIFFERENCES TABLE, REED'S NAUTICAL ALMANAC

Subordinate Station Calculation

Example 1

Find the times and heights of HW and LW at Chatham outer coast (near Cape Cod), on the morning of June 1st. The reference station is Boston, MA.

Times

Boston, June 1	HW	0458 EDT	LW	1117 EDT
differences, Chatham		+0032		+0026
Chatham	H W	0530		1143

Heights

Boston, June 1	HW	9.8 ft	LW	0.5 ft
differences,		x 0.70		x 0.70
Chatham		= 6.86 ft		= 0.35 ft

June 1, Chatham: H W 0530 EDT 6.9 ft LW 1143 EDT 0.3 ft

Example 2

Find the times and heights of HW and LW at George's Shoal (near Cape Cod), for the evening of July 2. The reference station is Boston, MA.

July 2, Boston HW	1841 EDT	9.2 ft.	(July 3) 0052	EDT 1.6
Differences, G's Shoal	- 0047	x 0.44	- 0043	x 0.44
George's Shoal	1754	4.05	0009	0.7

To Find Height of Tide At Any Time

Tide tables give the height of tide at HW and LW only. It is, however, often necessary to find the height of tide for a specific time somewhere between high and low water. A simple table enables the calculation of height of tide for any specific time. This table, called '***TABLE 3 - HEIGHT OF TIDE AT ANY TIME***'; is in Reed's after the differences tables.

TABLE 3

To use 'table 3' you need:

- the times and heights of the high and low waters which include the time you require;
- the duration of time and the range of the heights between the high and low waters;
- the time difference from your required time to the time of the nearest HW or LW.

TABLE 3 - HEIGHT OF TIDE AT ANY TIME

Duration of rise or fall (h. m.)	Time from the nearest high water or low water (h. m.)										
5 40											
6 00	0 12	0 24	0 36	0 48	1 00	1 12	1 24	1 36	[illegible]	2 00	2 12
6 20	0 13	0 25	0 38	0 51	1 03	1 16	1 29	1 41	1 54	2 07	2 19
6 40	0 13	0 27	0 40	0 53	1 07	1 20	1 33	1 47	[illegible]	2 13	2 27
6.50											

Range of tide (ft.)	Correction to height										
5.5											
6.0	0.0	0.1	0.1	0.3	0.4	0.6	0.8	1.0	[illegible]	1.5	1.8
6.5	0.0	0.1	0.2	0.3	0.4	0.6	0.8	1.1	1.3	[illegible]	1.9
7.0	0.0	0.1	0.2	0.3	0.5	0.7	0.9	1.2	1.4	1.8	2.1
7.5	0.0	0.1	0.2	0.3	0.5	0.7	1.0	1.2	1.5		
8.0	0.0	0.1	0.2	0.3	0.5	0.7	1.0	1.2	1		
8.5	0.0	0.1	0.2	0.4	0.6	0.8	1.1	1.4			
9.0											

Example of using table 3 to find height of tide:

Find the Height of Tide at 0730 EDT on June 1st at Chatham, outer coast,
reference station Boston, MA.

Boston, June 1	HW	0458	9.8 ft	LW	1117	0.5 ft
differences, Chatham		+0032	x 0.70		+0026	x 0.70
Chatham	H W	0530	6.86 ft		1143	0.35 ft
June 1, Chatham:	H W	0530	6.9 ft	LW	1143	0.3 ft

Duration of fall from 0530	**Range** 6.9	**time from nearest HW**	0530
to - 1143	- 0.3		to 0730
= 0613	**6.6 ft**		**0200**

1. Enter table with Duration of fall 6 20;
2. Move across the row until directly beneath 'time from nearest high water' 1 54;
3. Move down this column until opposite 'range of tide' 6.5;
4. Read off correction of 1.3 ft which is subtracted from the HW height of 6.9 ft; then height of tide at 0730 is 6.9 - 1.3 = 5.6 ft.

Height of tide - Example 2

Find Height of Tide at 2325 EDT on June the 2nd at Boston, MA.

Boston, June 2 HW 1835 9.1 LW 0038 1.7 (June 3)

	from 1835		9.1 LW		0038
	to - 0038		1.7	required time	2325
Duration of fall	= 0603	Range	7.4 ft	time from nearest LW	0113

From Table 3 a correction of 0.7 ft is to be added to the height of tide at LW

Therefore, the height of tide at 2325 EDT is 1.7 + 0.7 ft = 2.4 ft.

Practical use of 'Table 3'

Keep some photocopies of 'Table 3 - Height of tide at any time' on board.

Then, when required:

- write in the tidal data from the tide tables;
- underline the appropriate Duration of Rise or Fall row;
- underline the appropriate Range of Tide row;
- read off at a glance the correction to be added or subtracted from the high or low water heights.

For example, from the table above, set up for a Duration of 6 hours and a Range of 7.5', it can be immediately seen that 1 hour before Low Water 0.5' should be added to the height of tide at LW; 1 hour and 48 minutes after HW 1.5' should be subtracted from the height of tide at HW, and so on.

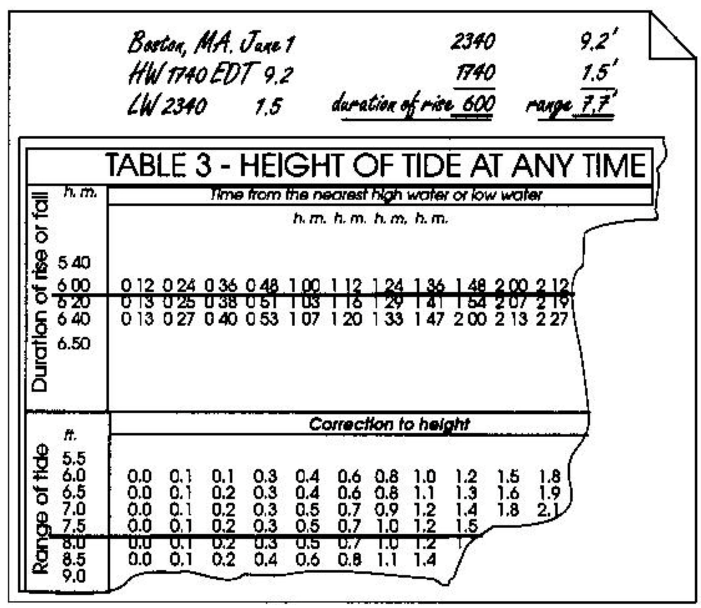


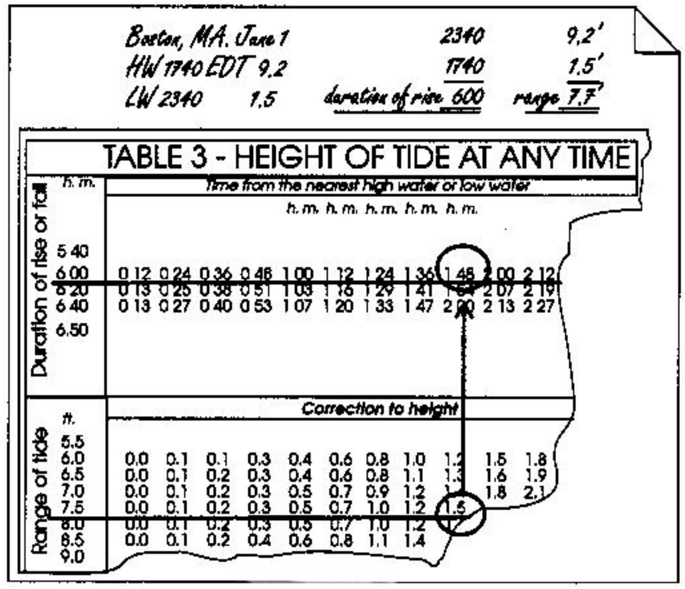
FIGURE 85
TABLE 3 UNDERLINED FOR
DURATION = 6 HOUR RANGE = 7.5 FEET

To find the time for a required Height

It is often necessary to find the time at which a required height of tide will be reached.

Suppose, for example, that on the late evening of June 1st a yacht can pass safely over a shoal bank near Boston on the falling tide when the height of tide is 3 ft, or more. The height of tide at low water is 1.5 ft so an additional 1.5 ft height of tide is required. From the completed Table 3 it can be seen that there will be an extra 1.5 ft added to the height of low water 1 hour and 48 minutes before the time of low water.

LW 2340
 - 0148
 2200



At **2152** EDT the height of tide is 3 ft, the yacht must therefore cross the shoal before 2152 EDT.

Tidal heights, the graphic method

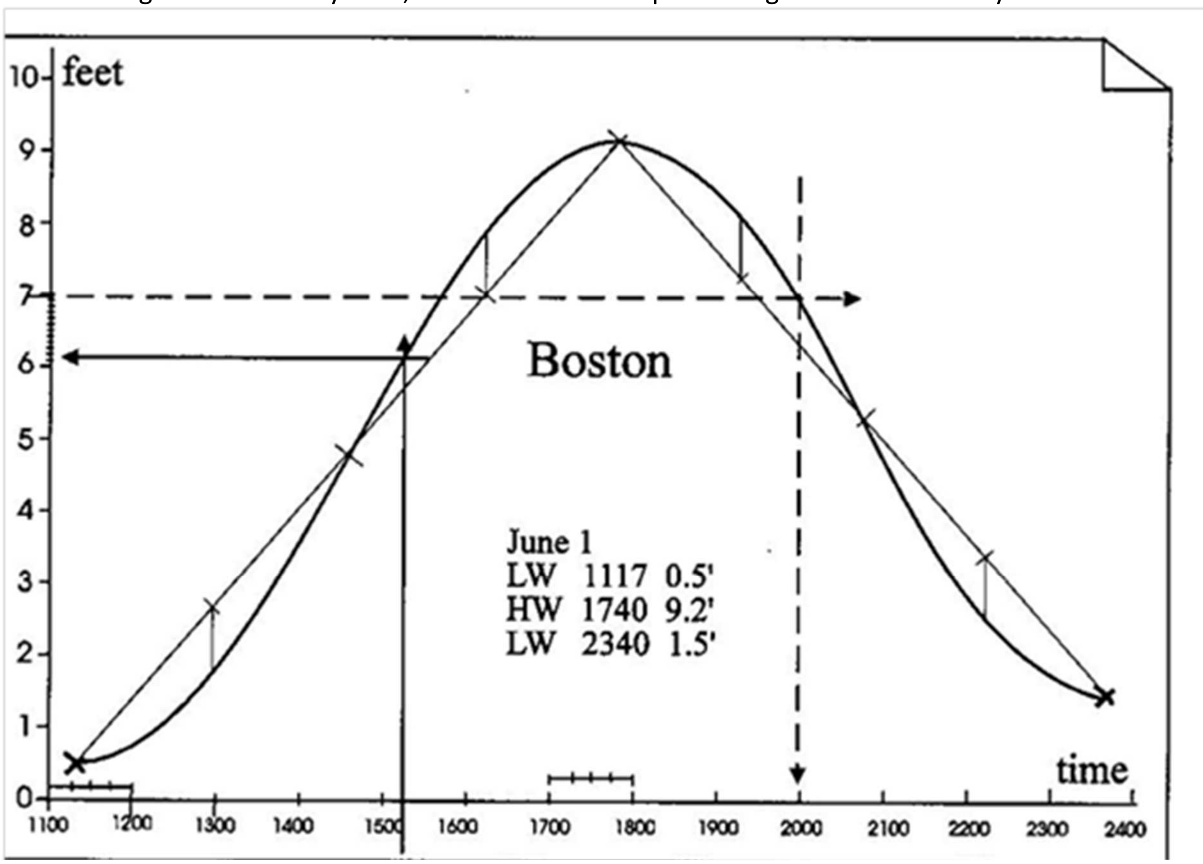
Instead of using the 'height of tide at any time' table it is possible to sketch a quick graph representing the rise and fall of the tide. This graph, once completed, makes it easy to find either the height of tide at a specific time or the time for a required height of tide. Although it may look a bit difficult at first it is actually quite easy to sketch up the graph.

"One-quarter,
one tenth-rule"

This rule is an aide memoir when drawing up the tide graph.
To draw the graph, using any scale of measurement that suits:

1. draw the horizontal axis marked off to represent time;
2. draw the vertical axis marked off to represent tide height;
3. plot the HW and LW points on the graph and join the points with a straight line;
4. divide these lines into 4 equal spaces. The curve passes through the center point;
5. draw a line up from the high water quarter point of length 1/10 th of the range of the tide;
6. draw a line down from the low water quarter point of length 1/10 th of the range of the tide;
7. draw a fair curve through the high and low water points and the intermediate points, rounding off carefully the top and bottom of the curve.

FIGURE 86
TIDE CURVE FOR BOSTON, MA, U.S.A. JUNE 1ST
The left hand side represents the rising tide, the right hand side represents the falling tide.
The height of tide at any time, or the time for a required height are read directly from the curve.



Examples of Using The Completed Tidal Curve:

Find the height of tide at Boston on June 1 at 1515 EDT?
From the curve the height of tide will be 6.1 feet, on a rising tide.

At what time will the height of tide at Boston be 7 feet on the falling tide during the evening of June 1?
From the curve the height of tide will be 7 feet at 2000 EDT, on a falling tide.

Examples of Tidal Height Problems

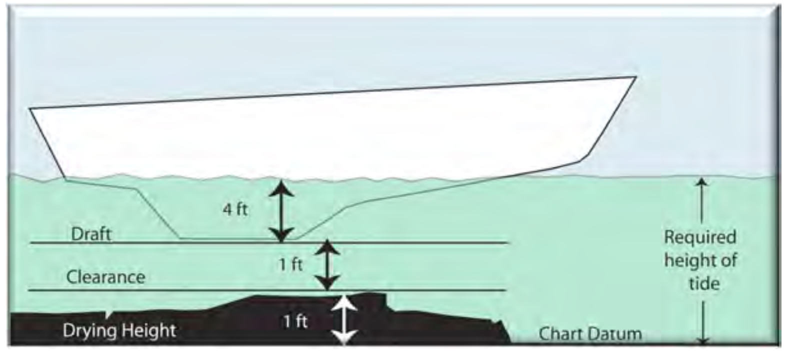
Height for a time,
time for a height
Remember that all the problems which involve working with tidal height problems will require that one of two things to be found:

1. the Height of Tide at a specific time, or
2. the Time for a specific Height of Tide

<u>What is the latest time during the falling tide on the evening of June the 1st that a yacht can pass over an area near Boston shown on the chart as having a drying height of 1 ft? The yacht has a draft of 4 ft and an extra clearance of 1 ft will be allowed for safety.</u>

A quick sketch is usually helpful when you are trying to understand the problem.

Here the height of tide to allow the boat to pass must be:
  1 ft to cover the drying height
+ 1 ft for the safety clearance
+ 4 ft for the boat's draft.



The height of tide required to cover a drying height of 1 ft	1 ft
+ the draft of 4 ft	4 ft
+ the clearance of 1 ft	<u>1 ft</u>
Height of tide required	**> 6 ft**

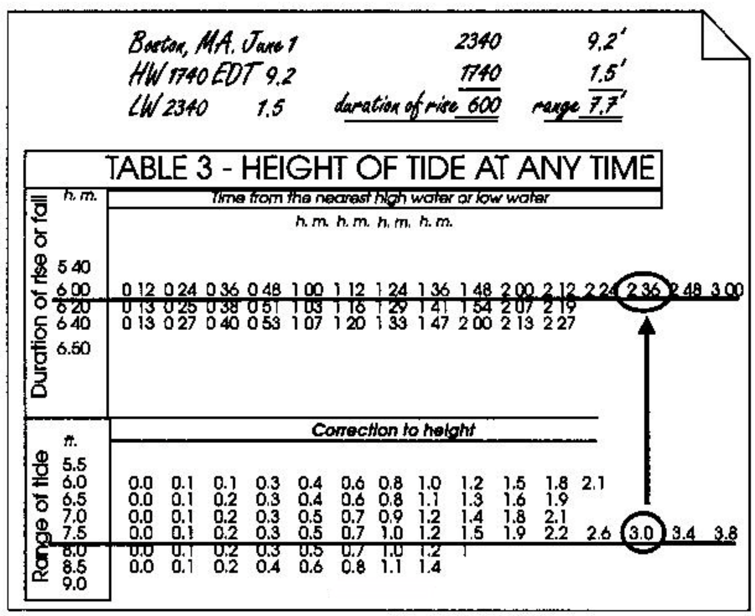
The problem now becomes: *at what time will the height of tide fall to 6 ft on the evening of June 1st?*

First extract the times and heights both high and low water from the Boston tide table for the period of time required

The height of tide at HW is 9.2 ft and the minimum height of tide required is 6 feet, so when the height of tide has dropped by 3.2 feet the yacht can no longer pass.

From the Height of Tide Table, the height of tide will have dropped by 3 ft 2 hours and 36 minutes after HW. Therefore, the yacht must cross the drying height before

1740
<u>+ 0236</u>
2016 EDT.



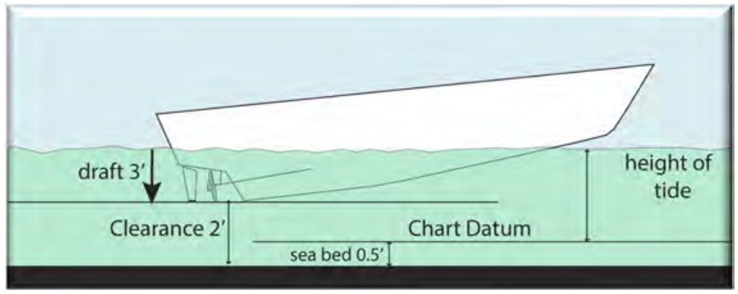
(NB: Do not interpolate when using 'Table 3')

A motorboat with a draft of 3 ft wishes to cross over a shoal near Chatham, outer coast, shown on the chart as having 0.5 ft depth at Chart Datum. What is the earliest the boat can cross the shoal on the rising tide during the morning of August the 2nd? Allow a safety clearance of 2 ft.

The boat will need an actual physical depth of:

the draft 3.0
+ the clearance 2.0
= 5.0 ft

But there is a depth of 0.5 ft at chart datum so the height of tide required is:
5.0 ft - 0.5 ft = 4.5 ft.



At what time will the height of tide be 4.5 ft?

LW Boston	0104 EDT	1.5 ft	HW 0716	8.4 ft.
Differences	+0026	x0.7	+0032	x0.7
Chatham	0130	1.05 ft	0748	5.88 ft.

Duration 0618 Range 4.9 ft.

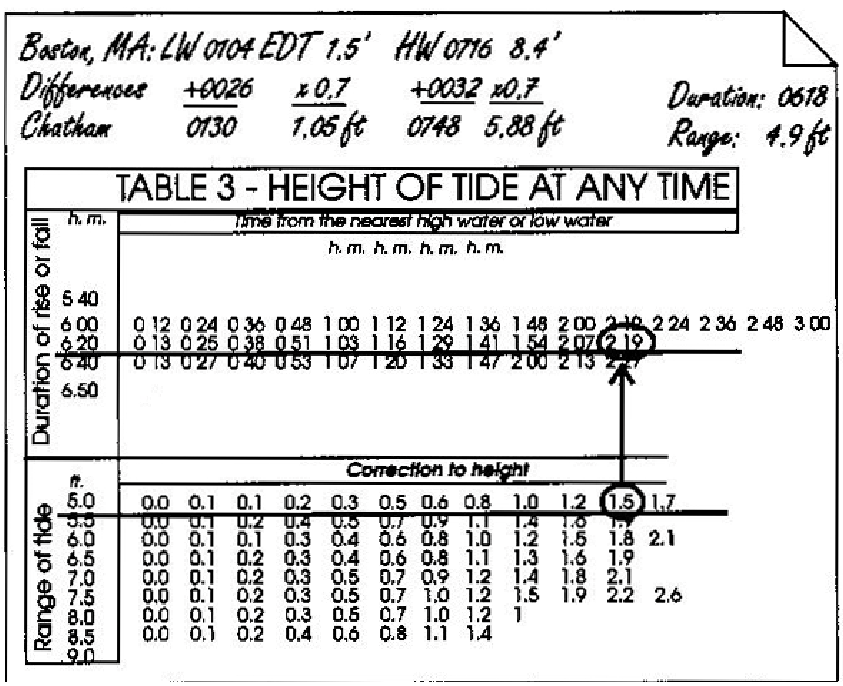
The Height of Tide at HW Chatham	5.9 ft
Required Height of Tide	4.5 ft
Therefore correction to height required	= 1.4 ft

When, from 'Table 3', will the height of tide be 1.4 ft less than 5.9 ft?

From the table the height of tide correction for 1.4 ft occurs 2 hours and 19 minutes before HW.

HW 0748
- 0219
= 0529

The boat can cross at 0529 EDT.



Boston, MA: LW 0104 EDT 1.5' HW 0716 8.4'
Differences +0026 x 0.7 +0032 x0.7 Duration: 0618
Chatham 0130 1.05 ft 0748 5.88 ft Range: 4.9 ft

TABLE 3 - HEIGHT OF TIDE AT ANY TIME

Time from the nearest high water or low water

Duration of rise or fall (h. m.)															
5 40															
6 00	0 12	0 24	0 36	0 48	1 00	1 12	1 24	1 36	1 48	2 00	2 10	2 24	2 36	2 48	3 00
6 20	0 13	0 25	0 38	0 51	1 03	1 16	1 29	1 41	1 54	2 07	2 19				
6 40	0 13	0 27	0 40	0 53	1 07	1 20	1 33	1 47	2 00	2 13	[illegible]				
6.50															

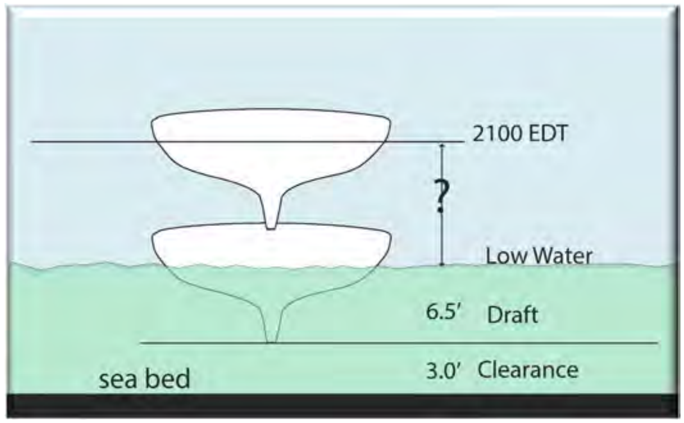
Correction to height

Range of tide (ft.)												
5.0	0.0	0.1	0.1	0.2	0.3	0.5	0.6	0.8	1.0	1.2	1.5	1.7
5.5	0.0	0.1	0.2	0.4	0.5	0.7	0.9	1.1	1.4	1.6	1.9	
6.0	0.0	0.1	0.1	0.3	0.4	0.6	0.8	1.0	1.2	1.5	1.8	2.1
6.5	0.0	0.1	0.2	0.3	0.4	0.6	0.8	1.1	1.3	1.6	1.9	
7.0	0.0	0.1	0.2	0.3	0.5	0.7	0.9	1.2	1.4	1.8	2.1	
7.5	0.0	0.1	0.2	0.3	0.5	0.7	1.0	1.2	1.5	1.9	2.2	2.6
8.0	0.0	0.1	0.2	0.3	0.5	0.7	1.0	1.2	1			
8.5	0.0	0.1	0.2	0.4	0.6	0.8	1.1	1.4				
9.0												

<u>A yacht wishes to anchor as close as possible to the shore near Boston at 2100 EDT on August 1st. The yacht's draft is 6.5 ft and it is decided to allow a safety clearance of 3 ft between the keel and the seabed at low water. What depth should the yacht anchor in?</u>

Quite simply the yacht should anchor in a depth equal to:

- the yacht's draft + the safety clearance + the amount by which the level of the sea will fall from 2100 until low water.



The draft and safety clearance are known; all that remains is to calculate by how many feet the level of the sea will fall between the time at which the yacht wishes to anchor and the next low water, i.e. between 2100 and LW. The first step will therefore be:

find the height of tide at 2100 EDT on August the 1st.

Boston, August 1: HW 1844 EDT 9.2 ft. LW 0104 1.5 ft. (August 2)

Duration of fall	2504	Range	9.2	Time from nearest high water	2100
	- 1844		- 1.5		1844
	620		7.7		216

Ht of tide at HW	9.2 ft
correction, table 3	- 2.2 ft
Ht of tide at 2100	7.0 ft
Ht of tide at 2100	7.0 ft
ht of tide at LW	1.5 ft
Sea level will fall	**5.5 ft**

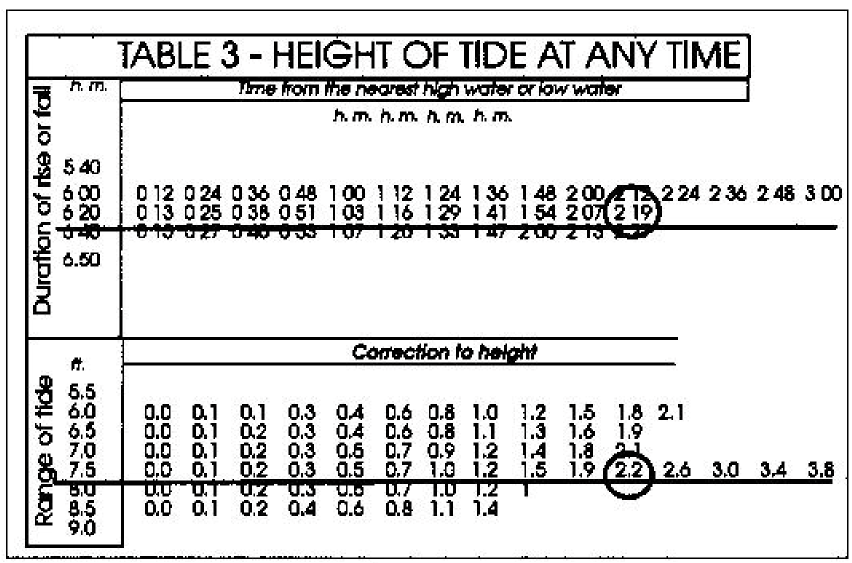


TABLE 3 - HEIGHT OF TIDE AT ANY TIME

Duration of rise or fall (h. m.)	Time from the nearest high water or low water (h. m.)														
5 40															
6 00	0 12	0 24	0 36	0 48	1 00	1 12	1 24	1 36	1 48	2 00	2 12	2 24	2 36	2 48	3 00
6 20	0 13	0 25	0 38	0 51	1 03	1 16	1 29	1 41	1 54	2 07	2 19				
6 40	0 13	0 27	0 40	0 53	1 07	1 20	1 33	1 47	2 00	2 13	[illegible]				
6.50															

Range of tide (ft.)	Correction to height														
5.5															
6.0	0.0	0.1	0.1	0.3	0.4	0.6	0.8	1.0	1.2	1.5	1.8	2.1			
6.5	0.0	0.1	0.2	0.3	0.4	0.6	0.8	1.1	1.3	1.6	1.9				
7.0	0.0	0.1	0.2	0.3	0.5	0.7	0.9	1.2	1.4	1.8	2.1				
7.5	0.0	0.1	0.2	0.3	0.5	0.7	1.0	1.2	1.5	1.9	2.2	2.6	3.0	3.4	3.8
8.0	0.0	0.1	0.2	0.3	0.5	0.7	1.0	1.2	1						
8.5	0.0	0.1	0.2	0.4	0.6	0.8	1.1	1.4							
9.0															

Therefore the yacht should anchor in a depth of:

the fall from 2100 to LW	5.5 ft
+ the draft of the yacht	6.5 ft
+ the required clearance	3.0 ft
anchor in a depth of	**15.0 ft**

This means that the yacht will be brought toward the shore until the depth sounder indicates a depth of 15 ft, at which point the yacht should anchor.

(Although a chart is not needed for the calculations it is obviously necessary to check on the chart that the yacht has picked a suitable spot and is not anchoring on foul ground, etc., etc.)

<u>A motor boat runs aground off Boston on a falling tide at 0715 EDT on June 1st. At what time will she refloat?</u>

It is not necessary to know the draft; nor is a chart needed (for the calculations). All that must be done is find out what the height of tide was at the time the boat ran aground. The boat will refloat when the height of tide on the next rising tide is the same as the height of tide was when the boat went aground.

The first step is: *find height of tide at 0715 EDT on the 1st of June.*

June 1, Boston HW 0458 EDT 9.8 ft. LW 1117 0.5 ft. HW 1740 9.2 ft.

When the boat ran aground:

Duration of fall 1117	Range 9.8	Time from nearest high water 0715
- 0458	- 0.5	0458
619	9.3	0217

From Table 3 the height of tide when the boat ran aground at 0715 was 9.8 - 2.8 = 7 ft.

The second step is to find:
at what time will the height of tide be 7 ft on the next rising tide?

The next rising tide is from
LW 1117 0.5 ft
HW 1740 9.2 ft.

Duration 0623, Range 8.7

TABLE 3 - HEIGHT OF TIDE AT ANY TIME

Duration of rise or fall (h. m.)	Time from the nearest high water or low water (h. m.)														
5 40															
6 00	0 12	0 24	0 36	0 48	1 00	1 12	1 24	1 36	1 48	[illegible]	2 12	2 24	2 36	2 48	3 00
6 20	0 13	0 25	0 38	0 51	1 03	1 16	1 29	1 41	1 54	2 07	2 19				
6 40	0 13	0 27	0 40	0 53	1 07	1 20	1 33	1 47	2 00	[illegible]	2 27				
6.50															
Range of tide (ft.)	**Correction to height**														
5.5															
6.0	0.0	0.1	0.1	0.3	0.4	0.6	0.8	1.0	1.2	1.5	1.8	2.1			
6.5	0.0	0.1	0.2	0.3	0.4	0.6	0.8	1.1	1.3	1.6	1.9				
7.0	0.0	0.1	0.2	0.3	0.5	0.7	0.9	1.2	1.4	1.8	2.1				
7.5	0.0	0.1	0.2	0.3	0.5	0.7	1.0	1.2	1.5	1.9	2.2	2.6	3.0	3.4	3.8
8.0	0.0	0.1	0.2	0.3	0.5	0.7	1.0	1.2	1						
8.5	0.0	0.1	0.2	0.4	0.6	0.8	1.1	1.4	1.8	2.1	2.5	2.9			
9.0															
9.5	0.0	0.1	0.2	0.4	0.6	0.9	1.2	1.6	2.0	2.4	2.8	3.3			

The height of tide at HW on the next rising tide is 9.2 feet but the boat will float before HW - when the height of tide reaches 7.0 ft, that is 2.2 ft before HW. From table 3 the correction for 2.2 feet occurs 2 hours and 07 minutes before HW. Therefore, the boat will float at 1740

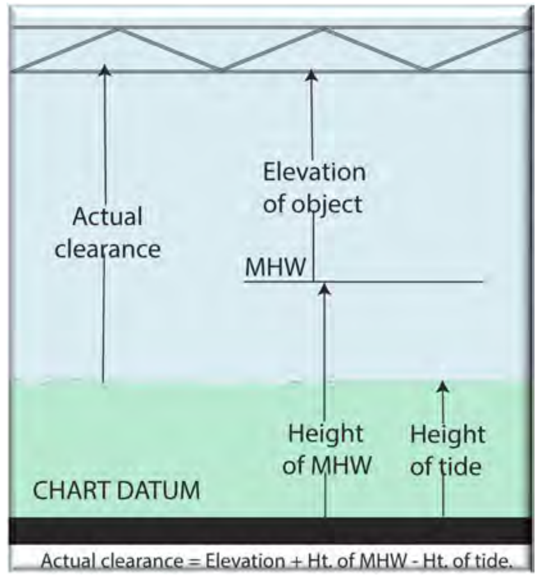
- 0207

1533 EDT, June 1.

Note that the height of HW for the rising tide is not the same as the height of the previous HW, when the boat went aground. As the range is therefore different two different rows in the table must be used.

Near Boston, on August the 16th at 1430 EDT, a yacht with a mast 55 ft above the water level wishes to pass underneath a bridge shown on the chart as having an authorized clearance of 50 ft. How much clearance, if any, will there be between the top of the mast and the bridge?

A quick sketch should help decide how to tackle the problem.



The elevation of the object may be found from the chart, or pilot book, and the height of tide at MHW from the chart for the area.

The height of the mast from the water level you should know and so the only thing left to find is the height of tide at the specific time. Remember that the height of the mast must include radio aerials, wind instruments, etc.

The actual clearance at any time will be:

the elevation of the object,
+ the height above chart datum of MHW,
- the height of tide at the time in question.

The first step is therefore:
Find the height of tide at Boston on August 16th at 1430 EDT.

Boston	LW 1250 EDT		0.5 ft	
	HW 1910		10.6	Time from nearest LW, (1430 - 1250)
Duration	620	Range	10.1	1h 40m

LW height is 0.5 ft
From Table 3 + 1.7 ft
∴ Height of tide 2.2 ft. at 1430 EDT

MHW 11.0 ft (from chart)
- height of tide 2.2 ft (at 1430 EDT)
8.8 ft

This means there is 8.8' from the actual sea level at 1430 EDT to the level of MHW.

Auth. clearance 50.0 ft (from MHW)
\+ 8.8 ft.
Bridge-to-sea 58.8 ft.
Mast height 55.0 ft
∴ Clearance = 3.8 ft

It is usually better to work out the time at which the yacht can pass under the obstruction because if, in the above example, there was not sufficient clearance the whole thing must be done again to find out when the yacht can pass. In other words, work out the height of tide required to allow the boat to pass safely under the obstruction and find out at what time this height of tide will be reached.

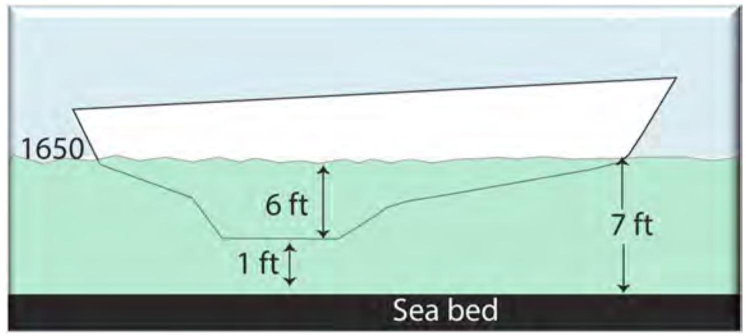
Do not forget to allow a safe clearance if the overhead obstruction is a power line and remember to check that there will be sufficient depth of water as well as sufficient overhead clearance!

<u>A boat docks alongside a harbor wall near Boston on a rising tide at 1650 EDT on August the 16th. The depth of water is 7' and the boat's draft is 6'.</u>
<u>At what time will the keel touch the sea bed?</u>

The depth of water is 7 ft, the draft is 6 ft and the tide is rising.

Step one:
find the height of tide at 1650 EDT, and the height of tide when the keel will touch the seabed

Step two:
find at what time the keel will touch the seabed on the next falling tide.



Then, *find height of tide at 1650:*

August 16, Boston LW
1250 0.5 ft HW 1910
10.6 ft

Duration of Rise 6h 20m
Range 10.1 ft
Time from nearest HW 0220

height of tide at HW	10.6 ft
height correction, from table 3	-3.0 ft
height of tide at 1650	= 7.6 ft

clearance, keel to seabed at 1650 = 1 ft.

Therefore, keel will touch when height of tide is 7.6 ft
-1.0ft
= 6.6 ft.

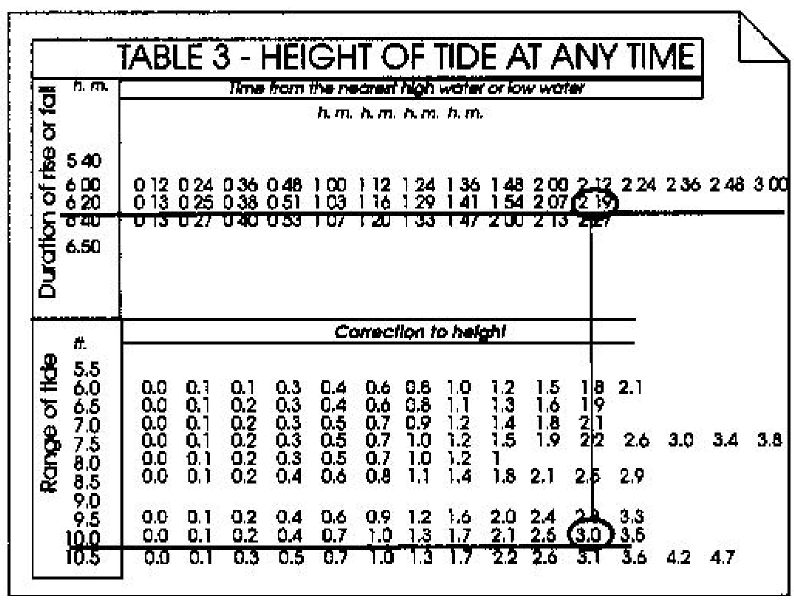


TABLE 3 - HEIGHT OF TIDE AT ANY TIME

Duration of rise or fall (h. m.)	Time from the nearest high water or low water (h. m.)														
5 40															
6 00	0 12	0 24	0 36	0 48	1 00	1 12	1 24	1 36	1 48	2 00	2 12	2 24	2 36	2 48	3 00
6 20	0 13	0 25	0 38	0 51	1 03	1 16	1 29	1 41	1 54	2 07	2 19				
6 40	0 13	0 27	0 40	0 53	1 07	1 20	1 33	1 47	2 00	2 13	2 27				
6.50															
Range of tide (ft.)	**Correction to height**														
5.5															
6.0	0.0	0.1	0.1	0.3	0.4	0.6	0.8	1.0	1.2	1.5	1.8	2.1			
6.5	0.0	0.1	0.2	0.3	0.4	0.6	0.8	1.1	1.3	1.6	1.9				
7.0	0.0	0.1	0.2	0.3	0.5	0.7	0.9	1.2	1.4	1.8	2.1				
7.5	0.0	0.1	0.2	0.3	0.5	0.7	1.0	1.2	1.5	1.9	2.2	2.6	3.0	3.4	3.8
8.0	0.0	0.1	0.2	0.3	0.5	0.7	1.0	1.2	1						
8.5	0.0	0.1	0.2	0.4	0.6	0.8	1.1	1.4	1.8	2.1	2.5	2.9			
9.0															
9.5	0.0	0.1	0.2	0.4	0.6	0.9	1.2	1.6	2.0	2.4	[illegible]	3.3			
10.0	0.0	0.1	0.2	0.4	0.7	1.0	1.3	1.7	2.1	2.5	3.0	3.6			
10.5	0.0	0.1	0.3	0.5	0.7	1.0	1.3	1.7	2.2	2.6	3.1	3.6	4.2	4.7	

Then, find at what time the height of tide will be 6.6 ft on the next falling tide:

HW 1910 10.6 ft
LW 0135 0.0 ft (Aug. 17)

Duration of Rise	6h 25m
Range	10.6 ft
feet from HW	4 ft.
time correction	+2h45m

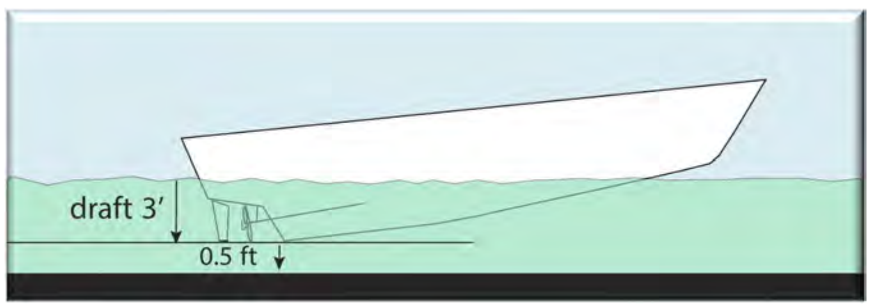
Therefore, the keel will touch at

1910
+ 0245
2155 EDT August 16

TABLE 3 - HEIGHT OF TIDE AT ANY TIME

Duration of rise or fall (h. m.)	Time from the nearest high water or low water (h. m.)														
5 40															
6 00	0 12	0 24	0 36	0 48	1 00	1 12	1 24	1 36	1 48	2 00	2 12	2 24	2 36	2 48	3 00
6 20	0 13	0 25	0 38	0 51	1 03	1 16	1 29	1 41	1 54	2 07	2 19	2 32	2 46	2 57	
6 40	0 13	0 27	0 40	0 53	1 07	1 20	1 33	1 47	2 00	2 13	2 27				
6.50															
Range of tide (ft.)	**Correction to height**														
5.5															
6.0	0.0	0.1	0.1	0.3	0.4	0.6	0.8	1.0	1.2	1.5	1.8	2.1			
6.6	0.0	0.1	0.2	0.3	0.4	0.6	0.8	1.1	1.3	1.6	1.9				
7.0	0.0	0.1	0.2	0.3	0.5	0.7	0.9	1.2	1.4	1.8	2.1				
7.5	0.0	0.1	0.2	0.3	0.5	0.7	1.0	1.2	1.5	1.9	2.2	2.6	3.0	3.4	3.8
8.0	0.0	0.1	0.2	0.3	0.5	0.7	1.0	1.2	1						
8.5	0.0	0.1	0.2	0.4	0.6	0.8	1.1	1.4	1.8	2.1	2.6	2.9			
9.0															
9.5	0.0	0.1	0.2	0.4	0.6	0.9	1.2	1.6	2.0	2.4	2.8	3.3			
10.0	0.0	0.1	0.2	0.4	0.7	1.0	1.3	1.7	2.1	2.5	3.0	3.5			
10.5	0.0	0.1	0.3	0.5	0.7	1.0	1.3	1.7	2.2	2.6	3.1	3.6	4.2	4.7	

At low water (1150 EDT) on May the 3rd the actual minimum depth of water beside a harbour wall near Boston is 1 ft. At what time can a motor boat with a 3 ft draft come alongside the wall. You will allow 0.5 ft clearance for safety.



The actual depth of water required is the draft + the clearance:
3 ft + 0.5 ft = 3.5 ft,

but there is already 1 ft depth beside the wall at low water.

Therefore the depth of water required above the level at low water is **3.5 ft - 1 ft = 2.5 ft.**

The problem now becomes: *at what time will the height of tide have risen by 2.5 ft from the height of tide at Low Water?*

Boston, May 3rd LW 1151 EDT 0.5 ft HW 1815 9.1 ft.

Duration of Rise	6h 24m
Range	8.6 ft
feet from LW	2.5 ft.
time correction	+2h19m

LW 1151
\+ 0219
1410 EDT
is the time at which the boat may come alongside the wall.

Caution
Tide tables are predictions and do not consider the effect of influences such as atmospheric pressure which can change from day to day; always allow a sensible safety margin in your calculations.

A simple check on tidal height calculations can sometimes be carried out by bringing your boat near a charted object and comparing the depth shown on the echo sounder with the charted sounding + the height of tide that you have calculated.

In the foregoing examples calculations have been carried out to decimals of a foot or slightly more than 1 inch. Obviously common sense demands that sensible clearances should be allowed when working out tidal height problems when afloat.

The Rule of Twelfth's

If you do not have a tidal curve on hand or if you just want a rough idea of the height of tide you can sometimes use what is known as the 'Rule of Twelfth's'. 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

Example of using the rule of twelfth's

Find the height of tide at Boston at 1400 EDT on May 3rd.

Boston, May 3rd LW 1151 EDT 0.5 ft HW 1815 9.1 ft

Range 8.6 ft.

1/12 of 8.6 ft = 0.7 ft. (first hour)
2/12 of 8.6 ft = 1.4 ft (second hour
Tide will rise 2.1 ft

Therefore height of tide at 1400
0.5 ft (LW)
2.1 ft (rise)
2.6 ft height of tide.

In this instance the result above, found using the rule of twelfths, compares favourably with the result using Table 3 as is demonstrated below.

Find the height of tide at Boston at 1400 EDT on May 3rd.

Boston, May 3rd LW 1151 EDT 0.5 ft HW 1815 9.1 ft

Duration of rise 6h24m
Range 8.6 ft.
Time from LW 2h09m

correction to height 2.1 ft.

Tide will rise 2.1 ft

Therefore, height of tide at 1400
0.5 ft (LW)
2.1 ft (rise)
2.6 ft height of tide.

TABLE 3 - HEIGHT OF TIDE AT ANY TIME

Duration of rise or fall h. m.	Time from the nearest high water or low water h. m.														
5 40															
6 00	0 12	0 24	0 36	0 48	1 00	1 12	1 24	1 36	1 48	2 00	2 12	2 24	2 36	2 48	3 00
6 20	0 13	0 25	0 38	0 51	1 03	1 16	1 29	1 41	1 54	2 07	2 19	2 32	2 45	2 57	
6 40	0 13	0 27	0 40	0 53	1 07	1 20	1 33	1 47	2 00	[illegible]	2 27				
6.50															

Range of tide ft.	Correction to height														
5.5															
6.0	0.0	0.1	0.1	0.3	0.4	0.6	0.8	1.0	1.2	1.5	1.8	2.1			
6.5	0.0	0.1	0.2	0.3	0.4	0.6	0.8	1.1	1.3	1.6	1.9				
7.0	0.0	0.1	0.2	0.3	0.5	0.7	0.9	1.2	1.4	1.8	2.1				
7.5	0.0	0.1	0.2	0.3	0.5	0.7	1.0	1.2	1.5	1.9	2.2	2.6	3.0	3.4	3.8
8.0	0.0	0.1	0.2	0.3	0.5	0.7	1.0	1.2	1						
8.5	0.0	0.1	0.2	0.4	0.6	0.8	1.1	1.4	1.8	2.1	2.5	2.9			
9.0															
9.5	0.0	0.1	0.2	0.4	0.6	0.9	1.2	1.6	2.0	2.4	2.8	3.3			
10.0	0.0	0.1	0.2	0.4	0.7	1.0	1.3	1.7	2.1	2.5	3.0	3.5			
10.5	0.0	0.1	0.3	0.5	0.7	1.0	1.3	1.7	2.2	2.6	3.1	3.6	4.2	4.7	

Chapter 10 UK TIDES

10.1 Key Objectives

THE OBJECTIVE OF THIS CHAPTER IS TO ENSURE CANDIDATES UNDERSTAND UK TIDES AND STANDARD, SECONDARY PORTS AND BIRITHS ADMIRALTY TIDE TABLES.

10.2 To Find Times of Heights at HW and LW

Most maritime nations publish tables of tidal predictions for the times and heights of High and Low for each day of the year. In the U.K. the British Admiralty publish Tide Tables each year as do various nautical almanacs, such as a Macmillan Reed Nautical Almanac. The time zone is usually given at the top of each page of the tide tables. The heights shown refer to Chart Datum in use in that area. Local tide tables can often also be found in nautical bookshops and marina offices and tidal prediction programmes can be bought and run on any PC or obtained readily from the Internet.

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.

Secondary Ports

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 port.

Standard Port Tide Table Layout for HW and LW

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. Check carefully whether the times in the tables have been corrected for British Summer Time which is + 1 hour on UT (Universal Time) which for tidal predictions can be considered the same as Greenwich Mean Time (GMT).
e. The predicted height of tide is given in metres and decimals (tenths) of a metre.
f. The height of tide given is the height above Chart Datum.
g. Check the Chart Datum. (They are different in UK and USA for example).
h. The tables do not say low or high water, the heights given will show which is which.
i. Underneath the date are printed the first few letters of the day, i.e. Tu = Tuesday.

j. The time zone will be shown - UT (GMT) for British Admiralty Tide Tables.
k. The date of new moon and full moon is shown by symbols on some tide tables.

LAT 51°07'n LONG 1°19'e

TIME ZONE UT (GMT) TIMES AND HEIGHTS OF HIGH AND LOW WATERS YEAR 2000

JANUARY						FEBRUARY					
	Time	m		Time	m		Time	m		Time	m
1	0127	2.1	16	0014	1.9	1	0246	2.2	16	0224	1.9
	0651	5.6		0541	5.8		0818	5.4		0802	5.8
SA	1401	1.9	SU	1300	1.8	TU	1515	2.0	W	1507	1.6
	1936	5.4		1832	5.6		2050	5.5		2041	5.8
2	0232	2.1	17	0133	1.9	2	0350	1.9	17	0341	1.5
	0759	5.7		0701	5.9		0916	5.7		0910	6.1
SU	1503	1.8	M	1415	1.6	W	1612	1.7	TH	1626	1.3
	2034	5.6		1946	5.8		2139	5.8		2141	6.2
3	0336	1.9	18	0248	1.7	3	0442	1.6	18	0455	1.1
	0855	5.8		0810	6.1		0959	5.9		1009	6.4
M	1601	1.7	TU	1525	1.4	TH	1700	1.5	F	1736	1.0
	2122	5.9		2048	6.1		2219	6.1		2232	6.5

MARCH						APRIL					
	Time	m		Time	m		Time	m		Time	m
1	0200	2.4	16	0209	1.9	1	0334	1.8	16	0435	1.1
	0737	5.1		0758	5.6		0855	5.7		0950	6.2
W	1436	2.2	TH	1457	1.8	SA	1559	1.6	SU	1707	1.1
	2014	5.3		2033	5.7		2115	5.9		2202	6.4
2	0312	2.1	17	0333	1.6	2	0425	1.4	17	0531	0.8
	0845	5.4		0909	6.0		0935	6.0		1031	6.4
TH	1539	1.9	F	1622	1.4	SU	1648	1.3	M	1755	0.9
	2110	5.6		2133	6.1		2153	6.2		2242	6.7
3	0410	1.7	18	0450	1.1	3	0512	1.1	18	0617	0.6
	0932	5.7		1005	6.3		1012	6.3		1107	6.6
F	1632	1.5	SA	1727	1.0	M	1733	1.1	TU	1835	0.8
	2151	6.0		2222	6.5		2229	6.5		2320	6.8

Extract from tide tables for Dover, England

Using the Tide Tables for HW and LW 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.

Find the times and heights of HW and LW at Dover, England on Tuesday the 1st of February.
We look up the tide tables for the day and port in question:

LW	0246 UT	2.2 m
HW	0818 UT	5.4 m
LW	1515 UT	2.0 m
HW	2050 UT	5.5 m

Note that 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.

Find the times and heights of HW, LW and the range of tide at Dover on the evening of March 2nd.

LW	1539 UT	1.9 m
HW	2110 UT	5.6 m
	Range	3.7 m

What the information found in the last example actually means is that high tide will be at 2110 by your watch and at that time there will be 5.6 m in addition to the depths shown on the chart of the area. Low tide will occur at 1539 when there will be 1.9 m in addition to the depths shown on the chart for the area. The range of this tide is from 1.9 m to 5.6 m = 3.7 m.

Secondary Port Layout for Times and Heights of HW and LW

The times of high and low water are found by supplying the tide differences to the daily tidal predictions to a suitable Standard Port. The standard port may not necessarily by the closest port and the time differences are based on normal weather conditions. The secondary port time and height differences are tabulated in, for example, Part II of the British Admiralty Tide Tables. The tables for secondary ports are sometimes called Tide Difference Tables.

How to use the tide difference tables:

a. Find the page for the secondary port, or place, required.
b. Note the name of the standard port in bold print at the top of the section.
c. The position of the port is 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.
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.
    a. 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.

Secondary Port HW and LW Tide Differences Table

These are given for differences in times and heights of HW and LW between the standard port and the secondary port. Because the times in the secondary port are rarely coincidental with the standard port we have to interpolate the given values from the standard port throughout a 24 hour period.

Times at a Secondary Port

Thus for a secondary port, such as Bognor Regis, the reference, standard port is Shoreham:

	HW		**LW**	
SHOREHAM	**0500** and **1700**	**1000** and **2200**	**0000** and **1200**	**0600** and **1800**
Bognor Regis	+0010	-0005	-005	-0020

The time differences between the standard port Shoreham 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 i.e. Shoreham. Thus, the HW time difference that occurs at Shoreham at, say, 1400 has to be interpolated between 1000 and 1700. Likewise, for times, say, of HW at Shoreham at 2300 or 0400 differences have to be interpolated between 2200 and 0500.

<u>The interpolation is carried out as follows:</u>

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 (-0005). 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) x3 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 +001. 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 0500 where correction is +10 min	
So = 10 min - 9 min	= 1 min correction from HW time at Shoreham

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
SHOREHAM	**6.3**	**4.8**	**1.9**	**0.6**
Bognor Regis	-0.6	-0.5	-0.2	-0.1

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

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 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

Standard Ports

Times and heights of tides that are in between the tabulated values are obtained using Mean Spring and Neap Curves. In the British Admiralty Tide Tables these tidal curves are reproduced before the standard port daily prediction tables. There are two types of problems:

1. ***What is the TIME of a REQUIRED HEIGHT of Tide?***
   We are required to find the time when the tide has reached 3.4m (above CD) during the early hours of the morning at Dover on 1st March.

   *Extract the times of LW and HW at Dover for 1st March:

Time	Height
0200	2.4m
0737	5.1m

   * Calculate the tidal range by subtracting the LW from HW
   Tidal Range: 5.1 - 2.4 = 2.7m

   *Apply a time correction i.e. GMT to BST. However, in March we are still GMT

   * Now set up the tidal curve diagram:
      a. Pencil in the time of HW and the hourly, relevant time intervals relative to the HW
      b. On the scale marked H.W. Hts.m plot the height of HW. (5.1m in this instance)
      c. On the scale L.W.Hts.m plot the height of the LW (2.4m)
      d. Connect up the two points with the 'range line'.

   * Mark the height required (3.4m in this example) on the H.W.Hts.m scale and construct a vertical line down to intercept the range line.

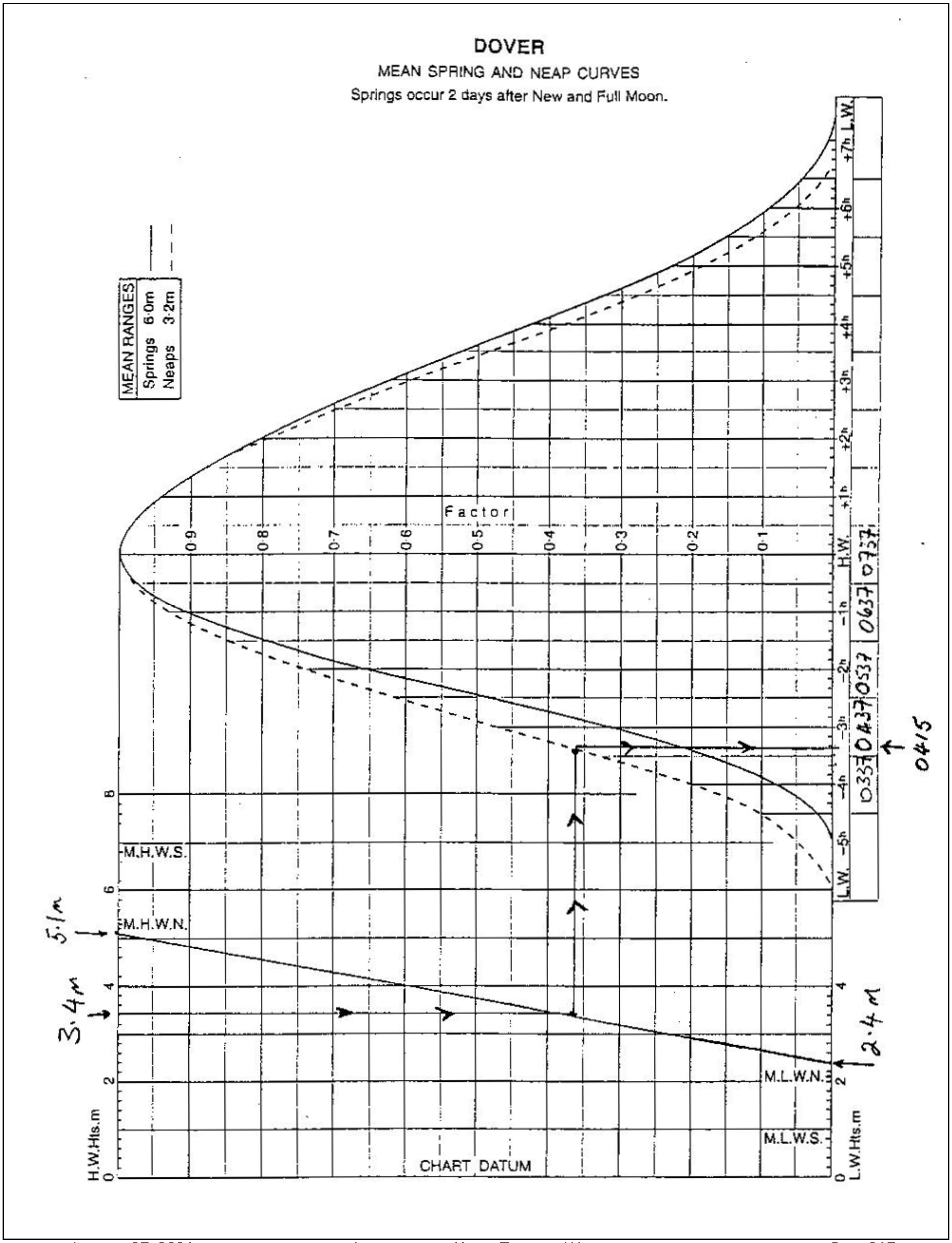
   * We have to interpolate between spring and neap tidal ranges - that is the solid and pecked tidal curves:
      a. Compare our extracted, calculated tidal range (2.7m) with the small table of MEAN RANGES displayed on the Admiralty tidal curves diagram.
      b. The tabulated Mean Springs range is 6.0m and Mean Neaps range is 3.2m. In this case our extracted, calculated range is 2.9m which is outside the neap curve. However, since we do not extrapolate outside the tidal curves, we must therefore use the neap curve which is the pecked curve. With the British Admiralty Tide Tables, it is important to never extrapolate beyond the solid mean spring and pecked mean neap curves. Thus, for extracted tidal ranges with values greater than the value given in the small table we must use the solid spring curve.
      Likewise, and as given in this example, for extracted ranges less than the mean neap values the pecked neap curve must be used. If the range had been say 4.6m we would have had to interpolate a distance between the curves - which in this case would be halfway.

* Next draw a vertical line down from the cutting point of the tidal curve to intercept the time axis of the curve.

* And read off the time which is equivalent to a height of 3.4m above chart datum.

* Each gradation is 10 minutes (i.e. 60 minutes divided by 6). Thus, the line is slightly to the left of the fourth gradation, say 8 minutes, so the time is 0337 + 38 minutes that is 0415

Thus, the time when the tide height will be 3.4m above Chart Datum on the 1st March will be at 0415 hours.


DOVER
MEAN SPRING AND NEAP CURVES
Springs occur 2 days after New and Full Moon.
MEAN RANGES
Springs 6·0m
Neaps 3·2m
Factor
H.W.
L.W.
M.H.W.S.
M.H.W.N.
M.L.W.N.
M.L.W.S.
CHART DATUM
H.W.Hts.m
L.W.Hts.m
5·1m
3·4m
2·4m
0415
0337
0437
0537
0637
0737

Chapter 11 CURRENTS, TIDAL STREAMS, OVERFALLS, TIDE RACES AND BARS

11.1 Key Objectives

THE KEY OBJECTIVES OF THIS CHAPTER ARE TO DISCUSS CURRENTS & TIDAL STREAMS, OVERFALLS, TIDE RACES & BARS AND WHY IS IT ESSENTIAL TO BOTH UNDERSTAND AND BE ABLE TO USE CURRENT & TIDE INFORMATION.

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 currents. It is essential both to understand, and to be able to use, the available current information.

Consider a yacht sailing through the water at 5 knots directly against a current of 3 knots; the yacht is actually only covering a distance over the ground of 2 miles in one hour. If the yacht changes her time of departure so that she sails in the same direction as the current 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 current 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 current and 23 miles motoring with the current, a difference of 6 miles in each hour. The resultant saving in time and fuel costs must be worthwhile.

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

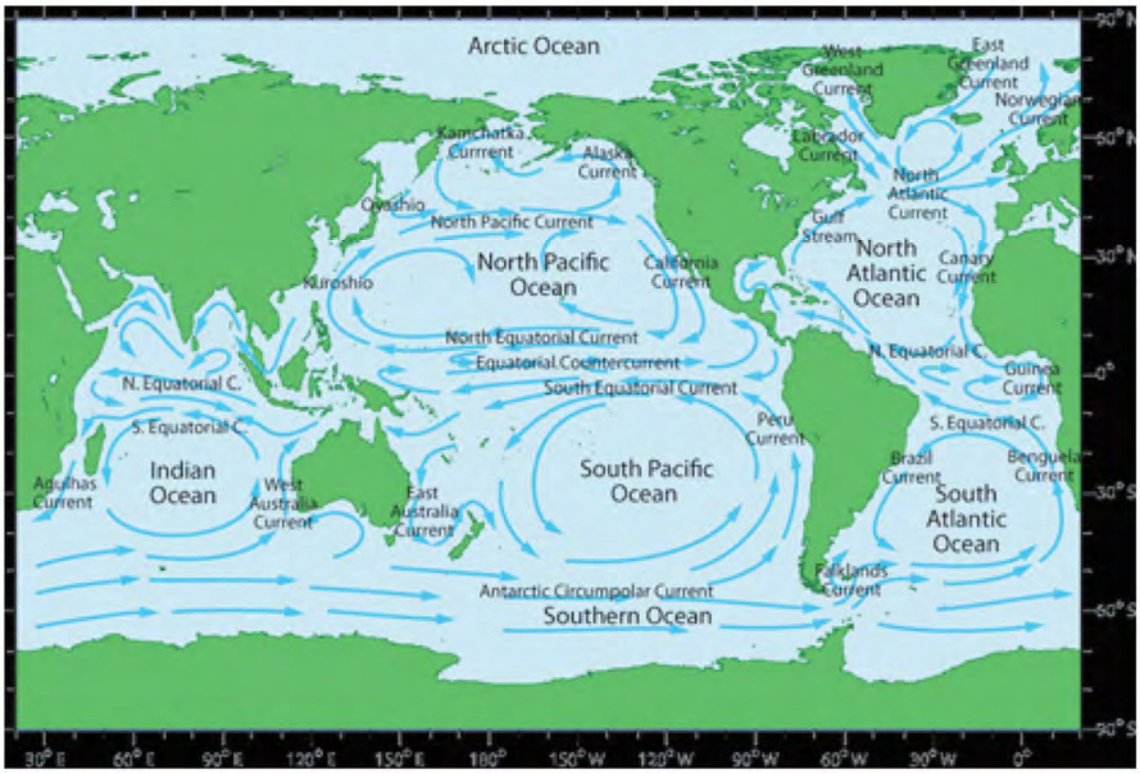
Currents

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:

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.

Deep Water Currents move around the ocean basins by density driven forces and gravity and do not affect the navigator.



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.

Flood Stream

When the tide is rising the current is called the flood current.

Ebb Stream

When the tide is falling the current is called the ebb current.
The tide may be said to be "flooding" or "ebbing".

Rectilinear Currents or Tidal Streams

When the current flows through relatively narrow channels the stream flows firstly in one direction and then reverses and flows in the opposite direction. Currents that flow in one of two directions like this are called rectilinear currents. 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 change of direction with rectilinear currents.

Dover Straits, Delaware Bay and Chesapeake Bay are examples of "narrow channels", the flood stream flowing generally in one direction and the ebb stream flowing back in the opposite direction. The currents run roughly parallel to the land which forms the physical barriers on either side.

Rotary Currents

In the open sea, away from close proximity to land, the current does not reverse direction but instead changes direction continuously through 360° in a clockwise direction (in the northern hemisphere). Rotary currents are usually found some distance offshore but can also occur close to land; for example, currents are rotary at Horse Head Channel near the entrance to the Bay of Fundy.

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.

The Effect of Headlands, Bays, Etc.

At sea the current runs parallel to the main land masses but close inshore the current will set into bays and estuaries. Headlands can create counter currents and eddies down tide.

Where there are large tidal basins with narrow entrances the rate at the narrows can be high, giving rise to overfalls and dangerous conditions, particularly when the wind blows in the opposite direction to the current ("wind over current" or "wind against current"). In calm conditions a yacht must have sufficient reliable power to ensure she can make way against strong currents. In some cases, running with a fast current can cause problems. With 8 knots of current and 6 knots boat speed the boat's speed over the ground becomes 14 knots, leaving surprisingly little time available for pilotage.

Inset, Bays Harbours & Estuaries

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

Current or Tidal Rips and Overfalls

Strong currents rushing over rough or shoaling seabeds 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

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 Current or Tidal Stream Information

Current information may be available from five different sources:

1. from current tables,
2. from arrows sometimes printed on the chart,
3. from current charts,
4. from pilot books and cruising guides, and
5. from practical observation.
6. from internet / software
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 boat 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 be best 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 steep 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.

Tidal Gates & 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 a 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:

1. **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.

2. **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.

3. **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.

4. **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.

Current Tables

Current tables are available from different sources such as nautical bookstores and Reed's Nautical Almanac contains full current tables for the East coast of the U.S.

Using the Current tables

The current tables are generally similar in layout to the tide tables having predictions for primary reference stations and a further table of differences which allow currents to be found for nearly 2,500 substations.

Current tables

- The current tables give the times of slack water;
- the time at which the current reaches its maximum speed, and what this speed is, on the flood tide;
- the time at which the current reaches its maximum speed; and what this speed is, on the ebb tide;
- the direction (in °T) of the flood and ebb current.

The current tables give the times of slack water;

- the time at which the current reaches its maximum speed, and what this speed is, on the flood tide;
- the time at which the current reaches its maximum speed; and what this speed is, on the ebb tide;
- the direction (in °T) of the flood and ebb current.

Thus, from the current table extract in Figure 87 - Chesapeake Bay Entrance current table extract, it can be seen that:

- the flood current runs in the direction of 300° (T), the ebb runs in the direction of 129° (T).
    - On June 16
- slack waters occur at 0430, 1134, 1659 and 2336;
- the flood current reaches a maximum speed of 0.9 knots at 0113 and 0.6 knots at 1351;
- the ebb current reaches a maximum speed of 1.3 knots at 0813 and 1.1 knots at 2036.

PEAKE BAY ENTRANCE, VA
CURRENT TABLE 199X Flood °300 Ebb °129
Corrected for Daylight Saving Time

JUNE

	Slack time	Max time	Fld knots	Ebb knots
16 Tu		0113	0.9	
	0430	0813		1.3
	1134	1351	0.6	
	1659	2036		1.1
	2336			
17 We		0207	0.8	
	0522	0904		1.3
	1226	1447	0.7	
	1820	2140		1.1

FIGURE 87 - CHESAPEAKE BAY ENTRANCE CURRENT TABLE EXTRACT

Subordinate stations

In the same way as with tidal heights there are difference tables which supply corrections allowing the calculation of current data for subordinate stations; these are again laid out in geographical order starting from north, going south.

These current difference tables supply corrections for times, and current speeds which are applied to the data for the primary station to arrive at the data required for the subordinate station.

Differences for time are added or subtracted as their sign (+ or -) indicates; differences of speed are found by multiplying the current speed given for the reference port by the 'speed ratio' given in the subordinate station difference table.

PLACE	POSITION	TIME DIFFERENCES				SPEED RATIOS		CURRENT DIRECTION AND MAX SPEED			
		slack before flood h m	max flood h m	slack before ebb h m	max ebb	flood	ebb	flood dir	ebb dir	flood knots	ebb knots
		on CHESAPEAKE BAY ENTR, p. C76									
Smith Point Light,1.5nm east (	37°52'. 76°09'	+4:27	+4:33	+3:44	+4:23	0.5	0.6	347°	159°	0.4	0.7
Smith Point Light,0.8nm NW (	37°53' 76°11'	+2:28	+2:45	+3:13	+2:27	1.1	0.6	021°	150°	0.9	0.8
Smith Point Light,6.0mi north	37°58' 76°11'	+4:28	+4:30	+4:19	+4:06	0.5	0.8	350°	135	0.4	1.0
Chesapeake Bay,MD											
Smith Island, 3.6nm NW of											

Example

Find the current data for a position 1.5 miles east of Smith Point Light, on the morning and early afternoon of June 16.

The reference station is Chesapeake Bay Entrance and the differences for 1.5 miles east of Smith Point Light are found from Reed's.

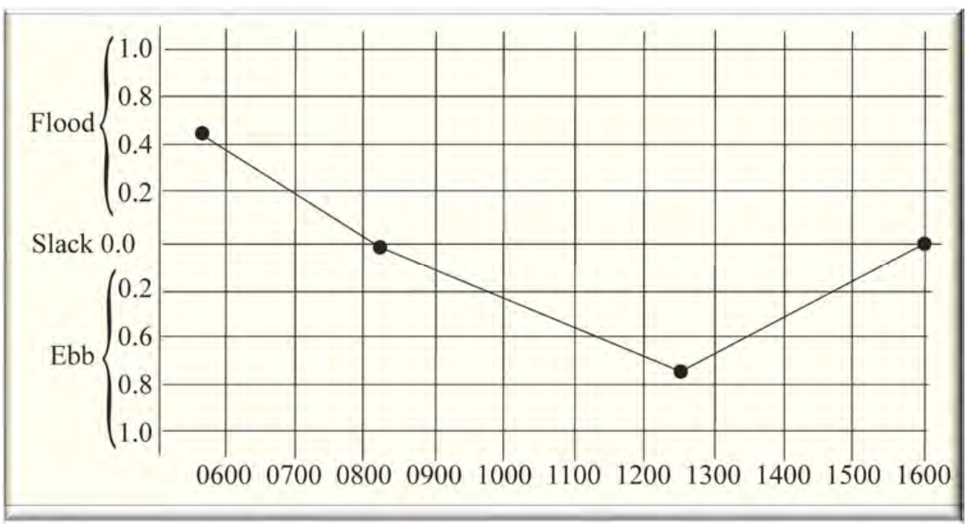
Chesapeake:	Max Fld 0113	0.9 knts	Slack 0430	Max ebb 0813	1.3 knts	slack 1134
Differences Smith Pt	+0433	x0.5	+0344	+0423	x 0.6	+0427
Smith Point	*0546*	*0.45*	*0814*	*1236*	*0.78*	*1601*

The direction of the current at Smith point, from the difference table, is:
Flood 347°(T), Ebb 159°(T).

Note that the max speed given in the extreme right hand side of Reed's difference table is an average speed only, the figures we have worked out above are correct for the day and take into account the effect of spring and neap tides.

Speed of current at a specific time

In order to find the speed of current at a specific time a simple straight line graph can be quickly drawn up plotting speeds against time. Using the current figures found for Smith Point above the graph would look like the figure below allowing the current to be read off for any moment of time.



Current graph for Smith Point for June 16th. The figures worked out above are plotted as follows:

the time of max flood (0546) against the speed of max flood (0.45);
the time of slack before ebb (0814) against the speed at slack (0.0);
the time of max ebb (1236) against the speed at max ebb (0.78)
the time of slack before flood (1601) against the speed at slack (0.0).
and so on for the period of time for which the graph is required.
The graph above the 0.0 (slack) line is for the flood and below for the ebb.

The approximate speed of the current can now be read off the graph for any moment in time, for example, at 1000 the current will have a speed of 0.3 knots and a direction of 159°(T)

Finding Current Set & Drift By Comparing The DR Position With A Fix

The figure below shows how the set and drift of a current might be found by comparing a DR position with an accurate fix.

The DR position has been determined by plotting the courses and distances the boat sailed from 1300 to 1400, thus giving a DR position at 1400. At 1400 an electronic fix derived from a GPS was plotted on the chart.

The difference in distance and direction between the DR and GPS position represents the cumulative effect of the current for the time involved.

In this case the set and drift of the current can be found as 170°(T) / 2.5 miles, which indicates an average direction and rate of 170°(T) / 2.5 knots.

It must be clearly understood that figures derived in this manner

1. include leeway, helmsman's error, etc.;
2. represent what happened during the past hour(s), it does not necessarily follow that this will continue to happen for any given period of time into the future.

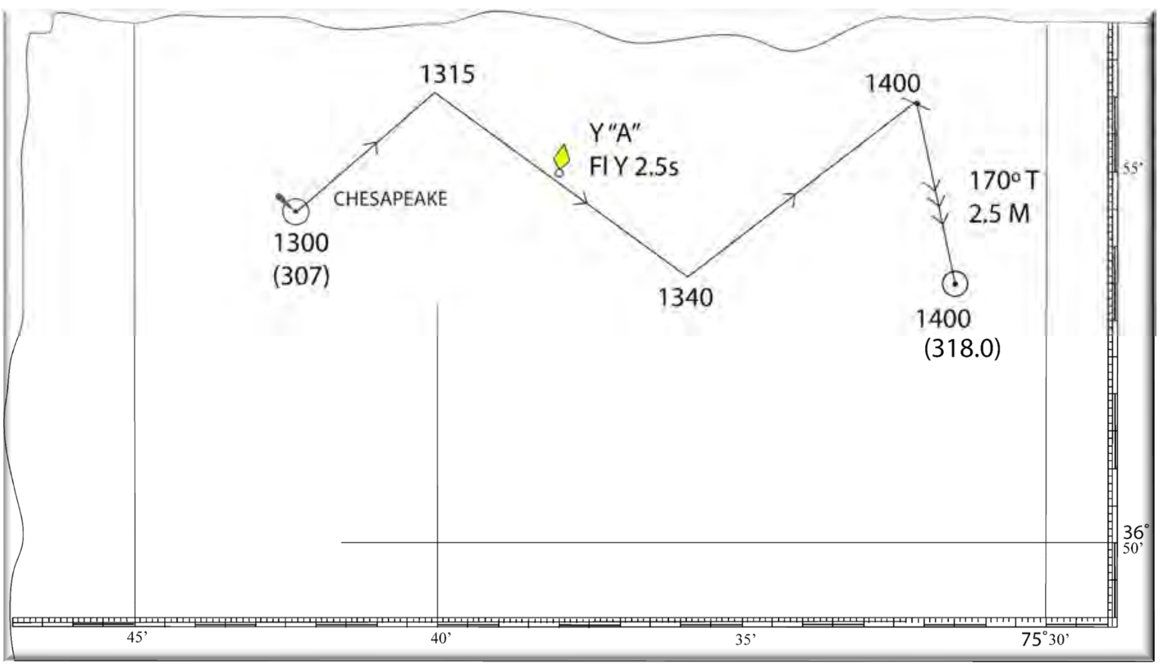


FIGURE 88 - CURRENT ESTIMATION BY COMPARING A DR WITH A FIX

Current Charts

Reeds also has current charts of Chesapeake Bay, Delaware Bay, New York Harbor, Long Island Sound and Block Island Sound, Narragansett Bay, Buzzards Bay and Nantucket Sound.

These charts show current direction by arrows and current speeds are printed on the chart. The time reference is printed on each of 12 charts.

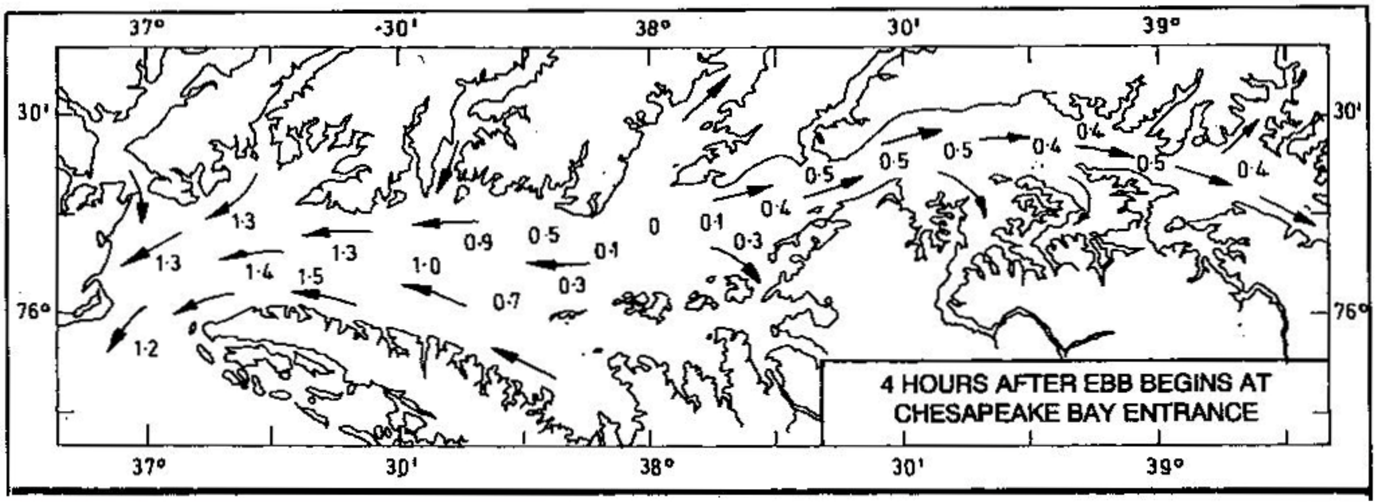


FIGURE 89 - CURRENT DIRECTION AND RATES FOR CHESAPEAKE BAY 4 HOURS AFTER EBB BEGINS AT CHESAPEAKE BAY ENTRANCE

Using current charts

Select the appropriate chart and line up the edge of the plotter as closely as possible with the current arrow.

Use the edge of the chart or page to ensure the north point of the protractor is pointing exactly north. Read off the direction.

This chart uses the current tables for Chesapeake Bay entrance as a time reference and shows how the currents run at 4 hours after ebb begins at Chesapeake Bay entrance.

Strictly speaking the data here is only correct for this one moment of time but we will use the direction and rate for one full hour centered on the time given. In other words, use the directions and rates from 30 minutes before “4 hours after ebb begins” until 30 minutes after “4 hours after ebb begins”.

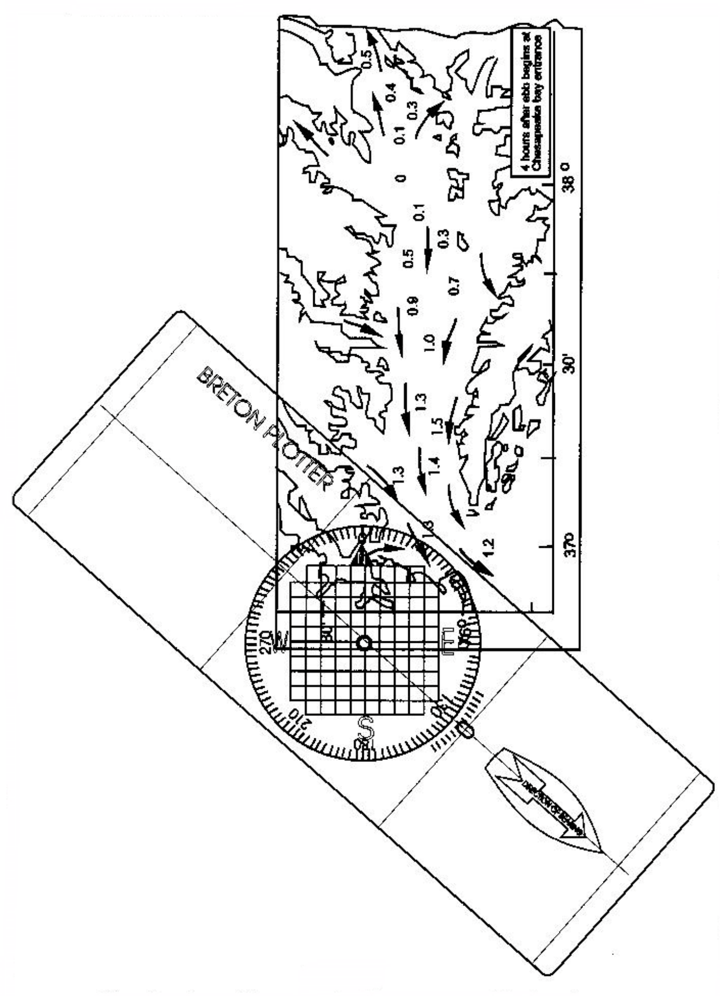


FIGURE 90 - THE DIRECTION OF THE CURRENT AT THE ENTRANCE OF THE BAY IS ABOUT 130° (T) AND THE SPRING RATE IS ABOUT 1.2 KNOTS

For example, on the morning of June 17 (from the tide table in Figure 87 - Chesapeake Bay Entrance current table extract) "slack before ebb begins" is at 0522 EDT at Chesapeake Bay entrance.

From 0452 until 0552 use the chart "slack before ebb".

from 0522 to 0652 use "1 hour after ebb begins"

from 0652 to 0752 use "2 hours after ebb begins"

from 0752 to 0852 use "3 hours after ebb begins"

from 0852 to 0952 use "4 hours after ebb begins"

The current rate shown on the current chart is the rate at spring tides; in order to find the rate for any specific day simply divide the rate found from the chart by the spring tidal range and multiply the result by the tidal range for the specific day.

For example: *find current rate on June 17 at 4 hours after ebb begins.*
Spring current rate = 1.2 knots, spring range = 3.6 ft, range on June 17 = 2.9 ft.
Therefore rate = 1.2 ÷ 3.6 x 2.9 = 0.96 knots or **1.0 knot**.

Non-Tidal Currents

Currents which are generated by forces other than tidal forces are also often of great importance to the navigator. Generally speaking, non-tidal currents run continuously in the same direction, although some currents experience seasonal changes of direction.

The Gulf Stream is an obvious example running up much of the east coast of the U.S.

The Gulf Stream

The Gulf Stream can reach speeds of 5 knots which has obvious implications for any yacht, sailing or motor.

Information on currents should be sought from Pilot Books and Sailing Directions. Reed's North American East Coast Almanac has two pages entitled Gulf Stream Information at the start of its Coast Pilot section.

The United States Coast Pilot, No 4 (Cape Henry to Key West) also gives useful information on Gulf Stream routing.

DMA chart 108 (INT 403), Southeast Coast of North America, shows the approximate position of the axis of the Gulf Stream starting between the north western tip of Cuba and the Florida Keys and continuing up the coast as far as Cape Hatteras from where the Stream turns north eastward out into the Atlantic, driven by the prevailing westerly winds and Coriolis force.

DMA chart 26320, Northern Part of Straits of Florida, shows the approximate position of the axis of the Gulf stream from Key Largo up to Jupiter Inlet; the axis of the Stream on this chart can be seen to be about 16 miles off Fort Lauderdale and rates of from 2 knots off the Bimini Islands to 3.5 knots at the axis are shown.

The position of the axis is given as being approximate as it is affected by seasonal and weather pattern changes; the speed and direction of the current are also modified by the effects of strong winds.

Tidal Data

Sources of tidal stream information (information may be available from six different sources:

1. tidal stream tables
2. arrows sometimes printed on the chart
3. tidal stream charts.
4. pilot books and cruising guides
5. practical observation
6. tidal diamonds.

Tidal Stream Diamonds

These are localised tidal predictions based on standard ports that are found on British Admiralty charts.

The information is tabulated for the time of HW at a standard port and at hourly intervals before and after HW. The localised tidal positions are identified by a letter inserted into a diamond-shaped frame.

		A 50 42'.3N 0 26'.5E			B 50 53'.0N 1 00'.0E			C 51 01'.0N 1 10'.0E		
Hours		Dir	Sp	Np	Dir	Sp	Np	Dir	Sp	Np
Before HW	6	248	0.8	0.4	213	1.6	0.9	224	0.9	0.5
	5	067	0.5	0.3	214	2.1	1.2	239	1.0	0.6
	4	068	1.9	1.0	215	1.8	1.1	235	1.1	0.6
	3	071	2.6	1.5	213	0.9	0.5	242	0.6	0.4
	2	069	2.3	1.3	S	lack		S	lack	
	1	068	1.2	0.6	033	0.8	0.5	052	0.6	0.3
HW		067	0.1	0.1	032	1.5	0.8	049	1.2	0.7
After HW	1	248	0.9	0.5	031	1.9	1.1	049	1.3	0.7
	2	247	1.4	0.8	030	1.7	1.0	056	1.0	0.5
	3	251	1.8	1.0	031	1.2	0.6	054	0.5	0.3
	4	253	1.7	1.0	032	0.4	0.2	S	lack	
	5	250	1.6	0.9	211	0.4	0.2	219	0.4	0.2
	6	249	1.2	0.7	212	1.3	0.7	217	0.8	0.4

Rate and direction of spring and neap tides are given in the table. It is important to realise that the tidal diamond information is for a specific location only. A short distance away the data may be very different.

If a yacht is sailing between two diamonds it becomes necessary to interpolate the tidal information from each of the diamonds. The diamonds are used to plot on a chart the effect of tidal streams when estimating the position of a yacht.

Direction and rate of tidal streams that are in the tables are the average values for one hour. Thus, the tabulated tidal information (i.e. Hours before of after HW at a standard port) applies to the tabulated value plus or minus a half hour.

Chapter 12 COURSE TO STEER TO COUNTERACT A CURRENT

12.1 Key Objectives

THE KEY OBJECTIVE OF THIS CHAPTER IS TO PROVIDE INFORMATION FOR ACCURATELY PLOTTING COURSE TO STEER INLUDING LEEWAY EFFECTS, ETC.

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 currents, 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 current would carry you down stream from your objective unless you continually adjusted the boat's heading to compensate for the effect of the current.

A better approach is to compensate from the start for the sideways movement caused by the current by pointing the boat not towards the place you want to arrive 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 currents on the boat's passage must be taken into account and compensated for. In addition to the effect of the current, 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 – see figures on next page

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 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 current vector is marked with 3 arrows, the ground track is marked with two arrows and the CTS is marked with a single arrow.

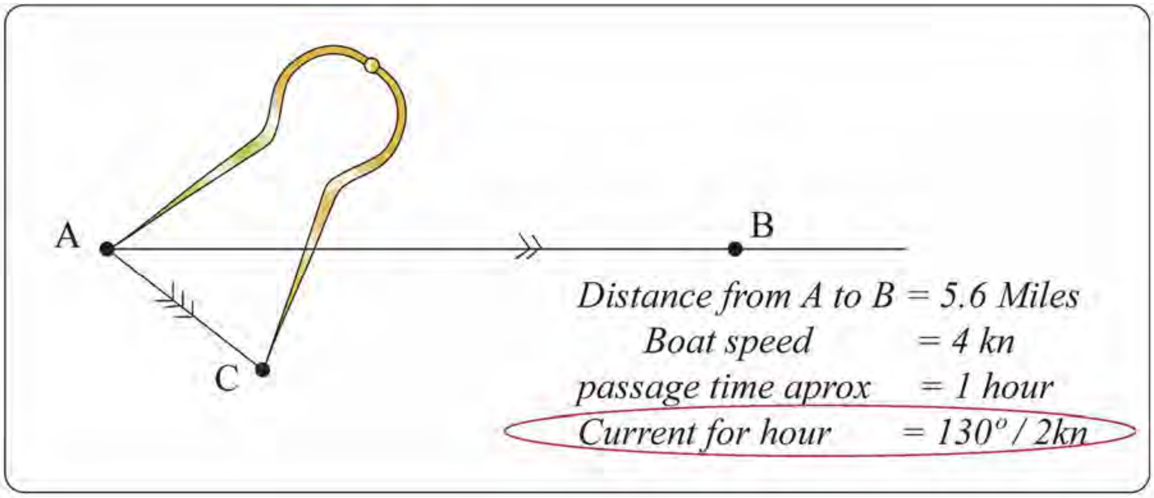


FIGURE 92 - PLOTTING THE CURRENT, SET AND DRIFT FOR THE FIRST HOUR

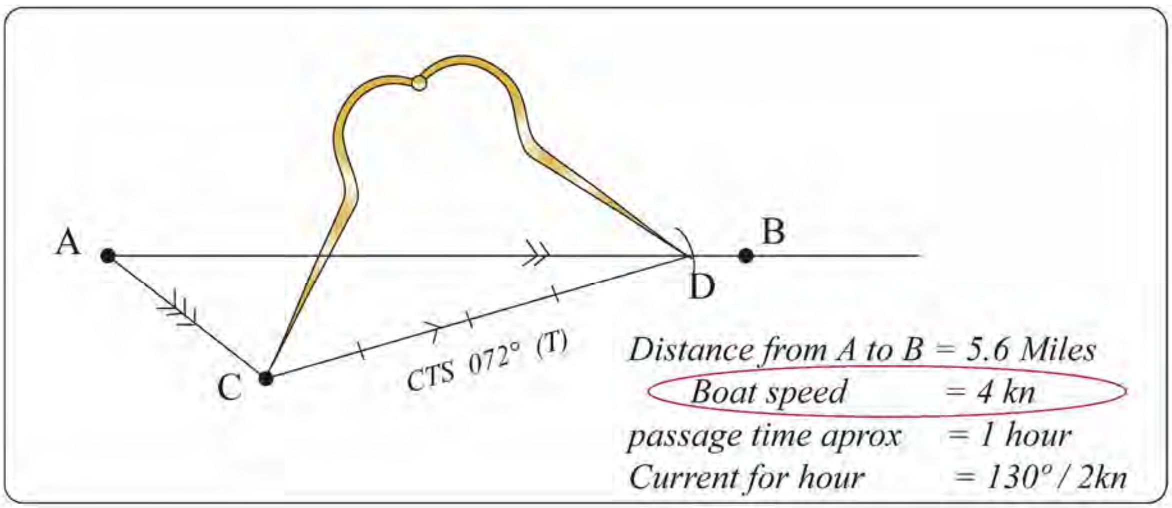


FIGURE 92 - PLOTTING THE DISTANCE THE BOAT WILL TRAVEL THROUGH THE WATER DURING THE FIRST HOUR

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. First, 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 current information. Once you know how many hours are involved in the passage the next step is to find the current direction and rate for each hour of the passage using Reed's, or a current atlas. From the point of departure plot the first current vector, AC and continue plotting the course to steer for the first hour as explained above and illustrated in Figure 92 - plotting the distance the boat will travel through the water during the first hour.

From the figure below it can be seen that after the first hour has elapsed the boat will be at D. From D plot the current vector for the second hour and find the next course to steer for one hour. Continue plotting the current vector and the course to steer for each individual hour as required.

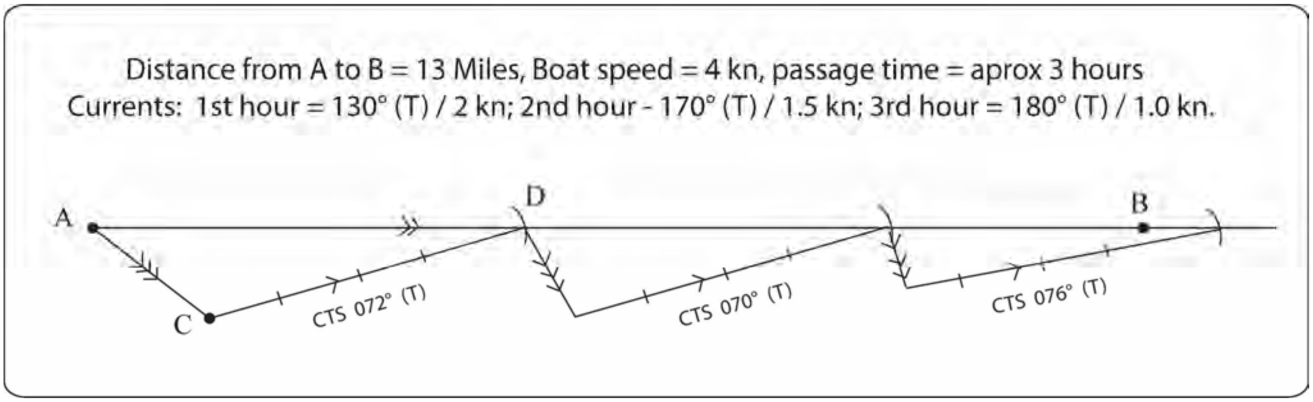


FIGURE 93 - PLOTTING THE COURSES TO STEER FOR THREE INDIVIDUAL HOURS

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 currents for the first two hours are 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 Entire 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 current 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 current 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 current vector and then swivel the paper until the second mark touches the ground track.

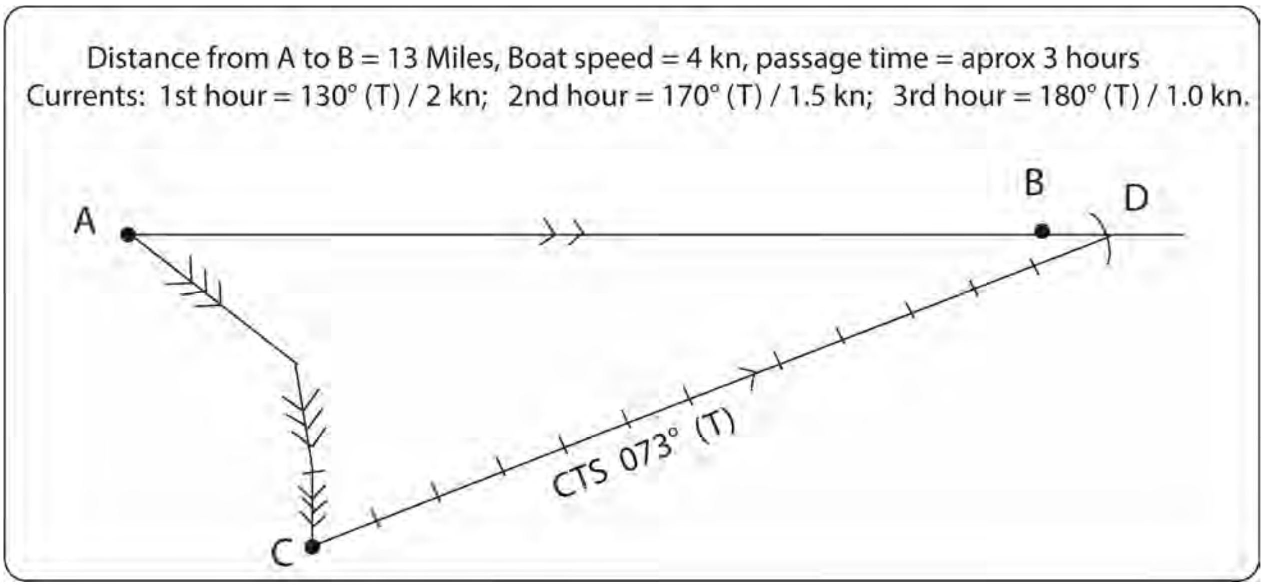


FIGURE 94 - SINGLE COURSE TO STEER TO COUNTERACT THE CURRENT OVER 3 HOURS

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, current 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 current drift and the distance which will be travelled by the yacht in a specific number of minutes.

Looking at the figure below, 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.

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.

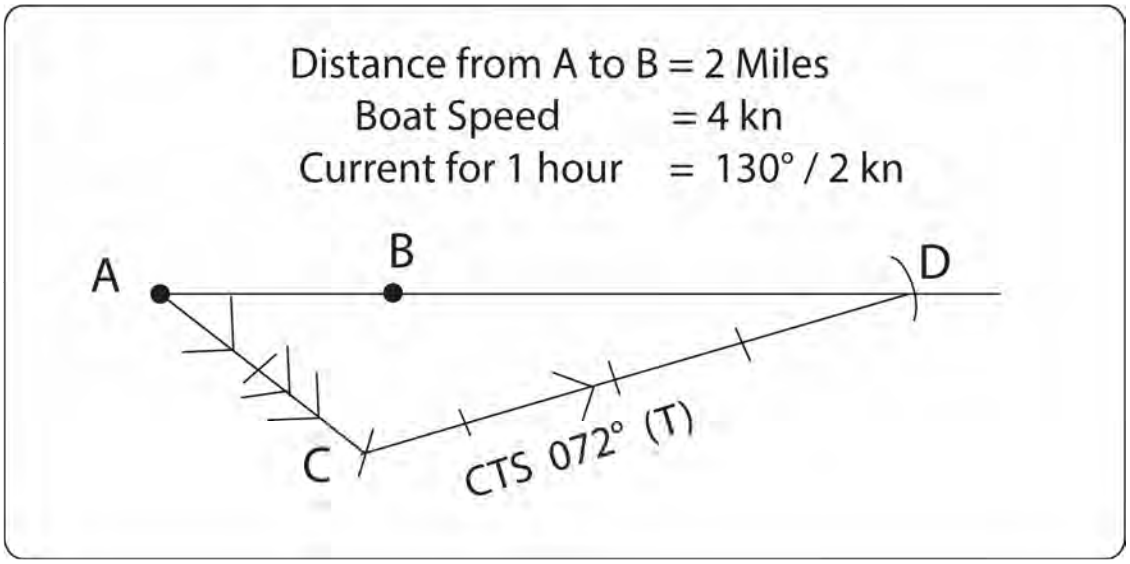


FIGURE 95 - COURSE TO STEER FOR A PERIOD OF TIME LESS THAN 1 HOUR

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.

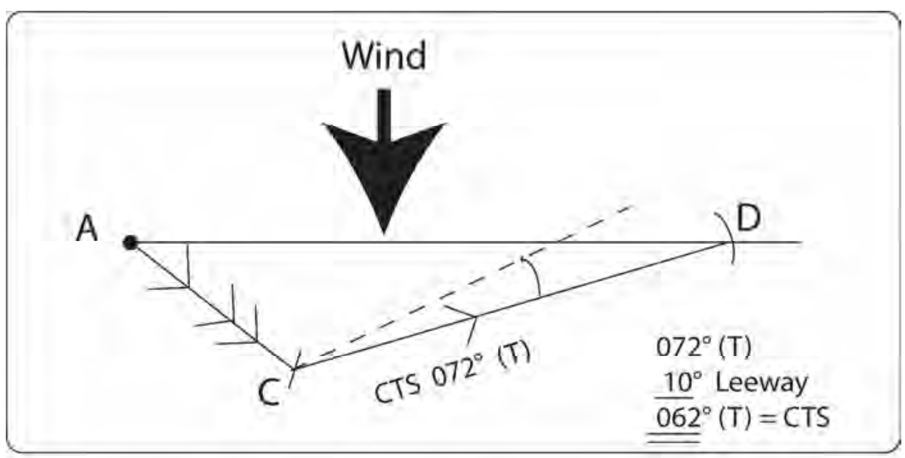


FIGURE 96 - ADJUSTING THE CTS TO COUNTERACT LEEWAY

In the diagram above 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.

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 motorboat 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 current

If a current is continuous in direction and speed a simple current triangle can be quickly plotted on a piece of paper using whatever units of scale are suitable. The Breton type plotter is ideal for this as 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.

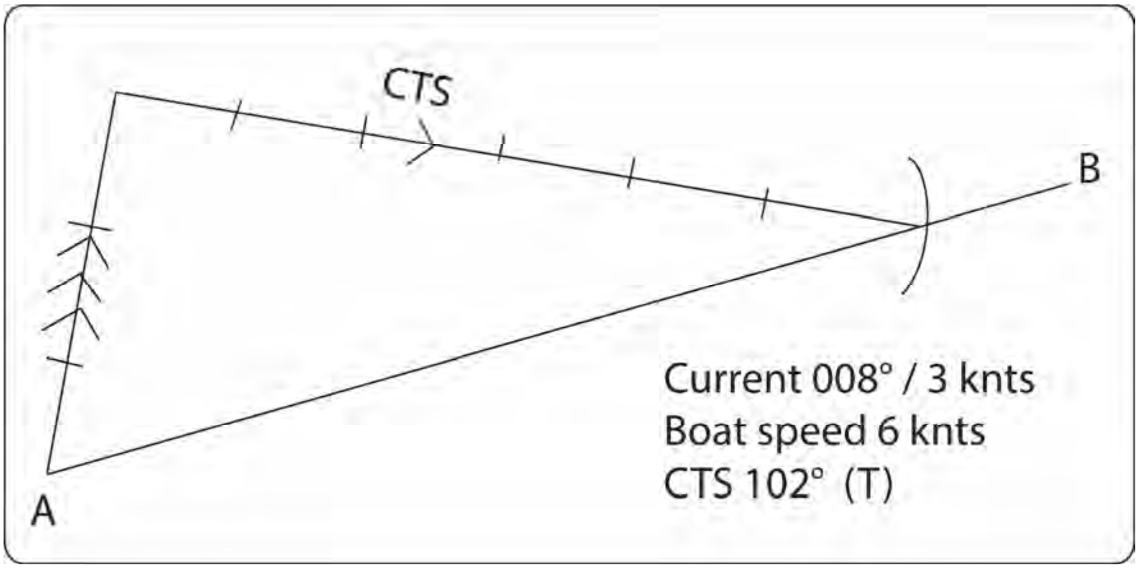


FIGURE 97

Chapter 13 PILOTAGE

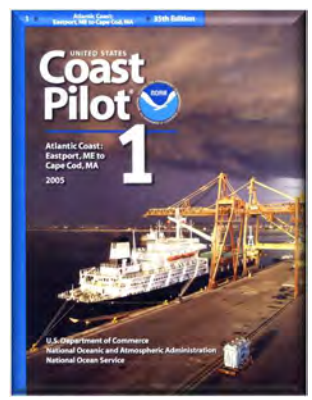
13.1 Key Objectives

THE KEY OBJECTIVES OF THIS CHAPTER IS TO COVER PILOT BOOKS, SAILING DIRECTIONS, PILOTAGE SYMBOLS AND WHAT TO DO IF THINGS GO WRONG. THE KEY TO A SAFE JOURNEY IS BEING PREPARED.

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 almanac.

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 & Charts

The secret of pilotage is planning ahead. You will need:

- Relevant chart(s), corrected to date.
- As many pilot books (also called sailing directions) as you can afford.
- A nautical almanac (such as Reed's Nautical Almanac) for the current year.

Pilot books

Sailing direction and pilot books 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.

NOS publishes a series of excellent United States Coast Pilots covering U.S. coastal waters at $20 each (in 1998). These pilots are available as follows:

Atlantic Coast

5. Eastport to Cape Cod
6. Cape Cod to Sandy Hook
7. Sandy Hook to Cape Henry
8. Cape Henry to Key West
9. Gulf of Mexico, Puerto Rico & Virgin Islands

Great Lakes

1. The Lakes & their Connecting Waterways

Pacific Coast

2. California, Oregon, Washington, Hawaii
3. Alaska – Dixon Entrance to Cape Spencer
4. Alaska – Cape Spencer to Beaufort Sea

Sailing Directions

The Defense Mapping Agency publish Sailing Directions containing information on harbors, 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.

The British Admiralty publishes Pilots covering much of the world; BA Pilots are intended for use by commercial shipping but in recent years they have included much information of use to the small boat navigator.
Pilot books and sailing directions are usually produced by cruising orientated clubs in the area or country. For example, the Florida Cruising Directory contains advice on navigation, marinas and similar facilities.

Nautical Almanacs

There are many nautical almanacs available ranging from small, inexpensive, locally produced versions to the best known, Reed's Nautical Almanac. The local ones usually contain tide tables and various brief items of general interest. Reed's is one of the best almanacs presently available, containing many pages of valuable information. Reed's publish almanacs covering most ports on the U.S. East coast, West coast and Caribbean. There are chartlets for many harbors 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 most areas covered by the almanac. Reed's North American East Coast Almanac cost $30 in 1998.

Eldridge, Tide and Pilot Book covers tides and currents from Boston to Miami on the East Coast and includes useful additional information; at $10 in 1999 it represents good value for money but Eldridge does not include harbor entrance chartlets.

Almanacs must be replaced every year. Reed's issue corrections each year which are mailed to you, free of charge, on request; you should fill out the request form in the almanac and keep the corrections with the almanac. Eldridge will also mail a supplement, listing changes to lights, buoys, fog signals, etc., to you on request.

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 availed of 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. nighttime) if you are not sure of your ETA at the pilotage area.
- Wherever possible use suitable 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 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 your pilotage plan, don't 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 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 helmsman, or helmswoman, are clear and unambiguous. Don't give vague orders like "steer for that light", rather pick a suitable range 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 or repaired or even 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 was 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 harbor. Suppose the tide is running towards the south. Plot a course to bring you, say, about 3 miles to the north (left) of the harbor. 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.

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.

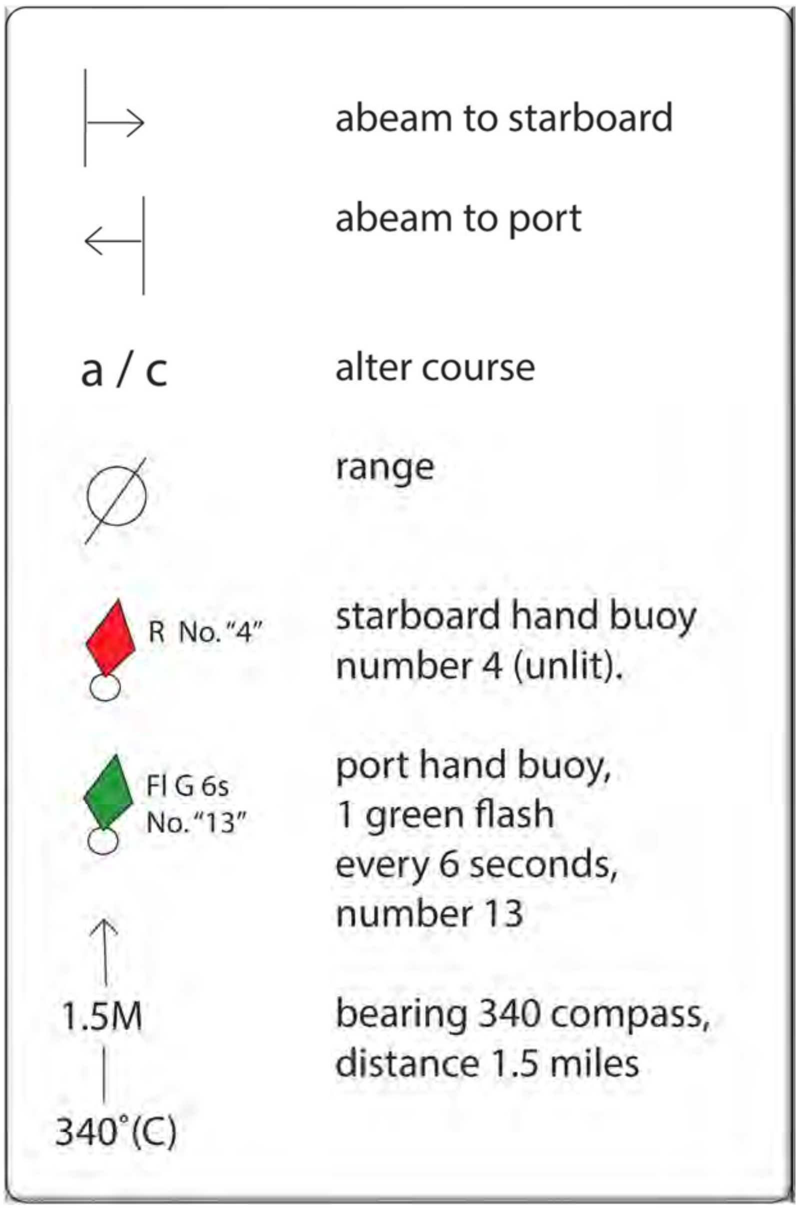


FIGURE 98 - SUGGESTED PILOTAGE PLAN SYMBOLS

<u>Example of pilotage notes for entry to Pogemahone for a boat approaching from the north east</u>

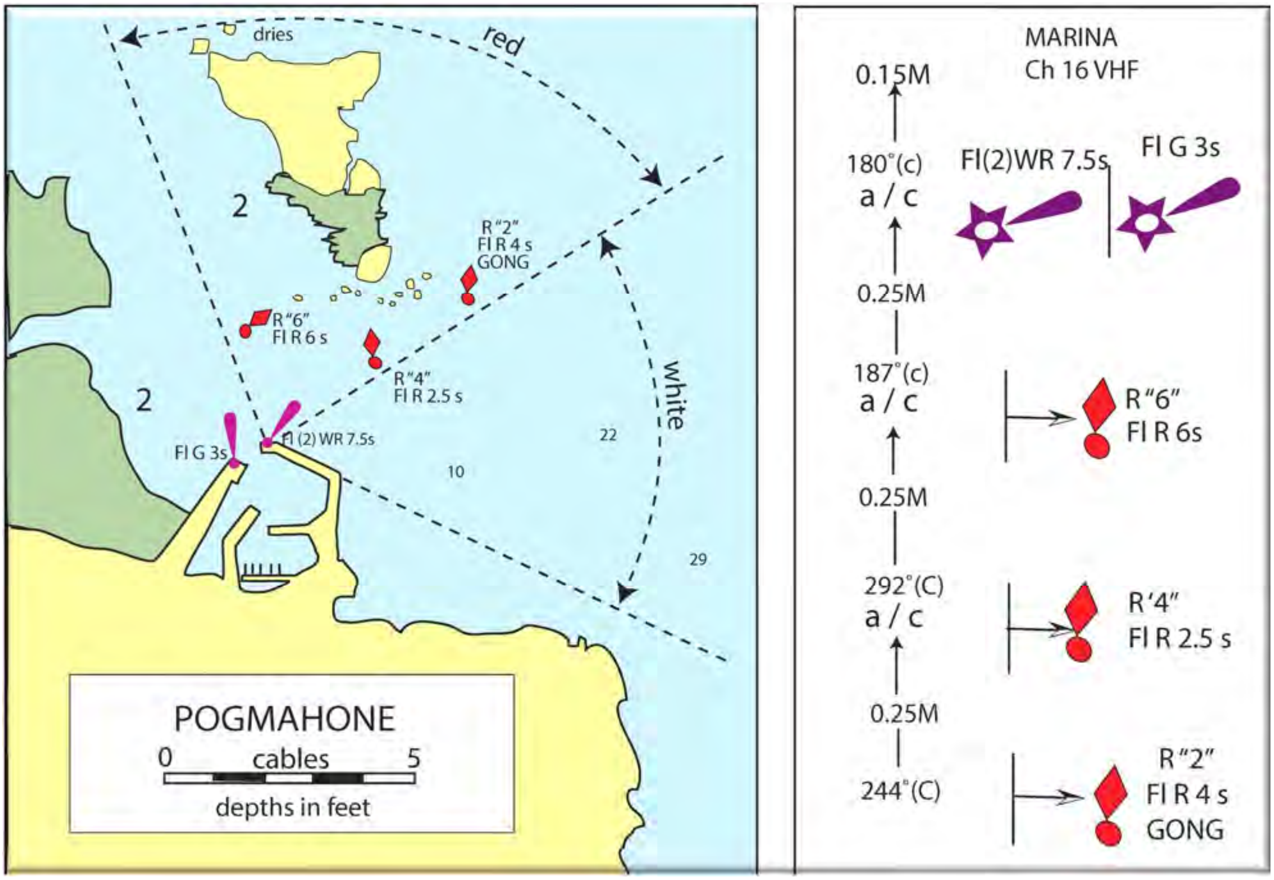


FIGURE 99

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.

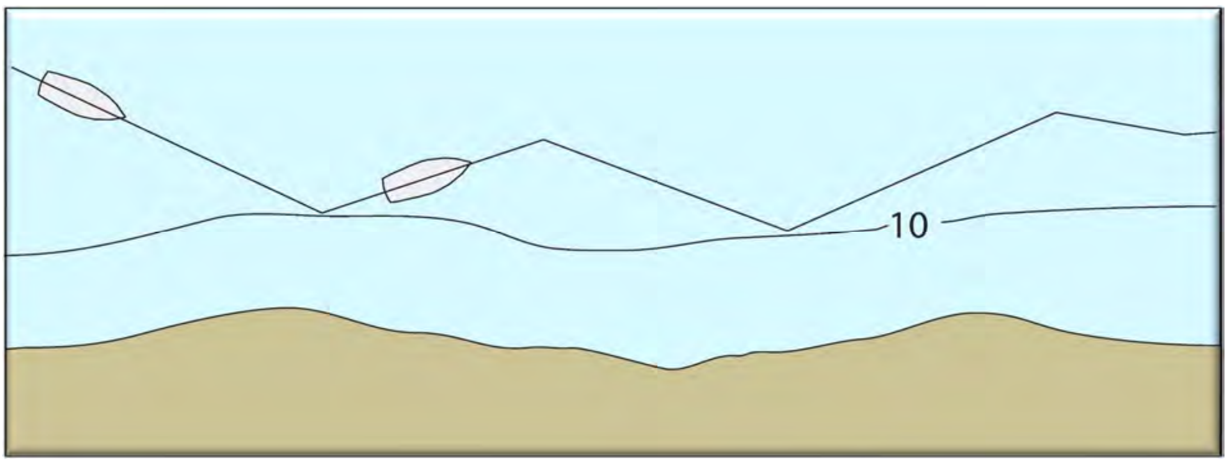
PILOTAGE NOTES ARE USUALLY DRAWN SO THAT THEY ARE READ FROM THE BOTTOM UPWARDS. NOTE THAT ALL COURSES HAVE BEEN CORRECTED FOR VARIATION AND (IF REQUIRED) DEVIATION.

The pilotage notes shown in the figure 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".

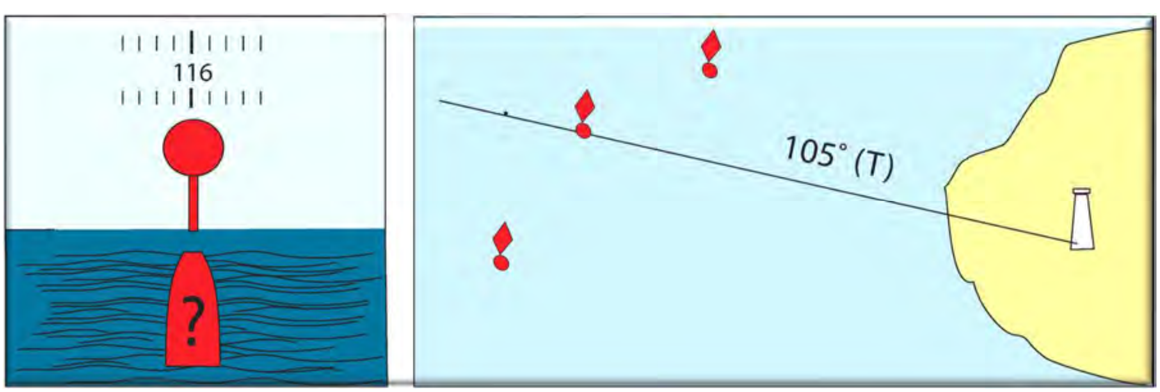
The notes in diagram form, shown on the right on the figure above, are, for most people, much easier to follow than text. The light on the end of the east pier, Fl(2)WR 7.5s, has red and white sectors. Approaching the harbour from the north east during darkness you should be in the white sector which 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



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 in the above figure. 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

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.

Chapter 14 PASSAGE PLANNING

14.1 Key Objectives

THE KEY OBJECTIVES OF THIS CHAPTER IS TO COVER ALL THE INFORMATION REQUIRED TO COMPLETE A PASSAGE PLAN.

Essentially passage planning consists of bringing together all of the general information you will require to complete the passage. The information you need 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 the owner 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. The free NOAA chart catalogs are very useful 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. 'harbors 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.

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.

14.2 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 enter 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.

14.3 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.

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 current directions relative to high water at the standard port.
- 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
- 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 refueling 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, 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.

14.4 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 100, 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.

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.

This system, when only two are available to keep watch, 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.

This system can work well when conditions are bad and tiring for the crew.

FIGURE 100

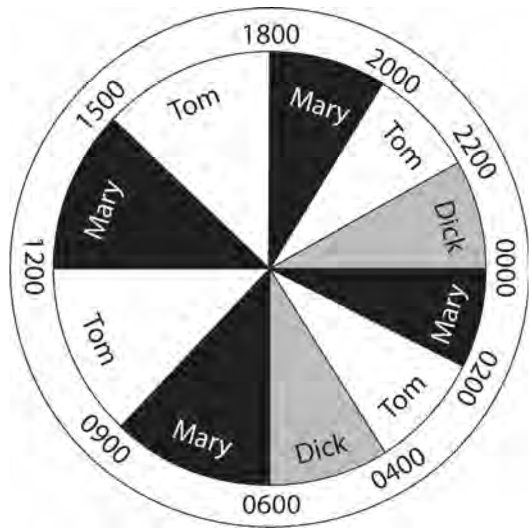


FIGURE 101

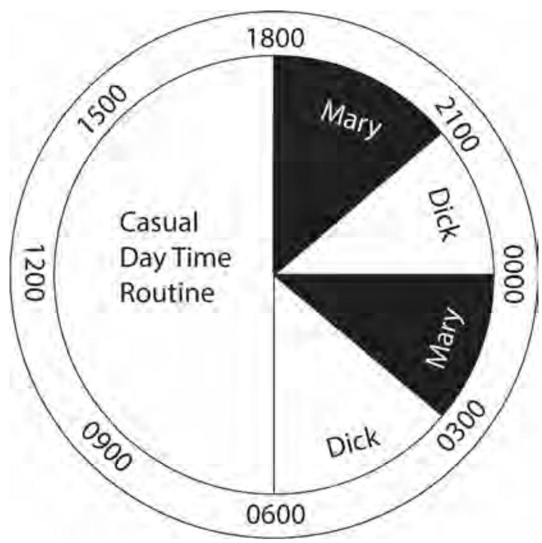


FIGURE 102

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 103

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 this system 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 104

Chapter 15 ELECTRONIC NAVIGATION AIDS

15.1 Key Objectives

THE KEY OBJECTIVES OF THIS CHAPTER IS TO COVER ALL THE ELECTONIC NAVIGATION AIDS AND HOW THE WORK.

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.

15.2 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, which is still in world-wide use today, was the first system designed specifically for navigational purposes using shore-based radio transmitters and a receiver carried onboard the ship.

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 'Transit' and '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 20 hours on ordinary small replaceable internal batteries are now readily available.

A radio navigation system has the great advantage that its signals are available 24 hours a day irrespective of darkness or cloud cover.

15.3 RDF

In operation a suitable RDF transmitter is located on the chart and the frequency on which it operates is found from Reed's Nautical Almanac under the heading RADIOBEACONS, or a similar source. As RDF beacons have a limited range beacons may share the same frequency; in order to ensure that you are not listening to the wrong beacon each one has its identity confirmed by transmitting two or three letters, slowly, in Morse code every so often. For example, the St. David's Head beacon on Bermuda transmits an RDF signal on 323.00 kHz, distinguished by the letters B S D (-... ... -..), and the beacon has a nominal range of 150 miles.

The RDF receiver is tuned to the correct frequency and when the signal is heard the receiver is swung around until the signal disappears; this is called the 'null' and at this point the receiver is pointing directly at the beacon being used. The receiver includes a small compass from which the bearing from your position to the beacon can be read. A position line can then be plotted on the chart through the charted position of the beacon. If another position line is found from a different beacon, or any other source, the two position lines will give a position fix.

RDF is still used by aircraft and these air navigation beacons can be used by boats for navigation provided their position is shown on the chart; there is an aero-beacon at Jacksonville, FL and another at Great Inagua, in the Bahamas for example. Aero beacons are not intended for marine use and the position lines derived from them should be used with a certain amount of caution.

RDF receivers do not give a position fix automatically rather they require position lines to be plotted on the chart by the navigator whereas the next generation of electronic position fixing systems to be discussed, such as Loran and GPS, give automatic position fixing in simple terms of latitude and longitude.

15.4 '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 transmitters located on purpose built satellites orbiting in space, such as GPS.

15.5 Satellite Positioning Systems

The ability to put radio transmitters into space made 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, 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 100m 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.

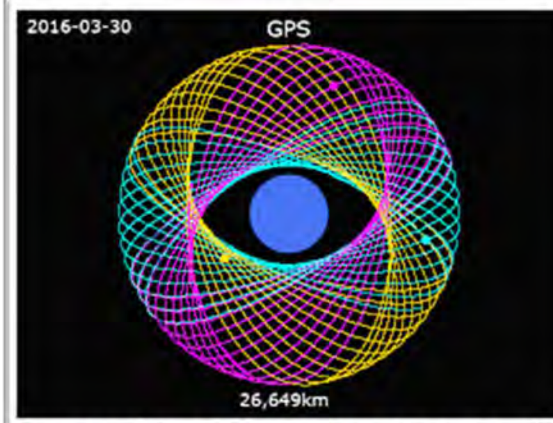
15.6 GPS

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 Navy, Army and Air Force and is intended to offer precise position and altitude, 24 hours a day, world-wide.

As of June 2020, 75 Global Positioning System navigation satellites have been launched, 31 of which are operational, 9 in reserve, 3 being tested, 30 have been retired and 2 were lost at launch.

The constellation requires a minimum of 24 operational satellites, and the official target count is 33. The GPS receiver needs 4 satellites to work out your position in 3-dimensions (location, velocity and altitude).

Each satellite knows its exact position and also sends out an individual signal which is picked up by the receiver. The receiver then measures how long it took for this signal to reach the receiver; using this information the receiver can work out its distance from the satellite.



Samples of three GPS satellites' orbits over a five-year period (2013 to 2018)
USA-242 · USA-239 · USA-151 · Earth

FIGURE 105

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, don't 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 microsecond. 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. The U.S. can, by introducing random errors, degrade the signal available on the civilian frequency if they wish. Selective availability gives accuracy of between 100 and 150 meters 95% of the time. This is 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. With dGPS, the GPS signal is received at a place, such as a lighthouse for which the exact position is known, the signal error is removed and the corrected signal re-transmitted to suitably equipped receivers. A special (add on) dGPS receiver must be purchased; in some areas this dGPS signal is free and in others an annual rental is charged.

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 set 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.

FIGURE 106 - A "TYPICAL" GPS SET

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 (torch) batteries. Some models may have more buttons than others and different manufacturers use different words to describe each individual function.

Figure 106 - A "typical" GPS set, shows a 'typical' full function GPS receiver which might be about 90 mm x 130 mm (3½" x 5") in size. The keypad of this GPS includes a full set of number buttons whereas some sets have much fewer buttons. Generally, the sets with full keypads like this are the easiest to use. The instrument is connected to its external aerial by a cable.

Using a GPS

When turned on a GPS set may take a couple of minutes (as long as 15 minutes) to work out its position. When the position is found it will be shown on the display in latitude and longitude. It will continue to update this position roughly every second until it is turned off; thus, as the boat moves, the latitude and longitude 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, etc.

Speed and Distance

Speed is given as actual speed over the ground. That is to say that on a boat making 6 knots through the water against a 3 knot tide the GPS will show a speed of 3 knots, whereas on a boat making 6 knots through the water with a 3 knot tide the GPS will show a speed 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 tell you the distance and direction from its present position to any other place, or destination. You must enter the latitude and longitude of the place or destination 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, the first one entered being WPT 1, the second WPT 2 and so on. Some GPS sets allow the name of the waypoint to be recorded in letters as well as with a number.

GPS Waypoints App

Waypoint

A waypoint is simply any place or position you define. It can be the entrance to Dune Harbour, a position 1 mile off the headland to the east of Seal Creek or a spot in the middle of the Pacific Ocean. The latitude and longitude of the position is found directly from the chart.

Remember 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 107, the GPS has found that the course from Dune Harbor to Seal Creek (waypoint 1) is 34º 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:

BRG	DST
034°	5.8M
WPT 1	SEALCRK

FIGURE 107

Once underway not only will the GPS give a constant readout of the boat's position, but it will also carry out many other navigational functions. It will give the boat's speed over the ground and the course over the ground as was mentioned earlier. 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 Harbor the navigator has decide on three turning points and then finds, from the chart, the latitude and longitude of each waypoint.

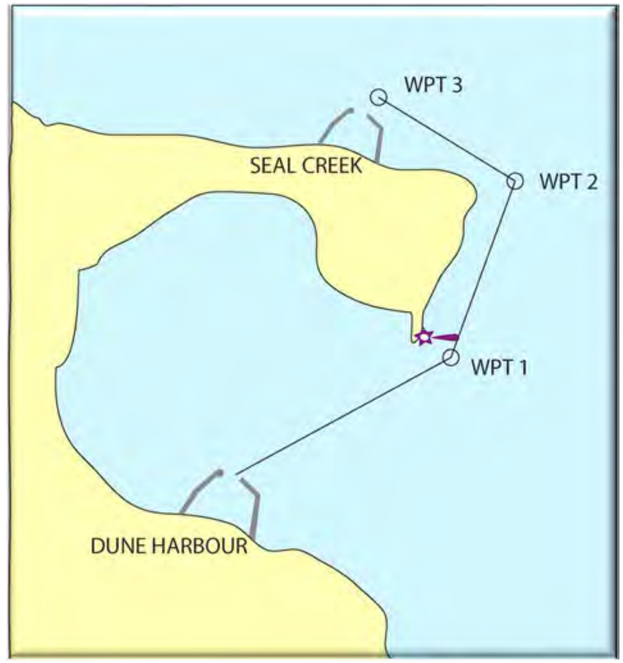


FIGURE 108

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 Harbor 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.

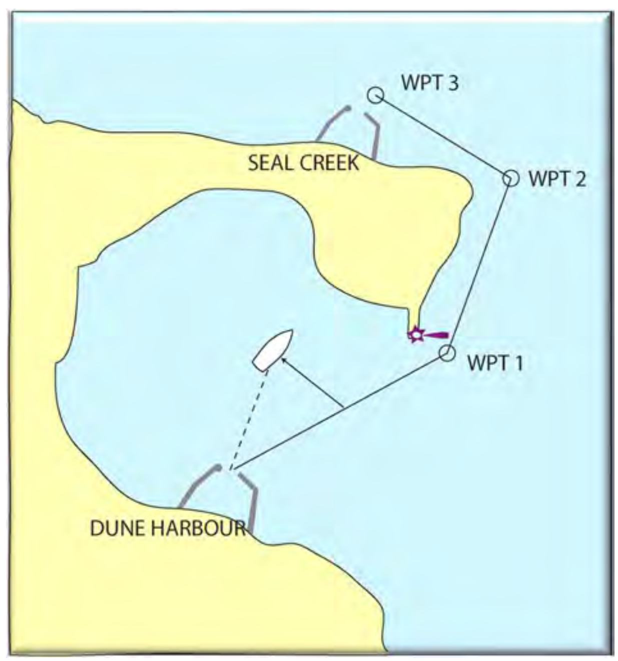


FIGURE 109

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 109 the boat has been allowed to move 1.25 miles off the desired ground track; the GPS might display something like this:

WPT 1	>>>>>>> 1.25
DST. 2.75	ETA. 0028

This display in Figure 109above 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
- the estimated time of arrival (ETA) under the current conditions of speed, tide, etc. is 28 minutes.

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.

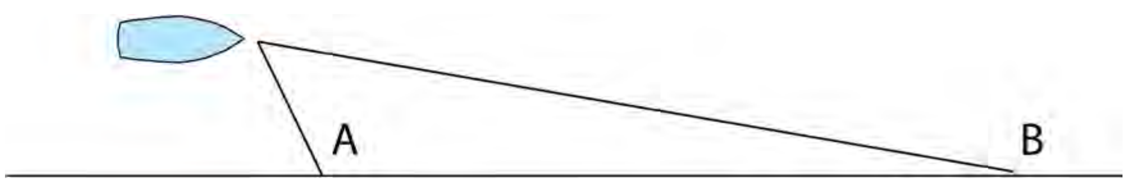


FIGURE 110 - A GENTLE COURSE CHANGE WILL RESULT IN LESS TIME WASTED GETTING BACK TO THE REQUIRED GROUND TRACK.

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.

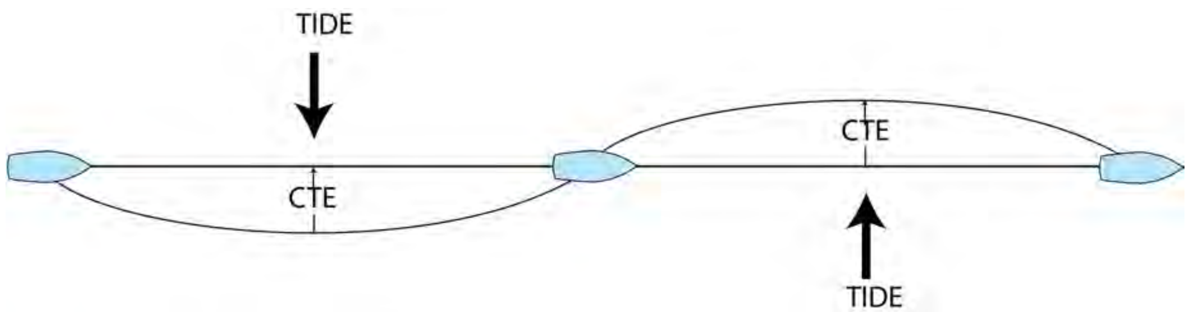


FIGURE 111

FIGURE 112

Many GPS sets show cross track error in pictorial form like a road or runway, as well as with figures. As an example, look at Figure 112. The display is meant to look like a road. It shows that you are off to the left of the track; therefore, you must turn 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 remaining 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.

Man Overboard

Virtually all sets have a MOB button. When the MOB button is pressed, the GPS automatically marks a waypoint at the current location and allows you to enable a "Go To" navigation line to take you back to the initiated MOB location. Remember, if there is a tide or current the man overboard will have drifted from the recorded MOB position.

Apart from its obvious use this MOB button is also very useful for recording the position of a place of interest, such as a buoy, for future reference if you are too busy to write it down at the moment you are beside it.

Map and Chart Datum's

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 worldwide. 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 will have a heading 'satellite-derived positions' followed by instructions to correct the GPS position to comply with the chart. For example, on NOAA chart 11470, of Fort Lauderdale, the instructions under horizontal datum are: ".......Geographic positions referred to the North American datum of 1927 must be corrected an average of 1.312'' northward and 0.837'' eastward to agree with this chart". There are 60'' (seconds of arc) in 1' of arc; 1.3 second may well be an insignificant amount unless you are attempting to utilise the precision of dGPS. 1.312'' of latitude represents about 133' making a nonsense of dGPS's potential accuracy if it is ignored.

'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. Thus, a PDOP of 4 would be very good, 8 is all right, 15 poor and 20 or more indicates that the position should be ignored or at least treated with great caution.

NMEA

Most sets have what is called a NMEA (National Marine Electronics Association) interface which allows information from the GPS to be transferred to NMEA compatible instruments such as an autopilot or chart plotter. The NMEA 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 problem. 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. 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

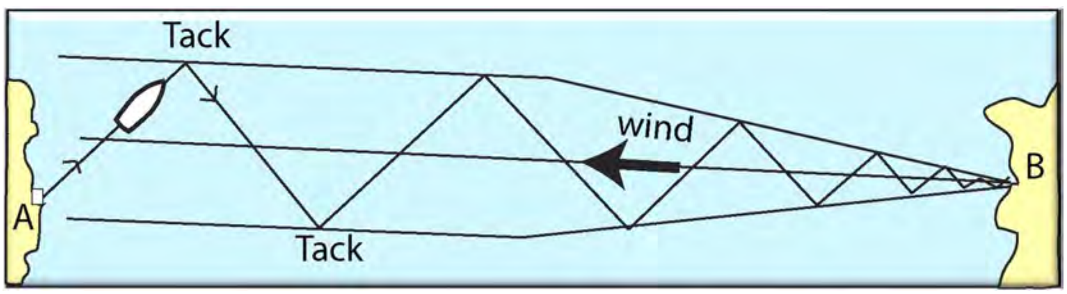


FIGURE 113 – SETTING UP TACKING PARAMETERS FOR A WINDWARD PASSAGE. THE WIDTH OF THE CORRIDOR AND LENGTH OF THE CONE ARE DECIDED BY THE NAVIGATOR. FOR THIS EXAMPLE, THE WIDTH OF THE CORRIDOR IS 5 MILES AND THE CONE ENTRANCE BEGINS ABOUT 10 MILES FROM THE DESTINATION, B.

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.

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.

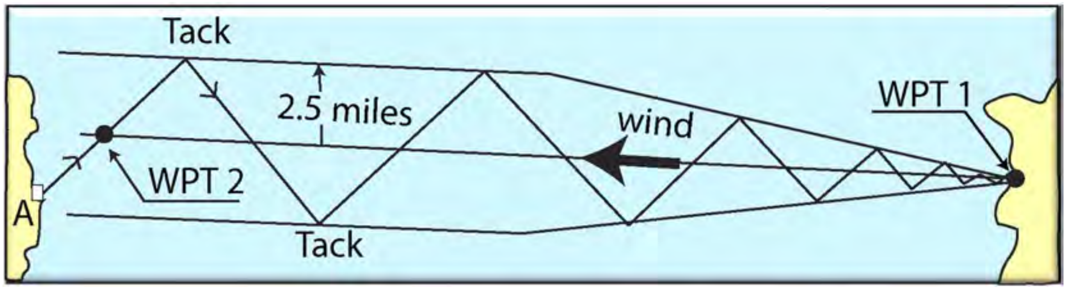


FIGURE 114 - THE DESTINATION HAS BEEN ENTERED INTO THE GPS AS WAYPOINT NUMBER 1 (WPT1). WHEN THE YACHT CROSSES THE CENTRAL LINE, ITS POSITION IS ENTERED INTO THE GPS AS WPT 2. THE GPS IS NOW PROGRAMMED TO DISPLAY THE YACHT'S CROSSTRACK ERROR FROM WPT 2 TO WPT 1. A CORRIDOR 5 MILES WIDE HAS BEEN DECIDED 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 affect when the yacht tacks, but they will of course affect the yacht's position within the corridor or cone so a check must be kept on the yacht's position as usual.

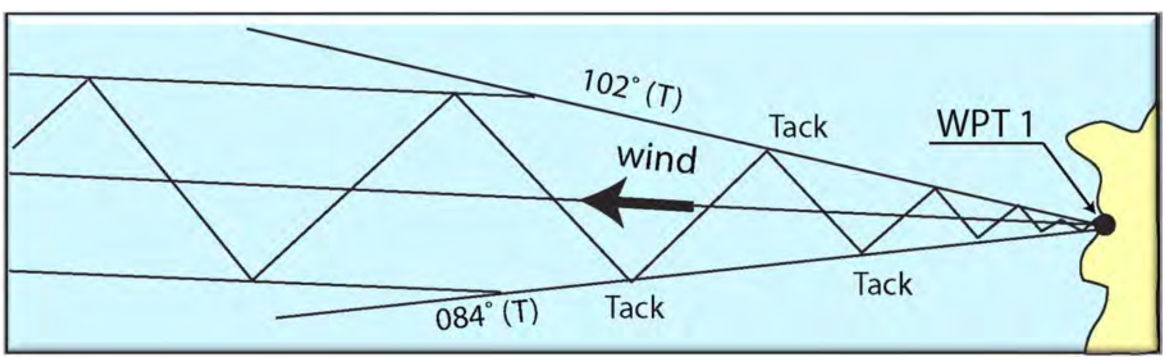


FIGURE 115 - THE BEARING TO THE DESTINATION ALONG THE TOP OF THE CONE IS 102° (T) AND ALONG THE BOTTOM OF THE CONE IS 084° (T). AS BEFORE THE YACHT IS SAILED ON THE BEST COURSE TO WINDWARD BUT IS NOW TACKED WHEN THE BEARING TO WAYPOINT DISPLAYED BY THE GPS BECOMES 102° OR 084°. THE BEARINGS SHOWN IN 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.

The example given is just an indication of one of the ways that the various functions that a GPS can perform may be combined to achieve the solution to a problem in navigation

Distance & 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 from the entrance to the Severn river (chart 12221) in the dark and wished to be certain not to come too close to the shoal area of Guinea Marshes. Enter the eastern tip of the marsh, 37° 16'.5N 76° 21'.0 W as WPT 99, say. Then monitor the distance and bearing to WPT 99. Keep the distance greater than 0.5 mile, say. If the distance to the WPT falls below this safety margin turn east until it returns to the safe value. When the bearing to waypoint becomes greater than about 290° (M) you know you are safely past the marsh. (Provided you found the correct figures from the chart and entered the correct figures into the GPS, and provided the marsh 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, etc. 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 handheld VHF radios 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 don't forget to allow 300 meters or so for the inaccuracies introduced by SA.

You should read and understand the GPS manufacturer's handbook in order to use the GPS effectively.

Chart Plotters

As we all know, electronic 'charts' can be displayed on a screen. At present it is not felt that electronic charts can replace paper charts. In the event of electronics failure or lightning strike it is imperative that paper charts are readily on hand.

The advantages of electronic position fixing aids are:

- Accurate position fixing out of sight of land regardless of conditions, 24 hours a day.
- They usually give a higher degree of accuracy than other methods of position fixing.
- Worldwide position fixing is possible with GPS.
- The position fix is (almost) instantaneous.
- They can be connected to other equipment such as chart plotters and radar

The disadvantages are

- They require complex radio receiving equipment which cannot be repaired on board.
- They rely on sophisticated electronic components which don't mix well with saltwater.
- 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 affected by thunderstorms, low voltage supply and sunspots, etc. Aerials can be shielded from satellite signals by salt-soaked sails, metal objects or other aerials.
- A lightening strike will destroy delicate electronics.
- They are not aware of operator error so be very careful when 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.

When navigating using GPS

- Always use the chart to check bearings and distances given by the GPS.
- Always plot positions on the chart, don't 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.
- Don't rely totally on GPS, or other electronics, as the sole method of navigation.

Chapter 16 CONSTRUCTION

16.1 Key Objectives

THE OBJECTIVE OF THIS MODULE IS TO PROVIDE A COMPLETE UNDERSTANDING OF VESSEL CONSTRUCTION, METHODS OF CONSTRUCTION, STRESS ON A VESSEL AND CLASSIFICATION SOCIETIES.

16.2 Ship Construction Terminology

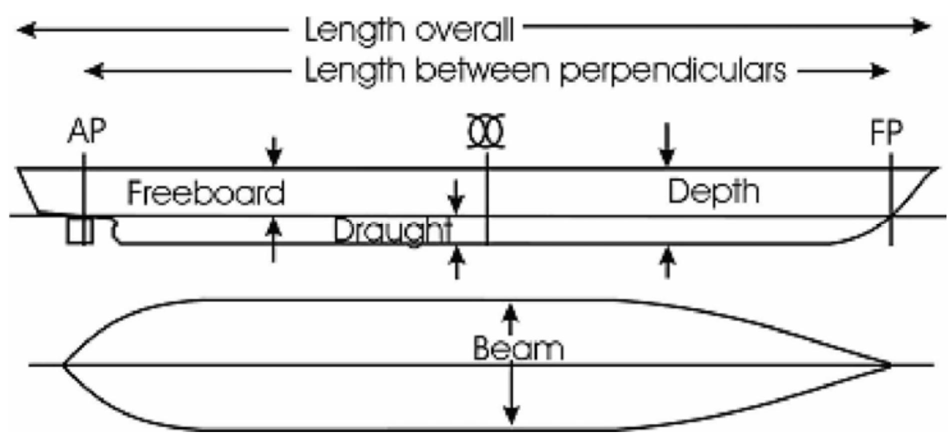


FIGURE 116

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 center 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 ship

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 ship 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 ship'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 ship's bow.

Rake – The departure from the vertical of vessel's profile, as in masts, stacks, etc.

Hull – The supporting body of the ship, 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 ship into compartments, running both transversely and longitudinally.

Strakes – Plates (steel) or planks (wood) which form the ship's hull, longitudinally. The keel forms the center 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

16.3 Tonnage

Gross Tonnage is a figure representing the total of all enclosed spaces within a ship, 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.

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

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16.4 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.

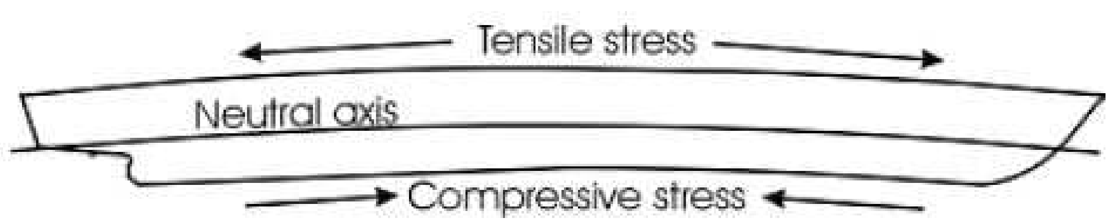


FIGURE 117

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 wavelength 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.

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 118 - RACKING STRESS

Panting, Pounding & 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.

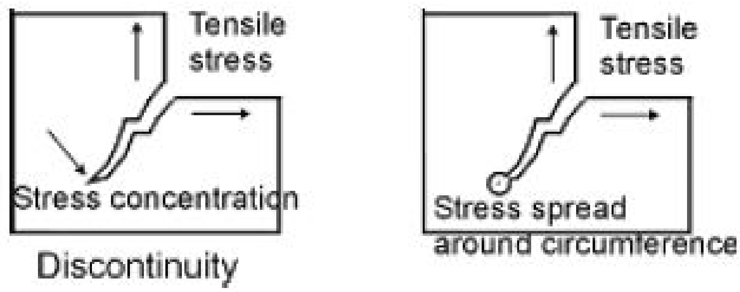


FIGURE 119

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

16.5 Methods of Construction

The traditional method of ship and boat 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.

Some ships combine transverse and longitudinal framing. The longitudinal are used on the bottom and the top of the hull with transverse frames supporting the sides.

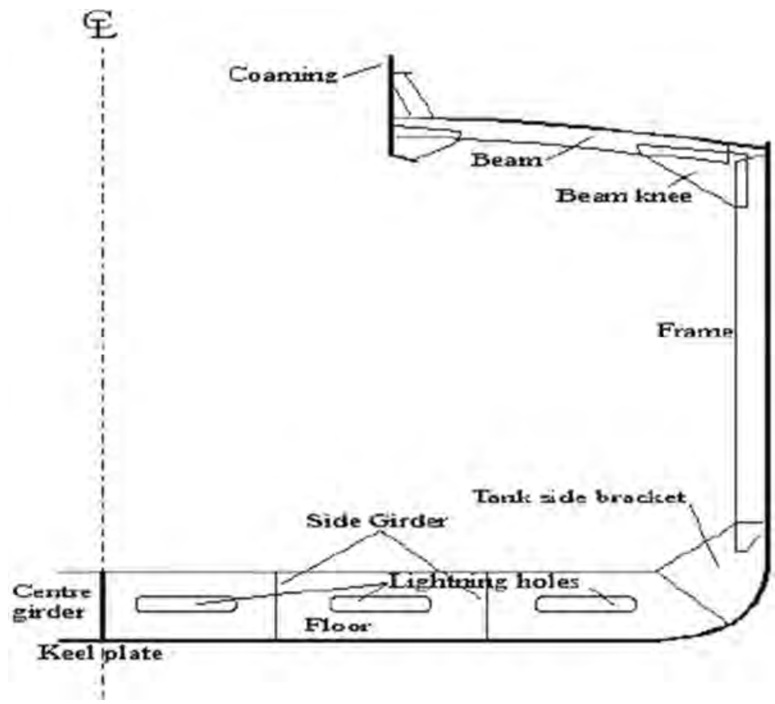


FIGURE 120

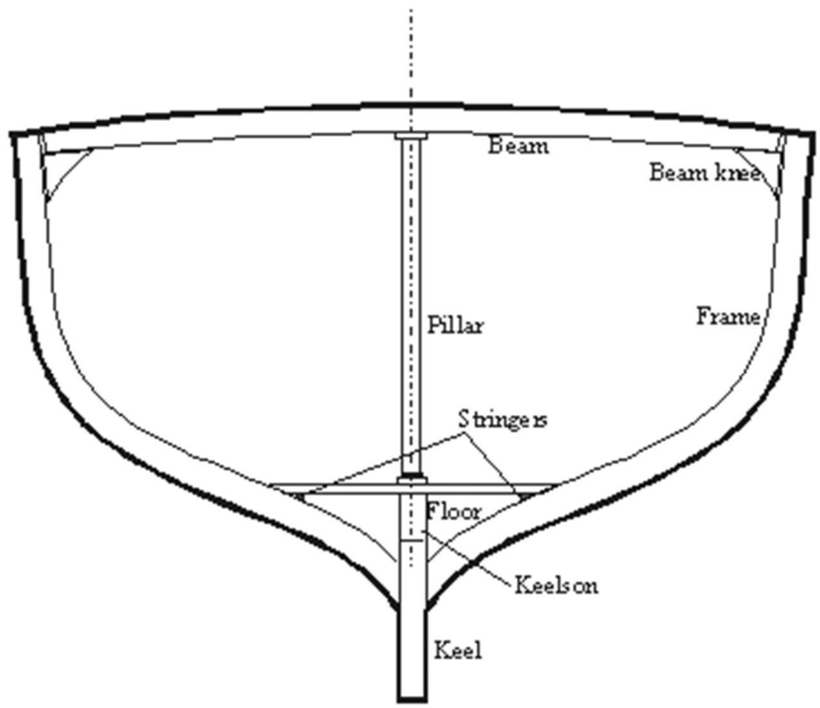


FIGURE 121

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.

16.6 Materials Used in Ship Construction

The advantages and disadvantages of wood, steel, aluminum 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 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.

Aluminum used in boat building is not the pure metal but some form of alloy of aluminum. Size for size, aluminum weighs roughly one third but has about two-thirds the strength of steel. Aluminum is softer and dents more easily, but it is more difficult to weld than steel. Aluminum does not corrode easily but when it does it can corrode with a dangerous rapidity.

The plastic in Glass Reinforced Plastic (GRP) (or fiberglass) is a resin of very complex chemistry beyond the scope of this work. These resins set hard and are reinforced with fibers 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 fibers have a tensile strength many times that of steel.

16.7 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.

<u>The Classification Societies carry out the following surveys;</u>

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

<u>At an annual survey the general condition of the vessel and machinery is assessed.</u> 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

<u>At a Docking survey, the ship is to be examined is in dry dock where attention is paid to the underwater hull:</u>

- Shell plating, rudder, stern frame, external fittings, and fittings which pass thro' the hull
- Areas liable to corrosion and any unfairness of the bottom plating.

<u>Loadlines and Freeboard</u>

The fundamental purpose of a Load Line is to allot a maximum legal limit up to which a ship can be loaded by cargo.

The freeboard deck is the uppermost continuous deck that can be closed weathertight. The assigned freeboard is the distance from the top of the deck line to the top of the Summer load line.

<u>Loadline/Plimsol Mark and Summer Zone</u>

S is the mark on the Summer load line the top of which must not be submerged when in the Summer Zone.

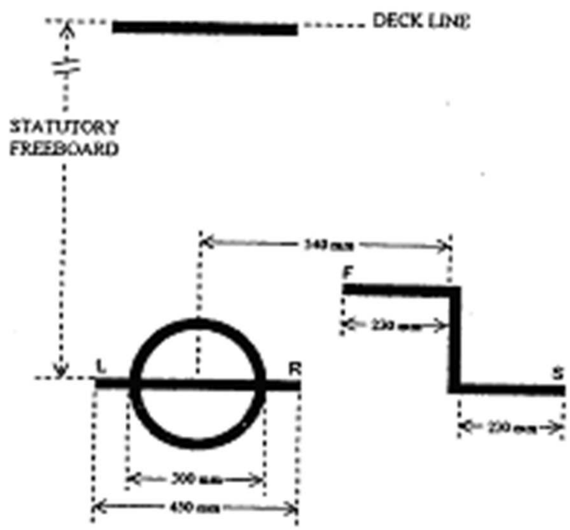


FIGURE 122

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 ship is assigned a freeboard which is greater than the minimum Summer freeboard and lower than all other appropriate load lines, is known as an '***<u>All Seasons Load Line'</u>***. The All Season Load Line may be just a single line (230 mm ´ 25 mm) without the vertical line used in other load lines.

Reserve buoyancy

A ship 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 and 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 ship 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 of a ship 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 ship will sink. A ship 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 ship settles in the water and some of the reserve buoyancy, in the compartments not filled with water, is converted into actual buoyancy allowing the ship to remain afloat.

Chapter 17 VESSEL STABILITY & DRYDOCKING

17.1 Key Objectives

THE OBJECTIVE OF THIS MODULE IS TO PROVIDE A COMPLETE UNDERSTANDING OF VESSEL STABILITY AND DRYDOCKING.

17.2 Basic Principles of Hydrostatics And Related Terms

Density is mass per unit volume

Density of Fresh Water	1,000 kgs per cubic meter
or	1.00 tonnes per cubic meter
Density of Salt Water	1.025 tonnes per cubic meter

Relative Density or Specific Gravity

Relative Density or Specific Gravity is the ratio of the weight of a substance to the weight of an equal volume of fresh water, therefore it has no units

R D of Fresh Water	1.000
R D of Saltwater	1.025

Specific Gravity is not used under Standards International (SI) units

Weight (Mass) = Volume ´ Density

Volume of Displacement ⍰ = Length x Breadth x Draught x Cb

Cb = Block coefficient: is the ratio of the underwater volume of the vessel to the volume of a rectangular block of the same extreme dimensions.

17.3 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 a ship, the water that is displaced (pushed aside) must weigh the same as the ship. The volume of water displaced (volume of displacement) is the same as the underwater volume of the ship. When this is multiplied by the density of the water, it gives the mass of the ship, that is, the displacement (Δ).

Mass = Volume x Density

The mass of the ship, or its displacement Δ, must act vertically downwards through its center 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 center of the underwater volume of the ship. This point is called the center of buoyancy B. For a ship 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 center of gravity and center of buoyancy as shown in diagram.

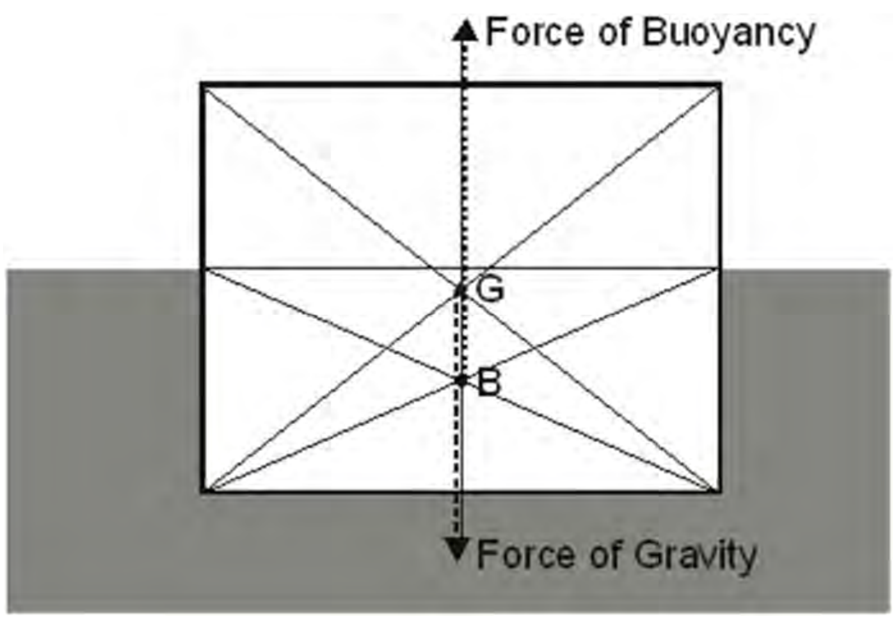


FIGURE 123

Light 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 ship 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 ship's tendency to return to its original position after an inclining force has been removed.

Positive stability – The ship, if inclined (up to a certain point) will right itself.

Negative stability – The ship inclined, will not return to an upright position

Neutral stability – An outside force will cause the ship to assume a new position, but it neither falls over nor returns to the original upright position.

G Center of Gravity - the point through which the entire weight of the ship and her contents are considered to act vertically downwards.

KG The vertical distance of G above the keel.

B Center of Buoyancy - the point through which the force of buoyancy is considered to act vertically upwards. It is the centroid of the underwater volume.

KB The vertical distance of B above the keel.

Initial Transverse Metacentre (M)

The point of intersection of verticals through the Transverse Center of Buoyancy for the upright and the slightly inclined positions. The Initial Transverse Metacentre is a fixed point. For angles of heel larger than 10° verticals through B no longer pass through the initial metacentre. The Transverse Metacentre is often abbreviated to just Metacentre.

GM The Transverse Metacentric Height is a measure of the ship's stability.

GZ The Righting Lever GZ = GM x Sin (up to a maximum angle of 10°).

Righting Moment = GZ x Displacement

A vessel in stable equilibrium heeled to a small angle showing the positions and forces through the center of gravity and center of buoyancy and the creation of the righting lever, righting moment, and transverse metacentre.

When a vessel is heeled by an external force, the center of buoyancy (B) moves to the new center of the underwater volume (B1). The force of buoyancy acts vertically upwards through B1 and through the initial transverse metacentre at angles of up to 10°. The perpendicular distance between the vertical line of action through B1 and the force of gravity is the righting lever GZ.

Gravity acts vertically downwards with the force of the Displacement and Buoyancy acts with a force equal and opposite to the Displacement. The above distance (GZ) and the above force (Displacement) combine to give the righting moment.

Transverse metacentric height, GM, as an assessment of initial stability.

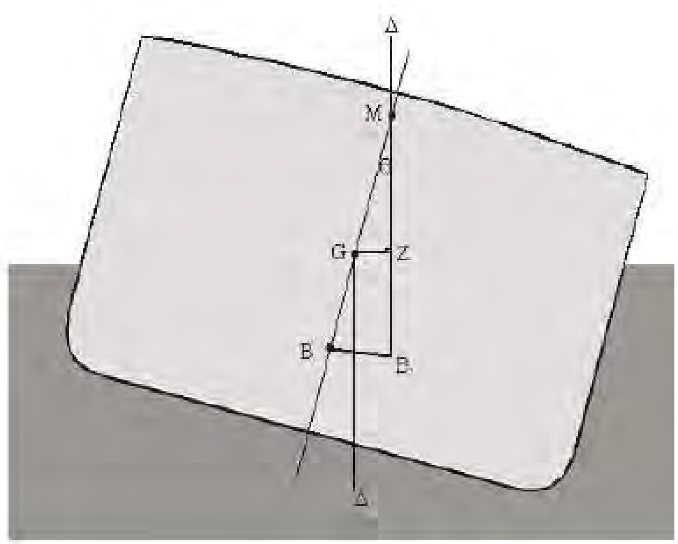


FIGURE 124

The transverse metacentric height (GM) gives an assessment of the initial stability of a ship, or the ability of a vessel to right itself. It does not give a full assessment as this can only be done by drawing a GZ curve. For any particular ship, the GM will give an idea of whether the ship will be stiff or tender.

Stiff & Tender Vessels, Their Advantages & Disadvantages.

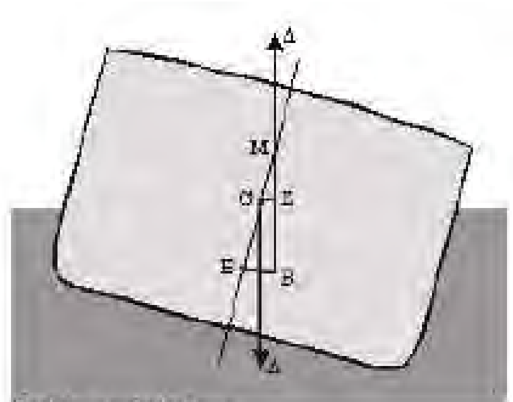
A stiff ship will have a large initial GM. The vessel is difficult to incline, she develops large righting moments. In heavy weather she will have a short, sharp rolling motion liable to cause structural stress, shifting of cargo and injury to personnel.

A tender ship will have a small initial GM. The 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 ship, the danger is that an unexpected reduction in stability will cause the ship to become initially unstable. Ships 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 ship becomes initially unstable, it will possibly capsize.

Stable, neutral and unstable equilibrium

Stable equilibrium

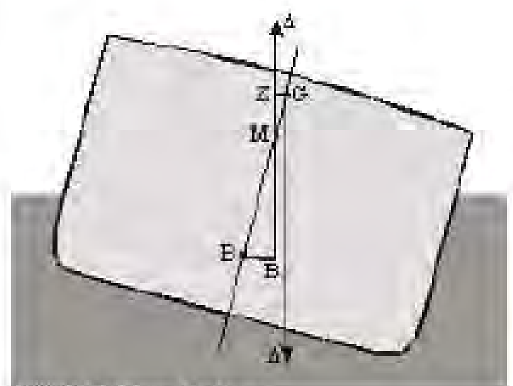
When the weights within the ship are low, G is low and below M; this is known as a positive GM. When heeled by an external force, the forces of buoyancy and gravity act in such a way as to bring the ship back towards the upright condition. This is stable equilibrium.



Stable equilibrium

Unstable equilibrium

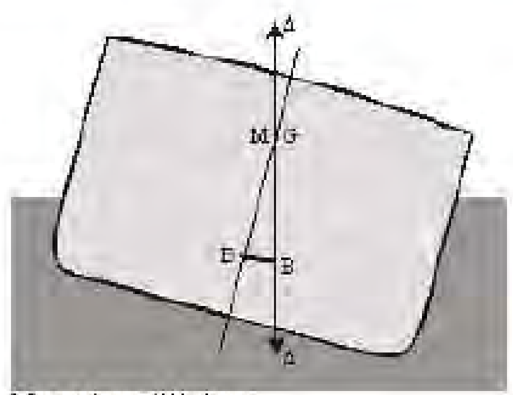
When weights are loaded high in the ship then G, the centre of gravity of the ship, will also be high. If G is so high that the forces of buoyancy and gravity and the lever between them cause the ship to capsize, then the ship is said to be in unstable equilibrium. The lever is now a capsizing lever or negative righting lever and G is above M, which is known as a negative GM.



Unstable equilibrium

Neutral equilibrium

This is a special case where the cargo is loaded such that G is in exactly the same position as M, (GM = zero). When the ship is heeled, no righting lever develops, therefore the ship can rotate freely. However, this situation exists for only a small angle from upright, say ten degrees. Beyond 10° the metacentre moves and either a righting lever develops, or no righting lever develops, and the ship capsizes. Whether or not the ship capsizes depends upon the shape of the hull, the depth, the beam, the freeboard and the sheer.



Neutral equilibrium

GM changes due to adding, removing and transferring weights

When a weight is loaded into a ship, G moves directly towards the weight. Therefore, if a weight is loaded low down then G will move down and the GM will increase.

When a weight is discharged from a ship, G moves directly away from the weight. Therefore, if a weight is discharged from low down then G will move up and the GM will decrease.

If a weight is shifted within a ship, then G moves in a direction parallel to the weight. So, if a weight is moved across the ship then G will move across.

Fuel and water are usually stored at or near the bottom of the ship. When they are used during a voyage, this is the same as discharging a weight from low down. G will rise, the GM will get smaller and the ship will become less stable. If sea water is retained on deck, as it may do in heavy weather, then the effect is the same, G will rise and the GM become smaller.

For suspended weights the effective center of gravity is at the point of suspension.

When a weight is suspended from a point then the weight acts as if it were at that point, as far as the centers of gravity are concerned. If a weight is suspended from a ship's derrick or crane, the center of gravity of the weight acts as if it were at the head of the derrick or crane. When a load is lifted from the quayside by the ship's derrick, the weight acts at the derrick head as soon as the load lifts off the quay.

This means that the center of gravity of the ship (G) will move directly towards the derrick head. This will cause G to move up and may give the ship a negative GM.

The Effect of Free Surface

This can be considered as a reduction in GM or a rise in KG and this change is known as the free surface correction.

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 ship 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. The effect of the movement of liquid is the same as if G rises. G does not actually rise but the effect is the same as if it did. We say there is a virtual or apparent rise of G causing an apparent reduction in the GM (or increase in KG). The amount by which G apparently rises is known as the free surface correction.

The reason that this effect occurs is because the free liquid moves around, increasing the roll and reducing the righting effect of the GZ lever.

Stability Formulae

$$T = \frac{.44 \times B}{\sqrt{GM}}$$

T = Rolling Period
B = Beam
GM = Metacentric Height

$$GM = \left(\frac{.44 \times B}{T}\right)^2$$

$$FSE = \frac{RL(B)^3}{420 \times D}$$

FSE = Free Surface Effect

$$R = \frac{\text{S.G. of liquid in tank}}{\text{S.G. of seawater}}$$

L = Length of tank

B = Breadth of tank

D = Displacement in tons

17.4 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 for Drydocking

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 Lloyds 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

Chapter 18 ROPEWORK – REFRESHER/REFERENCE

18.1 Key Objectives

THE OBJECTIVE OF THIS MODULE IS TO ENSURE THAT ALL CANDIDATES CAN DEMONSTRATE THE ABILITY TO TIE KNOTS AND KNOW THE CORRECT PROCEDURE FOR SECURING A BOAT TO A DOCK BY TYING LINES TO CLEATS.

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.

18.2 Ropework

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. Rope making is essentially a series of twisting operations. After fibres are made the rope is constructed by three twisting processes.

Normally rope is made as "right-laid" rope. First 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.

Types of Rope and their applications

In the past natural fibers were used to construct rope, but they were always susceptible to damage by rot, sunlight and chemical attack. Today most ropes are made from man made fibers.
Natural fibre rope is made from plant fibers such as:

- **Manila** was made from the abaca plant. It is smooth, pliable, tough, strong, and tan in color. Its main use was where strength, ease of handling, and safety were important. E.g. mooring lines.
- **Sisal** was made from the agave plant and similar to Manila but lighter in colour. E.g. towing and mooring lines.
- **Hemp** was made from the hemp plant. Eg. mooring lines.
- **Cotton and flax** lines are made of ordinary cotton and linen respectively. Eg. used for lead lines, and signal halyards.

The size of fiber rope was specified by its circumference in inches whilst its length is given in fathoms. Small cordage was usually known on shipboard as small stuff.

Inspection of wires and ropes

Wires, flexible steel wire ropes, supplied to ships 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 ships 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

Natural fiber rope has been replaced to a large extent by man made fiber ropes, but is still used, especially in lifeboats for lifelines and grablines and for manropes on pilot ladders. If man made fiber ropes are used, these must be approved for LSA use.

Most natural fiber is sisal, but hemp and manila are also used. Only manila resists the effects of seawater, sisal and hemp should be tarred to prevent their rotting when exposed to seawater. The table gives the approximate breaking strains for commonly used rope. The size of a rope is the circumference. It is normally three stranded, right hand hawser laid and supplied in 120 fathom coils. The breaking strain is in tones and the size is given in inches. The breaking strain for sisal is approximately half of that for nylon. These strengths are approximate and apply to new rope. 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. Contact with chemicals causes serious damage to natural fiber ropes and salt water had an adverse effect on them. Man made fiber ropes are badly affected by ultra-violet radiation and require protection from direct tropical sunlight. Man made fiber ropes, especially nylon are 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.

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. It is not as round as twisted rope and coarser to the touch. It is less prone to kinking than twisted rope and, depending on the material, very flexible and therefore easy to handle and knot.

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.

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 128 - OVERHAND KNOT

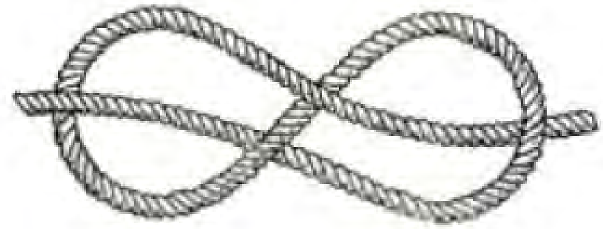


FIGURE 127 - FIGURE OF EIGHT KNOT

FIGURE 126 - GRANNY KNOT

FIGURE 125 - REEF OR SQUARE KNOT

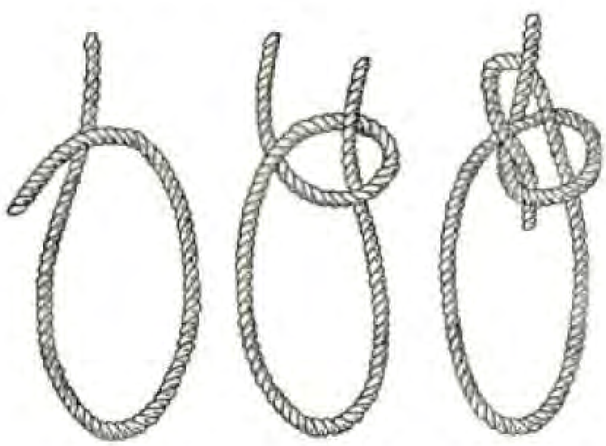


FIGURE 130 - BOWLINE

FIGURE 129 - RUNNING BOWLINE

Figure 131 - Half Hitch

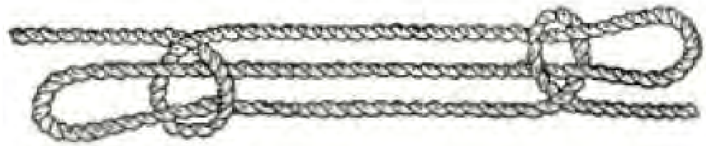


Figure 132 - Sheep Shank

Figure 136 - Clove Hitch

Figure 133 - Clove Hitch

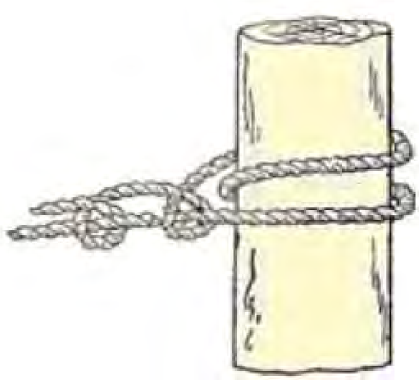


Figure 135
Round Turn and 2 Half Hitches

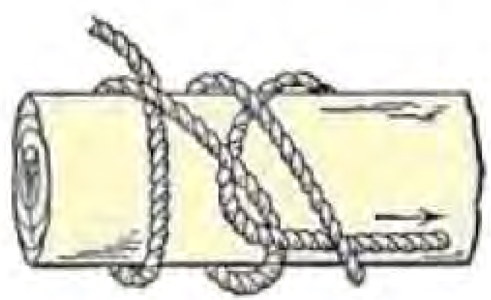


Figure 134 - Rolling Hitch

FIGURE 137 - BLACKWALL HITCH

FIGURE 138 - CATSPAW

FIGURE 140 - SHEET BEND

FIGURE 139 - DOUBLE SHEET BEND

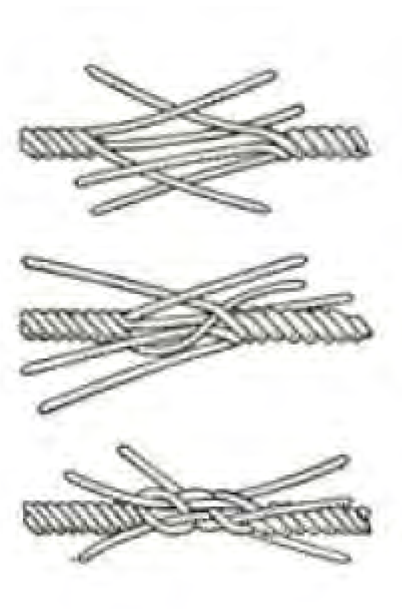


FIGURE 141 - SHORT SPLICE

FIGURE 142 - EYE SPLICE

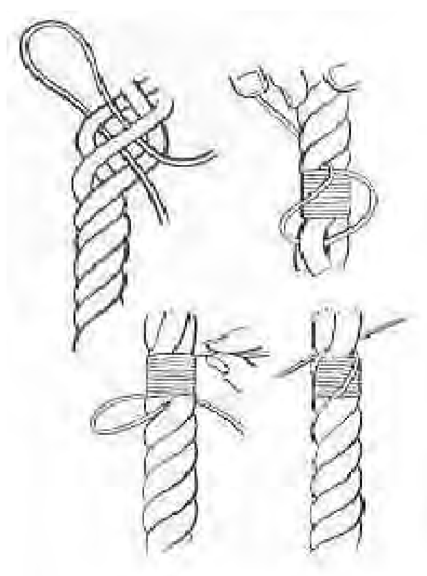


FIGURE 143 -= SAILMAKERS WHIPPING

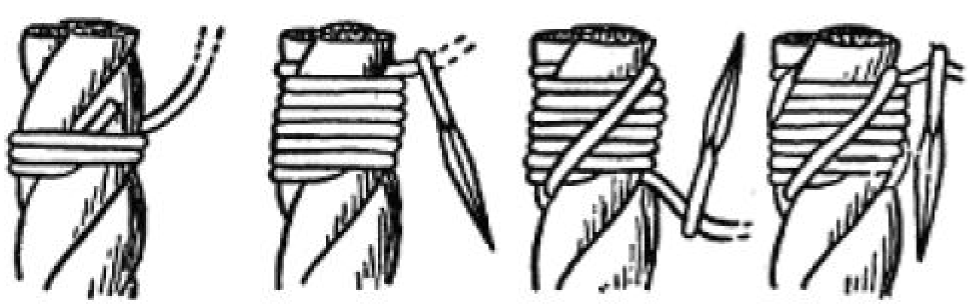


FIGURE 144 - COMMON WHIPPING

Blocks and Tackles

The parts to a block and tackle are shown below. It is rove to disadvantage. (pulling from the standing block).

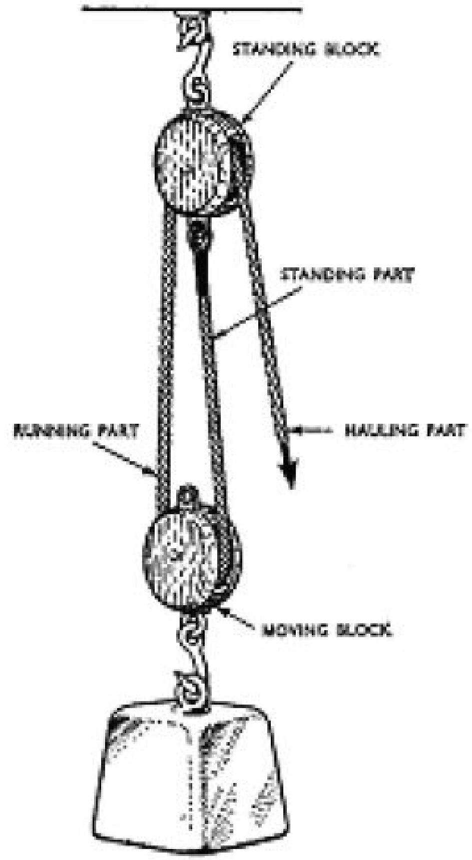


FIGURE 145 - BLOCK & TACKLE

If the hauling part is from the moving block the pull required to move the weight is less than if the block and tackled are rigged the other way. The two ways are known as rigged to advantage/disadvantage.

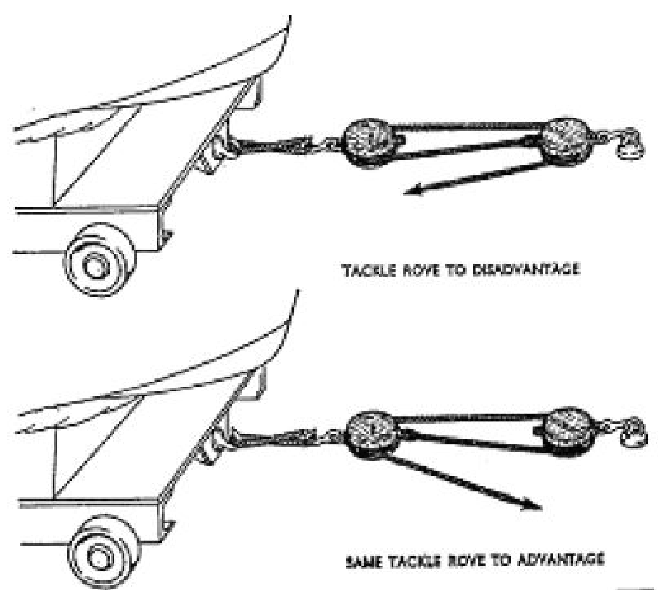
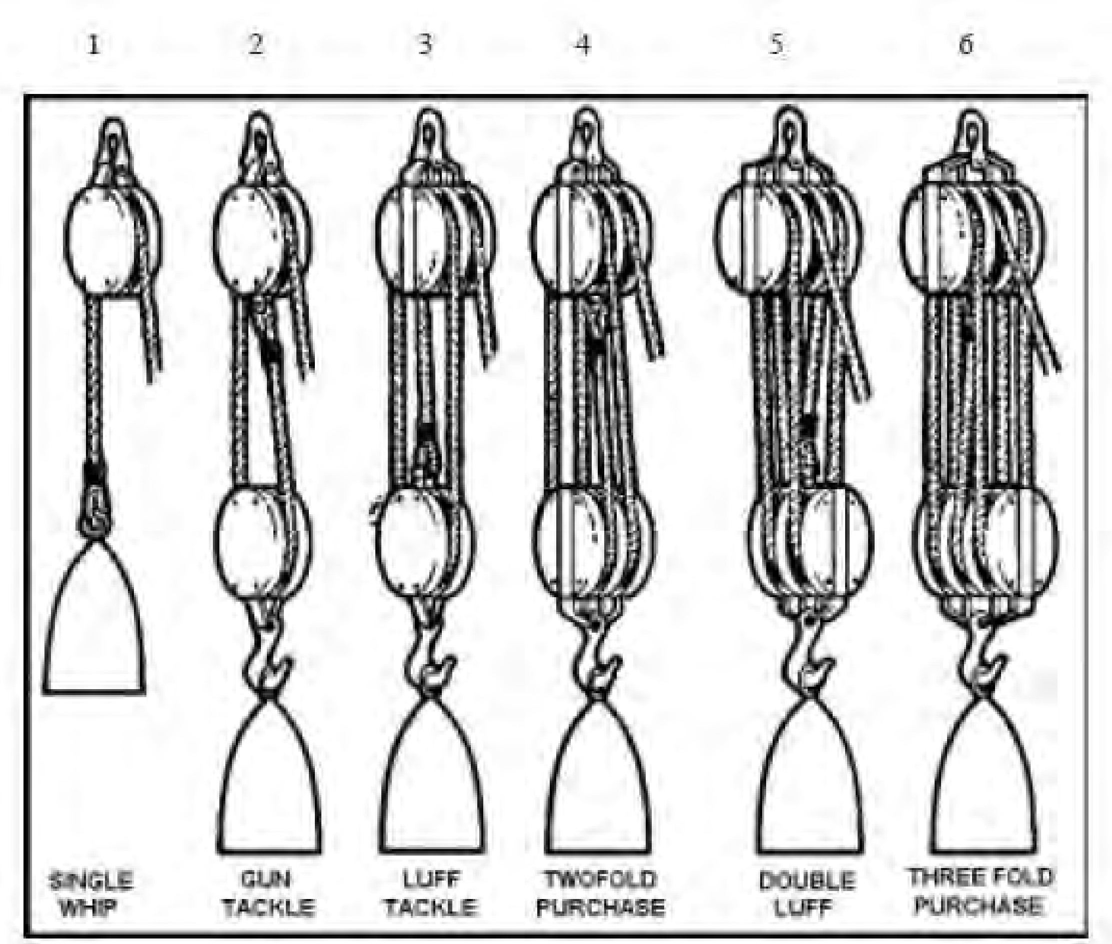


FIGURE 146

Examples of blocks and tackles are shown below.



NOTE: The numbers above the first six blocks are equal to their theoretical mechanical advantage. (Tackle #3 has a TMA of3)

The theoretical mechanical advantage is equal to the number of falls at the movable block. Example Tackle #3 would have a mechanical advantage of 3.

To find the mechanical advantage of a block and tackle that is bent to the hauling part of another, you must multiply the mechanical advantages of both block & tackle units.

<u>Example Problem:</u>

You are using tackle number 4 to lift a weight. The hauling part of this tackle is bent to the weight hook of tackle number 5. What is the mechanical advantage?

The mechanical advantage of tackle 4 is 4 because it has 4 falls at the movable block. The mechanical advantage of tackle 5 is 5 because it has 5 lines at the movable block. 4 x 5 = 20.
20 is the mechanical advantage of these rigs combined.

Some problems require you to figure how much power is required to lift a certain amount of weight with a particular block & tackle. 10% friction of that weight at each sheave is required to be applied. Here is the formula to calculate these types of problems.

Power = 1. (number of sheaves) x weight/ mechanical advantage

Example Problem:

You are using tackle number 6 to lift a weight of 300 lbs. If you include 10 % of the weight for each sheave for friction, what is the pull on the hauling part required to lift the weight?

Step.l. Count number of sheaves. (# of sheaves) = 1 x 6 = 6
Step 2. Find weight you want to lift from problem = 300 Ibs.
Step 3. Find mechanical advantage by counting number of lines at movable block = 7.

Using the formula
1 x (number of sheaves) x weight/ mechanical advantage = amount of pull.

1 x 6 x 300/ 7 = 68.57 This is the amount of pull required to lift 300 lbs.

Chapter 19 TOWING

19.1 Key Objectives

THE OBJECTIVE OF THIS MODULE IS TO DISCUSS METHODS OF 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.

Two Basic Types of Tow, Astern & Alongside

Astern Tow (Bridle 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.

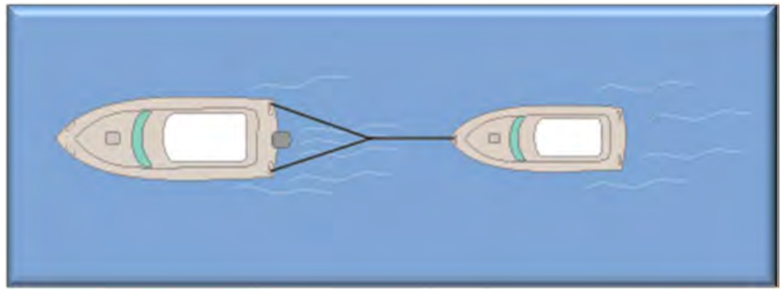


FIGURE 147 - BRIDLE TOWING

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.

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.

FIGURE 148 - TOW BOAT - TOW LINE AND 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 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.

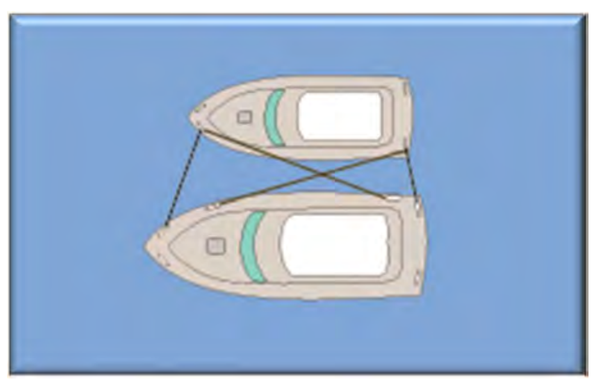


FIGURE 149 - TOWING ALONGSIDE

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.

Chapter 20 ANCHORS, ANCHORING, MOORING & DOCKING

20.1 Key Objectives

THE OBJECTIVES OF THIS CHAPTER IS TO REVIEW THE MOST COMMON TYPES OF ANCHORS AND ANCHORING, ANCHORING AND MOORING PROCEDURES AND DOCKING.

20.2 Types of Anchors

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.

An anchor can be used during an engine failure emergency or during bad weather to keep you from drifting towards obstacles.

Choosing the right anchor depends on the size and weight of your boat and the characteristics of the waterway bottom you generally operate on (i.e. Sand, rock or mud). Larger anchors are recommended for adverse conditions and are equipped with a shackle pin should have a locking device.

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.

FIGURE 150 – FISHERMAN ANCHOR

CQR/Plough Type

The CQR is a proprietary type of anchor, sometimes also called a plow. 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.

FIGURE 151 - PLOUGH TYPE ANCHOR

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 its 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.

FIGURE 152 - DANFORTH

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.

FIGURE 153 - BRUCE ANCHOR

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 its way very deep into the seafloor, making it difficult or impossible to retrieve.

Grapnel Anchor

1. A good anchor to hold on coral and rock and useful to use as a kedge.

FIGURE 154 - GRAPNEL ANCHOR

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.

FIGURE 155 - KEDGE ANCHOR

20.3 Anchoring

Anchors hold best in soft bottoms such as sand and mud, but will also hold in hard sand, shingle or pebbles. Smooth rock and weed are not good for holding. The Fisherman is probably the best for holding in rock. On vessels >10M it is best to carry two anchors of different types. The anchor line is called "rode" or "warp". The rode may be line (nylon warp or fiber rope), chain, wire rope or a combination of line or wire rope and chain. The end of the rode that is attached to the boat is known as the "bitter end".

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 rode. This means that in 3m of water, you would lower 15 feet of chain or 21m of chain and rode.

Scope is defined as the ratio of length of anchor line in use, to the vertical distance from the bow of the vessel to the bottom of the water. Larger boats generally carry all chain while smaller boats are more likely to carry a short length of chain attached to a nylon warp.

FIGURE 156 – ANCHOR WITH RODE & CHAIN

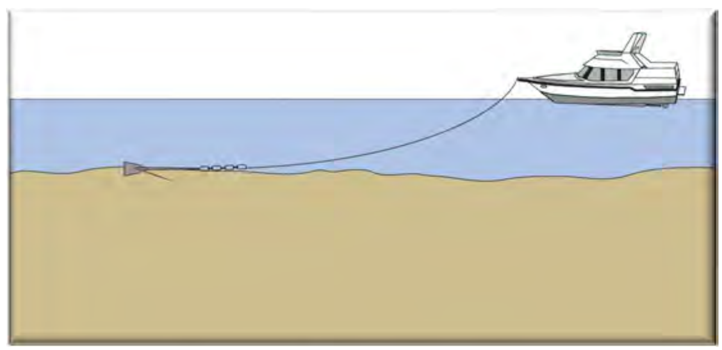


FIGURE 157 - SIMPLE ANCHORING

The Advantages & Disadvantages Of Chain, Line And Chain & Warp Combined.

Chain

Advantages:

2. The heavier weight gives better horizontal pull.
3. The weight of chain increases the catenary, which reduces the chances of snatching when anchored in rough seas.
4. 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 affect performance.
4. A snubber may have to be used to absorb shock.

Line (also referred to as Warp)

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.

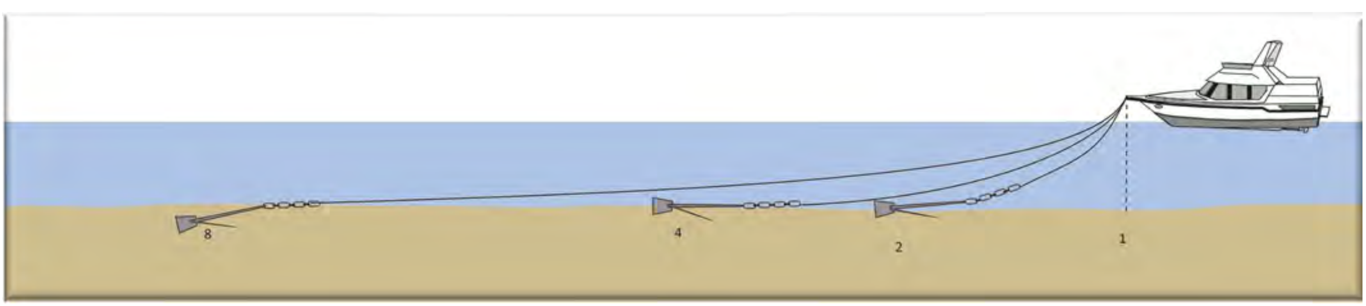


FIGURE 158

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.

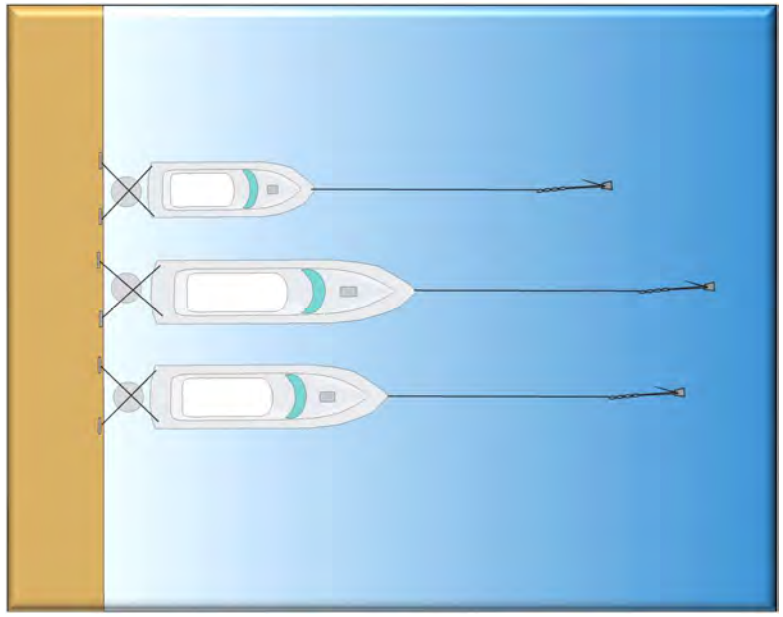


FIGURE 159 MEDITERRANEAN MOOR

Bahamian Moor

Use of two anchors meeting at a swivel, reduces swinging room.

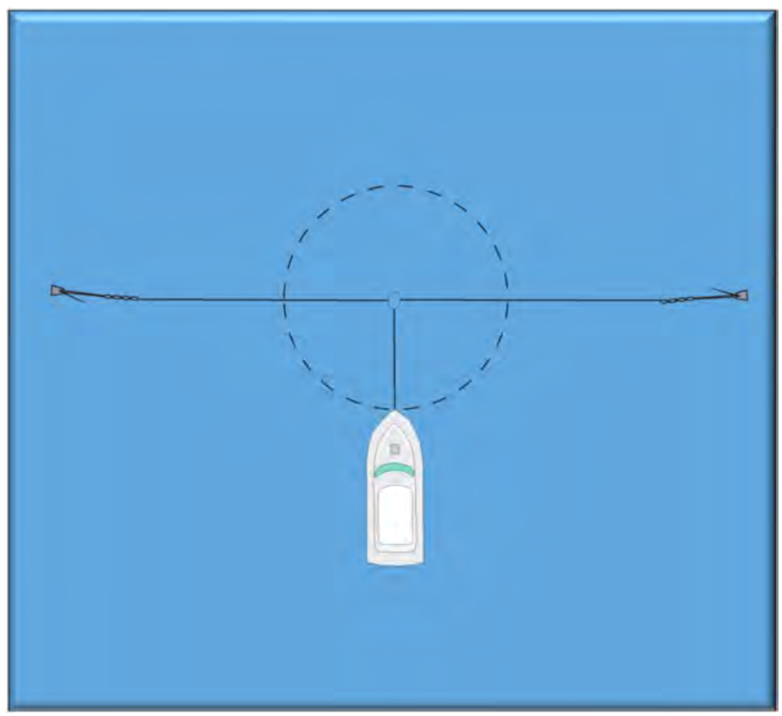


FIGURE 160 BAHAMIAN MOOR

Baltic Moor

Alongside with an anchor laid out abeam midships to hold vessel off the dock.

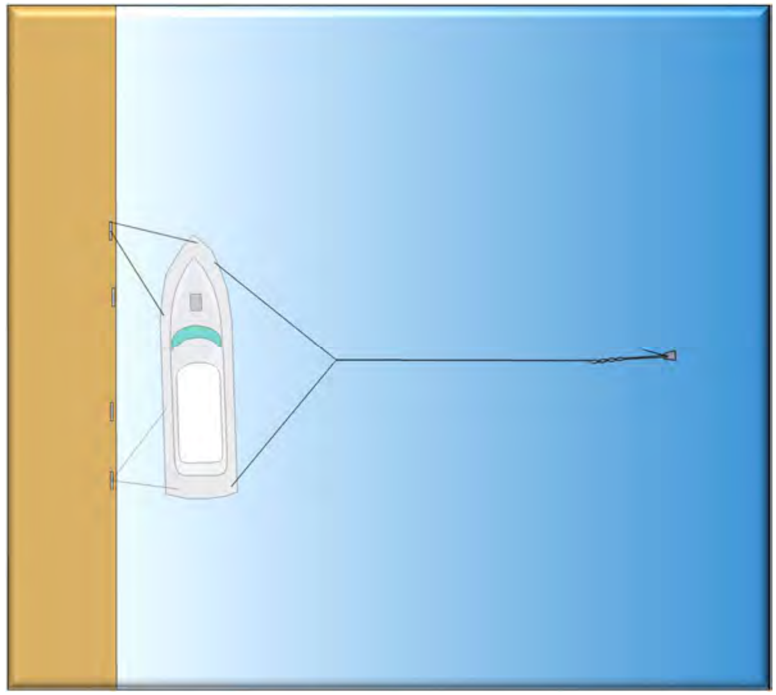


FIGURE 161 BALTIC MOOR

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 both from the bows, 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. In calm conditions both anchors can be led out over the bow, the heaviest one laid towards the strongest tidal stream; but in a cross wind, both anchors may drag.

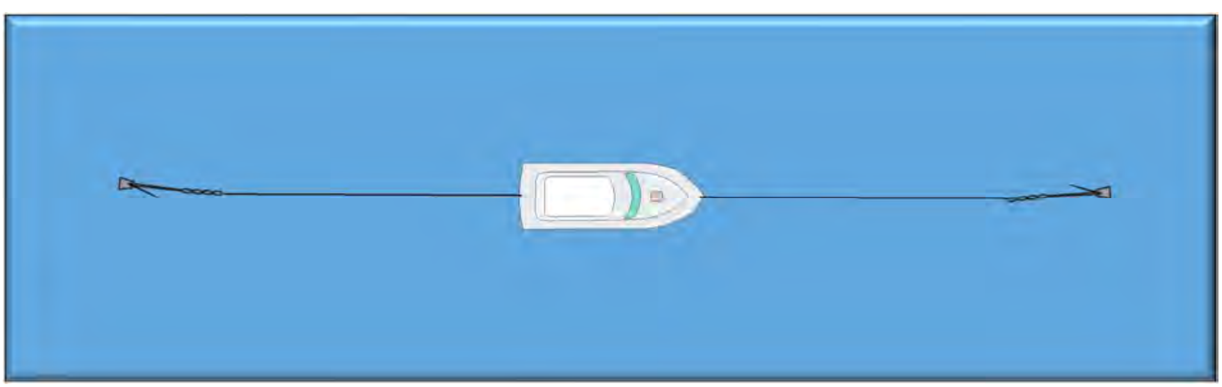


FIGURE 162 LAYING A SECOND ANCHOR

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.

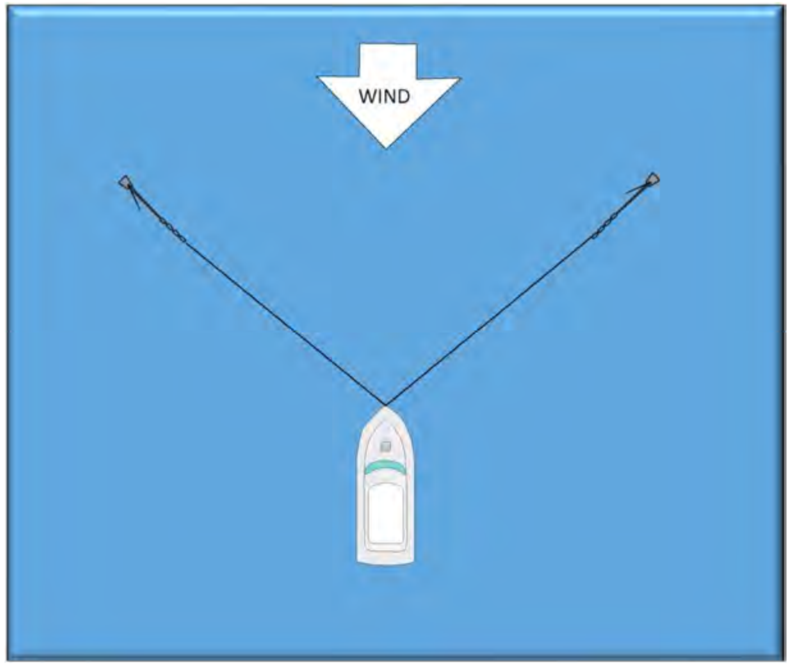


FIGURE 163 ANCHORING FORE AND AFT

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: 1/8 inch (3mm) for every 9 feet of (2.7m) overall boat length.
Length: Bow and 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:

- Bow line. A line lead forward from the bows of the boat.
- Stern line. A line lead aft from the stern of the boat.
- 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.
- 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.

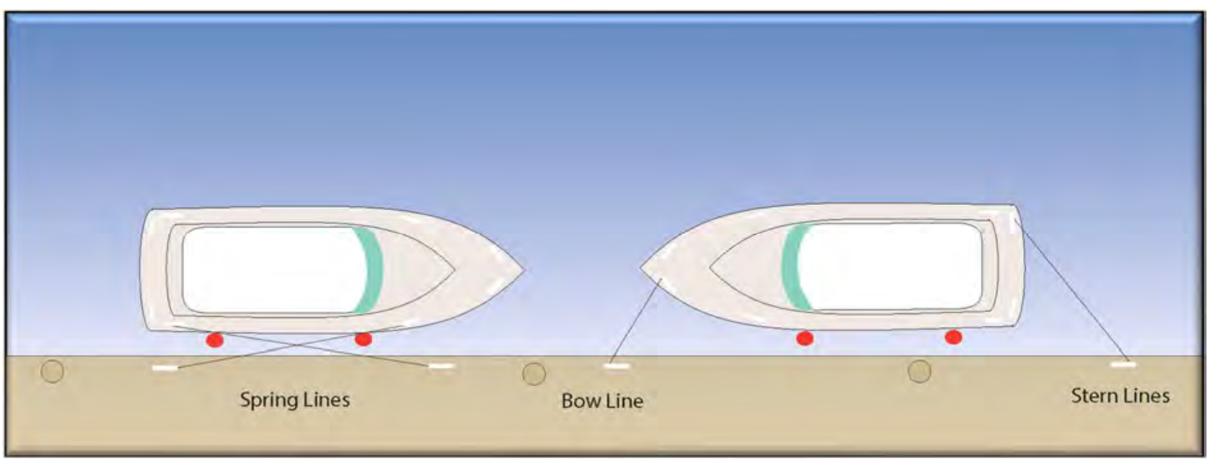


FIGURE 164 DOCKING LINES

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

- Always “Dip the Eye” (lead the eye of your dockline 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.
- 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’ departure if she wishes to leave before the outer boat. In the case of a raft of several boats this also relieves the strain on the cleats of the innermost boat and will stabilize the raft.
- Adequate fenders must be placed between boats or between the boat and the pontoon.
- Spreaders should be staggered to avoid clashing in a swell.
- 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.
- If on a sailboat rig frapping lines to prevent halyards slapping the mast.
- Keep noise to a minimum.

Safety Issues When Handling Mooring Lines & 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

Chapter 21 EMERGENCY PROCEDURES

21.1 Key Objectives

THE OBJECTIVE OF THIS CHAPTER IS TO ENSURE EMERGENCY PROCEDURES ARE COMPLETELY UNDERSTOOD AND HOW TO RESPOND TO THOSE EMERGENCIES SHOULD THEY ARISE.

Emergency situations can be caused by fire, collision, stranding or foundering. Should an emergency situation arise the procedures that have been practiced at musters and drills will come into play. Survival at sea depends on the awareness of the crew, the survival equipment onboard the vessel and how to use that equipment with maximum effect. In an emergency the 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.

Every vessel must have a contingency plan for coping with such emergencies and each crewmember must know his responsibilities. Survival equipment 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.

21.2 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!

- Engine Room
    - Fuel – Diesel – Petroleum. Insufficient ventilation or 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.
- Cigarettes
    - Crew or guests fall asleep while smoking. Carpet and interior destruction. Cigarette getting blown into the 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 – overloading 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 9ft) 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 situation – 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. During the mating season, a whale can affectionately “brush” itself against the hull thus puncturing it beyond repair.

Containers

- Approximately 40,000 40ft 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 increased chances of MOB occurring.
- Always use harnesses for any activity which might lead to MOB, i.e. 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

There are 2 possible situations that could arise:

If person is seen to fall:

1. Alert crew.
2. DO not take eyes off victim!

3. Throw them a lifebuoy or ring.
4. Slow vessel.
5. Mark MOB position on GPS.
6. Crew to muster stations.

Radio Mayday or Pan

FIGURE 165
CODE FLAG O
REPRESENTS MAN OVERBOARD

If a person is missing:

1. Alert crew.
2. Slow vessel.
3. Turn Vessel on reciprocal course.
4. Radio Mayday.
5. Crew to muster stations.
6. 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 person (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

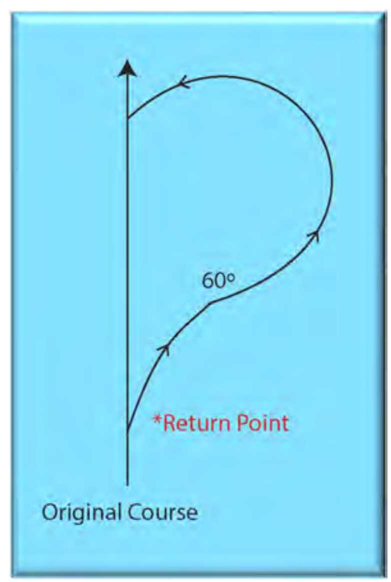
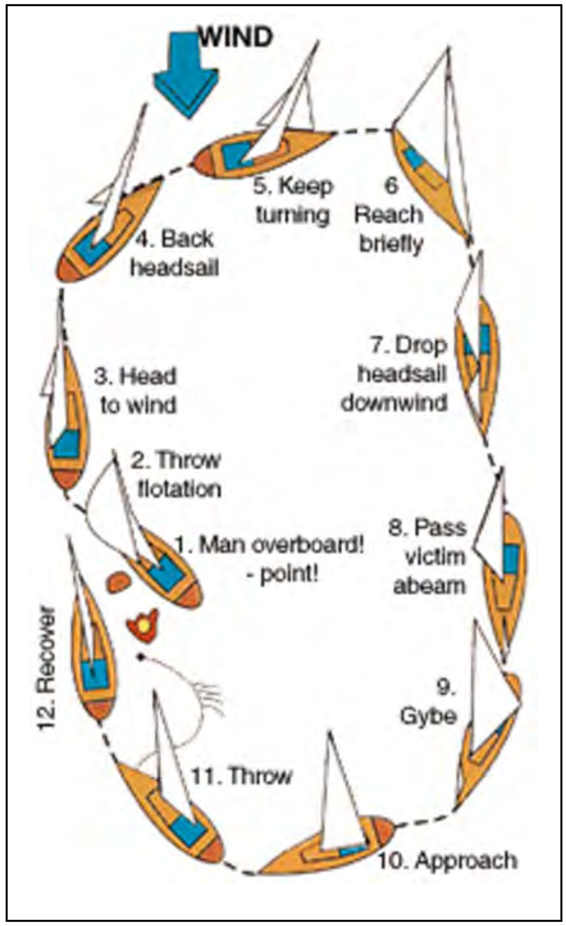


FIGURE 166 - WILLIAMSON TURN

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.

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

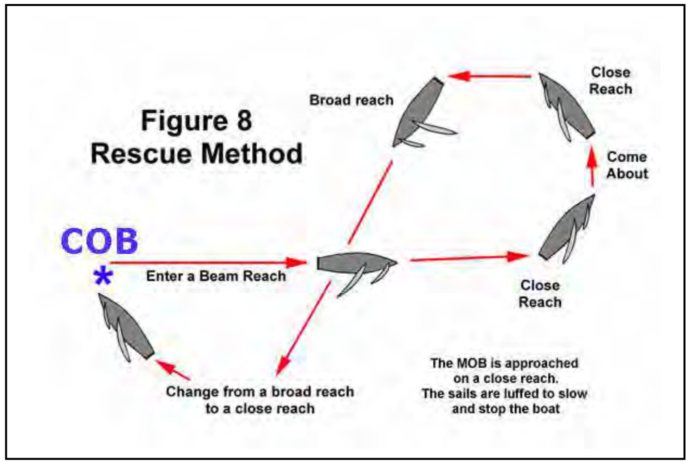
The advantages of this method:

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.

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, i.e., 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.

21.3 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 Position because if the Watch keeper knew where he was then the ship would probably not have run aground. Consider holding the ship in position with anchors, attached to a rope or wire. Consider holding the ship in position with anchors, attached to a rope or wire.
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 ship to determine the nature of the ground on which the ship lies. How much of the ship 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 or a call to arrange a tug.
7. Passengers 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 ship off then good communications are essential between ship 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, by rocket line and by helicopter.
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 affect this.
6. Repairs where is the nearest port that will have the necessary facilities to make repairs. Again, divers may be required.

Heavy Weather Damage

It is important to take all possible steps to avoid damage especially to the bridge windows as this will certainly disrupt the control systems of the ship. 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 lifelines, 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 ship or the other one involved?
3. Inform shore authorities of the problem and your course of action.
4. Remember that you must render assistance to the other ship if required.
5. Repairs it is most 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 and ship side valves. Ensure crew is clear of compartments affected. Start all necessary pumps, including bilge injection systems if required.
3. Effect repairs if possible or make to nearest safe anchorage or harbor. Arrange shore assistance, extra labor pumps and divers.

Assisting a Disabled Ship

1. Ships - assistance to a disabled ship can take many forms depending on the circumstances.
2. On approaching a ship in difficulty, the first priority is to establish communication. Only then can the extent 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 may be required, either short or long range.
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 upon 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 center 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 ship 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 the ship 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.

Place 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:

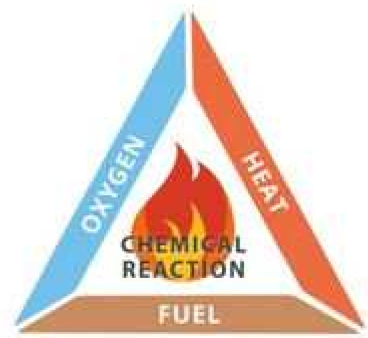
External
Securing anchors.
Securing boats.
Storm shutters on exposed windows.
Loose gear around the decks.
Securing gangways.

Internal
Around the galley with particular attention to bars on the stoves.
Passenger and crew cabins.
Storerooms in all departments.
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 temperature 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.

- Removing heat is called cooling.
- Removing oxygen is called smothering.
- 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:

- Those that cool.
- 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, such as wood and paper. 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, such as grease, gasoline, oil, etc. 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 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.

Class D

Extinguishers are designed for use on flammable metals 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.

Class K

Class K fires are fires in cooking oils and greases such as animal fats and vegetable fats.

	Colours	A	B	C	D	(electrical)	F
Type:		Fires involving freely burning materials. For example wood, paper, textiles and other carbonaceous materials.	Fires involving flammable liquids. For example petrols and spirits. NOT ALCOHOL OR COOKING OIL.	Fires involving flammable gasses. For example propane and butane.	Fires involving burning metals.	Fires caused by electrical equipment where electric current may be present.	Fires involving cooking oil and fat. For example olive oil, maize oil, lard and butter.
Water		✓	✗	✗	✗	✗	✗
Foam		✓	✓	✗	✗	✗	ABF Foam Only
Dry Powder		✓	✓	✓	✗	✓*	✗
M28/L2		✗	✗	✗	✓	✗	✗
CO2 Gas		✗	✓	✗	✗	✓	✗
Wet Chemical		✓	✗	✗	✗	✗	✓

Multipurpose Extinguishers

Most portable extinguishers are rated for use with more than one classification of fire. For example, an extinguisher with a BC rating is suitable for use with fires involving flammable liquids and energized electrical equipment. An extinguisher with an ABC rating is suitable for use with fires involving ordinary combustibles, flammable liquids and energized electrical equipment. An extinguisher that is rated for use with multiple hazards should include a symbol for each hazard type.

How To Use a Fire Extinguisher

Remember the acronym "P.A.S.S." which is the method to fight a fire onboard.

PULL

Pull the safety pin on the handle of the fire extinguisher.

AIM

Aim at the base of the flames.

SQUEEZE

Squeeze the handle

SWEEP

Sweep the fire by spraying from left to right in a sweeping motion.

Ensure the extinguisher is suitable for the type of fire you are trying to put out. Stand at a safe distance from the source of the flame.

Important Tips Regarding Fire Extinguishers

- Use an extinguisher designed for marine use.
- Use an extinguisher with an external gauge which includes the condition of the charge.
- CO2 type extinguishers should be weighed annually and re-filled when they have diminished to less than 90% capacity.
- If using CO2 type extinguishers in an enclosed area proceed with caution as they utilize colourless, odorless gases that displace oxygen.
- Always use a fire extinguisher to put out electrical fires or flammable liquid fires. Never use water as it will spread the fire as water conducts electricity.
-

Maintenance of Fire Extinguishers

Monthly inspections are required to keep fire extinguishers in good working order. When inspecting a fire extinguisher, you should do the following:

- Check the gauge to ensure the extinguisher is fully charged
- Check the seals and hoses and replace any that are cracked or broken

- Turn the extinguisher upside down and shake at least once per month to prevent the agent from clumping.

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, two immediate dangers occur:

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 echo 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, observed 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 careful 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 coastguard 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.

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 20m, 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.

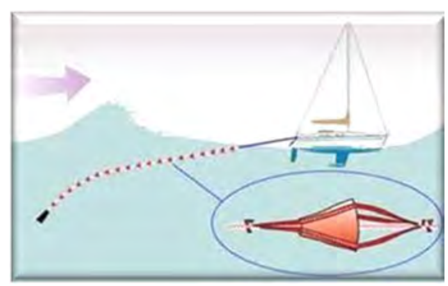


FIGURE 167 - DROGUE

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.

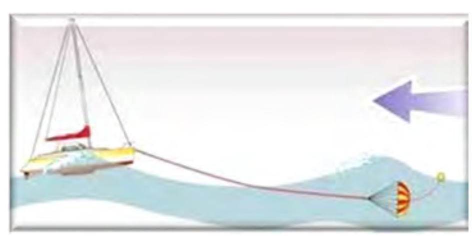


FIGURE 168 - SEA ANCHOR

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 harbor 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 harbor, 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 Masters' 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 equipment.
- 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.

Chapter 22 VESSEL'S POWER PLANT

22.1 Key Objectives

THE OBJECTIVE OF THIS CHAPTER IS TO DISCUSS VESSEL POWER PLANT TO UNDERSTAND THE ADVANTAGES OF 2 OR 4 STROKE ENGINES AND DISCUSS TURBOCHARGERS

Whether the engine is a single cylinder, multi-cylinder, horizontally opposed, V or in Line, four stroke or two stroke, petrol or diesel, it operates on a continually repeated cycle in which fuel is drawn in, compressed, ignited and discharged.

With either the ***petrol*** or ***diesel*** engine there are two types of engine cycle, the ***Two stroke*** and the ***Four stroke***

In the Four Stroke, the valves, which control the entry and discharge of the fuel mixture and the exhaust gases, are external components operating in the cylinder head.
In the two-stroke unit the valves, called ***PORTS,*** are internal, being formed by openings in the cylinder walls which are covered and uncovered by the movement of the piston.

The petrol engine has to mix the air and fuel to form a combustible gas BEFORE it enters the engine. In order for the air and fuel to be mixed correctly the mixture must be atomised, that is broken up into fine particles, and this operation is achieved in the ***CARBURETTOR***.

Electrical ignition is required in the petrol engine to ignite the compressed air/fuel mixture. This is achieved by the sparking plug in which a high voltage electric current "jumps" the gap between the electrodes.
The resulting spark ignites the fuel mixture at precisely the correct moment on the compression stroke.

In the diesel engine, air is drawn into the cylinder and highly compressed which causes it to become very hot and at a high pressure and at the correct moment a metered quantity of fuel is injected under pressure into the cylinder.

Injecting fuel into the cylinder at high pressure causes the fuel to vaporise and the resulting mixture immediately ignites. No electrical ignition is required for the fuel mixture to ignite in the Diesel engine.

The Diesel Engine is defined as a: - ***COMPRESSION IGNITION ENGINE.***

The Petrol Engine is defined as a: - ***SPARK IGNITION ENGINE.***

ENGINE TERMS

Top Dead Centre:
When the piston is at the limit of it's upward travel, it is at the TOP DEAD CENTRE (T.D.C.) and any further rotation of the engine will cause the piston to move down the cylinder.

Bottom Dead Centre:
When the piston is at it's inward most or lowest point, it is at BOTTOM DEAD CENTRE (B.D.C.), and any further rotation of the engine will cause the piston to travel up the cylinder.

Stroke:
The vertical distance travelled by the piston between TDC & BDC is called the stroke.

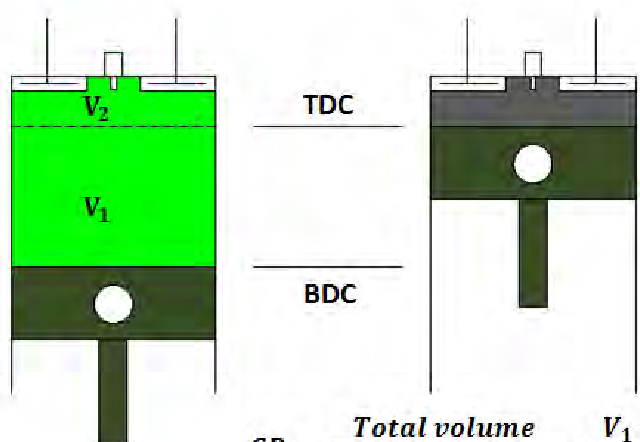
Swept volume:
Is the volume swept or covered by the piston when moving in the cylinder from BDC to TDC, and equals the piston area x the stroke. Sometimes referred to as the Stroke or Displacement volume.

Clearance Volume:
The space left between the piston at TDC, and the cylinder head.

Compression Ratio:
The compression ratio is the ratio of the volume of the gas at the beginning of compression to the volume at the end of compression i.e.

Initial Volume Divided by the Final Volume.

Initial Volume ÷ Final Volume = Compression Ratio



$$CR = \frac{Total\ volume}{Clearance\ volume} = \frac{V_1 + V_2}{V_2}$$

Action of the 4 Stroke Cycle for the Internal Combustion Engine

The 4 stroke cycle is completed in four strokes of the piston, or two revolutions of the crankshaft. To enable this cycle to operate, a means of opening the valves is needed, this is done by the camshaft operating on a push rod or valve stem.

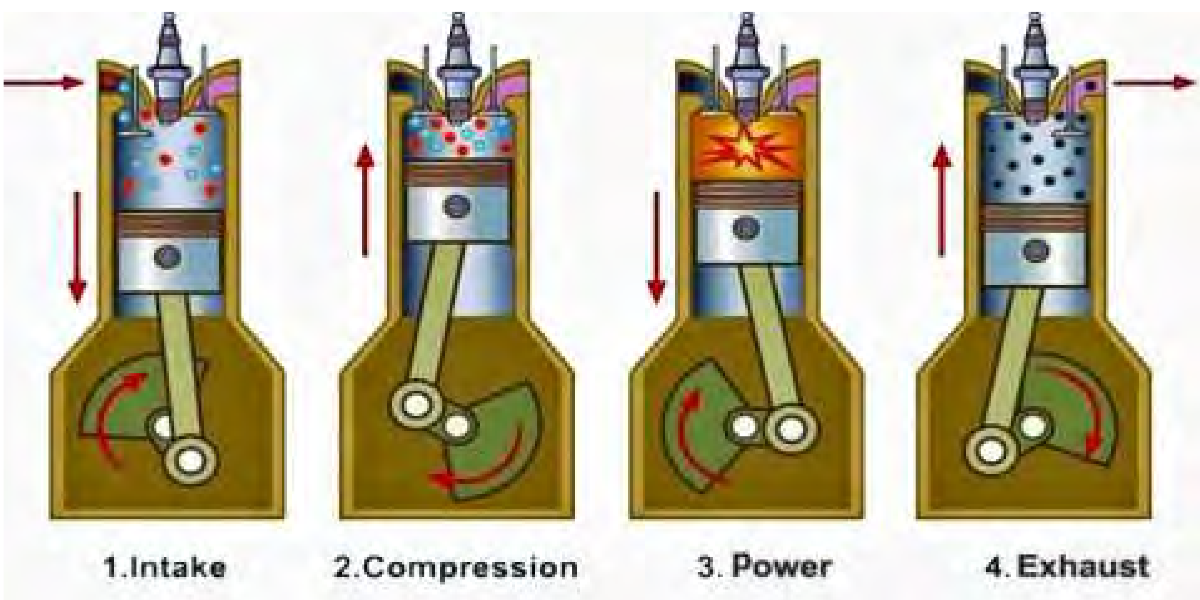
<u>For Diesel Engines</u>

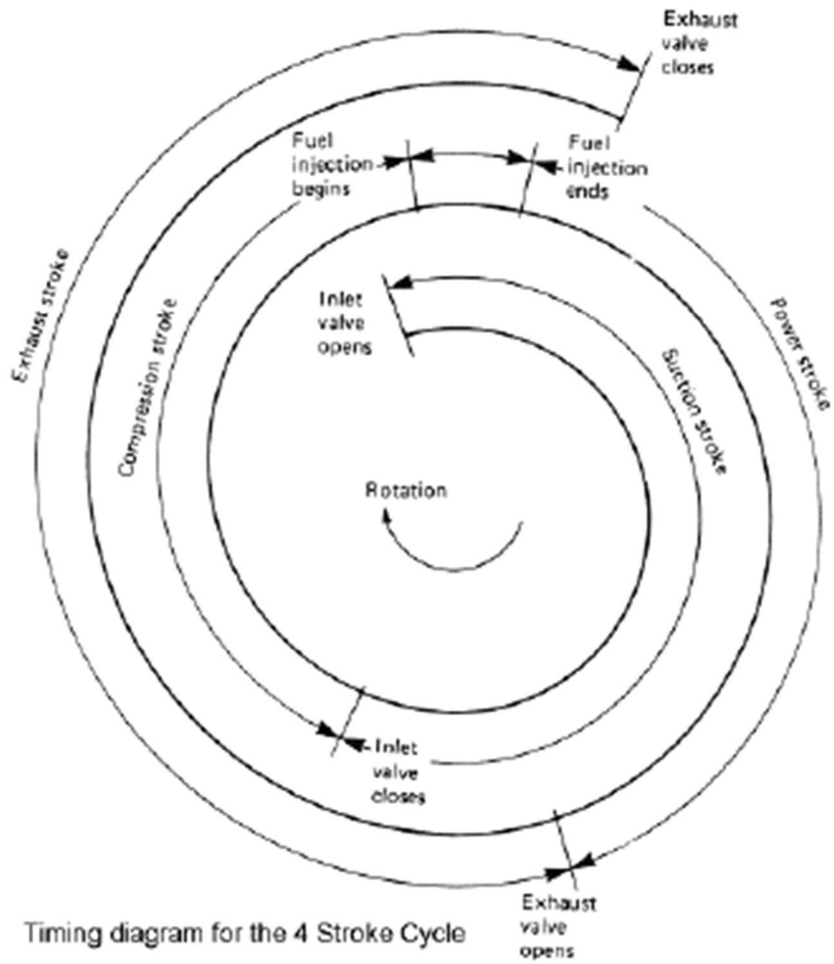
Intake Stroke. (Picture 1)
Down-stroke. Air enters the cylinder by inlet port. Inlet valve opened by the camshaft. On Turbocharged engines the air is blown out.

Compression Stroke. (Picture 2)
Up-stroke. The air is compressed by the piston to such an extent that its temperature is high enough to ignite the fuel when it is injected. Inlet and Exhaust valves closed.

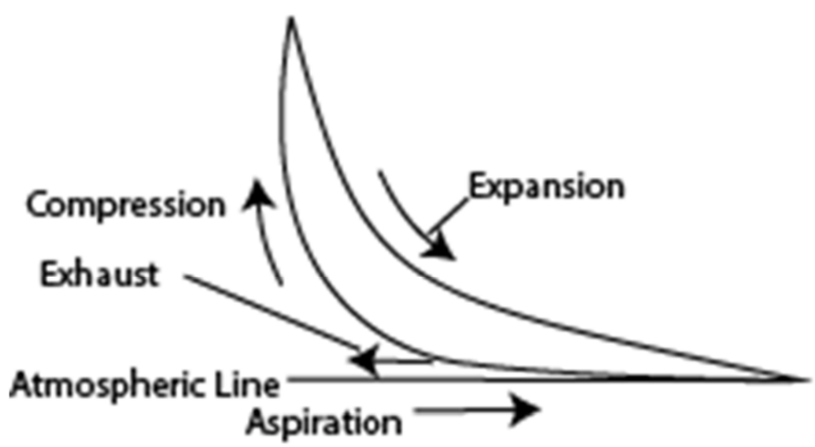
Power Stroke. (Picture 3)
Down-stroke. Fuel is injected before TDC. and is ignited by the compressed gasses the piston is forced down by rapidly expanding gasses. Inlet and exhaust valves closed.

Exhaust Stroke. (Picture 4)
Up-stroke. Exhaust gasses are forced out of cylinder by piston and helped by the new charge blown in by the turbocharger. Exhaust valve opened by the camshaft.





Timing diagram for the 4 Stroke Cycle



Indicator Diagram for a Four Stroke Cycle

The 2 Stroke Cycle

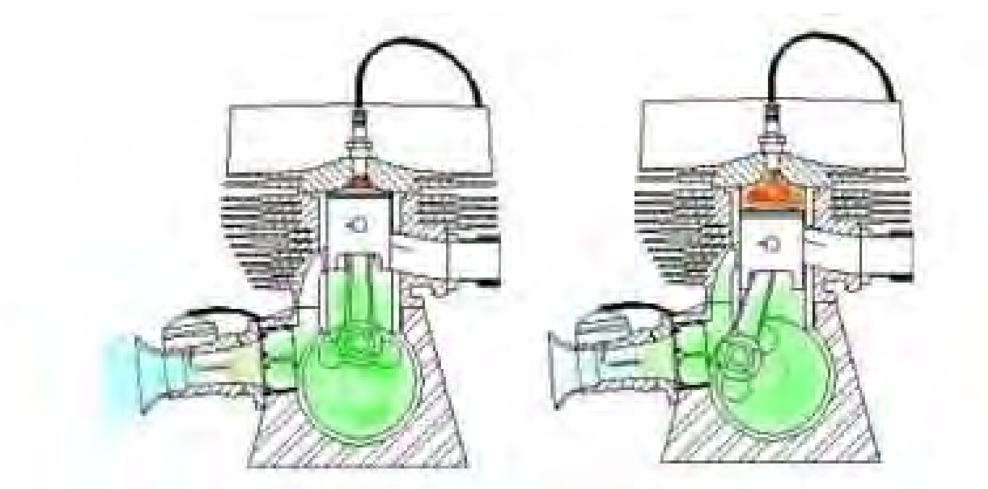
The 2 stroke cycle is completed in two strokes of the piston or one revolution of the crankshaft. Each event in this cycle is accomplished in a short space of time; in order to operate the engine needs a number of special arrangements. The air of air/fuel must be forced in under pressure. This in turn is then used to dean out the exhaust gases and provides the next charge ready for burning.
Modern engines use the turbocharger to force in the air.

Piston passing top dead center, Ignition and rapid burning taking place above piston.

Down-stroke. Expansion of burning gasses above piston and Exhaust port opening.

Piston near bottom. Exhaust port open (left), and Scavenge ports opening to allow a fresh charge of air from the scavenge space top of piston (right).

Piston on up-stroke. Scavenge ports close. Exhaust Ports close and compression of previous charge of air.



Turbo-Charging and Turbochargers

This process is the introduction of extra air into a cylinder using a compressor driven by a turbine mounted on the same shaft. Expansion of the exhaust gases through the nozzles results in a high velocity gas stream entering the turbine wheel of the turbocharger. The whole shaft spins at high speed turning the compressor as it spins. Compressed air leaves the compressor and is passed to a cooler. Cooling the air has the effect of making it denser so an even larger amount of air is introduced into the cylinder. The extra air now in the cylinder allows a larger amount of fuel to be burnt and thus more power is produced for a given size of engine. Turbo-charging actually uses energy in the exhaust gases which would otherwise be lost. The exhaust gas temperature is lower after the turbine than it is when leaving the cylinder.

Advantages

A substantial increase in power output for any stated engine size and piston speed, alternatively, a substantial reduction in engine size and weight for any stated horsepower.
Appreciable reductions in the specific fuel consumption rate at all engine loads.
A reduction in initial cost.
Increased reliability and reduced maintenance costs, resulting from less exacting conditions in the cylinders due to the increase in air and thus lower temperatures.
Increased reliability and reduced maintenance costs, resulting from less exacting conditions in the cylinders due to the increase in air and thus lower temperatures.

A. Hot gases from the manifold drive the turbine
B. The exhaust gases exit through the exhaust pipe silencer or is cooled by seawater injected into the exhaust via the water injection bend elbow
C. Air from the air cleaner is fed into the compressor
D. The compressed air is fed through the air inlet manifold to the cylinders where it can burn an increased amount of fuel compared to a normally aspirated engine

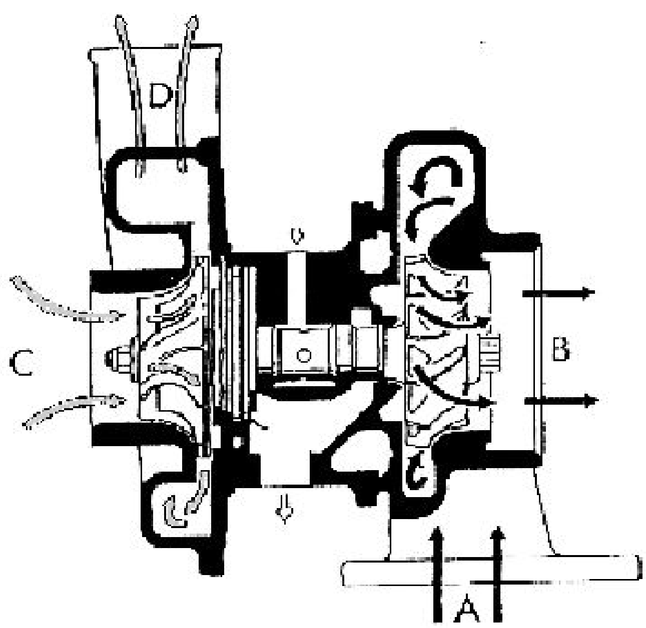


FIGURE 169 – INDICATOR DIAGRAM FOR A 2 STROKE CYCLE

Cleaning of Turbochargers

Under operating conditions, turbo-charge systems may become fouled, causing reduced efficiency, loss in power and maybe surging. Compressor surfaces can be contaminated by oil and dust drawn from the engine room atmosphere, passing through the intake filters and adhering to working surfaces. This gives loss in compressor efficiency and chokes the charge air cooler.

Contamination can be removed while the engine is running by water washing. A small spray of clean, fresh water is injected into the air stream at the compressor inlet: water droplets are drawn through and scour the surfaces clean. Water drains must be open and the quantity of water limited since some of this, together with contaminants, may pass into the engine cylinder. Additives to improve the cleaning effects of the water must not be used in trunk piston engines where it is possible for them to pass through the cylinder to the crankcase oil. Hydrocarbon based additives must not be used since there may be an explosion risk, and they may add further combustibles to the cylinder which have bypassed the governor control.

Fouling of the exhaust system and turbine is the build-up of the products from combustion of fuel, used cylinder oil and its additives, ash and any other non-combustibles present in the fuel. These will create hard deposits that interfere with gas flow, may cause local overheating, reduce turbine efficiency and even destroy balance of the rotor.

Water washing may also be used to clean the gas side of the system. A small water jet sprayed into the gas flow, upstream of the protection grids for the turbine, will dampen and soften the deposits, reducing adhesion and enabling them to be blown clear by the gas stream. The introduction of water to very hot surfaces can cause thermal shock, so before water washing the turbine engine power must be reduced so that temperatures in the system are lowered. Water drains must be open and great care exercised since removal of deposits may affect the balance of the turbine rotor.

Examination and more comprehensive cleaning of parts by physical and chemical means can be carried out during overhaul.

Charge Air Cooler

Compression will raise the air temperature and a charge air cooler is fitted to reduce the temperature of the air between the turbocharger and the engine inlet manifold, causing increased air density at lower induction temperature. The engine is maintained at safe working temperatures and the lower compression temperature reduces stress on piston rings, piston and liner.

Increased density will raise scavenge efficiency and allow a greater mass of air to be compressed; more fuel may now be burned giving an increase in power.

The air makes a single pass through the cooler and, for efficient cooling; its velocity should be low and cooling area large. This is obtained by making the air inlet connection divergent; the outlet is convergent to restore air velocity after cooling.

Condensation of moisture in the compressed air will occur during cooling and a drain is fitted to the outlet side air easing to allow this condensate to be removed. A moisture eliminator may also be fitted to remove entrained water droplets from the air stream. The drain should be kept open and its discharge noted; this will also indicate if a cooling water leak has occurred.

The cooler consists of a tube stack of aluminium brass tubes rolled and solder-bonded into two brass tube plates. Cast iron water boxes are attached to the tube plates and allow salt-water circulation within the tubes to make two passes. One tube plate is secured to the casing while the other is free to move axially as thermal expansion occurs. The air seal is maintained by means of a fitted rubber joint ring. An air vent is fitted to the top water box to remove air that may have been released from the saltwater system. Corrosion plugs may be fitted within the water space.

Thin copper fins are soldered to the outside of the cooler tubes. The air will pass between the plates, which greatly increase the area of heat transfer. There are two side plates of mild steel or aluminium alloy.

Temperatures and pressures are recorded at each inlet and discharge. Discharge air temperature should not exceed 55°C since engine temperatures, notably the exhaust temperatures, will increase, with loss in efficiency due to reduction in air density.

Air at very low temperatures will also cause thermal shock when in contact with hot liners and pistons.

Some medium speed engines turbocharger systems may be adapted to improve low speed operation. A by-pass valve may automatically return some charge air to the compressor inlet to improve acceleration when running up to speed. Engines designed to operate with high power at reduced speed may have an excess of charge air at full speed and require a blow-off valve to open at 85% full speed.

In recent years, the efficiency of turbochargers and their systems has been increased considerably. In addition to increased engine power, greater stability is possible at low speeds. Part of the exhaust gas energy may be used to drive power units that increase the overall thermal efficiency of the plant.

Under Cooling of Air

This occurs when the air is cooled to a temperature below the dew point at that pressure. To prevent under cooling and excessive condensation, air temperature should not be taken below 20 - 25°C.

Some measure of cooler efficiency can be ascertained from the difference between air discharge temperature and cooling water inlet temperature under normal running conditions: a rise in this indicates fouling of the cooler. An increase in the air pressure drop indicates fouling of the air passages, while an increase in water pressure drop indicates fouling of the water side.

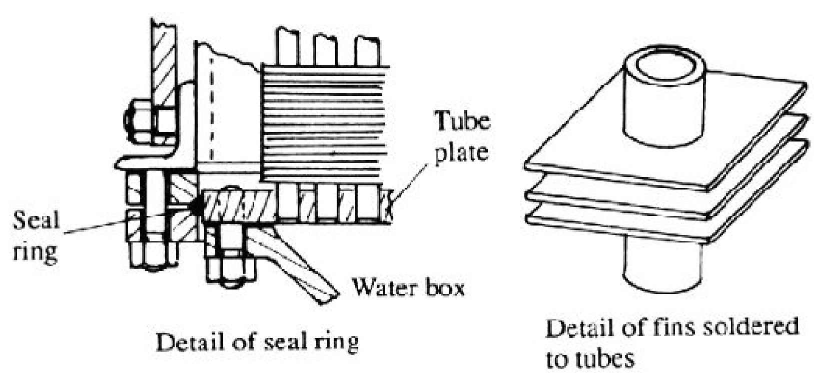
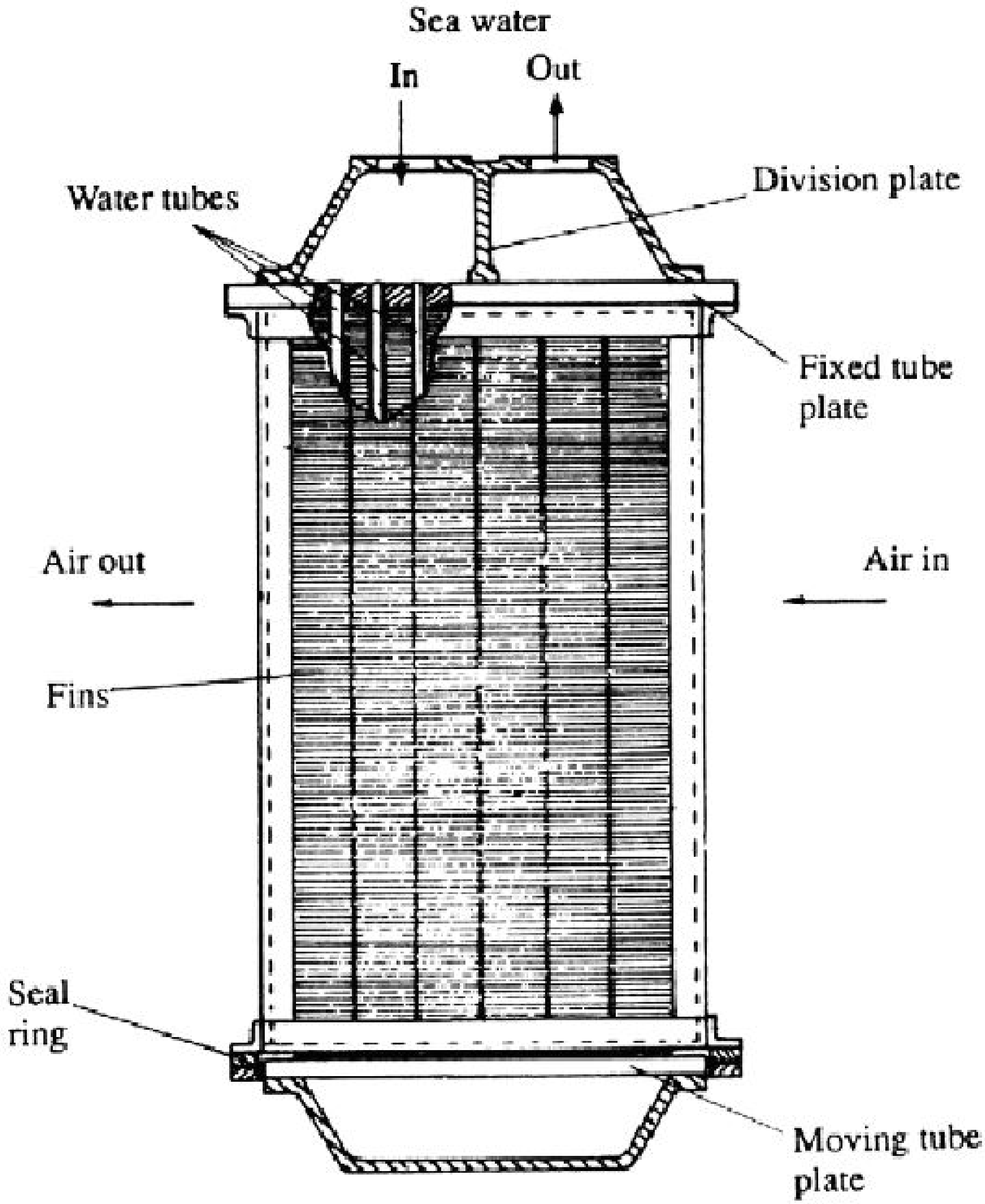


FIGURE 170


Sea water
In
Out
Water tubes
Division plate
Fixed tube plate
Air out
Air in
Fins
Seal ring
Moving tube plate

Chapter 23 MARITIME BUSINESS & LAW

23.1 Key Objectives

THE OBJECTIVE OF THIS CHAPTER IS TO GIVE STUDENTS A BASIC UNDERSTANDING OF MARITIME LAW AND BUSINESS LAW. ***THIS COURSE IS ALSO AVAILABLE ONLINE.***

23.2 Introduction & Important Information About the Course

This course is mandatory for students wishing to sit their IYT Master of Yachts 200 Tons / Mate 500 Tons examination or the Australian Master Class 5 Crossover. It may also be required for other IYT courses requiring an understanding of the basics of International Maritime Law or Admiralty Law .

Students may be orally examined on any or all aspects of this course prior to obtaining the IYT Master of Yachts 200 Ton certification by an IYT or MCA examiner.

This course is broadly based on United Kingdom (UK) law and its application to UK Vessels. It is the duty of all Masters and Officers to know and understand the Laws and Procedures required by their own Flag State when serving on vessels registered in that State.

The Master of every vessel needs to understand the regulations which must be followed, wherever they are in the world and ALSO the jurisdiction under which they fall.

Course Overview & Objectives

This course covers General Maritime law and is aimed at giving students an understanding of:

1. The legal obligations of a Master for the safe operation of a vessel with regard to civil law, criminal law and statutory obligations.

2. Aspects of UK & International law necessary for the administration of a commercially operated vessel registered in the Red Ensign (British) Administrations and other international jurisdictions.

The objective of this course is to give IYT students a basic understanding of maritime law and business law. The expected learning outcome is that the student understands the theory and practical applications of:

1. Legal Framework, National & International Law
2. International Conventions
3. Customs and Immigration

4. Official Logbook & Ships Documents
5. Vessel Certificates & Classification Societies
6. Command Duties
7. Employment Law, Code of Conduct & Occupational Health & Safety
8. Chartering Yachts
9. Salvage & Wreck Law
10. Marine Insurance

23.3 Legal Framework, National and International Law

All legal systems recognize dual functions of law.

Criminal law and Civil law

<u>Criminal law examples</u> are: theft, arson, murder, rape, drunk driving, drug dealing, assault or any crime that may involve being arrested by the police.

<u>Civil law examples</u> are: marriage and divorce, probate, property ownership, suing for injuries, unlawful dismissal, debt collection, trademark infringements and equity suits.

<u>Both criminal and civil law apply on all yachts & vessels</u>

The administration of criminal law is usually independent of civil law, and each has their own courts and distinct rules of law.

There is a third aspect of law that concerns seafarers,

<u>Maritime Law (or Admiralty Law)</u>: A body of laws, conventions and treaties that governs international private business or other matters involving yachts, ships, shipping or crimes occurring on or around the water and on-board yachts and ships.

Criminal Law

The function of Criminal Law is to Enforce, on behalf of society, agreed minimum standards of behavior 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 behavior is designated as a crime.

Maritime Criminal Law

Examples:

- Not complying with the Load Line requirements
- Going to sea in an unseaworthy vessel
- Sailing under- manned
- Sailing with crew who do not meet the minimum qualifications required in the Safe Manning document

or

- Assaulting a fellow crew member, theft or rape would be considered to be unacceptable behavior
- In each case, if the crime is likely to affect the safety or survival of the crew or the vessel and if convicted in a court of law, this would be designated as a "crime".

When a crime is committed, it is the state which then takes action

Civil Law

The function of Civil Law (or 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.

There must be some form of measurable loss to succeed in a civil action.

Civil Law Breaches are based on the premise that each individual is personally liable for the damage he/she causes acting in breach of civil law duties and obligations.

An example would be that the Officer Of the Watch or Mate of a vessel, 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.

A civil dispute is between individuals or companies where the state is not involved in the process and is heard in a civil court.

Civil Law and Marine Operations

In the context of marine operations, the following are those most frequently relied upon:

The Law of Contract
Provides the rules for agreements, promises and claims for compensation when promises and agreements have not been fulfilled.

An example would be failure to pay crew wages, or conversely if crew do not do the job satisfactorily that they were hired for in their crew contract.

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:

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.

Tort of 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 to a vessel that is in dry dock and someone falls resulting in physical injury or allowing someone who has not been specifically trained to use the vessels tender or specialised equipment such as launch davits.

Duty of Care

While no precise legal definition of Duty of Care exists, it has however 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 vessels captain (for example) owes a duty of care to, amongst others, the owner for the care of the vessel, the crew for their health and safety, and the guests for their health and safety and for protection of the marine environment.

Possible sanctions in a civil tort or contract case , would be financial compensation damages for injury or loss.

Vicarious Liability

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 vessels manager) is usually liable for the torts committed by his employees i.e. the Captain and crew.

An example of vicarious liability could be:
A vessel owner or 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 vessel.

Licensing/Certificates of Competency

Flag State: When a yacht or ship is registered in a particular country, the yacht and its crew are subjects to the laws of that country, both criminal and civil.

Administrations recognise that a minimum number of crew on every vessel need to have appropriate levels of skills, training and competence. The rules for the issue and suspension or withdrawal or cancellation of certificates of competence vary with each flag administration.

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
- Have failed to render assistance and exchange information after a collision.

Sanctions may be suspension, withdrawal or cancellation of certificates of competence / licenses.
Usually licensing and conduct issues are dealt with independent of and separate from the criminal and civil courts.

Safe Manning

The number of crew required on any vessel is determined by the "Safe Manning Document" for the vessel.

The Safe Manning Document states the number and type of qualified crew that is required to safely operate the vessel.

This is enforced through the issuing of certificates of competency or licenses, ie Licensing & Certification based on the manning scales mandated by the Flag States

Note: Only the Flag State which issued the Licenses or Certificates of Competency (COC) can suspend, withdraw or cancel these certificates.

In some instances, a Government may authorize a third pasty to issue certificates on their behalf. For instance, International Yacht Training is authorized to issue commercial Master of Yachts 200 Ton certificates by the British Maritime & Coastguard Agency (MCA).

23.4 International Conventions

Conventions covering maritime affairs derive from the International Maritime Organisation (IMO), a specialist agency of the United Nations. The IMO has approx. 181 member states as well as 3 Associate Members. It has its Headquarters in London England.

International Conventions

- Ships operating in an international arena have to comply with the laws of the countries visited. To avoid conflicts of national interest, states have had to agree to minimum standards for safe ship operations, using International Conventions.
- There is no international law enforcement agency and international law can only be enforced by individual sovereign states concerned in the matter and only when the matter has been embodied in the national law of that state.
- When visiting a particular state, a vessel is bound to comply with the laws of that state.
- As a general rule, coastal states accept the certificates and documents issued by the flag state as sufficient evidence that a vessel complies with Convention requirements.

Maritime Conventions include:

STCW 95/2010	International Convention on the "Standards of Training, Certification and Watchkeeping" for Seafarers
COLREGs	International Regulations for Preventing Collisions at Sea
SOLAS	International Convention for the Safety of Life at Sea
GMDSS	Global Maritime Distress and Safety System
MARPOL	(Maritime Pollution) International Convention for the Prevention of Pollution from Ships
ILC	International Load line Convention
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 & is less than 3,000 gross tons (GT). Once these numbers are exceeded, then it is considered to be a passenger ship. (there are however new rules coming into place exceeding this number for yachts only).

- ***Engaging in trade*** - means a yacht used for financial commercial gain such as chartering or carrying "paying passengers".

- ***Passenger Vessel*** - vessel carrying more than 12 passengers and >3,000 GT.

- ***Pleasure Vessel*** is any vessel of whatever size used by the owner for his or his immediate families sport or pleasure on a voyage and 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 company, employees of the company and their 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 on a vessel that is:

- travelling on board the vessel and is not employed or engaged in the business of the vessel
    - A person on board the vessel who has been shipwrecked, distressed or other persons for any reason that the master could not have prevented being aboard.
    - 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 vessel, registered, employed or engaged in any capacity on board.

- ***Trainee*** means apprentice or cadet in a training capacity on board a vessel. They are generally (due to lack of experience) not included in a safe manning certificate.

- ***Jurisdiction*** is defined as an area over which authority extends.
    - The country whose laws a vessel operates and it's crew must comply with at all times and depends on the following factors:

- ***The Geographical Position Of The Vessel*** - A Coastal State has Jurisdiction as well as the Flag state

- ***The Nationality Of The Vessel*** **-** Flag State has Jurisdiction

- ***Innocent Passage*** **-** Passage means navigating through the territorial seas of a state and must be continuous and expeditious. However a passage can include stopping and anchoring, or in the case of "force majeure" which is when a vessel has problems outside of her control, such as mechanical breakdown and needs to enter a port or to anchor.
    - Passage is innocent so long as it is not prejudicial to the peace, good order or security of the coastal state.

  Innocent passage excludes actions such 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 or people etc.,
    - Pollution, fishing or research.

Nationality of Vessels & Flag State Registration

The nationality of a vessel is an important factor when deciding which state has jurisdiction over the vessel.

"Flag State" means where the yacht is registered and granting nationality to a vessel is the absolute link between the State and the vessel.

Each state has the right to determine the conditions under which it is prepared to allocate its nationality to a vessel.

- Vessels have the nationality of the State whose flag they are entitled to fly and are subject to all of its laws.

- Vessels shall sail under the flag of one State only.

- A vessel may only be registered in one State at any given time.

- A vessel may not change its flag State registration during a territorial voyage or while in a port of call

National Law and International Law

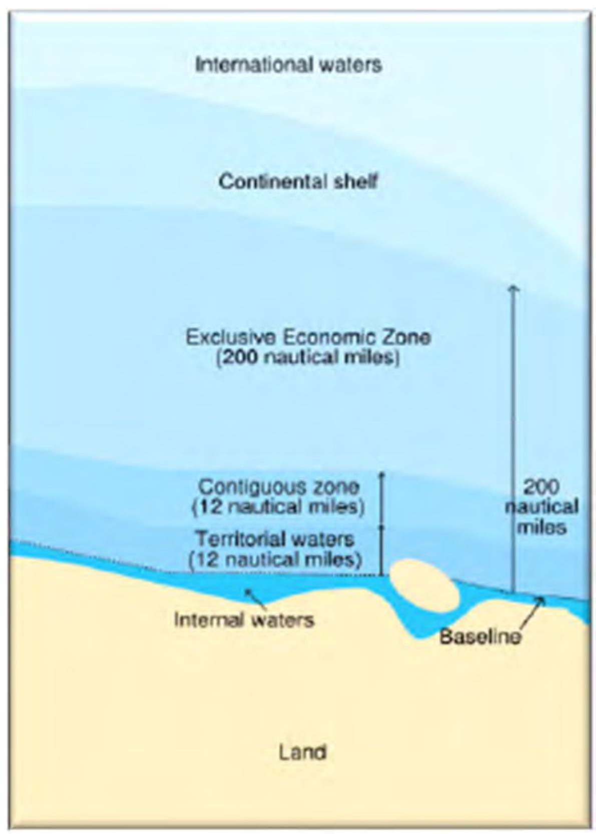
- Vessels operating on International voyages move from the control and jurisdiction of one country's legal system to another country's legal system.

- On the high seas, countries have very limited jurisdiction

- Owners/ operators and individual crew members are at all times subject to the laws of the flag state

- Vessel and crew come under the jurisdiction of the country in whose waters/ports they operate.

Geographical Position



The United Nations Convention of the Law of the Sea, (UNCLOS), establishes a comprehensive legal framework to regulate all ocean space, its uses and its resources.

Definitions:

Base Line

- The Convention allows 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 (12 miles)

A maximum limit to the width of the territorial sea is 12 nautical miles.

- ***<u>Every coastal state has full jurisdiction over its territorial sea</u>*** and thus the right to regulate vessels of any nationality whilst they are within that area, subject to all vessels having innocent passage through territorial seas.

Internal Waters of a State

- Internal waters include all ports and harbour areas and reserves the ***"right to deny passage"***
- Coastal states usually limit their actions to those areas that affect the ***peace, good order and security of the coastal state.***

The Contiguous Zone (24 nautical miles)

- This 24 nautical mile jurisdiction 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 baseline.

The Exclusive Economic Zone (EEZ) of a State (200 nautical miles)

- 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 (offshore oil, gas etc.)
- The right of freedom of navigation of vessels through these zones is expressly preserved. An Exclusive Economic Zone must not extend more than 200 nautical miles from the baseline from which the territorial sea is measured.

The High Seas

- ***The High Seas include all Seas NOT included in the EEZ, Territorial Seas, or Internal Waters of a State.***
- If no EEZ is claimed by a country, the High Seas start after the Territorial Seas (12 nautical miles). The High Seas are reserved for peaceful purposes, but any state may take action on the High Seas against vessels of any nationality suspected of:
    - Drug running
    - Illegal broadcasting
    - Piracy
    - Slavery

Freedom of the High Seas

- The high seas are open to all States, whether coastal or land locked.

Jurisdiction Under Which All Crew of a Vessel Belong:

- 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 another country's (or states/ regional) territorial waters or their ports, they will also come under the laws of that country or state.

- For example: a Cayman Island registered vessel is berthed in Monaco, therefore the crew on board will be subject to the laws of the Cayman Islands as well as the laws of Monaco. If a stabbing takes place on the vessel, the guilty crew member could find themselves in a jail in Monaco.

- In the event of a crew member not being allowed into a country, the vessels Captain or owner are responsible for repatriation of the crew member (returning them home or to a pre-agreed destination) including sundry travel expenses.

23.5 Customs and Immigration

Immigration

- It is the Captains responsibility to make sure that all crew have current passports and appropriate and valid visas for the countries that they will be visiting. Visas should be applied for well in advance of travel to allow for ample processing time.

- It is the Captain's and owner's responsibility to repatriate crew members (at the vessels cost) in the event that they have to leave the vessel for any reason.

- Repatriation costs include air, train or bus fare to their home country or where they boarded the vessel (if visa allows) or a pre-agreed location. Sundry travel and meal allowances must also be provided.

- Visa restrictions for crew in some popular destinations are increasing, so proper research during the "passage planning" process is required.

Customs

- Customs officials are involved in the control of the arrival and departure of a vessel, and all crew personal items and souvenirs.

- Customs officers are very important in the paperwork process when entering a country. Customs may demand to see any and all vessels documents at any time. They are also usually responsible for clearing out procedures, and in most parts of the world, "clearance out" papers are needed at the next port of arrival.

- In many parts of the world the movement of antiquities are controlled as well as obvious items such as drugs, tobacco and alcohol, weapons and pornographic materials.

- It is important to make sure that all customs documents are completed truthfully and honestly and to the satisfaction of customs officials.

- ***<u>Remember that the result of transporting illegal items through customs can result in a vessel being impounded as well as the crew being detained or arrested</u>***

If Drugs Are Found Aboard (for guidance only)

If any illegal substances are found on board a vessel, the response will depend on the drug policy in the state you are berthed, however:

- If a person employed on board a vessel is found to be in possession of drugs (such as marijuana for personal use), then the Master could use his discretion as how to deal with it. This would usually mean disposal of the drugs, instant dismissal and repatriation (remember to log every action taken in the Official Log Book).
- 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 and flag state.
- ***<u>However, if an offence such as theft is reported to the state you are visiting (such as Saudi Arabia) then the crew member may be subject to national law and in this case could have his hand severed off.</u>***

23.6 Official Log Book & Ships Documents

It is the obligation of every Master to understand the paperwork, certificates and documents that are required to be carried on board a vessel under UK and International Maritime law.

Some of these documents (such as the Official Logbook) are UK specific, while others apply to various international conventions that have been agreed upon at the International Maritime Organisation (IMO). To date (Jan 2015) 194 countries are members of the IMO and are signatories to its multiple conventions.

It is imperative that you check with your individual Flag State as to which documents and certificates are required for the size and tonnage of the vessel under your command.


mca

OFFICIAL LOG BOOK

Documents

- ***<u>It is the responsibility of the Master (and the Designated Person Ashore, or Yacht management company) to be aware of the documents that are required to be carried onboard a vessel.</u>***

- There is an increasingly complex number of certificates and documents which must be carried and presented to the authorities in countries and ports visited.

- Any failure to produce the appropriate documentation may result in delays and inconvenience. The vessel may be detained and the Master may face prosecution.

- The period of their validity and the need for annual and periodic inspection and renewal, together with the dates of issue and authority issuing them is varied. It should also be noted that most certificates /documents need to be renewed ever few years.

Official Log Book (OLB)

The OLB is the record of the legal life on board the vessel and is not to be confused with the navigation or deck logbook.

The OLB maintains a record of all events that happen on board a vessel such as accidents, breaches of the Code of Conduct, disciplinary action against crew, hiring or firing of crew and anything of relevance.

It is opened when the Crew Agreement is opened, and it is closed when the Crew Agreement is terminated, both remain open for 12 months. 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 in Cardiff, Wales.

Every UK registered vessel is required to keep an OLB in the statutory format, but not if they are:

- Vessels of less than 25 gross tons
- Pleasure yachts
- 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 he may enter in the OLB.
There are statutory entries required to be made such as Change in Command, Accidents, Deaths, etc.

Seaworthiness

- The Master and owners of a vessel both have a criminal and civil law duty to take reasonable care to ensure that at the commencement of a voyage, their vessel is seaworthy.

- This duty is owed to charterers, passengers and crew members.

- The seaworthiness of the vessel is also a requirement of marine insurance contracts and underwriters may avoid liability for any loss or damage attributable to such unseaworthiness. UK Law also provides that if going beyond a distance of 5 nautical miles from land, one copy of each of the following publications is to be carried:

    - 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)

STCW Certificates (Standards of Training and Certification of Watchkeepers)

- As a Master, it is your duty to make sure you and your crew hold the correct certificates of competency required by seamen and watchkeepers.
- Expired certificates may be cause to terminate a crew members employment or may confine the ship to Port until suitably qualified crew are found.
- According to the STCW convention, original copies must be carried aboard, copies are not acceptable.
- Port inspectors have full authority to inspect all crew members certificates at any time. Required STCW documents:
    - National Certificates of Competency (CoC) for the tonnage and type of vessel that you and your crew are operating
    - Endorsements of recognition such as sailing or towing
    - Certificates showing specific safety or pollution prevention duties
    - Medical Fitness certificate

Oil Record Book

- All vessels over 400gt must carry an “Oil record book”(ORB) and must be used to record the following:
    - Cleaning or ballasting of fuel tanks
    - Taking on fuel (bunkering)
    - Discharge of ballast or cleaning water from the oil tanks
    - Automatic and manual discharge of bilge water overboard
    - Any special circumstances where fuel/oil needed to be dumped to save the vessel, save life or prevent a fire

Note: In Jan 2015, an Italian shipping company was fined $2.75 million in an American court for discharging oil into the ocean and falsifying entries in the ORB.

Garbage Record Book/Garbage Management Plan

- Every vessel over 12 meters must display a sign/placard outlining the garbage regulations.
- All vessels over 400gt 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.
- The plan must follow IMO guidelines.
- There must be nominated a person in charge of the plan.

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:
- The area is environmentally sensitive
- There is a lack of movement of water
- High traffic volume and or an area of dense population.

MARPOL - International Convention on the Prevention of Pollution from Ships

- The requirements for complete compliance covers all vessels over 400gt.
- Care of the environment is of the utmost importance for all vessels that ply the oceans.
- The Convention identifies six major sources of pollution from ships
  - Petroleum oil
  - Bulk chemicals as cargo
  - Packaged chemicals as cargo
  - Ship sewage
  - Ship garbage
  - Air Pollution

Sewage Treatment regulations:

- No discharge within 4 miles of land, except from an approved sewage treatment plant or holding tank.

- No discharge between 4 and 12 miles from land except from an approved system for comminuting and disinfecting sewage

- 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).

Rules entered force Jan 1st 2013

Type of garbage	Ships outside special areas	Ships within special areas	Offshore platforms and all ships within 500 m of such platforms
Food waste comminuted or ground	Discharge permitted ≥3 nm from the nearest land and *en route*	Discharge permitted ≥12 nm from the nearest land and *en route*	Discharge permitted ≥12 nm from the nearest land
Food waste not comminuted or ground	Discharge permitted ≥12 nm from the nearest land and *en route*	Discharge prohibited	Discharge prohibited
Cargo residues[1] not contained in wash water	Discharge permitted ≥12 nm from the nearest land and *en route*	Discharge prohibited	Discharge prohibited
Cargo residues[1] contained in wash water		Discharge only permitted in specific circumstances[2] and ≥12 nm from the nearest land and *en route*	Discharge prohibited
Cleaning agents and additives[1] contained in cargo hold wash water	Discharge permitted	Discharge only permitted in specific circumstances[2] and ≥12 nm from the nearest land and *en route*	Discharge prohibited
Cleaning agents and additives[1] contained in deck and external surfaces wash water		Discharge permitted	Discharge prohibited
Carcasses of animals carried on board as cargo and which died during the voyage	Discharge permitted as far from the nearest land as possible and *en route*	Discharge prohibited	Discharge prohibited
All other garbage including plastics, domestic wastes, cooking oil, incinerator ashes, operational wastes and fishing gear	Discharge prohibited	Discharge prohibited	Discharge prohibited
Mixed garbage	When garbage is mixed with or contaminated by other substances prohibited from discharge or having different discharge requirements, the more stringent requirements shall apply		

Disposal of Garbage Outside of Special Areas

No disposal of plastics of any kind, anywhere.

- No disposal within 3 miles off the nearest land
- More than 3 miles off the nearest land, all food waste, rags, glass, crockery, metals and paper can be disposed of provided it is ground down so that it can be passed through a mesh screen with openings no greater than 25 mm "required standard"
- More than 12 miles off the nearest land, all food waste, rags, glass, crockery, metals and paper can be disposed of.

- More than 25 miles off the nearest land, dunnage, lining, cardboard and packing materials can be disposed of

Disposal of Garbage - Inside Special Areas

- No garbage other than food waste may be disposed of 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 up to a size of <25mm.

23.7 Vessel Certificates Classification Societies

List of required MCA certificates to be issued for yachts > 500 gross tons

1. International Tonnage certificate: measures the tonnage of a vessel, gross tonnage is a measurement of space, not weight, where 1 gross ton = 100 cubic feet.
2. International Load Line certificate: measures the freeboard of a vessel and is marked accordingly with plimsoll lines midships on the hull.
3. Safety Construction certificate: ensures the safe construction of a vessel and tests construction integrity for fire protection and means of escape.
4. Safety Equipment certificate: tests all fire & life saving appliances, liferafts, firefighting equipment, navigation lights, sounds and signals.
5. Safety Radio certificate: tests the working order of VHF and GMDSS equipment required for vessels over 300gt.
6. Safe Manning Document: outlines the minimum number of crew required for the safe operation of a vessel.
7. International Oil Pollution Prevention certificate: ensures adequate system in place to deal with oil pollution and oil spills.
8. International Sewage Pollution Prevention certificate: ensures system in place to deal with sewage pollution and its prevention
9. Anti-fouling certificate of compliance: Hull anti –fouling compliance declaration, only environmentally friendly anti fouling is allowed on hulls.
10. Safety Management certificate: compliance with maritime safety code and regulations
11. International Ship Security certificate: covers the security system and equipment and the availability of an approved ship security plan.
12. Maritime Labour certificate: regulates the conditions of employment, accommodation, wages, food, working hours and medical care of seafarers.
13. Certificate of Compliance: covers aspects surveyed under the MCA Large Yacht Code for which other certificates are not required.

Classification Societies

A classification society is a non-governmental organisation that establishes technical standards for the construction and operation of vessels. Class Society compliance may not be compulsory for a small yacht but may be required for insurance purposes if commercially operated. It lays down the standards for construction, safety equipment and maintenance of vessels and issues a certificate of "class" when the vessel is compliant.

If the vessel has the class suspended or withdrawn, it will normally lose its Safety Certificates and also insurance cover.

All commercial vessels are required to be classed by a Classification Society that is recognized by the MCA. These are currently recognized:

- Lloyd's Register of Shipping (LR)
- And the British Committees of,
- Bureau Veritas (BV)
- Det Norske Veritias- Germanische Lloyd (DNV-GL)
- American Bureau of Shipping (ABS)
- Registro Italiano Navale (RINA)
- Nippon Kaiji Kyokai (NKK)

23.8 Command Duties

Duties on taking over command:

<u>It is of vital importance that a Master fully understands his duties when taking over a vessel and the importance of these duties with regard to the safety of the crew, passengers, vessel and the environment.</u>

Inspect the vessel thoroughly, its overall condition, safety equipment including all fire fighting apparatus, liferafts, lifejackets, flares, radio, epirbs, sarts and all other safety equipment.

Check all ships documents, the hand over notes from the previous Master, check 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, entries in the narrative section to include change in command and receipt of all documents.

Standing Orders

The Standing Orders and yacht Operational Procedures Manual 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.

Duty to Carry Navigational and Safety Publications

In addition to the documents required to be carried on board listed on the previous slides 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 also must be corrected.

Chart corrections are available in the "Notice to mariners" UK publications.

Publications to be carried on board UK registered vessels:

- Merchant Shipping Notices, Marine Guidance Notes
- Marine Information Notes (MCA)
- 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 also 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.

- ***Also, 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 including:

- Dangerous ice
- Dangerous derelict (floating dangers)
- Tropical storms
- Air temperatures below freezing with gale force winds causing severe ice accretion
- Winds of force 10 or above for which no storm warning has been received
- Any other direct danger to navigation, logs, containers, etc.

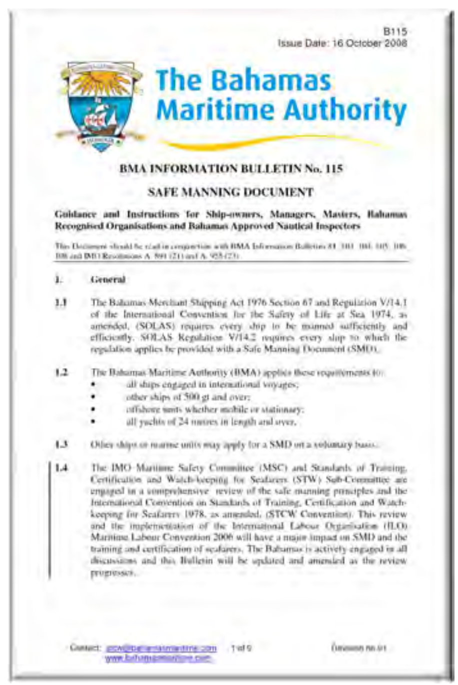
The information is to be communicated by all means. The message sent by radio is a ***"securite"*** call.

Safe Manning

- Safe manning means having enough crew to safely operate a vessel during normal operations and while on a navigational voyage. It does not include interior crew such as stewardess's or chefs.

- 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 the safe manning requirements, the owner, managers and/or master are liable to criminal prosecution and substantial penalties.***


B115
Issue Date: 16 October 2008

The Bahamas Maritime Authority

BMA INFORMATION BULLETIN No. 115

SAFE MANNING DOCUMENT

Guidance and Instructions for Ship-owners, Managers, Masters, Bahamas Recognised Organisations and Bahamas Approved Nautical Inspectors

This Document should be read in conjunction with BMA Information Bulletins [illegible] and IMO Resolutions A. [illegible] and A. [illegible]

1. General

1.1 The Bahamas Merchant Shipping Act 1976 Section 67 and Regulation V/14.1 of the International Convention for the Safety of Life at Sea 1974, as amended, (SOLAS) requires every ship to be manned sufficiently and efficiently. SOLAS Regulation V/14.2 requires every ship to which the regulation applies be provided with a Safe Manning Document (SMD).

1.2 The Bahamas Maritime Authority (BMA) applies these requirements to:
- all ships engaged in international voyages;
- other ships of 500 gt and over;
- offshore units whether mobile or stationary;
- all yachts of 24 metres in length and over.

1.3 Other ships or marine units may apply for a SMD on a voluntary basis.

1.4 The IMO Maritime Safety Committee (MSC) and Standards of Training, Certification and Watch-keeping for Seafarers (STW) Sub-Committee are engaged in a comprehensive review of the safe manning principles and the International Convention on Standards of Training, Certification and Watch-keeping for Seafarers 1978, as amended, (STCW Convention). This review and the implementation of the International Labour Organisation (ILO) Maritime Labour Convention 2006 will have a major impact on SMD and the training and certification of seafarers. The Bahamas is actively engaged in all discussions and this Bulletin will be updated and amended as the review progresses.

Contact: [illegible] 1 of 9

New regulations for 2015

Bridge Navigational Watch Alarm System (BNWAS)

- First periodical or renewal survey during 2015: This new piece of equipment will be enforced on yachts of 150 gt and greater. The purpose of a BNWAS is to monitor bridge activity and detect operator disability, which could lead to marine accidents.

- The system monitors awareness of the officer of the watch and automatically alerts the master or another qualified person if for any reason the OOW becomes incapable of performing his/her duties. This purpose is achieved by a series of indications and alarm to alert first the OOW and, if he is not responding, the master or another qualified person.

- Additionally, the BNWAS provides the OOW with a means of calling for immediate assistance if required.

23.9 Employment Law, Code of Conduct & Occupational Health & Safety

Employment Law

- Any employee in UK Law is defined as: "anyone employed under a contract of employment and is protected under UK Employment protection legislation".

    - A contract of employment is a contract of service or apprenticeship. Its terms may be expressed in writing or orally.

    - Every administration has its own laws and regulations concerning employment law and protection of employment.

    - The master of every vessel should make him/herself aware of these regulations and comply with them as necessary.

- 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.

- All crew on UK vessels are employed either under an MCA Crew Agreement or in the case of the master, a Masters Contract (not being a seaman under the Crew Agreement and is exempt from signing it).

- 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 an employment contract. For a job on a yacht the format 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 not 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 Maritime Labour Convention, 2006 or MLC, 2006

- Is an international labour Convention adopted by the International Labour Organization (ILO). It provides international standards for the world’s first genuinely global industry. For UK Flag vessels it comes into force on 7th August 2014 and replaces the many ILO Conventions that went before it.

- Widely known as the “seafarers’ bill of rights,” the MLC, 2006 was adopted by government, employer and workers representatives at a special ILO International Labour Conference in February 2006.

- It is unique in that it aims both to achieve decent work for seafarers and to secure economic interests through fair competition for quality ship owners.

- The Convention is comprehensive and sets out, in one place, seafarers' rights to decent working conditions. It covers almost every aspect of their work and life on board including:
    - minimum age
    - seafarers’ employment agreements
    - hours of work or rest
    - payment of wages
    - paid annual leave
    - repatriation at the end of contract
    - On board medical care
    - the use of licensed private recruitment and placement services
    - accommodation, food and catering
    - health and safety protection and accident prevention
    - seafarers’ complaint handling

The Code of Conduct for the Merchant Navy

Maintaining Discipline on Board

- 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

- 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

- ✓ Assault
- ✓ Wilful damage to ship or any property on board
- ✓ Theft or possession of stolen property
- ✓ Possession of offensive weapons
- ✓ Persistent or wilful failure to perform duty
- ✓ Unlawful possession or distribution of drugs
- ✓ Conduct endangering the ship or persons on board
- ✓ Combination with others at sea to impede the progress of the voyage or navigation of the ship
- ✓ Disobedience of orders relating to safety of the ship or any person on board
- ✓ 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

- ✓ 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
- ✓ Intimidation, coercion and/or interference with the work of other employees
- ✓ Behaviour which seriously detracts from the safe and/or efficient working of the ship
- ✓ 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.
- ✓ Behaviour which seriously DFT acts from the social well-being of any other person on board.
- ✓ Causing or permitting unauthorized persons to be on board whilst it is at sea
- ✓ 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 for a serious Breach (Para 9)

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)

The Master must only be reasonably satisfied that an appropriate breach of the Code has occurred.

There are 3 choices if established that 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.

- ✓ A warning (verbal)
- ✓ Written reprimand
- ✓ Dismissal 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

Less Serious Breaches (Paragraph 11) include:

Minor offenses covered under paragraph 9 where the nature of the offence can dealt with by Department Heads and where the Master need not be involved.

Remedies include:

- ✓ Verbal Warning from Immediate Supervisor
- ✓ Written warning by Department Head
- ✓ Verbal Warning from the Master
- ✓ All actions should include a written report of the personnel file/s

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:
    - Employers have a duty to ensure the health and safety of workers. This includes the provision and maintenance of safe plant and equipment.
    - The safety of the working environment on board receives proper consideration at all levels of management.
    - Employers have a duty for the provision of safety information, training and supervision.
    - 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)
    - Employers have a duty to produce a Safety policy and annual review

Duties of the employee:

- To take reasonable care for his own and his co workers health and safety on board.

- To cooperate with the employer and any other person to enable all health and safety duties are carried out.

- Not to intentionally act recklessly or interfere with anything provided in the interests of health and safety.

23.10 Chartering Yachts

Chartering Law

The word "Charter" is used to identify a contract, the objective of which is to charter/ hire the use of a vessel for:

1. ***Voyage Charter:*** for a specific purpose
    a. The charterer hires the vessel for a single voyage to make a specific trip between identified ports, carrying cargo and /or passengers for and on behalf of the charterer.
    b. The charterer pays for the use of the vessel either on the basis of a lump sum or, in the case of cargo, a "freight rate" (so much per ton carried).

2. ***Time Charter*** : for a specified period of time.
   A time charter is a contract for the hire of the vessel & can take on one of two basic forms.

Basic Time Charter or Bareboat charter is an agreement between the owner of a vessel and a charterer to use it for his own purposes without being responsible for the operation of the ship nor its day to day management.

It may be considered similar to the hire of a chauffeur driven car.

3. ***Demise or Bareboat Charter*** –
This arrangement is different from both voyage charters and time charters
    a) This is an agreement between the owner of the vessel and a charterer.
    b) the charterer obtains full possession and control over the use of the "bare" vessel for the period of time agreed.
    c) 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.
    d) In a demise charter, the vessel is chartered under one agreement, and the Master and crew are employed under a separate agreement. In this case, the Master and crew work for the charterer and the vessel must be returned in the condition received less "reasonable wear and tear".
    e) It may be considered similar to a vehicle leasing contract.

Under UK Contract law, it is not necessary for charters to be in writing to be enforceable in law. Generally, 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.

Any failure to perform any part of any promise contained in a charter gives the injured party a claim in contract law for compensation.

The country whose law will determine disputes arising out of a charter is usually set at the time of contracting when it becomes a term of the charter.

Various standard forms of charter agreements are available modifying them as necessary to suit their particular arrangements.

23.11 Salvage & Wreck Law

Salvage was originally defined as "A voluntary service which successfully saves, or assists in saving, Maritime property in danger at sea".

Practical Aspects of Salvage

A salvage service implies that there is some degree of danger or some need of extraordinary assistance to the vessel & crew which characterises a salvage service.

The danger does not need to be one that is necessarily imminent or an absolute danger but may become imminent if assistance is not rendered.

To be a salvage operation, there has to be no pre-existing contract such as with a towing service.

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.

This is a contract agreed for towing and therefore cannot be Salvage which has no contract

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.

Masters Actions

The immediate need is for the master to assess the threat and decide urgently whether and what assistance is required.

The master should always overreact on the side of safety and pollution prevention rather than delay in the hope of improving circumstances.

Lloyd's Open Form

If a vessel is in trouble, the master will have to decide whether the service he requires is towage or salvage.

If there is danger, then his decision is likely to be salvage.

Because of the many disputes that arise in salvage cases, and because increasing danger may make the outcome more lucrative for the salver, it is to the advantage of both parties to use some form of salvage agreement.

The most widely known and used is "***Lloyd's Open Form of Salvage Agreement" or simply Lloyds Open Form, (LOF).***

LOF provides the mechanism for deciding remuneration to the salver after successful salvage of the vessel.

Virtually every mariner carries out some form of salvage services during his career and Lloyds Open Form is the universally accepted salvage agreement.

Advantages of using LOF

- ✓ LOF is a contract for a salvage service, which spells out exactly what each party is to expect from the other.

- ✓ It sets out who is responsible for doing what.

- ✓ The 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.

The right of the person in charge of a 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.
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.

The Salvage Convention

Sets out the rules and conditions for Salvage:

- 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.

Five Basic Principles of Salvage under The Salvage Convention

1. There has to be success, that is, some value in property saved.
2. It has to be non-contractual, i.e. not a towing service.
3. It has to be on navigable waters.
4. There has to be danger.
5. The saved items have to be related to the vessel and his cargo

Duties of the Salver

The salver owes a duty to the Master/owner of the vessel in danger:

1. To carry out the salvage operations with due care
2. 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 in danger.

Criteria for fixing the reward -Article 13 The Salvage Convention

The reward shall be fixed with a view to encouraging salvage operations taking into account the following:

- ✓ The salved value of the vessel and other property
- ✓ The skill and efforts of the salvers in preventing or minimizing damage to the environment
- ✓ The measure of success obtained by the salver
- ✓ The nature and degree of the danger
- ✓ The skill and efforts of the salvers in salving the vessel, other property and life
- ✓ The time used and expenses and losses incurred by the salvers
- ✓ The risk of liability and other risks run by the salvers or their equipment
- ✓ The availability and use of vessels or other equipment intended for salvage operations

"The salvage 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".

23.12 Marine Insurance

Importance of Insurance

- ✓ It is important for the Master and owner of a vessel to make sure that there is an insurance policy in place that covers the vessel, the Captain and crew, as well as third party liability.

- ✓ The policy should also cover the area in which it is intended to operate.

- ✓ The policy may also include a clause that requires the vessel NOT to be in certain geographical areas during certain times of the year, for example: vessels may not be insured during the hurricane season in the Caribbean or Florida.

The principle of insurance is that a "marine venture" involves risk, and therefore the possibility of loss or damage to the vessel itself or other vessels on the water.

This risk of loss can be insured against; 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 called 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 insurance are set out in a document called a policy.

An insurance policy is a contract between the vessel owner and the insurer.

Policies on vessels may be underwritten by a marine insurer most likely providing property and liability insurance in one policy.

Coverage in an insurance policy

Generally, cover is provided for hull, fixtures and fittings and either replacement of the vessel or agreed value depending on the policy.
Protection and indemnity cover, that is, 3rd partly liability in the event of accidents.

During construction, an unfinished vessel is not insured by the owner, so Builder's risk insurance is available to cover damage to a vessel under construction.

Insurance policies are written based on 3 principles:

1. Insurable interest: the insured has to have something of value to lose, usually the yacht

2. 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.

3. Utmost good faith: 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 judgment 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 insurer.

Warranties in Insurance

All marine insurance policies have warranties. (Broadly these are conditions or clauses that make up the policy)

A warranty may be express or implied.

Express Warranties: ***are*** written clauses in the policy.

Some examples of express warranties:
- ***Operation limits clause:*** limitations on operational areas during hurricane season
- ***Carrying of passengers for payment***, using the yacht for commercial purposes
- ***Not to tow or be towed***, except perhaps in an emergency

Implied Warranties are implied by law to form part of the contract, but they are not written into the policy.

Both Express and Implied Warranties must be strictly complied with.

There are 3 major implied warranties: seaworthiness, legality, and neutrality.

1. ***Seaworthiness***
   It is implied that the vessel must be seaworthy at the commencement of the voyage. If the assured sends a vessel to sea in an unseaworthy condition, the insurer is not liable for any loss arising out of that unseaworthiness. To be seaworthy, the vessel must be reasonably fit in all respects to encounter the ordinary perils of the seas on the intended adventure.

2. ***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.

3. ***Neutrality***
   It is assumed that the vessel is neutral.

ANSWER KEY - CORRECTIONS FOR VARIATION AND DEVIATION

Answers in Red				
A.) Correcting from true (chart) to magnetic (compass)				
TRUE	**VAR**	**MAG**		
035°	10°W	045°		
127°	5°W	132°		
256°	3°E	253°		
318°	12°W	330°		
097°	4W°	101°		
004°	4°E	000°		
182°	15°W	197°		
098°	7°E	091°		
359°	6°W	005°		
B) Correcting from magnetic to true				
MAG	**VAR**	**TRUE**		
283°	9°W	274°		
108°	12°W	96°		
343°	5°E	348°		
027°	7°E	034°		
184°	6°E	190°		
127°	10°E	137°		
000°	7°W	353°		
278°	1°E	279°		
002°	7°W	355°		
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.				
TRUE	**VAR**	**MAG**		
075°	4°W	079°		
039°	3°E	036°		
246°	11°E	235°		
137°	12°W	149°		
200°	2°W	202°		
359°	5°W	004°		
Answer key at end of course; please try to work these out without referring to the answer key				

Answers in Red

D) Try these

T	V	M	D	C
256	5W	261	6W	267
096	7W	103	5E	098
061	3W	064	4E	060
310	3E	307	9W	310
027	5E	022	3E	019
352	7W	359	0	359

GLOSSARY OF TERMS

A

Aback	Sail sheeted so that the wind fills the "back" of the sail.
Abeam	At right angles to the side of the boat.
Aboard	Situated on the boat.
Adrift	A boat drifting without being propelled.
Aft	At or towards the stern or behind the boat.
Aground	A boat whose keel is touching the bottom.
Amidships	Towards the center of the boat.
Apparent wind	The wind aboard a moving boat.
Astern	Behind the stern of the boat.
Athwartships	Across the boat from side to side.

B

Backstay	The standing rigging running from the stern to the top of the mast, keeping the mast from falling forward.
Back	1. To Sheet a sail to windward and fill the back of the sail and thus stop the boat or propel it backwards. 2. In the case of the wind - to shift counter clockwise from its previous direction.
Bail	To empty the boat of water.
Ballast	Weight in the keel of a boat that provides stability.
Barometer	An instrument that measures air pressure, an aid to forecasting the weather.
Batten	A thin wood or fiberglass slat that slides into a pocket in the leech of a sail, helping to maintain an aerodynamic shape.
Beam	The width of a boat at its widest point.
Beam reach	(Point of sail) Sailing in a direction at approximately 90º to the wind.
Bear away	To "fall off" or head away from the wind.
Bearing	The direction from one object to another expressed in compass degrees.
Beating	A course sailed up wind.
Below	The area of a boat beneath the deck.
Bend	To attach a sail to a spar or a headstay or to attach a line to a sail.
Bight	A loop in a line.
Bilge	The lowest part of the boats interior where water on board will collect.
Bitter end	The end of a line.
Blanket	To use the sail or object to block the wind from filling a sail.
Block	A pulley on a boat.
Boat hook	A pole with a hook on the end used for grabbing hold of a mooring or retrieving something that has fallen overboard.
Boat speed	The speed of a boat through the water.
Boltrope	The rope that is sewn into the foot and luff of some mainsails and the luff of some jibs by which the sails are attached to the boat.
Boom	The spar extending directly aft from the mast to which the foot of the main sail is attached.

Boom vang	A block and tackle system, which pulls the boom down to assist sail control.
Bottom	The underside of a boat.
Bow	The forward part of the boat.
Bow line	A line running from the bow of the boat to the dock or mooring.
Bow Spring	A line running from the bow of the boat parallel to the dock or mooring that stops the boat from moving forward along the dock.
Bowline	A knot designed to make a loop that will not slip and can be easily untied.
Breastline	A short line leading directly from the boat to the dock.
Broach	An uncontrolled rounding up into the wind, usually from a downwind point of sail.
Broad reach	(Point of sail) Sailing in a direction with the wind at the rear corner (the quarter) of the boat. Approximately 135º from the bow of the boat.
Bulkhead	A wall that runs athwart6ships on a boat, usually providing structural support to the hull
Buoy	A floating navigation marker.
Buoyancy	The ability of an object to float.
Bulwark	A solid side wall, often about waist high, from the outside edge of the deck to prevent someone falling overboard.
Burdened vessel	The vessel required to give way for another boat when the two may be on a collision course.
By the lee	A sailboat running with the wind coming over the same side of the boat as the boom.

C

Cabin	The interior of the boat
Can	In the U.S. an odd numbered green buoy marking the left side of the channel when returning to harbour.
Capsize	To tip or turn a boat over.
Cast off	To release a line when leaving a dock or mooring.
Catamaran	A twin hulled vessel with a deck or trampoline between the hulls.
Catboat	A boat with only a mainsail and an unstayed mast located at the bow.
Centerboard	A pivoting board that can be lowered and used like a keel to keep a boat from slipping to leeward.
Centerline	The midline of the boat running from bow to stern.
Chafe	Wear on a line caused by rubbing.
Chainplates	Strong metal plates which connect the shrouds to the boat.
Channel	A (usually narrow) lane, marked by buoys, in which the water is deep enough to allow a vessel safe passage.
Chart	A nautical map.
Charter	To rent a boat.
Chock	A guide mounted on the deck through which docklines and anchor rode are run.
Chop	Rough, short, steep waves.
Cleat	A nautical fitting that is used to secure a line.
Clew	The lower aft corner of a sail. The clew of the mainsail is held taut by the outhaul. The jib sheets are attached to the clew of the jib.

Close hauled — (Point of sail). The point of sail that is closest to the wind, when the sails are hauled close to the centerline of the boat.
Close reach — (Point of sail) Sailing in a direction with the wind forward of the beam (about 70º from the bow).
Coaming — The short protective wall that surrounds the cockpit or hatch.
Cockpit — The lower area of the deck in which the steering and sail controls are located.
Coil — To loop a line neatly so it can be stored, or a reel of line.
Come about — See tack.
Companionway — The steps leading from the cockpit or deck to the cabin below.
Compass — The magnetic instrument which indicates the direction in which the boat is headed.
Compass rose — The circles on a chart which indicate the direction of true and magnetic north.
Course — The direction in which the boat is being steered.
Crew — Besides the skipper, anyone on board whom helps run the boat.
Cunningham — A line running through a grommet a short distance above the tack of the mainsail which is used to tension the luff of the main.
Current — The horizontal movement of water caused by tides, wind and other forces.
Cutter — A single masted boat rigged with both jib and staysail.

D

Daysailer — A small sailboat.
Dead downwind — Sailing in a direction straight downwind.
Deck — The mostly flat area on top of the boat.
De-power — To reduce the power in the sails by:

1. Luffing, pointing the boat too close to the wind so that the sails are unable to draw power.
2. Easing the sheets so that the sails flutter.
3. Stalling. Sheeting the sails in so hard that the airflow over them stalls.

Dhow — The generic name of a number of traditional sailing vessels with one or more masts with lateen sails used in the Red Sea and Indian Ocean region.
Dinghy — A small sailboat or rowboat.
Displacement — The weight of the boat; therefore the amount of water that it displaces.
Dock — The quay or pontoon where a boat may be tied up OR the act of bringing a boat alongside to rest alongside.
Dockline — A line used to secure a boat to the dock.
Dodger — A canvas protection in front of the cockpit of some boats that is designed to keep spray off the skipper and crew.
Downhaul — A line used to pull down on the movable gooseneck on some boats to tension the luff of the mainsail. The cunningham has the same function.
Draft — The depth of a boat's keel from the water's surface.

E

Ease — To let out a line or sail.
Ebb — An outgoing tide.

F

Fairlead	A fitting that guides sheets and other lines in a way that reduces friction and therefore chafe.
Fairway	The center of a channel.
Fake (flake)	Lay out a line on the deck using large loops to keep it from becoming tangled.
Fall off	(See also head down & bear away) Alter course away from the wind.
Fast	Secured.
Fathom	A measure of the depth of water. One fathom equals six feet.
Fender	An inflated rubber or plastic bumper used to protect a boat by keeping it from hitting the dock.
Fend off	Push off.
Fetch	The distance of open water to windward between the shore and the boat
Fid	A tapered spike used to open the lay of a rope when splicing.
Flood	An incoming tide.
Following sea	Wave pattern hitting the stern of the boat.
Foot	The bottom edge of the sail.
Fore	Forward.
Forepeak	An accommodation or storage area in the bow below the deck.
Foresail	A jib or genoa.
Forestay	The standing rigging running from the bow to the mast top and to which the foresail is secured.
Forward	Towards the bow.
Fouled	Tangled.
Fractional rig	When the forestay is attached to the mast some distance below the top.
Foul weather gear	Water resistant clothing.
Freeboard	The height of the hull above the water's surface.
Full	Not luffing.
Furl	To fold or roll up a sail.

G

Gaff	On some boats, a spar along the top edge of a four sided fore and aft sail.
Genoa	A large fore sail whose clew extends aft of the mast.
Give way vessel	The vessel required, by the regulations, to give way in a collision situation.
G.M.T	Greenwich Mean Time. The time at the prime meridian in Greenwich, London, England. Now referred to as Universal Time Coordinated U.T.C.
Gooseneck	The strong fitting that connects the boom to the mast.
Great Circle	A line drawn on a chart which is accurate over a long distance, a section of the Earth which intersects the center of the Earth.
Grommet	A reinforcing ring set in a sail.
Ground tackle	Collective term for the anchor and rode (chain and line).
Gudgeon	A fitting attached to the stern into which the pintles of a rudder are inserted.
Gunwale	(gunnel) The edge of the deck where it meets the topsides.
Gybe	See jibe.

H

Halyard	A line used to raise or lower a sail.
Hank	A snap hook which is used to secure the luff of a foresail to the forestay.
Hard a-lee	(also Helms a-lee, lee oh, lee ho) The call given to the crew that will initiate the action of tacking.
Hard over	To turn the helm or tiller as far as possible in one direction.
Hatch	A large covered opening in the deck.
Haul in	to tighten a line.
Head	Top corner of a sail OR the toilet on a boat.
Headboard	The small reinforcing board affixed to the head of a sail.
Headed	A wind shift which causes the boat to head down or causes the sails to be sheeted in.
Heading	the direction of the boat expressed in degrees.
Head down	To fall off, changing course away from the wind.
Head off	See head down.
Head up	To come up, changing course towards the wind.
Headsail	A jib, genoa attached to the forestay.
Headstay	See forestay. The standing rigging running from the bow to the top of the mast.
Head to wind	When the bow of the boat is dead into the wind.
Headway	Forward progress.
Heave	To throw.
Heave to	To hold one's position in the water by using the force of the sails and the rudder to counteract each other.
Holding ground	The seabed or bottom ground in an anchorage.
Hove to	A boat that has completed the process of heaving to with its aback, its main trimmed and its rudder positioned to hold the vessel close to the wind.
Heavy weather	Strong winds and large waves.
Heel	The lean of the boat caused by the wind.
Helm	The tiller.
Helmsman	The person responsible for steering the boat.
Hull	The body of the boat, excluding the rig and sails.
Hull speed	The theoretical maximum speed of a sailboat determined by the length of its waterline. The formula is 1.4x the square root of the waterline length in feet.

I

Inboard	Inside of the rail of the boat.
In irons	A boat that is head to wind and unable to move or maneuver.

J

Jackstay	A wire or webbing strap attached at the front and back of a vessel along the deck to which a safety harness line may be clipped.
Jib	The small forward sail of a boat that is attached to the forestay.
Jibe	See also gybe. To change the direction of the boat by steering the stern through the wind
Jibe oh	The command given to the crew when starting a jibe.

Jiffy reef	See slab reefing. A quick reefing system allowing a section of the mainsail to be pulled down and tied to the boom.
Jury rig	An improvised temporary repair.

K

Kedge	A smaller anchor than the main or bower anchor. Often used for maneuvering or kedging off.
Kedge off	To use an anchor to pull a boat into deeper water after it has run aground.
Keel	The heavy vertical fin beneath a boat that helps keep it upright and prevents it from slipping sideways in the water.
Ketch	A two masted sailboat on which the mizzen (after) mast is lower than the mainmast and is located forward of the rudderpost.
Knockdown	A boat heeled so far that one of its spreaders touches the water.
Knot	one nautical mail per hour.

L

Land breeze	A wind that blows over the land and out to sea.
Lash	To tie down.
La.	To sail a course that will clear an obstacle without tacking.
Lazerette	A storage compartment built into the cockpit or deck.
Lazy sheet	The windward side jib sheet that is not under strain.
Lead	To pass a line through a fitting or block.
Lee helm	The boats tendency to turn away from the wind.
Lee shore	Land which on the leeward side of the boat. A potential danger because the wind will be blowing the boat towards it.
Leech	The after edge of a sail.
Leeward	The direction away from the wind that is the direction that the wind is blowing to.
Leeward side	The side of the boat or sail that is away from the wind.
Leeway	The sideways slippage of the boat in a downwind direction.
Lifeline	Rope or wire supported by stanchions, around the outside of the deck to help prevent crew members from falling overboard.
Lift	The force that results from air passing by a sail or water past a keel that moves the boat forward and sideways, OR a change in the direction of the wind which allows the boat to head up.
Line	A rope.
LOA	The maximum Length Overall fore and aft along the hull.
Lubber line	A line on a magnetic compass to help the helmsman steer the correct course.
Luff	The leading edge of a sail, OR the fluttering of a sail caused by aiming too close to the wind.
Lull	A decrease in wind speed for a short duration.
LWL	The length fore and aft along the hull measured at the waterline.

M

Magnetic	In reference to the magnetic north rather than true north.
Mainmast	The taller of two masts on a boat.
Mainsail	The sail hoisted on the mast of a sloop or cutter or the sail hoisted on the mainmast of a ketch or yawl.
Mainsheet	The controlling line for the mainsail.
Marlinspike	A pointed tool used to loosen knots.
Mast	The vertical spar in the middle of a boat from which the mainsail is set.
Masthead	The top of the mast
Maststep	The fitting in which the foot of the mast sits.
Mizzen	The small aftermost sail on a ketch or yawl hoisted on the mizzenmast
Mizzenmast	The shorter mast aft of the main mast on a ketch or yawl.
Mooring	A permanently anchored ball or buoy to which a boat can be tied.

N

Nautical mile	Standard nautical unit of distance, equal to one minute of arc of the Earth's latitude or 6080 feet.
Navigation rules	Laws established to prevent collisions on the water.
No-go zone	An area into the wind in which a sailboat cannot produce power to sail.
Nun	A red even numbered buoy marking the right side of a channel when returning to port. Nuns are usually paired with cans.

O

Offshore wind	Wind blowing off (away from) the shore and out to sea.
Offshore	Away from or out of sight of land.
Off the wind	Not close-hauled.
On the wind	Sailing up wind, close-hauled.
Outboard	Outside the rail of a boat.
Outhaul	The controlling line attached to the clew of a mainsail used to tension the foot of the sail.
Overpowered	A boat that is heeling too far because it has too much sail up for the amount of wind.

P

Painter	The line attached to the bow of a dinghy.
Pay out	To ease a line.
P.F.D.	Abbreviation for Personal Flotation Device such as a life jacket.
Pinching	Sailing too close to the wind.
Pintle	Small metal extension on a rudder that slides into a gudgeon on the transom. The gudgeon/pintle fitting allows the rudder to swing back and forth.
Point	To steer close to the wind, OR a compass point equals 11¼ degrees. Compass annotation used before headings were referred to in 360º notation.
Points of sail	Boats direction in relation to the wind - i.e., close hauled, reaching etc.

Port	The left hand side of the boat when facing forward, OR, a harbour, OR, a window in a cabin on a boat.
Port tack	Sailing on any point of sail with the wind coming over the port side of the boat.
Prevailing wind	Typical or consistent wind direction.
Puff	An increase in wind speed.
Pulpit	A guardrail at the bows of a vessel.

Q

Quarter	The sides of the boat near the stern.

R

Rail	The outer edges of the deck.
Rake	The angle of the mast.
Range	The alignment of two objects that indicate the middle of a channel.
Reach	One of the several points of sail across the wind.
Ready about	The command given to the crew to prepare to tack.
Ready to jibe	The command given to the crew to prepare to jibe.
Reef	To reduce the area of a sail.
Reeve	To pass a line through a ring or block.
Rhumb line	A straight line drawn on a Mercator chart, which intersects all meridians at the same angle. Accurate enough for courses of less than 600 miles. For great distances a Great Circle route is used.
Rig	The design of a boat's masts, standing rigging and sail plan, OR, to prepare a boat to go to sea.
Rigging	The wires and lines used to support and control sails.
Roach	The sail area aft of a straight line running between the head and clew of a sail.
Rode	The line and chain attached from the boat to the anchor.
Roller-furling	A mechanical system to roll up a headsail around the headstay.
Rudder	A vertical blade attached to the bottom of the hull which is used to steer the boat.
Run	Point of sailing when the wind is coming from dead astern.
Running rigging	The lines used to control the sails.

S

Sail ties	Lengths of line or webbing used to secure sails when they are dropped or to secure the unused portion of a reefed sail.
Schooner	A two masted boat whose foremast is the same height or shorter than its mainmast.
Scope	The length of anchor rode paid out in relation to the maximum depth of water.
Scull	To propel a boat with a single oar fixed in a notch through the transom.

Scupper	A cockpit or deck drain.
Sea breeze	A wind that blows from the sea onto the land.
Seacock	A valve which opens and closes a hole used as an intake or discharge from the boat.
Secure	The make safe or tie down.
Set	The direction of the current, OR, to trim the sails.
Shackle	A metal fitting at the end of a line used to attach the line to a sail or another fitting.
Shake out	To remove a reef.
Sheave	The wheel inside a block or fitting over which the line runs freely.
Sheet	A line used to control a sail by pulling it in or easing it out.
Shoal	An area of shallow water.
Shroud	Standing rigging at the side of the mast.
Singlehanded	Sailing alone.
Skeg	A vertical fin in front of the rudder.
Slab Reefing	See Jiffy reef. A quick reefing system allowing a section of the mainsail to be pulled down and tied to the boom.
Sloop	A single masted sailboat with mainsail and headsail.
Sole	The floor in a cockpit or cabin.
Spar	A pole used to attach a sail on a boat, for example the mast, the boom or a gaff.
Spinnaker	A large down wind headsail not attached to the head stay.
Splice	The joining of two lines together by interweaving their strands.
Spreader	A support strut extending athwartships from the mast used to support and guide the shroud from the top of the mast to the chainplate.
Spring line	A dockline running forward or aft from the boat to the dock to keep the boat from moving fore or aft.
Squall	A fast moving short intense storm.
Stanchions	Stainless steel or aluminum supports at the edge of the deck which hold the lifelines.
Standing rigging	The permanent rigging of a boat, including the forestay, backstay and shrouds.
Starboard	The right hand side of the boat when looking forward from the stern.
Starboard tack	Sailing on any point of sail with the wind coming over the starboard side of the boat.
Stay	A wire support for a mast, part of the standing rigging.
Staysail	On a cutter, a second small inner jib attached between the bow and the mast. Any sail which is attached to a stay.
Steerage Way	The minimum speed of the boat through the water that allows the rudder to function efficiently.
Stem	The foremost tip of the boat.
Stern	The aft part of the boat.
Stern Spring	A line running from the stern of the boat parallel to the dock or mooring that stops the boat from moving backward along the dock.
Stow	To store properly.
Swamped	Filled with water.

T

Tack	To alter course so as to cause the bow of the boat to pass through the eye of the wind, OR, the forward lower corner of a sail.
Tackle	A series of blocks and line that provide a mechanical advantage.
Tail	To hold the end of a line so as to keep it under tension on a winch.
Telltales	Short lengths of yarn or cloth attached to the sails which indicate when the sail is properly trimmed.
Tide	The rise and fall of water level due to the gravitational effects of the sun and the moon.
Tiller	A long handle attached to the rudder which is used to steer the boat.
Toe rail	A low rail around the outer edge of the deck.
Topping lift	A line used to hold the boom up when the mainsail is lowered or stowed.
Topsides	The sides of a boat between the waterline and the deck.
Transom	The vertical surface of the stern.
Trim	To adjust the sail controls to create optimum lift from the sails.
Trimaran	A three hulled vessel.
True wind	The actual speed and direction of the wind as you would feel when standing still.
Tune	To adjust the boats standing rigging.
Turnbuckle	A mechanical fitting (a bottlescrew) attached to the lower ends of stays allowing the standing rigging to be adjusted.

U

Underway	A boat that is not attached to the ground by either anchor or mooring lines is said to be underway.
Upwind	Towards the direction of the wind.
USCG	United States Coast Guard.
U.T.C.	Universal Time Coordinated. The modern term for Greenwich Mean Time, this is the standard reference time which is used internationally for navigational information.

V

Vang	See boom vang.
Veer	A clockwise change in the wind direction.
Vessel	Any sailboat, powerboat or ship.

W

Wake	Waves caused by a boat moving through the water.
Waterline	The horizontal line on the hull of a boat where the surface of the water should be.
Weather helm	The tendency of the boat to head up towards the wind, this increases as the sailboat becomes overpowered.
Weather side	See windward side.

Whip	To bind together the strands at the end of a line.
Whisker pole	A pole temporarily mounted between the mast and the clew of the jib. Used to hold the sail out and keep it full when sailing down wind.
Winch	A deck-mounted drum with a handle offering mechanical advantage when used to trim sheets. Winches may also be mounted on the mast to assist with raising sails.
Windward	Towards the wind.
Windward side	The side of the boat closest to the wind.
Wing-and-wing	Sailing downwind with the jib set on the opposite side to the mainsail.
Working sails	The mainsail and the standard jib.
Working sheet	The leeward sheet that is under tension.

Y

Yawl	A two masted vessel on which the mizzenmast is mounted aft of the rudderpost.

FIGURES

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