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MILITARY EMERGENCY BOAT SERVICE SEAMANSHIP MANUAL

MEBS SEA-MAN

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DIVISION OF MILITARY AND NAVAL AFFAIRS
NEW YORK NAVAL MILITIA
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Ref: (a) *COMDINST M15114.5C*, the U.S. Coast Guard BOAT CREW Seamanship Manual
(b) Naval Expeditionary Combat Command Standard Answers Book for Tactical Craft PQS

1. Training is an essential team quality. A good team can be greater than the sum of its parts; and in our MEBS program, no chain is stronger than its weakest link.

2. The Military Emergency Boat Service (MEBS) Seamanship Manual (MEBS SEA-MAN) is provided as a training and knowledge resource for the boat operators of the New York Naval Militia. This manual is more of a textbook than a policy document.

3. The information contained within is largely based on references (a) and (b). The U.S. Coast Guard and U.S. Navy have developed exhaustive references that provide outstanding nuggets of information. The intent of this document is to provide information relevant to members of the N.Y. Naval Militia. For that reason, much of what is found in the references has been pared down from inclusion in this document.

4. There are certain subject areas that could easily be included in this document. Since they are well-covered by other publications they are not part of this manual. They include:

a. Towing
b. Person in Water
c. Rules of the Road
d. Heavy Weather

Some of the contents are not necessarily relevant for MEBS operations, but more for developing our boat operators to be subject matter experts in the general area of seamanship.

TEN EYCK B. POWELL, III

TABLE OF CONTENTS

Chapter 1
Boat Characteristics

Introduction

Knowledge of a boat's characteristics is crucial in performing safe boat operations. All crewmembers must be able to recognize and correctly apply boat related terminology.

BOAT NOMENCLATURE AND TERMINOLOGY

Definitions
As with any profession or skill, there are special terms that mariners use. Fellow mariners will expect that these terms will be used in routine conversation. The following are common terms used for location, position and direction aboard a boat. **Figure 1-1** provides a diagram of a boat with the more common terms noted.

Bow	The front end of a boat is the bow. Moving toward the bow is going forward; when the boat moves forward, it is going ahead. When facing the bow, the front right side is the starboard bow, and the front left side is the port bow.
Amidships	The central or middle area of a boat is amidships. The right center side is the starboard beam, and the left center side is the port beam.
Stern	The rear of a boat is the stern. Moving toward the stern is going aft. When the boat moves backwards, it is going astern. Standing at the stern looking forward, the right rear section is the starboard quarter and the left rear section is the port quarter.
Starboard	Starboard is the entire right side of a boat, from bow to stern.
Port	Port is the entire left side of a boat, from bow to stern.
Fore and Aft	A line, or anything else, running parallel to the centerline of a boat is fore and aft.
Athwartships	A line or anything else running from side to side is athwartships.
Outboard	Outboard is from the centerline of the boat toward either port or starboard side.
Inboard	Inboard is from either side of the boat toward the centerline. However, there is a variation in the use of outboard and inboard when a boat is tied up alongside something (e.g., pier or another vessel). In this example, the side tied up is inboard; the side away is outboard.
Going Topside	Going topside is moving from a lower area to a weather deck.
Going Below	Going below is moving from an upper deck to a lower deck.
Weather Deck	The weather deck is the deck exposed to the elements (weather).
Windward	Windward is moving in the direction from which the wind is blowing; toward the wind.

Leeward	Leeward is the opposite point from which the wind is blowing; away from the wind.

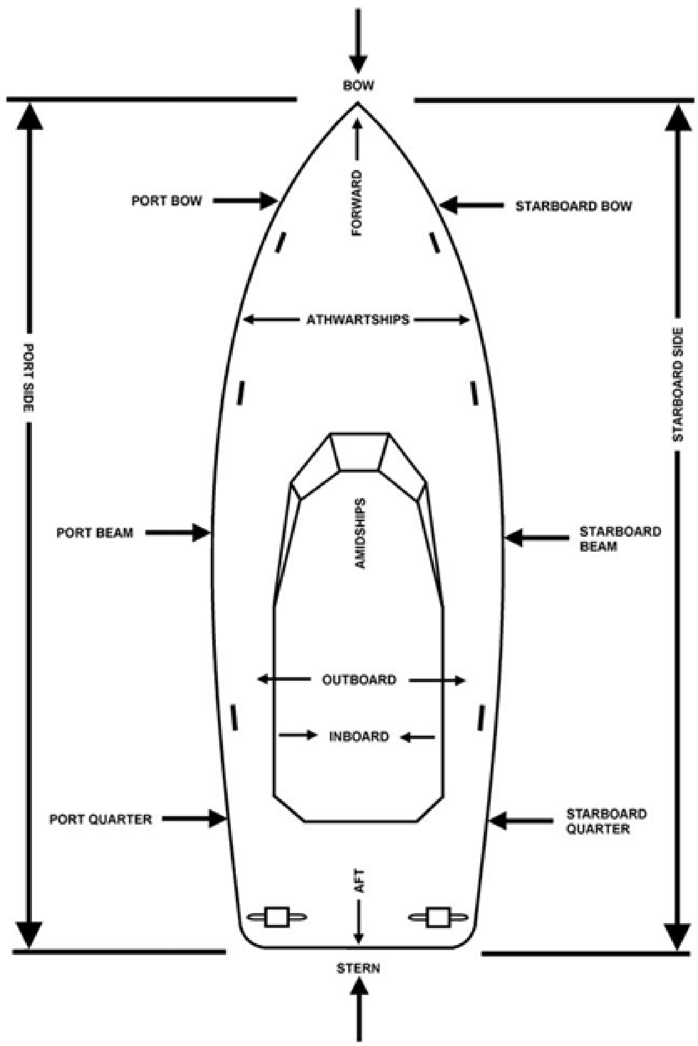


Figure 1-1 Position and Direction Aboard Boats

BOAT CONSTRUCTION

Factors Influencing Hull Shapes

Many factors influence hull shapes and affect the boat's buoyancy (its ability to float) and stability (its ability to remain upright). Factors that influence hull shapes are discussed as follows:

Factor	Description

Flare	Flare is the outward turn of the hull as the sides of the hull come up from the waterline. As the boat is launched into the water, the flare increases the boat's displacement and creates a positive buoyant force to float the boat.
Tumble home	Tumble home is the reverse of flare and is the shape of the hull as it moves out going from the gunwale to the waterline. This feature is most noticeable when viewing the transom of an older classic cruiser.
Camber	A deck usually curves athwartships, making it higher at the centerline than at the gunwales so the water flows off the deck. This curvature is called camber.
Sheer	Sheer is the curvature of the main deck from the stem to the stern. When the sheer is pronounced and the bow of the boat is higher than the main deck at amidships, additional buoyancy is provided in the bow. This additional flotation, known as reserve buoyancy, is provided by flare and sheer.
Chine	The turn of the boat's hull below the waterline is called the chine. It is "soft" if it is rounded, and "hard" if it is squared off. Chine affects the boat's speed on turning characteristics.
Transom	The transom at the stern of the boat is either wide, flat, or curved. The shape of the stern affects the speed, hull resistance, and performance of the boat.
Length on waterline	The boat's length on waterline (LWL) is the distance from the bow to the stern, measured at the waterline when the boat is stationary. Note that this length changes as the boat rides high or low in the water.
Length overall	The boat's length overall (LOA) is the distance from the foremost to the aftermost points on the boat's hull measured in a straight line. It does not change according to the way the boat sits in the water.
Beam	Beam is a measure of a boat's width. Beam is the measurement of the widest part of the hull. Molded beam is the distance between outside surfaces of the shell plating of the hull at its widest point.
Draft	Draft is the depth of the boat from the actual waterline to the bottom of its keel.
Navigational Draft	Navigational Draft is the depth of the boat from the actual waterline to the bottom of its keel or other permanent projection (e.g., propeller, rudder, skeg, etc.), if such a projection is deeper than the keel. The draft is also the depth of water necessary to float the boat. The draft varies according to how the boat lies in the water.
Trim	Trim is a relative term that refers to the way the boat sets in the water and describes generally its stability and buoyancy. A change in trim may be defined as the change in the difference between drafts forward and aft. A boat is trimmed by the bow when the draft forward increases and the draft is greater than the stern draft. A boat is trimmed by the stern if it is down by the stern.

DISPLACEMENT

Displacement is the weight of a boat and is measured in long tons (2,240 lbs.) or pounds.

Deadweight	Deadweight is the difference between the light displacement and the maximum loaded displacement of a boat and is expressed in long tons or pounds.
Light Displacement, AKA *"Light Ship*"	Light displacement is the weight of the boat excluding fuel, water, outfit, cargo, crew, and passengers.
Loaded Displacement	Loaded displacement is the weight of the boat including fuel, water, outfit, cargo, crew, and passengers.

THREE HULL TYPES

The hull is the main body of a boat. It consists of a structural framework and a skin or shell plating. The hull may be constructed of many different materials, the most common being metal or fiberglass. A metal skin is usually welded to the structural framework. A vessel could be monohull or multi-hull, such as catamarans and trimarans.

Displacement Hull	A displacement hull boat pushes away (displaces) water allowing the hull to settle down into the water. Underway, the hull pushes out this water, creating waves. (see **Figure 1-2**) The water separates at the bow and closes at the stern. Tremendous forces work against a displacement hull as the power pushing it and the boat's speed both increase. At maximum displacement speed, there is a distinct bow and stern wave. The length of these waves depends upon the boat's length and speed. (The longer the boat, the longer the wave length.) The bow and the stern ride lower in the water while increasing speed, and the water level alongside, amidships becomes lower than that of the surrounding water. This lower water level is caused by the increase in the velocity of the water flowing under the boat and its interaction with the bow and stern wave.
Planing Hull	At rest, the planing hull and the displacement hull both displace the water around them. The planing hull reacts nearly the same as a displacement hull when it initially gets underway - it takes considerable power to produce a small increase in speed. However, at a certain point, external forces acting on the shape cause an interesting effect - the hull is lifted up onto the surface of the water. (see **Figure 1-3**) The planing hull skims along the surface of the water whereas the displacement hull always forces water around it. This is called planing. Once "on-plane," the power/speed ratio is considerably altered-very little power increase results in a large increase in speed. Crewmembers must apply or reduce power gradually when going from the displacement mode to the planing mode or from the planing mode to the displacement mode.
Semi-Displacement Hull	The semi-displacement hull is a combination of characteristics of the displacement hull and the planing hull. This means that up to a certain power level and speed (power/speed ratio), the hull remains in the displacement mode. Beyond this point, the hull is raised to a partial plane. Essentially, the semi-displacement hull, like the displacement hull, always remains in the water; it never gets "on-plane." When in the displacement

	mode, the power/speed ratio is similar to the power/speed ratio described above for the displacement hull. When in the semi-planing mode, it is affected by a combination of forces for the displacement mode and some for the planing mode. Thus, while a small power increase will increase speed, the amount of resulting speed will not be as great as the same power increase would produce for a planing hull.

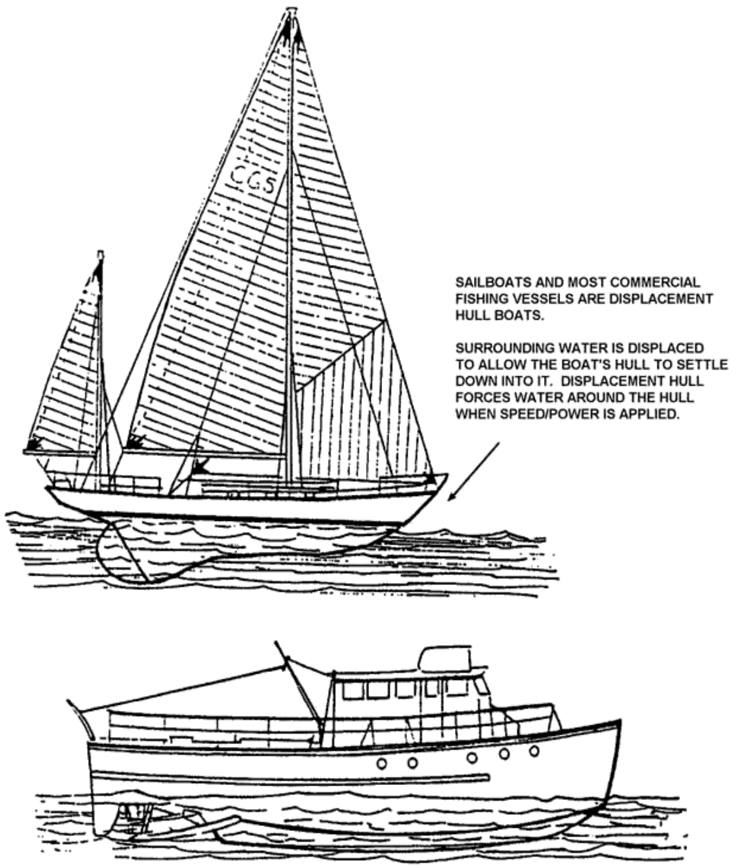


Figure 1-2 Displacement Hulls

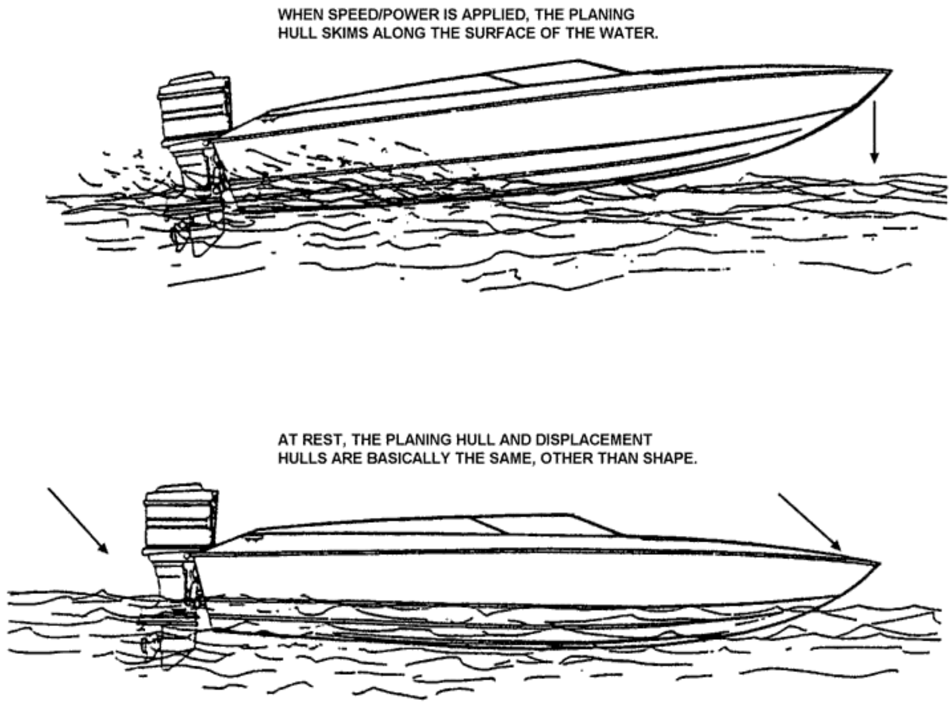


Figure 1-3 Planing Hulls

PRINCIPLE BOAT PARTS

Bow	The shape of a boat's bow, its profile, form, and construction determine hull resistance as the boat advances through the water. Hull resistance develops from friction and from the wave the hull makes as it moves in the water. Wave-making resistance depends on the boat's speed. The bow of a boat must be designed with enough buoyancy so it lifts with the waves and does not cut through them. The bow flare provides this buoyancy. Boats intended for operation in rough seas and heavy weather have "full" bows. The bow increases the buoyancy of the forward part of a boat and deflects water and spray. When a boat is heading into a wave, the bow will initially start to cut into the wave. It may be immersed momentarily if the seas are rough. As the bow flare cuts into the wave, it causes the water to fall away from a boat's stern, shifting the center of buoyancy to move forward from the center of gravity. The bow lifts with the wave and the wave passes under the boat, shifting the center of buoyancy aft. This action causes the bow to drop back down and the vessel achieves a level attitude.
Keel	The keel is literally the backbone of the boat. It runs fore and aft along the center bottom of the boat.
Frames	Frames are attached to the keel, which extend athwartships (from side to side). The skin of the boat is attached to the frames. The keel and the frames strengthen the hull to resist external forces and distribute the boat's weight.

Stem	The stem is an extension of the forward end of the keel. Although there are a number of common stem shapes, all are normally slanted forward (raked) at an upward angle to reduce water friction.
Sternpost	The sternpost is a vertical extension of the aft end of the keel.
Stern	The shape of the stern affects the speed, resistance, and performance of the boat. It also affects the way water is forced to the propellers. The design of the stern is critical in following seas where the stern is the first part of a boat to meet the waves. If the following waves lift the stern too high, the bow may be buried in the sea. The force of the wave will push the stern causing it to pivot around toward the bow. If this is not controlled, the result can be that a boat broach.
Rudder	On certain boats, the rudder controls the direction of the boat and may vary widely in size, design, and method of construction. The shape of the stern, the number of propellers, and the characteristics of the boat determine the type of rudder.
Propeller	(see **Figure 1-4**) Most boats are driven by one or more screw propellers, which move in spirals somewhat like the threads on a screw. That is why the propeller is commonly referred to as a screw. The most common propellers are built with three and four blades. The propeller on a single- screw boat typically turns in a clockwise direction (looking from aft forward) as the boat moves forward. Such screws are referred to as right-handed. On twin-screw boats, the screws turn in opposite directions, rotating outward from the centerline of the boat. The port screw is left-handed and turns counterclockwise. The starboard screw is right-handed and turns clockwise.
Propeller Edge	The edge of the blade that strikes the water first is the leading edge; the opposite is the following edge. The diameter of the screw, the circle made by its tips and its circumference, is called the tip circle. Each blade has a degree of twist from root to tip called pitch. (see **Figure 1-4**)
Pitch	Pitch is the distance a propeller advances in one revolution with no slip. (see **Figure 1-4**) Generally, less pitch in the same diameter propeller makes it easier for the engine to reach its preferred maximum RPM; thus, like putting a car in first gear, more power, and sometimes more speed, is available. Similarly, like third gear in a car, more pitch may give more speed, but lower RPMs gives less power. Optimum performance is obtained when pitch is matched to the optimum design speed (RPM) of the engine.
Transverse Frames	Watertight bulkheads or web frames are located at certain points in the hull to further increase the strength of the hull. Just as the keel is the backbone of the hull, transverse frames are often referred to as ribs. Transverse frames extend athwartships and are perpendicular (vertical or upright) to the keel and are spaced at specified distances. (They vary in size from the bow to the stern giving the boat hull its distinct shape when the skin is attached.
Longitudinal frames	Provide hull strength along the length of the hull (fore and aft). They run parallel to the keel and at right angles to the transverse frames. In addition to

	strengthening the hull, the top longitudinal frames provide a skeletal structure over which deck plating is laid.
Decks	A deck is a seagoing floor and provides strength to the hull by reinforcing the transverse frames and deck beams. The top deck of a boat is called the weather deck because it is exposed to the elements and is watertight. In general, decks have a slight downward slope from the bow. The slope makes any water taken aboard run aft. A deck also has a rounded, athwartship curve called camber. The two low points of this curve are on the port and starboard sides of the boat where the weather deck meets the hull. Water that runs aft down the sheer line is forced to the port or starboard side of the boat by the camber. When the water reaches one of the sides, it flows overboard through holes, or scuppers, in the side railings.
Watertight Integrity	Watertight integrity describes a compartment or fitting that is designed to prevent the passage of water into it. An important concern in boat operations is to ensure the watertight integrity of the vessel. A boat may sustain heavy damage and remain afloat if watertight integrity is maintained.

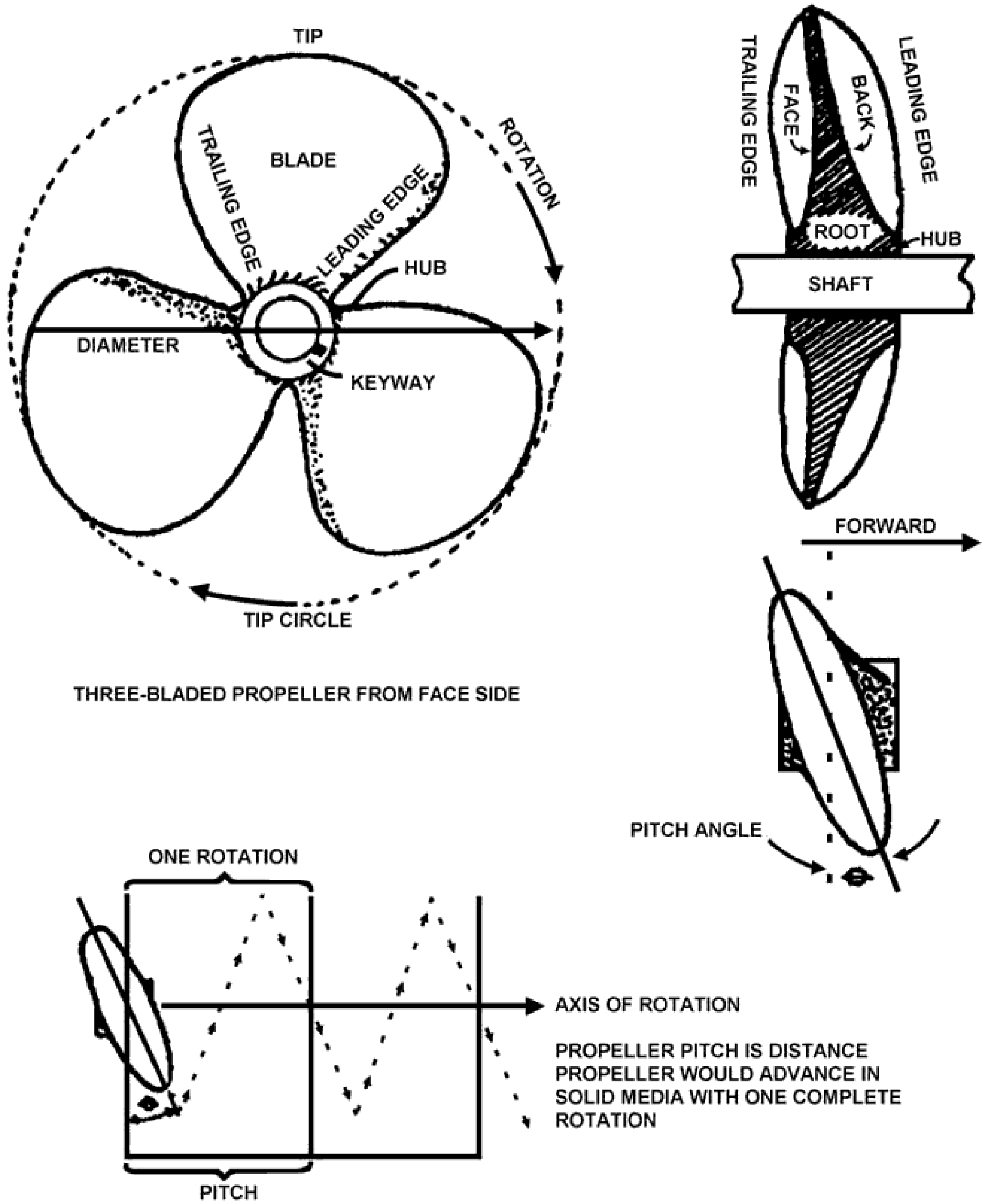


Figure 1-4 Parts of a Propeller

Chapter 2
Marlinespike Seamanship

Introduction
Marlinespike seamanship is the art of handling and working with all kinds of line or rope. It includes knotting, splicing, and fancy decorative work. In the nautical world, what landlubbers call "rope" is called "line," while metal cable wire is called "wire rope."

LINE
Lines are made of natural or synthetic fibers twisted into yarns. The yarns are grouped together in such a way as to form strands. Finally, the strands are twisted, plaited, or braided, in various patterns, to form line.

Size
No matter what the line is made of (natural or synthetic), it is measured the same way, by its circumference or distance around the line. This makes it different from wire rope, which is measured by diameter.
Depending on its size, the line is placed into one of the following three categories:

Small stuff	Up to 1.5" in circumference
Line	1.5" to 5" in circumference
Hawser	Everything over 5" in circumference

Construction
Strands are twisted to either the right or the left. This twisting is the "lay" of the line. Line may have either a left lay or a right lay depending upon how the strands are twisted together. Line is usually constructed as plain-laid, plaited, and double-braided lines. **Figure 2-1** illustrates fiber rope components and construction. The type of construction will depend upon the intended use of the line. The following describes line types:

Line Type	**Characteristics**
Plain-laid	Made of three strands, right- or left-laid. Most common is right- hand laid.
Cable-laid	Made of three, right-hand, plain-laid lines laid together to the left to make a larger cable.
Plaited	Made of eight strands, four right-twisted and four left-twisted. Strands are paired and worked like a four strand braid.
Braided	Usually made from three strands (sometimes four) braided together. The more common braided lines are hollow-braided, stuffer-braided, solid-braided, and double-braided.
Double-braided	Made of two hollow-braided ropes, one inside the other. The core is made of large single yarns in a slack braid. The cover is also made of large single yarns

	but in a tight braid that compresses and holds the core. This line is manufactured only from synthetics, and about 50% of the strength is in the core.

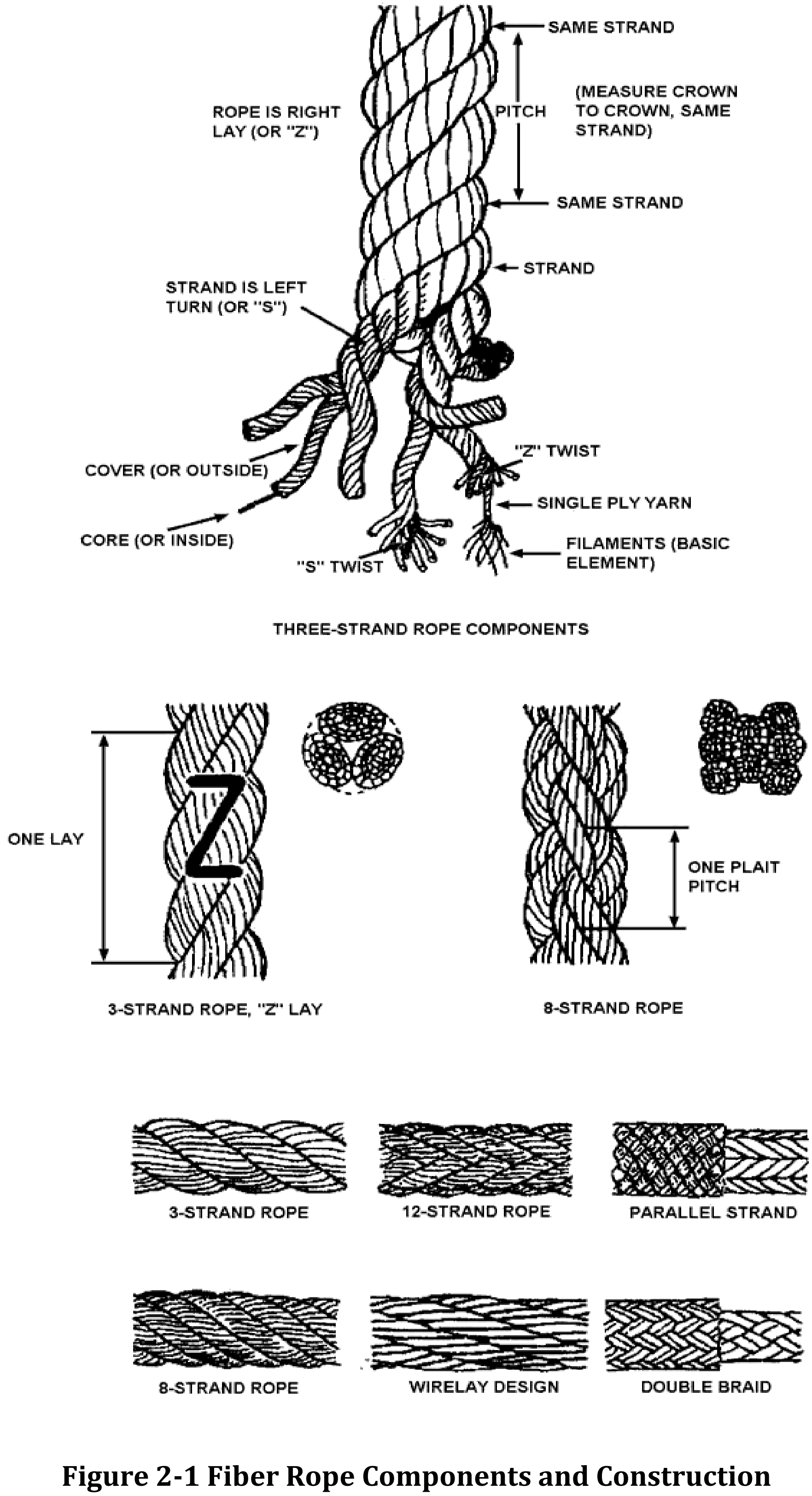


Figure 2-1 Fiber Rope Components and Construction

Natural Fiber Line

Natural fiber line is made from organic material, specifically, plant fiber. Natural fiber line, usually manila, hemp or sisal, are used for securing chafing gear, and doing other small projects where line strength is not a major concern. Braided line is most commonly used for halyards, heaving lines, and lead lines. Plain-laid line may be used for securing loose gear, fender lines, and fancy work. Natural fiber line has a lower breaking strength than synthetic fiber line of an equal size, and unlike synthetic line, natural fiber line does not recover after being stretched (elasticity). Another limitation of natural fiber line is the likelihood of rotting if stowed wet. The following describes the various natural fiber lines:

Type	Characteristics
Manila	Made from fibers of the abaca plant and is the strongest and most expensive of the natural fibers.
Sisal	Made from the agave plant and is next in strength to manila, being rated at 80% of manila's strength.
Hemp	Made from the fiber of the stalk of the hemp plant, is now rarely used.
Cotton	Made from natural fibers of the cotton plant, may be three-stranded, right-lay or of braided construction used for fancy work and lashings.

Synthetic Fiber Line

Synthetic fiber line is made of inorganic (man-made) materials. The characteristics of synthetic fiber line are considerably different from natural fiber line. The differences will vary depending on the type of material from which the line is made. The following identifies the various types of synthetic fiber line used:

Type	Characteristics
Nylon	A synthetic fiber of great strength, elasticity, and resistance to weather. It comes in twisted, braided, and plaited construction, and can be used for almost any purpose where its slippery surface and elasticity is not a disadvantage. While its superior strength makes double-braided nylon line the preferred choice for load bearing, there are disadvantages. Because it will stretch further (elongate) and still recover (elasticity), the snap back potential if the line parts is greater than with natural fiber line. Also, if nylon line is doubled and placed under excessive strain, there is a danger that the deck fittings might fail. If that happens, the line will snap back like a rubber band, bringing the deck fitting with it. Additionally, damage to the engine or deck fittings could occur if the bollard pull is exceeded.
Dacron	A synthetic fiber of about 80% of the strength of nylon that will only stretch 10% of its original length.
Polyethylene and Polypropylene	A synthetic fiber with about half the strength of nylon, 25% lighter than nylon making it easier to handle, and it floats in water. The main disadvantage of plain-laid polypropylene line is lack of strength compared to

	nylon line of equal size. Its loose, course weave makes it easy to splice but susceptible to chafing. Aggravating this is polypropylene's characteristic of deteriorating rapidly when exposed to continuous sunlight. It can, in fact, lose up to 40% of its strength over three months of exposure. For this reason, the line is best kept covered when not in use, and inspected and replaced on a regular basis

Stowing Line

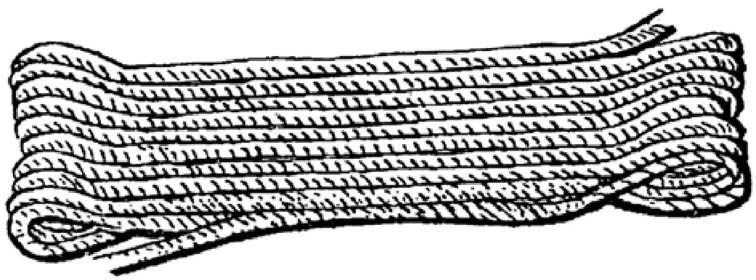


Figure 2-2 Line Faked Down

Synthetic line should not be constantly coiled in the same direction, as doing this tends to tighten the twist. Three-strand synthetic line is often coiled clockwise to reduce a natural tendency to tighten up. It can be coiled in figure eights to avoid kinks when paying out. (See Figure 2-3)

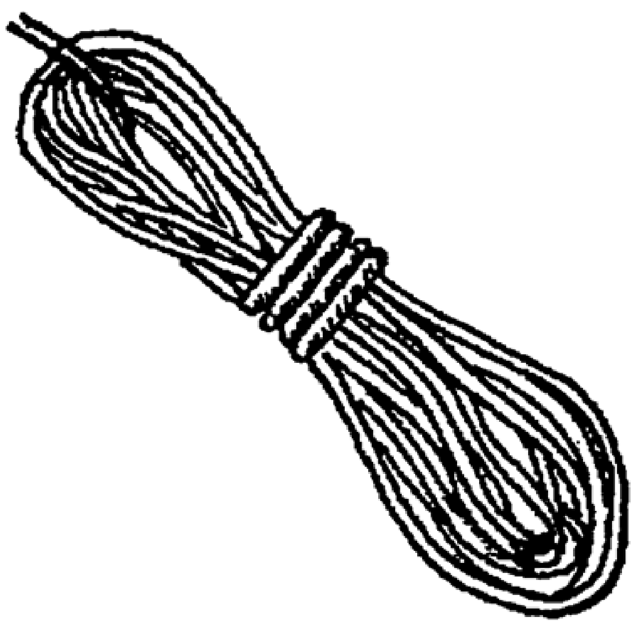


Figure 2-3 Figure Eight Coils

The most common method of stowing the extra line on deck or on the dock after making fast to a cleat is to coil it, as a Flemish Coil.

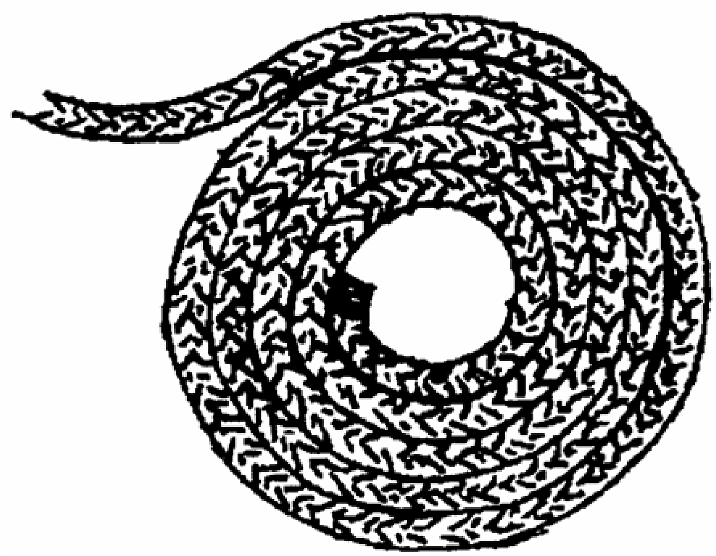


Figure 2-4 Flemishing a Line

KNOTS AND SPLICES

Estimating the Length of a Line

Estimating the length of a line can be a useful skill. One method of doing so is as follows:

Step	Procedure
1	Hold the end of a length of line in one hand.
2	Reach across with the other hand and pull the line through the first hand, fully extending both arms from the shoulder.

The length of line from one hand to the other, across the chest, will be roughly six feet (one fathom). Actually, this distance will be closer to the person's height, but this measure is close enough for a rough and quick estimate of line needed. If more line is needed, the process should be repeated keeping the first hand in place on the line as a marker until the length of line required has been measured off. For example, if 36' of line is needed, the procedure should be repeated six times.

BASIC KNOTS

Knots are the intertwining of the parts of one or more lines to secure the lines to themselves, each other (bends), or other objects (hitches). Because knots decrease the strength of the line, they should always be treated as temporary. If something permanent is needed, a splice can be used.

Knot	Description
Running End (Bitter End)	The running end (bitter end) or the free end of a line. It is the end of the line that is worked with.
Standing Part	The standing part is the long unused end of a line. It is the remaining part of the line, including the end that is not worked.
Overhand Loop	The overhand loop is a loop made in a line by crossing the bitter end over the standing part.
Underhand Loop	The underhand loop is a loop made in the line by crossing the bitter end under the standing part.

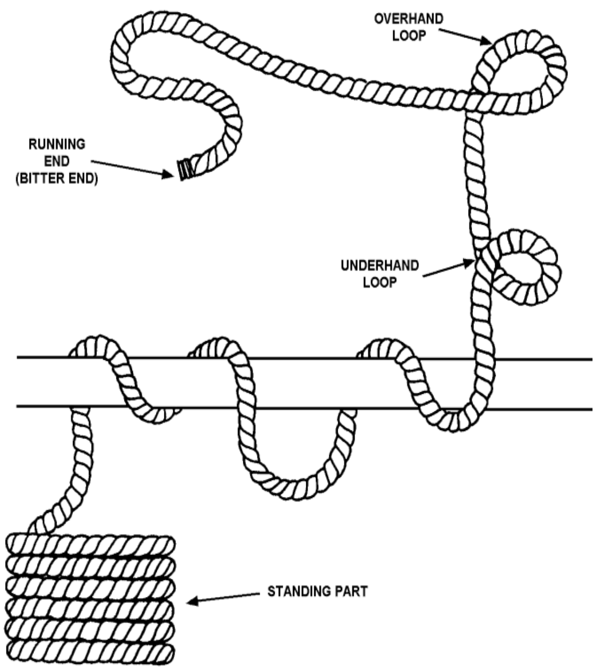


Figure 2-5 Basic Parts and Loops

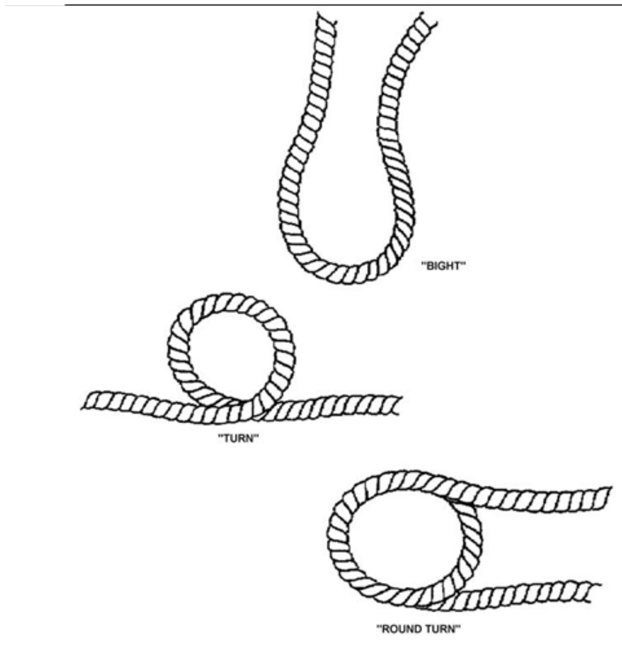


Figure 2-6 Bight and Turns

Knot	Description
Bight	A bight is a half loop formed by turning the line back on itself.
Turn	A turn is a single wind or bight of a rope, laid around a belaying pin, post, bollard, or the like.
Round Turn	A round turn is a complete turn or encircling of a line about an object, as opposed to a single turn.

Anatomy of a Knot

Good knots are easy to tie, are easy to untie, and hold well. A good knot will not untie itself. In sailing vernacular, a knot is used to tie a line back upon itself, a bend used to secure two lines together, and a hitch is used to tie a line to a ring, rail or spar. A knot used to secure a line to an object, such as a ring or eye, is a hitch. The knots listed below are those most commonly used in boat operations.

Bowline

The bowline is a versatile knot and can be used anytime a temporary eye is needed in the end of a line. An advantage of bowlines is that they do not slip or jam easily. Refer to **Figure 2-7** while performing the following procedures:

Step	Procedure
1	Make an overhand loop in the line the size of the eye desired.
2	Pass the bitter end up through the overhand loop.

3	Bring the bitter end around the standing part and back down through the overhand loop.
4	Pull the knot tight by holding the bitter end and the loop with one hand, and pulling on the standing part with the other.

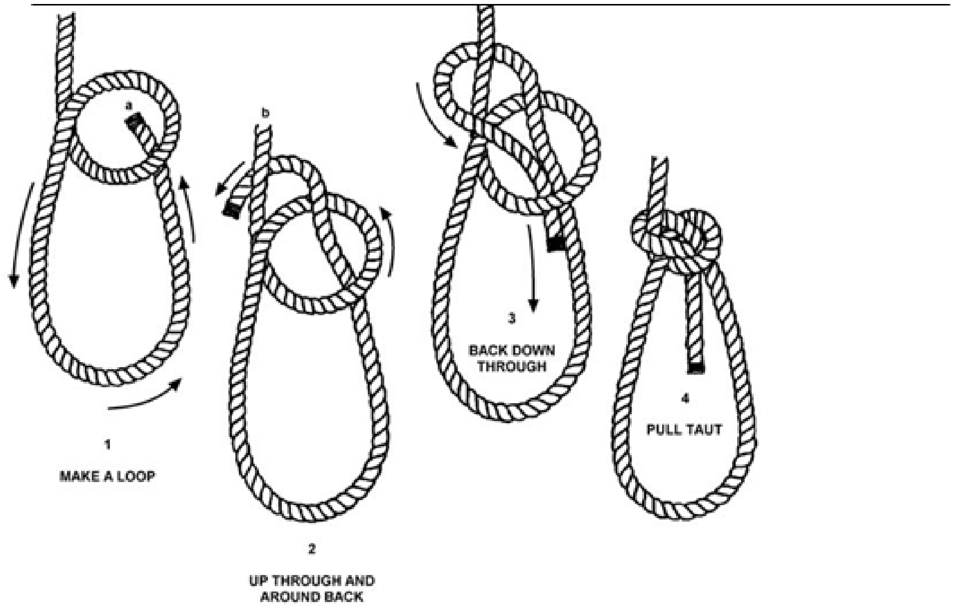


Figure 2-7 Bowline

Half Hitches

Hitches are used for temporarily securing a line to objects such as a ring or eye. One of their advantages is their ease in untying. The half hitch is the smallest and simplest hitch. It should be tied only to objects having a right-hand pull. Since a single half hitch may slip easily, care should be taken in cases where it will encounter stress. Refer to **Figure 2-8** while performing the following procedures:

Step	Procedure
1	Pass the line around the object.
2	Bring the working end "a" around the standing part and back under itself.

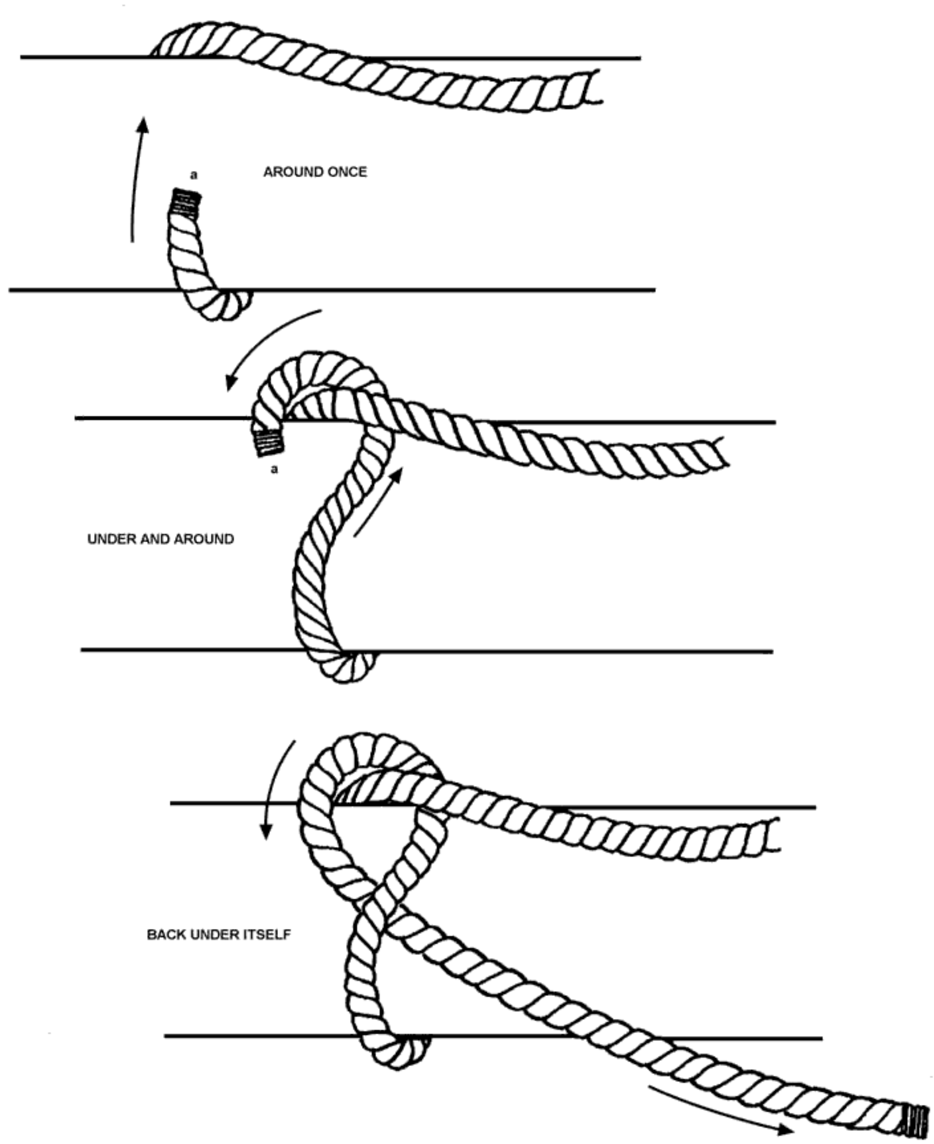


Figure 2-8 Half Hitch

Two Half Hitches

To reinforce or strengthen a single half hitch, the rope can be tied once more. Two half hitches make a more reliable knot than a single half hitch and can be used to make the ends of a line fast around its own standing part. A round turn or two, secured with a couple of half hitches, is a quick way to secure a line to a pole or spar. Two half hitches are needed to secure a line at an angle where it might slide vertically or horizontally. Refer to **Figure 2-9** while performing the following procedures:

Step	Procedure
1	Take a turn around the object.

2	Bring the running end (bitter end) under and over the standing part and back under itself.
3	Continue by passing bitter end under and over the standing part and back under itself

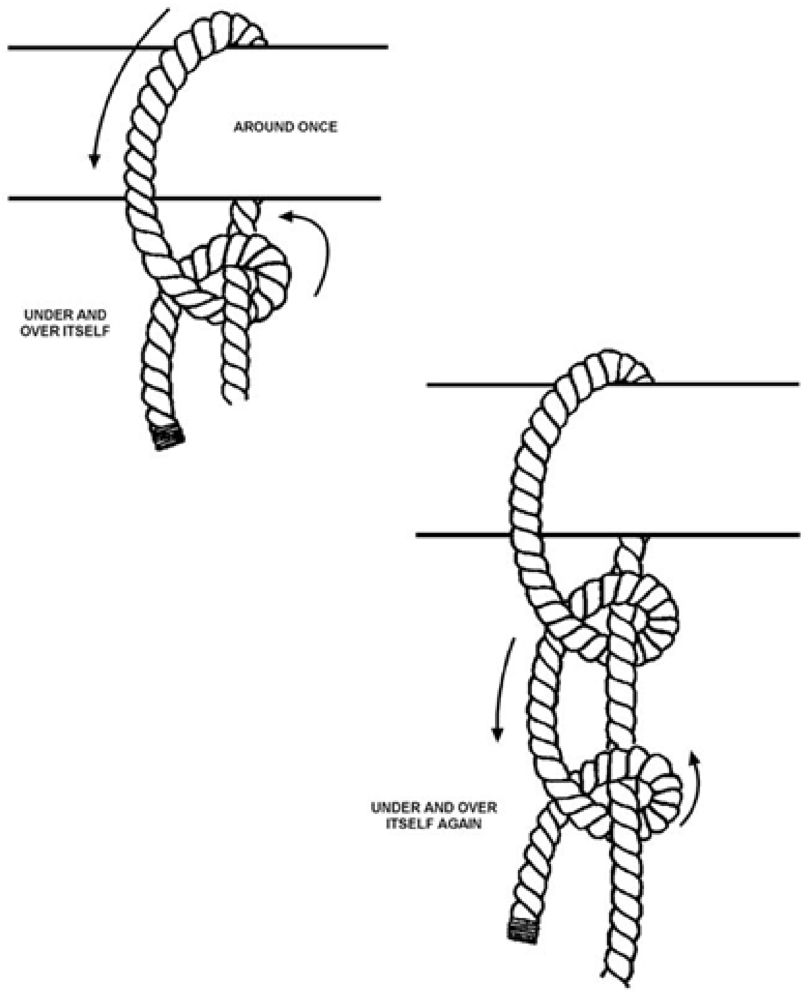


Figure 2-9 Two Half Hitches

Rolling Hitch (Stopper) A rolling hitch is used to attach one line to another, where the second line is under a strain and cannot be bent. Refer to **Figure 2-10** while performing the following procedures:

Step	**Procedure**
1	With the bitter end “a”, make a turn over and under the second line “b” and pass the link over itself.
2	Pass “a” over and under “b” again bringing “a” through the space between the two lines on the first turn.

3	Pull taut and make another turn with the bitter end “a” taking it over, then under, then back over itself.
4	Pull taut and tie a half hitch.

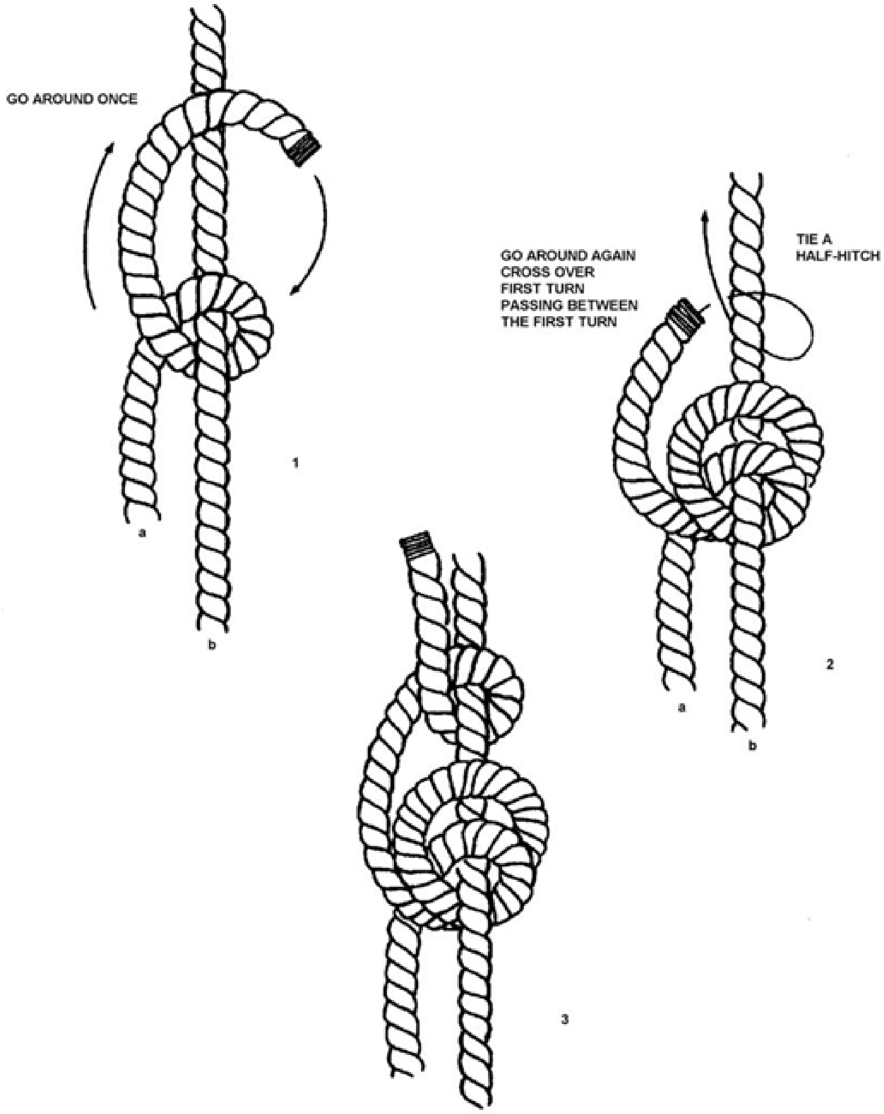


Figure 2-10 Rolling Hitch

Clove Hitch

A clove hitch is the best all-around knot for securing a line to a ring or spar. Correctly tied, a clove hitch will not jam or loosen. However, if it is not tied tight enough, it may work itself out. Reinforcing it with a half hitch will prevent this from happening. Refer to **Figure 2-11** while performing the following procedures:

Step	Procedure
1	Pass the bitter end "a" around the object so the first turn crosses the standing part.
2	Bring the bitter end "a" around again and pass it through itself.
3	Pull taut.
4	Reinforce by tying a half hitch.

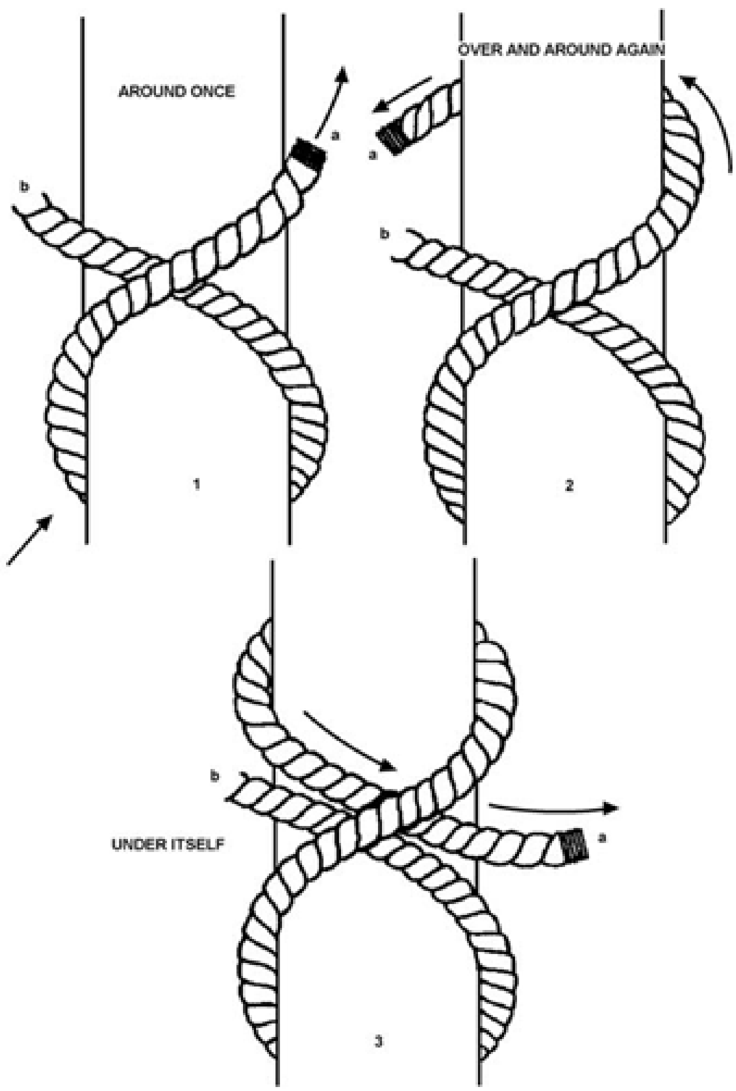


Figure 2-11 Clove Hitch

Slip Clove Hitch

A slip clove hitch should be used in lieu of a clove hitch when a quick release is required. It should be tied in the same manner as the clove hitch but finish it with a bight to allow for quick release. (see **Figure 2-12**) It is sometimes used for stowing lines and fenders. It should not be used when working with the line.

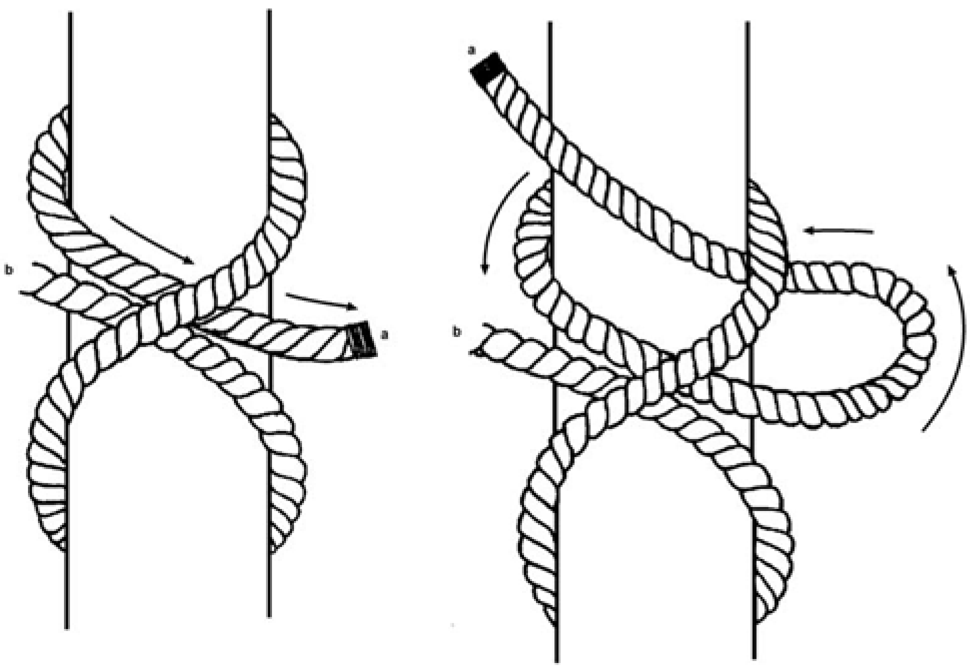


Figure 2-12 Slip Clove Hitch

Timber Hitch
Timber hitches are used to secure a line to logs, spars, planks or other rough-surfaced material, but should not be used on pipes or other metal objects. Refer to **Figure 2-13** while performing the following procedures:

Step	**Procedure**
1	Tie a half hitch.
2	Continue taking the bitter end “a” over and under the standing part.
3	Pull the standing part taut.
4	Add two half hitches for extra holding, if necessary. (see **Figure 2-14**) Unless the half hitch can be slipped over the end of the object, tie it before making the timber hitch.

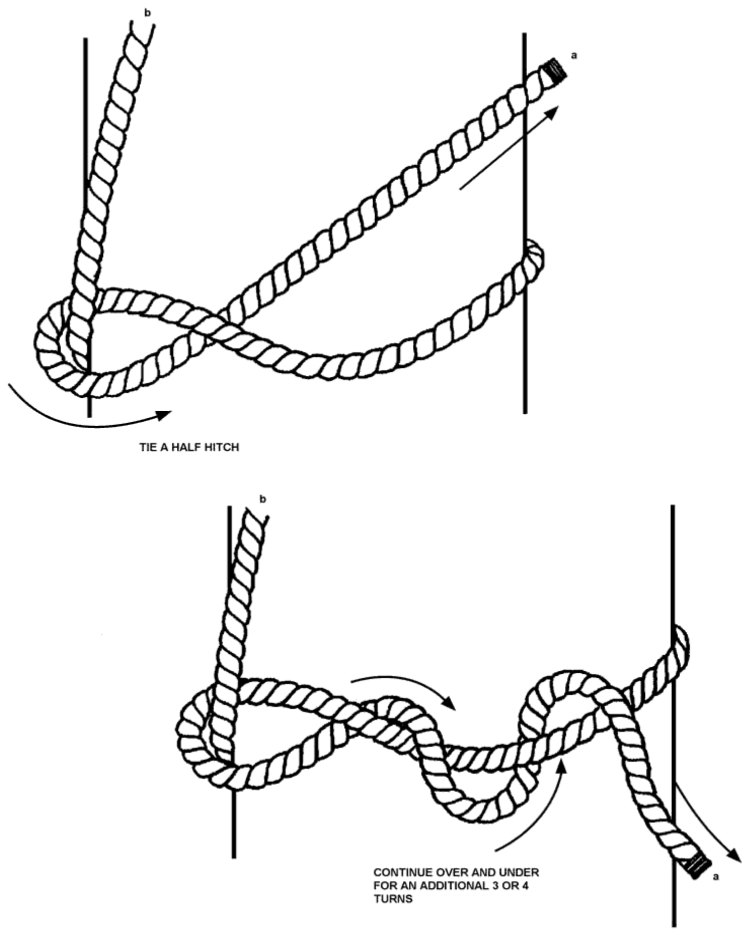


Figure 2-13 Timber Hitch

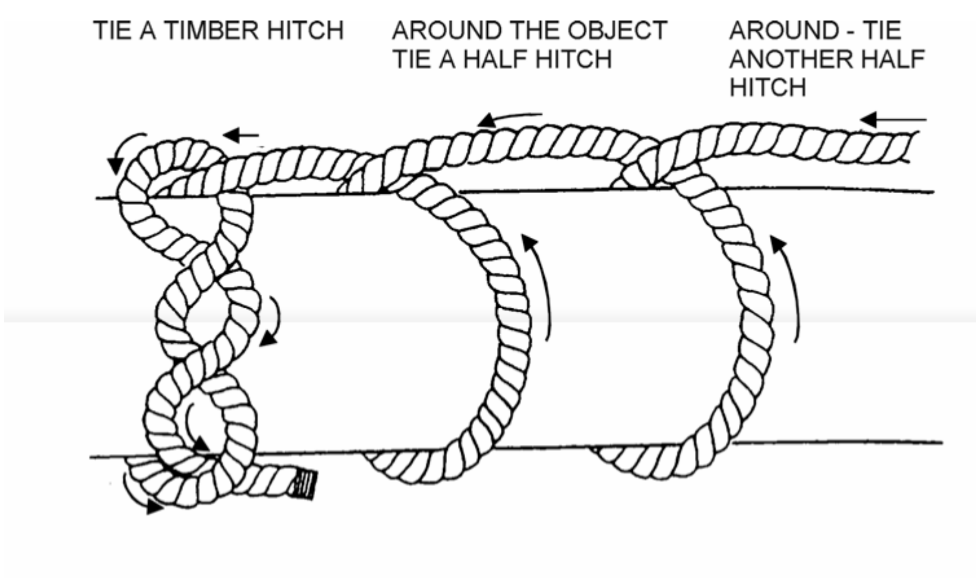


Figure 2-14 Timber Hitch with Two Half Hitches

Single Becket Bend (Sheet Bend)
Lines can be lengthened by bending one to another using a becket bend. It is the best knot for connecting a line to an eye splice in another line. It can be readily taken apart even after being under a load. Single becket bends are used to join line of the same size or nearly the same size. It is intended to be temporary. Refer to **Figure 2-15** while performing the following procedures:

Step	Procedure
1	Form a bight in one of the lines to be joined together, line "a".
2	Pass the bitter end of the second line "b" up through the bight formed by the first line "a."
3	Wrap the end of line "b" around the bight in "a."
4	Pass the end of "b" under its own standing part.
5	Pull taut.

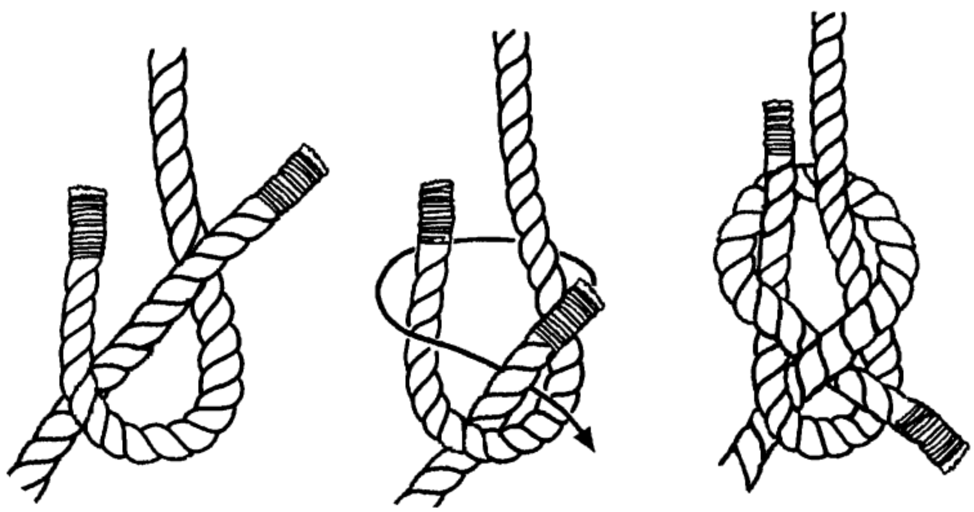


Figure 2-15 Single Becket Bend/Sheet Bend

Double Becket Bend (Double Sheet Bend)
The double becket bend works for joining lines of unequal size. It is tied in the same manner as the single becket bend except for the following variation in step 4 above: Pass line "b" around and under its standing part twice. (see **Figure 2-16**)

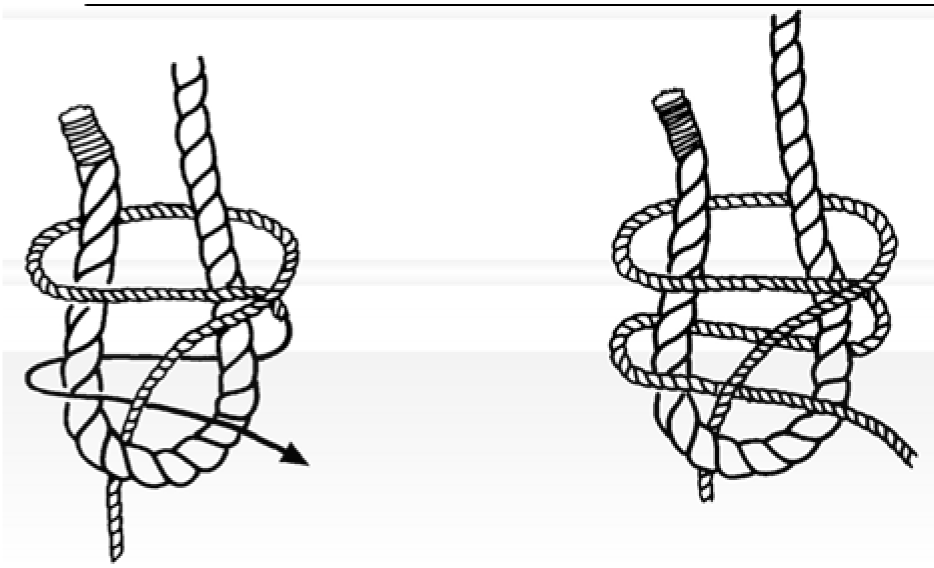


Figure 2-16 Double Becket Bend/Sheet Bend

Reef Knot (Square Knot)
Called a square knot by Boy Scouts, the reef knot is one of the most commonly used knots in marlinespike seamanship. Reef knots are primarily used to join two lines of equal size and similar material. Caution should be used if the line is going to be under heavy strain since the reef knot can jam badly and become difficult to untie afterwards. Reef knots are best used to finish securing laces (canvas cover, awning, sail to a gaff, etc.), temporary whippings, and other small stuff. Refer to **Figure 2-17** while performing the following procedures:

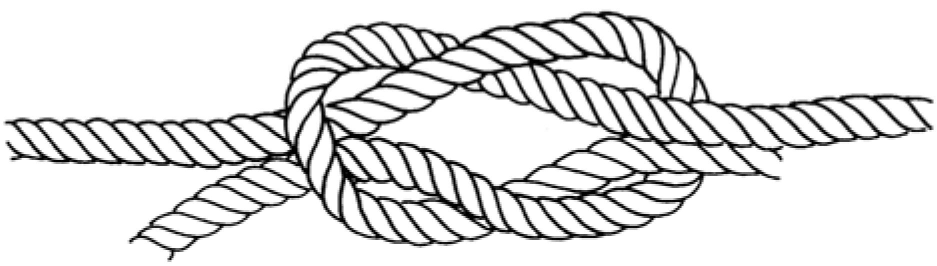


Figure 2-17 Reef Knot (Square Knot)

Figure Eight (Stopper)
A figure eight knot is an overhand knot with an extra twist. It will prevent the end of a line from feeding through a block or fairlead when loads are involved. It is also easier to untie and does not jam as hard as the over hand knot. (see **Figure 2-18**)

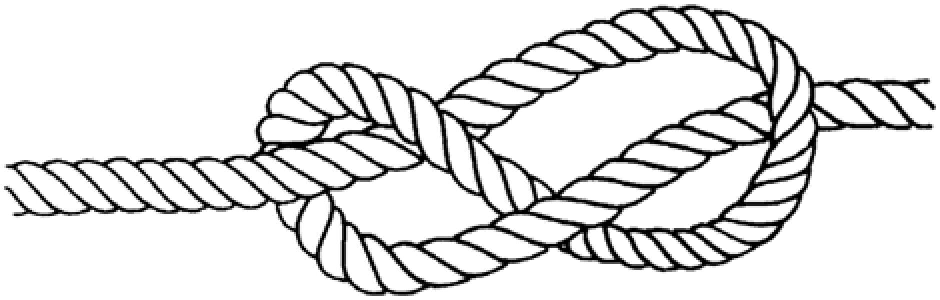


Figure 2-18 Figure Eight Knot

Sheepshank

The sheepshank hitch is used for temporarily shortening a piece of line. It consists of two nights of line, side-by-side, with a half hitch at either end. (see **Figure 2-19**)

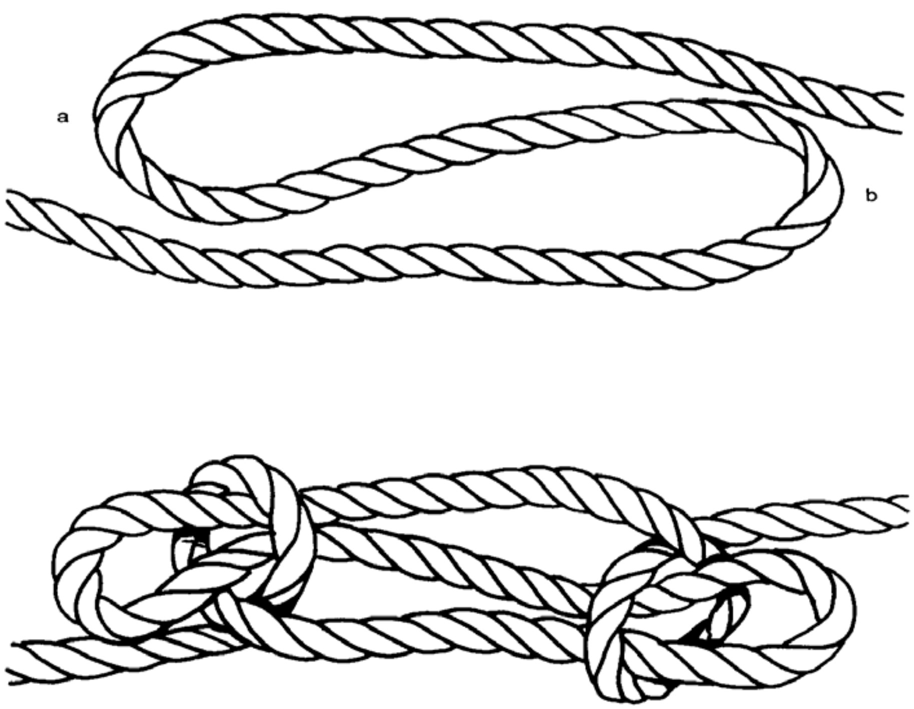


Figure 2-19 Sheepshank

Fisherman's or Anchor Bend

The fisherman's, or anchor bend is used to secure a line to a ring in an anchor or mooring buoy. It can also be tied around a spar. Refer to **Figure 2-20** while performing the following procedures:

Step	Procedure

1	Pass the bitter end through the ring and around twice creating two loops spiraling downward.
2	Wrap the bitter end up around the standing end and pass back through the loops at the top.
3	Tie a half hitch.
4	Pull taut.

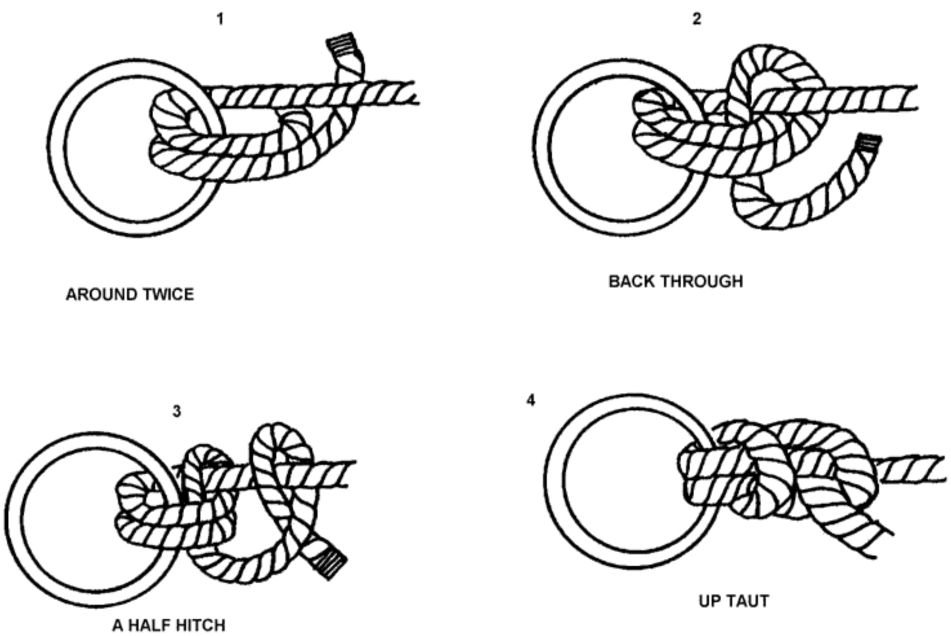


Figure 2-20 Fisherman's or Anchor Bend

SPLICES

Splices form a more permanent joining of two lines or two parts of a line. Splicing can be done with many different styles of line including three-strand and doubled-braided. Three-strand lines are un-layed and woven back into themselves or into another line. Double-braided lines go through a series of core/cover removals and tucks in order to complete the splice. Splices are preferred over knots since they allow the line to retain more of its original working strength. The type of splice used depends on the type of joint and the type of line. The most common splices are eye splices at the working end of the towline, side lines, and mooring lines.

Eye Splice in Three-Strand Plain-Laid Line

The eye splice makes a permanent loop (the eye) in the end of a line. Refer to **Figure 2-21** while performing the following procedures:

Step	Procedure

1	Unlay the strands of the line about 12".
2	Make a bight the size of the eye required.
3	Hold the strands up so the middle strand is facing you.
4	Tuck the middle strand “a.”
5	Cross-strand “b” over the strand just tucked and then under the strand just below it.
6	Turn the entire eye splice over and tuck strand “c.”
7	Pull all strands tight.
8	Pass each strand over the adjacent strand and under the next strand (over & under). The number of tucks depends on the material of the line being worked with. Natural fiber lines should be tucked a minimum of three times. Synthetic fiber lines require four or more tucks to ensure they do not slip.

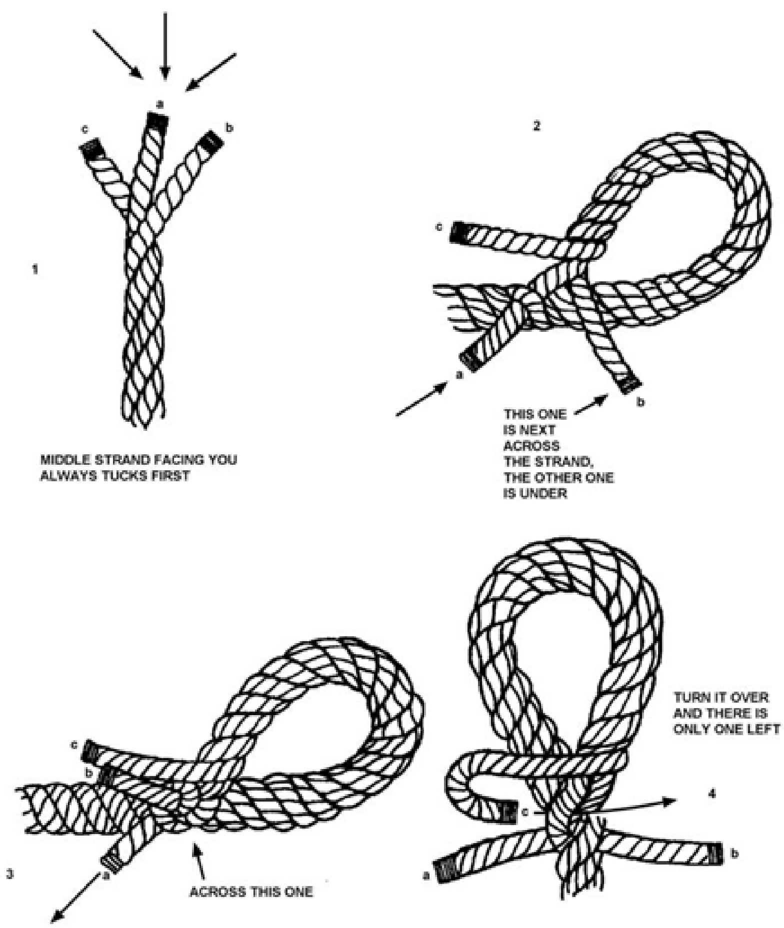


Figure 2-21 Three-Stranded Eye Splice

Back Splice in Three-Strand Plain-Laid Line

A back splice is commonly used to finish off the end of a line. It can be used on the ends of fender lines. Care should be used when selecting a back splice to finish off a line. The splice will increase the diameter of the line that may cause it to jam or foul when running through a block or deck fitting. If the line must be able to run free, a permanent whipping on the end is preferred to prevent unraveling. Crewmembers should start with un-laying the strands at the end, then bending them back on the line, and then interweaving them back through the strands of the standing part. Refer to **Figure 2-22** while performing the following procedures:

Step	Procedure
1	Begin the back splice by tying a crown knot (see **Figure 2-22**). Each strand goes under and out from its neighbor in the direction of the lay.
2	Pass each strand under itself, just beneath the crown knot. Do not pull these first tucks too tight.
3	Proceed with three more rounds of tucks - over one, under one, as in an eye splice.
4	If preferred, it can be finished by trimming the ends of the strands.

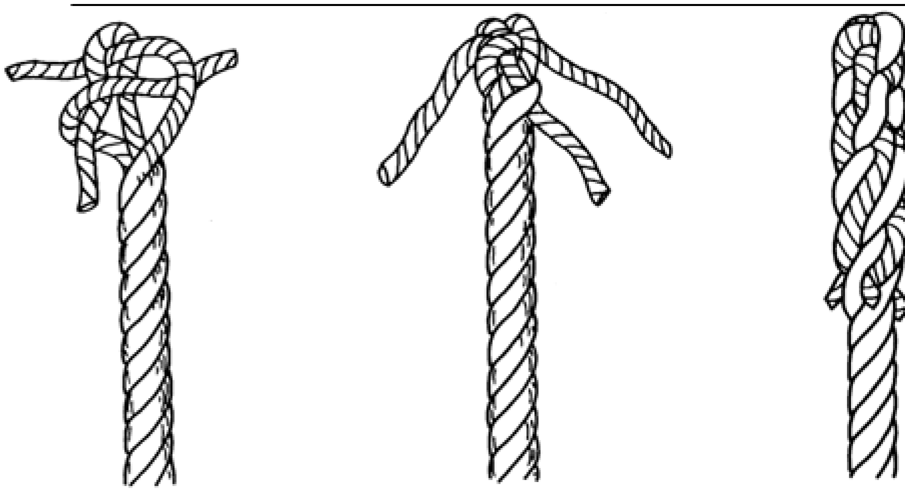


Figure 2-22 Back Splice (Three-Strand)

Short Splice
A short splice is used to permanently connect two ends of a line. It is important to note that a short splice is never used in a line that must pass over a pulley or sheave. Refer to **Figure 2-23** while performing the following procedures:

Step	Procedure
1	Unlay the strands of the lines to be spliced, about 12".
2	Bring the ends together by alternating strands.

3	Slide the two ends together, that is, butt them and temporarily seize them with sail twin or tape.
4	Tuck each strand over and under three times, the same way as in eye splicing. (Synthetic line requires an additional tuck.)
5	Remove the seizing.

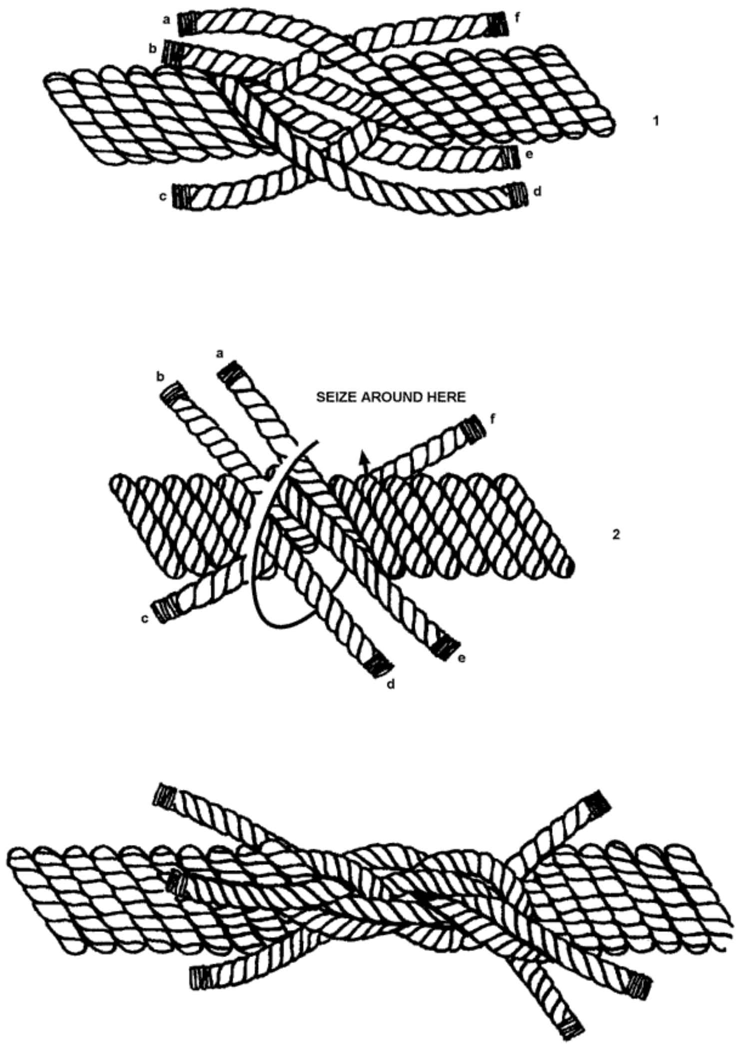


Figure 2-23 Short Splice

WHIPPING

The end of a cut line will unravel and fray if not secured with a whipping or back splice. Whippings may be permanent or temporary.

Temporary Whipping

Sometimes called the common whipping, temporary whippings make temporary repairs and secure strands of lines while splicing. They are not very durable and unravel easily if snagged. Whippings are normally made using sail twine, although almost any small stuff will do. Refer to **Figure 2-24** while performing the following procedures:

Step	Procedure
1	Cut a piece of sail twine or small stuff, in length about ten times the circumference of the line being seized.
2	Lay the sail twine or small stuff alongside the line to be whipped. (see **Figure 2-24**)
3	Form an overhand loop in the sail twine or small stuff such that the loop extends about ½" beyond the end.
4	Holding end “a”, make a series of turns over the loop toward the bitter end of the line. Make enough turns so that the length of turns is almost equal to the diameter of the line.
5	Slip end “a” through the loop “c”.
6	Secure by pulling loop end from sight by pulling on “b”.
7	Cut off excess whipping ends or secure them by tying them together with a reef or square knot.

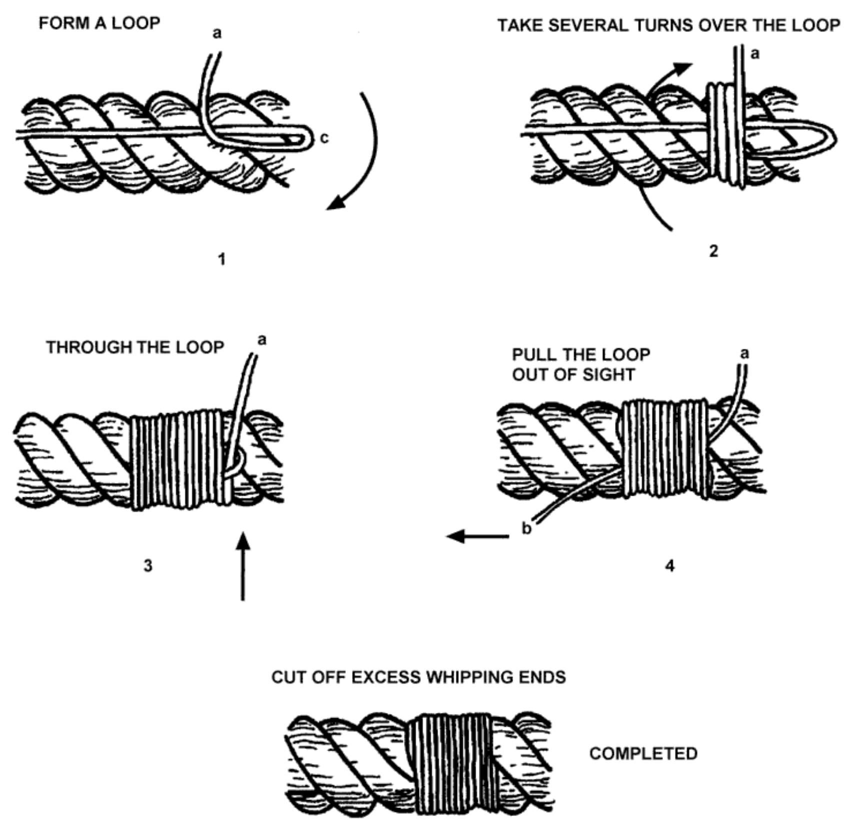


Figure 2-24 Temporary Whipping

DECK FITTINGS
Deck fittings are attachments or securing points for lines. They permit easy handling and reduce wear and friction on lines. There are three basic types of deck fittings:

- Bitts.
- Cleats.
- Chocks.

Several types of deck fittings are shown in **Figure 2-25**.

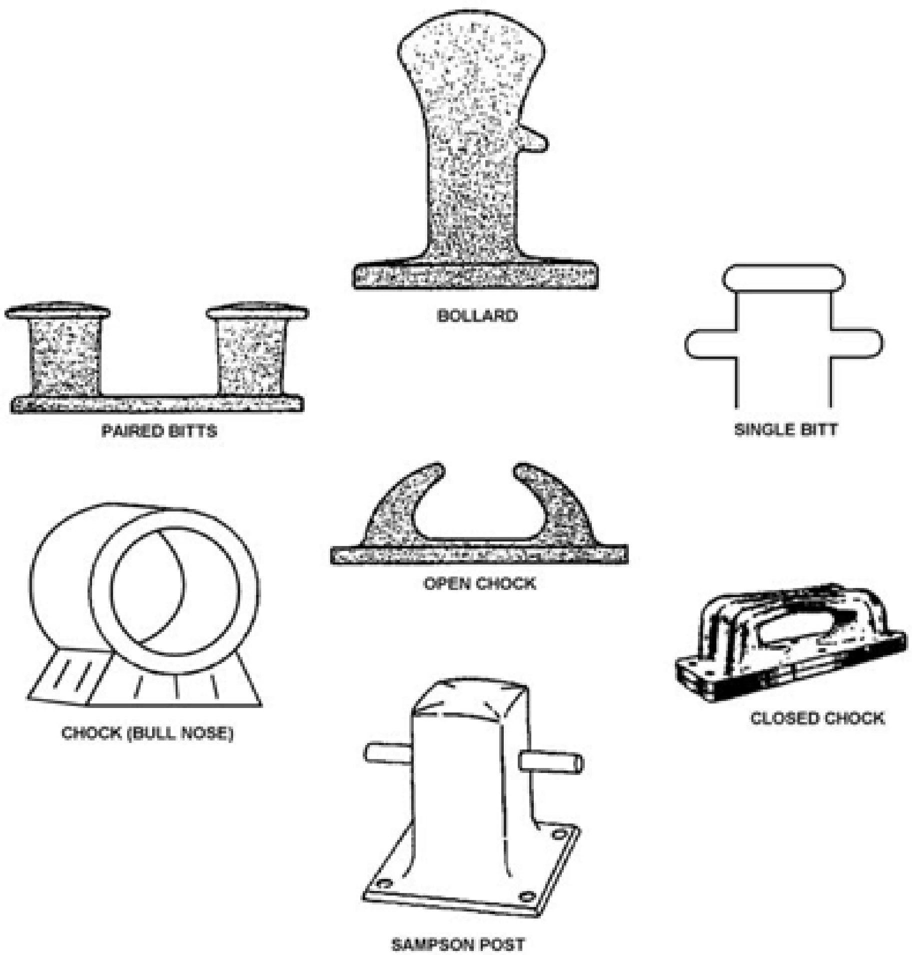


Figure 2-25 Types of Deck Fittings

Cleats may be found on the decks next to the gunwales on each side of a boat used with bitts and cleats to help prevent chafing of the line. The chock provides a smooth surface for the line to run over or through. Because of the difference in the structural design of nonstandard boats, the strength of their deck fittings will vary widely.

LINE HANDLING

Using Properly Sized Line

The size of the deck hardware depends on the size of line to be used for mooring, docking and towing. Cleats are sized by length, and the rule of thumb is the line should be $^1/16$" in diameter for each inch of cleat ($^3/8$" line = 6" cleat, ½" line = 8" cleat.

Securing a Line to a Bitt

The following procedures describe how to secure a line to a set of bitts (see **Figure 2-26**):

Step	Procedure
1	Make a complete turn around the near horn.
2	Make several figure eights around both horns. (Size of line and cleats may restrict the number of turns. Minimum of 3 turns is the standard).
3	Finish off with a round turn.

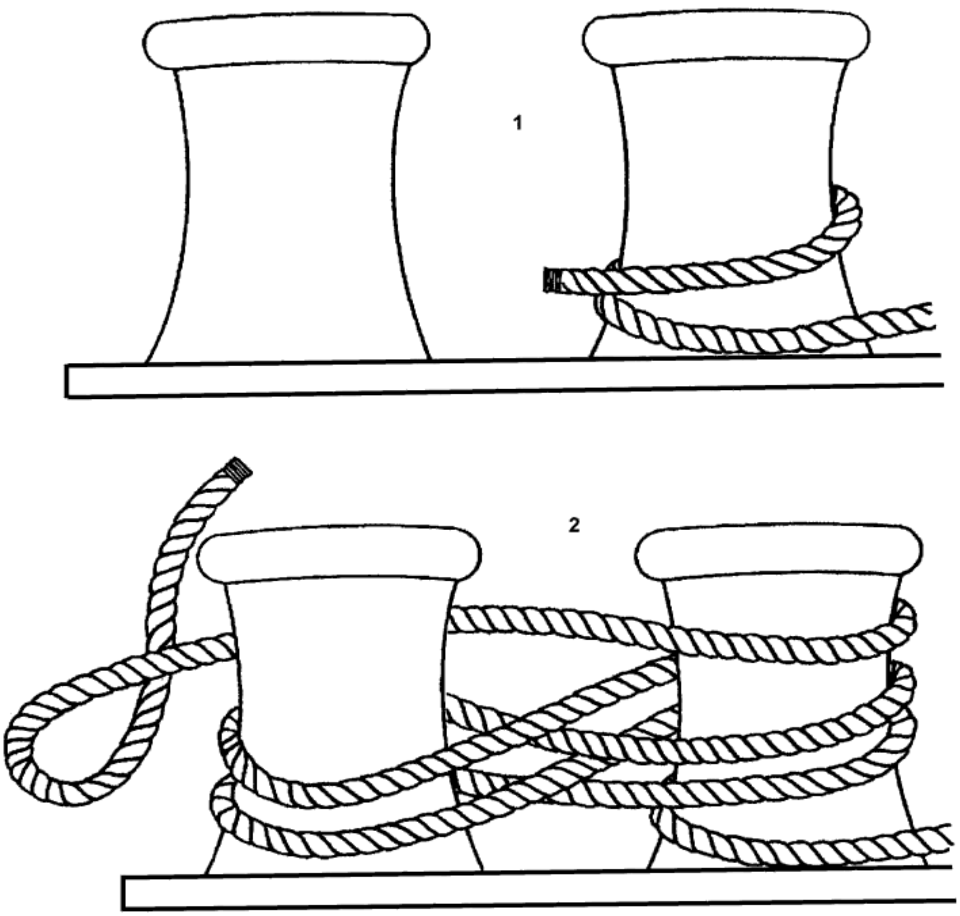


Figure 2-26 Securing a Line to a Bitt

Securing a Line to a Standard Cleat
The following procedures describe how to secure a line to a standard cleat (see **Figure 2-27**):

Step	Procedure
1	Make a complete turn around the cleat.
2	Lead the line over the top of the cleat and around the horn to form a figure eight.
3	If possible, make two more figure eights.

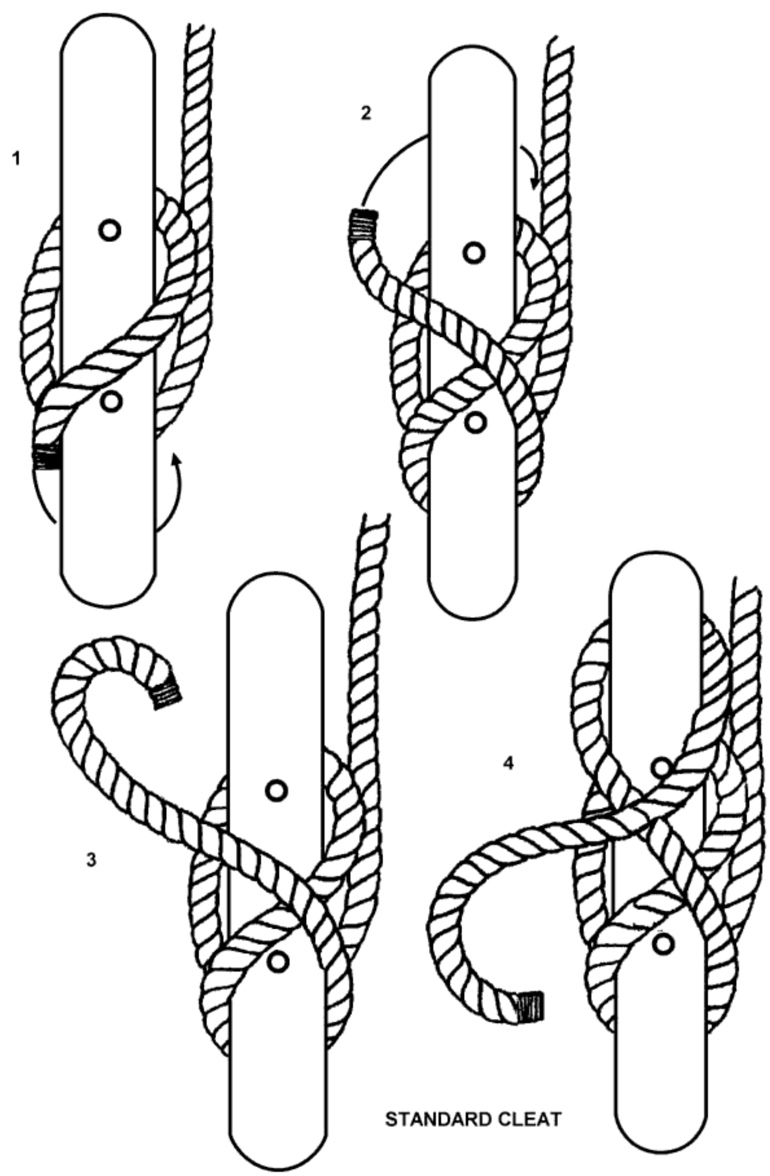


Figure 2-27 Securing a Line to a Standard Cleat

Securing a Line to a Mooring Cleat
The following procedures describe how to secure a line to a mooring cleat (see **Figure 2-28**):

Step	Procedure
1	Feed the eye of the line through the opening.
2	Loop the line back over both horns and pull the line taut.

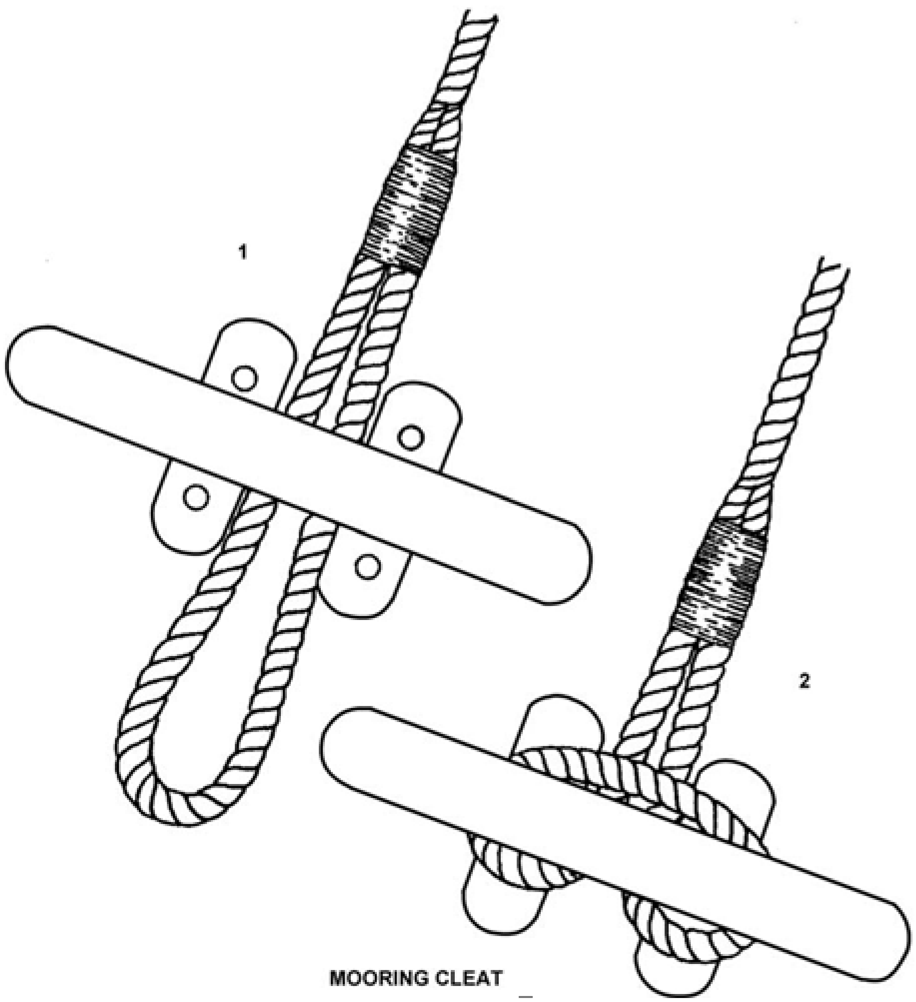


Figure 2-28 Securing a Line to a Mooring Cleat

Dipping the Eye
When two lines with eye splices are placed on a bollard, it may not be possible to remove the bottom line until the top line is removed. By dipping the eye, both lines can be placed for easy removal. The following procedures describe how to dip the eye (see **Figure 2-29**):

Step	Procedure
1	Place the eye of one mooring line over the bollard.
2	Take the eye of the second line up through the eye of the first line.
3	Place the eye of the second line over the bollard.

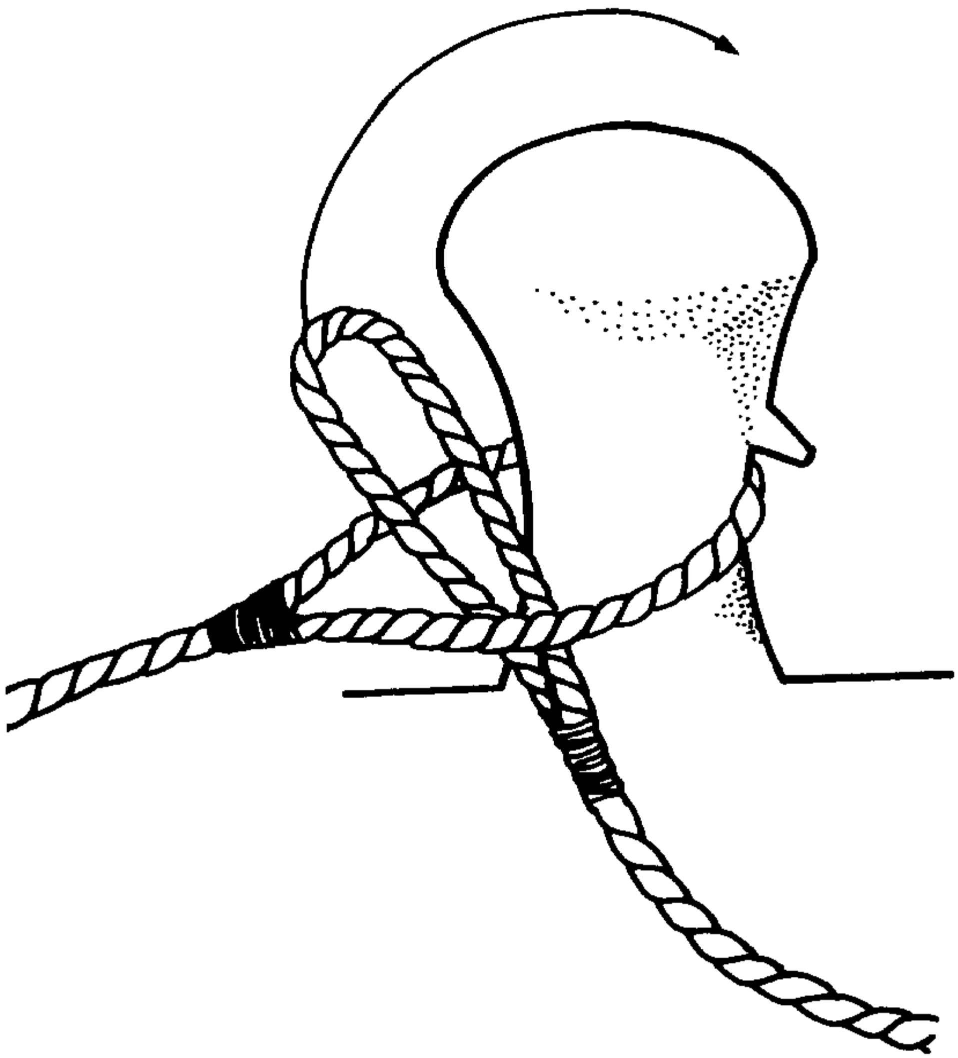


Figure 2-29 Dipping the Eye

Chapter 3
Stability

Introduction

Stability is defined as the ability of a vessel to return to an upright position after being heeled over. Many forces influence the stability of a vessel in the water, and each type of vessel reacts differently.

When a vessel is heeled over in reaction to some external influence, other than damage to the vessel, it tends to either return to an upright position or continue to heel over and capsize. The tendency of a vessel to remain upright is its stability. The greater the tendency to remain upright, and the stronger the force required to heel the vessel over in any direction, the more stability the vessel achieves. Gravity and buoyancy are the two primary forces acting upon a floating vessel that affect stability.

GRAVITY

Gravity pushes the vessel down into the water, while buoyancy is the force that pushes up from the water to keep the vessel afloat. The interaction of these two forces determines the vessel's stability.

Center of Gravity

The center of gravity is the point at which the weight of the boat acts vertically downwards. Thus, the boat acts as though all of its weight were concentrated at the center of gravity. Generally, the lower the center of gravity, the more stable the vessel.

The center of gravity of a boat is fixed for stability and does not shift unless weight is added, subtracted, or shifted. When weight is added (e.g., vessel takes on water), the center of gravity moves toward the added weight. When the weight is removed, the center of gravity moves in the opposite direction.

BUOYANCY

The buoyancy is the upward force of water displaced by the hull. The force of buoyancy keeps the boat afloat; however, it may be overcome if too much weight is added.

Center of Buoyancy

Similar to the center of gravity, this is the point on which all upward/vertical force is considered to act. It lies in the center of the underwater form of the hull. (see **Figure 3-1**)

Equilibrium

When a boat is at rest, the center of buoyancy acting upwards/vertically is below the center of gravity acting downwards. It is at this point that a boat is considered to be in equilibrium. Equilibrium is affected by movement of the center of gravity or center of buoyancy or by some outside forces, such as wind and waves. (see **Figure 3-1**)

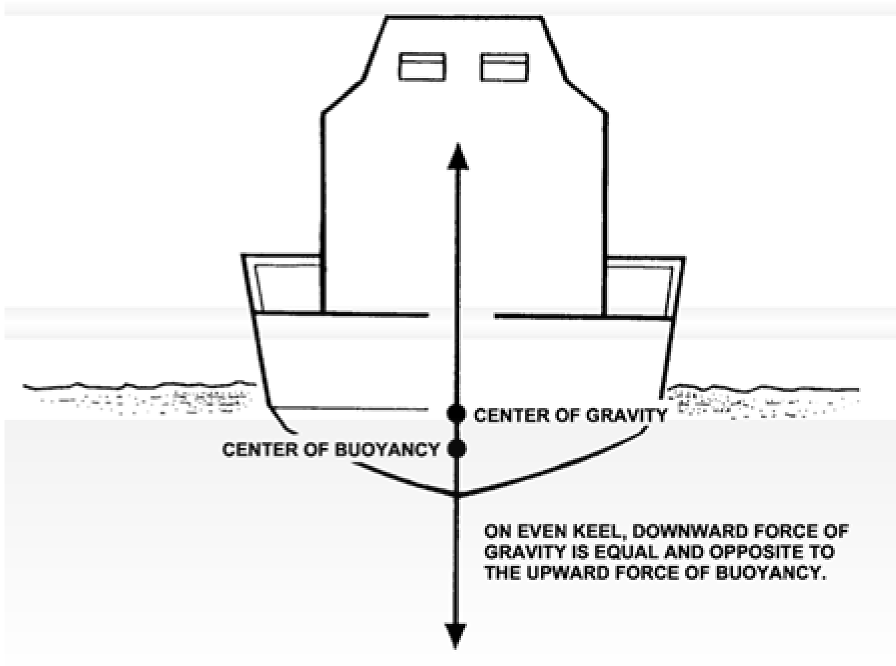


Figure 3-1 Stability in Equilibrium

Rolling
When a boat rolls, the force of the center of gravity will move in the same direction as the roll. The downward force of gravity is offset by the upward force of buoyancy and causes the boat to heel.

Heeling
In heeling, the underwater volume of the boat changes shape causing the center of buoyancy to move.

The center of buoyancy will move towards the part of the hull that is more deeply immersed. When this happens, the center of buoyancy will no longer be aligned vertically with the center of gravity. The intersection of the vertical line through the center of buoyancy and the vertical centerline is called the metacenter. When the metacentric height (the distance between center of gravity and metacenter) is positive, that is the metacenter is above center and gravity, the center of buoyancy shifts so that it is outboard of the center of gravity. Now the boat is considered to be stable, and the forces of buoyancy and gravity will act to bring the boat back to an upright position. If the center of buoyancy is inboard of the center of gravity that is the metacentric height is negative, the forces of buoyancy and gravity will tend to roll the boat further towards capsize. (see **Figure 3-2**)

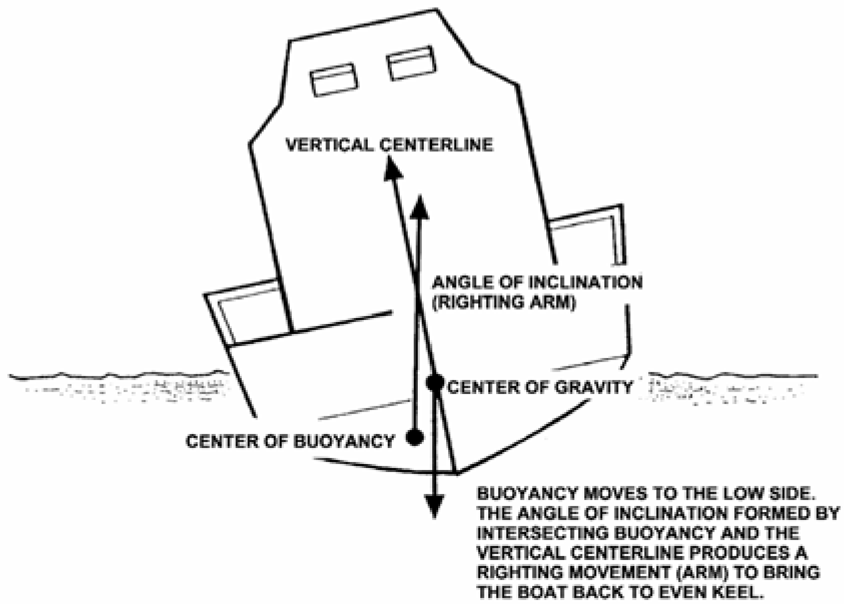


Figure 3-2 Heeling

Listing
If the center of gravity is not on the centerline of the boat, the boat will heel until equilibrium is reached with the center of buoyancy and center of gravity in alignment. This condition is referred to as listing.

Types of Stability
A boat has two principle types of stability:

- Longitudinal.
- Transverse.

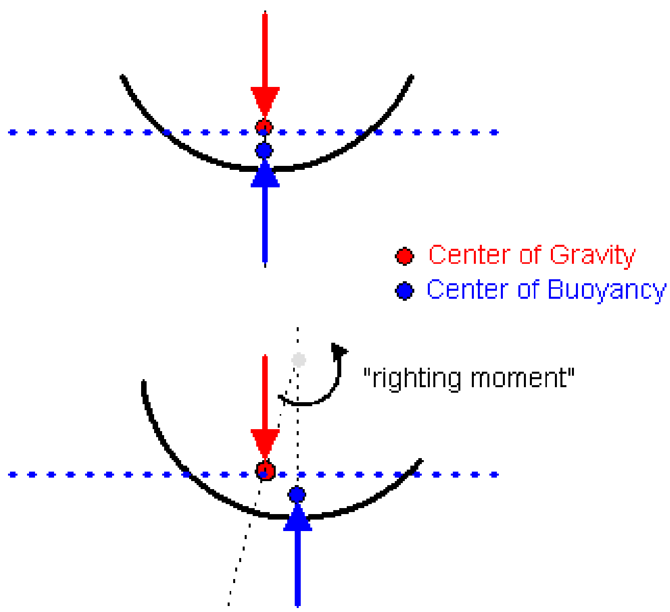
A boat is usually much longer than it is wide. Therefore, the longitudinal plane (fore and aft) is more stable than its transverse plane (beam).

Longitudinal (Fore and Aft) Stability
Longitudinal (fore and aft) stability tends to balance the boat, preventing it from pitching end-over-end (pitch poling). Vessels are designed with enough longitudinal stability to avoid damage under normal circumstances. However, differences in vessel design varies the longitudinal stability characteristics of different vessels depending on the purpose for which a vessel is designed. Some vessels can suffer excessive pitching and offer a very wet and uncomfortable ride during rough sea and weather conditions. Such an uncomfortable ride often affects the endurance and capability of the crew as well as the people on the vessels being assisted.

Transverse (Athwartships) Stability

Transverse (athwartships) stability tends to keep the boat from rolling over (capsizing). Additional weight above the center of gravity increases the distance from the center of gravity up to the center of buoyancy. As a result, stability is also decreased. Removal of weight from below the center of gravity also decreases stability. If the center of gravity is raised enough, the boat will become unstable.

Moment and Forces
The force that causes a vessel to return to an even keel, or upright position, is called the vessel's moment. Both static and dynamic forces can reduce stability and moment. Moments, and the internal and external forces that act to increase or decrease the righting moment, are important factors in determining the stability of a vessel at any given point in time.



RIGHTING MOMENT AND CAPSIZING
A righting moment is the force causing a vessel to react against a roll and return to an even keel. Generally, the broader a boat's beam, the more stable that boat will be, and the less likely it is to capsize. For any given condition of loading, the center of gravity is at a fixed position. As a boat heels, the center of buoyancy moves to the lower side of the boat forming an angle of inclination. Larger changes in the movement of the center of buoyancy will result with any given angle of heel. This change provides greater righting movement up to a maximum angle of inclination.
Too much weight added to the side of the vessel that is heeled over can overcome the forces supporting stability and cause the vessel to capsize. (see **Figure 3-3**)
A boat may also capsize when aground as the volume of water beneath the vessel decreases and the vessel loses balance. As the amount of water supporting the vessel is reduced, there is a loss of buoyancy force being provided by that water. In addition, the upward force acting at the point of grounding will increase and cause the unsupported hull to fall to one side.

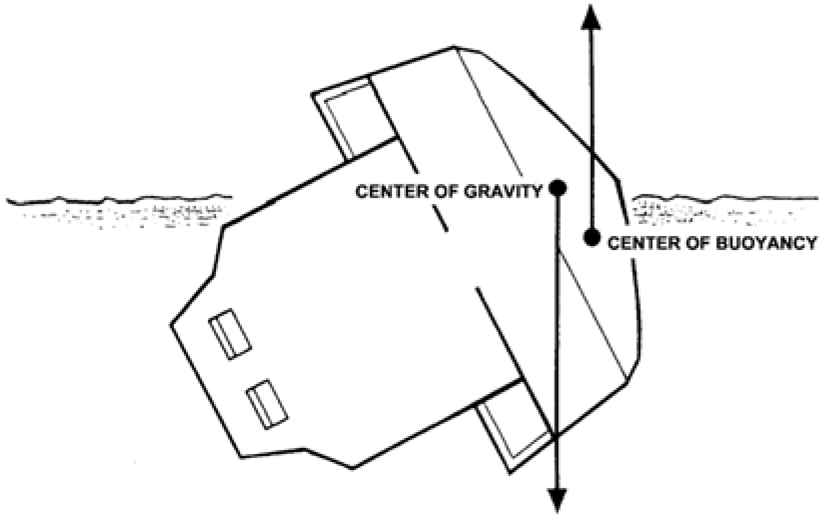


Figure 3-3 Righting Moment and Capsizing

Static and Dynamic Forces

Unless acted upon by some external force, a boat that is properly designed and loaded remains on an even keel. The two principle forces that affect stability are static and dynamic forces.

- Static forces are caused by placement of weight within the hull. Adding weight on one side of a boat's centerline or above its center of gravity usually reduces stability. Flooding or grounding a boat makes it susceptible to static forces which may adversely affect stability.
- Dynamic forces are caused by actions outside the hull such as wind and waves. Strong gusts of wind or heavy seas, especially in shallow water, may build up a dangerous sea tending to capsize a boat.

Observing the vessel's roll can provide some initial indications about the stability of the vessel.

- Watch the time required for a complete roll from side to side. The time should remain about the same regardless of the severity of the angle or roll.
- If the time increases significantly or the boat hesitates at the end of the roll, the boat is approaching or past the position of maximum righting effect. Take immediate steps to decrease the roll by changing course or speed, or both.

Vessel Design

General vessel design features that influence stability include:

- Size and shape of the hull.
- Draft of the boat (the distance from the surface of the water to the keel).
- Trim (the angle from horizontal at which a vessel rides).
- Displacement.
- Freeboard.
- Superstructure size, shape, and weight.
- Non-watertight openings.

Losing Stability

A vessel may be inclined away from its upright position by certain internal and external influences such as:

- Waves. Wind.
- Turning forces when the rudder is put over.
- Shifting of weights onboard.
- Addition or removal of weights.
- Loss of buoyancy (damage).

These influences exert heeling moments on a vessel causing it to list (permanent) or heel (temporary). A stable boat does not capsize when subjected to normal heeling moments due to the boat's tendency to right itself (righting moment).

Free Surface Effect

Compartments in a vessel may contain liquids as a matter of design or as a result of damage. If a compartment is only partly filled, the liquid can flow from side to side as the vessel rolls or pitches. The surface of the liquid tends to remain parallel to the waterline. Liquid that only partly fills a compartment is said to have free surface and water in such a compartment is called loose water. When loose water shifts from side to side or forward and aft due to turning, speed changes, or wave action, the vessel does not want to right itself. This causes a loss of stability. This can cause the vessel to capsize or sink. (see **Figure 3-4** and **Figure 3-5**)

Corrective actions include:

- Minimize the number of partially filled tanks (fuel, water, or cargo.
- Prevent cargo from rolling back and forth on the deck.
- If possible, store cargo low and close to the centerline.

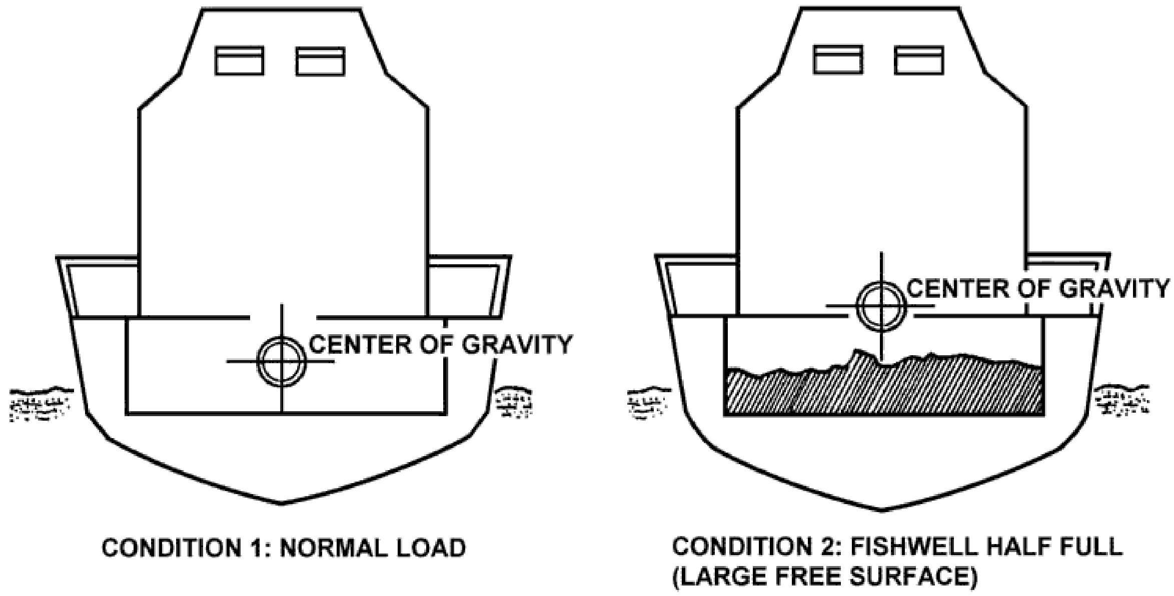


Figure 3-4 Effects of Free Surface

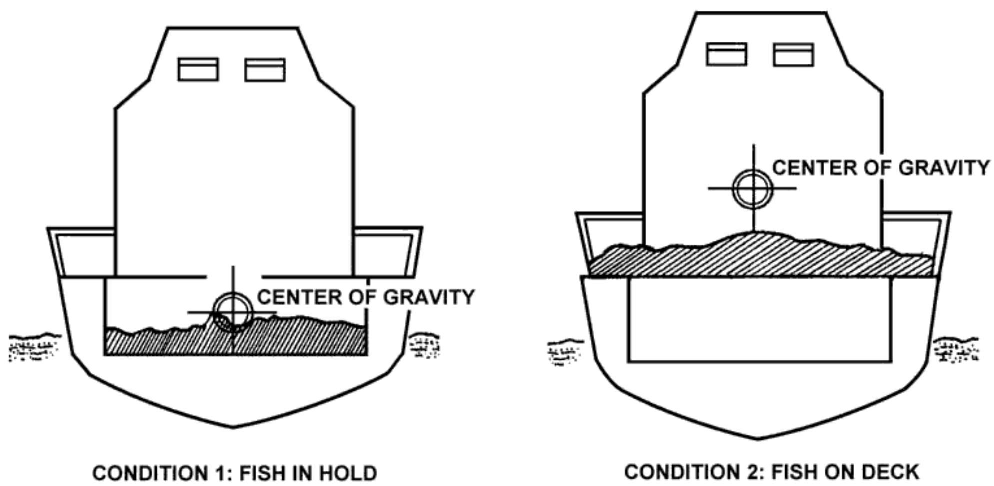


Figure 3-5 Effects of Load Weight

Free Communication with the Sea
Damage to the hull of a vessel can create free communication with the sea, which is the unobstructed movement of seawater into and out of the vessel.
Corrective actions include:

- Patch the hull opening.
- Place weight on the high side to decrease the list toward the damaged side.
- Remove weight above the center of gravity on the damaged side.

Effects of Icing

Icing can increase the displacement of a boat by adding weight above the center of gravity causing the center of gravity to rise. This can cause a vessel to heel over and greatly reduce stability. Sea swells, sharp turns, or quick changes in speed can capsize a vessel that has accumulated ice on its topside surfaces. (see **Figure 3-6**)
Corrective actions include:

- Change course, speed, or both to reduce freezing spray and rolling. P
- Physically remove the ice.

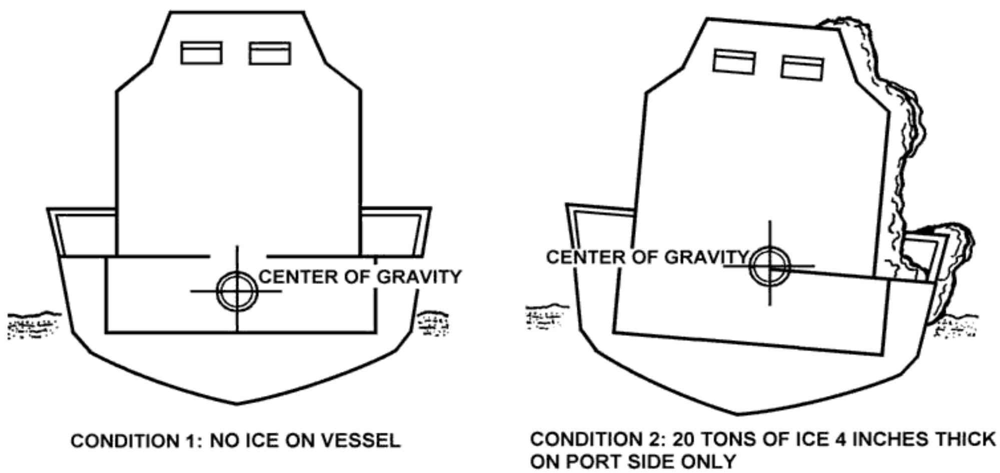


Figure 3-6 Effects of Icing

Effects of Down-flooding
Down-flooding is the entry of water into the hull, resulting in progressive flooding and loss of stability. Vessels are designed with sufficient stability and proper righting moments as long as they are not overloaded. (see **Figure 3-7**)
Corrective actions include:

- Keep all watertight fittings and openings secured when a vessel is underway.
- Pump out the water.

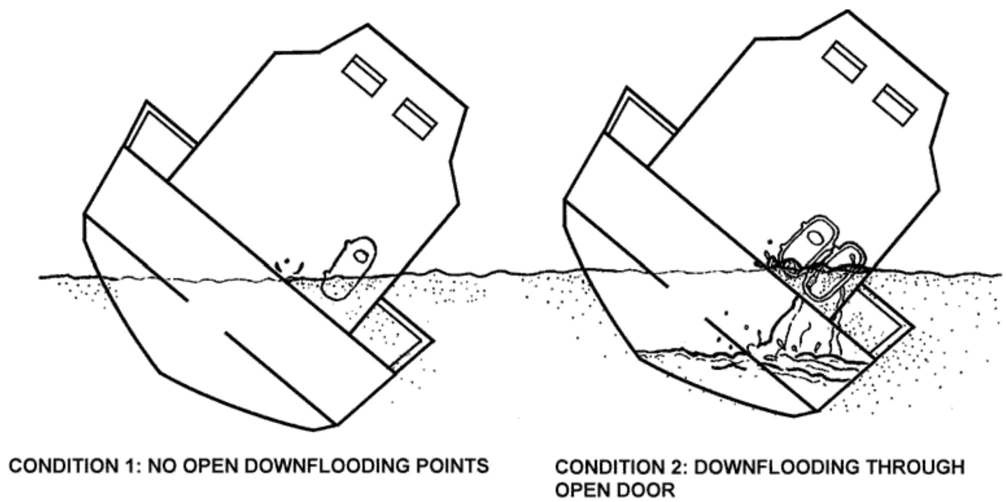


Figure 3-7 Effects of Downflooding

Effects of Water on Deck
Water on deck can cause stability problems by (see **Figure 3-8**):

- Increasing displacement (increasing draft and decreasing stability and trim).
- Contributing to free surface effect.
- Amplifying the rolling motion of the vessel which may result in capsizing.

Corrective actions include:

- Decrease trim, increase freeboard.
- Change course, speed or both.
- Ensure drain openings and scuppers are unobstructed.

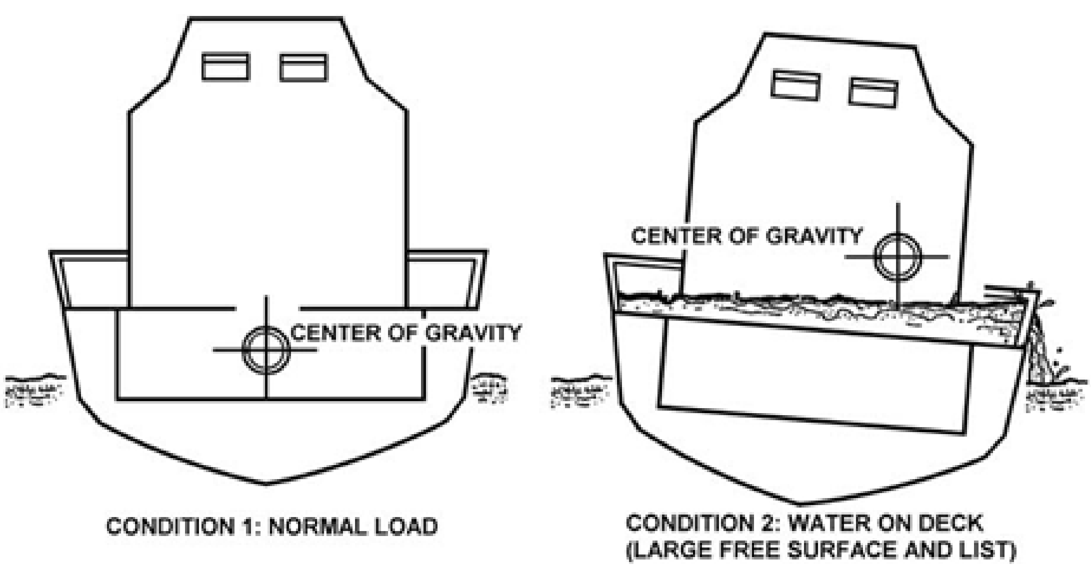


Figure 3-8 Effects of Water on Deck

Chapter 4
Boat Handling

FORCES

Different forces act on a vessel's hull, causing it to move in a particular direction or to change direction. These forces include environmental forces, propulsion, and steering.

Winds

The wind acts upon any portion of the vessel that is above the waterline. This includes the hull, superstructure, and on smaller boats, the crew. The amount of surface upon which the wind acts is called sail area. The vessel will make "leeway" (drift downwind) at a speed proportional to the wind velocity and the amount of sail area. The "aspect" or angle the vessel takes due to the wind will depend on where the sail area is centered compared to the underwater hull's center of lateral resistance. A vessel with a high cabin near the bow and low freeboard aft (see **Figure 4-1**) would tend to ride stern to the wind. If a vessel's draft were shallower forward than aft, the wind would affect the bow more than the stern. A sudden gust of wind from abeam when mooring a vessel like this might quickly set the bow down on a pier.

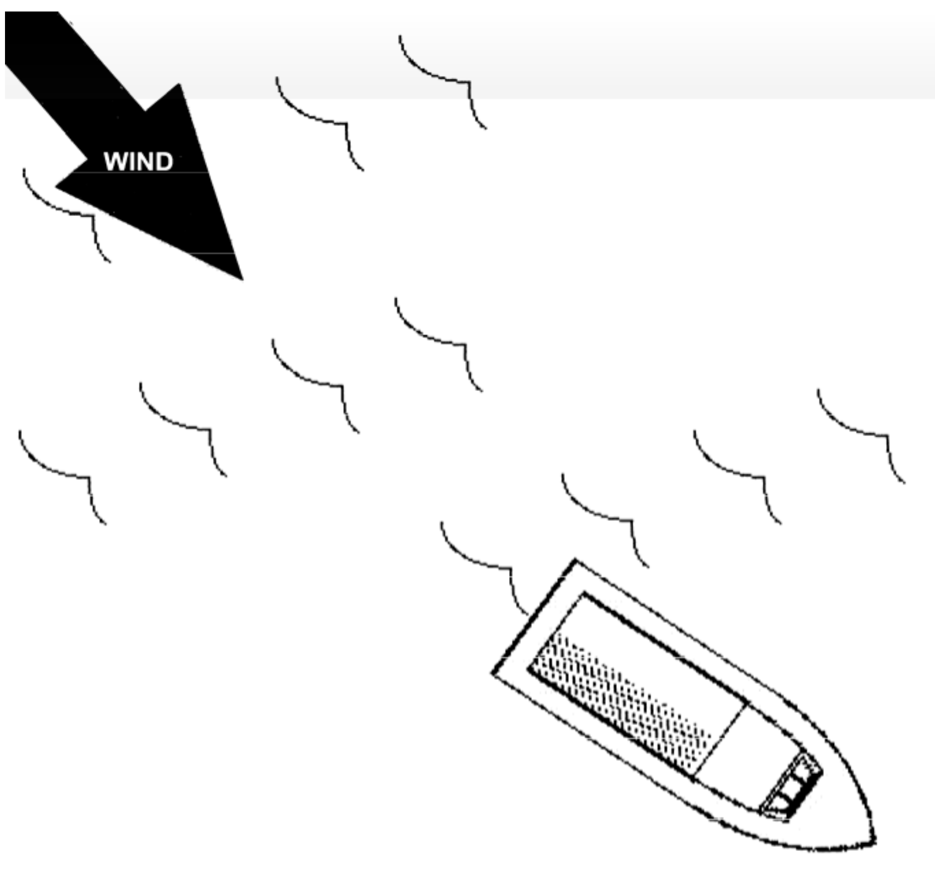


Figure 4-1 High Cabin Near Bow, Low Freeboard Aft

Close Quarters

Knowledge of how the wind affects a vessel is very important in all close quarters situations, such as mooring, recovery of an object in the water, or maneuvering close aboard another vessel. If maneuvering from a downwind or leeward side of a vessel or pier, the coxswain should look for any wind shadow the vessel or pier makes by blocking the wind. (see **Figure 4-2**) The coxswain should also account for the change in wind by planning maneuvers with this wind shadow in mind.

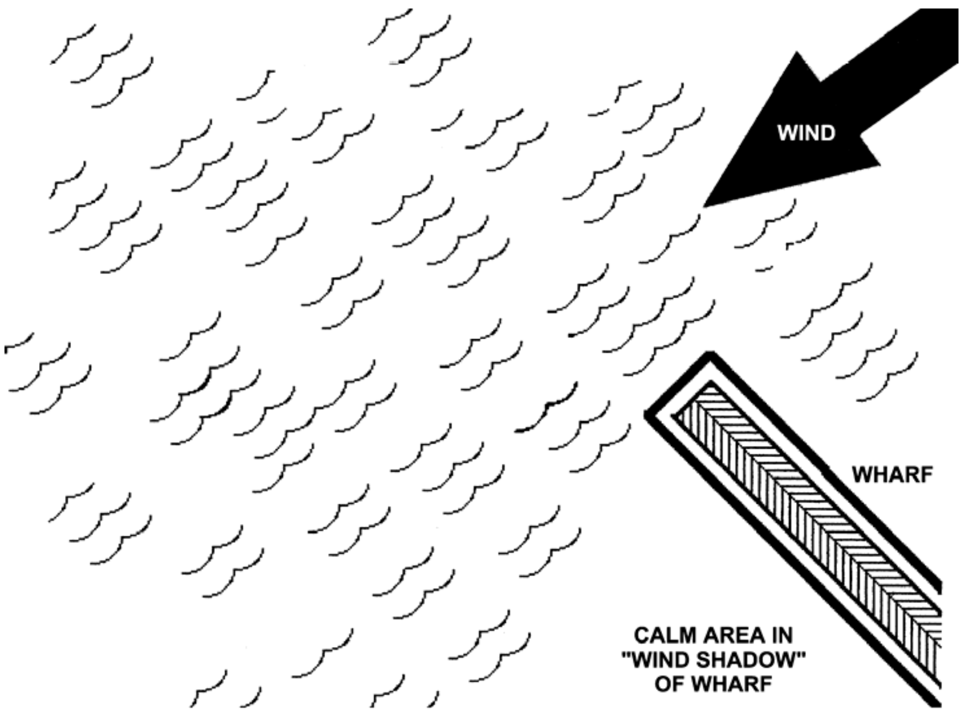


Figure 4-2 Wind Shadow

Seas

Seas are a product of the wind acting on the surface of the water. Seas affect boat handling in various ways, depending on their height and direction and the particular vessel's characteristics. Vessels that readily react to wave motion, particularly pitching, will often expose part of the underwater hull to the wind. In situations such as this, the bow or stern may tend to "fall off" the wind when cresting a wave, as less underwater hull is available to prevent this downwind movement.

Current

Current acts on a vessel's underwater hull in the same manner as wind pushes on a vessel's superstructure. The amount of draft a vessel has will determine how much affect current will have. A one-knot current may affect a vessel to the same degree as a 30-knot wind. A strong current will easily move a vessel upwind.

The coxswain should learn to look for the signs of current flow so as to be prepared when current affects the vessel, and should be particularly aware of instances where current shear is present. As with wind, a large, stationary object like a breakwater or jetty will cause major changes in the amount and direction of current. (see **Figure 4-3**) Crewmembers should note the amount of current around floating moorings or those with open pile supports. Caution should be used when maneuvering in close quarters to buoys and anchored vessels. Crewmembers should observe the effect of current by looking for current wake or flow patterns around buoys or piers and should watch how currents affect other vessels.

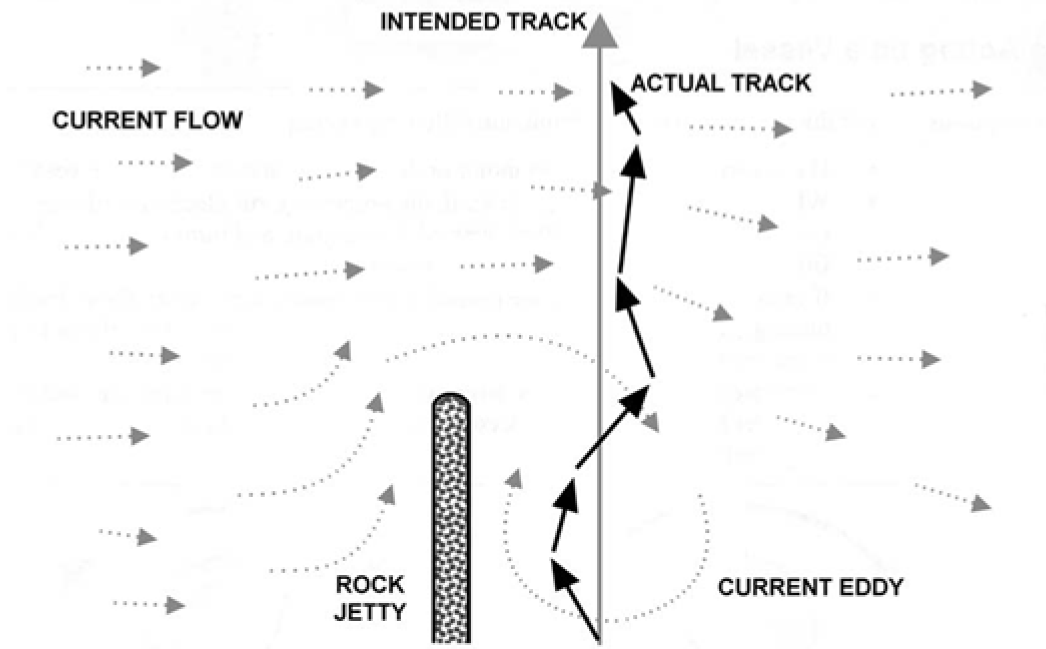


Figure 4-3 Effects of Current

PROPULSION AND STEERING

The key to powered vessel movement is the effective transfer of energy from the source of the power (an internal combustion engine) to the water through a mechanism that turns the engine's power into thrust. This thrust moves the boat. There must also be an element of directional control, both fore and aft, and from side to side.

Propulsion and steering are considered together here for two reasons. Applying thrust has no use if the vessel's direction cannot be controlled, and often the device providing the propulsion also provides the steering.

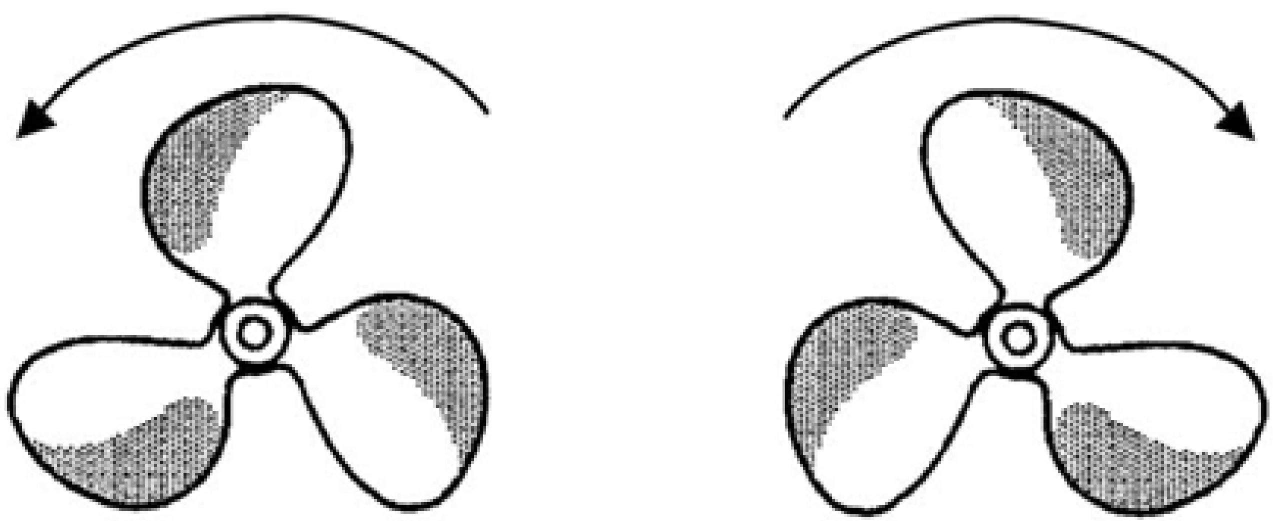
There are three common methods to transfer power and provide directional control:

- Rotating shaft and propeller with separate rudder ("inboard").
- A movable (steerable) combination as an outboard motor or stern drive.

- An engine-driven pump mechanism with directional control, called a waterjet.

All three arrangements have their advantages and disadvantages from the standpoint of mechanical efficiency, ease of maintenance, and vessel control. There is no single "best choice" for all applications. Regardless of which type you use, become familiar with how each operates and how the differences in operation affect vessel movement.

- If a vessel has a single-shaft motor or drive unit, it is mounted on the vessel's centerline.
- When applying thrust to go forward, the propeller turns clockwise (the top to the right or a "right-handed" propeller), viewed from astern, and turns counterclockwise viewed from astern when making thrust to go astern.
- If twin propulsion is used, the propeller to starboard operates as above (right-hand turning), while the port unit turns counterclockwise when making thrust to go forward when viewed from astern (left-hand turning). (see **Figure 4-4**)



VIEWED FROM ASTERN, TURNING FOR PROPULSION TO GO AHEAD. PROPELLER ON RIGHT (STARBOARD SHAFT) TURNS CLOCKWISE AND IS CALLED A RIGHT-HANDED PROPELLER. WHEN BACKING, ROTATION IS OPPOSITE.

Figure 4-4 Twin Propulsion

INBOARD ENGINES

Shaft

In small craft installations, the propeller shaft usually penetrates the bottom of the hull at an angle to the vessel's designed waterline and true horizontal. The practical reason for this is because the engine or marine gear must be inside the hull while the diameter of the

propeller must be outside and beneath the hull. Additionally, there must be a space between the propeller blade arc of rotation and the bottom of the hull. For single-screw vessels, the shaft is generally aligned to the centerline of the vessel. To finish the installation, the rudder is usually mounted directly astern of the propeller.
For twin-screw vessels, both shafts are parallel to the vessel's centerline, rudders are mounted astern of the propellers, and the rudders turn on vertical rudder posts.

Propeller Action
When rotating to move in a forward direction, a propeller draws its supply of water from every direction forward of and around the blades. Each blade's shape and pitch develop a low-pressure area on the forward face of the blade and a high-pressure area on the after face of the blades, forcing it in a stream toward the stern. This thrust, or dynamic pressure, along the propeller's rotation axis is transmitted through the shaft, moving the boat ahead as the propeller tries to move into the area of lower pressure.

Screw Current
Regardless of whether the propeller is turning to go ahead or astern, the water flow pattern into the propeller's arc of rotation is called suction screw current, and the thrust flow pattern out of the propeller is called discharge screw current. The discharge screw current will always be stronger and more concentrated than the suction screw current.

Side Force
In addition to the thrust along the shaft axis, another effect of propeller rotation is side force.

The important facts to know: for a right-handed screw turning ahead, the stern will tend to move to starboard (see **Figure 4-5**), and for a right-handed screw when backing, the stern will tend to move to port. For a left-handed screw (normally the port shaft on a twin-screw boat), the action is the opposite.
An easy way to remember how side force will push the stern is to think of the propeller as a wheel on the ground. As the wheel rolls clockwise, it moves to the right. As a propeller turns clockwise when viewed from astern, the stern moves to starboard.

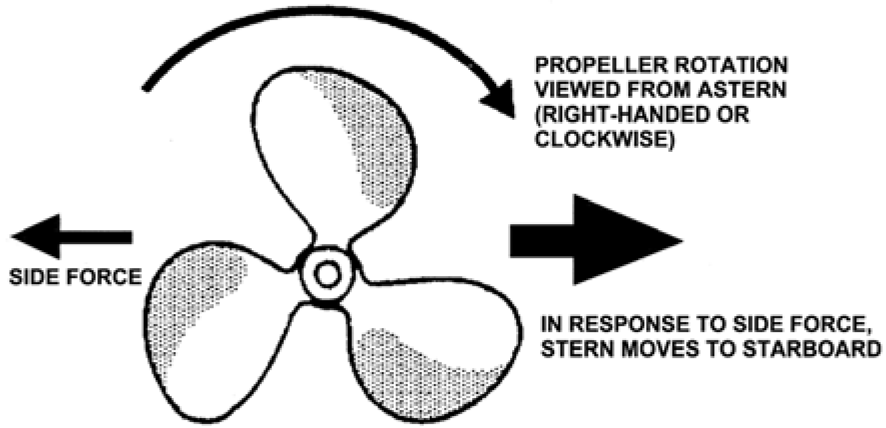


Figure 4-5 Side Force

Cavitation
Cavitation usually occurs when the propeller rotates at very high speed and a partial vacuum forms air bubbles at the tips of the propeller blades. Cavitation can also occur when trying to get a stopped propeller to spin at maximum speed, rapidly going from ahead to astern (or vice-versa), or by operating in aerated water where bubbles are dragged into the propeller flow.
Cavitation occurs more readily when trying to back, as the suction screw current draws water from behind the transom, and air at the waterline mixes with the water and is drawn into the propeller. Cavitation frequently occurs when backing with outboard motors. In this case, through-hub exhaust gas bubbles are also drawn forward into the propeller blade arc.

Rudder Action
When a vessel moves through the water (even without propulsion), the rudder is normally used to change the vessel's heading. As a hull moves forward and the rudder is held steady, amidships, pressure on either side of the rudder is relatively equal and the vessel will usually keep a straight track. When turning the rudder to port or starboard, pressure decreases on one side of the rudder and increases on the other. This force causes the vessel's stern to move to one side or the other. As noted above, because a vessel rotates about its pivot point, as the stern moves in one direction, the bow moves in the other direction.

The speed of the water flowing past the rudder greatly enhances the rudder's force. The thrust or screw discharge current from a propeller while operating ahead increases the water flow speed past the rudder. Also, while turning the rudder to a side, it directs about one-half of the propeller's thrust to that side, adding a major component of force to move the stern.
When operating astern, the rudder is in the screw suction current. The rudder cannot direct any propeller thrust, and since the screw suction current is neither as strong nor as concentrated as the screw discharge current, water flow past the rudder does not increase

as much. The combined effects of screw current and rudder force when operating astern are not nearly as effective as when operating ahead.
As rudder force is determined by water flow along it, a rudder loses some of its effectiveness if the propeller cavitates and aerated water flows along the rudder.

OUTBOARD MOTORS AND STERN DRIVES

Major Differences

Outboard motors and stern drives will be considered together, as both include a pivoting gear case and propeller drive unit (called a lower unit on an outboard). The difference between these drive arrangements and the "inboard" shaft/propeller/rudder arrangement is that the screw currents and thrust from an outboard or stern drive can be developed at an angle to the vessel centerline. Also, the point where thrust and steering are developed is usually aft of the vessel hull.

The lower unit contains drive gears, a spline connection, and on many set-ups, through-the-propeller hub exhaust. Both outboards and stern drives can usually direct thrust at up to 35° to 40° off the vessel centerline. Also, both types generally allow the coxswain some amount of trim control. Trim control adjusts the propeller axis angle with the horizontal or surface of the water.

The major difference in operation between the I/O and outboard is that the outboard motor, operating with a vertical crankshaft and driveshaft, develops a certain degree of rotational torque that could cause some degree of "pull" in the steering, usually when accelerating or in a sharp turn to starboard. If caught unaware, the coxswain could have difficulty stopping the turning action. The easiest way to overcome this torque-lock is to immediately reduce RPMs before trying to counter-steer.

Thrust and Directional Control

Outboards and stern drives have a small steering vane or skeg below the propeller. The housing above the gearcase (below the waterline) is generally foil shaped. Though these features help directional control, particularly at speed, the larger amount of steering force from an outboard or stern drive is based upon the ability to direct the screw discharge current thrust at an angle to the vessel's centerline. This directed thrust provides extremely effective directional control when powering ahead. When making way with no propeller RPMs, the lower unit and skeg are not as effective as a rudder in providing directional control.

Propeller Side Force

When backing, it is possible to direct outboard/outdrive thrust to move the stern to port or starboard. When backing with the unit hard over to port, propeller side force introduces an element of forward motion (see **Figure 4-5**), but can be countered through less helm. When backing to starboard, the side force tends to cause an element of astern motion and also tries to offset the initial starboard movement. Many lower units are fitted with a small vertical vane, slightly offset from centerline, directly above and astern of the propeller. This vane also acts to counter side force, particularly at higher speeds.

Vertical Thrust

Outboards and stern drive usually allow a level of vertical thrust control. Trim controls the angle of attack between the propeller's axis of rotation and both the vessel waterline and the surface of the water. Vertical thrust control, especially applied aft of the transom, changes the attitude the vessel hull will take to the water. (see **Figure 4-6**) Small amounts of trim should be used to offset for extreme loading conditions or to adjust how the vessel goes through chop.

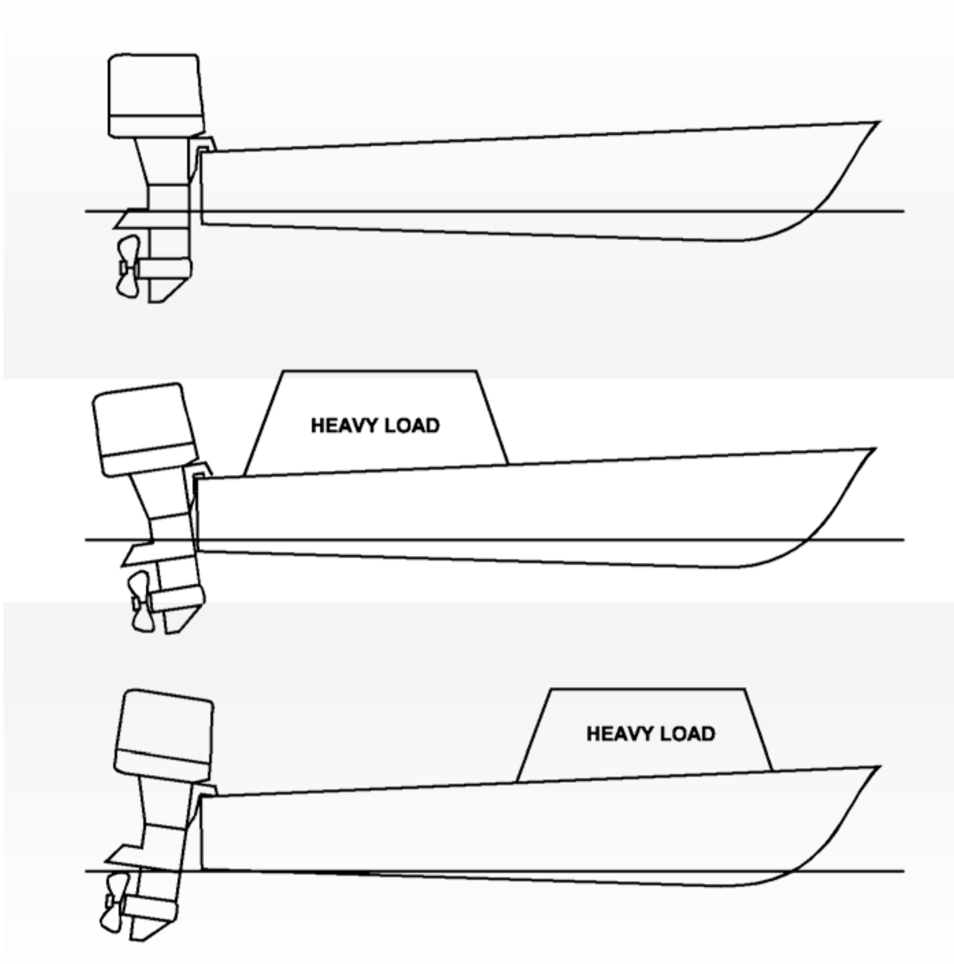


Figure 4-6 Trim to Offset Loading Condition

In addition to trim, a vertical component of thrust develops in another situation. Depending on the type of hull, if a vessel is forced into an extremely tight turn with power applied, thrust is directed sideways while the vessel heels, actually trying to force the transom up out of the water, causing a turn to tighten even more.

Cavitation
As noted earlier, cavitation frequently occurs when backing with outboard motors. As through-hub exhaust gas bubbles are drawn forward into the propeller blade arc, the aerated water increases the possibility of cavitation. Though outboards and stern-drives are fitted with an anti-cavitation plate above the propeller, the coxswain should always take care to limit cavitation, particularly when backing or maneuvering using large amounts of throttle.

WATERJETS

Operation
A waterjet is an engine-driven impeller mounted in a housing. The impeller draws water in and forces it out through a nozzle. The suction (inlet) side of the waterjet is forward of the nozzle, usually mounted at the deepest draft near the after sections of the hull. The discharge nozzle is mounted low in the hull, exiting through the transom. The cross-sectional area of the inlet is much larger than that of the nozzle. The volume of water entering the inlet is the same as being discharged through the nozzle, so the water flow is much stronger at the nozzle than at the intake. This pump-drive system is strictly a directed-thrust drive arrangement. A waterjet normally has no appendages, nor does it extend below the bottom of the vessel hull, allowing for operation in very shallow water.

Thrust and Directional Control
Vessel control is through the nozzle-directed thrust. To attain forward motion, the thrust exits directly astern. For turning, the nozzle pivots (as a stern drive) to provide a transverse thrust component that moves the stern. For astern motion, a bucket-like deflector drops down behind the nozzle and directs the thrust forward. Some waterjet applications include trim control as with a stern drive or outboard. With this, thrust can be directed slightly upward or downward to offset vessel loading or improve ride. If a waterjet craft is proceeding at high speed, power brought down quickly to neutral, and the helm put over, no turning action will occur. Of the three drive arrangements discussed; the waterjet alone has no directional control when there is no power.

No Side Force
Since the waterjet impeller is fully enclosed in the pump-drive housing, no propeller side force is generated. The only way to move the stern to port or starboard is by using the directed thrust.
Waterjet impeller blades revolve at an extremely high speed. A much higher degree of cavitation normally occurs than associated with external propellers without a loss of effective thrust. In fact, a telltale indicator of waterjet propulsion is a pronounced aerated, water discharge frequently seen as a rooster tail astern of such craft.

Cavitation
As the impeller rotation does not change with thrust direction, frequent shifting from ahead to astern motion does not induce cavitation. However, as the thrust to make astern motion

reaches the waterjet inlet, the aerated water is drawn into the jet, causing some reduction of effective thrust. As with all types of propulsion, slowing the impeller until clear of the aerated water reduces cavitation effects.

BASIC MANEUVERING

When going from the *ahead* position to the *astern* position, and when going from the *astern* position to the *ahead* position, pause briefly at the *neutral* position.

Moving Forward in a Straight Line

When moving forward in a straight line, throttle should be advanced gradually and firmly. If the vessel is single-screw, outboard, or outdrive, propeller side force will tend to move the stern slightly to starboard. (see **Figure 4-7**) The side force should be offset with slight starboard helm. If twin-engine, throttles should be advanced together. The vessel should not yaw in either direction if power is applied evenly. Engine RPMs should be checked so both engines turn at the same speed. Some vessels have a separate indicator to show if engine RPMs match, but also compare tachometer readings.

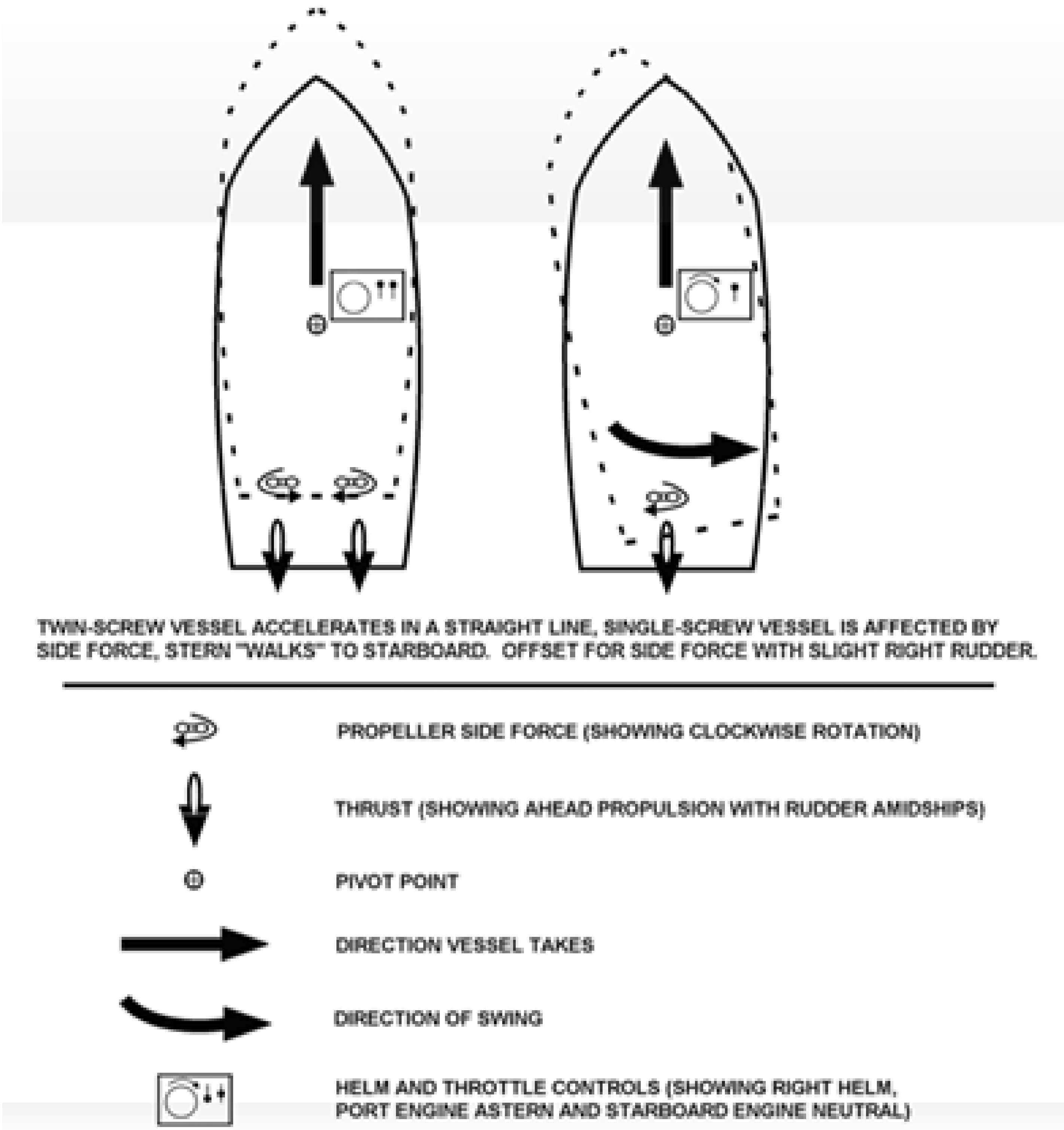
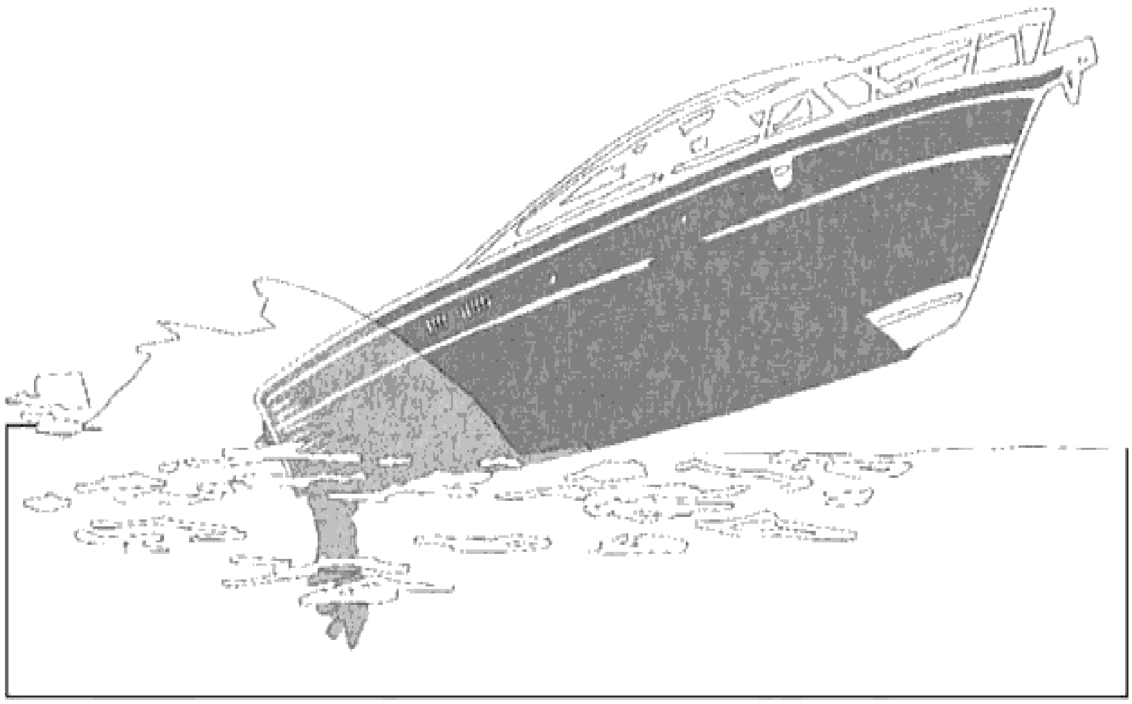


Figure 4-7 Accelerated Ahead



EXCESSIVE POWER APPLIED CAUSES STERN TO SQUAT. LARGE STERN WAVE AND RAISED BOW RESULT. COXSWAIN LOSES FORWARD VISIBILITY UNTIL CRAFT ATTAINS PLANING MODE.

Figure 4-8 Pronounced Squat on Acceleration

Direction Control
Small amounts of helm should be used to offset any propeller side force or the effects of winds and seas. Compass course should always be noted and corrected frequently to stay on course. It is important to develop a practiced eye and steer on a geographic point or range such as a point between buoys. Small, early helm corrections should be applied to stay on course, rather than large corrections after becoming well off course. Oversteering, leaving a snake-like path, should be avoided. At low speeds, helm correction will be more frequent and require more rudder than at higher speeds.

Planing
For planing or semi-displacement hulls, the boat will gradually gain speed until planing. If fitted with trim control (including trim tabs on inboard boats), slight, bow-down trim may lessen the amount of time needed to get on plane or "on step."

Appropriate Speed
Running at full speed all of the time should be avoided. This wastes fuel and can cause excessive wear on the boat and crew. Many vessels will not exceed or will only marginally exceed a given speed, regardless of the power applied. At some point, the only effect of

applying additional throttle is increased fuel consumption with no speed increase. Finding a speed that offers a comfortable ride as well as allows mission completion is advised.

Safe Speed
A boat at high speed has a large amount of force. With an untrained operator, this force can be dangerous. The following different factors should be considered to determine safe speed.

High seas	Slow down as winds and seas increase; the boat will handle more easily. Pounding or becoming airborne fatigues the hull and could injure the crew or cause them chronic skeletal problems. Minimize taking spray and water on deck.
Traffic density	Do not use high speed in high traffic density areas. A safe speed allows response to developing situations and minimizes risk of collision, not only with the nearest approaching vessel, but with others around it.
Visibility	If conditions make it difficult to see, slow down. Fog, rain, and snow are obvious limits to visibility, but there are others. Geographic features and obstructions (river bends, piers, bridges and causeways), along with heavy vessel traffic, can limit the view of “the big picture.” Darkness or steering directly into the sun lessens ability to see objects or judge distances. Prevent spray on the windscreen (particularly salt spray or freezing spray) as much as possible and clean it regularly. Spray build-up on the windscreen is particularly hazardous in darkness or in glare.
Shoal waters	In shallow water, the bottom has an effect on the movement of the vessel. Slow down in shallow water. In extremely shallow water, the vessel’s stern tends to “squat” and actually moves closer to the bottom.

Bank Cushion and Bank Suction
In extremely narrow channels, a vessel moving through the water will cause the “wedge” of water between the bow and the nearer bank to build up higher than on the other side. This bank cushion tends to push the bow away from the edge of the channel.
As the stern moves along, screw suction and the movement of water to “fill-in” where the boat was creates bank suction. This causes the stern to move towards the bank. The combined effect of momentary bank cushion and bank suction may cause a sudden shear toward the opposite bank. Bank cushion and bank suction are strongest when the bank of a channel is steep. They are weakest when the edge of the channel shoals gradually and extends in a large shallow area. When possible, a trainee should stay exactly in the center of an extremely narrow channel to avoid these forces. (see **Figure 4-9**) Slower speed also reduces the amount of cushion and suction. Some rudder offset towards the closer bank will help to avoid continuous cushion and suction effects by.

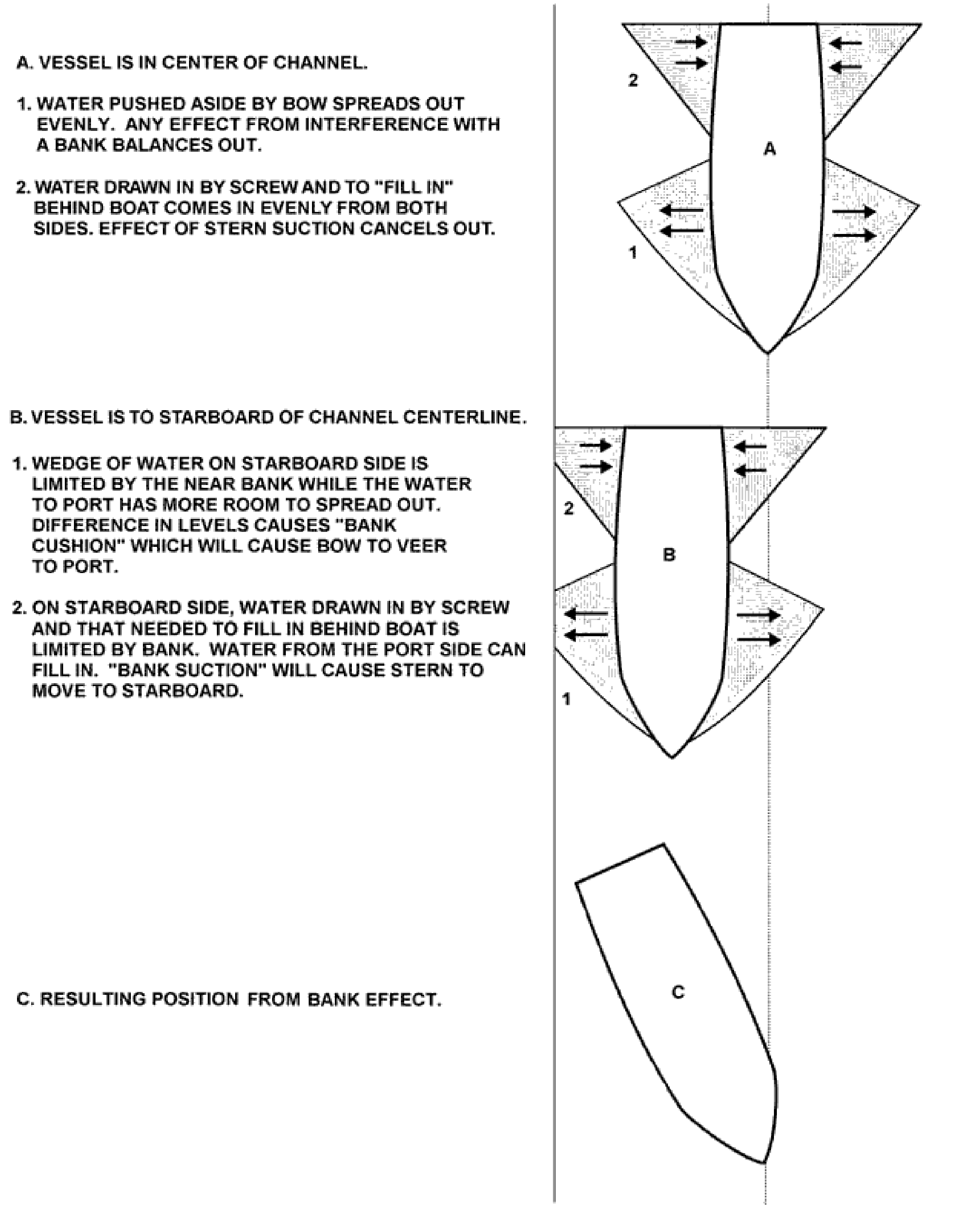


Figure 4-9 Bank Cushion and Bank Suction

Bow Cushion and Stern Suction

When meeting another vessel close aboard, bow cushion and stern suction occur between the vessels much the same as bank cushion and suction. Helm corrections should be used to compensate. As both vessels move through the water, the combined effect is greater than what a single vessel encounters from bank interaction. Caution should be used so the bow does not veer too far from the intended track and the stern swings into the path of the other vessel.

A port-to-port meeting situation is assumed. Before vessels are bow-to-bow, a small amount of right rudder should be used to ensure the bow is clear. The bow cushion will increase separation. As the vessels near bow-to-beam, using left rudder will enable the vessel to keep away from the right-hand bank and to stay parallel to the channel. When the vessels are bow-to-quarter, the bow cushion will be offset by the stern suction, and bank cushion may need to be offset by some right rudder. Finally, as the vessels are quarter-to-quarter, stern suction will predominate, and will require left rudder to keep the sterns apart.

Wake Awareness

As a vessel proceeds, a combination of bow and stern waves move outward at an angle to the vessel track. The wake height and speed depend on vessel speed and hull type. Relatively large, semi-displacement hulls, proceeding at cruising speed, cause some of the largest wakes. Some lighter craft actually make less wake at top speed in the planing mode rather than at a slower speed. Displacement craft make the largest wake at hull speed. The coxswain should determine how to make the vessel leave the least wake; it might require slowing appreciably.

All vessels are responsible for their wake and any injury or damage it might cause. Only an unaware coxswain trails a large wake through a mooring area or shallows, tossing vessels and straining moorings. A large, unnecessary wake, particularly in enclosed waters or near other smaller vessels, ruins the credibility of a professional image.

In New York State, there are many designated “No Wake Zones.” When determining proper speed through a No Wake Zone, the coxswain must actually look at the wake of their own boat. “No Wake” means no wake. Typically, boat speed is 5MPH or less.

Pivot Point

The pivot point is the center of the turning circle, or the point around which the boat pivots. The direction of the bow may be changed by moving the stern in the opposite direction. As the stern swings a certain angle, the bow swings the same angle. Depending on the fore and aft position of the pivot point, the stern could swing through a larger distance than the bow, at the same angle. When a hull moves forward through the water, the effective pivot point moves forward. The higher the forward speed, the farther the pivot point moves forward.

Propulsion Type and Turning

Because outboards, stern drives, and waterjets use propulsion thrust for directional control, they can make a much tighter turn (using helm alone) with a given hull shape than if the same hull had shaft, propeller, and rudder. With extended outboard mounting brackets, the directed, lower-unit thrust is farthest aft of the pivot point compared to other configurations. The location aft of the pivot point, along with the amount of directed thrust determines how much the stern will kick away from the direction of the turn. With directed thrust, the stern will usually skid outward more than with shaft, propeller and rudder, making the bow describe a very tight arc. (see **Figure 4-10**)

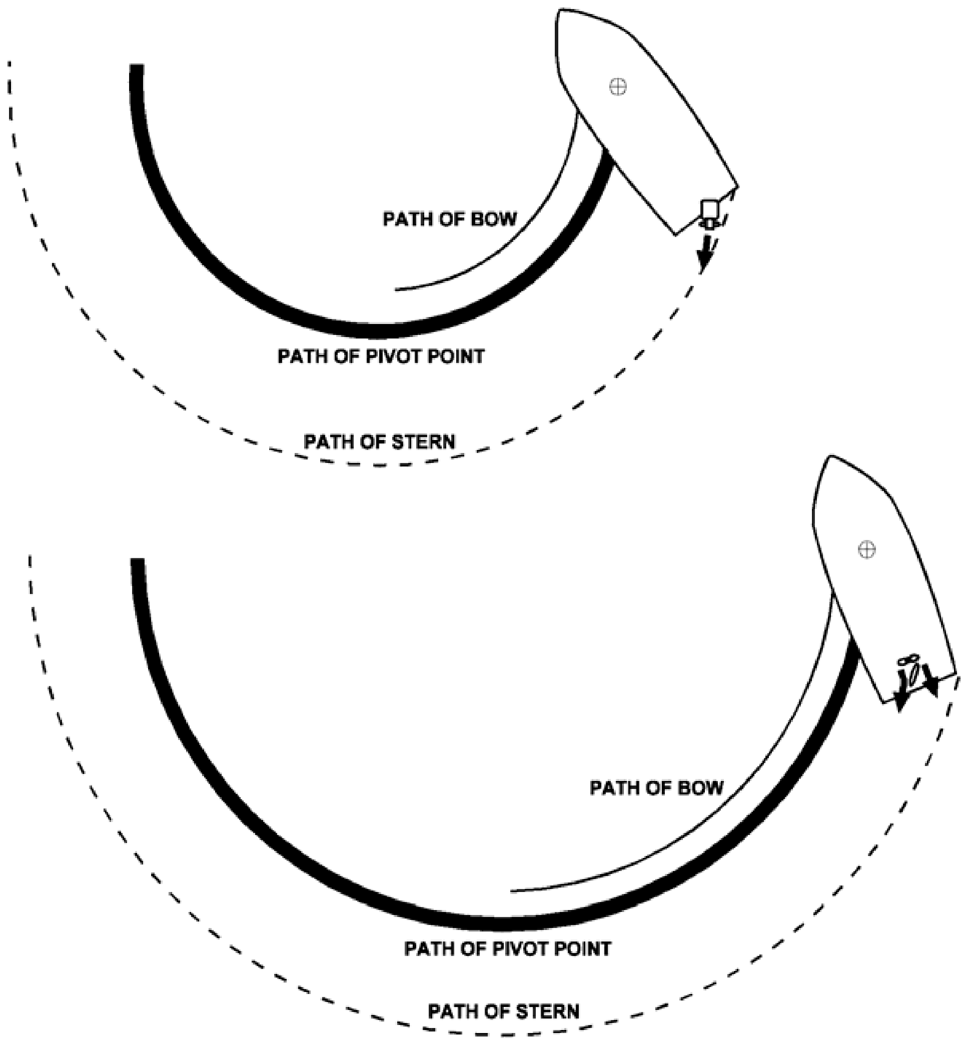


Figure 4-10 Pivot Point, Skid, Kick, Inboard vs. Outboard

VESSEL'S TURNING CHARACTERISTICS

When proceeding on a steady heading, putting the helm over to one side or the other, begins to turn the boat. Up to the time the boat turns through 90°, the boat has continued to **advance** in the original direction. By the time the boat has turned through 90°, it is well off to the side of the original track. This distance is **transfer**. As the boat continues through 180°, its path has defined its tactical diameter. If the vessel holds the turn through 360°, the distance it takes to reach the point where it first put the helm is referred to as its final diameter. For a particular vessel, these values vary for speed and rudder angle. (see **Figure 4-11**)

Developing a working knowledge of the vessel's turning characteristics will enable decision-making such as whether to make a particular maneuver in a certain space solely with the helm or whether other maneuvering tactics are needed. Learning when to ease the helm will help to prevent oversteering a course.

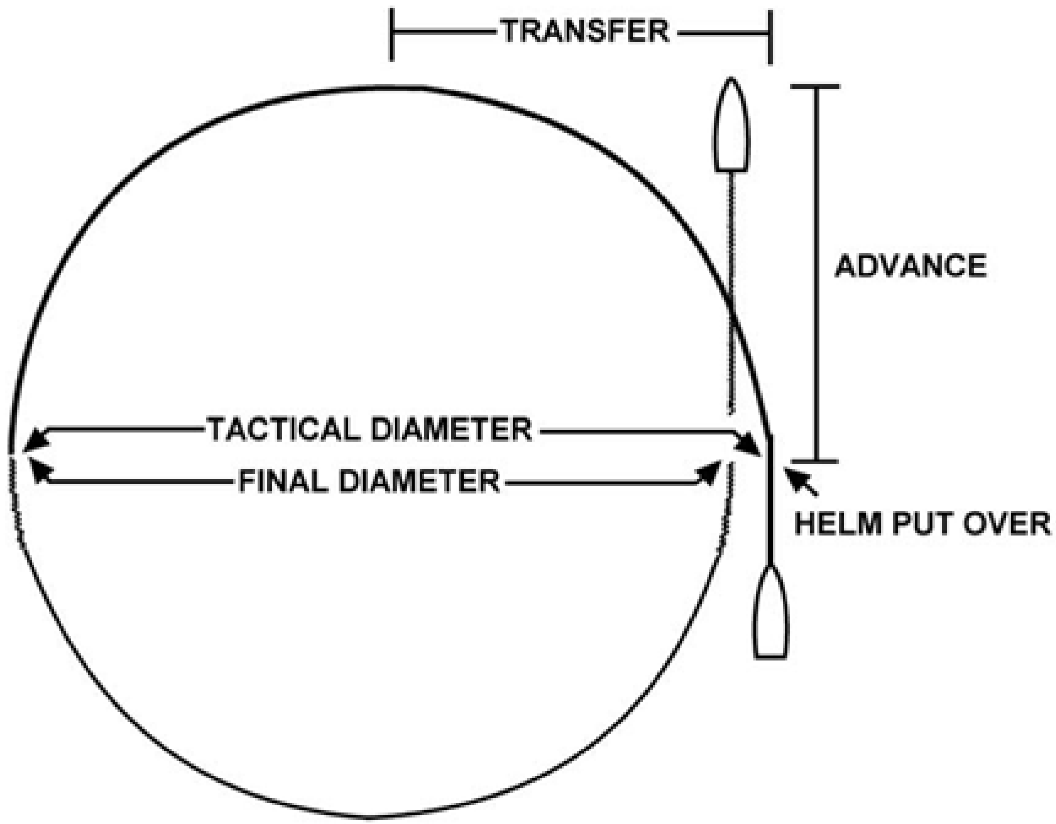


Figure 4-11 Turning Characteristics

Loss of Speed
Some planing hulls and most semi-displacement craft will slow appreciably when turning at high speeds. As the boat heels into a turn, the hull provides less buoyancy to keep the vessel on plane at a given speed. Also, as the aft part of the hull skids across the water while in a heel, it presents a flat shape in the original direction of movement and pushes water outward. The bottom becomes a braking surface.

Making Course Changes and Turns in Channels
Bank suction, bank cushion, and currents will all affect a boat navigating a sharp bend in a narrow channel. Where natural waterways have bends or turns, the water is always deepest and the current is always strongest on the outside of the bend. This happens because the water flow has a great degree of momentum and resists having its direction changed. As it strikes the outside of the bank, it erodes the earth and carries the particles with it. The

particles fall out farther downstream in areas of less current (the inside of a turn or bend) and cause shoaling.

Because bank cushion and suction are strongest when the bank of a channel is steep and weakest when the edge of the channel shoals gradually, bank effect is stronger on the outside of bends or turns. The coxswain should be aware of the mix of current and bank effect and use these forces to the fullest extent.

Stopping the Boat

Pulling back the throttle to *neutral* will cause the vessel to begin to lose forward motion. For a heavy-displacement vessel, once propulsion is stopped, the vessel will continue to move forward for some distance. The vessel carries its momentum without propulsion. For a semi-displacement hull or planing hull, retarding the throttle and reduce power will cause the boat to quickly come off plane. As the vessel reverts to displacement mode, the resistance of the hull going through the water instead of on top of the water slows the boat. The vessel still carries some way, but at only a fraction of the original speed.

Using Astern Propulsion to Stop the Vessel

Slowing the vessel's forward movement is not always enough. In an emergency situation, a complete and quick stop to dead-in-the-water or crash stop may be required. This is done by applying astern propulsion while still making forward way. The first step is to slow the vessel by retarding throttle. After the vessel begins to lose way, astern propulsion should be applied firmly and forcefully. Power must be higher than that available at clutch speed to prevent engine stall. On a single-screw vessel, the stern will want to swing to port. After all way is off, the throttle should be placed in *neutral*.

At low forward speeds, astern propulsion is frequently used to maneuver, both to check forward way and to gain sternway.

With a waterjet, reverse thrust is immediate. There is no marine gear or drive unit that requires the shaft and propeller to change rotation directions. The clamshell or bucket-shaped deflector plate drops down and redirects thrust forward. As with other drives, enough astern engine power should be used to overcome potential engine stall.

Though many vessels are tested and capable of immediately going from full speed ahead to full reverse throttle, this crash stop technique is extremely harsh on the drive train and may cause engine stall. Though much of the power goes to propeller cavitation, this technique can be effective in an emergency.

Backing the Vessel

Control while making sternway is essential. Because vessels are designed to go forward, many vessels do not easily back in a straight line. Due to higher freeboard and superstructure forward (increased sail area), many vessels back into the wind. Knowledge of how environmental forces affect a boat is critical when backing.

Besides watching where the stern goes, the coxswain should keep track of the bow. The stern will move one direction and the bow the other direction around the pivot point. As a vessel develops sternway, the apparent pivot point moves aft and the bow may swing through a greater distance. Firm control of the helm should be maintained to prevent the rudder or drive from swinging to a hard-over angle.

Outboards

Use the directed thrust to pull the stern to one side or the other. As the power is applied aft of the transom use care to keep the bow from falling off course due to winds, avoiding cavitation that can easily occur when backing with a lower unit. Propeller side force is present, but is offset through helm. A lower unit that is not providing thrust is not efficient when trying to steer while backing. It is better to keep steady, slow RPMs than to vary between high power and *neutral*.

Single-Outboard	For single-outboard/outdrive, propeller side force is offset by turning the helm slightly to the right. Astern power is then applied gradually, but care should be taken not to cause propeller cavitation.
Twin-Outboard	If astern power is matched, propeller side forces will cancel. As with twin inboards, offsetting any stern swing with helm should be attempted before using asymmetric power. If less thrust than that provided by both drives at clutch speed is needed, one motor or engine should be used. This will keep speed low but will keep thrust available for steering, rather than shifting one or both engines from *reverse* to *neutral*. If using one unit, compensate with helm for propeller side force and the increased, off-centered drag caused by the other lower unit.

Waterjets

There is no propeller side force and thrust is directed as with an outboard. Going from *forward* to *reverse* thrust has no marine gear or drive train to slow things. Thrust is simply redirected with the "bucket." Unless thrust is applied and being directed, there is no directional control at all. The power must be on and applied to steer either *forward* or in *reverse*.

USING ASYMMETRIC OR OPPOSED PROPULSION (TWIN-SCREW THEORY)

The techniques presented here are methods of maneuvering that capitalize on twin-engine vessel capability to differ the amount or direction of thrust produced by the two engines. Any difference in thrust affects the boat's heading. The amount of this difference can vary from that needed to hold a course at cruising speed to turning a boat 360° in its own length by opposing propulsion (splitting throttles). The concept of asymmetric or opposed propulsion can be likened to "twisting" the boat, but the forces and fundamentals discussed earlier still apply and affect vessel response. Pivot point, propeller side force, and turning characteristics remain important. Because the drives are offset from vessel centerline on a twin-engine vessel, they apply a turning moment to the hull.

PERFORMING SINGLE-SCREW COMPOUND MANEUVERING (SINGLE-SCREW THEORY)

Back and Fill (Casting)

The back and fill technique, also known as casting, provides a method to turn a vessel in little more than its own length. To back and fill, the coxswain should rely on the tendency of a vessel to back to port, and then use the rudder to direct thrust when powering ahead to starboard.

Maneuvering to or from a Dock

The most challenging and probably most frequent maneuvering encountered is that associated with getting in and out of slips, dock areas, piers, boat basins or marinas. When maneuvering to or from a dock, the following points in mind.

Step	Procedure
1	Check the conditions before maneuvering. Always take advantage of wind and current when docking or mooring. To maintain best control, approach against the wind and current and moor on the leeward side of a mooring when possible. Chances are that when mooring, conditions are not the same as when getting underway.
2	Rig and lead mooring lines and fenders well before the approach. Have everything ready on deck before the coxswain must concentrate and maneuver to the dock.
3	Emphasize control, not speed, when docking. Keep just enough headway or sternway to counteract the winds and currents and allow steerage while making progress to the dock. Keep an eye on the amount of stern or bow swing. With a high foredeck, the wind can cause the bow to swing much easier, making it harder to control. In higher winds, a greater amount of maneuvering speed may be needed to lessen the time exposed to the winds and currents, but be careful not to overdo it.

MANEUVERING TO/FROM DOCK

Often, the presence of other craft or obstructions will complicate the clearing of a berth, or any simple maneuver. Wind and/or current can also become a factor. Before maneuvering, the options should be evaluated in order to take full advantage of the prevailing conditions.

Clearing a Slip

Clearing a slip assumes that there is no wind or current, and that the vessel is a single-screw. (see **Figure 4-12**)

Step	Procedure
1	Set rudder amidships.
2	Apply slight right rudder to offset propeller side force.
3	Use throttle and move ahead slowly (b).
4	As the boat gains headway, apply additional helm to turn (c). Remember that the rudder causes the stern to swing in the opposite direction of the bow around the pivot point. Before starting a turn, make sure the stern will clear the pier.

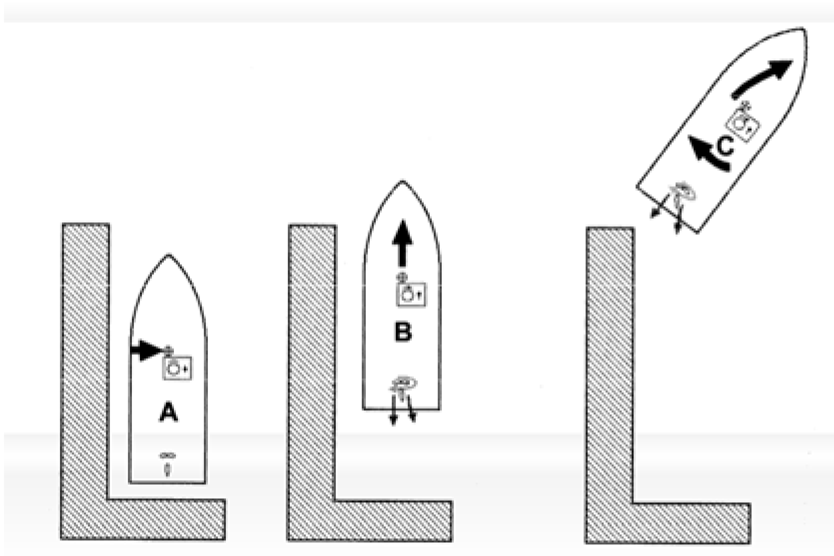


Figure 4-12 Clearing a Slip (No Wind or Current, Single-Screw)

Backing into a Slip
Backing into a slip assumes that there is no wind or current and the vessel is a single-screw, outboard or I/O. (see **Figure 4-13**)

Step	Procedure
1	Approach at low speed, perpendicular to slip, approximately one-half to one boat-length away.
2	As the amidships section is even with the nearest edge of the slip, apply hard left rudder and "bump" throttle ahead to swing the stern to starboard.
3	As bow swings to port, go to neutral throttle and aim lower unit at the back corner of the slip. Immediately apply astern throttle to stop headway and acquire sternway. Side force will stop swing.
4	Steer lower unit towards slip, just aft of desired final position, offsetting for side force as necessary, using astern clutch speed and neutral to keep speed down.
5	When almost alongside, apply slight left rudder and "bump" throttle ahead, then go to neutral.

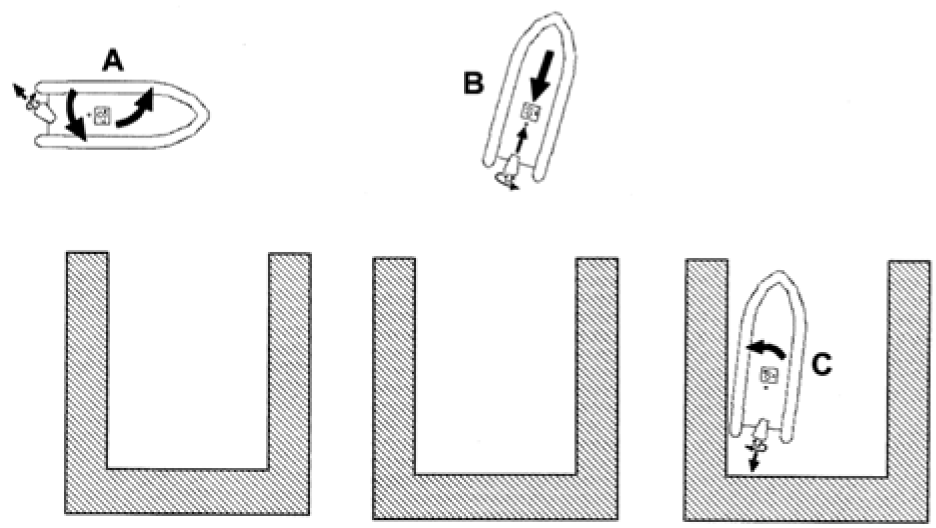


Figure 4-13 Backing Into a Slip (No Wind or Current, Single Outboard/Stern Drive)

Identifying Mooring Lines
Before using mooring lines to help maneuver at the dock, crewmembers need to first know their names and what they do (see **Figure 4-14**):

- The bow line (#1) and stern line (#4) are used to keep the vessel secured to the dock.
- The after bows spring (#2) and forward quarter spring (#3) are used to keep the vessel from surging forward or aft at the dock.

Normally, only these four lines are required when mooring. During times of foul weather, breast lines (#5) may be used to provide additional holding strength. Fenders should be used at strategic points along the hull to prevent chafing against the dock or float.

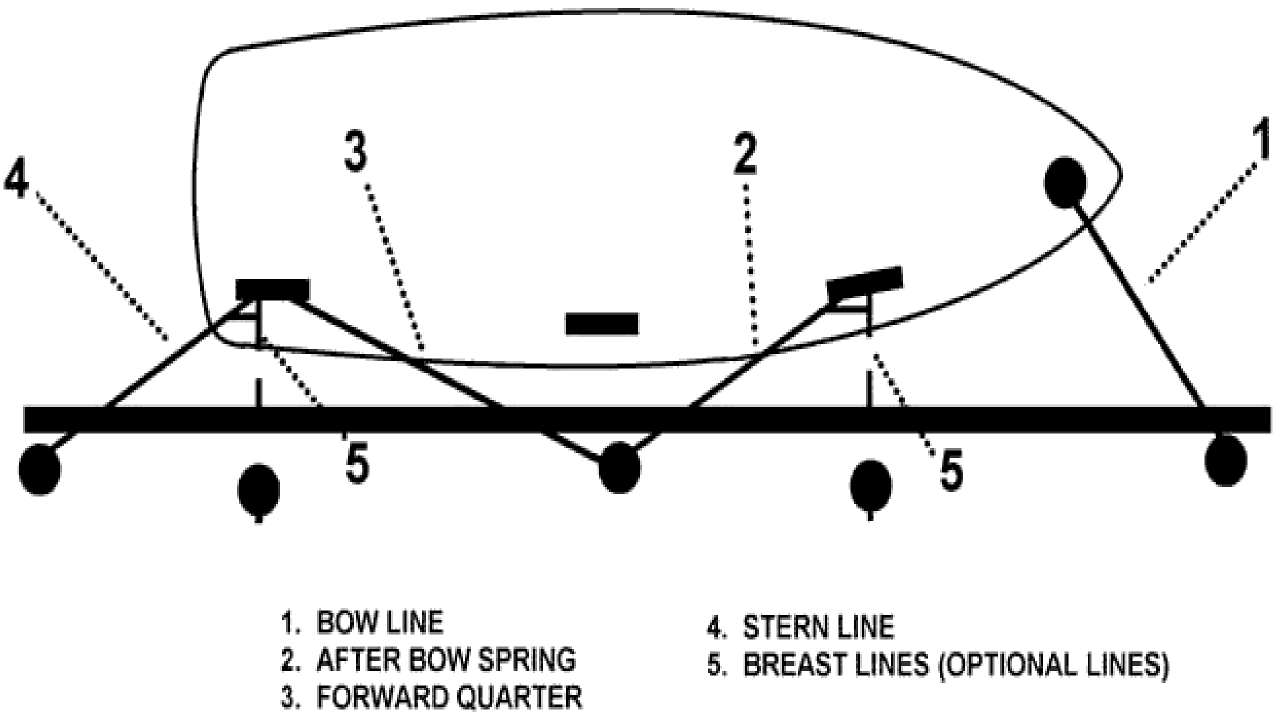


Figure 4-14 Mooring Lines

Using Spring Lines

If it becomes necessary to hold position alongside a dock, but swing the bow or stern out in order to clear another vessel or obstacle, using a spring line can help to accomplish this.

The forward quarter spring, or stern spring (#3) should be used to "spring out" or move the bow away from the dock. By backing down on a boat's engine with just the forward quarter spring attached to the dock, the bow will move away from the dock.

The after bow spring, or bow spring (#2) should be used to "spring out" or move the stern away from the dock. The stern will move away with the rudder full toward the dock and the engines ahead. With the rudder turned the other direction or away from the dock, the stern will move towards the dock or "spring in". (see **Figure 4-15**)

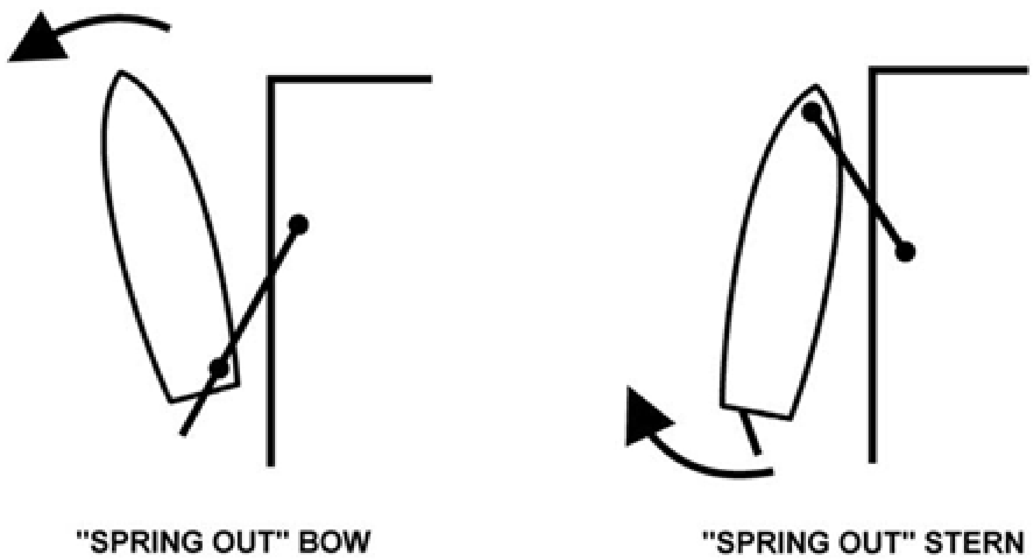


Figure 4-15 Basic Spring Line Maneuvers

Ensure there is adequate and properly placed fenders between the boat and the dock before attempting a spring maneuver.

Rigging Mooring Lines to “Slip”

Knowing how to rig mooring lines to “slip” can be helpful, particularly when no shore-side line handlers are available. Both bitter ends should be aboard the boat with a bight around the shore-side attachment point. Then the spring line may be let go, or cast off, releasing one end and hauling in the other. A spring line should be carefully tended so that it does not foul the rudder or screw or get caught on the dock. When maneuvering, a line tied to a bitt or cleat should always be watched and never left unattended.

Rules of Thumb

The following rules of thumb should be adhered to when maneuvering to or from a dock.

Slow Speeds	On single-screw vessels maneuvering at slow speeds alongside another object, the coxswain should use full left (or right) rudders for better maneuverability. On twin-screw boats, the coxswain should leave the rudders amidships and use the engines at *clutch* (*idle*) speed to maneuver.
Alongside	When maneuvering alongside, speed should be kept to a minimum. Power should be applied in short bursts (with rudder at left or right full for single-screw boats) to get changes in heading; but the bursts should be kept short enough so as not to increase speed.
Port Side	Port side moorings are the easiest for single-screw boats with “right-hand” props.
Backing and Filling	Slow speed maneuvers to starboard are best for single-screw boats with “right-hand” props in restricted areas.

Precise Control	When requiring precise control, the boat's heading should be kept into the predominate wind or current, or as close as possible. The boat should be maneuvered so that the set from the wind or current is either on the starboard or port bow allowing the boat to "crab" (move sideways) in the opposite direction.
Wind and Current	Wind and current are the most important forces to consider in maneuvering. The operator should use them to their advantage, if possible, rather than attempting to fight the elements.
Spring Lines	Spring lines are very useful when mooring with an off-dock set or when unmooring with an on-dock set. The spring lines should be used to spring either the bow or stern in or out. (See **Figure 4-16** and **Figure 4-17**).
Thrusting Away from Another Boat	To thrust away from another boat, a camel, or a ship, the coxswain should use the prop wash or "screw knuckle." By applying full power astern in a short burst then returning to *neutral*, the prop wash will move forward between the boat and the surface alongside, pushing the boat away.
Fenders	The coxswain should never attempt to fend a boat off a pier, float, etc., by hand or by foot, but should always use a fender. The proper sized fenders should be kept at hand.
Mooring/ Off-Dock Wind	When mooring with an off-dock wind, the approach should be made at a sharp angle - 45° or more.
Mooring/On-Dock Wind	When mooring with an on-dock wind, the approach should be made parallel with the intended berth and the fender should be rigged in appropriate positions. The coxswain should ensure that the boat has no fore and aft movement when contacting the dock.
Tying Down	Except for using the forward quarter spring, (see **Figure 10-19**) the stern of a boat should never be tied down while maneuvering beside a dock. This restricts maneuverability.
Pivot Point	The pivot point of a boat is approximately one-third of the way aft of the bow when the boat is underway at standard speed. This point moves forward as speed is increased and aft as speed is decreased.
Protecting the Stern	The stern should be kept away from danger. If propellers and rudder become damaged, the boat is crippled. If the stern is free to maneuver, usually the boat can be worked out of trouble.
Controlling the Boat	The greatest amount of control over the boat is gained by maneuvering into the prevailing face of the wind or sea. Boats turn more slowly into the wind and sea than away from them. A single-screw boat will generally back into the wind when the boat has more "sail" area forward of the boat's pivot point than aft.

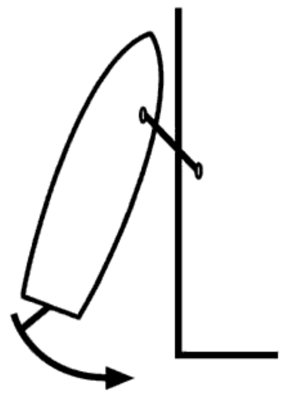


Figure 4-16 Going Ahead With Left Rudder Use of Spring Line

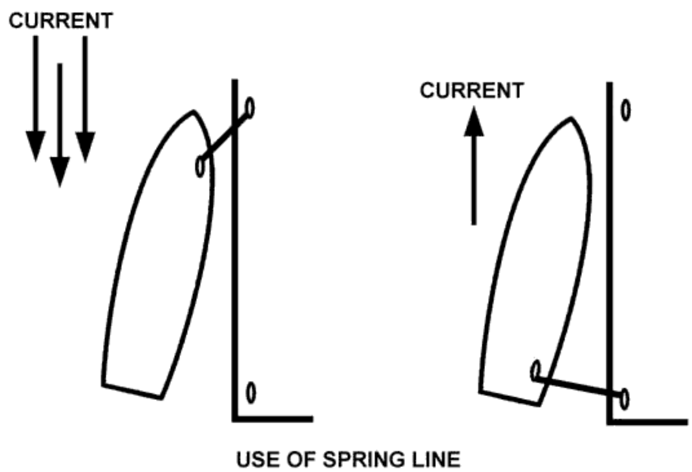


Figure 4-17 Making Use of Current

MANEUVERING ALONGSIDE ANOTHER VESSEL

When determining approach, the following conditions should be considered:

- Prevailing weather.
- Currents.
- Location.
- Vessel conditions.
- Vessel sizes.
- Traffic density.
- The coxswain should discuss intentions with the other vessel's master.

Approach From Leeward and Astern

A large vessel will create a wind shadow and block most of the seas allowing a smoother approach on the leeward side of a vessel. When approaching smaller vessels, the coxswain should first determine the smaller vessel's rate of drift. The coxswain can then determine if an approach on the leeward side (better control over approach) or windward side (a wind shadow will be created) would be better.

Contacting and Closing In

After completing approach preparations, the coxswain should go alongside and determine where to make contact on both vessels. Perform the following procedures to close in on another vessel:

Step	Procedure
1	Conditions permitting, match speed to the other vessel, and then start closing in from the side.
2	Close at a 15° to 30° angle to the other vessel's heading. This should provide a comfortable rate of lateral closure at no more than one-half the forward speed.

ANCHORING

Anchor Types

There are different types of anchors with specific advantages of each type. The type of anchor and size (weight) of anchor a boat uses depends upon the size of the boat. A working, or service anchor should have the holding power equal to approximately 6% of the boat's displacement.

Danforth Anchor

Most small boats use a Danforth type anchor because of their excellent holding strength compared to their overall weight, it is described below (see **Figure 4-18):**

Part #	Part Name	Description
1	**Shank**	Aids in setting and weighing the anchor. Attachment point for the anchor line.
2	**Flukes**	Dig in the bottom and bury the anchor, providing holding power.
3	**Crown**	Lifts the rear of the flukes, and forces the flukes into the bottom.
4	**Stock**	Prevents the anchor from rolling or rotating

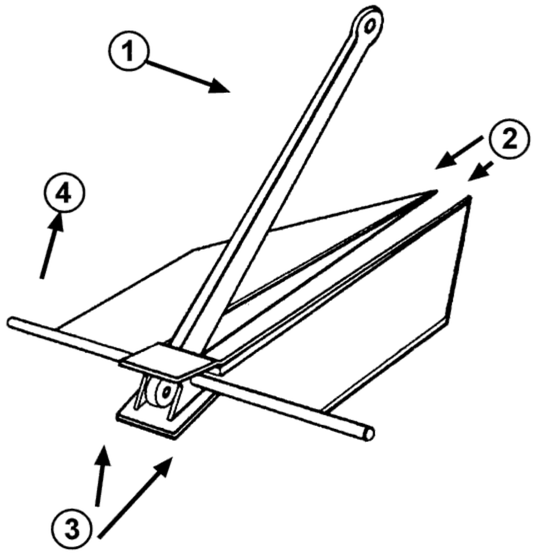


Figure 4-18 Main Parts of a Danforth Anchor

Ground Tackle
The complete anchor system consists of the anchor, the rode, and the various fittings connecting the rode to the anchor.

Anchor Rode
The rode is the line from the boat to the anchor and is usually made up of a length of line plus a short length of chain.

Nylon and Chain
Chain added with the rode has several advantages:

- Lowers the angle of pull (the chain tends to lie on the bottom).
- Helps to prevent chafing of the line on a coral or rocky bottom.
- Sand has less chance to penetrate strands of the fiber line higher up.
- Sand does not stick to the chain.
- Mud is easily washed off.

Precautions for Selecting Anchorage Area
Sometimes it may be possible to choose a sheltered anchorage area in shallow water (40' or less).

- Check charts to ensure that the anchorage area avoids any submerged cables or other obstructions.
- If other boats are in the same area, be careful not to anchor too close to another vessel.
- Never drop within the swing area of another boat. (see **Figure 4-19**)
- Always approach the anchorage into the wind or current. (see **Figure 4-20**)

- Never anchor by the stern especially with small boats. Weather and seas may swamp the craft.

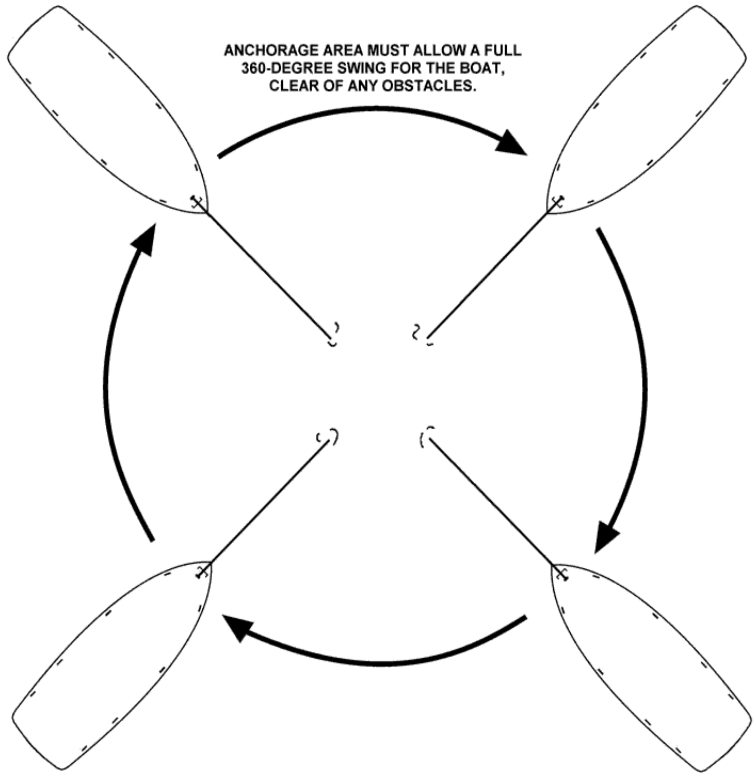


Figure 4-19 Anchorage Swing Area

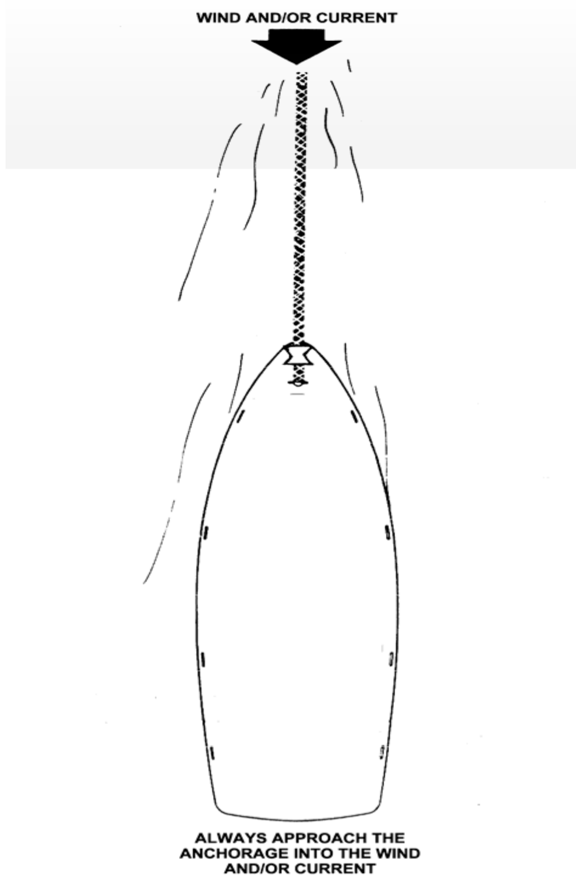


Figure 4-20 Approaching an Anchorage

Approaching the Anchorage
Having selected a suitable spot, the coxswain should run in slowly, preferably on some range ashore selected from marks identified on the chart, or referring to the vessel's position to radar ranges or GPS data to aid in locating the chosen spot. Use of two ranges will give the most precise positioning. Later these aids will be helpful in determining whether the anchor is holding or dragging.

Bottom characteristics are of prime importance. The following characteristics of the bottom are normally shown on charts:

Type	Description
Firm sand	Excellent holding quality and is consistent.
Clay	Excellent holding quality if quite dense, and sufficiently pliable to allow good anchor engagement.
Mud	Varies greatly from sticky, which holds well, to soft or silt that has questionable holding power.

Loose sand	Fair, if the anchor engages deeply.
Rock	Less desirable for holding an anchor unless the anchor becomes hooked in a crevice.
Grass	Often prevents the anchor from digging into the bottom, and so provides very questionable holding for most anchors.

Lowering the Anchor
As the anchor is lowered into the water, it is important to know how much rode is paid out when the anchor hits the bottom. It is advisable to take a working turn on the forward bitt or cleat to maintain control of the rode. If anchoring in a strong wind or current, the anchor rode may not be held with hands alone.

Length of Rode (Scope)
The scope is a ratio of the length of rode paid out to the depth of the water. Enough rode should be paid out so the lower end of the rode forms an angle of 8° (or less) with the bottom. This helps the anchor dig-in and give good holding power.

Step	Procedure
1	Haul out enough line from the locker and fake it on deck so as to run freely without kinking or fouling.
2	On the coxswain's command, lower the anchor over the side hand-over-hand until it reaches bottom.
3	Once the anchor is on the bottom, take a working turn on the forward bitt to control how fast and how much anchor rode is released.
4	Once the desired length is paid out, make up the anchor rode to the forward bitt.

Never stand in the coils of line on deck and do not attempt to "heave" the anchor by casting it as far as possible from the side of the boat.

Setting the Anchor
An anchor must be set properly if it is to yield its full holding power. Setting refers to the anchor digging in or otherwise holding in one spot. An anchor that is merely laying on the bottom and can be dragged by the movement of the boat is NOT set. The best techniques for setting an anchor will vary from type to type; only general guidelines can be given here. Experimenting will help determine the best procedures for the boat, the anchors, and the cruising waters.

Step	Procedure
1	With the anchor on the bottom and the boat backing down slowly, pay out line as the boat takes it with a turn around the bitt or cleat.

2	When the predetermined scope has been paid out, hold the line quickly and the anchor will probably get a quick bite into the bottom.
3	If the anchor becomes shod with mud or bottom grass adhering to the flukes, lift it, wash it off by dunking at the surface, and try again.

After Anchor is Set
After the anchor is set, perform the following procedures:

Step	Procedure
1	Pay out or take in rode to the proper length for the anchorage, accounting for the prevailing and expected weather conditions.
2	The scope must be adequate for holding, but in a crowded anchorage consider the other boats in the vicinity.
3	Attach chafing gear to the rode at the point where it passes through the chocks and over the side to prevent abrasion and wear-and-tear on the rode and boat.

Scope of the anchor rode should have a ratio range between 5:1 and 7:1. For heavy weather use 10:1. (Example: For the 5:1 ratio, anchoring in 20 feet of water would require 100 feet of rode.)

Checking the Anchor Holding
There are several ways to make a positive check to ensure the anchor is holding, and not dragging.

- If the water is clear enough to see the bottom, movement may be detected easily.
- If the anchor rode is jerking, or vibrating, the anchor is most likely not holding.
- Monitor bearings taken on at least two landmarks (if available) that are a minimum of 45° apart, or use radar ranges and bearings. Small changes usually mean that the wind, tide, or current has caused the boat to swing around the anchor. If the compass heading is constant, but the bearings change, the anchor is dragging.
- If using a buoyed trip line from the crown of the anchor, apply reverse power to test the anchor's holding. The float on this line should continue to bob up and down in one spot unaffected by the pull on the anchor rode.
- Some electronic navigation units (GPS chart plotters) have anchoring features that will warn if the vessel has drifted out of its swing circle.

Making Fast
After the anchor has gotten a good bite and the proper scope has been paid out, the line should be made fast to the connection fitting (bitt, cleat, etc.). A check should be made to

ensure the vessel is not dragging anchor before shutting off the motor. The fundamental idea in making fast is to secure in such a manner that the line can neither slip nor jam.

Anchor Watch
Maintain a live watch whenever anchored to monitor the conditions and equipment. Things to watch for are:

- Dragging anchor.
- Changes in the weather.
- Other vessels dragging their anchor or anchoring near your vessel.
- Connection of the anchor rode to the fitting.

Weighing Anchor
When it is time to weigh anchor and get underway, perform the following procedures:

Step	Procedure
1	Go forward slowly and take in the anchor rode to prevent fouling the screws.
2	Fake the line on the deck as it comes onboard.
3	When the boat approaches the spot directly over the anchor, and the rode is tending straight up and down, the anchor will usually free itself from the bottom.

Cleaning the Anchor
The anchor should be cleaned before bringing it onboard, as it may have some “bottom” on it.

Maintenance
After anchoring in salt water, ground tackle should be rinsed off with fresh water before stowing it, if possible. Nylon rode dries quickly and can be stowed while damp.

Chapter 5
Survival Equipment

Introduction

The danger of falling overboard, capsizing, or sinking is always present while underway. Few people can stay alive for long in the water without some type of survival equipment. Fear, fatigue, and exposure are the enemies of water survival. The desire to live, and the ability to think clearly and proficiently use available equipment can make the difference between life and death. The boat coxswain has overall responsibility for the safety of the boat and crew including ensuring that all required safety equipment is onboard, readily accessible, in working condition, and its use and operation understood by all. However, each boat crewmember has the personal responsibility to stay alert and knowledgeable in these matters.

PERSONAL FLOTATION DEVICE (PFD)/LIFE JACKET

The term personal flotation device (PFD) is a general name for the various types of devices designed to keep a person afloat in water. PFDs include life jackets, vests, cushions, rings, and other throw-able items. They are available in five different types: Type I, II, III, IV and V. Each type of PFD provides a certain amount of flotation. Regardless of the type, all PFDs must be Coast Guard-approved, meaning they comply with Coast Guard specifications and regulations relating to performance, construction, and materials. A usable PFD is labeled Coast Guard-approved, in good serviceable condition, and of appropriate size for the intended user. Each boat crewmember must wear a usable PFD appropriate for the weather conditions and operations in which he/she will be performing.

TYPE I PFD

The Type I PFD, or “offshore life jacket,” provides an unconscious person the greatest chance of survival in the water. It comes in two sizes, an adult size (90 pounds and over) which provides at least 20 pounds of buoyancy and a child size (less than 90 pounds) which provides at least 11 pounds of buoyancy. The PFD must be international orange in color.
A Type I PFD is effective for all waters, especially open, rough, or remote waters where rescue may be delayed. It is designed to turn most unconscious wearers in the water from a face-down position to a vertical or slightly backward position, allowing the wearer to maintain that position. It provides at least 11-20 pounds of buoyancy. This buoyancy will allow the wearer to relax and save energy while in the water, thus extending survival time.

TYPE II PFD

The Type II PFD, also known as a “near-shore buoyant vest,” is a wearable device that will turn some unconscious wearers to a face-up position in the water. It comes in different colors and in three categories:

- Adult (more than 90 pounds) which provides at least 15.5 pounds of buoyancy.
- Child, medium (50 to 90 pounds) which provides at least 11 pounds of buoyancy.

- Infant (available in two sizes, less than 50 pounds and less than 30 pounds), which provides at least 7 pounds of buoyancy.

This type is usually more comfortable to wear than the Type I. It is usually the preferred PFD if there is a chance of a quick rescue, such as when other boats or people are nearby. The turning characteristic of the Type II is not as strong as with a Type I because of a lesser amount of flotation material, and therefore, under similar conditions, will not be as effective in turning a person to a face-up position.

TYPE III PFD

The Type III PFD, also known as a "flotation aid," is routinely worn aboard boats when freedom of movement is required and the risk of falling over the side is minimal. It is not designed to turn an unconscious wearer to a face-up position; the design is such that conscious wearers can place themselves in a vertical or slightly backward position. It has a minimum of 15.5 pounds of buoyancy and comes in many sizes and colors. **Figure 5-1** shows the Type III Float Coat and PFD vest that MEBS boat crews are authorized to wear.

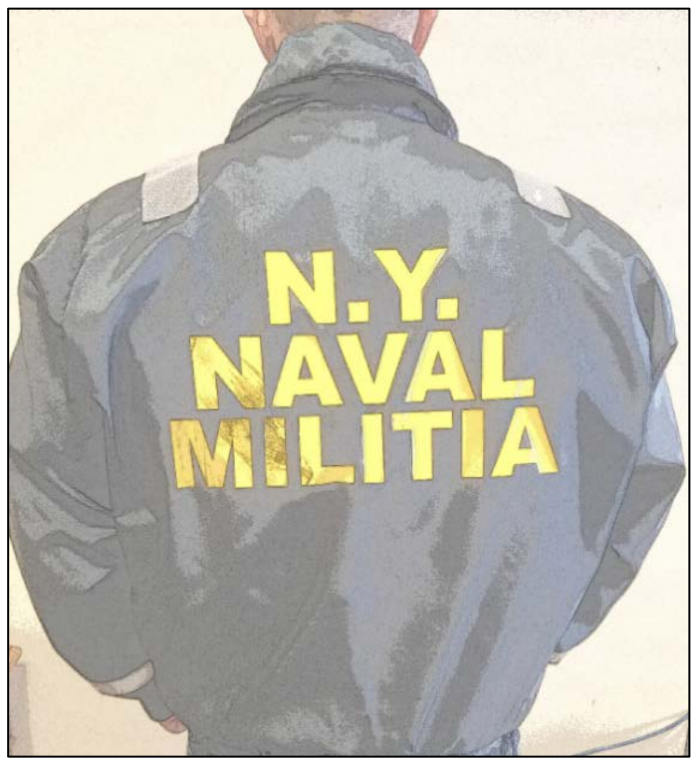


Figure 5-1 Type III PFD Float Coat

Figure 5-1 Type III PFD Vest

Type III PFDs offer boat crewmembers greater comfort and freedom of movement. It is designed so wearers can place themselves in a face-up position in the water. The Type III PFD allows greater wearing comfort.

The following are some disadvantages to the Type III PFD:

- Flotation characteristics are marginal and not suitable for wear in heavy seas.
- Wearer may have to tilt head back to avoid a face-down posture in the water.
- While the Type III has the same amount of buoyancy material as the Type II PFD, the distribution of the flotation material in a Type III reduces or eliminates the turning ability.

Donning
Before entering the water, don and adjust a Type III PFD using the following procedures:

Step	Procedure
1	Place your arms through the openings in the vest.
2	Close zipper, if provided.
3	Adjust waist straps for a snug fit.
4	Secure any additional belts, zippers, and straps the PFD provides for high- speed operation.

TYPE IV PFD

The Type IV PFD is a Coast Guard-approved device that is thrown to a person-in-the-water and is grasped by the user until rescued. The most common Type IV devices are buoyant cushions and ring buoys. Ring buoys (see Figure 5-2) must be white or orange in color.

Figure 5-2 Ring Buoy

An advantage of the Type IV PFD is that since it is not worn like other PFDs, there are no size restrictions. This type of PFD is designed to be stored on deck for easy deployment should someone fall overboard. If quickly deployed following a man overboard, the Type IV PFD also acts as a marker assisting in returning to the area where the person originally fell overboard.

A disadvantage of the Type IV PFD is that it is not worn, although some can be secured to the body once reached in the water.

TYPE V PFD

Type V PFDs are also known as "special-use devices." They are intended for specific activities and may be carried instead of another PFD only if used according to the approval condition on the label. For example, a Type V PFD designed for use during commercial white-water rafting will only be acceptable during commercial rafting. It is not acceptable for other activities unless specified on the label. Examples of Type V PFDs are:

- Work vest with unicellular foam pads.
- Thermal protective PFDs (anti-exposure coveralls/immersion suits).
- CG authorized hybrid automatic/manual inflatable PFDs.

Inflatable PFDs

The Type V inflatable PFD offers boat crewmembers greater comfort and maneuverability compared to the typical Type III vest. Lightweight and not as bulky, the Type V inflatable is especially beneficial to units in warmer climates. When inflated, the Type V provides more buoyancy as well as the positive righting feature found in a Type II PFD.

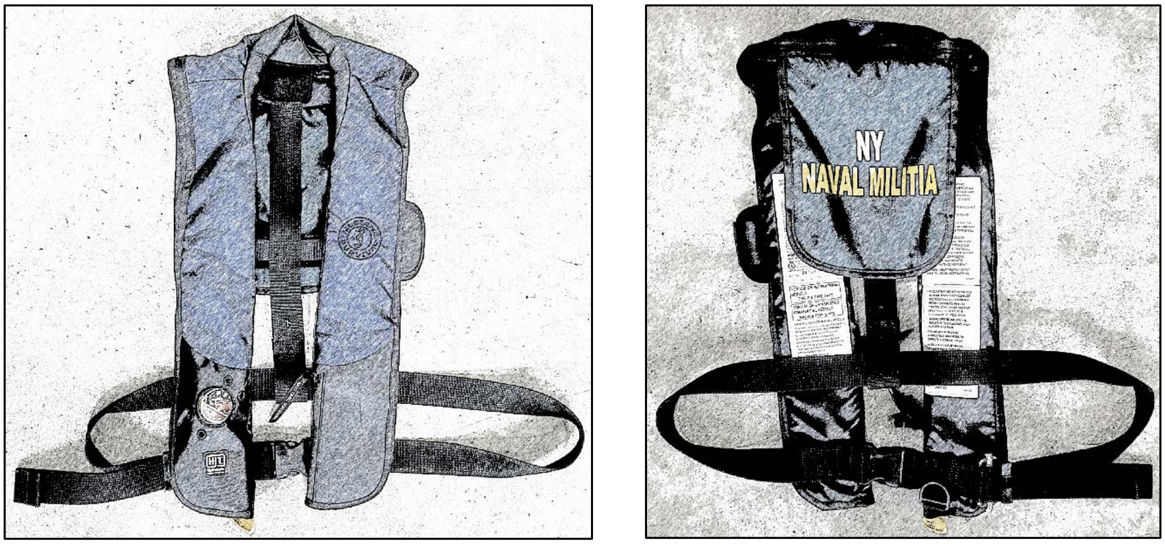


Figure 5-3 Type V Inflatable PFD

As with any other automated feature, if the auto-inflate mechanism were inoperative, the PFD would have to be manually inflated. This could be a problem if the crewmember was knocked unconscious while falling overboard.

Chapter 6

Weather and Oceanography

Introduction

Boat crews operate in constantly changing environments. Weather and sea conditions interact causing many different types of situations. It is important to understand these conditions and how to operate in them.

WIND

Everyone knows water seeks its own level; the same is true with air. Air tends to equalize its pressure by flowing from a high-pressure area to a low-pressure area, producing wind.

Afternoon Wind Increases

Members of the boating public often get underway in the calm waters of the cool early morning. By afternoon, when they try to get home, the bay or ocean is so choppy that they may find themselves in need of assistance. The wind changes so drastically because the sun warms the earth. The land warms faster than the surface of the water and radiates heat to the overlying air, warming it. This warm air rises, reducing the atmospheric pressure in that area. The air offshore over the ocean is cool, and cool air is dense and heavy.
The cool air from offshore flows inland in an attempt to equalize the pressure differential caused by the rising warm air. This flow produces wind, known as sea breeze. After sunset, the inland area cools more quickly than the water, and the wind diminishes.
Sea breezes typically reach their highest speeds during the period of maximum heating (i.e., during mid-afternoon). In some areas a land breeze can be established late at night or early in the morning. For this breeze to occur, the sea surface temperature must be higher than the air temperature over land, along with weak winds prior to the breeze.

Beaufort Wind Scale

The Beaufort Wind Scale (see **Table 6-1**) numbers define a particular state of wind and wave. The scale allows mariners to estimate the wind speed based on the sea state.

NOTE: The Beaufort Wind Scale extends to force 18. For boat operating purposes, Table 6-1 is limited to force 10.

Table 6-1 Beaufort Wind Scale

Beaufort Scale	Wind Speed (Knots)	Indications	Approximate Wave Height (Feet)
0	Calm	Mirror like.	0
1	1-3	Ripples with appearance of scales.	0.25

2	4-6	Small wavelets that do not break. Glassy appearance.	0.5-1
3	7-10	Large wavelets. Some crests begin to break. Scattered whitecaps.	2-3
4	11-16	Small waves becoming longer. Fairly frequent whitecaps.	3.5-5
5	17-21	Moderate waves. Pronounced long form. Many whitecaps.	6-8
6	22-27	Large waves begin to form. White foam crests are more extensive. Some spray.	9.5-13
7	28-33	Sea heaps up. White foam from breaking waves begins to blow in streaks along the direction of the waves.	13.5-19
8	34-40	Moderately high waves of greater length. Edges of crests break into spindrift foam blown in well-marked streaks in the direction of the waves.	18-25
9	41-47	High waves. Dense streaks of foam. Sea begins to roll. Spray affects visibility.	23-32
10	48-55	Very high waves with over-hanging crests. Foam in great patches blown in dense white streaks. Whole surface of sea takes on a white appearance. Visibility affected	29-41

Weather Warning Signals
The National Weather Service provides radio weather broadcasts. Although no longer required to be displayed, various shore activities may still use a system of flag and light signals to announce weather warnings. These weather warnings and their flags and lights signals are summarized in **Table 6-2**.

Table 6-2
Marine Advisories and Warnings Included in Coastal and Offshore Forecasts

Marine Advisories and Warnings	Winds	Day Signal Onshore	Night Signal Onshore
Special Marine Warning	A severe local storm warning affecting coastal water areas, or a warning of potentially hazardous weather conditions usually of short duration (2 hours or less) and producing wind speeds of 34 KT or more, that is not adequately covered by existing marine warnings.		

Small Craft Advisory(conditions dangerous to small craft operations)	An advisory in coastal waters for winds from approximately 18 to 33 KT inclusive (lower limit may vary by region) or for sea conditions, either predicted or occurring, that are considered potentially hazardous to small boats. There is no legal definition for "small craft."	Red pennant	Red-over-white light
Gale Warning	A warning of sustained winds in the range 34 to 47 KT inclusive either predicted or occurring, not associated with tropical cyclones.	Two red pennants	White-over-red lights
Storm Warning	A warning of sustained winds of 48 KT or more, not associated with a tropical cyclone.	Square red flag with black center	Two red lights
Hurricane Force Wind Warning	A warning for sustained winds of 64 KT or greater either predicted or occurring, not associated with a tropical cyclone.		
Tropical Storm Warning	A warning of sustained winds from 34 to 63 KT inclusive either predicted or occurring, associated with tropical cyclones.		
Hurricane Warning	A warning for sustained winds of 64 KT or greater either predicted or occurring, associated with a tropical cyclone.	Two square red flags with black centers	Three vertical lights - red, white, red

THUNDERSTORMS
Thunderstorms have violent vertical movement of air. They usually form when air currents rise over locally warmed areas or a cold front forces warm moist air aloft. Thunderstorms are dangerous not only because of lightning, but also because of the strong winds and the rough, confused seas that accompany them.

Lightning.
Lightning is a potentially life-threatening phenomenon associated with some storms. Not all storms are thunderstorms, but all thunderstorms have lightning. Lightning occurs when opposite electrical charges within a thundercloud, or between a cloud and the earth, attract. It is actually a rapid equalization of the large static charges built up by air motion within the

clouds. Lightning is very unpredictable and has immense power. A lightning “bolt” usually strikes the highest object on the boat, generally the mast or radio antenna.

Distance from a Thunderstorm

The boat’s distance from a thunderstorm can be estimated by knowing it takes about five seconds for the sound of thunder to travel each mile.

- Observe the lightning flash.
- Count the number of seconds it takes for the sound of its thunder to arrive.
- Convert to miles by dividing the number of seconds by 5.

Safety

If caught in a lightning strike area, the following procedures apply:

Step	Procedure
1	Head for shore or the nearest shelter.
2	While underway, stay inside the boat, keep crewmembers low, and stay dry.
3	Avoid touching metal, such as metal shift and throttle levers and metal steering wheels.
4	Avoid contact with the radio.
5	If lightning strikes, expect the compass to be inaccurate and onboard electronics to suffer extensive damage.

WATERSPOUTS

A waterspout is a rotating column of air, usually pendant from a cumulus or cumulonimbus cloud, that forms over water and whose circulation extends to the surface. There are two types of waterspouts:

- Violent convective storms over land moving seaward (tornadoes).
- Storms formed over sea with fair or foul weather (more common than tornadoes).

Waterspouts develop as a funnel-shaped cloud and when fully developed extend from the water’s surface to the base of a cumulus cloud. The water in a waterspout is mostly confined to its lower portion. The air in waterspouts may rotate clockwise or counterclockwise, depending on the manner of formation.

FOG

Fog is a multitude of minute water droplets suspended in the atmosphere, sufficiently dense to scatter light rays and reduce visibility.

Advection Fog

The most troublesome type of fog to mariners is advection fog. Advection means horizontal movement. This type of fog occurs when warm, moist air moves over colder land or water surfaces. The greater the difference between the air temperature and the underlying surface temperature, the denser the fog. Sunlight hardly affects advection fog. It can occur during either the day or night. An increase in wind speed or change in direction may disperse advection fog; however, a slight increase in wind speed can actually make the fog layer thicker.

Radiation (Ground) Fog
Radiation fog occurs mainly at night/early morning with the cooling of the earth's surface, which cools faster than the surrounding air. The air near the surface is stagnated by light winds, then cooled to its dew point by the colder surface, producing a shallow layer of fog. It is most common in middle and high latitudes, near the inland lakes and rivers, which add water vapor to the fog. It clears slowly over water because the land heats and cools three times faster from night to day than water. Sunlight burns off radiation fog by warming the air. Surface winds break up the fog by mixing the air.

Fog Frequency
The nation's Atlantic Coast fog is most common from the northern tip of Maine to the southern tip of New York. Fog appears, on the average, more than 10% of the time in these waters.

Operating in Fog
Consider anchoring to await better visibility, especially if transiting congested areas or narrow channels.

Step	Procedure
1	Slow down to allow enough time to maneuver or stop (i.e., operate the boat at a safe speed).
2	Display the proper navigation lights and sound appropriate sound signals.
3	Employ all available navigation aids.
4	Station a lookout well forward and away from the engine sounds and lights, to listen and look for other signals. Navigation rules require the use of a proper lookout.
5	Besides listening for other boats, the lookout should listen for surf in case the navigational plot is incorrect.
6	If the facility has dual steering stations, one inside and one exposed, use the exposed one in restricted visibility conditions. Being outside allows the lookout and operator the best chance to hear dangers to the boat.

ICE
Temperature and salinity govern the freezing point of water; however, winds, currents, and tides can slow the formation of ice by mixing in warmer water from below the surface. Fresh

water freezes at 0° C/32°F, but the freezing point of seawater decreases to -2°C/28°F because of its salinity.

Shallow bodies of low-salinity water freeze more rapidly than deeper basins because a lesser volume must be cooled. Once the initial cover of ice has formed on the surface, no more mixing can take place from wind/wave action, and the ice will thicken. As a result, the first ice of the season usually appears in the mouths of rivers that empty over a shallow continental shelf. During the increasingly longer and colder nights of late autumn, ice forms along the shorelines as a semi-permanent feature and widens by spreading into more exposed waters. When islands are close together, ice can cover the sea surface between the land areas.

One of the most serious effects of subfreezing air temperatures is that of topside icing, also known as ice accretion, particularly if the ice continues to accumulate. This icing is caused by freezing spray, which is an accumulation of freezing water droplets on a vessel, caused by some combination of cold seawater, wind, or vessel movement. Precipitation may freeze to the vessel as well. Ice will continue to accumulate as long as freezing spray continues to occur, in turn, causing increased weight on decks, superstructures, and masts. Ice also produces complications with the handling and operation of equipment, and creates slippery deck conditions. The ice accumulation causes the boat to become less stable and may lead to capsizing.

FORECASTING

Listening to either a news media broadcast meteorologist or NOAA Weather Radio, coupled with local knowledge, should make everyone informed weather-wise. Also, many old common weather "hunches" are often correct, but should not be the only source without some basic weather knowledge and a tool (e.g., barometer or thermometer) with which to crosscheck the belief. Using multiple sources to confirm personal hunches is recommended.

Weather Indicators

Even experts are far from 100% correct. However, the following generalized table, **Table 6-3**, can assist in forecasting weather changes:

Table 6-3 Generalized Weather Indicators

Condition	Deteriorating Weather	Impending Precipitation	Clearing Weather	Continuing Fair Weather	Impending Strong Winds
CLOUDS					
Clouds lowering and thickening	**X**				
Puffy clouds beginning to develop vertically and darkening	**X**				
Sky is dark and threatening to the west					**X**

Clouds increasing in numbers, moving rapidly across sky	**X**			**X**	
Clouds moving in different directions at different heights	**X**			**X**	
Clouds moving from east or northeast toward the south	**X**				
Transparent veil-like cirrus clouds thickening; ceiling lowering		**X**			
Increasing south wind with clouds moving from the west		**X**			
Cloud bases rising			**X**		
Rain stopping, clouds breaking away at sunset			**X**		
Clouds dotting afternoon summer sky				**X**	
Clouds not increasing, or instead decreasing				**X**	
Altitude of cloud bases near mountains increasing				**X**	
SKY					
Western sky dark and threatening	**X**				
A red sky in morning	**X**				**X**
Red western sky at dawn		**X**			
Gray early morning sky showing signs of clearing			**X**		**X**
Red eastern sky with clear western sky at sunset				**X**	
Clear blue morning sky to west				**X**	
PRECIPITATION					

Heavy rains occurring at night	**X**				
Rain stopping, clouds breaking away at sunset			**X**		
Temperatures far above or below normal for time of year	**X**				
A cold front passing in the past four to seven hours (in which case the weather has probably already cleared)			**X**		
FOG, DEW, AND FROST					
Morning fog or dew			**X**		
Early morning fog that clears				**X**	
Heavy dew or frost				**X**	
No dew after a hot day		**X**			
WIND					
Wind shifting north to east and possibly through east to south	**X**				
Strong wind in morning	**X**				
Increasing south wind with clouds moving from the west		**X**			
Gentle wind from west or northwest				**X**	
Bright moon and light breeze				**X**	
Winds (especially north winds) shifting to west and then to south		**X**			
BAROMETER					
Barometer falling steadily or rapidly	**X**				
Steadily falling barometer		**X**			
Barometer rising			**X**		

Barometer steady or rising slightly				X	
VISUAL PHENOMENA					
A ring (halo) around the moon	X				
Distant objects seeming to stand above the horizon		X			
If on land, leaves that grow according to prevailing winds turnover and show their backs					X
Halo around sun or moon		X			
Smoke from building stacks rising			X		
Smoke from building stacks lowering	X				X
Bright moon and light breeze				X	
AUDIBLE PHENOMENA					
Very clear sounds that can be heard for great distances		X			
Dull hearing, short-range of sound				X	
Static on AM radio	X				

OCEANOGRAPHY

Oceanography is a broad field encompassing the study of waves, currents, and tides. It includes the biology and chemistry of the oceans and the geological formations that affect the water. Boat crewmembers must have an appreciation of all these factors to safely operate in an ever-changing environment.

WAVES

By understanding how waves form and behave, boat crewmembers know what to expect and how to minimize danger to both boat and crew.
The following definitions will help in understanding waves:

Term	Definition
Breaker	A breaking wave.
Breaker Line	The outer limit of the surf. All breakers may not present themselves in a line. Breakers can occur outside the breaker line and seem to come from nowhere.
Comber	A wave on the point of breaking. A comber has a thin line of white water upon its crest, called feathering.
Crest	The top of a wave, breaker, or swell.
Fetch	The distance over water in which seas are generated by an unobstructed wind of a constant direction and speed.
Foam Crest	Top of the foaming water that speeds toward the beach after the wave has broken, popularly known as white water.
Frequency	The time interval between successive wave crests passing a fixed point.
Interference	Waves refracted or reflected can interact with other waves. This action may increase or decrease wave height, often resulting in unnaturally high waves. Interference may even result in standing-wave patterns (waves that consistently appear to peak in the same spot). Interference can be of particular concern because it may result in a boat being subjected to waves from unexpected directions and of unexpected size.
Period	The time, in seconds, it takes for two successive crests to pass a fixed point.
Seas	The combination of waves and swells, generally referred to as seas.
Series	A group of waves that seem to travel together, at the same speed.
Surf	Several breakers in a continuous line.
Surf Zone	The area near shore in which breaking occurs continuously in various intensities.
Swell	Swells are waves that have moved out of the area in which they were created. The crests have become lower, more rounded and have a longer period than waves. They can travel for thousands of miles across deep-water without much loss of energy.
Trough	The valley between waves.
Wave Height	The height from the bottom of a wave’s trough to the top of its crest; measured in the vertical, not diagonal.
Wave Length	The distance from one wave crest to the next in the same wave group or series.
Wave Reflection	Any obstacle can reflect part of a wave. This includes underwater barriers (e.g., submerged reefs or bars), although the main waves may seem to pass over them without change. These reflected waves move back

	towards the incoming waves. When the obstacles are vertical or nearly so, the waves may be reflected in their entirety.
Waves	Local waves generated from the action of the wind on the water's surface (and sometimes by earthquakes). Waves usually have a shorter period than swells.

Wave Types
The wind generates waves by moving over the water's surface. As wind speed increases, white caps appear. As the wind continues from a constant direction and speed over a given area (fetch), the waves become higher and longer. The Beaufort Wind Scale (**Table 6-1**) shows the size of waves in open water for a given wind strength. There are two major types of waves:

- More choppy waves found in shallow water (e.g., in bays and inland lakes).
- Broad, rounded waves associated with deep-water.

Breaking Waves
Breaking waves are the most dangerous kind of wave for boat operations. How dangerous the wave is depends on the ratio of wave height to length, and on wave frequency. Steep sloped waves are the most dangerous. There are three main types of breaking waves:

- Plunging waves.
- Spilling breakers.
- Surging breakers.

Plunging Waves
Plunging waves result when there is a sudden lack of water ahead of the wave, such as in a steep rise of the ocean floor. This situation prevents the wave from traveling along, and causes the crest to be hurled ahead of the front of the wave and break with tremendous force.

Spilling Breakers
Spilling breakers result from waves of low steepness moving over a gentle sloping ocean floor. They normally have a small crest of white water spreading evenly down the wave, and break slowly without violence.

Surging Breakers
A surging breaker occurs on very steep beaches. The wave builds very quickly and expends its energy on the beach. It is very unlikely that a surging breaker will be encountered while aboard a boat unless beaching it on a very steep beach.

Deepwater Wave

A deep-water wave is a wind wave where the depth of the water is greater than one-half the wavelength.

Shallow Water Wave
A shallow water wave travels in water where the depth is less than one-half the wavelength. If the depth of water is small in comparison to the wavelength, the bottom will change the character of the wave.

Wave Series
Wave series are irregular because of constant shifting of wind direction and speed. Storms at sea create masses of waves that build up in groups higher than other waves. Breakers vary in size and there is no regular pattern or sequence to their height. But while the space or interval between series of breakers may vary, it is fairly regular. Despite the interval, breakers tend to stay the same for hours at a time.
The height and period of a wave depends on:

- The speed of the wind.
- The amount of time the wind has been blowing.
- The distance over water which the wind travels unobstructed, known as fetch. Nearness to land will limit fetch, if the wind is blowing offshore.

The lifecycle of a wave consists of its:

- Generation by wind.
- Gradual growth to maximum size.
- Distance traveled across the sea.
- Dissipation as wind decreases or when the wave impacts against the shore or an object.

SURF
Irregular waves of deep-water become organized by the effects of the contact with the bottom. They move in the same direction at similar speeds. As the depth of water decreases to very shallow, the waves break and the crests tumble forward. They fall into the trough ahead usually as a mass of foaming white water. This forward momentum carries the broken water forward until the wave's last remaining energy becomes a wash rushing up the beach. The zone where the wave gives up this energy and the systematic water motions is the surf. (see **Figure 6-1**)

Tidal currents going against the waves will make the waves steeper.

As the waves travel out from their origin, they become swells developing into a series of waves equidistant apart which track more or less at a constant speed. Consequently, it is possible to time series of breakers.

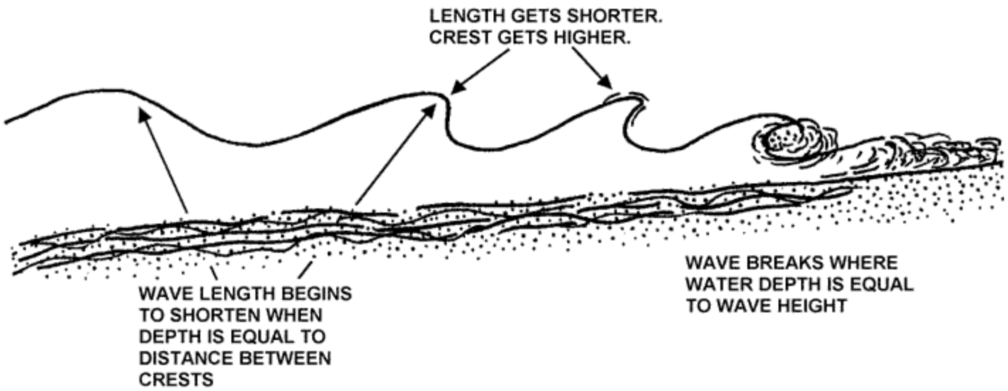


Figure 6-1 Surf

Sometimes there are two breaks of surf between the beach and the outer surf line. These breaks result from an outer sand bar or reef working against the wave causing the seas to pile up. The movement of water over such outer bars forms the inner surf belt as the water rolls toward the shore. The surf that forms around an inlet depends on the size of approaching swells and the bottom contours. The waves' speed and shape change as they approach shallow coastal waters. They become closer together (as their speed slows) and steeper as they contact the bottom. This change typically happens at a point where the water is approximately one half as deep as the wave's length.

As a wave steepens, its momentum will cause it to fall forward or curl. It is this momentum that gives a curl of breakers its tremendous force.

CURRENTS

Tide is the vertical rise and fall of the ocean water level caused by the gravitational attraction of the sun and moon. A tidal current is the horizontal motion of water resulting from the change in the tide. It is different from ocean currents, river currents, or those created by the wind. Flood current is the horizontal motion of water toward the land, caused by a rising tide. Ebb current is the horizontal motion away from the land, caused by a falling tide. Slack water is the period that occurs while the current is changing direction and has no horizontal motion. An outgoing or ebb current running across a bar builds up a more intense sea than the incoming or flood current. The intense sea results because the rush of water out against the incoming ground swell slows the wave speed and steepens the wave prematurely.

Longshore Currents

Longshore currents run parallel to the shore and inside the breakers. They are the result of the water transported to the beach by the waves.

Eddy Currents

Eddy currents (eddies) occur at channel bends, near points of land, and at places where the bottom is uneven.

Wind Effects on Current

Wind affects the speed of currents. Sustained wind in the same direction as the current increases the speed of the current by a small amount. Wind in the opposite direction slows it down and may create a chop. A very strong wind, blowing directly into the mouth of an inlet or bay, can produce an unusually high tide by piling up the water. Similarly, a very strong wind blowing out of a bay can cause an unusually low tide and change the time of the high or low tide.

Effects on Boat Speed

When going with the current, a boat's speed over ground is faster than the speed/RPM indication. When going against the current, a boat's speed over ground is slower than the speed/RPM indication.

Effects on Boat Maneuverability

When working in current, the boat's maneuverability depends on its speed through the water. When going into the current, maneuverability is usually improved as long as enough headway is maintained. However, at slow speeds, even a small change in course can have the bow swing greatly as the water flow pushes on one side of the bow.

Crossing the Current

When crossing the current to compensate for the set, a boat may be put into a crab (i.e., the boat may be forced off course by the current or wind). Because of this maneuver, the boat heading and the actual course made good will be different. When the boat is crabbing, the heading will not be the intended course of the boat. Therefore, navigate the current or wind by sighting on a fixed object (such as a range) or by marking the bearing drift on an object in line with the destination.

Tide and Tidal Current Changes

Tides in New York State effect the waters in around Long Island, New York City, and the Hudson River Valley as far north as the Troy Lock. All other New York waters are NOT tidal, including the entire canal system, Great Lakes, Finger Lakes, etc.

The change of direction of the tidal current always lags behind the turning of the tide. This difference occurs by a time period that varies according to the physical characteristics of the land around the body of water, as well as the bottom topography. For instance, with a straight coast and only shallow indentations, there is little difference between the time of high or low tide and the time of slack water. However, where a large body of water connects with the ocean through a narrow channel, the tide and the current may be out of phase by as much as several hours. In a situation such as this, the current in the channel may be running at its greatest velocity when it is high or low water outside.

Tidal Current Tables
It is important to know the set (direction toward) and drift (speed expressed in knots) of the tidal currents in the area. This information can be obtained from NOAA Tide Predictions. The table lists the daily times of slack water and the times and velocities of maximum flood and ebb at the reference stations. (see **Figure 6-2**).

Time and Speed
Boat crews should select the station closest to their area of concern. (Sometimes it may be a reference or harmonic station, which means no calculating is needed). If using a subordinate station, its time differences should be applied to the time of slack and maximum current at the reference station to obtain the corresponding times at the subordinate station.
The maximum speed at the subordinate station is calculated by multiplying the maximum speed at the reference station by the appropriate flood or ebb ratio.

Current Velocity
Flood direction is the approximate true direction toward which the flooding current flows. Ebb direction is generally close to the reciprocal of the flood direction. Average flood and ebb speeds are averages of all the flood and ebb currents.

```
# Source:           NOAA/NOS/CO-OPS
# Disclaimer:       These data are based upon the latest information
#                   available as of the date of your request, and may
#                   differ from the published tidal current tables.
# Product Type:     Weekly Current Predictions
# Station ID:       HUR0617
# Depth:            32 feet
# Station Name:     Castleton-on-Hudson Bridge
# Latitude:         42.5044
# Longitude:        -73.7774
# Station Type:     Harmonic
# Data Range:       Weekly
# From:             2017-12-01 to 2017-12-07
# Units:            knots
# Time Zone:        LST/LDT
# Mean Flood Dir:   49° (T)
# Mean Ebb Dir:     229° (T)
```

Date	Time (LST/LDT)	Event	Speed (knots)
2017-12-01	01:06 AM	slack	-
2017-12-01	03:54 AM	ebb	-0.91
2017-12-01	08:42 AM	slack	-
2017-12-01	10:42 AM	flood	1.15
2017-12-01	01:36 PM	slack	-
2017-12-01	04:18 PM	ebb	-0.98
2017-12-01	09:30 PM	slack	-
2017-12-01	11:12 PM	flood	0.97
2017-12-02	02:00 AM	slack	-
2017-12-02	04:36 AM	ebb	-0.92
2017-12-02	09:30 AM	slack	-
2017-12-02	11:30 AM	flood	1.23
2017-12-02	02:18 PM	slack	-
2017-12-02	04:54 PM	ebb	-0.98
2017-12-02	08:30 PM	ebb	-0.64
2017-12-02	10:24 PM	slack	-
2017-12-03	12:06 AM	flood	1.00
2017-12-03	02:42 AM	slack	-
2017-12-03	05:18 AM	ebb	-0.89
2017-12-03	10:18 AM	slack	-
2017-12-03	12:24 PM	flood	1.28
2017-12-03	02:54 PM	slack	-
2017-12-03	05:36 PM	ebb	-0.95
2017-12-03	08:18 PM	ebb	-0.61
2017-12-03	09:24 PM	ebb	-0.66
2017-12-03	11:12 PM	slack	-
2017-12-04	12:54 AM	flood	0.99
2017-12-04	03:30 AM	slack	-
2017-12-04	06:12 AM	ebb	-0.83
2017-12-04	11:12 AM	slack	-
2017-12-04	01:12 PM	flood	1.28
2017-12-04	03:36 PM	slack	-
2017-12-04	06:24 PM	ebb	-0.90
2017-12-04	08:54 PM	ebb	-0.59
2017-12-04	10:24 PM	ebb	-0.67
2017-12-05	12:06 AM	slack	-
2017-12-05	01:42 AM	flood	0.96
2017-12-05	04:18 AM	slack	-
2017-12-05	07:06 AM	ebb	-0.75
2017-12-05	12:06 PM	slack	-
2017-12-05	02:00 PM	flood	1.22
2017-12-05	04:24 PM	slack	-
2017-12-05	07:12 PM	ebb	-0.84
2017-12-05	09:36 PM	ebb	-0.58
2017-12-05	11:18 PM	ebb	-0.70
2017-12-06	01:00 AM	slack	-

Figure 6-2 Tidal Current Tables

Chapter 7
Navigation

Introduction
The art and science of navigation is an ancient skill. For thousands of years sailors navigated by using the stars as their guide. In the distant past only a select few were allowed access to the mysteries of navigation for possession of them gave one considerable power. A person who could safely follow the stars and navigate a ship - from one point to another - exercised significant influence over crewmembers who could not.
The art of navigation has expanded from using the stars and planets (celestial navigation) to sophisticated electronic systems (electronic navigation). The safe and confident navigation of the boat - is an absolute necessity. Boat navigation falls into three major categories:

- Piloting: use of visible landmarks and AtoN as well as by soundings.
- Dead Reckoning: by true or magnetic course steering and using speed to determine distance traveled from a known point in a known period.
- Electronic Navigation: by GPS and other electronic systems.

The coxswain is responsible for knowing the position of the boat at all times. A crewmember must learn all landmarks, charts and navigation aids used for the waters while operating.

THE EARTH AND ITS COORDINATES

Introduction
Navigation is concerned with finding a position and calculating distances measured on the surface of the earth, which is a sphere. However, the earth is not a perfect sphere - the diameter through the equator is about 23 nautical miles longer than is the diameter through the North and South Poles. This difference is so small that most navigational problems are based on the earth being a perfect sphere. Charts are drawn to include this slight difference. Distance is figured from certain reference lines. Position at any given time, while underway, may be determined by location relative to these lines as well as visible landmarks in the local area. Knowing what these lines are and how to use them is essential.

REFERENCE LINES OF THE EARTH
The earth rotates around an axis; this axis may be defined as a straight line drawn through the center of the earth. The axis line meets the surface of the earth at the North Pole and at the South Pole. To determine location, a system of reference lines is placed on the surface of the earth as shown in **Figure 7-1**. This figure reveals the difficulty a boat navigator faces - the earth is curved as a sphere but navigation is typically done on a flat chart with straight reference lines running top to bottom and left to right.

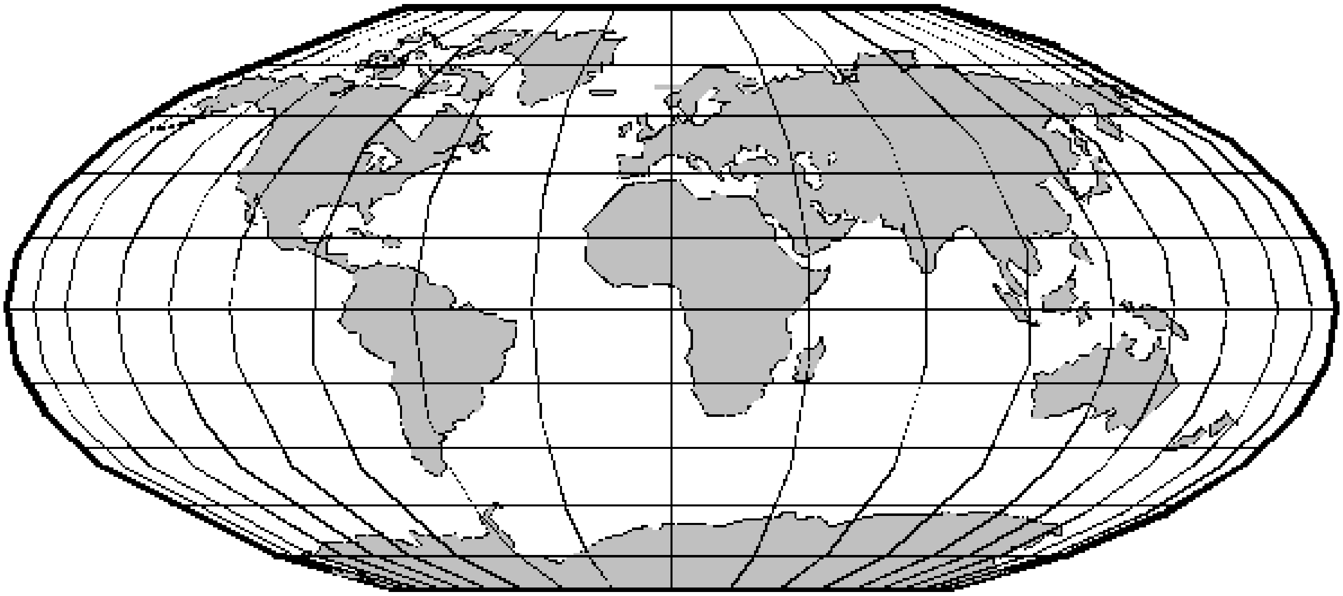


Figure 7-1 Earth with Reference Lines

Great Circles

A great circle is a geometric plane passing through the center of the earth, which divides the earth into two equal parts. A great circle always passes through the widest part of the earth. The equator is a great circle. All circles that pass through both the North and South Poles are great circles. The edge of a great circle conforms to the curvature of the earth, similar to seeing a circle when looking at a full moon.

The earth's circumference is 21,600 nautical miles. Determine a degree of arc on the earth's surface by dividing the earth's circumference (in miles) by 360 degrees.

Circle Properties

The outline of the moon also reveals another fact about great circles which is a property of all circles: each circle possesses 360° around its edge, which passes through a sphere, as to divide the sphere into two equal half-spheres. There are an infinite number of great circles on a sphere.

Degrees

Great circles have 360° of arc. In every degree of arc in a circle, there are 60 minutes. Sixty (60) minutes is equal to 1° of arc, and 360° are equal to a complete circle. When degrees are written, the symbol (°) is used.

Minutes

For every degree of arc, there are 60 minutes. When minutes of degrees are written, the symbol (') is used; 14 degrees and 15 minutes is written: 14°15'.When written, minutes of degrees are always expressed as two digits. Zero through nine minutes are always preceded with a zero. Three minutes and zero minutes are written as 03' and 00' respectively.

Seconds
For every minute of arc in a circle, there are 60 seconds of arc. Sixty (60) seconds is equal to one minute of arc, and 60 minutes is equal to 1° of arc.
For every minute of arc, there are 60 seconds. When seconds are written, the symbol (") is used; 24 degrees, 45 minutes, and 15 seconds is written: 24°45'15".
When seconds are written, they are always expressed as two digits. Zero through nine seconds are always preceded with a zero. Six seconds and zero seconds are written as 06" and 00" respectively.
Seconds may also be expressed in tenths of minutes; 10 minutes, 6 seconds (10'06") can be written as 10.1'.
The relationship of units of “arc” can be summarized as follows:

Circle = 360 degrees (°)
1 degree (°) = 60 minutes (')
1 minute (') = 60 seconds (")

PARALLELS
Parallels are circles on the surface of the earth moving from the equator to the North or South Pole. They are parallel to the equator and known as parallels of latitude, or just latitude.
Parallels of equal latitude run in a west and east direction (left and right on a chart). They are measured in degrees, minutes, and seconds, in a north and south direction, from the equator. (0° at the equator to 90° at each pole).
The North Pole is 90° north latitude, and the South Pole is 90° south latitude. The equator itself is a special parallel because it is also a great circle. One degree of latitude (arc) is equal to 60 nautical miles (NM) on the surface of the earth; one minute (') of latitude is equal to 1 NM. The circumference of the parallels decreases as they approach the poles. (see **Figure 14-2**)
On charts of the northern hemisphere, true north is usually located at the top. Parallels are normally indicated by lines running from side to side. Latitude scales, however, are normally indicated along the side margins by divisions along the black-and-white border as shown in the upper left and the lower right margins of **Figure 7-2**.

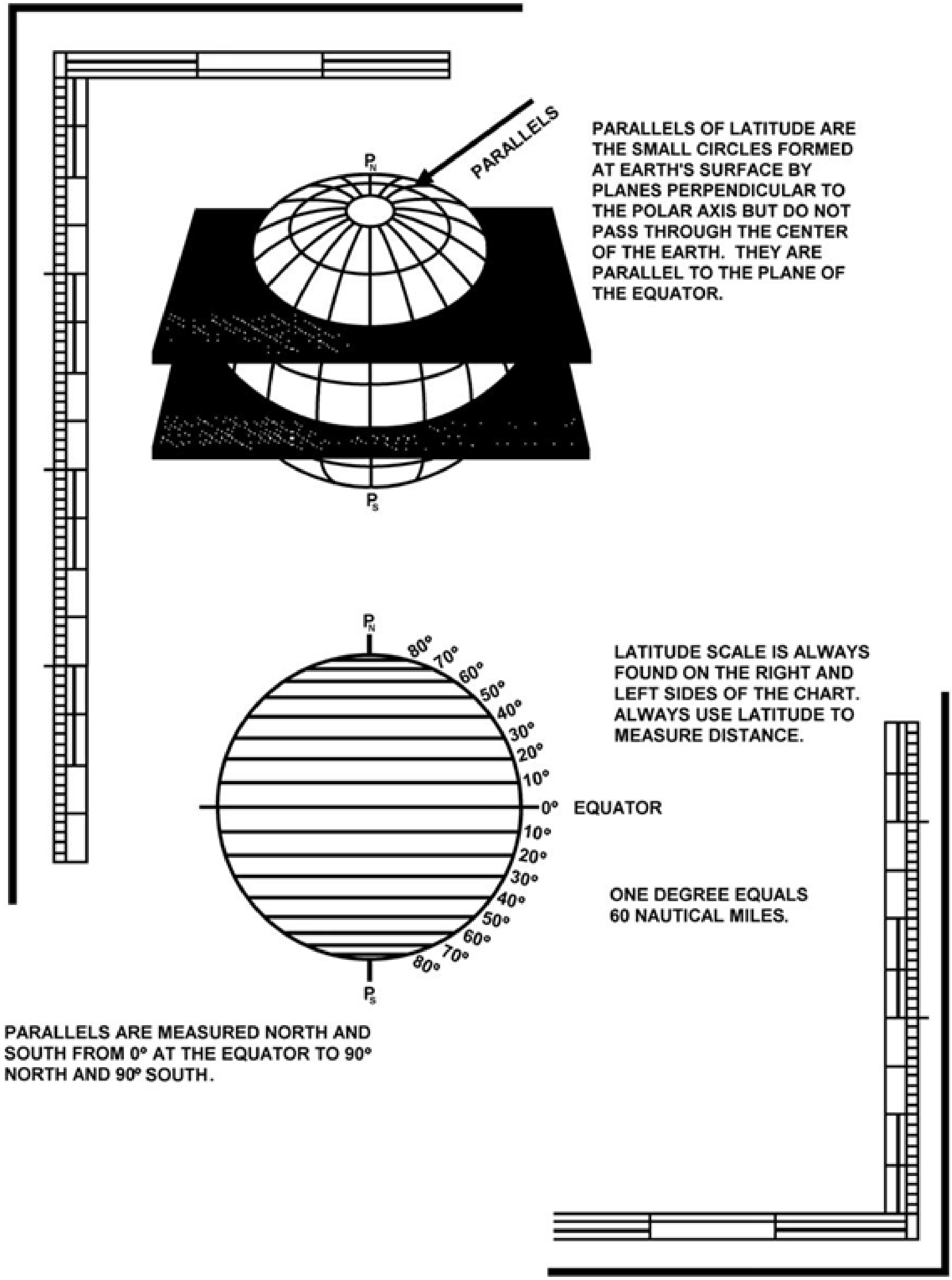


Figure 7-2 Parallels of Latitude

Measuring Latitude
To measure the latitudinal position of an object on a nautical chart, perform the procedures as follows:

Step	Procedure
1	Put one point of a pair of dividers on the parallel of latitude nearest to the object.
2	Place the other point of the dividers on the object.
3	Move the dividers to the nearest latitude scale, keeping the same spread on the dividers.
4	Place one point on the same parallel of latitude as used in step 1. The second point of the dividers will fall on the correct latitude of the object.
5	Read the latitude scale.

- Always use the latitude scale to measure distance in navigation.
- A degree of latitude is measured up or down.

On a Mercator projection chart (normally used for boat navigation), the scale varies along the latitude scale, but will always remain accurate in relation to actual distance within the latitude bounded by that scale.

MERIDIANS
A meridian is a great circle formed by a plane, which cuts through the earth's axis and its poles. Such circles are termed meridians of longitude.
The meridian which passes through Greenwich, England, by international convention, has been selected as 000° and is called the Prime Meridian. From this point, longitude is measured both east and west for 180°.
The 180° meridian is on the exact opposite side of the earth from the 000° meridian. The International Date Line generally conforms to the 180th meridian. The great circle of the Prime Meridian and the International Date Line divide the earth into eastern and western hemispheres.
A degree of longitude equals 60 miles only at the equator and is undefined at the poles since all meridians meet there at one point. Meridians of Longitude run in a north and south direction (top to bottom on a chart) and are measured in degrees, minutes, and seconds, in an east or west direction. (see **Figure 7-3**)

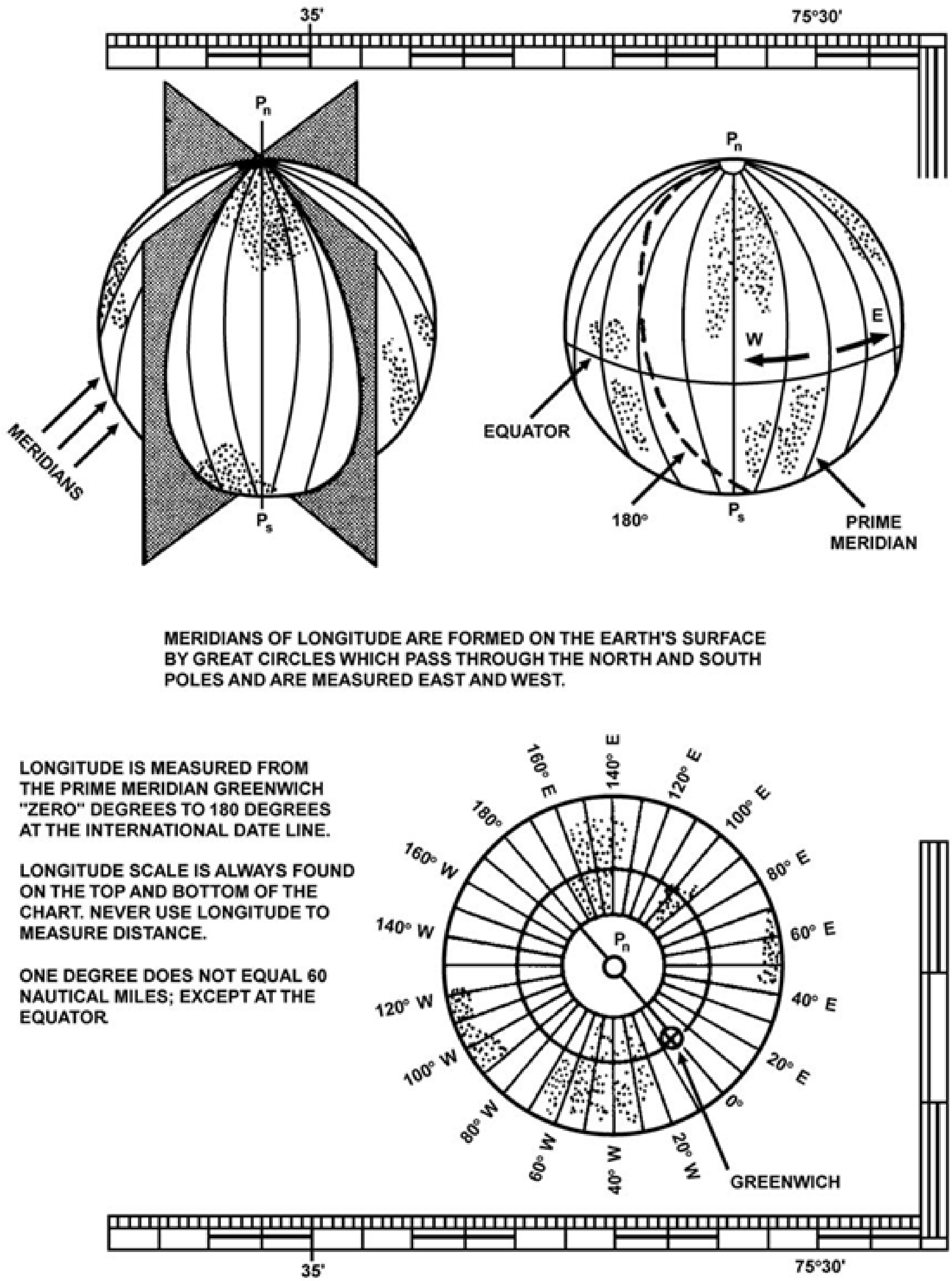


Figure 7-3 Meridians of Longitude

To Measure Longitude
To measure the longitude of an object on a nautical chart, the same procedures as in measuring a latitude position using the longitude scale shall be followed.

Rhumb Line
Typical boat navigation is done by plotting rhumb lines on a Mercator chart. A rhumb line is an imaginary line that intersects all meridians at the same angle. The rhumb line on the surface of a sphere is a curved line. On most nautical charts, this curved line (rhumb) is represented as a straight line.
A course line, such as a compass course, is a rhumb line that appears as a straight line on a Mercator chart. Navigating with a rhumb line course allows the helmsman to steer a single compass course.

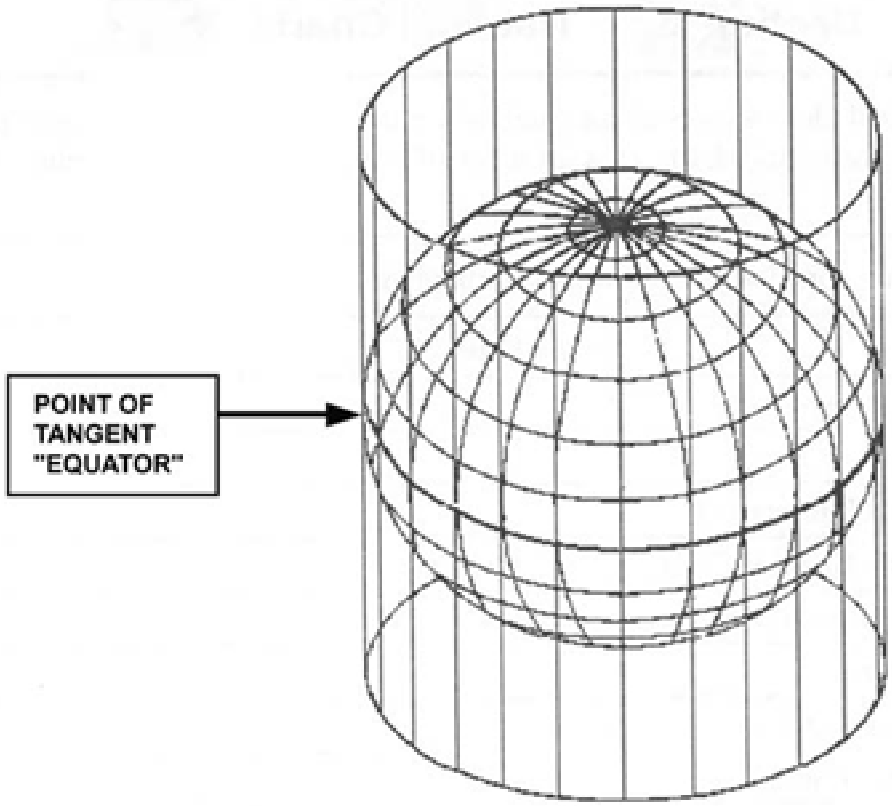
Chart Projections
For the purpose of coastal navigation, the earth is considered to be a perfect sphere. To represent the features of the earth's spherical surface on the flat surface of a chart, a process termed "projection" is used. Two basic types of projection used in making piloting charts are:

- Mercator.
- Gnomonic.

Mercator Projection
Mercator charts are the primary charts used aboard boats. A Mercator projection is made by transferring the surface of the globe (representing the earth) onto a cylinder.

The equator is the reference point for accomplishing the projection from one geometric shape to another. The distinguishing feature of the Mercator projection is that the meridians are projected so they appear to be equal distance from each other and parallel.

Only the latitude scale is used for measuring distance.



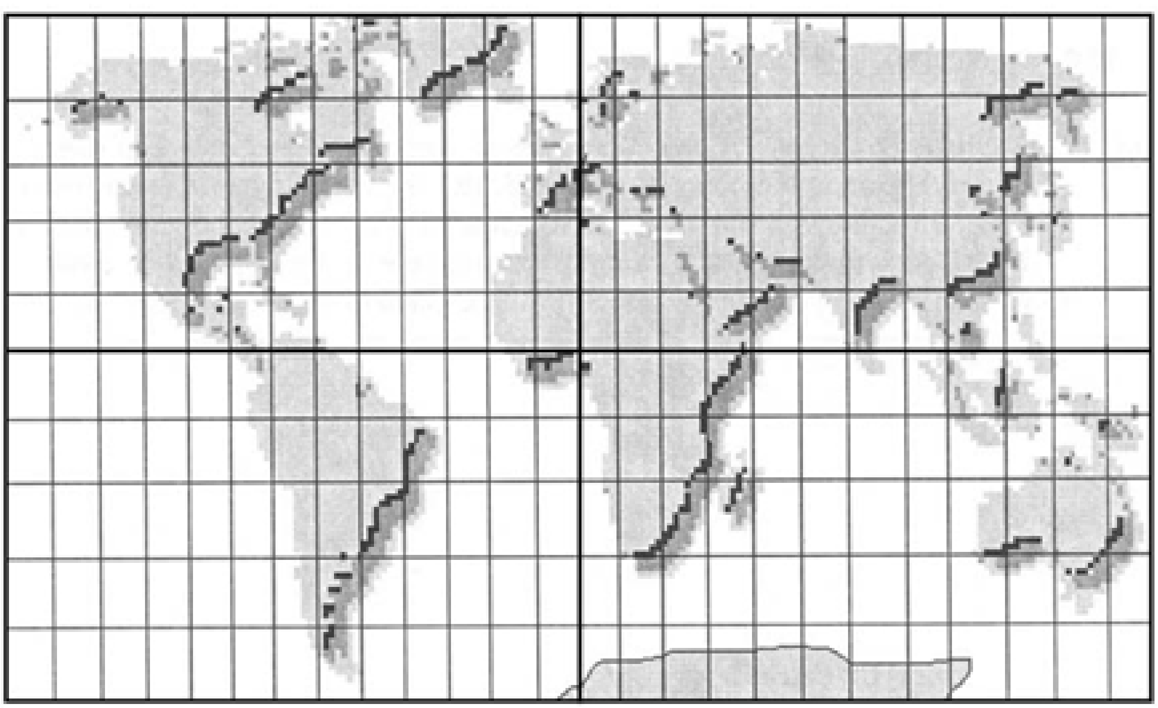


Figure 7-4 Mercator Projection

Gnomonic Projection

Gnomonic projections aid in long distance navigation by allowing navigators to use great circle courses. Meridians appear as straight lines that converge as they near the closest pole. The equator is represented by a straight line; all other parallels appear as curved lines.

Gnomonic charts are not normally used for boat navigation.

NAUTICAL CHARTS

Introduction

The nautical chart is one of the mariner's most useful and most widely used navigational aids. They are not called "maps." Navigational charts contain a lot of information of great value to you as a boat coxswain. Nautical charts usually have one or more compass roses printed on them. They are oriented with north at the top. Directions on the chart are measured by using the compass rose. (see **Figure 7-5**) Direction is measured as a straight line from the center point of the circle to a number on the compass rose.

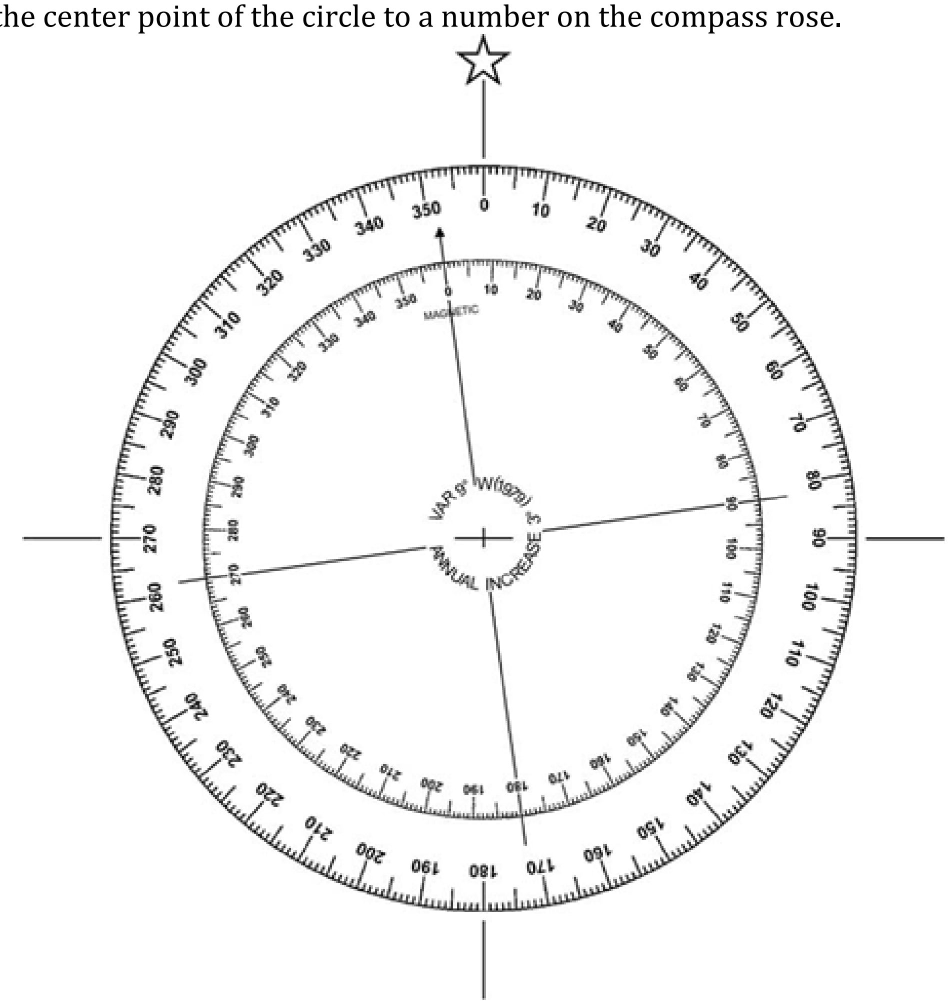


Figure 7-5 Compass Rose

True Direction
True direction is printed around the outside of the compass rose.

Magnetic Direction
Magnetic direction is printed around the inside of the compass rose. An arrow points to magnetic north.

Variation
Variation, the difference between true and magnetic north for the particular area covered by the chart, is printed in the middle of the compass rose (as well as any annual change).

SOUNDINGS
One of the more vital services a chart performs is to describe the bottom characteristics to a boat operator. This is accomplished through the use of combinations of numbers, color codes, underwater contour lines, and a system of symbols and abbreviations.

Datum
The nautical chart water depth is measured downward from sea level at low water (soundings). Heights or landmarks are given in feet above sea level. In the interest of navigation safety, the mean, or average, of the lower of the two tides in the tidal cycle is used for soundings.

Mean Low Tide
Most of the numbers on the chart represent soundings of the water depth at mean ("average") low tide. Datum refers to a base line from which a chart's vertical measurements are made.

Mean Low Water
"Mean low water" is a tidal datum that is the average of all the low water heights observed over the National Tidal Datum Epoch (19 year average).

Average Low Tide
Since the greatest danger to navigation is during low tide, a number of the depths of low tide are averaged to produce the average low tide.

Mean Lower Low Water
"Mean lower low water" is a tidal datum that is the average of the lowest low water height of each tidal day observed over the National Tidal Datum Epoch (19 year average).

Color Code
Generally, shallow water is tinted darker blue on a chart, while deeper water is tinted light blue or white.

Contour Lines

Contour lines, also called fathom curves, connect points of roughly equal depth and provide a profile of the bottom. These lines are either numbered or coded, according to depth, using particular combinations of dots and dashes. Depth of water may be charted in feet, meters or fathoms (a fathom equals six feet). The chart legend will indicate which unit (feet, meters or fathoms) is used.

BASIC CHART INFORMATION

The nautical chart shows channels, depth of water buoys, lights, lighthouses, prominent landmarks, rocks, reefs, sandbars, and much more useful information for the safe piloting of the boat. The chart is the most essential part of all piloting equipment. Below are some basic facts to know about charts:

- Charts are oriented with north at the top.
- The frame of reference for all chart construction is the system of latitude and longitude.
- Any location on a chart can be expressed in terms of latitude or longitude. (see **Figure 7-6**)

The latitude scale runs along both sides of the chart.
The longitude scale runs across the top and bottom of the chart.
Latitude lines are reference points in a north and south direction with the equator as their zero reference point.
Longitude lines are the east and west reference points with the prime meridian as their zero reference point.

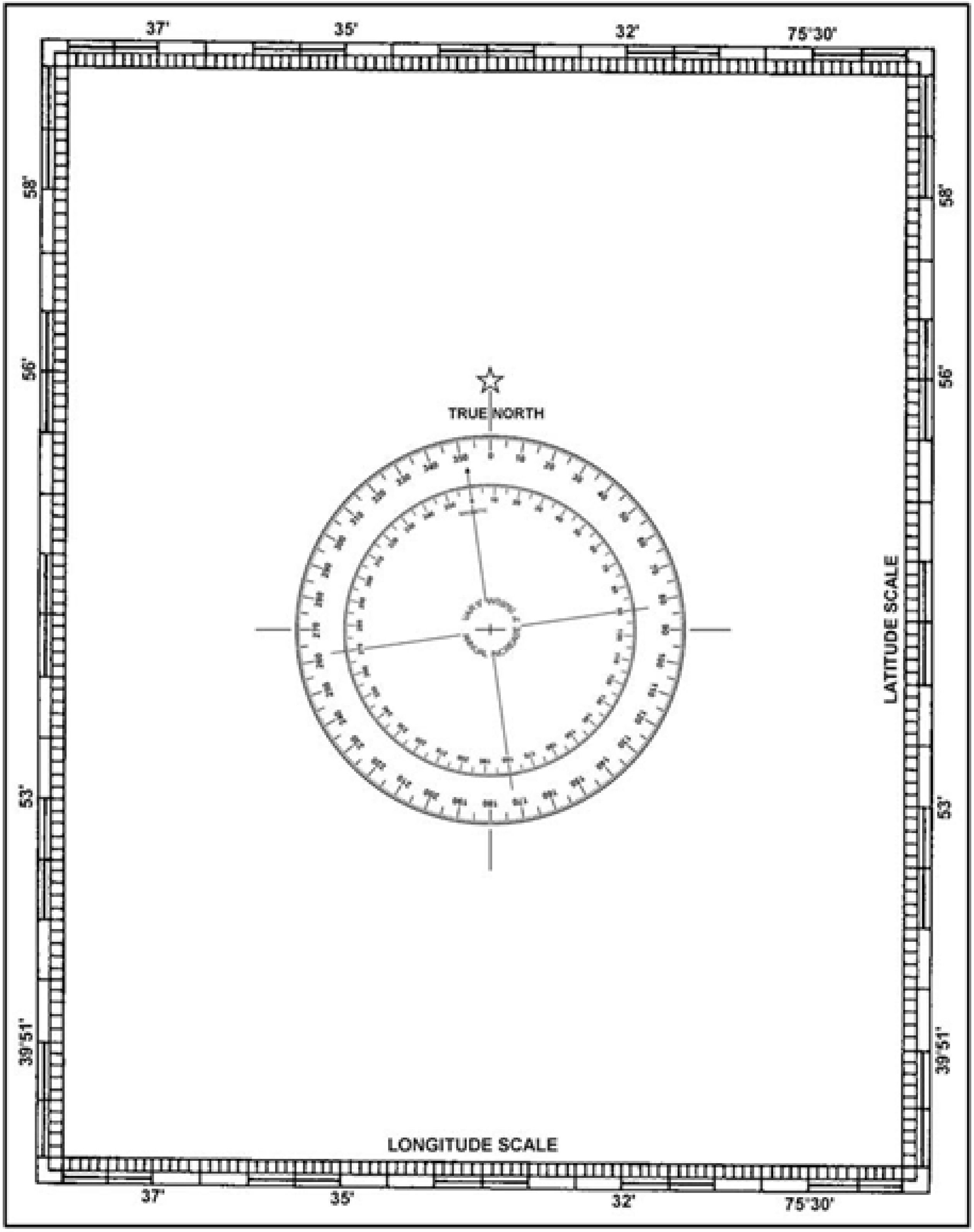


Figure 7-6 Chart Orientation

Title Block

The general information block (see **Figure 7-7**) contains the following items:

- The chart title which is usually the name of the prominent navigable body of water within the area covered in the chart.
- A statement of the type of projection and the scale.
- The unit of depth measurement, listed as soundings (feet, meters or fathoms).

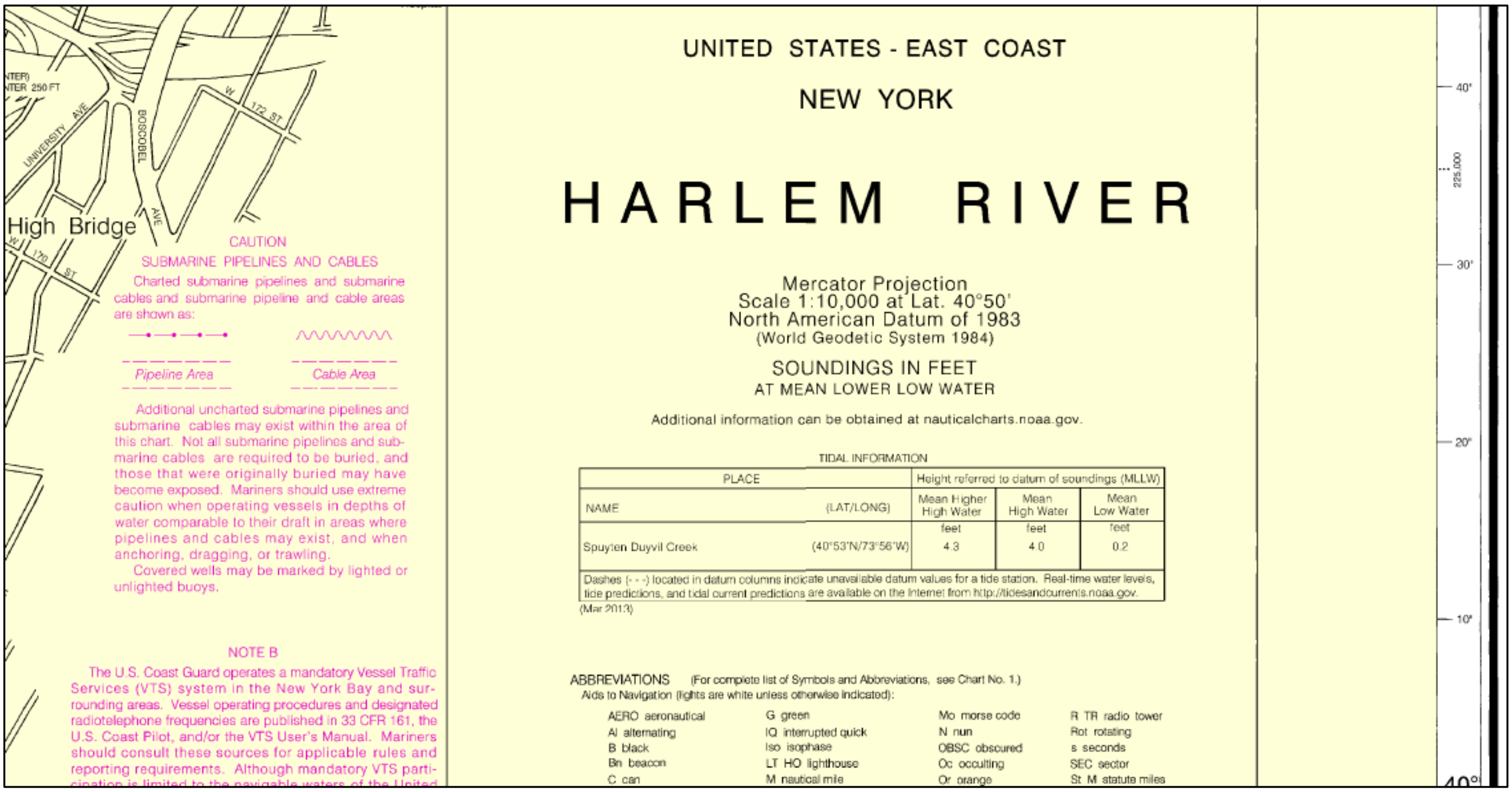


Figure 7-7 Title Block of a Chart

Notes

Notes are found in various places on the chart, such as along the margins or on the face of the chart. They may contain information that cannot be presented graphically, such as:

- The meaning of abbreviations used on the chart.
- Special notes of caution regarding danger.
- Tidal information.
- Reference to anchorage areas.

Edition Number

The edition number of a chart and latest revisions indicate when information on the chart was updated.

- The edition number and date of the chart is located in the margin of the lower left hand corner.
- The latest revision date immediately follows in the lower left hand corner below the border of the chart. Charts show all essential corrections concerning lights, beacons, buoys and dangers that have been received to the date of issue.

Corrections occurring after the date of issue are published in the Notice to Mariners and must be entered by hand on the chart of your local area upon receipt of the notice.

Scale of the Nautical Chart

The scale of a nautical chart is the ratio comparing a unit of distance on the chart to the actual distance on the surface of the earth.

For example: The scale of 1:5,000,000 means that one of some kind of measurement of the chart is equal to 5,000,000 of the same kind of measurement on the earth's surface. One inch on the chart would equal 5,000,000 inches on the earth's surface. This would be a small scale, chart, since the ratio 1/5,000,000 is a very small number.

A large scale chart represents a smaller area than that of a small scale chart. There is no firm separation between large scale and small scale.

NOTE: Remember large scale - small area, and small scale - large area.

For example: The scale of 1:2,500 (one inch on chart equals 2,500 inches on the earth's surface) is a much larger number and is referred to as a large scale chart.

NOTE: Navigate with the largest scale chart available.

Sailing Charts

Sailing charts are produced at scales of 1:600,000 and smaller. They are used in fixing the mariners position for approach to the coast, from the open ocean, or for sailing between distant coastal ports. On such charts, the shoreline and topography are generalized. Only offshore soundings, such as the principal lights, outer buoys and landmarks visible at considerable distances are shown.

General Charts

General charts are produced at scales between 1:150,000 and 1:600,000. They are used for coastwise navigation outside of outlying reefs and shoals when the ship or boat is generally within sight of land or AtoN and its course can be directed by piloting techniques.

Coastal Charts

Coastal charts are produced at scales between 1:50,000 and 1:150,000. They are used for inshore navigation, for entering bays and harbors of considerable width, and for navigating large inland waterways.

Harbor Charts
Harbor charts are produced at scales larger than 1:50,000. They are used in harbors, anchorage areas, and the smaller waterways.

Small Craft Charts
Small craft charts are produced at scales of 1:40,000 and larger. There are special charts of inland waters, including the intracoastal waterways. Special editions of conventional charts, called small craft charts, are printed on lighter weight paper than a normal chart and folded. These "SC" charts contain additional information of interest to small craft operators, such as data on facilities, tide predictions, and weather broadcast information.

CHART SYMBOLS AND ABBREVIATIONS
Many symbols and abbreviations are used on charts. It is a quick way to determine the physical characteristics of the charted area and information on AtoN. These symbols are uniform and standardized, but may vary depending on the scale of the chart or chart series. These standardized chart symbols and abbreviations are shown in the Pamphlet 'CHART No. 1'; published jointly by the Defense Mapping Agency Hydrographic Center and the National Ocean Service.

Color
Nearly all charts employ color to distinguish various categories of information such as shoal water, deep-water, and land areas. Color is also used with AtoN to make them easier to locate and interpret.
Nautical purple ink (magenta) is used for most information since it is easier to read under red light normally used for navigating at night.

Lettering
Slanted Roman lettering on the chart is used to label all information that is affected by tidal change or current (with the exception of bottom soundings). All descriptive lettering for floating AtoN is found in slanted lettering.
Vertical Roman lettering on the chart is used to label all information that is not affected by the tidal changes or current. Fixed aids such as lighthouses and ranges are found in vertical lettering. (see **Figure 7-8**)

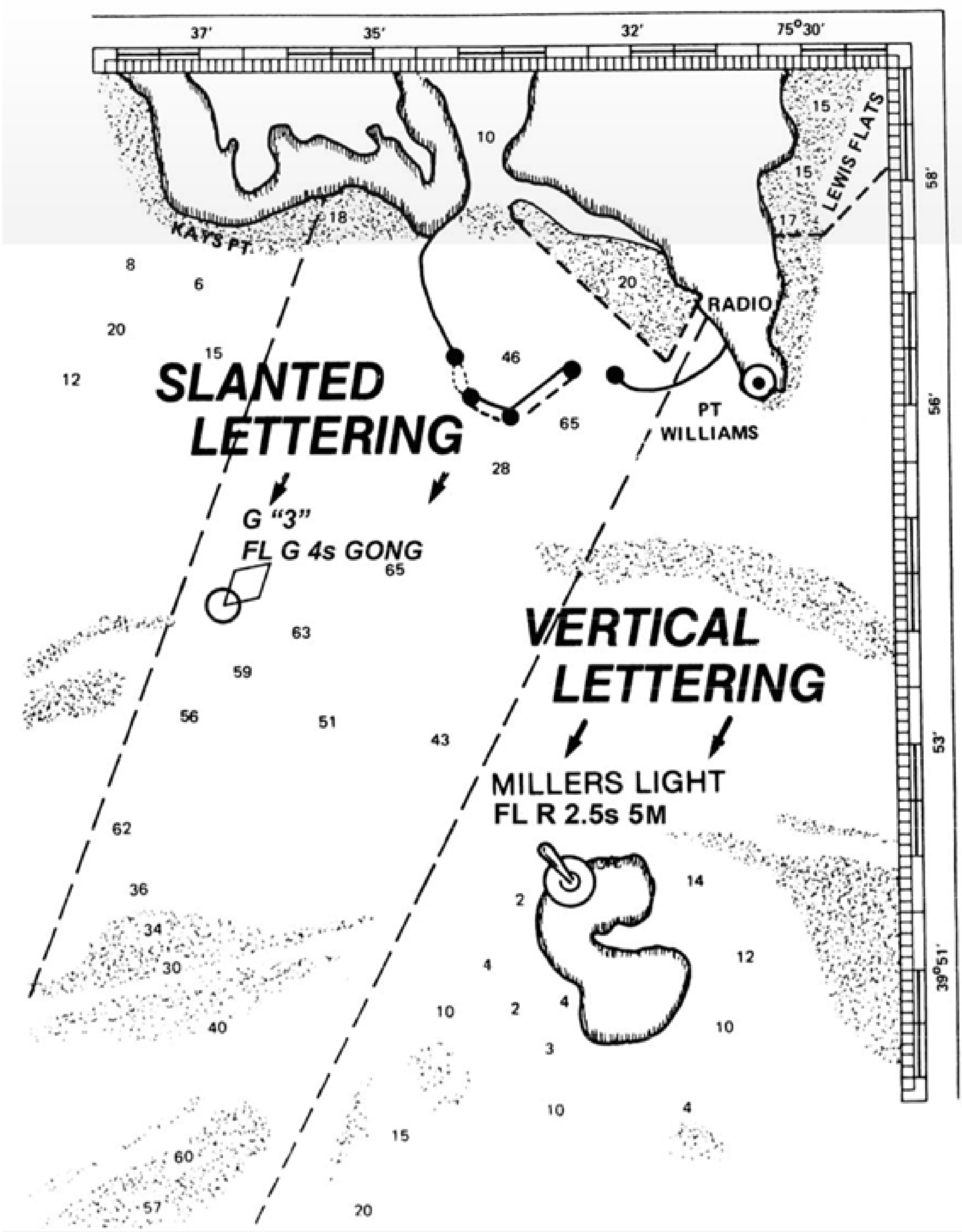


Figure 7-8 Chart Lettering

Buoy Symbols
Buoys are shown with the following symbols:

- The basic symbol for a buoy is a diamond and small circle.
- A dot will be shown instead of the circle on older charts.
- The diamond may be above, below or alongside the circle or dot.
- The small circle or dot denotes the approximate position of the buoy mooring.
- The diamond is used to draw attention to the position of the circle or dot and to describe the aid.

Lighthouses and Other Fixed Lights
The basic symbol is a black dot with a magenta "flare" giving much the appearance of a large exclamation mark (!). Major lights are named and described; minor lights are described only.

Ranges and Beacons
Ranges are indicated on charts by symbols for the lights (if lighted) and dashed line indicating the direction of the range. Daybeacons are indicated by small triangles or squares, which may be colored to match the aid. Daybeacons, also commonly called day marks, are always fixed aids. That is, they are on a structure secured to the bottom or on the shore. They are of many different shapes.

Prominent Landmarks
Prominent landmarks, such as water towers, smoke stacks, and flagpoles, are pinpointed by a standard symbol of a dot surrounded by a circle. A notation next to the symbol defines the landmark's nature. The omission of the dot indicates the location of the landmark is only an approximation. (see **Figure 7-9**)

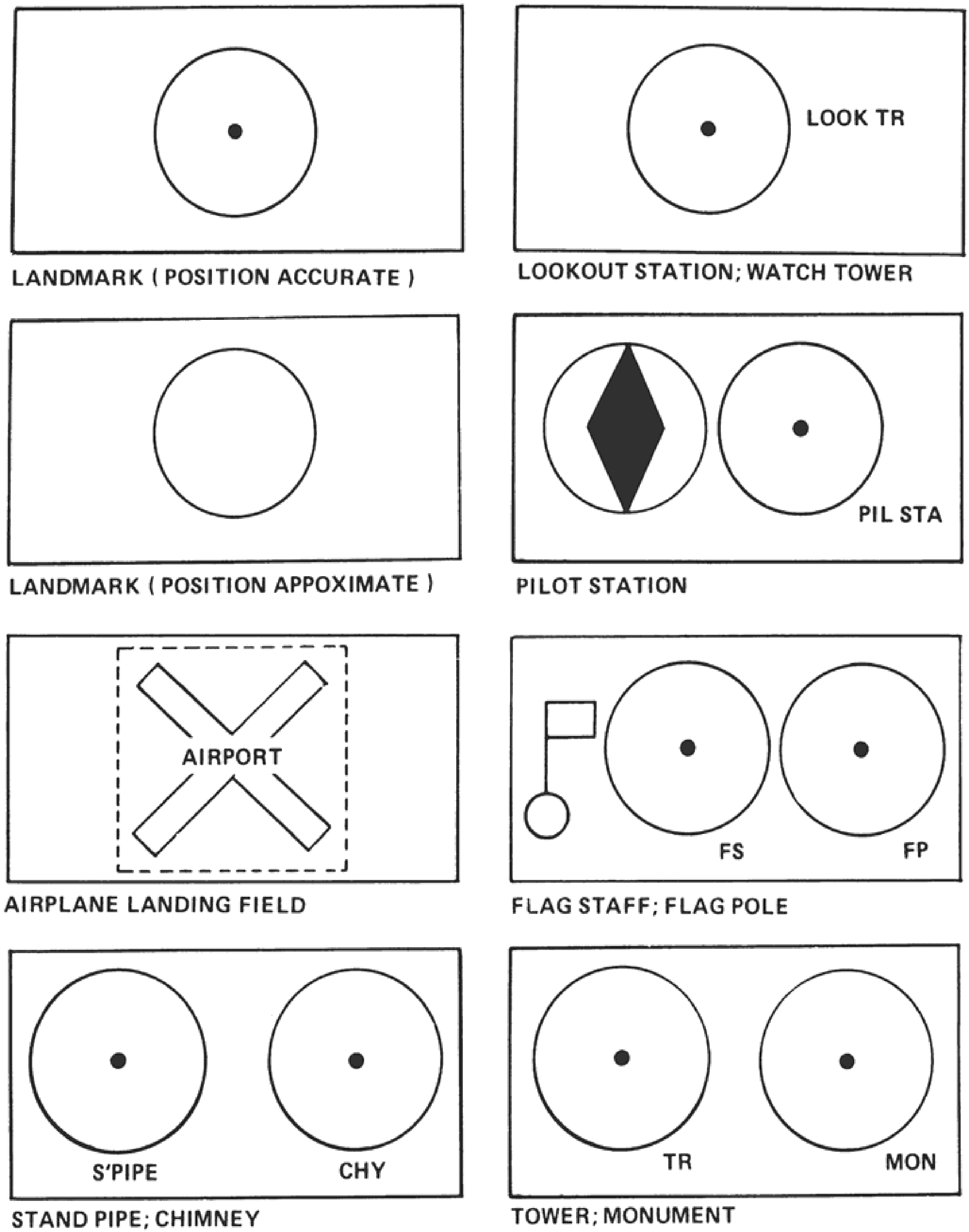


Figure 7-9 Symbols for Prominent Landmarks

Wrecks, Rocks, and Reefs

These are marked with standardized symbols, for example, a sunken wreck may be shown either by a symbol or by an abbreviation plus a number that gives the wreck's depth at mean low or lower low water. A dotted line around any symbol calls special attention to its hazardous nature. (see **Figure 7-10**)

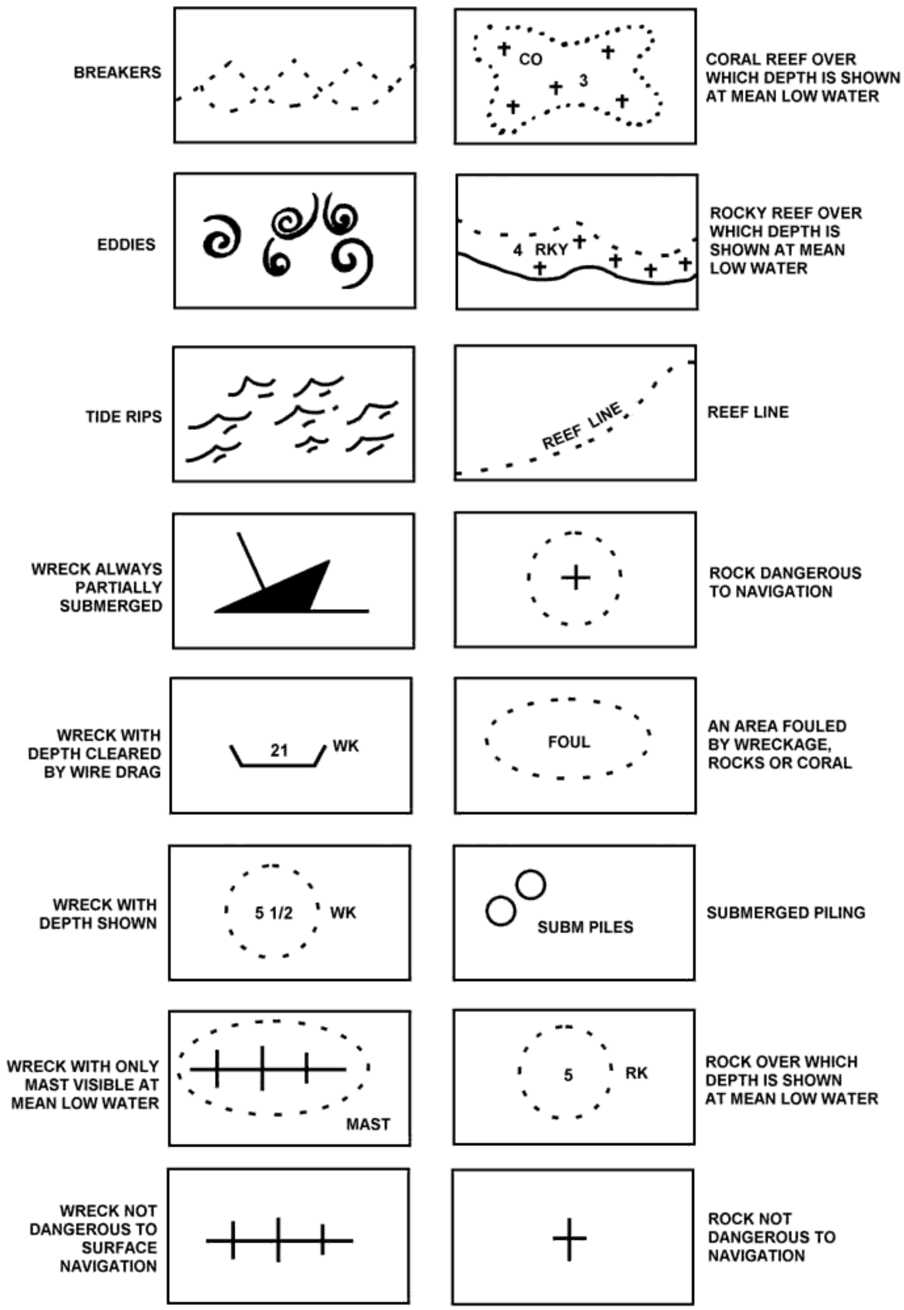


Figure 7-10 Breakers, Rocks, Reefs, and Pilings

Bottom Characteristics
A system of abbreviations, used alone or in combination, describes the composition of the bottom allowing selection of the best holding ground for anchoring. (see **Table 7-1**)

Abbreviation	Composition
Hrd	Hard
M	Mud; Muddy
Sft	Soft
G	Gravel
S	Sand
Stk	Sticky
Cl	Clay
Br	Brown
St	Stone
Gy	Gray
Co	Coral
Wd	Seaweed
Co Hd	Coral Head
Grs	Grass
Sh	Shells
Oys	Oysters

Table 7-1 Bottom Composition

Structures
Shorthand representations have been developed and standardized for low-lying structures such as jetties, docks, drawbridges, and waterfront ramps. Viewed from overhead. (see **Figure 7-11**)

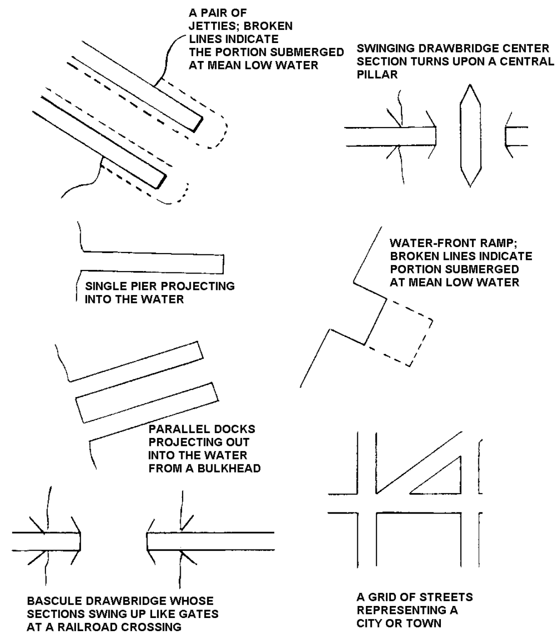
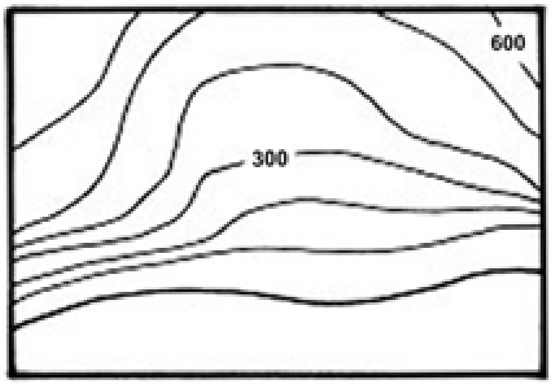
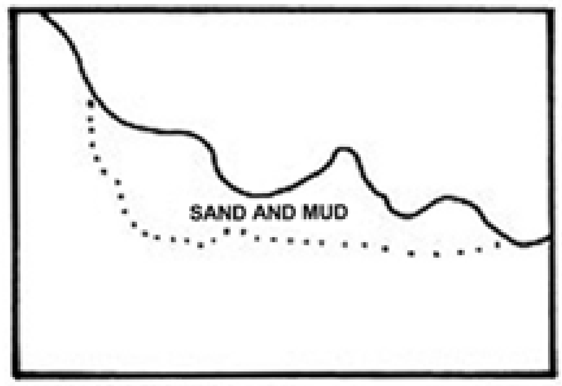


Figure 7-11 Structures

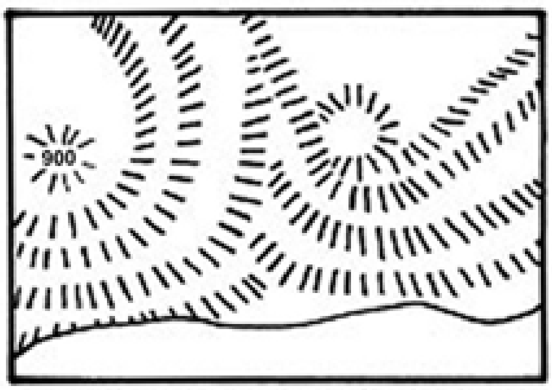
Coastlines
Coastlines are viewed at both low and high water. Landmarks that may help in fixing position are noted and labeled. (see **Figure 7-12**)



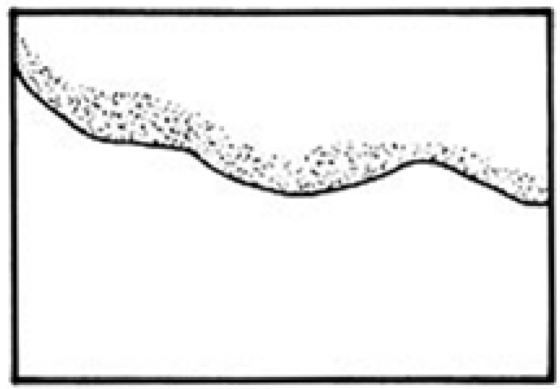
COASTAL HILLS; CONTOURED LINES INDICATE ELEVATIONS.



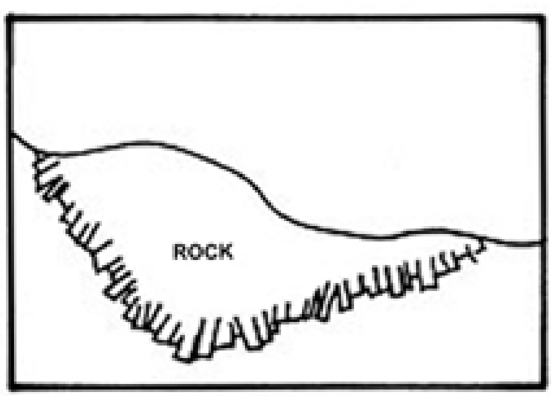
SAND AND MUD FLATS, THAT ARE EXPOSED AT MEAN LOW WATER.



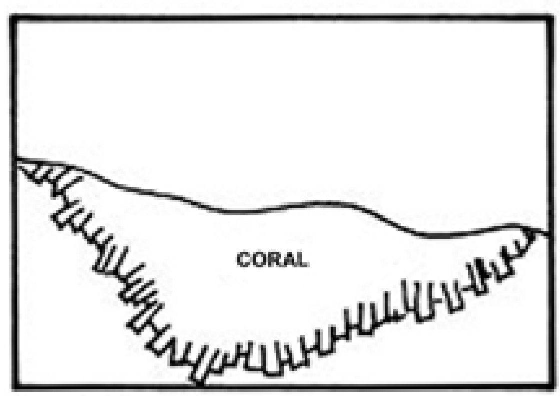
STEEP INCLINED COASTLINE; HACHURES (HATCH MARKS) ARE DRAWN IN THE DIRECTION OF THE SLOPES.



SANDY SHORE, THAT IS EXPOSED AT MEAN LOW WATER.



ROCK SHELF; UNCOVERS AT MEAN LOW WATER.



CORAL SHELF; UNCOVERS AT MEAN LOW WATER.

Figure 7-12 Coastlines

MAGNETIC COMPASS

The magnetic compass, even though it has been around for a long time, is still very important for safely navigating a boat. Whether steering a course out of sight of landmarks or in poor visibility, the magnetic compass is a primary tool for guiding the boat to its destination. Though used by larger vessels, the gyrocompass will not be discussed since it is not commonly used by boats.

Components of the Magnetic Compass

The magnetic compass is standard equipment on all boats. Mechanically, it is a simple piece of equipment. The magnetic compass is used to determine the boat's heading. A prudent seaman will check its accuracy frequently realizing that the magnetic compass is influenced, not only by the earth's magnetic field, but also by fields radiating from magnetic materials aboard the boat. It is also subject to error caused by violent movement as might be encountered in heavy weather.

Direction

Direction is measured clockwise from 000° to 359°. When speaking of degrees in giving course or heading, three digits should always be used, such as 270° or 057°. The heading of 360° is always referred to or spoken as 000°.

True and Magnetic

Directions measured on a chart are in true degrees or magnetic degrees as follows:

- True direction uses the North Pole as a reference point.
- Magnetic direction uses the magnetic North Pole as a reference point. True direction differs from magnetic direction by variation.
- Directions steered on the compass by the boat are magnetic degrees.

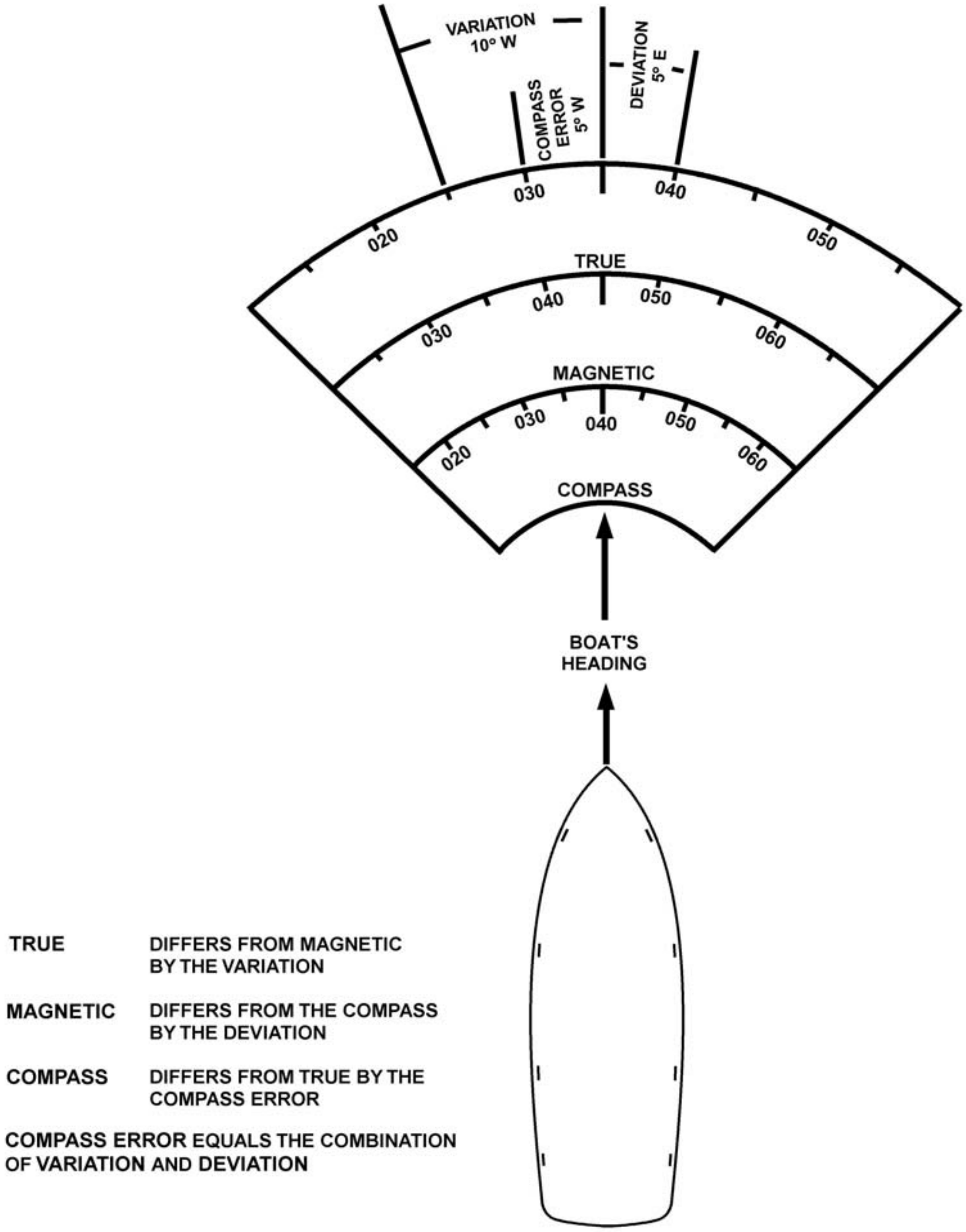


Figure 7-13
True, Magnetic, and Compass Courses

Compass Error

Compass error is the angular difference between a compass direction and its corresponding true direction. The magnetic compass reading must be corrected for variation and deviation.

Variation

Variation is the angular difference, measured in degrees, between true and magnetic north. It varies according to geographic location.

Amount of Variation
The amount of variation changes from one point to the next on the earth's surface. It is written in degrees in either an easterly or a westerly direction. The variation is on the inside of the compass rose of the chart.

Variation Increases/ Decreases
Increases in variation may continue for many years, sometimes reaching large values, remaining nearly the same for a few years and then reverse its trends (decrease). Predictions of the change of variation are intended for short-term use that is a period of only a few years. The latest charts available should always be used. The compass rose will show the amount of predicted change.

Deviation
Deviation is the amount of deflection influenced by a vessel and its electronics on the compass. It varies according to the heading of the vessel and can be caused by:

- Metal objects around the compass.
- Electrical motors.
- The boat itself.

Deviation creates an error in the compass course that a boat attempts to steer. For navigational accuracy and the safety of the boat and crew, the boat's compass heading must be corrected for deviation so that the actual magnetic course can be accurately steered.

PILOTING

Piloting is directing a vessel by using landmarks, other navigational aids, and soundings. Safe piloting requires the use of correct, up-to-date charts. Piloting deals with both present and future consequences. Therefore, it is important to be alert and attentive, and always be consciously aware of where the vessel is and where it soon will be.

Basic Piloting Equipment

Piloting is the primary method of determining a boat's position. In order for a boat coxswain to make good judgment on all decisions in navigation, tools such as compasses, dividers, stopwatches, parallel rulers, pencils, and publications must be available. (see **Figure 7-14**)

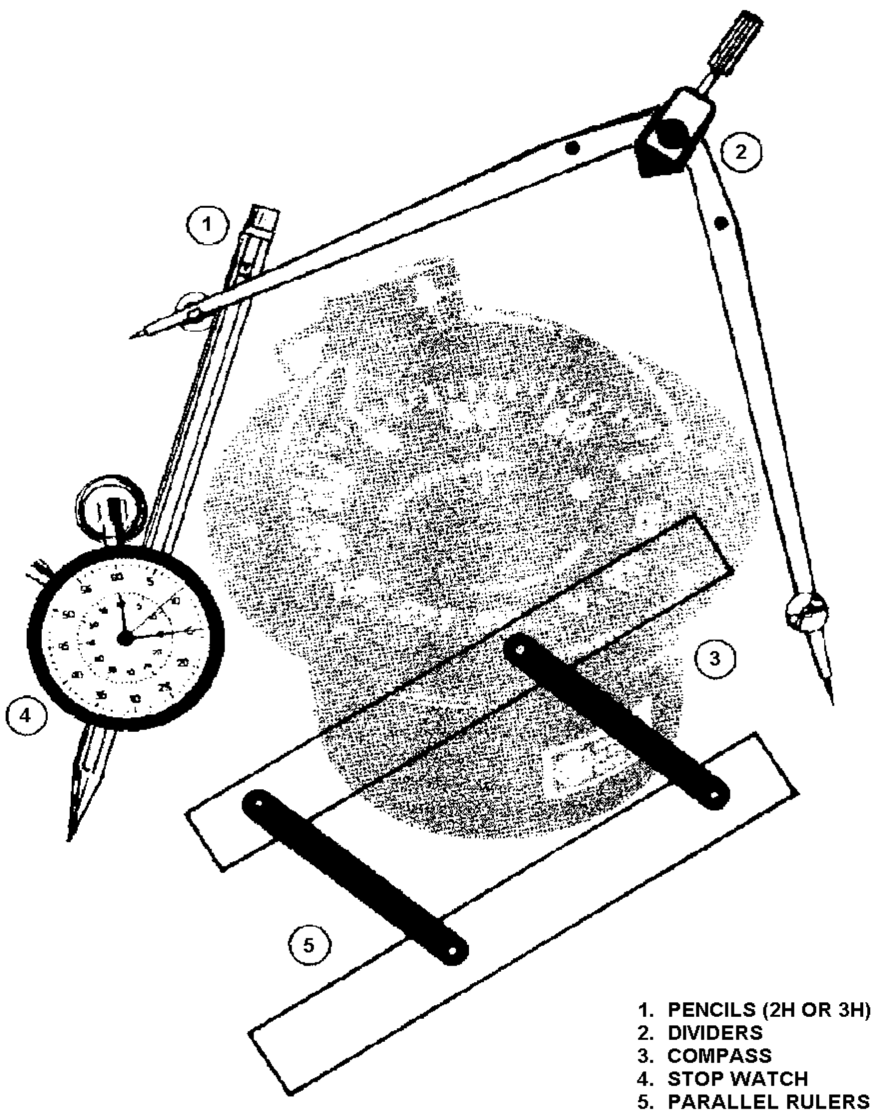


Figure 7-14 Basic Piloting Tools

Compass

For a boat, the magnetic compass is used:

- To steer the course.
- To give a constant report on the boat's heading.
- As a sighting instrument to determine bearings.

Parallel Rulers

Parallel rulers are two rulers connected by straps that allow the rulers to separate while remaining parallel. They are used in chart work to transfer directions from a compass rose to various plotted courses and bearing lines and vice versa. Parallel rulers are always walked so that the top or lower edge intersects the compass rose center to obtain accurate courses.

Course Plotter

A course plotter may be used for chart work in place of the parallel rulers discussed above. It is a rectangular piece of clear plastic with a set of lines parallel to the long edges and semi-circular scales. The center of the scales is at or near the center of one of the longer sides and has a small circle or bull's eye. The bull's eye is used to line up on a meridian so that the direction (course or bearing) can be plotted or read off of the scale. A popular model is the "Weems Plotter" that is mounted on a roller for ease of moving.

Pencils

It is important to use a correct type of pencil for plotting. A medium pencil (No. 2) is best. Pencils should be kept sharp; a dull pencil can cause considerable error in plotting a course due to the width of the lead.

Dividers

Dividers are instruments with two pointed legs, hinged where the upper ends join.
Dividers are used to measure distance on a scale and transfer them to a chart.

Stopwatch

A stopwatch, or navigational timer, which can be started and stopped at will, is very useful to find the lighted period of a navigational aid. This is usually done for purposes of identification. Also, it is used to run a speed check.

Nautical Slide Rule

The nautical slide rule will be discussed in the Distance, Speed, and Time portion of this chapter.

Drafting Compass

The drafting compass is an instrument similar to the dividers. One leg has a pencil attached. This tool is used for swinging arcs and circles.

Speed Curve (Speed vs. RPMs)

A speed curve is used to translate tachometer readings of revolutions per minute (RPMs) into the boat's speed through the water. A speed curve is obtained by running a known distance at constant RPM in one direction and then in the opposite direction. The time for each run is recorded and averaged to take account for current and wind forces. Using distance and time, the speed is determined for the particular RPM.

Charts
Charts are essential for plotting and determining your position, whether operating in familiar or unfamiliar waters. Boat crews should never get underway without the appropriate charts.

Depth sounder
There are several types of depth sounders, but they operate on the same principle. The depth sounder transmits a high frequency sound wave that reflects off the bottom and returns to the receiver. The "echo" is converted to an electrical impulse and can be read from a visual scale on the depth sounder. It shows only the depth of water the vessel is in; it does not show the depth of water being headed for.

Transducer
The transducer is the part of the depth sounder that transmits the sound wave. The transducer is usually mounted through the hull or on the bottom of the transom and sticks out a very short distance. It is not mounted on the lowest part of the hull. The distance from the transducer to the lowest point of the hull must be known. This distance must be subtracted from the depth sounding reading to determine the actual depth of water available.
Example: Depth sounder reading is 6 feet. The transducer is 1 foot above the lowest point of the hull - the boat extends 1 foot below the transducer. This 1 foot is subtracted from the reading of 6 feet, which means the boat has 5 feet of water beneath it.

Always consider the location of the transducer; it is usually mounted above the lowest point of the hull.

Lead Line
Depth of water is one of the most important dimensions of piloting. A hand-held lead line is used for ascertaining the depth of water when a depth sounder is not available, the depth sounder is not operational, or the crew is operating in known shallow water.

Light List.
Light Lists provide more complete information concerning aids to navigation than can be shown on charts. They are not intended to replace charts for navigation.

Tide Tables.
Tide Tables give daily predictions of the height of water, at almost any place, at any given time, and are published online by NOAA.

Tidal Current Tables.
Tidal current tables provide the times of maximum flood and ebb currents, and times of the two slack waters when current direction reverses. They also tell the predicted strength of the current in knots. The time of slack water does not correspond to times of high and low tide.

Coast Pilots.
The amount of information that can be printed on a nautical chart is limited by available space and the system of symbols that is used. Additional information is often needed for safe and convenient navigation. Such information is published in the *Coast Pilot*.
Each *Coast Pilot* contains sailing directions between points in its respective area, including recommended courses and distances. Channels with their controlling depths and all dangers and obstructions are fully described. Harbors and anchorages are listed with information on those points at which facilities are available for boat supplies and marine repairs. Information on canals, bridges, docks, and more, is included.

COLREGS.
The Rules of the Road set forth regulations for navigable waters and are covered in *Navigation Rules, International – Inland*.

Distance, Speed, and Time.
Distance, speed, and time are critical elements in navigational calculations. Each has its own importance and use in piloting. All three are closely associated in the way they are calculated. In planning the sortie or while underway, the typical navigation problem will involve calculating one of these elements based on the value of the other two elements.

Expressing Distance, Speed, and Time
Units of measurement are:

- Distance in nautical miles (NM).
- Speed in knots.
- Time in minutes.

In calculations and answers, express:

- Distance to the nearest tenth of a nautical mile.
- Speed to the nearest tenth of a knot.
- Time to the nearest minute.

Nautical Slide Rule.
The nautical slide rule ("Whiz Wheel") was designed to solve speed, time and distance problems. Use of the slide rule provides greater speed and less chance of error than multiplication and division. There are several types of nautical slide rules but all work on the same basic principle.
The nautical slide rule has three scales that can rotate. The scales are clearly labeled for:

- Speed.

- Time.
- Distance.

By setting any two of the values on their opposite scales, the third is read from the appropriate index. See Figure 14-23 which is set for the approximate values of speed of 17.4 knots, time of 3.4 minutes and distance of 1 nautical mile (NM) or 2,000 yards.

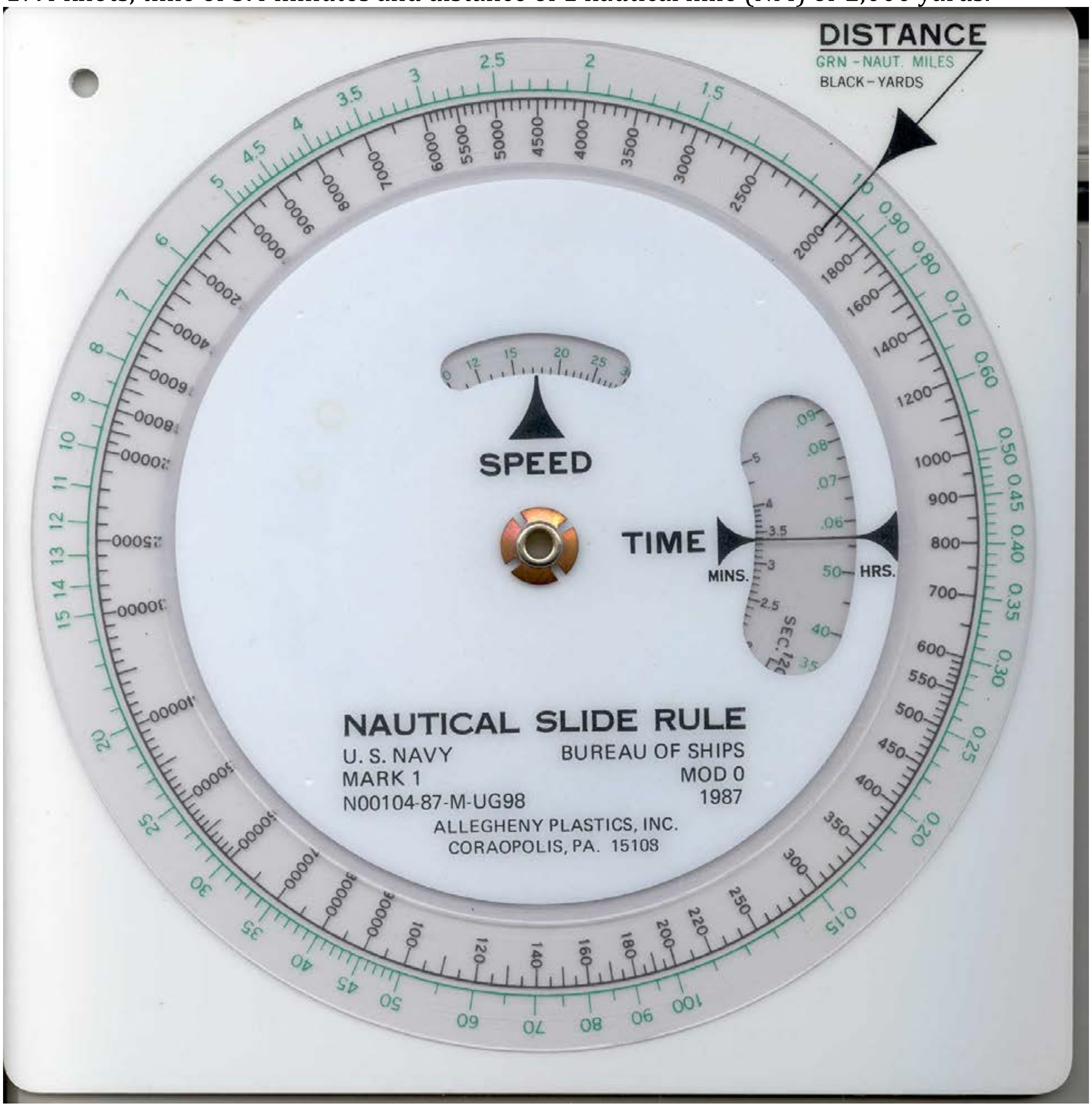


Figure 7-15 Nautical Slide Rule

Terms Used In Piloting

The following terms and their definitions (**Table 7-2**) are the most commonly used in the practice of piloting.

Table 7-2 Piloting Terms

Term	Abbreviation	Description
Bearing	B, Brg.	The horizontal direction of one terrestrial (earth bound) point from another (the direction in which an object lies from the vessel) is its bearing, expressed as the angular distance (degrees) from a reference direction (a direction used as a basis for comparison of other direction). A bearing is usually measured clockwise from 000° through 359° at the reference direction - true north, magnetic north or compass north.
Course	C	The intended horizontal direction of travel (the direction intended to go), expressed as angular distance from a reference direction clockwise from 000° through 360°. For marine navigation, the term applies to the direction to be steered. The heading of 360° is always referred to or spoken as 000°.
Heading	Hdg.	The actual direction the boat's bow is pointing at any given time.
Course line		Line drawn on a chart going in the direction of a course.
Dead reckoning	DR	Dead reckoning is the determination of approximate position by advancing a previous position for course and distance only, without regard to other factors, such as, wind, sea conditions and current.
Dead reckoning plot		A DR plot is the plot of the movements of a boat as determined by dead reckoning.
Position		Position refers to the actual geographic location of a boat. It may be expressed as coordinates of latitude and longitude or as the bearing and distance from an object whose position is known.
DR position		A DR position is a position determined by plotting a single or a series of consecutive course lines using only the direction (course) and distance from the last fix, without consideration of current, wind, or other external forces on a boat.
Estimated position	EP	A DR position modified by additional information, which in itself is insufficient to establish a fix.
Estimated time of arrival	ETA	The ETA is the best estimate of predicted arrival time at a known destination.

Fix		A fix is a position determined from terrestrial, electronic or celestial data at a given time with a high degree of accuracy.
Line of position	LOP	A line of bearing to a known object, which a vessel is presumed to be located on at some point.
Coast piloting		Coast piloting refers to directing the movements of a boat near a coast.
Range		There are two types of ranges used in piloting: • Two or more fixed objects in line. Such objects are said to be in range. • Distance in a single direction or along a great circle. Distance ranges are measured by means of radar or visually with a sextant.
Running fix	R Fix	A running fix is a position determined by crossing LOPs obtained at different times.
Nautical mile	NM	A nautical mile is used for measurement on most navigable waters. It is 6076 feet or approximately 2000 yards and is equal to one minute of latitude.
Knots	Kn or kt	A knot is a unit of speed equal to one nautical mile per hour.
Speed	S	The rate of travel of a boat through the water measured in knots is the speed.
Speed of Advance	SOA	The average speed in knots that must be maintained to arrive at a destination at any appointed time.
Speed over ground	SOG	The speed of travel of a boat along the track, expressed in knots.
		The difference between the estimated average speed (SOA) and the actual average speed (SOG) is caused by external forces acting on the boat (such as wind, current, etc.).
Track	TR	A track is the course followed or intended to be followed by a boat. The direction may be designated in degrees true or magnetic.
Set		The direction toward which the current is flowing expressed in degrees true.
Drift		The speed of the current usually stated in knots.
Course over ground	COG	The resultant direction of movement from one point to another.

Laying the Course. The navigation plot typically includes several course lines to steer from the beginning point to arrival at the destination. The technique for laying each course line is the same and is summarized as follows: (see **Figure 7-16**)

Step	Procedure
1	Draw a straight line from the departure point to the intended destination. This is the course line.
2	Lay one edge of the parallel rulers along the course line.
3	Walk the rulers to the nearest compass rose on the chart, moving one ruler while holding the other in place.
4	Walk the rulers until one edge intersects the crossed lines at the center of the compass rose.
5	Going from the center of the circle in the direction of the course line, read the inside degree circle where the ruler's edge intersects. This is the magnetic course (M).
6	Write the course along the top of the penciled trackline as three digits followed by the letter (M) magnetic, for example, C 068° M. **Figure 14-24** shows a course of 068° M between two buoys as measured by parallel rulers on a chart's compass rose.

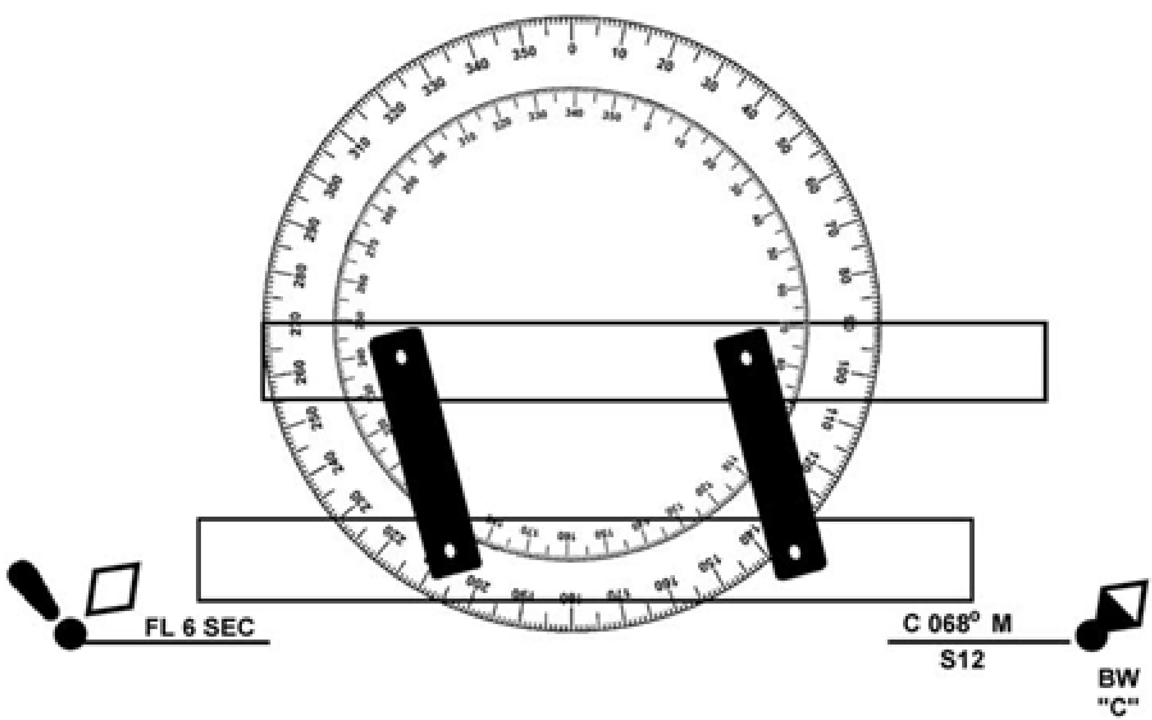


Figure 7-16 068° Magnetic Course between Two Buoys

DEAD RECKONING (DR).

Dead reckoning (DR) is widely used in navigation. It is the process of determining a boat's approximate position by applying its speed, time, and course from its last known position. The key elements of dead reckoning are the course steered and the distance traveled without consideration to current, wind or other external forces.

Course Steered

Only courses steered are used to determine a DR. Course for a boat is normally magnetic (M) since it usually does not carry a gyrocompass, which gives true (T) direction.

Distance Traveled

Distance traveled is obtained by multiplying speed (in knots) by the time underway (in minutes). D = S x T/60

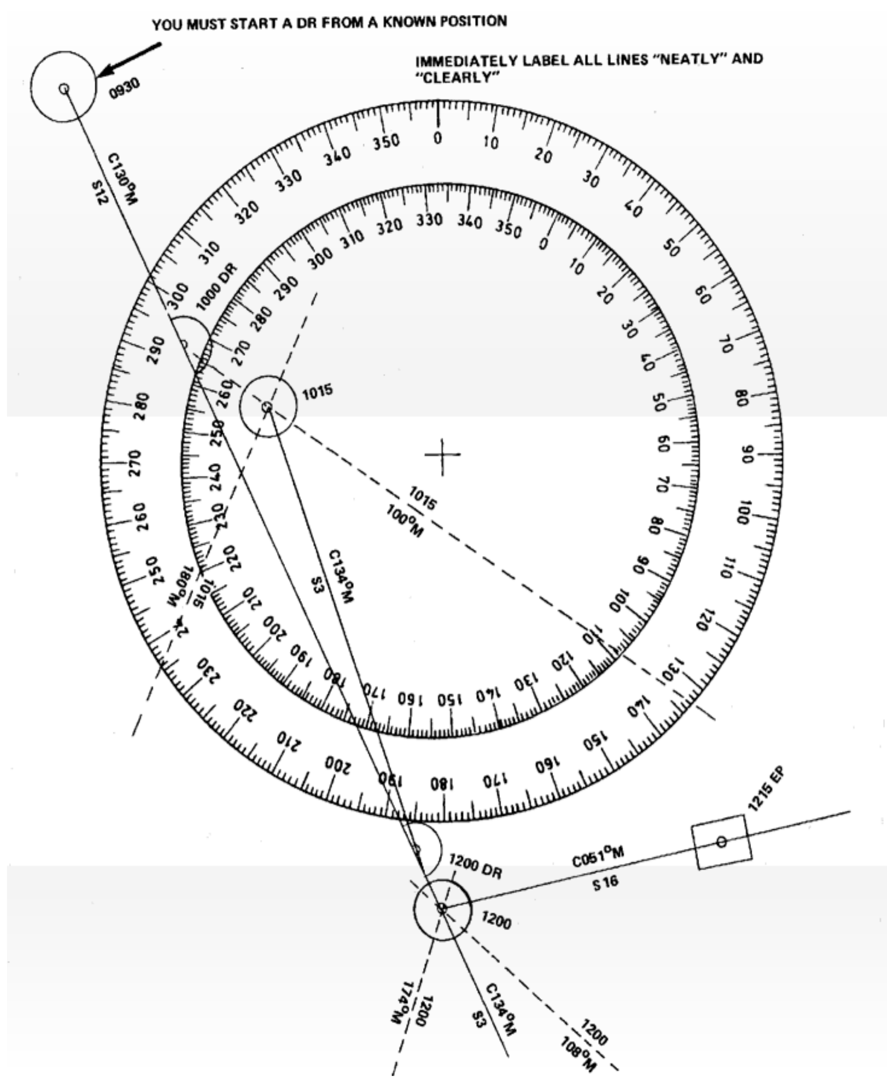


Figure 7-17 Labeling a DR Plot

BASIC ELEMENTS OF PILOTING

Direction, distance, and time are the basic elements of piloting. With these elements, an accurate navigation plot can be maintained.

Direction

Direction is the relationship of one point to another point. Direction, referred to as bearing, is measured in degrees from 000 through 360°.

Bearings

Bearings are a direction, expressed in degrees from a reference point. Bearings may be true, magnetic, compass, or relative. All of the above reference directions may be used except relative direction to designate headings or courses. Relative direction, which uses the boat's bow as the reference direction, changes constantly.
In boat navigation, magnetic courses and bearings will usually be used, since true bearings are obtained from gyrocompasses, which are not normally found on boats.

Obtaining Bearings

Bearings are obtained primarily by using a magnetic compass (compass bearings) or radar (relative bearings). Bearings of fixed, known, objects are the most common sources for LOPs in coastal navigation. When using a compass to take bearings, the object should be sighted across the compass.

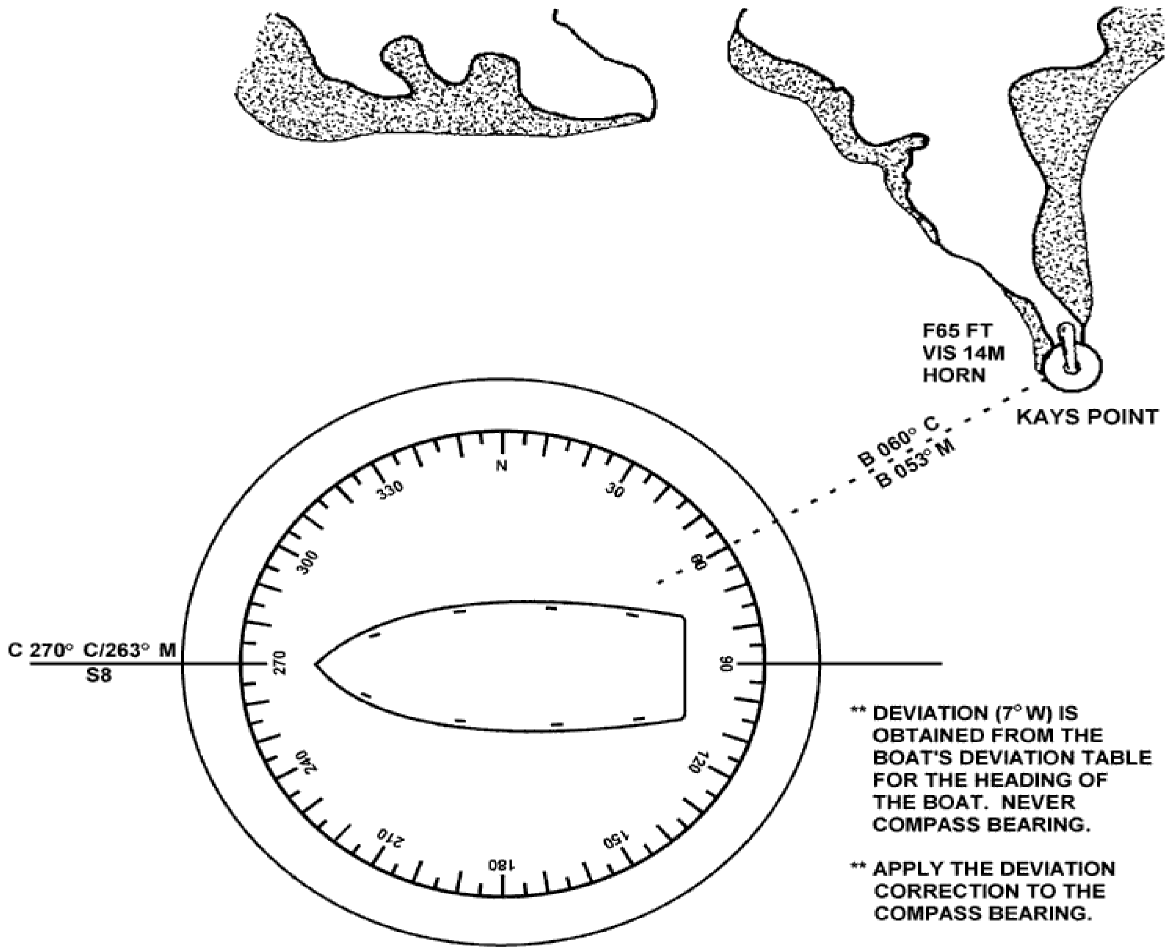


Figure 7-18 Converting Compass Bearing to Magnetic

Relative Bearings

Relative bearing of an object is its direction from the boat's bow at 000°, measured clockwise through 360°.

Distance

The second basic element in piloting is the special separation of two points measured by the length of a straight line joining the points without reference to direction. In piloting, it is measured in miles or yards. There are two different types of miles used:

- Nautical miles.
- Statute miles.

Nautical Mile

The nautical mile is used for measurement on most navigable waters. One nautical mile is 6076 feet or approximately 2000 yards and is equal to one minute of latitude.

Statute Mile
The statute mile is used mainly on land, but it is also used in piloting inland bodies of water.

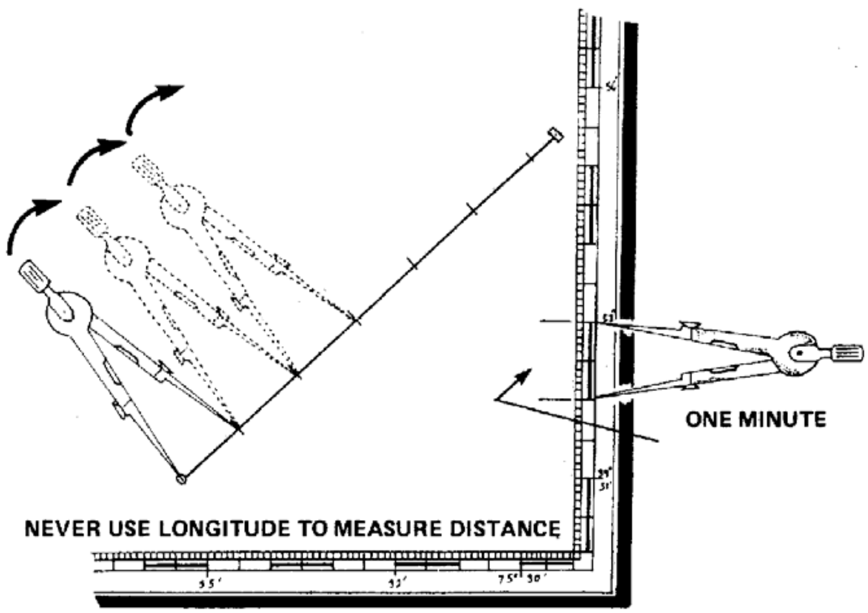
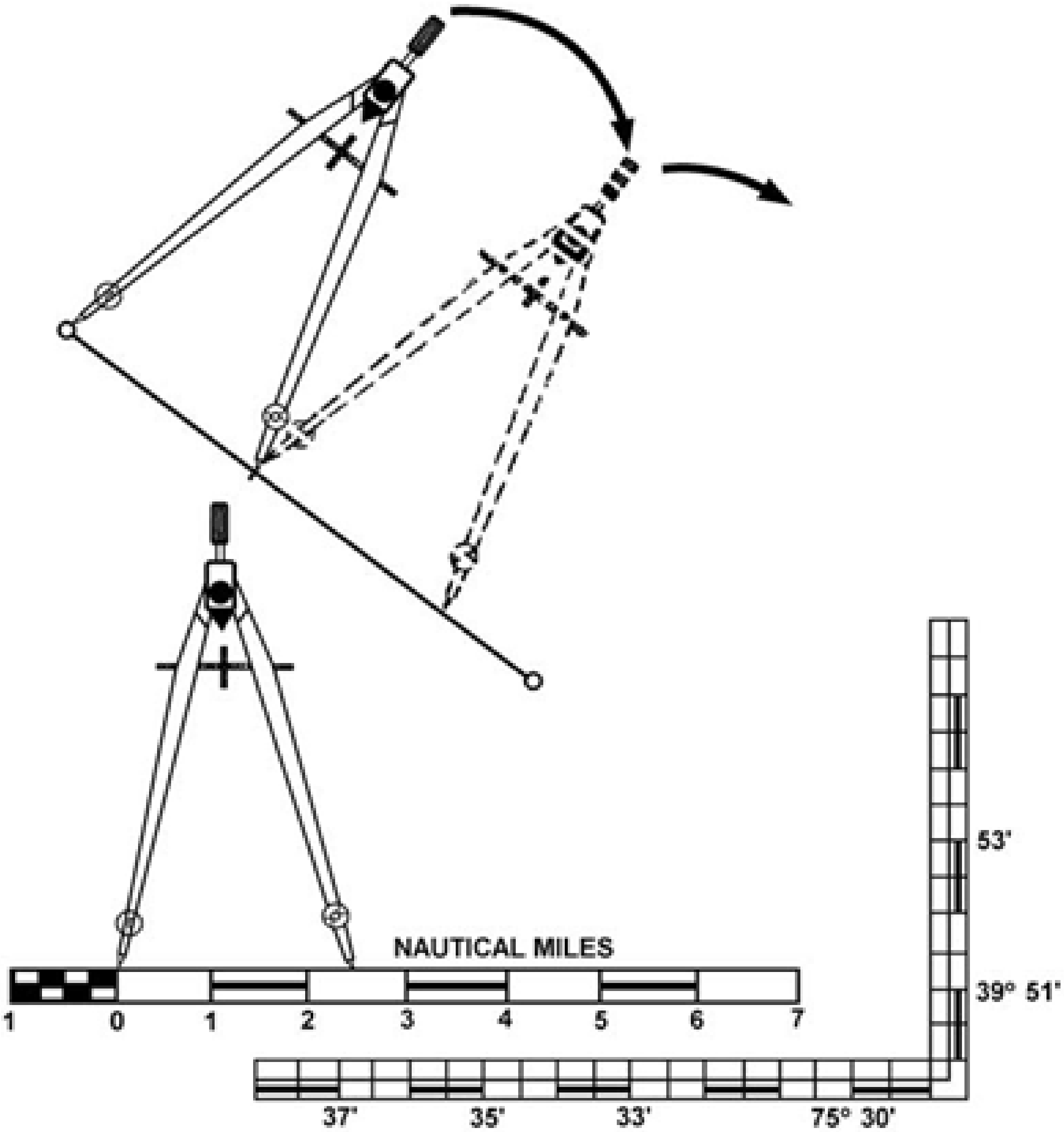


Figure 7-19 Measuring Distance, Latitude

Measuring Distance
Measure the distance by performing the following procedures:

Step	Procedure
1	Place one end of a pair of dividers at each end of the distance to be measured, being careful not to change the span of the dividers.
2	Transfer them to the latitude scale closest to the latitude being measured. Read the distance in minutes. (see **Figure 7-20**)
3	When the distance to be measured is greater than the span of the dividers, the dividers can be set at a minute or number of minutes of latitude from the scale and then "stepped off" between the points to be measured.
4	The last span, if not equal to that setting on the dividers, must be separately measured. To do this, step the dividers once more; closing them to fit the distance.
5	Measure this distance on the scale and add it to the sum of the other measurements.
6	The latitude scale nearest the middle of the line to be measured should be used.



The longitude scale is never used for measuring distance.

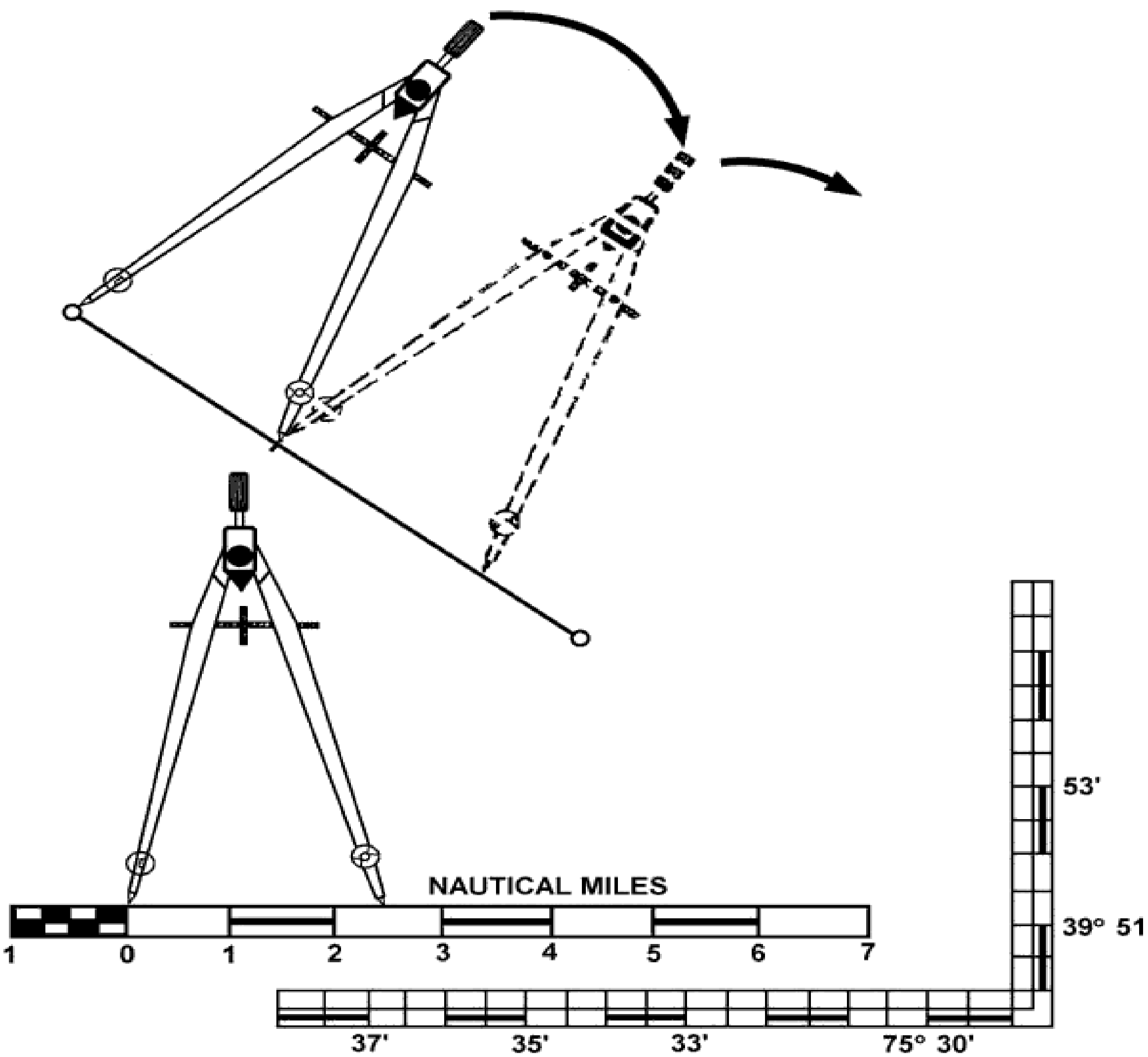


Figure 7-20 Measuring Distance, Nautical Miles

To measure short distances on a chart, the dividers can be opened to a span of a given distance, then compared to the NM or yard scale on the chart. (see **Figure 7-20**)

Time

Time is the third basic element in piloting. Time, distance, and speed are related. Therefore, if any two of the three quantities are known, the third can be found. The basic equations for distance, speed, and time; the speed curve; and nautical slide rule and their use have been discussed earlier.

Plotting Bearings

A bearing or series of bearings can be observed as compass (C), magnetic (M), true (T), or as a relative bearing (visual or radar). The compass bearing reading usually needs to be converted for plotting and then drawn on the chart as a line of position (LOP).

Parallel

One common method of plotting bearings on a chart is using parallel rulers or a course plotter.

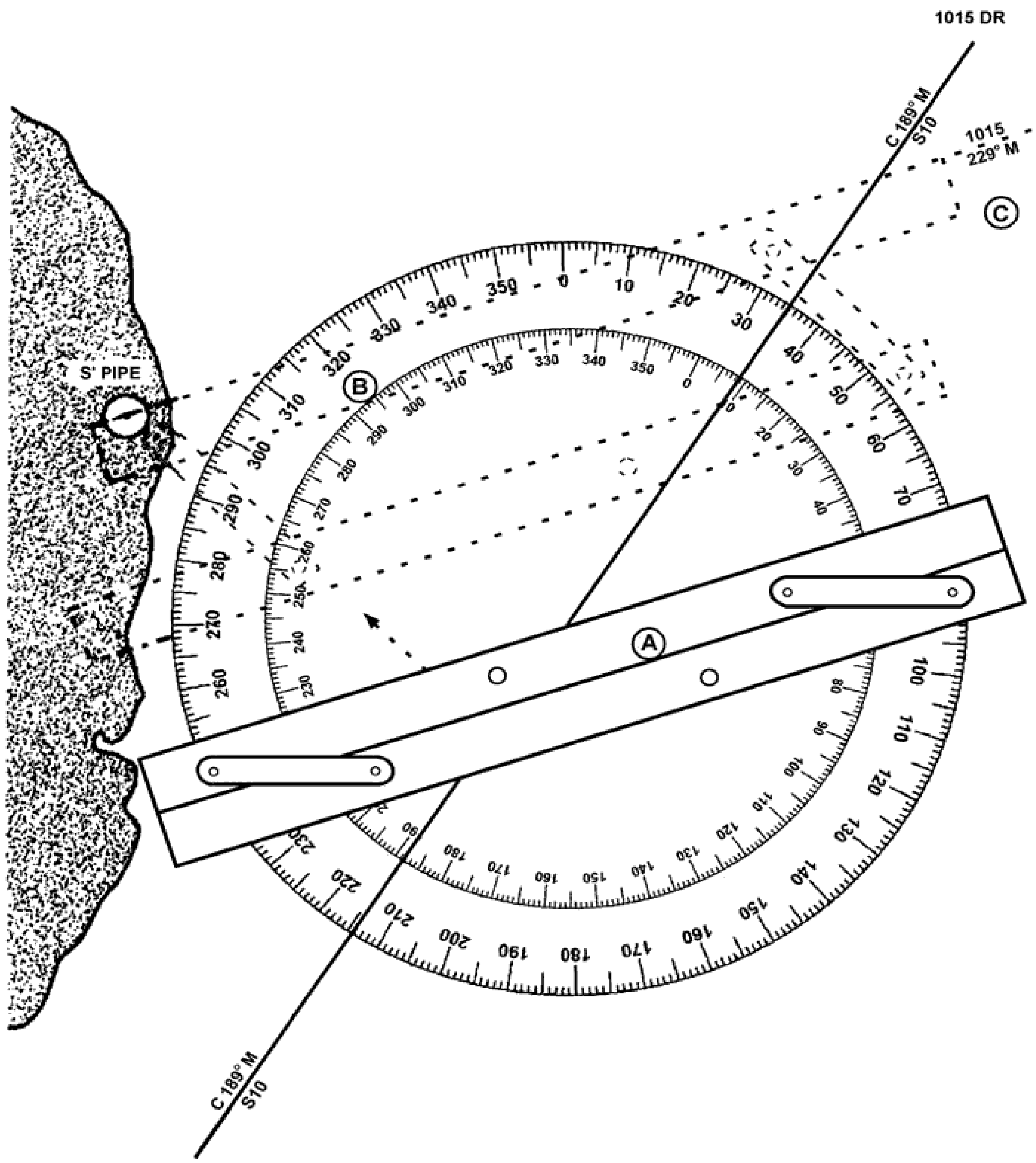


Figure 7-21 Plotting Bearings

Line of Position (LOP)

The position of a boat can be determined by many methods of piloting. The LOP is common to all methods of piloting. For example, if a standpipe and a flagstaff in a line are observed,

the boat is somewhere on the line drawn from the standpipe through the flagstaff and towards the boat. This line is called a range or a visual range.
If the bearing is taken on a single object, the line drawn is called a bearing LOP. The observed bearing direction must be corrected to magnetic or true direction and plotted. The compass rose can be used to provide the direction.
A single observation gives an LOP, not a position. The boat is located somewhere along that LOP. (see **Figure 7-22**)

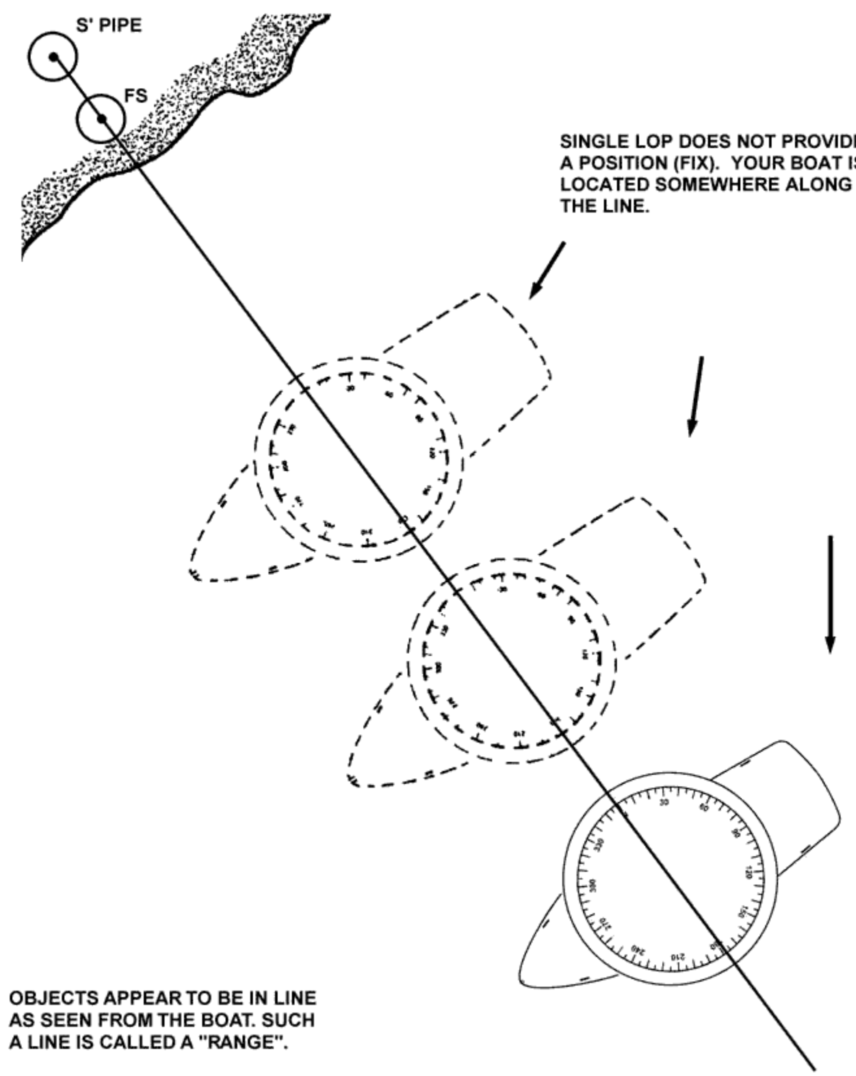


Figure 7-22 Visual Range LOP

Selecting Objects to Obtain a Fix
The primary consideration in selecting charted objects to obtain a fix is the angle between the bearings. Also, attempts should always be made to take bearings on objects as close as

possible to the boat because minor errors in reading are magnified when increasing distance from the object.

Two Lines of Position
When there are only two LOPs for a fix, the quality of the fix will be best when there is a 90° difference in the lines. Serious error in position could result if a difference of less than 60° or more than 120° between the two lines exist. Therefore, two LOPs should intersect at right angles or near right angles wherever possible.

Three Lines of Position
An ideal fix has three or more LOPs intersecting at a single point and the LOPs have a separation of at least 60°, but not more than 120°.

Set and Drift (Current Sailing)
Current sailing is the method of computing course and speed through the water, considering the effects of current so that, upon arrival at the destination, the intended course (track) and the actual course made good are the same. The difference in position between a DR position and a fix taken at the corresponding time is due to various external forces acting on the boat. These forces are usually accounted for as set and drift.

- Set is the direction of these forces and includes factors such as wind, current, and sea condition. Set is expressed in degrees. "Set 240° magnetic" means that the boat is being pushed towards 240° magnetic.
- Drift is the strength of the set and is expressed in knots. "Drift 1.5 knots" means that the boat is being pushed in a given direction (set) at a speed of 1.5 knots.

Making Allowances
In working problems involving set and drift, allow for their effect upon the boat. This can be accomplished by comparing actual fix position information with the DR track and determining the difference. However, conditions do not always allow for this. Also, this can only be done after some portion of the voyage has already occurred.

Current
The current triangle is a vector diagram indicating the course and speed the boat will make good when running a given course at a given speed. (see **Figure 7-23**) It can also be used to determine the course to steer and the speed necessary to remain on the intended track. This information may be obtained by using the chart's compass rose for constructing a current triangle to provide a graphic solution.

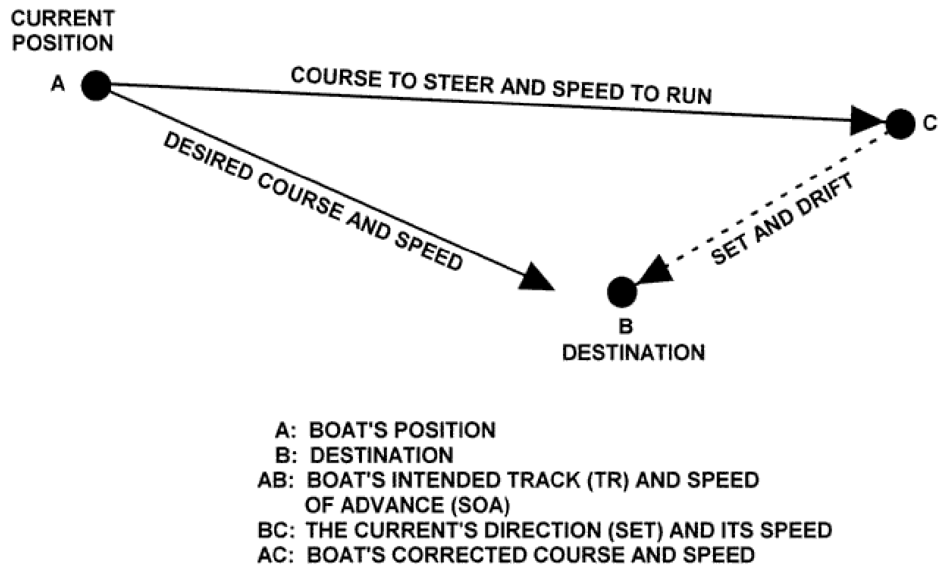


Figure 7-23 Current Triangle

- The first line (AB) on a current triangle indicates the boat's intended direction and the distance to travel in a given period of time. The length of this line represents the boat's speed in knots.
- The second line, (CB) laid down to the destination end of the intended direction (the first line), shows the set (direction) of the current. The length of this line represents the drift (speed) of the current in knots.
- The third line (AC) provides the resulting corrected course to steer and the speed of advance to arrive safely at the destination. If any two sides of the triangle are known, the third side can be obtained by measurement.

Radar

Radar is an aid in navigation, but it is not the primary means of navigation. Boat navigation using radar in limited visibility depends on the coxswain's experience with radar operation. It also depends on the coxswain's knowledge of the local operating area and is not a substitute for an alert visual lookout. A radar radiates radio waves from its antenna to create an image that can give direction and distance to an object. Nearby objects (contacts) reflect the radio waves back and appear on the radar indicator as images (echoes).
Advantages of radar include:

- Can be used at night and in low visibility conditions.
- Obtains a fix by distance ranges to two or more charted objects. An estimated position can be obtained from a range and a bearing to a single charted object.
- Enables rapid fixes.
- Fixes may be available at greater distances from land than by visual bearings.
- Assists in preventing collisions.

The disadvantages of radar include:

- Mechanical and electrical failure.
- Minimum and maximum range limitations.

Reading and Interpolating Radar Images

The radar display shows a tracer sweep extending outward from the center of a radar screen. It represents the radar beam rotating with the antenna. It reflects images on the screen as patches of light (echoes).

In viewing any radar indicator, the direction in which the boat's heading flasher is pointing can be described as up the indicator. The reciprocal of it is a direction opposite to the heading flasher, or down the indicator. A contact moving at right angles to the heading flasher anywhere on the indicator would be across the indicator. The center of the radar screen represents the position of the boat. The indicator provides relative bearings of a target and presents a map-like representation of the area around the boat. The direction of a target is represented by the direction of its echo from the center, and the target's range is represented by its distance from the center. (see **Figure 7-24**)

The cursor is a movable reference and is controlled by the radar cursor control. The cursor is used to obtain the relative bearings of a target on the indicator.

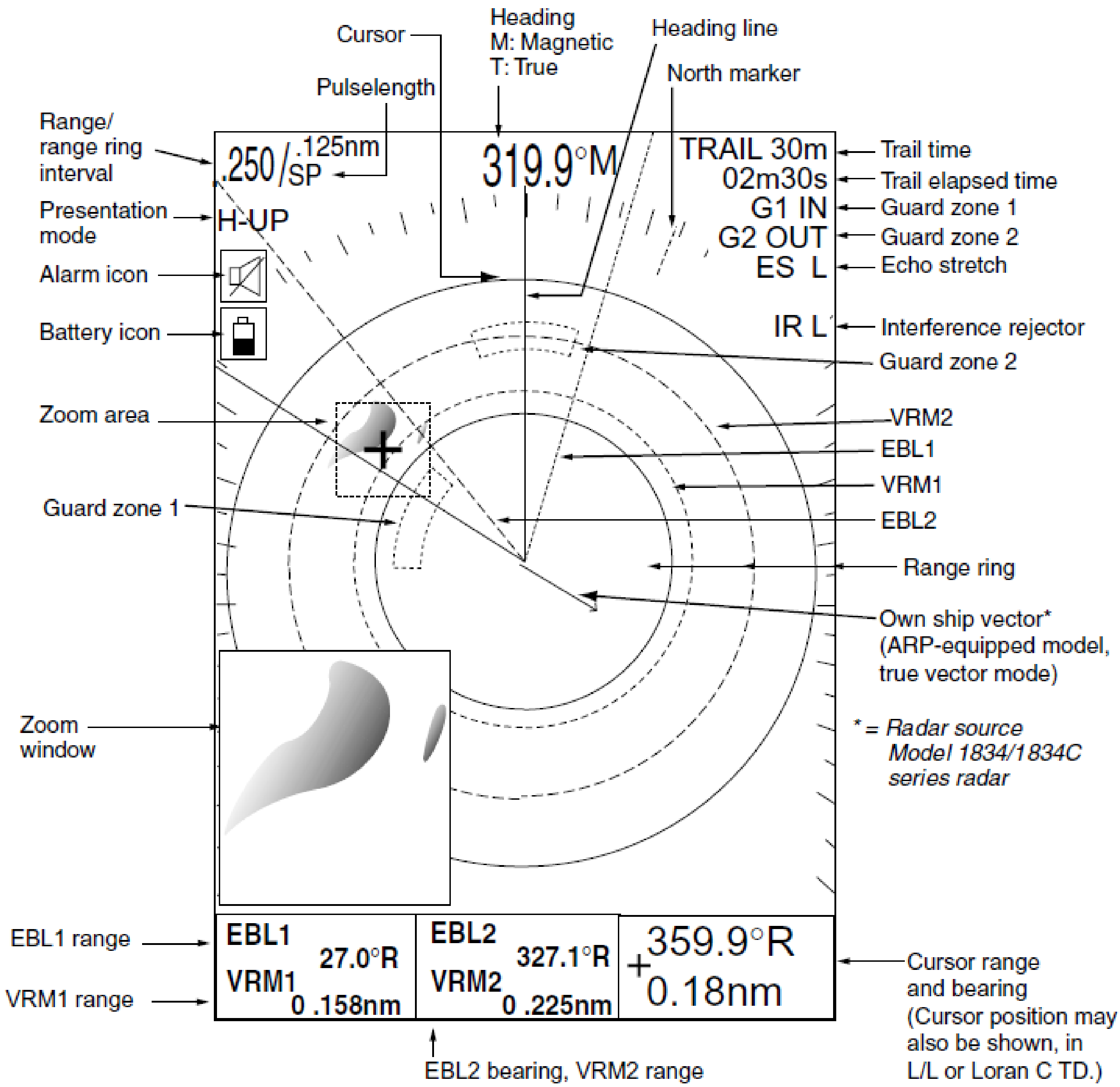


Figure 7-24 Radar Range Rings

Radar Contacts

Images on a radar screen differ from what is seen visually by the naked eye. This is because some contacts reflect radio waves (radar beams) better than others.

A list of common radar contacts and reflection quality follows:

Contact	Integrity
Reefs, shoals, and wrecks	May be detected at short to moderate ranges, if breakers are present and are high enough to return echoes. These echoes usually appear as cluttered blips.

Sandy spits, mud flats, and sandy beaches	Return the poorest and weakest echoes. The reflection, in most cases, will come from a higher point of land from the true shoreline such as bluffs or cliffs in back of the low beach. False shorelines may appear because of a pier, several boats in the area, or heavy surf over a shoal.
Isolated rocks or islands off shore	Usually return clear and sharp echoes providing excellent position information.
Large buoys	May be detected at medium range with a strong echo; small buoys sometimes give the appearance of surf echoes. Buoys equipped with radar reflectors will appear out of proportion to their actual size.
Piers, bridges, and jetties	Provide strong echoes at shorter ranges.
Rain showers, hail, and snow	Will also be detected by radar and can warn of foul weather moving into the area. Bad weather appears on the screen as random streaks known as 'clutter'.

Radar Fixes
Radar navigation provides a means for establishing position during periods of low visibility when other methods may not be available. A single prominent object can provide a radar bearing and range for a fix, or a combination of radar bearings and ranges may be used. Whenever possible, more than one object should be used. Radar fixes are plotted in the same manner as visual fixes.
NOTE: If a visual bearing is available it is more reliable than one obtained by radar.

Range Rings
Radar range rings show up as circles of light on the screen to assist in estimating distance. Major range scales are indicated in miles and are then subdivided into range rings. Typical range scales for a boat radar are ½, 1, 2, 4, 8, and 16 NM.

LOPs
Radar LOPs may be combined to obtain fixes. Typical combinations include two or more bearings, a bearing with distance range measurement to the same or another object, or two or more distance ranges. Radar LOPs may also be combined with visual LOPs.
Care should be exercised when using radar bearing information only since radar bearings are not as precise as visual bearings.

Global Positioning System (GPS)
GPS is a radio-navigation system of 24 satellites operated by the DoD. It is available 24 hours per day, worldwide, in all weather conditions. Each GPS satellite transmits its precise location, meaning position and elevation. In a process called "ranging," a GPS receiver on the boat uses the signal to determine the distance between it and the satellite. Once the receiver has computed the range for at least four satellites, it processes a three-

dimensional position that is accurate to about 9-110 feet, with constant improvements in accuracy as time passes.

Equipment Features
Positional information is shown on a chart plotter screen as geographical coordinates (latitude and longitude readings). Navigational features available in the typical GPS receiver include:

- Entry of waypoints and routes in advance.
- Display of course and speed made good.
- Display of cross-track error.
- Availability of highly accurate time information.

Chapter 8
Aids to Navigation

Introduction

This chapter introduces the aids to navigation (AtoN) used in the United States. AtoN are devices or marks that assist mariners in determining their vessel's position, or course, or to warn of dangers, obstructions, or regulatory requirements affecting safe navigation. In the U.S., the Coast Guard is responsible for servicing and maintaining AtoN under federal jurisdiction. This includes both short and long-range navigation systems found in the navigable waters, along the U.S. coast, Intracoastal Waterway (ICW) system, and the Western Rivers system. Lakes and inland waterways that fall under state jurisdiction use the Uniform State Waterway Marking System (USWMS).

U.S. AIDS TO NAVIGATION SYSTEM

Buoys, beacons, and other short-range AtoN are used the same way signs, lane separations, and traffic lights guide motor vehicle drivers. Together, these AtoN make up the short-range AtoN system, which uses charted reference marks to provide information for safely navigating waterways. In the U.S., short-range aids conform to the International Association of Lighthouse Authorities (IALA) Region B. This is called System B, the U.S. Lateral System, or the U.S. Aids to Navigation System. The Coast Guard maintains short-range aids to provide:

- Daytime visual system of daymarks, beacons and buoys. Nighttime visual system of lights and retroreflective signals.
- A sound system of various non-directional sound producing devices, though not required by IALA.

LATERAL AND CARDINAL SIGNIFICANCE

Prior to the mid-1970's, there were over 30 different navigation systems in use around the world. To reduce confusion, IALA established two systems of buoyage for conveying navigation information to mariners. The IALA System A and B were established, with the U.S. complying with the IALA B System. The IALA-A and IALA-B systems use the Lateral and Cardinal Systems to define the conventions of buoyage, and to mark channels with AtoN. "Lateral significance" or "cardinal significance" means that the rules for the Lateral or Cardinal System apply in that instance. However, if something has no lateral or cardinal significance, the respective system's rules do not apply to the situation. The differences between the markings and conventions used in the Lateral and Cardinal Systems are discussed in the following paragraphs. **Table 8-1** describes the IALA Systems A and B:

Buoyage System		
	IALA-A System	**IALA-B System**

Location	Europe, Africa, Australia, New Zealand, and most of Asia	North and South America, Japan, South Korea, and the Philippines
Information shown by	Buoy shapes, colors, and if lighted, rhythm of flashes and colored lights	
Topmarks	Small distinctive shapes above the basic aid that assist in identification of the aid.	
Marks	Cardinal and lateral marks	Mostly lateral, some cardinal in the Uniform State Waterway Marking System (USWMS)
Cardinal marks have black and yellow horizontal bands regardless of the IALA system.		
When entering from seaward:		
Keep red buoys to	Port	Starboard, “red, right, returning”
Keep green buoys to	Starboard	Port

Table 8-1
IALA-A and IALA-B Systems

Lateral System
In the lateral system, buoys and beacons indicate the sides of the channel or route relative to a conventional direction of buoyage (usually upstream). They also mark junctions, a point where two channels meet when proceeding seaward; or bifurcations, the point where a channel divides when proceeding from seaward, or the place where two tributaries meet.
In U.S. waters, AtoN use the IALA-B system of lateral marks with few exceptions (see A.3 below), arranged in geographic order known as the “conventional direction of buoyage”. Under this, the memory aid 3R rule of “red, right, returning” applies when a vessel is returning from seaward. This means, when returning from sea, keep red markers to the right of the vessel from:

- North to south along the Atlantic Coast.
- South to north and east to west along the Gulf Coast. South to north and east to west along the Pacific Coast.
- East to west in the Great Lakes except for Lake Michigan which is north to south.

Cardinal System
The Cardinal System uses a buoy to indicate the location of a danger relative to the buoy itself. In the U.S., the USWMS uses cardinal marks on waters where a state exercises sole jurisdiction. The colors of these marks differ from those of IALA. For instance, a white buoy with a black top indicates unsafe water to the south and west. Various countries throughout the world, including Canada, Bermuda, and the Bahamas, also use Cardinal marks along with lateral marks. Cardinal marks are not used on waters where the U.S. Coast Guard maintains short-range AtoN.

General Characteristics of Short-Range AtoN
Aids to navigation (AtoN) have many different characteristics. An aid's color, size, light, or sound signify what mariners should do when they see it. Characteristics of short-range aids used in the U.S. are described in the following paragraphs.
Type
The location and the intended use determine which one of the two types of AtoN will be placed in a spot or waterway:

- Floating (buoy).
- Fixed (beacon).

AtoN IDENTIFICATION (NUMBERS AND LETTERS)
Solid red AtoN buoys and beacons bear even numbers and all solid green AtoN bear odd numbers. No other AtoN are numbered. When proceeding from seaward toward the direction of conventional navigation, the numbers increase. Numbers are kept in approximate sequence on both sides of the channel. Letters may be used to augment numbers when lateral AtoN are added to channels with previously completed numerical sequences. For instance, a buoy added between R"4" and R"6" in a channel would be numbered R"4A". Letters will also increase in alphabetical order.
Not every buoy or beacon is numbered. Preferred channel, safe water marks, isolated danger, special marks, and information/regulatory AtoN use only letters."

Color
During daylight hours, the color of an AtoN indicates the port or starboard side of a channel, preferred channels, safe water, isolated dangers, and special features. Only red or green buoys, or beacons fitted with red or green dayboards, have lateral significance.

Shape
Shapes of buoys and beacons help identify them from a distance or at dawn or dusk, when colors may be hard to see. Like other characteristics of AtoN, mariners should not rely solely on shape to identify an aid.

Cylindrical Buoys (Can)
Cylindrical buoys, often referred to as "can buoys," are used as a lateral mark, they indicate the left side of a channel or of the preferred channel when returning from seaward. They are painted solid green or have green and red horizontal bands; the topmost band is always green. Can buoys are also used as unlighted special marks and will be colored based on their use. (see **Figure 8-1**)

Conical Buoys (Nun)
Conical buoys, often referred to as "nun buoys," are used as a lateral mark, nun buoys indicate the right side of a channel or of the preferred channel when returning from seaward. They are painted solid red or red and green with horizontal bands and always with a red

topmost band. Nun buoys are also used as unlighted special marks and will be colored based on their use. (see **Figure 8-1**)

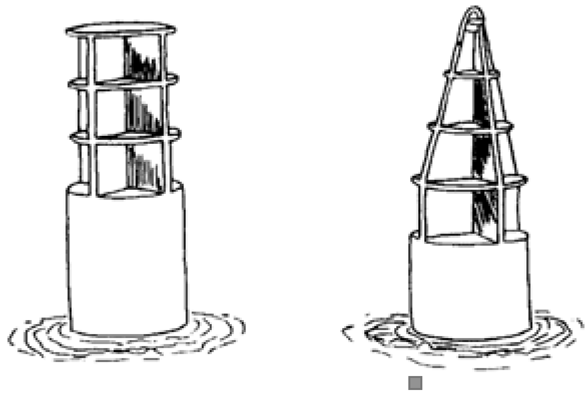


Figure 8-1 Can and Nun Buoys, "When Returning From Sea"

Beacons

Beacons have dayboards attached to a structure. When returning from sea, a triangular shaped dayboard marks the starboard side, and a rectangular shaped dayboard marks the port side of the channel. (see **Figure 8-2**)

Buoys other than a can and nun or buoys fitted with a top mark, such as isolated danger or safe-water buoys, have no shape significance. Their meanings are shown by numbers, colors, top marks, lights, and sound signal characteristics.

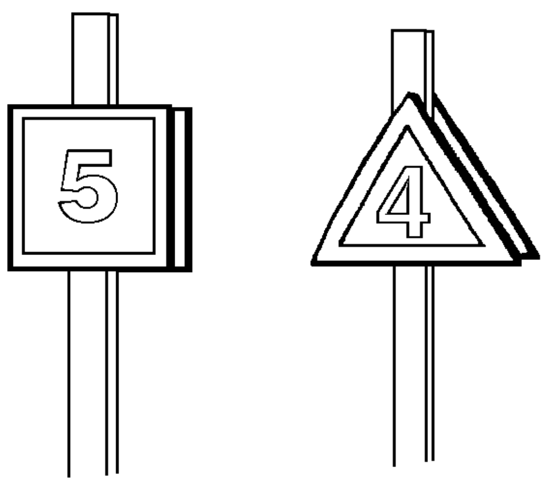


Figure 8-2 Daybeacon, "When Returning From Sea"

Though there are white and yellow lights, only AtoN with green or red lights have lateral significance. When proceeding in the conventional direction of buoyage, AtoN will display the following light colors:

Green
Green lights mark port sides of channels and wrecks or obstructions. When proceeding from seaward, these aids are passed by keeping them on the port side. Green lights are also used on preferred channel marks where the preferred channel is to starboard. When proceeding along the conventional direction of buoyage (from seaward), a preferred channel mark fitted with a green light would be kept on the port side.

Red
Red lights mark starboard sides of channels and wrecks or obstructions. When proceeding from seaward, these aids would be passed by keeping them on the starboard side. Red lights are also used on preferred channel marks where the preferred channel is to port. When proceeding along the conventional direction of buoyage (from seaward), a preferred channel mark fitted with a red light would be kept on the starboard side.

White and Yellow
White and yellow lights have no lateral significance. However, the characteristic (rhythm) of the light does give information such as safe water, danger, or special purpose.

Light Signals
Lights are installed on AtoN to provide signals to distinguish one navigation light from another, or from the general background of shore lights.

Light Characteristics
Lights displayed from AtoN have distinct characteristics which help in identifying them. AtoN with lateral significance display flashing, quick, occulting, or isophase light rhythms.

Light Identification
To identify a light, the following information should be determined:

Color	Color of the light beam (color of its lens).
Characteristic	Pattern of flashes or eclipses (dark periods) observed from the start of the one cycle to the start of the next cycle.
Duration	Length of time for the light to go through one complete cycle of changes.
Example: Buoy “8” displays one single flash of red every 4 seconds. That light color and rhythm information is indicated on the chart as shown below: R"8" Fl R 4s	

Sound Signals

Though not a requirement of IALA B system, in the U.S., some AtoN have sound signals to provide information to mariners during periods of restricted visibility. Different types of devices are used to produce these sounds. Sound signals may be activated as follows:

- Continuously (bell, gong, or whistle buoy).
- Manually.
- Remotely.
- Automatically (when equipped with a fog detector).

Sound signals can be identified by their tone and phase characteristics. Horns, sirens, whistles, bells, and gongs produce distinct sound signals. The sound signal characteristics for specific AtoN are briefly described on the chart, and in length in Column 8 of the *Light List*. Unless it is specifically stated that a signal "Operates Continuously" or the signal is a bell, gong, or whistle, signals will only operate in fog, reduced visibility, or adverse weather.

Device	Characteristic
Tone Characteristics	
Electronic horns	Pure tone
Sirens	Wail
Whistle buoys	Loud moaning sound
Bell buoys	One tone
Gong buoys	Several tones
Phase Characteristics	
Fixed structures	Produce a specific number of blasts and silent periods every minute.
Buoys with a bell, gong, or whistle	Are wave actuated and do not produce a regular characteristic.
Buoys with electronic horn	Operate continuously.

Summary of Lateral Significance of Buoys and Beacons

Direction of Buoyage
While proceeding in the conventional direction of buoyage in IALA System B, boat crews will see the following AtoN:

Marking Starboard Side
Red buoys and beacons with triangular shaped red dayboards mark the starboard side of a channel when returning from seaward. This is the red, right, returning rule. AtoN displaying these characteristics are kept to starboard when returning from seaward.

MEMORY AID: Red, right, returning.

Marking Port Side

Green buoys and beacons with square shaped green dayboards mark the port side of a channel when returning from seaward.

Marking Channel Junction or Bifurcation

Red and green, or green and red, horizontally banded buoys and beacons are called preferred-channel marks. They are used to indicate a channel junction or bifurcation (point where a channel divides or where two tributaries meet). They may also mark wrecks or obstructions and may be passed on either side. When returning from sea, and the topmost band is:

- Green: keep the aid to port to follow the preferred channel.
- Red: keep the aid to starboard to follow the preferred channel.

Safe Water Marks

Safe water marks are buoys with alternating red and white vertical stripes, and beacons with red and white vertically striped dayboards. (see **Figure 8-3**) They also mark a mid- channel, fairway, channel approach points and the "In" and "Out" channels of a "Traffic Separation Scheme." If lighted, they will display a white light with the characteristic Morse Code "A". Safe water buoys should be fitted with a red sphere as a visually distinctive top mark.

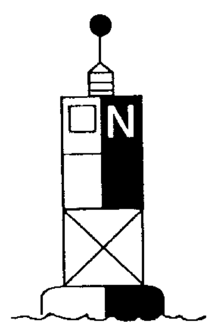


Figure 8-3 Safe-Water Mark

Isolated Danger Marks

Black and red horizontally banded buoys are called "Isolated Danger Marks". They are used to mark isolated dangers (wrecks or obstructions) which have navigable water all around. Isolated danger marks display a white light with a "group-flashing" characteristic; and are fitted with a visually distinctive topmark, consisting of two black spheres, one above the other.

Special Marks

Yellow buoys and beacons are called "special marks". They mark anchorages, and other special areas or features. When lighted, special marks will display a yellow light with a Fixed ("F") or Flashing ("Fl") characteristic. Special marks may also be used to mark the center of the traffic separation scheme.

Marking Regulated Areas
Information and regulatory buoys and beacons indicate various warnings or regulatory matters. They are colored with white and orange shapes. They will only display a white light and may display any light rhythm except quick flashing.

Ranges
Ranges are pairs of beacons located to define a line down the center of a channel or harbor entrance. They are usually lighted and arranged so that one mark is behind and higher than the other mark. When both markers of the range are in line, a vessel's position is along a known LOP. Ranges are located on specially built structures, existing AtoN structures, or structures such as buildings or piers. Ranges are found in entrance channels to harbors, piers, or successive straight reaches. Again, range marks are located so that when viewed from the channel the upper mark is above, and a considerable distance beyond, the lower mark.

Range Characteristics
Ranges are considered to be non-lateral AtoN. Some ranges have rectangular daymarks that are striped in various colors. Most are lit 24 hours per day and may display either red, green, or white lights or combinations of the same. The *Light List* should be consulted for the light characteristics and color combinations displayed on the daymarks.

If…	Then…
the two marks are vertically aligned	the upper (rear) mark appearing directly above the lower (front) mark, the vessel is in the center of the channel. (see **Figure 8-4**)
the upper mark is seen to the left of the lower mark,	the vessel is to the left of the center of the channel.
the upper mark is to the right of the lower mark	the vessel is to the right of the center of the channel.

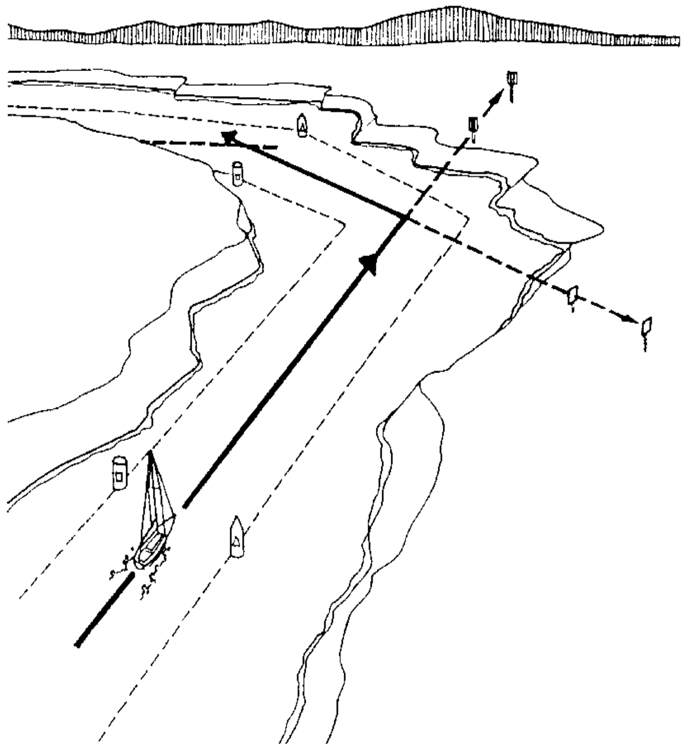
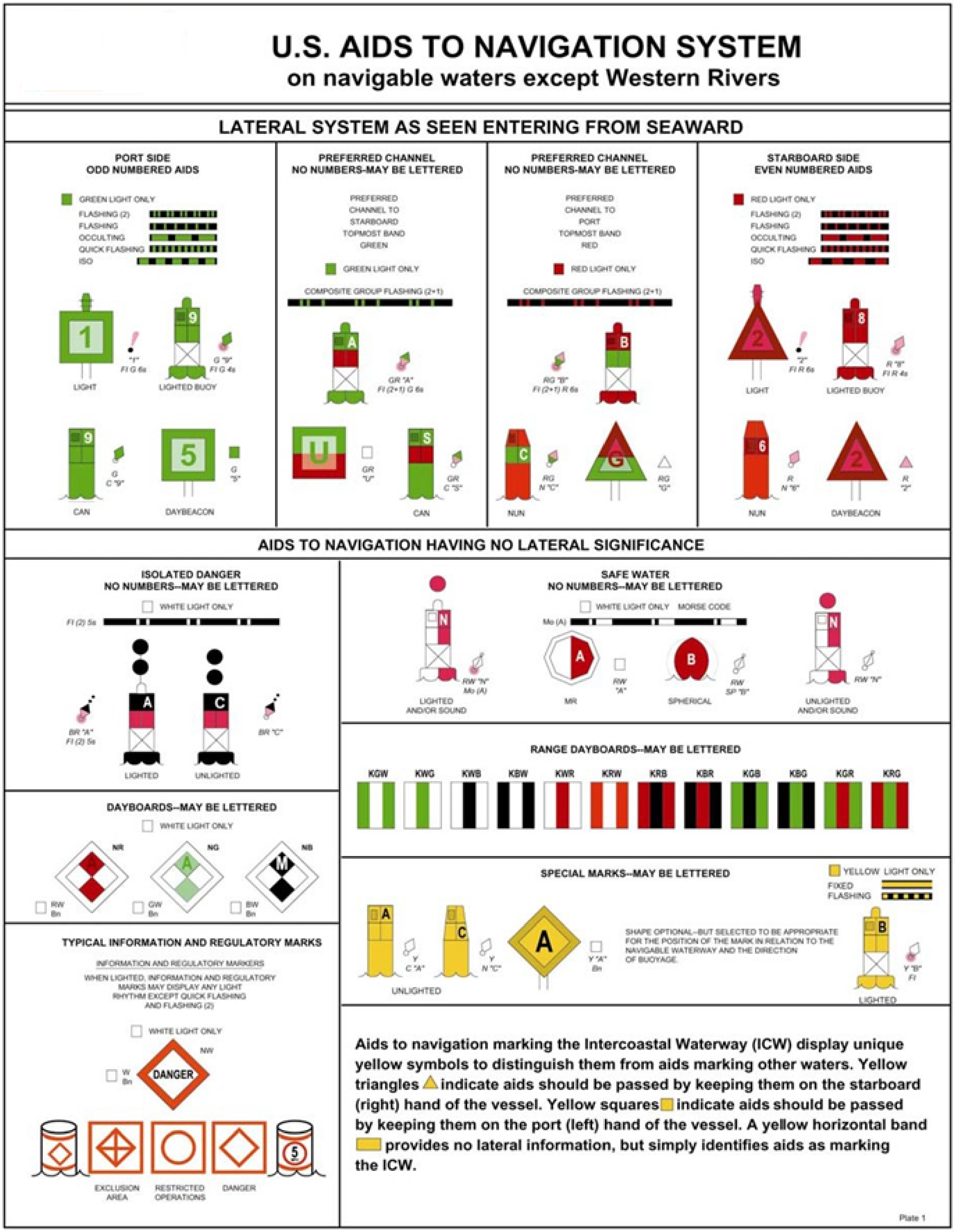
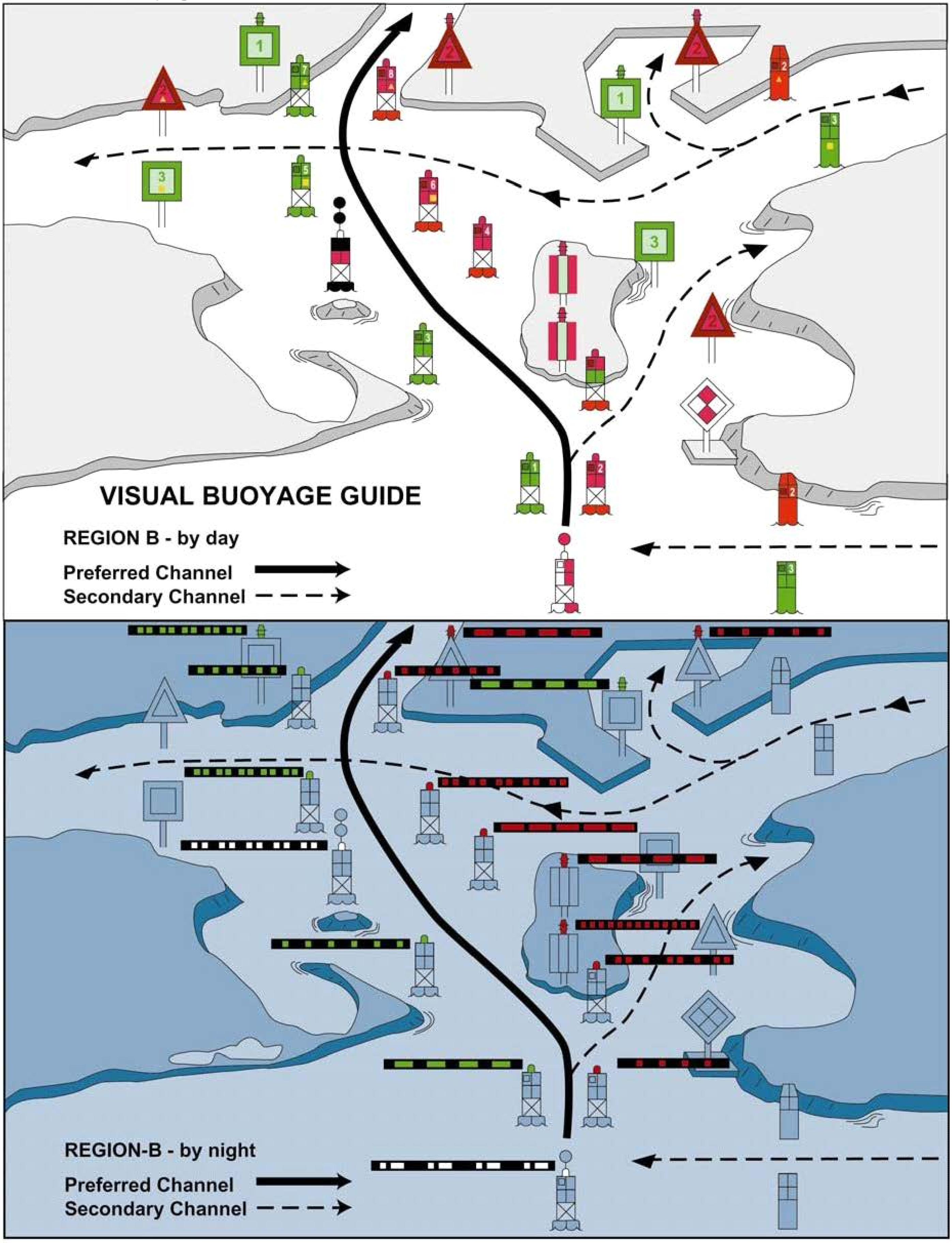


Figure 8-4 Using Range Lights

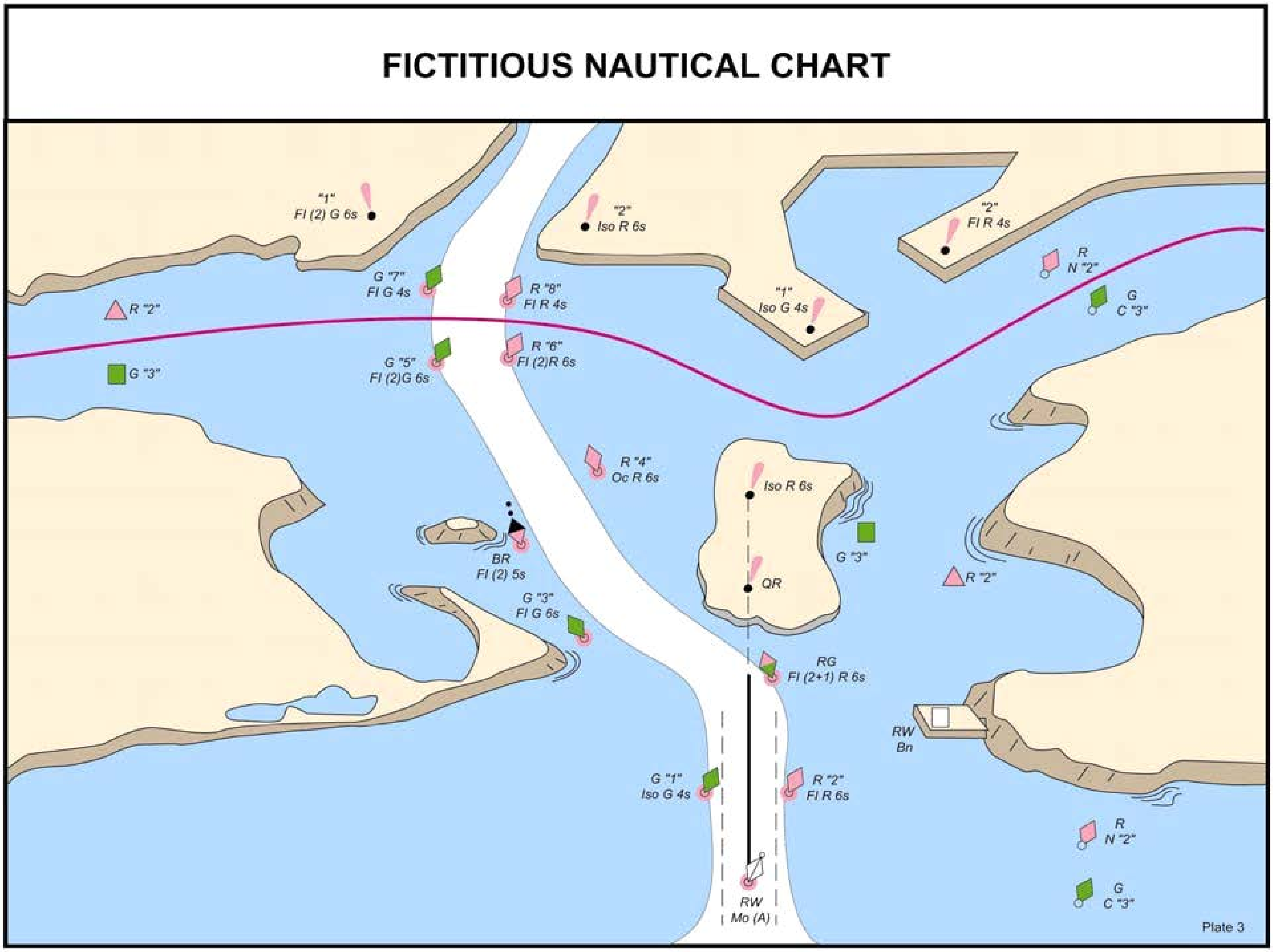
U.S. Aids to Navigation System on Navigable Waters, Except the Western River System



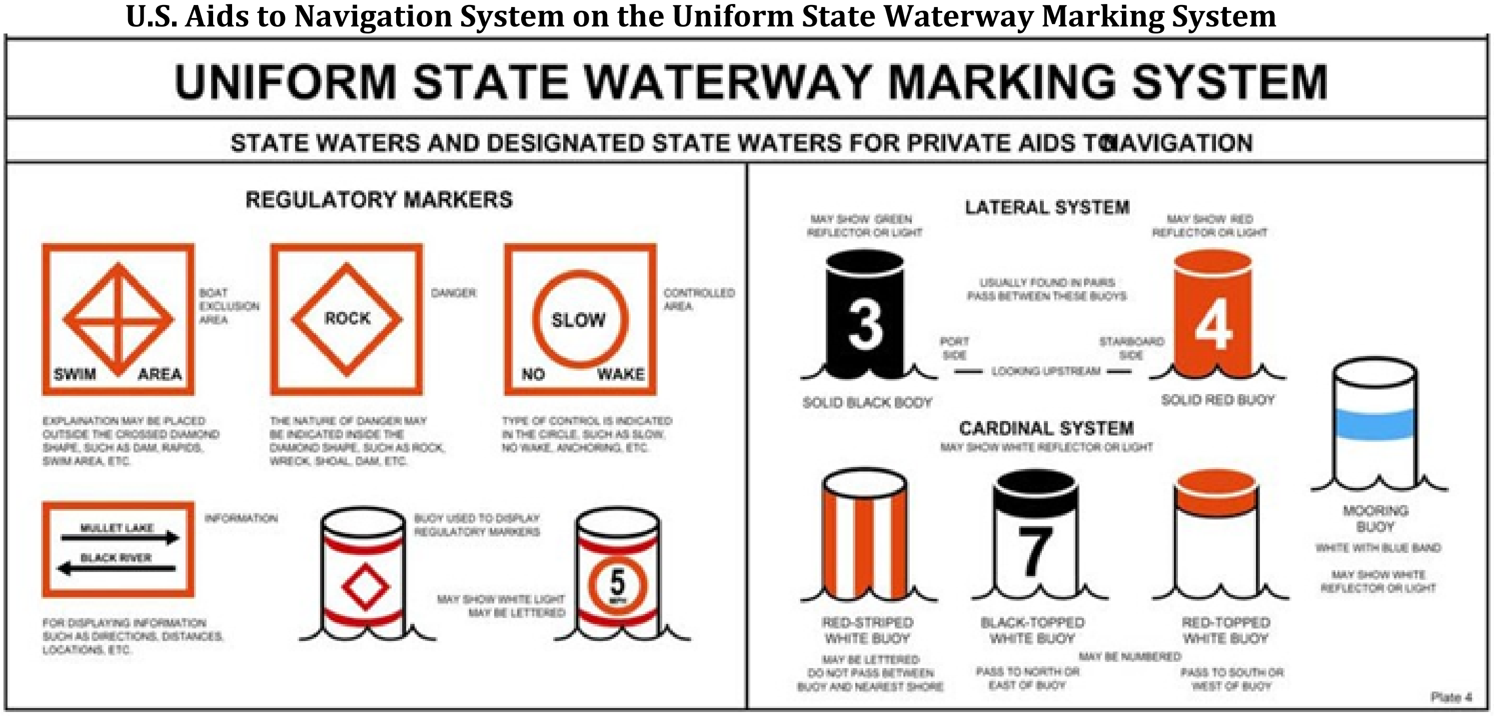
Visual Buoyage Guide



How the Visual Guide Would (Fictitious Nautical Chart) Appear on a Nautical Chart



U.S. Aids to Navigation System on the Uniform State Waterway Marking System



Chapter 9
First Aid

Introduction

This chapter provides basic first aid and transporting information for injuries encountered in the marine environment. First aid is doing what must be done before expert help is available. It may include:

- Providing immediate temporary assistance. Saving life.
- Preventing further injury or unfavorable progression.
- Preserving vitality and resistance to infection.
- Delivering the victim if necessary.

SHOCK

Treatment for Shock

Shock can be effectively reduced or eliminated if proper steps are taken. It is important to understand how to identify and treat shock. It may accompany injury and can reduce a victim's ability to deal with and survive serious injuries. Shock by itself, even when no injuries are involved, can be very serious and life threatening.

Description

Shock is a depressed physiological or mental state. Shock syndrome, a set of symptoms which occur together, can change throughout treating an injury and are unique for every casualty. Signs and symptoms may develop rapidly or be delayed for up to several hours after the apparent cause. The symptoms usually precede the signs. Several types of shock exist, therefore, recognizing and treating shock immediately is important. Some syndromes do not appear in every casualty nor are they equally noticeable.

NOTE Shock can occur at any time during first aid and should be assessed first and monitored throughout treatment.

Causes

Some events that typically cause shock are:

- Trauma (bleeding, blunt (e.g., a fall, being struck by a blunt object, etc.), fractures, and burns).
- Allergic reactions.
- Hypothermia.
- Drugs.
- Toxins.

- Heart attack.
- Illnesses such as diabetes.
- Emotional.

Symptoms
Symptoms include:
- Restlessness.
- Fainting.
- Thirst.
- Nausea.
- Weakness.
- Anxiousness.
- Fright.
- Dizziness.
- Signs include:
- Pulse - weak and rapid.
- Breathing - shallow, rapid, and irregular.
- Skin - cold, clammy (sweating).
- Pupils – dilated.
- State of consciousness - alert (may be deceiving) to unconscious.

Assessment
Strong signs and symptoms of shock can be identified by skin color, pulse rate, monitoring respiration, and a victim's level of consciousness.

Area	Normal	Signs of Shock
Skin color	Adult skin is normally dry, not excessively pale or wet to the touch.	A person in shock may have pale looking skin that is cold and clammy to the touch.
Eyes	Responsive to movement and light conditions.	Pupils appear to be dilated.
Pulse	Normal pulse for an adult is regular, strong, and between 60- 100 beats per minute.	A shock patient will appear restless, and has a pulse that feels weak and is more rapid than normal, usually greater than 100 beats per minute.
Respiration	Normal adult respiration is between 16-24 breaths per minute.	A strong indicator of respiratory distress would be less than 16 breaths per minute, rapid and irregular, or greater than 24 breaths per minute. Immediate assistance is required in these instances to avoid respiratory arrest.

Consciousness	Any time a patient's level of consciousness is other than fully alert, it is a serious indication to seek medical assistance immediately.	Person can appear anywhere from alert (may be deceiving) to unconscious.

Treatment
To properly treat shock once it has been identified, boat crewmembers must administer initial treatment, followed by executing steps to ensure the effects of shock are kept at a minimum.

Initial Treatment
Initial treatment for shock includes limiting a patient's activity, ideally having the person lie down and remain alert for the signs and symptoms of shock. If unconscious, appropriate treatment is to activate EMS and institute resuscitation procedures.

If CPR is not necessary, the victim should remain lying down, should be kept warm, if not already overheated, and should be checked for other injuries.

Continuing Treatment
Additional procedures must be followed and completed in order to control the effects of shock upon the victim:

- Check for "medic alert" or other information tags.
- Obtain history for medical problems (heart disease, diabetes, allergies, and medications).
- Provide specific treatment if advised and trained to do so.
- If there is not a head injury or breathing trouble, place victim flat on back and elevate the lower extremities about 8 to 10 inches. Be careful of any other injuries (.
- Perform cardiopulmonary resuscitation (CPR), if indicated and trained to provide.
- Warm with blankets. If hot, do not warm.
- If conscious, moisten lips, if requested.
- Do not allow patient to eat or drink.
- Never give alcohol.
- Handle gently.

Anaphylactic Shock

Description
Anaphylactic shock is a rapid, extreme allergic reaction. People who are subject to this type of shock should carry medical identification at all times. Sensitivity reactions can occur within seconds of contact and can result in death within minutes of contact. It is imperative

to be able to recognize the signs and symptoms of anaphylactic shock in order to relay the gravity of the situation to qualified medical personnel.

Causes
Anaphylactic shock can be caused by eating fish or shellfish, ingesting particular types of berries or oral drugs such as penicillin. Insect stings from yellow jackets, hornets, wasps, etc., injected drugs, exercise, cold, and inhaled substances such as pollen or dust may also cause sensitivity reactions.

Symptoms
Symptoms of anaphylactic shock include:

- Skin: itching, hives (raised rash), flushing (redness).
- Swelling of lips, tongue, feet, throat, hands.
- Respiratory tract: wheezing, shortness of breath, coughing.
- Gastrointestinal: nausea and vomiting, abdominal cramps, diarrhea.
- Headache.
- Altered mental status. Loss of consciousness.

Onset of symptoms may be rapid, within seconds, or delayed (up to two hours). The signs for anaphylaxis are the same as those of shock.

Assessment
Anaphylactic shock is a severe, sometimes life-threatening, allergic reaction that can occur within minutes of exposure to an offending substance. The substance may enter the body orally or through contact. Anaphylactic shock can be identified by visual changes to the subject's normal appearance and by changes in vital signs. The following table provides indications that a person may be encountering anaphylactic shock.

Area	Normal	Signs of Shock
Skin color	Adult skin is normally dry, not excessively pale or wet to the touch.	Sudden appearance of hives. Widespread blotchy swelling of the skin. Paleness, bluish skin color. Tingling in lips, mouth and tongue are also common.
Eyes	Responsive to movement and light conditions.	Pupils may be dilated.
Pulse	Normal pulse for an adult is regular, strong, and between 60-100 beats per minute.	Increased pulse rate, or weak and thin pulse accompanied by a drop in blood pressure (shock). Blood pressure remains low even when lying down.

Respiration	Normal adult respiration is between 16-24 breaths per minute.	Wheezing or difficulty in breathing. Chest tightness. Coughing. Throat swelling, with a feeling of throat tightness, a lump in throat, hoarseness or obstructed air flow.
Consciousness	Any time a patient's level of consciousness is other than fully alert, it is a serious indication to seek medical assistance immediately.	Light-headedness or fainting.
Internal		Nausea, vomiting, abdominal cramps, diarrhea.

Treatment
Anaphylactic shock requires medication to counteract the allergic reaction to the substance. If the victim carries an epinephrine kit, crewmembers may assist them in administration, if trained. The victim should be treated for shock and, if necessary, administered CPR. All that is observed or performed should be recorded. Medical attention should be obtained regardless of patient's response. Anaphylactic shock can be very serious resulting in death within a few minutes.

RESUSCITATION METHODS AND EMERGENCIES

When a person stops breathing, seconds count. Death can occur within four to six minutes after respiratory failure. It is imperative to start resuscitation immediately. Naval Militia crewmembers are encouraged to maintain their skills through training by qualified, certified instructors and maintain their record of certification.

Events that may cause people to stop breathing include:

- Near drowning.
- Suffocation.
- Electrocution.
- Poison gas.
- Heart attack.
- Drug overdose.
- Choking.

Resuscitation Procedures
Resuscitation is a general term that covers all measures taken to restore life or consciousness to an individual. Measures taken to restore life include artificial respiration, cardiac compression, and CPR.

Artificial Respiration
Artificial respiration, starting normal respiratory function, includes rescue breathing maneuvers such as mouth-to-mouth, mouth-to-nose, and mouth-to-stoma. A stoma is the opening in the lower neck through which individuals breathe when they have had their voice box removed.

Cardiac Compression
Cardiac compression is a method used to restore normal blood-flow to the brain.

CPR
CPR uses both artificial respirations and chest compressions to revive a victim in respiratory and cardiac arrest. The standard protocols of shore-based civilian EMS systems usually require starting CPR in the field and rapidly transporting these patients to a hospital for continued resuscitation efforts.

Step	**Procedure**
1	Make sure the area around the victim is safe to be in.
2	Ensure there are universal precautions: gloves, pocket mask, etc.
3	Check the level of responsiveness of the victim by tapping and shouting, "Are you OK?"
4	If no response, notify EMS.
5	Position the victim on their back.
6	Open the airway with a head-tilt, chin-lift, or jaw thrust maneuver.
7	LOOK, LISTEN and FEEL for 5-10 seconds. • LOOK to see if the chest rises and falls. • LISTEN for air exhalation through the nose or mouth. • FEEL for breath coming from the nose or mouth. If there is no sign of breathing, check the victim's airway to ensure there is nothing blocking it and try opening the airway again.
8	If there is still no sign of breathing, administer two rescue breaths with a duration of two seconds each.
9	LOOK, LISTEN and FEEL for sign of breathing again as well as check for signs of circulation (movement, pink warm skin).
10	If there is no sign of breathing or circulation, start CPR procedure prescribed by the American Heart Association or American Red Cross for basic life support.
11	If victim recovers, treat for shock and monitor conditions.
12	If victim's heart stops or respiratory failure reoccurs after initial resuscitation, start again at step 3.

Obstructed Airway Procedures
An obstruction to the airway such as choking on an object can cause a victim to stop breathing or inability to provide rescue breathing.
The following procedures should be performed if the victim begins choking:

Step	Procedure
1	If victim is still able to breathe or cough, monitor the situation until either the victim frees the article from their throat, or they can no longer breathe on their own.
2	If they are no longer able to breath, notify EMS.
3	Attempt to free the article from their throat by the following methods: • Back blows for infants. • Chest thrusts for obese or pregnant persons. • Abdominal thrusts (Heimlich maneuver). • Continue back blows, chest thrusts or abdominal thrusts until the object is removed, or until the patient goes unresponsive.
4	If the object is still not cleared, lay the victim of their back and open the airway using the head-tilt, chin-lift method and check for breathing using the LOOK, LISTEN and FEEL techniques.
5	If no signs of breathing, attempt one rescue breath. If unsuccessful, reposition the head and try one more rescue breath.
6	If second ventilation is unsuccessful, begin CPR looking in the mouth before each attempted rescue breath.
7	A finger sweep of the mouth can be performed (ADULTS ONLY), but be careful not to force the object deeper into the throat.
8	If object is removed, check airway, breathing, and circulation. If no signs of breathing, but signs of circulation, administer rescue breaths. If no sign of breathing or circulation, begin CPR.

HEART ATTACK

Description
A heart attack is always considered a medical emergency since the victim is in significant danger of going into cardiopulmonary arrest and dying. Medical assistance should be contacted immediately.

Symptoms
There are many symptoms of a heart attack, some of which may not be noticed or recognized by a victim. Though heart attacks can occur without displaying all of these symptoms, the following are all symptoms of a heart attack:

- Severe, crushing type of pain under the breastbone, arms, neck, and jaw.
- Profuse sweating.
- Shortness of breath.
- Extreme anxiety.
- Nausea and vomiting.
- Bluish discoloration of lips, fingernails, and skin.

Treatment
The following is the treatment for a heart attack:
- Keep the victim quiet and at rest.
- Administer oxygen (if available and trained to do so).
- Place the victim in the position of most comfort. Sometimes the victim may want to sit up, especially if the person is short of breath.
- Seek immediate medical assistance, activate local EMS.
- Determine if the victim is on any type of medication for a heart condition such as nitroglycerin. If so, determine if the victim has taken the medication as prescribed.
- Reassure the patient that assistance is on the way or that transport to a hospital is imminent.
- Transport as quickly, but as safely, as possible.

STROKE

Description
A stroke is any bleeding or clotting affecting the blood vessels of the brain. Strokes can be mild or extremely serious and care must be taken to treat and transport stroke victims so that additional injury does not occur. Seek medical attention immediately.

Symptoms
The symptoms of a major stroke are:
- Unconsciousness.
- Shock.
- Confusion.
- Dizziness.
- Numbness/weakness to one side of the body.
- Seizures.
- Impaired vision.

However, if brain damage is slight, the only symptoms may be:
- Headache.
- Facial droop.
- Difficulty speaking, or limited usage of or difficulty in using a limb.

Treatment
The following is the treatment for stroke:
- Activate EMS.
- Obtain medical assistance immediately.
- Treat as for shock.
- If the victim has difficulty breathing, help the person maintain an open airway and provide rescue breathing if needed.
-

TREATMENT FOR WOUNDS, FRACTURES, AND BURNS

Introduction
In emergency situations, boat crewmembers must be able to temporarily treat severe hemorrhaging wounds, broken bones, and burn victims. As first responder, boat crewmembers must try to keep a victim calm, immobile, and alive until professional medical assistance can be provided.

Bandages
A bandage is a strip of woven material that holds a wound, dressing, or splint in place, helping to immobilize, support, and protect an injured part of the body. Preferably, sterile bandage material in standard first aid or EMT kits should be used. Otherwise, any large piece of clean cloth can be used as a bandage, binder, or sling.
Various types of bandages come in first aid kits. They are designed to be adaptable to many different situations. For example, some are for covering large areas but may be used as slings, and others are useful as a thick pad for applying pressure over a wound to control hemorrhaging.

Bandage Application
There are two general principles for bandage application:

- A bandage should be snug, but not so tight as to interfere with circulation either at the time of application or later if swelling occurs.
- A bandage is useless if tied too loose.

Circulation
Interfering with circulation is prevented by:

- Leaving the person's fingertips or toes exposed when applying a splint or bandage to arms or legs.
- Loosening bandages immediately if a victim complains of numbness or a tingling sensation.
- Watching for swelling, color changes, and cold or cool tips of fingers or toes.

BLEEDING

Types of Bleeding

Hemorrhage, or bleeding, is the escape of blood from arteries, veins, or even capillaries because of a break in their walls. There are several different types of bleeding. Boat crewmembers must learn to recognize the basic types in order to know how to stop the hemorrhaging as quickly as possible. Types of bleeding include:

Arterial Bleeding

Arterial bleeding is characterized by blood that is coming from an artery, is bright red, and gushes forth in jets or spurts that are synchronized with the victim's pulse.

Venous Bleeding

Venous bleeding is characterized by blood that is coming from a vein, is dark red, and comes in a steady flow.

Capillary Bleeding

Capillary bleeding is characterized by blood that is coming from damaged capillaries (smaller veins), is bright red, and oozes from the wound.

PREVENTION OF BLOODBORNE PATHOGENS

The risk of acquiring a bloodborne pathogen such as Hepatitis B or HIV should be evaluated. Risk may be managed by the use of appropriate PPE. At least latex or vinyl gloves must be used. More extensive equipment may be required depending on the situation.

CONTROL OF BLEEDING

Control of a severe hemorrhage is always urgent. With only 10 pints of blood in the human body, arterial bleeding can cause death in a short time.

Direct Pressure

The best method to control hemorrhaging is by applying direct pressure to the wound. To apply direct pressure, the palm of a gloved hand should be placed over the wound. Sterile, disposable gloves should be used. An ungloved hand should never be placed onto an exposed wound. To reduce the flow of bleeding, the injury should be raised so that it is at a level higher than the heart. This should only be done if a change in position will not cause additional harm to a victim. If immediately available, or if direct pressure does not control the bleeding, a thick pad of cloth held between the gloved hand and the wound may be used. (**see Figure 9-1**)

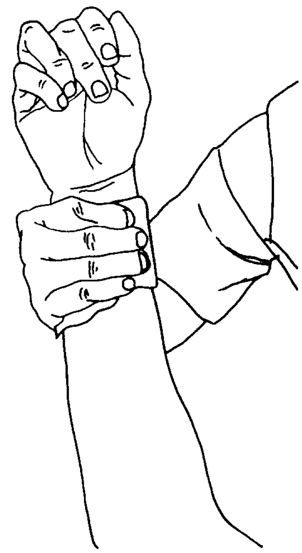


Figure 9-1 Applying Direct Pressure

Pressure Points
If bleeding persists after applying direct pressure or if there is severe arterial bleeding, digital pressure can be applied at pressure points. Pressure points are areas in the body where a major artery flows over a bony prominence. By applying pressure to these areas of the body, blood-flow to the area of the wound is further reduced. (see **Figure 9-2**)

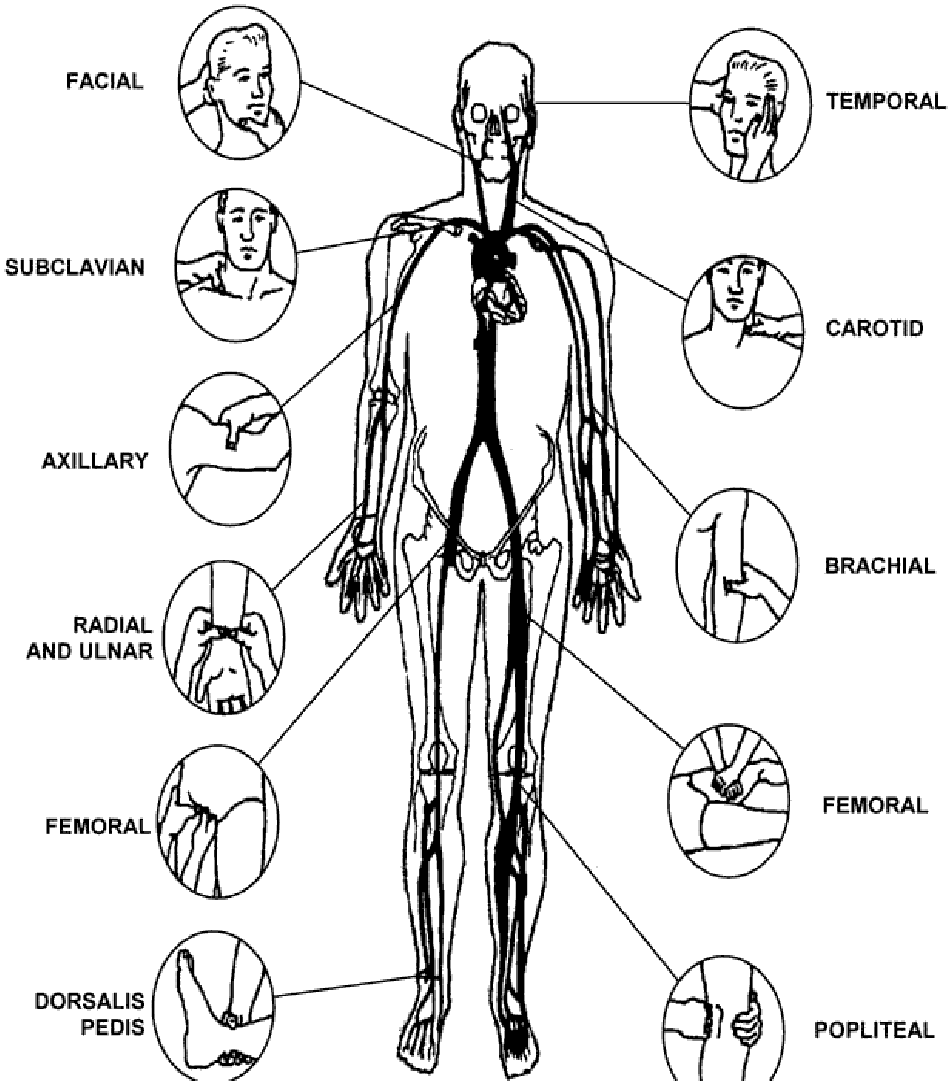


Figure 9-2 Pressure Points

CAUTION !: Always be extremely careful when applying indirect pressure (pressure points) as it may cause damage to the limb due to inadequate blood flow. Do not substitute indirect pressure for direct pressure, use both simultaneously.

Refer to the following for location of pressure points and related areas, and the appropriate procedures to apply pressure to each area:

Pressure Point	Location	Procedure
Temporal	Scalp or head.	Use this pressure point for no longer than 30 seconds as it may cut off blood to the brain.

Facial	In the "ridge" along the lower edge of the bony structure of the jaw.	Use only for a minute or two to help slow blood-flow from a cut on the face.
Carotid	Begin at the trachea at the midline of the neck.	Slide your fingers to the sight of the bleeding and feel for the pulsations of the carotid artery. Place fingers over the artery and thumb behind the neck. Apply pressure by squeezing fingers toward the thumb. Never apply pressure to both sides of the neck at the same time. Apply pressure for only a few seconds as this procedure cuts off blood circulation to the brain.
Subclavian	Deep behind the collar bone in the "sink" of the shoulder.	Push thumb through the thick layer of muscle at the top of the shoulder and press the artery against the collarbone.
Axillary	Under the upper arm.	Press the artery just under the upper arm against the bone from underneath.
Brachial	Groove on the inside of the arm and elbow; two locations, near the elbow joint.	Apply pressure to the point, grasp the victim's arm with the thumb on the outside of the arm and fingers on the inside. Press fingers towards the thumb. (see **Figure 9-3**)
Radial and Ulnar	Radial point located on forearm close to the wrist on the thumb side of the hand; ulnar point located on little finger side of the hand.	Apply pressure to both points to control bleeding of the hand. Use the radial point to control bleeding of the wrist.
Femoral	Front center part of the crease in the groin area, pelvic basin; two locations.	Used to control severe bleeding on the lower extremity and any bleeding caused by leg amputation. Place heel of the hand directly on the point and apply a small amount of pressure to the artery across the pelvic basin.
Popliteal	Back of the knee.	Apply pressure to the point to control bleeding from a leg wound.
Dorsalis Pedis	Top of foot.	Apply pressure to control bleeding from the foot and toes.

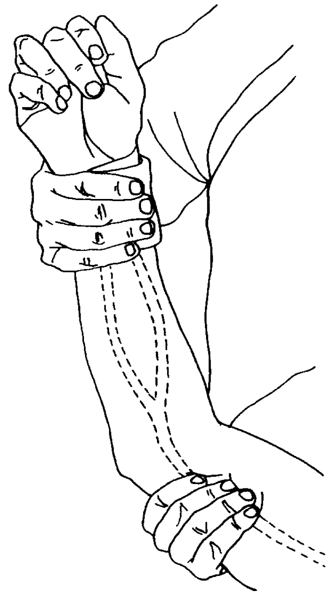


Figure 9-3 Brachial Artery

Treatment

Refer to the following procedures for treating hemorrhages:

Step	Procedure
Bandage Application	Apply a sterile bandage, if available, or clean piece of gauze or cloth to the wound. Do not remove this dressing if it becomes blood soaked. Reinforce the dressing with a second or third bandage on top of the original one. Elevating the extremity after applying direct pressure should control most bleeding.
Pressure Bandage	A pressure bandage can replace direct hand pressure on most parts of the body. Apply the pressure bandage by placing the center of the bandage or strip of cloth directly over the pad. Hold the pad in place by circling the bandage ends around the body part and tie it off with a knot directly over the pad.
Elevating Injured Area	If direct pressure does not control the bleeding, then elevate the injured area, but only if no bone injury is involved.
Pressure Points	Apply pressure by placing the heel of the gloved hand directly over the spot. Lean forward with the arm straight to apply direct and constant pressure.
Tourniquet	If severe bleeding cannot be controlled after trying all other means and the victim is in danger of bleeding to death, use a tourniquet. Remember that a tourniquet is useful only on arms and legs. A tourniquet is a constricting band placed around an extremity, then tightened until bleeding from an artery has stopped. When a tourniquet is required, use the tourniquets available in a standard Coast Guard first aid kit. Otherwise, use any wide gauge material such as a webbed belt strap with a buckle.

Applying Tourniquets
Refer to the following procedures when applying a tourniquet:

Step	Procedure
1	Place the tourniquet two to three inches above the wound, but not touching the wound edges. If the wound is in a joint area or just below a joint, place the tourniquet directly above the joint.
2	Wrap the tourniquet band tightly around the limb twice and secure it in place.
3	Attach a note to the victim giving the location of the tourniquet and the time that it was applied. Always leave the tourniquet exposed to view. If it is not possible to attach a note, write the letter "T" on the patient's forehead with a grease pen, lipstick, or other suitable marker, and show the time it was applied.
4	After making the decision, and applying a tourniquet, DO NOT LOOSEN IT.
5	Continue to treat for shock and obtain medical attention IMMEDIATELY.

FRACTURES (BROKEN BONES)

Types of Fractures
A fracture is a broken or cracked bone.
For performing first aid, boat crewmembers should be aware that there are two types of fractures:

- Compound (open) fracture: The bone has broken and an open wound is present. The bone may protrude from the wound, leaving little doubt that there is a fracture.
- Simple (closed) fracture: No open wound is present, but the bone may be broken or cracked. Care must be taken when handling a closed fracture; careless treatment may cause an open fracture, lacerate a blood vessel, or cause other injuries.

Symptoms
Indications that a fracture has occurred may include:

- Pain, swelling, and discoloration at the injury site.
- Misalignment (deformity) and/or disability of the injured part.
- Victim's indication (may have heard a "crack" or "snap").

Handling a Fracture
Every suspected fracture should be treated as if it were a fracture until it is proven otherwise. The following procedures outline the proper treatment for a fracture:

Step	Procedure
1	Do not attempt to straighten broken limbs. Eliminate all unnecessary handling of the injured part. Be gentle and use great care when handling any broken limb.

2	Protect and immobilize all injured areas. Check for the possibility of more than one fracture. Do not be deceived by the absence of deformity and/or disability. (In many fracture cases, the victim may still have some ability to use the limb). Keep the broken bone ends and the joints immobilized above and below the injury.
3	Check pulse in the area of the fracture before and after splint application.
4	Use a splint to immobilize the fracture. Selecting exactly the proper splint is less important than achieving immobilization. Whenever possible, splint a fractured arm to the patient's chest and a fractured leg to the other (unbroken) leg. Apply splints before moving the victim, while avoiding manipulating the injured areas. Apply the splint snugly, but do not cut off circulation. Splints should be well padded. Leave tips of fingers and toes exposed and check them often for circulation adequacy.
5	Treat the injured person for shock. Be alert for the development of shock during treatment. Shock may develop as a result of the fracture, pain from the treatment or other injuries not evident on initial assessment.

Treatment of Specific Bones
There are 206 bones in the human body. Several of these bones, if broken or injured, require very specific treatment based on the sensitive nature of their functions or their proximity to delicate organs or arteries.

Spine
Any actual or suspected damage to the spine requires definitive care and careful management. Permanent disability, paralysis, or death can result from a spine injury. The following are procedures to treat spine injuries:

Step	Procedure
1	Treat all suspected spinal injuries by maintaining alignment and immobilizing the spine as quickly and completely as possible.
2	Seek further medical assistance immediately.
3	Move a patient only as a last resort.
4	Keep a patient flat and do not move the person’s head.
5	When transporting a patient, immobilize on a rigid stretcher and carry the patient face up.
6	Do not splint neck and spine fractures unless properly trained.

Skull
The primary aim is to prevent further injury to the head. Time should not be spent figuring out whether there is a fracture or penetration to the skull. The following precautions should be utilized when dealing with head injuries:

Step	Procedure

1	Keep the patient as still as possible.
2	Keep the patient warm and do not give the person anything to drink or any pain medication.
3	Control bleeding using absorbent dressings without applying direct pressure.
4	Seek immediate medical assistance.

Extremities
When encountering actual or suspected fractures to any of a victim's extremities, the following general procedures must be followed:

Step	Procedure
1	Check for a pulse and sensation of touch in fingers or toes before and after a splint has been applied. If either of these is absent, it increases the likelihood of permanent damage. Make certain a splint is not applied over a bony prominence or tied too tightly. Loosen, if necessary, to reestablish feeling and pulse.
2	If possible, splint the injured part in proper alignment. If this is not possible, splint to immobilize the limb in the position found.
3	If bone ends protrude from the skin, cover the exposed bone with a sterile dressing and handle with great care when splinting.

Forearm
For forearm fractures, the following procedures must be performed:

Step	Procedure
1	Place two well-padded splints, top and bottom, from elbow to wrist.
2	Bandage in place.
3	Hold the forearm across the chest with a sling.

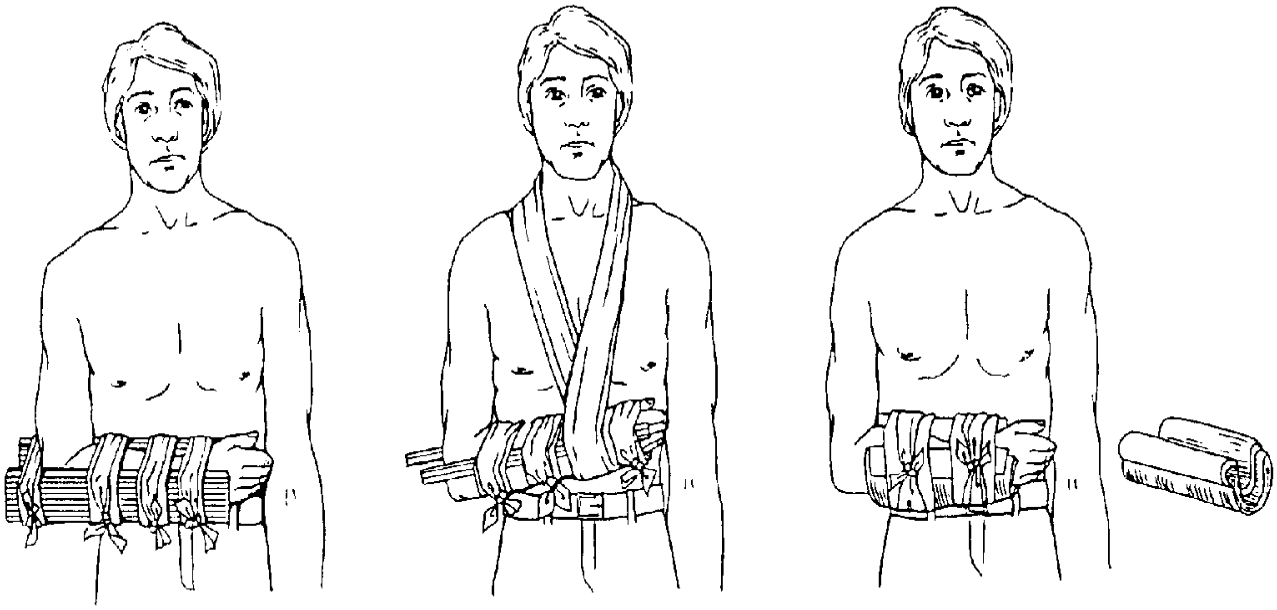
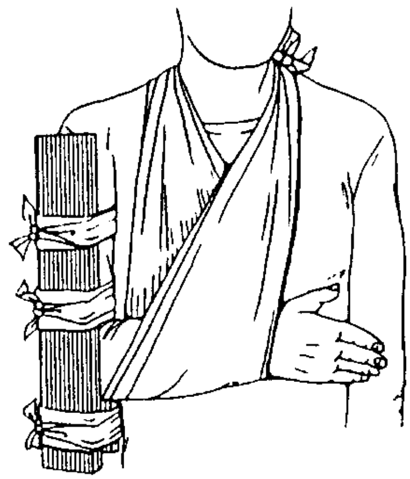


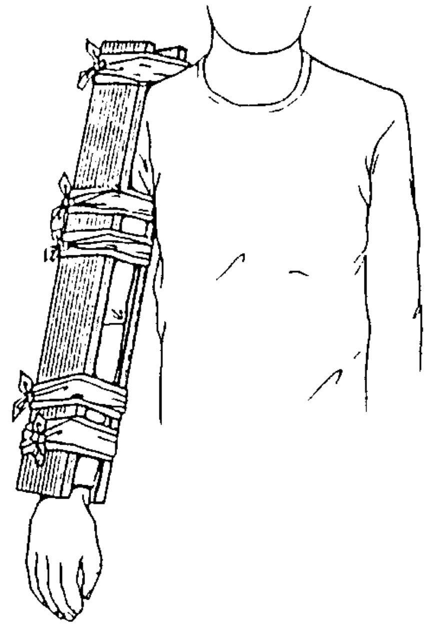
Figure 9-4 Broken Forearm

Upper Arm
For upper arm fractures, the following procedures must be performed:

Step	Procedure
1	For fracture near the shoulder, put a towel or pad in the armpit, bandage the arm to the body, and support the forearm in a sling.
2	For fracture of the middle upper arm, use one splint on the outside of the arm, shoulder to elbow. Fasten the arm to the body and support the forearm in a sling.
3	For a fracture near the elbow, do not move the arm at all. Splint it as it is found. (see **Figure 9-5**)



Splinting fracture of middle upper arm.



Splinting fracture of arm near elbow.

Figure 9-5 Broken Upper Arm

Thigh

Due to the large artery and muscle mass, a thigh injury is often a major injury and a traction splint may be required. Medical assistance must be sought immediately. This treatment management requires an emergency medical technician (EMT) or person with more detailed training.

If an EMT or other qualified person is unavailable, perform the following procedures:

Step	Procedure
1	Use two splints, an outside one from armpit to foot and an inside one from crotch to foot.
2	Fasten the splints around the ankle, over the knee, below the hip, around the pelvis, and below the armpit.
3	Tie both legs together. Do not move a patient until this has been done. (see **Figure 9-6**)

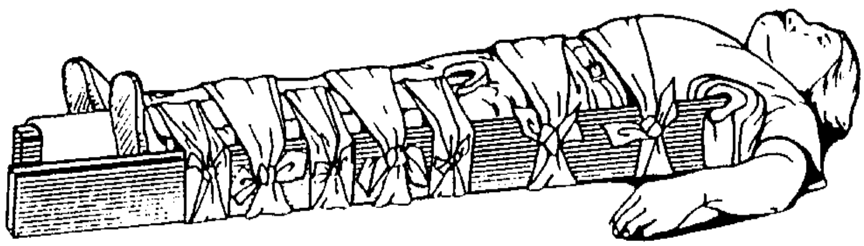


Figure -9-6 Broken Thigh

Lower Leg
To treat a broken lower leg, perform the following procedures:

Step	Procedure
1	Use three splints, one on each side and one underneath.
2	Always pad the splints well, especially under the knee and at the ankle bones.
3	Use a pillow under the leg with the edges brought around in front and pinned; then add two side splints. (see **Figure 9-7**)

This injury is often associated with major trauma, and bleeding may occur if the thigh bone severs the adjacent femoral artery. The patient should be monitored closely for signs of shock and the leg should not be manipulated.

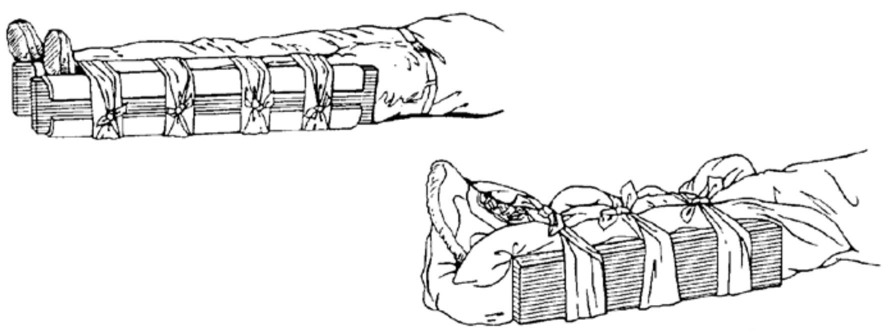


Figure 9-7 Broken Lower Leg

Collarbone
Use the following procedures to immobilize the collarbone:

Step	Procedure
1	On the injured side, place the forearm across the chest, palm turned in, and thumb up, with hand four inches above the elbow.
2	Support the arm in this position with a sling.

3	Fasten the arm to the body with several turns of bandages around the body and over the hand to keep the arm close against the body. (see **Figure 9-8**)

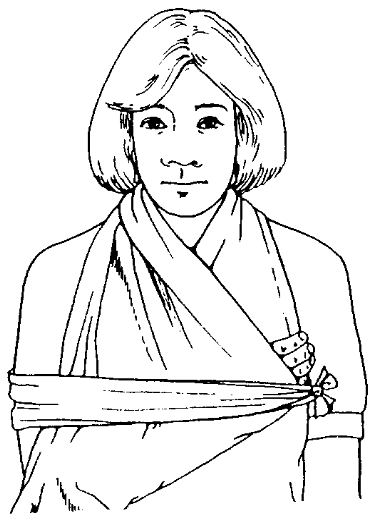


Figure 9-8 Broken Collarbone

Rib
A broken rib can be very painful and very dangerous because of the opportunity for a broken rib to puncture a lung. A patient coughing up frothy bright red blood may have a punctured lung. Immediate assistance should be sought and EMS should be activated.

If the crewmember believes that a rib is broken, but the victim indicates that there is no pain, then nothing should be done to try to ease pain.

If oxygen is available and the crewmember is properly trained to do so, he/she may administer oxygen with the patient at rest in a sitting position. This eases the effort required to breathe. Patients with known or suspected fractured ribs should be given a high priority for transport to a medical facility.

Nose
If an injury to the nose occurs, utilize the following procedures:

Step	Procedure
1	Stop the bleeding.
2	If conscious, have the patient sit and lean forward applying gentle pressure to the sides of the nose.
3	Apply a cold compress or an ice bag over the nose to ease pain, reduce swelling, and assist in stopping the bleeding.
4	Place unconscious victim on his or her side to keep airway open.

Jaw
If an injury to the jaw area interferes with a victim's breathing, utilize the following procedures:

Step	Procedure
1	Pull the lower jaw and tongue forward and keep them forward.
2	Apply a four-tailed bandage under the jaw, with two ends tied on top of the front of the head.
3	Tie the other two tails on top of the head, and at the back, so that the bandage pulls the jaw up and to the rear.

A bandage must support and immobilize the jaw, but not press on the throat. An unconscious victim should be placed on his or her side, while a conscious victim should sit up.

Pelvis
A patient with a pelvis injury should be treated for shock, but should not be moved unless absolutely necessary. When moving a patient, the person should be treated the same as a victim with a fractured spine.

- Bandage the legs together at the ankles and knees and place a pillow at each hip and secure them.
- Fasten the patient securely to the stretcher.

A pelvis injury is often associated with major trauma and frequently involves bleeding that is undetectable. The patient should be closely monitored for signs of shock which may be caused by heavy internal bleeding.

BURNS

Causes of Burns
Causes of burns include:

- Thermal.
- Chemical.
- Sunburn.
- Electric shock.
- Radiation.

Burn Classification
Burns can range from minor irritations to life threatening and disabling. Proper first aid, administered quickly, can minimize damage resulting from burns and can make the

difference between life and death in serious situations. For these reasons, it is very important to quickly determine the type and seriousness of burns in order to treat them quickly and properly. In general, the size of the burn is more important than the degree of the burn. Burns are classified by depth or degree of skin damage.

First-Degree
First-degree burns are the mildest form of burns. These burns involve only the outer layer of skin and produce redness, increased warmth, tenderness, and mild pain.

Second- Degree
Second-degree burns extend through the outer layers of the skin. These burns involve the inner layers of the skin, but not enough to prevent rapid regeneration. They produce blisters and are characterized by severe pain, redness, and warmth.

Third- Degree
Third-degree burns are those that penetrate the full thickness of the skin, destroying both the outer and inner layers. Severe pain, characteristic of second-degree burns, may be absent because nerve endings have been destroyed. Color may range from white and lifeless to black (charred). Healing requires many months, and usually results in scarring of the skin tissue. Skin grafts are generally required to achieve full healing.

Burn First Aid

General first aid procedures for all burns include the following:

- Eliminate the source of the burn. Extinguish and remove smoldering clothing. Do not remove charred clothing that may be sticking to the burn.
- For burns resulting from electrical shock, ensure the patient is no longer receiving electrical shock.
- Treat to prevent or reduce shock.
- Try to prevent infection.
- Do not apply any type of ointment on burns.

In addition to these general steps, the following are first aid procedures for burns that apply specifically to particular classes of burns:

Burn Type	First Aid Procedure
First-Degree	• Immerse in cool water until pain is relieved. • Flush chemical burns for at least 20 minutes. • Cover with clean or sterile dressing.
Second-Degree	• Use the same treatment as for first-degree burns. • Do not break open any blisters.

	• Cover with a dry sterile • non-adhesive dressing. • For deep second-degree burns follow the procedures for third- degree burns.
Third-Degree	For third-degree or deep second-degree burns: • Cover the burn to reduce exposure to air. • Cool the burn. • Do not remove clothing unless smoldering. • Treat for shock even if not apparent. • Always obtain medical care. • Monitor the patient’s airway. • Assess vital signs every 5 minutes. • Give nothing to eat or drink. • Do not place ice on the burn. • Do not apply ointments to the burn. • Burns of the respiratory tract are always a medical emergency.

Chemical Burns
Chemical burns of the skin or eyes produce the same type of burn as flash fires, flames, steam, or hot liquids. The following procedures should be performed:

Step	Procedure
1	Wash the chemical away completely, as quickly as possible, using large quantities of water.
2	Continue flushing the burn for at least 20 minutes.
3	When the burn involves an eye, flush the eye with water for up to 20 minutes.
4	Cover both eyes with a clean, dry, protective dressing and seek medical attention as quickly as possible.
5	Give first aid for shock.
6	If the chemical is a powder, brush off as much as possible before flushing with water.

ENVIRONMENTAL INJURIES

Introduction
Environmental injuries occur when an individual suffers from over-exposure to extreme environmental elements or when taking poor precautions for activities in environmental elements. In severe cases, environmental injuries can cause permanent damage or loss of life. These types of injuries include emergencies caused by heat or cold such as heat stroke or hypothermia.

Additionally, these injuries are not only limited to environmental conditions, but include other environmental factors such as injuries inflicted by non-human predators of the habitat. In the marine habitat, environmental injuries include those inflicted by aquatic life.

EMERGENCIES CAUSED BY HEAT

Excessive heat or prolonged exposure to heat can cause at least three types of emergencies:
Heat Cramps. Heat cramps are painful contractions of various skeletal muscles. They are caused by depletion of salts from body fluids, normally due to excessive sweating.

Symptoms

Heat cramps affect the muscles of the extremities and abdominal wall. Pain may be severe. Body temperature may be normal or elevated.

Treatment

The treatment for heat cramps is drinking cool fluids which afford both relief and continued protection. "Sport" drinks may speed up recovery. Re-exposure to heat should be avoided for at least 12 hours.

Heat Exhaustion

Heat exhaustion results from too much fluid lost by perspiration. Even the most physically fit person can fall victim to heat exhaustion while working in a hot environment. With proper treatment, heat exhaustion is seldom fatal.

Symptoms

The signs and symptoms of heat exhaustion are similar to those of shock. An individual that collapses in the heat and continues to perspire freely almost surely has heat exhaustion. The presence of sweating usually rules out heat stroke.

Treatment

To treat a person with heat exhaustion, utilize the following procedures:

Step	Procedure
1	Remove the patient from the hot environment to a cool location.
2	Place a patient on his or her back, with legs elevated.
3	Cool a patient but DO NOT chill. Be aware of shivering.
4	If the victim is conscious, administer cool sips of water or sports drink.
5	Treat for shock.
6	If equipped and trained, administer oxygen.

With general supportive treatment, a victim of heat exhaustion will usually recover consciousness promptly, although the person may not feel well for some time. Re-exposure to heat should be avoided for at least 24 hours.

Heat Stroke

Heat stroke is a serious medical emergency. The most important sign of heat stroke is an extreme elevation of body temperature, indicating failure of the body's sweating mechanism. Heat stroke calls for immediate measures to reduce body temperatures in order to prevent brain damage and/or death.

Symptoms

The symptoms of heat stroke are:

- Headache.
- Dizziness.
- Irritability.
- Disturbed vision.

A person will suddenly become unconscious and have hot, dry skin, and contracted pupils. A heat stroke victim will also have a strong pulse, may have convulsions, and will have a body temperature that ranges from 105° F to 109° F.

Treatment

To treat a person with heat stroke, utilize the following procedures:

Step	Procedure
1	Seek help and activate the local EMS.
2	Place the patient in the shade or a cool place. Assess breathing and circulation, loosen clothing, and lay the victim down with the head and shoulders slightly elevated.
3	Begin the movement of air by fanning with a shirt, electric fan or other means.
4	Reduce the body temperature as rapidly as possible to prevent brain damage. Total immersion in a cool water bath is probably the most efficient method. If this is not possible, decrease the patient's body temperature by pouring cool or cold water over the body and apply ice packs to "hot spots" (neck, groin, armpits). Avoid direct ice to skin contact if possible. Cover the patient with sheets soaked in ice water and continue to re-apply cold water as needed.
5	DO NOT give anything by mouth.
6	Treat for shock.

EMERGENCIES CAUSED BY COLD

Exposure to Cold

The type and severity of cold injuries depends on the temperature and amount of exposure an individual has endured.
Refer to the following for a description of various cold injury causes and symptoms:

Injury	Cause	Signs/Symptoms
Chilblains	Repeated exposure for several hours to temperatures between 32° F and 60° F, generally associated with high humidity.	Redness and swelling, itching dermatitis, tingling, and deep aches in later stages.
Immersion Foot	Exposure to cold water, 50° F and below, for 12 hours or more, or exposure to water of approximately 70° F for several days.	Swelling of the legs and feet, cyanosis (a bluish discoloration, especially of the skin due to a lack of properly oxygenated blood), numbness, tingling, itching, blisters, intense burning, and neuromuscular changes.
Trench Foot	Exposure to cold between 32° F and 50° F, damp weather for periods ranging from several hours to 14 days. The average length of exposure to produce symptoms is three days.	Swelling of the legs and feet, cyanosis, blisters, intense burning, and neuromuscular changes. The body part affected blanches, tingles, then becomes numb.
Frostbite	Generally, brief exposure to extreme cold, -20° F and below, or exposure to approximately 0° F weather for several hours will cause frostbite.	First burning and stinging then numbness. Ice crystals in the skin which cause white or gray waxy color, skin moves over bony prominences, edema (excessive accumulation of fluids within portions of the body), blisters, pain, loss of motion, gangrene, and loss of tissue in later stages.
Freezing	Exposure of skin to temperatures of –20° F and below. May happen rapidly to exposed toes and fingers with other extremities involved as exposure is prolonged.	Ice crystals in entire thickness of the body part, including the bone, which is indicated by pallid, yellow waxy color; skin will not move over bony prominences. After thawing, patient may experience edema, large blisters, intense pain, and loss of motion, gangrene, and possibly the loss of the body part.

Treatment

When treating cold injuries:

DOs	DON'Ts
• Take care when removing clothing or gear so as not to injure the numbed skin. Remove only if blankets or dry clothing are available. • Cover the area with a dry dressing and warm with a blanket. • Exercise care to prevent infection if open sores are present. • Under the supervision of a medical professional, rapidly warm a frostbitten body part in a controlled temperature water bath (105° F to 110° F). Attempt this only where there is a certainty of the water temperature. • Transport the patient to an appropriate medical facility as soon as possible. • Monitor for shock.	• Do not place anything constricting on the affected area. • Do not give the victim alcohol or tobacco. • Do not massage or rub the affected parts. • Do not break blisters. • Do not thaw an affected part if the transport time is short or if there is a possibility that the body part may refreeze after warming.

HYPOTHERMIA

Hypothermia is a lowering of a person's core temperature. It occurs when a person suffers a loss of body heat. General body hypothermia is the leading cause of death among shipwrecked crews and other disasters at sea. If not recognized and treated promptly, hypothermia can rapidly turn survivors into fatalities. Survivors in critical hypothermia conditions may suffer a fatal loss of body temperature from physical exertion, or as a result of any delay in taking immediate and positive measures to restore body heat. Struggling survivors, trying to aid in their own rescue, may drive their body temperature down to the point where unconsciousness and/or death results. Survivors removed from the water and left untreated may suffer further critical loss in body temperature, bringing on death after being rescued. Survivors in "warm" water can also suffer from hypothermia if exposed for long enough periods of time. Also, cold air temperatures can bring on hypothermia if adequate protective clothing is not worn.

Survivability

Survival times in water vary considerably. Survival depends on the type of clothing worn, the amount of physical exertion, the blood alcohol levels, and other factors. Some survivors, when taken aboard during a SAR case, may appear to be under the influence of drugs or alcohol. A person moderately hypothermic will manifest symptoms of an intoxicated person.

Symptoms
When a victim is suffering from hypothermia, some symptoms are visible and some must be measured to establish a diagnosis. Symptoms include:

- Low body temperature.
- Low blood pressure.
- Slow, weak pulse.
- Unconsciousness. General appearance.
- Cold skin.
- May simulate or accompany shock.

Signs may include:

- Shivering.
- Clouded mental capacity (may seem disoriented).
- Slow and labored breathing.
- Weak and slow pulse (may be irregular or absent).
- Dilated pupils.
- Slurred speech (may seem intoxicated).

Visible symptoms are outwardly visible symptoms that can help to identify hypothermia victims:
Level of consciousness becomes clouded as their body temperature approaches 90F and they generally lose consciousness at 85F.

- Pale in appearance, with constricted pupils, and slow and labored respiration.
- Violent shivering or muscular rigidity may be present. Victims may appear to be intoxicated.
- Begin treatment if a victim's skin feels cold to the touch.

Body Temperature
Body temperature is the most useful yardstick for identifying hypothermia. Hypothermia victims will have a rectal temperature below normal (normal is 98° F to 99° F). Only rectal temperatures are of value, since it is the body's core temperature that determines the severity of hypothermia.

Blood Pressure
Hypothermia victims may have a lower than normal blood pressure (normal is about 120/80).

Rescue Precautions
When it is suspected a survivor has critical hypothermia, rescue attempts should be made that avoid rough handling and minimize the amount of exertion by a victim. This can be accomplished by sending a surface swimmer into the water to assist the survivor into the

rescue craft. Care should be taken to handle the victim gently. Excessive movement may cause heart beat irregularities which can be fatal. During the rescue and afterwards, the patient should be kept calm and quiet.

The leading cause of death in cold water maritime accidents is hypothermia.

Temperature	Visible Signs and Symptoms
96° F - 99° F	• Intense uncontrollable shivering. • Impaired ability to perform complex tasks.
91° F - 95° F	• Violent shivering. • Difficulty speaking. • Sluggish movements. • Amnesia begins.
86° F - 90° F	• Shivering is replaced by muscular rigidity. • Muscle coordination impaired. • Erratic movements.
81° F - 85° F	• Irrational • Stupor. • Lost contact with surroundings. • Pulse and respiration slow.
78° F - 80° F	• No response to words. • Reflexes stop working. • Heartbeat is erratic. • Victim loses consciousness.
Below 78° F	• Failure of heart and lungs. • Internal bleeding; death.

Basic Treatment
Treatment for hypothermia will depend on both the condition of the patient and treatment facilities available. Survivors who are rational and capable of recounting their experiences, although shivering dramatically, will generally only require that wet clothes be removed and replaced with dry clothes or blankets and a warm environment to rest.

Advanced Treatment
In more serious cases, where victims are semiconscious or near death, a medical facility should be contacted as soon as possible for detailed instructions for proper care and handling. While awaiting medical instructions, immediately administer first aid to survivors using the following procedures:

Step	Procedure
1	After recovering a victim from the cold, avoid rough handling of the victim as this can cause further harm. Check for the presence of breathing and heartbeat. If the

	victim is not breathing and has no heartbeat, begin CPR immediately. If the victim is breathing, and has a pulse, gently transfer the person to a warm environment. Be sure to check the person's breathing and heart beat frequently. Always remain prepared to immediately begin CPR if breathing and heart beat stop. Activate EMS and obtain medical help.
2	Lay an unconsciousness or semiconscious victim face up with the head slightly lower than the rest of the body. If vomiting occurs, turn the patient's head to one side. Observe respiration closely and remove any secretions from the victim's nose and mouth.
3	Remove the victim's clothes with minimum movement of the body. Cut the clothes away with scissors or a knife if necessary. If a patient cannot be removed to a compartment to be warmed with blankets, dry clothing, or other warming methods, then DO NOT remove wet clothing. Under these circumstances, the wet clothing is better than no clothing.
4	Do not give anything orally, especially alcohol.
5	Insulate a victim from further heat loss by wrapping the person in a blanket. Do not attempt to aggressively rewarm an unconscious or semiconscious victim, as rapid warming can cause dangerous complications. Do not rub frozen body areas. A victim will be very sensitive to rough handling. The primary objective after a person has been removed from the water is to prevent the person from getting colder.
6	If properly trained and equipped, administer warm, humidified oxygen by face mask. The oxygen will not only assist victims if they are having difficulty breathing or have a low respiratory rate, it will also provide rewarming of the internal body core
7	When there will be a delay getting a victim to a hospital, begin gentle rewarming techniques. Rewarming techniques include: • Wrapping the victim in a blanket. Under the blanket, apply heating pads or hot water bottles (if available) to the victim's head, neck and groin. • Applying your body warmth by direct body-to-body contact with a victim. A blanket should be wrapped around you and the victim to preserve the heat.
8	Treat for shock.
9	Evacuate a victim to a medical facility soon after or during emergency treatment.

Near-Drowning

Mammalian Diving Reflex

Victims who inhale water or who are found floating face-down in the water may be suffering from near-drowning. Medical researchers have only recently discovered the phenomena of the "mammalian diving reflex." In this condition, a person immersed in water (particularly a child), even under ice, could still be alive. Even after extended periods of time, the body delivers a tiny trickle of oxygen to the brain. A victim also exhibits an almost complete constriction of all peripheral blood vessels. Their respiration and circulation almost stop. Properly administered CPR may successfully revive a near-drowning victim without serious complications, even after being underwater for an hour or longer.

Treatment
To treat a person in a near-drowning situation, perform the following procedures:

Step	Procedure
1	Evaluate ABC's
2	Identify any other injuries.
3	Activate EMS.
4	Initiate CPR if indicated and if trained.
5	Treat for shock.
6	Inform higher headquarters of status of victim.
7	Transport as soon as possible.
8	Remove wet clothing (if dry clothes or blankets available).
9	Treat for hypothermia as appropriate.
10	Constantly monitor the victim's airway.
11	Reevaluate victim's vital signs every 5 minutes.
12	Document: • Length of submersion. • Water temperature. • Fresh or salt water. • Drug or alcohol use. • Any treatment rendered.

CARBON MONOXIDE POISONING

Description
Carbon monoxide (CO) is a colorless, odorless toxic gas that is the product of incomplete combustion. Motor vehicles, heaters, and appliances that use carbon based fuels are the main sources of this poison.

Signs and Symptoms
Signs and symptoms of carbon monoxide poisoning can include the following:

- Headache.
- Dizziness.

- Fatigue.
- Weakness.
- Drowsiness.
- Nausea.
- Vomiting.
- Loss of consciousness. S
- Skin pallor.
- Shortness of breath on exertion.
- Palpitation.
- Confusion.
- Irritability.
- Irrational behavior.

Treatment
Utilize the following procedures when treating for carbon monoxide poisoning:

Step	Procedure
1	Remove patient from the carbon monoxide containing atmosphere.
2	Treat the patient for shock.
3	Administer oxygen if available and trained to do so.
4	Start CPR as appropriate.

POISONING BY MOUTH
When poisoning occurs, it is vital that proper first aid be given immediately.

Seeking Advice
The product container will often include specific treatment instructions. If poisoning has occurred, medical assistance should be sought immediately. The boat crew should contact the poison control hotline, provide information about substance taken, an estimate of the quantity taken, and have the unit immediately contact the local poison control center. The container and any samples of vomit should be taken with the victim when transporting to a medical facility.

Medical Assistance Not Available
If medical advice is not immediately available and the patient is conscious, an attempt should be made to determine if the poison is a strong acid, alkali, or petroleum product. If this is the case, no attempt should be made to induce vomiting.

EYE INJURIES

Description

Eye injuries are potentially serious, and may be permanent, unless handled promptly and properly. Eyes should be moist. Any dressing applied to eyes should also be moist to prevent excessive drying.
Eye movement is conjugal, that is if one eye moves, the other also moves in the same manner. When dealing with a penetrating injury to an eye, or a foreign object in an eye, the objective is to limit eye movement. Because of conjugal movement, this is best accomplished by covering both eyes. In most cases, a patient with an eye injury is transported sitting up.

Blindness
Patients who have experienced a blinding injury become totally dependent upon their rescuer. These patients should never be left alone. Constant contact and continuous conversation with them should be maintained to reduce anxiety.

Types of Eye Injuries
There are many injuries that may occur to a victim's eyes. Any eye injury is normally the cause of great anxiety for a victim, many times causing more concern than more serious injuries to other parts of the body.

Symptoms and Treatments
The following table describes the symptoms and appropriate treatments for the various eye injuries:

Eye Injury	Symptom	Treatment
Blunt Eye Trauma	Blows to a victim's head and eye area may result in a fracture to the orbit (the bony socket encircling the eye), entrapping vessels and nerves to the eye.	Managing such injuries requires covering both eyes with a moist dressing. This is important since movement by an uninjured eye is mimicked by the injured eye. Refer the patient to medical care for follow-up. Since this injury may involve a head injury, closely observe the patient for signs of further damage.
Penetrating Objects and Foreign Bodies	Common objects include fish hooks, wood splinters, or pieces of glass.	Any object that has penetrated the eye must not be removed as first aid treatment. Cover both eyes with a moist dressing, and support the object if it protrudes to prevent movement. A protective cup for the eye can be made from a plastic or Styrofoam cup taped over the eye, with a moist dressing inside. Immediately refer the patient for further medical care.

Caustics, Acids, or Burns	May include remains of the substance itself, pain, swelling, discoloration of the skin, peeling of skin, and blisters.	Immediately flush both eyes with large quantities of gently flowing water. Each eye should be flushed with water for a minimum of 10-15 minutes away from the unaffected eye. Never use a neutralizing agent for flushing, use only plain tap water. A moist dressing may be helpful. After flushing, refer the patient for further medical care

Appendix A.
Glossary

This appendix contains a list of terms that may be useful when reading this Manual.

Abaft: Behind, toward the stern of a vessel.

Abeam: To one side of a vessel, at a right angle to the fore-and-aft centerline.

Aft: Near or toward the stern.

Aground: With the keel or bottom of a vessel fast on the sea floor.

Aids to Navigation (AtoN): Lighthouses, lights, buoys, sound signals, racon, radio beacons, electronic aids, and other markers on land or sea established to help navigators determine position or safe course, dangers, or obstructions to navigation.

Air Draft: The distance from the surface of the water to the highest point on a vessel.

Allision: The running of one vessel into or against another, as distinguished from a collision, i.e., the running of two vessel against each other. Also used to refer to a vessel striking a fixed structure (i.e. bridge, pier, moored vessel, etc.).

Amidships: In or towards center portion of the vessel, sometimes referred to as "midships."

Anchorage Area: A customary, suitable, and generally designated area in which vessels may anchor.

Astern: The direction toward or beyond the back of a vessel.

Athwartships: Crosswise of a ship; bisecting the fore-and-aft line above the keel.

Attitude: A vessel's position relative to the wind, sea, hazard, or other vessel.

Back and Fill: A technique where one relies on the tendency of a vessel to back to port, then uses the rudder to direct thrust when powering ahead. Also known as *casting*.

Backing Plate: A reinforcement plate below a deck or behind a bulkhead used to back a deck fitting. It distributes stress on a fitting over a larger area and prevents bolts from pulling through the deck.

Backing Spring (Line): Line used when towing a vessel alongside which may be secured near the towing vessel's stern and the towed vessel's bow.

Ballast: Weight placed in a vessel to maintain its stability.

Beacon: Any fixed aid to navigation placed ashore or on marine sites. If lighted, they are referred to as minor lights.

Beam: The widest point of a vessel on a line perpendicular to the keel, the fore-and-aft centerline.

Beaufort Wind Scale: A scale whose numbers define a particular state of wind and wave, allowing mariners to estimate the wind speed based on the sea state.

Bell Buoy: A floating aid to navigation with a short tower in which there are several clappers that strike the bell as it rocks with the motion of the sea.

Below: The space or spaces that are underneath a vessel's main deck.

Bend/Bending: A knot in a line. Tying a knot.

Bilge: The lowest point of a vessel's inner hull, which is underwater.

Bilge Alarm System: An alarm for warning of excessive water or liquid in the bilge.

Bilge Pump: A pump used to clear water or liquid from the bilge.

Bitt: A strong post on deck in the bow or stern, to which anchor, mooring, or towing lines may be fastened.

Boat hook: A hook on a pole with a pushing surface at the end used to retrieve or pick up objects, or for pushing objects away.

Bollard: A single strong vertical fitting, usually iron, on a deck, pier, or wharf, to which mooring lines or a hawser may be fastened.

Bolo Line: A nylon line with a padded or wrapped weight thrown from vessel to vessel or between vessels and shore which is used for passing a larger line (see heaving line).

Bow: The forward end of the vessel.

Bow Line: A line secured from the bow of a vessel. In an alongside towing operation, the bow line is secured on both the towing and the towed vessel at or near the bow and may act as breast line of each.

Bowline: A classic knot that forms an eye that will not slip, come loose or jam, and is not difficult to untie after it has been under strain.

Breaker: A wave cresting with the top breaking down over its face.

Breast Line: Mooring or dock line extended laterally from a vessel to a pier or float as distinguished from a spring line.

Broach: To be thrown broadside to surf or heavy sea.

Broadcast Notice to Mariners: A radio broadcast that provides important marine information.

Broadside to the Sea: A vessel being positioned so that the sea is hitting either the starboard or port side of the vessel.

Bulkhead: Walls or partitions within a vessel with structural functions such as providing strength or watertightness. Light partitions are sometimes called partition bulkheads.

Buoy: A floating aid to navigation anchored to the bottom that conveys information to navigators by their shape or color, by their visible or audible signals, or both.

Buoyage: A system of buoys with assigned shapes, colors, or numbers.

Buoyancy: The tendency or capacity of a vessel to remain afloat.

Can Buoy (Cylindrical): A cylindrical buoy, generally green, marking the left side of a channel or safe passage as seen entering from seaward, or from the north or east proceeding south or west.

Capsize: To turn a vessel bottom side up.

Cardinal Marks: Indicate the location of navigable waters by reference to the cardinal directions (N, E, S, W) on a compass.

Casting: See back and fill.

Catenary: The sag in a length of chain, cable, or line because of its own weight and which provides a spring or elastic effect in towing, anchoring, or securing to a buoy.

Cavitation: The formation of a partial vacuum around the propeller blades of a vessel.

Center of Gravity: Point in a ship where the sum of all moments of weight is zero. With the ship at rest, the center of gravity and the center of buoyancy are always in a direct vertical line. For surface ships, center of buoyancy is usually below center of gravity, and the ship is prevented from capsizing by the additional displacement on the low side during a roll. Thus the point at which the deck edge enters the water is critical because from here onward, increased roll will not produce corresponding increased righting force.

Centerline: An imaginary line down the middle of a vessel from bow to stern.

Chafe: To wear away by friction.

Chafing Gear: Material used to prevent chafing or wearing of a line or other surface.

Characteristic: The audible, visual, or electronic signal displayed by an aid to navigation to assist in the identification of an aid to navigation. Characteristic refers to lights, sound signals, racons, radio beacons, and daybeacons.

Chart: A printed or electronic geographic representation generally showing depths of water, aids to navigation, dangers, and adjacent land features useful to mariners (See *Nautical Chart*).

Chine: The intersection of the bottom and the sides of a flat bottom or “V” hull boat.

Chock: A metal fitting through which hawsers and lines are passed.

Chop: Short steep waves usually generated by local winds and/or tidal changes.

Cleat: An anvil-shaped deck fitting for securing or belaying lines. Wedge cleats are used in yachting to hold sheets ready for instant release.

Closing: The act of one vessel reducing the distance between itself and another vessel, structure, or object.

Clove Hitch: A hitch often used for fastening a line to a spar, ring, stanchion, or other larger lines or cables.

Coast Guard- Approved: Label denoting compliance with Coast Guard specifications and regulations relating to performance, construction, and materials.

Coastal: At or near a coast.

Coil Down: To lay out a line in a circle with coils loosely on top on one another. (see fake down, Flemish down)

Comber: A wave at the point of breaking.

Combination Buoy: A buoy that combines the characteristics of both sound and light.

Combustion: Rapid oxidation of combustible material accompanied by a release of energy in the form of heat and light.

Compartment: A room or space onboard a vessel or ship.

Compass: An instrument for determining direction: magnetic, depending on the earth's magnetic field for its force; gyroscopic, depending on the tendency of a free-spinning body to seek to align its axis with that of the earth.

Constant Bearing – Decreasing Range (CBDR): is a term in navigation which means that some object, often another vessel viewed from the pilot house of one's own vessel, is getting closer but maintaining the same relative bearing. If this continues, the objects will collide.

Course (C): The horizontal direction in which a vessel is steered or intended to be steered, expressed as angular distance from north, usually from 000° at north, clockwise through 360°.

Coxswain: Person in charge of a boat, pronounced "COX-un."

Crab: To move sidewise through the water.

Craft: Any air or sea-surface vehicle, or submersible of any kind or size.

Crash Stop: Immediately going from full speed ahead to full reverse throttle; this is an emergency maneuver.

Crest: The top of a wave, breaker, or swell.

Crucifix: Type of deck or boat fitting that resembles a cross, used to secure a line to (e.g., Sampson post).

Current (Ocean): Continuous movement of the sea, sometimes caused by prevailing winds, as well as large constant forces, such as the rotation of the earth, or the apparent rotation of the sun and moon. Example is the Gulf Stream.

Damage Control: Measures necessary to preserve and reestablish shipboard watertight integrity, stability, and maneuverability; to control list and trim; to make rapid repairs of material. Inspection of damage caused by fire, flooding, and/or collision and the subsequent control and corrective measures.

Datum: In SAR, refers to the probable location of a distressed vessel, downed aircraft, or PIW, which is corrected for drift at any moment in time. Depending on the information received this may be represented as a point, a line or an area.

Day Mark: The daytime identifier of an aid to navigation (see *Daybeacon*, *Dayboard*).

Daybeacon: An unlighted fixed structure which is equipped with a highly visible dayboard for daytime identification.

Dayboard: The daytime identifier of an aid to navigation presenting one of several standard shapes (square, triangle, rectangle) and colors (red, green, white, orange, yellow or black).

Dewatering: The act of removing water from inside compartments of a vessel. Water located high in the vessel, or sufficiently off-center should be removed first to restore the vessel's stability. Used to prevent sinking, capsizing or listing.

Dead-in-the-Water (DIW): A vessel that has no means to maneuver, normally due to engine casualty. A vessel that is adrift or no means of propulsion.

Dead Reckoning (DR): Determination of estimated position of a craft by adding to the last fix the craft's course and speed for a given time.

Deck: The horizontal plating or planking on a ship or boat.

Deck Fitting: Permanently installed fittings on the deck of a vessel which can be attached to machinery or equipment.

Deep "V" Hull: A hull design generally used for faster seagoing types of boats.

Digital Selective Calling (DSC): A technique using digital codes which enables a radio station to establish contact with, and transfer information to, another Station or group of Stations.

Direction of Current: The direction toward which a current is flowing. See *set*.

Displacement Hull: A hull that achieves its buoyancy or flotation capability by displacing a volume of water equal in weight to the hull and its load.

Distress: As used in the Coast Guard, when a craft or person is threatened by grave or imminent danger requiring immediate assistance.

Draft: The point on a vessel's underwater body, measured from the waterline that reaches the greatest depth.

Drag: Forces opposing direction of motion due to friction, profile and other components. The amount that a ship is down by the stern.

Drift: The rate/speed at which a vessel moves due to the effects of wind, wave, current, or the accumulative effects of each.

Drogue: A device used to slow rate of movement. Commonly rigged off the stern of a boat while under tow to reduce the effects of following seas. May prevent yawing and/or broaching. (see *sea anchor*)

Dry Suit: A coverall type garment made of waterproof material having a rubber or neoprene seal around the neck and wrist cuffs. Allows the wearer to work in the water or in a marine environment without getting wet.

Dynamic Forces: Forces associated with the changing environment e.g., the wind, current, weather.

Ebb: A tidal effect caused by the loss of water in a river, bay, or estuary resulting in discharge currents immediately followed by a low tidal condition.

Ebb Current: The horizontal motion away from the land caused by a falling tide.

Eddy: A circular current.

Emergency Position-Indicating Radio Beacon (EPIRB): A device, usually carried aboard a maritime craft that transmits a signal that alerts search and rescue authorities and enables rescue units to locate the scene of the distress.

Eye: The permanently fixed loop at the end of a line.

Eye Splice: The splice needed to make a permanently fixed loop at the end of a line.

Fairways (Mid- Channel): A channel that is marked by safemarks that indicate that the water is safe to travel around either side of the red and white vertically striped buoy.

Fake Down: To lay out a line in long, flat bights that will pay out freely without bights or kinks. A coiled or flemished line cannot do this unless the coil of the line is able to turn, as on a reel. Otherwise, a twist results in the line which will produce a kink or jam (see *coil down* and *Flemish down*).

Fatigue: Physical or mental weariness due to exertion. Exhausting effort or activity. Weakness in material, such as metal or wood, resulting from prolonged stress.

Fender: A device slung over the side of a boat/ship in position to absorb the shock of contact between vessels or between a vessel and pier.

Ferry: To transport a boat, people or goods across a body of water.

Fetch: The unobstructed distance over which the wind blows across the surface of the water.

Fitting: Generic term for any part or piece of machinery or installed equipment.

Fix: A geographical position determined by visual reference to the surface, referencing to one or more radio navigation aids, celestial plotting, or other navigation device.

Fixed Light: A light showing continuously and steadily, as opposed to a rhythmic light.

Flash: A relatively brief appearance of light, in comparison with the longest interval of darkness in the same character.

Flashing Light: A light in which the total duration of light in each period is clearly shorter than the total duration of darkness and in which the flashes of light are all of equal duration. Commonly used for a single-flashing light which exhibits only single flashes which are repeated at regular intervals.

Flemish down: To coil down a line on deck in a flat, circular, tight arrangement.

Flood: A tidal effect caused by the rise in water level in a river, bay, or estuary immediately followed by a high tidal condition.

Flood Current: The horizontal motion of water toward the land caused by a rising tide.

Fore: Something situated at or near the front. The front part, at, toward, or near the front; as in the forward part of a vessel.

Forward: Towards the bow of a vessel.

Foul: To entangle, confuse, or obstruct. Jammed or entangled; not clear for running. Covered with barnacles, as foul bottom.

Frames: Any of the members of the skeletal structure of a vessel to which the exterior plating is secured.

Freeboard: Distance from the weather deck to the waterline on a vessel.

Global Positioning System (GPS): A satellite-based radio navigation system that provides precise, continuous, worldwide, all- weather three-dimensional navigation for land, sea and air applications.

Gong Buoy: A wave actuated sound signal on buoys which uses a group of saucer-shaped bells to produce different tones. Found inside harbors and on inland waterways. Sound range about one mile.

Grommet: A round attaching point, of metal or plastic, normally found on fenders, tarps, etc.

Gunwale: The upper edge of a boat's side. Pronounced "gun-ul."

Half Hitch: A hitch used for securing a line to a post; usually seen as two half hitches.

Harbor: Anchorage and protection for ships. A shelter or refuge.

Hatch: The covering, often watertight, placed over an opening on the horizontal surface of a boat/ship.

Head Up (Heads Up): A warning given before throwing a messenger, heaving, or towline to alert people to be ready for receipt of line and to avoid being hit by the object being thrown. Potential danger warning.

Heads Up Display: Setting for radar display to show the vessel's course vice North at the top of the screen.

Heading: The direction in which a ship or aircraft is pointed.

Heaving Line: Light, weighted line thrown across to a ship or pier when coming along side to act as a messenger for a mooring line. The weight is called a monkey fist.

Heavy Weather: Seas, swell, and wind conditions combining to exceed 8 feet and/or winds are exceeding than 30 knots.

Heel: Temporary leaning of a vessel to port or starboard caused by the wind and sea or by a high speed turn.

Helm: The apparatus by which a vessel is steered; usually a wheel or tiller.

High Seas: That body of water extending seaward of a country's territorial sea to the territorial sea of another country.

Hoist: To lift. Display of signal flags at yardarm.

Holed: A hole or opening in the hull of a damaged vessel.

Hull: The body or shell of a ship or seaplane.

Hull Integrity: The hull's soundness.

Hypothermia: A lowering of the core body temperature due to exposure of cold (water or air) resulting in a subnormal body temperature that can be dangerous or fatal. The word literally means "under heated."

Impeller: A propulsion device that draws water in and forces it out through a nozzle.

Inboard: Toward the center of a ship or a group of ships, as opposed to outboard.

Inboard/Outdrive (I/O): An inboard engine attached through the transom to the outdrive.

Incident Command System (ICS): A management system for responding to major emergency events involving multiple jurisdictions and agencies.

Inlet: A recess, as a bay or cove, along a coastline. A stream or bay leading inland, as from the ocean. A narrow passage of water, as between two islands.

Keel: The central, longitudinal beam of a ship from which the frames and hull plating rise.

Knot (kn or kt): A unit of speed equivalent to one nautical mile (6,000 feet) per hour. A measurement of a ship's speed through water. A collective term for hitches and bends.

Lateral System: A system of aids to navigation in which characteristics of buoys and beacons indicate the sides of the channel or route relative to a conventional direction of buoyage (usually upstream).

Latitude: The measure of angular distance in degrees, minutes, and seconds of arc from 0° to 90° north or south of the equator.

Lazarette: A compartment in the extreme after part of the boat generally used for storage.

Leeward: The side or direction away from the wind, the lee side.

Leeway: The drift of an object with the wind, on the surface of the sea. The sideward motion of a ship because of wind and current, the difference between her heading (course steered) and her track (course made good). Sometimes called drift.

Life Jacket: See *personal flotation device*.

Life Ring (Ring Buoy): A buoyant device for throwing to a person- in-the-water.

Light: The signal emitted by a lighted aid to navigation. The illuminating apparatus used to emit the light signal. A lighted aid to navigation on a fixed structure.

Light List: A United States Coast Guard publication (multiple volumes) that gives detailed information on aids to navigation.

Light Sector: The arc over which a light is visible, described in degrees true, as observed from seaward towards the light. May be used to define distinctive color difference of two adjoining sectors, or an obscured sector.

Lighthouse: A lighted beacon of major importance. Fixed structures ranging in size from the typical major seacoast lighthouse to much smaller, single pile structures. Placed onshore or on marine sites and most often do not show lateral aid to navigation markings. They assist the mariner in determining his position or safe course, or warn of obstructions or dangers to navigation. Lighthouses with no lateral significance usually exhibit a white light, but can use sectored lights to mark shoals or warn mariners of other dangers.

List: The static, fixed inclination or leaning of a ship to port or starboard due to an unbalance of weight.

Local Notice to Mariners: A written document issued by each U.S. Coast Guard District to disseminate important information affecting aids to navigation, dredging, marine construction, special marine activities, and bridge construction on the waterways with that district.

Log: A device for measuring a ship's speed and distance traveled through the water. To record something is to log it. Short for logbook.

Logbook: Any chronological record of events, as an engineering watch log.

Longitude: A measure of angular distance in degrees, minutes, and seconds east or west of the Prime Meridian at Greenwich.

Longitudinal: A structural member laid parallel to the keel upon which the plating is secured. Longitudinals usually intersect frames to complete the skeletal framework of a vessel.

Longshore Current: A currents that runs parallel to the shore and inside the breakers as a result of the water transported to the beach by the waves.

Lookout: A person stationed as a visual watch.

LORAN-C: An acronym for long-range aid to navigation; an electronic aid to navigation consisting of shore-based radio transmitters

Loudhailer: A loudspeaker; public address system.

Magnetic Compass: A compass using the earth's magnetic field.

Magnetic Course (M): Course relative to magnetic north; compass course corrected for deviation.

Maritime: Located on or close to the sea; of or concerned with shipping or navigation.

Maritime Domain Awareness: The maritime domain is defined as all areas and things of, on, under, relating to, adjacent to, or bordering on a sea, ocean, or other navigable waterway, including all maritime-related activities, infrastructure, people, cargo, and vessels and other conveyances**.** Maritime Domain Awareness is the effective understanding of anything associated with the maritime domain that could impact the security, safety, economy, or environment of the United States.

Mark: A visual aid to navigation. Often called navigation mark, includes floating marks (buoys) and fixed marks (beacons).

Mast: A spar located above the keel and rising above the main deck to which may be attached sails, navigation lights, and/or various electronic hardware. The mast will vary in height depending on vessel type or use.

Mayday: The spoken international distress signal, repeated three times. Derived from the French *M'aider* (help me).

Medevac: "Medical Evacuation". Evacuation of a person for medical reasons.

Messenger: Light line used to carry across a larger line or hawser. Person who carries messages.

Mid-Channel: Center of a navigable channel. May be marked by safemarks.

Mooring: A chain or synthetic line that attaches a floating object to a stationary object. (e.g., dock, sinker)

Mooring Buoy: A white buoy with a blue stripe, used for a vessel to tie up to, also designates an anchorage area.

Nautical Chart: Printed or electronic geographic representation of waterways showing positions of aids to navigation and other fixed points and references to guide the mariner.

Nautical Mile (NM): 2000 yards; Length of one minute of arc of the great circle of the earth; 6,000 feet compared to 5,280 feet per a statute (land) mile.

Nautical Slide Rule: An instrument used to solve time, speed, and distance problems. "Whiz Wheel"

Navigable Channel: A channel that has sufficient depth to be safely navigated by a vessel.

Navigable Waters: Coastal waters, including bays, sounds, rivers, and lakes, that are navigable from the sea.

Navigation: The art and science of locating the position and plotting the course of a ship or aircraft

Nun Buoy (Conical): A buoy that is cylindrical at the waterline, tapering to a blunt point at the top. Lateral mark that is red, even numbered, and usually marks the port hand side proceeding to seaward.

Occulting Light: A light in which the total duration of light in each period is clearly longer than the total duration of darkness and in which the intervals of darkness are all of equal duration. (Commonly used for single-occulting light which exhibits only single occulations that are repeated at regular intervals.)

Offshore: The region seaward of a specified depth. Opposite is inshore or near-shore.

On Scene Commander (OSC): A person designated to coordinate search and rescue operations within a specified area associated with a distress incident.

Opening: The increasing of distance between two vessels.

Out of Step: The position of two boats (i.e., towing operations) where one boat is on the top of the crest of a wave and the other is in the trough between the waves.

Outboard: In the direction away from the center line of the ship. Opposite is inboard. Also, an engine which is attached to the transom of a vessel.

Outdrive: A transmission and propeller or jet drive attached to the transom of a vessel.

Overdue: When a vessel or person has not arrived at the time and place expected.

Overload: Exceeding the designed load limits of a vessel; exceeding the recommended work load of line or wire rope.

Pacing: Two vessels matching speed and course.

Pad-Eye: A metal ring welded to the deck or bulkhead.

Painter Line (Painter): A line at the bow or stern of a boat which is used for making fast; a single line used to take a vessel in tow alongside, commonly used with ships and their boats when placing the boat into use over the side.

Parallel Approach: An arc approach used where one vessel is approached parallel to another.

Persons Onboard (POB): The number of people aboard a craft.

Personal Flotation Device (PFD): A general name for various types of devices designed to keep a person afloat in water (e.g., life preserver, vest, cushion, ring, and other throwable items).

Piling: A long, heavy timber driven into the seabed or river bed to serve as a support for an aid to navigation or dock.

Pitch: The vertical motion of a ship's bow or stern in a seaway about the athwartships axis. Of a propeller, the axial advance during one revolution. (see *roll*, *yaw*)

Planing Hull: A boat design that allows the vessel to ride with the majority of its hull out of the water once its cruising speed is reached.

Polyethylene Float Line: A line that floats, used with rescue devices, life rings.

Port: The left side of the vessel looking forward toward the bow.

Port Hole: An opening in the hull, door, or superstructure of a boat/ship often covered with a watertight closure.

Prop Wash: The result of the propeller blade at the top of the arc transferring energy to the water surface.

Propeller: A device consisting of a central hub with radiating blades forming a helical pattern and when turned in the water, creates a discharge that drives a boat.

Pyrotechnics: Ammunition, flares, or fireworks used for signaling, illuminating, or marking targets.

Quarantine Anchorage Buoy: A yellow special purpose buoy indicating a vessel is under quarantine.

Quarter: One side or the other of the stern of a ship. To be broad on the quarter means to be 45° away from dead astern; starboard or port quarter is used to indicate a specific side.

RACON: See *radar beacon*.

Radar: Radio detecting and ranging. An electronic system designed to transmit radio signals and receive reflected images of those signals from a "target" in order to determine the bearing and distance to the 'target."

Radar Beacon (RACON): A radar beacon that produces a coded response, or radar paint, when triggered by a radar signal.

Radar Reflector: A special fixture fitted to or incorporated into the design of certain aids to navigation to enhance their ability to reflect radar energy. In general, these fixtures will materially improve the aid to navigation for use by vessels with radar. They help radar equipped vessels to detect buoys and beacons. They do not positively identify a radar target as an aid to navigation. Also used on small craft with low radar profiles.

Range: A measurement of distance usually given in yards. Also, a line formed by the extension of a line connecting two charted points.

Range Lights: Two lights associated to form a range which often, but not necessarily, indicates a channel centerline. The front range light is the lower of the two, and nearer to the mariner using the range. The rear range light is higher and further from the mariner.

Range Line: The lining up of range lights and markers to determine the safe and correct line of travel, the specific course to steer to remain in the center of the channel.

Range Marker: High visibility markers that have no lights. (see *range lights*)

Red, Right, Returning: A saying to remember which aids a crewmember should be seeing off vessel's starboard side when returning from seaward.

Rig: To devise, set up, arrange. An arrangement or contrivance. General description of a ship's upper works; to set up spars or to fit out. A distinctive arrangement of sails (rigging), as in a schooner rig. An arrangement of equipment and machinery, as an oil rig.

Rip Current: A current created along a long beach or reef surf zone due to water from waves hitting the beach and traveling out to the sides and parallel to the shore line, creating a longshore current that eventually returns to sea.

Riprap: Stone or broken rock thrown together without order to form a protective wall around a navigation aid or shoreline.

River Current: The flow of water in a river.

Rode: The line to which a small boat rides when anchored. Also called an anchor line.

Roll: Vessel motion caused by a wave lifting up one side of the vessel, rolling under the vessel and dropping that side, then lifting the other side and dropping it in turn.

Roller: A long usually non-breaking wave generated by distant winds and a source of big surf, which is a hazard to boats.

Rooster Tail: A pronounced aerated-water discharge astern of a craft.

Rubrail: A permanent fixture, often running the length of a boat, made of rubber that provides protection much as a fender would.

Rudder: A flat surface rigged vertically astern used to steer a ship, boat, or aircraft.

Sail Area: On a vessel, the amount of surface upon which the wind acts.

Sampson Post: Vertical post on the forward deck of a boat used in towing and securing. Sometimes used as synonym for king post.

Scope: The length of anchor line or chain. Number of fathoms of chain out to anchor or mooring buoy. If to anchor, scope is increased in strong winds for more holding power. Also, the length of towline or distance from the stern of the towing vessel to the bow of the tow.

Screw: A vessel's propeller.

Scupper: An opening in the gunwale or deck of a boat which allows water taken over the side to exit. Common to most self-bailing boats.

Scuttle: A small, quick-closing access hole; to sink a ship deliberately.

Sea Anchor: A device streamed by a vessel in heavy weather to hold the bow up to the sea. Its effect is similar to a drogue in that it slows the vessel's rate of drift. However, it is usually made off to the bow opposed to the stern as in the use of a drogue.

Seaward: Toward the main body of water, ocean.

Seaworthy: A vessel capable of putting to sea and meeting any usual sea condition. A seagoing ship may for some reason not be seaworthy, such as when damaged.

Set (of a Current): The direction toward which the water is flowing. A ship is set by the current. Measured in degrees (usually true).

Shackle: A U-shaped metal fitting, closed at the open end with a pin, used to connect wire, chain, or line.

Shaft: A cylindrical bar that transmits energy from the engine to the propeller.

Ship: Any vessel of considerable size (greater than 100 feet in length) navigating deep-water, especially one powered by engines and larger than a boat. Also, to set up, to secure in place. To take something aboard.

Situation Report (SITREP): Reports to interested agencies to keep them informed of on-scene conditions and mission progress.

Skeg: The continuation of the keel or outboard engine under the propeller.

Slack Water: The period that occurs while the current is changing direction and has no horizontal motion.

Spring Line: A mooring line that makes an acute angle with the ship and the pier to which moored, as opposed to a breast line, which is perpendicular, or nearly so, to the pier face; a line used in towing alongside that enables the towing vessel to move the tow forward and/or back the tow (i.e., tow spring and backing spring).

Stanchion: A vertical post aboard a vessel.

Starboard: The right side of the vessel looking forward toward the bow.

Static Electricity: A quantity of electricity that builds up in an object and does not discharge until provided a path of flow.

Static Forces: Constant or internal forces.

Station Keeping: The art of keeping a boat in position, relative to another boat, aid, or object with regard to current, sea, and/or weather conditions.

Steerage: The act or practice of steering. A ship's steering mechanism.

Steerageway: The lowest speed at which a vessel can be steered.

Stem: In metal ships, the stem is the foremost vertical or near-vertical strength member, around which or to which the plating of the bow is welded or riveted. Compare stern-post.

Stem Pad-Eye (Trailer Eye Bolt): An attaching point available on most trailered small boats.

Stern: The extreme after end of a vessel.

Stokes Litter: A rescue device generally used to transport non-ambulatory persons or persons who have injuries that might be aggravated by other means of transportation.

Strobe Light: A device that emits a high intensity flashing light visible for great distances. Used to attract the attention of aircraft, ships, or ground parties, it flashes white light at 50 plus or minus 10 times per minute.

Strut: An external support for the propeller shaft integral to the hull/under water body.

Superstructure: Any raised portion of a vessel's hull above a continuous deck (e.g., pilot house).

Swell: Wind-generated waves which have advanced into a calmer area and are decreased in height and gaining a more rounded form. The heave of the sea. See *roller*.

Tactical Diameter: The distance made to the right or left of the original course when a turn of 180° has been completed with the rudder at a constant angle.

Taffrail: A rail around a vessel's stern over which a towline is passed. Used to reduce the effects of chafing on the towline.

Tidal Current: The horizontal motion of water caused by the vertical rise and fall of the tide.

Tide: The periodic vertical rise and fall of the water resulting from the gravitational interactions between the sun, moon, and earth.

Tie Down: A fitting that can be used to secure lines on a deck or dock.

Topside: The area above the main deck on a vessel; weather deck.

Tow Line: A line, cable, or chain used in towing a vessel.

Transom: Planking across the stern of a vessel.

Triage: The process of assessing survivors according to medical condition and assigning them priorities for emergency care, treatment, and evacuation.

Trim: The fore-and-aft inclination of a ship, down by the head or down by the stern. Sometimes used to include list. Also means shipshape, neat.

Trough: The valley between waves.

U.S. Aids to Navigation System: A system that encompasses buoys and beacons conforming to the IALA buoyage guidelines and other short-range aids.

Uniform State Waterway Marking System (USWMS): Designed for use on lakes and other inland waterways that are not portrayed on nautical charts. Supplemented the existing federal marking system and is generally compatible with it.

Venturi Effect: To move water from one place to another by entraining the pumped liquid in a rapidly flowing stream.

Vessel: By U.S. statutes, includes every description of craft, ship or other contrivance used as a means of transportation on water. "Any vehicle in which man or goods are carried on water."

Wake: The disturbed water astern of a moving vessel.

Wave: A periodic disturbance of the sea surface, caused by wind (and sometimes by earthquakes).

Wave Frequency: The number of crests passing a fixed point in a given time.

Wave Height: The height from the bottom of a wave's trough to the top of its crest; measured in the vertical, not diagonal.

Wave Length: The distance from one wave crest to the next in the same wave group or series.

Wave Period: The time, in seconds, it takes for two successive crests to pass a fixed point.

Wet Suit: A tight-fitting rubber suit worn by a diver in order to retain body heat. Designed to protect wearer from exposure to cold, wind, and spray.

Wind-Chill Factor: An estimated measurement of the cooling effect of a combination of air temperature and wind speed in relation to the loss of body heat from exposed skin.

Wind Shadow: When an object blocks the wind, creating an area of no wind.

Windward: Towards the wind.

Yaw: Rotary oscillation about a ship's vertical axis in a seaway. Sheering off alternately to port and starboard.

Appendix B.
List of Acronyms

Introduction

This appendix contains a list of acronyms that may be useful when reading this manual.

ACRONYM	DEFINITION
A/C	Air Conditioning
AAR	After Action Report
AIS	Automatic Identification System
ANSI	American National Standards Institute
ANT	Aids to Navigation Team
AO	Area of Operations
AOR	Area of Responsibility
API	American Petroleum Institute
AtoN	Aids to Navigation
BAC	Blood Alcohol Content
BM	Boatswain’s Mate
BOSN	Boatswain
BWI	Boating While Intoxicated
C2	Command and Control
CASREP	Casualty Report
CBDR	Constant Bearing, Decreasing Range
CBRN	Chemical, Biological, Radiological, Nuclear
CDR	Commander
CFR	Code of Federal Regulations
CISM	Critical Incident Stress Management
CMAA	Chief Master at Arms
CO	Commanding Officer
COG	Course Over Ground
COLREG	International Regulations for Preventing Collisions at Sea
COMMS	Communications
CONOPS	Concept of Operations
COTP	Captain-of-the-Port
CPO	Chief Petty Officer
CPR	Cardiopulmonary Resuscitation
CPU	Central Processing Unit
CWO	Chief Warrant Officer

DAN	Diver's Alert Network
DEC	NYS Department of Environmental Conservation
DGPS	Differential Global Positioning System
DHSES	NYS Department of Homeland Security and Emergency Services
DIW	Dead-in-the-Water
DMA	Defense Mapping Agency
DoD	Department of Defense
DOT	Department of Transportation
DR	Dead Reckoning
DSC	Digital Selective Calling
EBL	Electronic Bearing Line
ECS	Electronic Chart System
EMS	Emergency Medical Services
EMT	Emergency Medical Technician
EP	Estimated Position
EPA	Environmental Protection Agency
EPIRB	Emergency Position Indicating Radio Beacon
ET	Electronics Technician
ETA	Estimated Time of Arrival
FAA	Federal Aviation Agency
FAR	Federal Acquisition Regulations
FEDEX	Federal Express
FM	Frequency Modulation
FOIA	Freedom of Information Act
FOUO	For Official Use Only
FPCON	Force Protection Conditions
GAR	Green-Amber-Red
GPH	Gallons Per Hour
GPS	Global Positioning System
GSA	Government Service Administration
HAZMAT	Hazardous Material
HAZWASTE	Hazardous Waste
HF	High Frequency
HIN	Hull Identification Number
HVAC	Heating, Ventilation, and Air Conditioning
IACS	International Association of Classification Societies

IALA	International Association of Lighthouse Authorities
ICS	Incident Command System
I&I	US Marine Corps Instructor-Inspector
IMO	International Maritime Organization
ISO	International Standards Organization
IT	Information Systems Technician
JQR	Job Qualification Requirement
LE	Law Enforcement
LEO	Law Enforcement Officer
LNG	Liquid Natural Gas
LOA	Length Overall
LOB	Line-of-Bearing
LOC	Letter of Commendation
LOD	Line of Duty (Investigation)
LOP	Line of Position
LORAN-C	Long-Range Aid to Navigation
LOS	Line-of-Sight
LWL	Length on Waterline
MAA	Master at Arms
MARAD	US Maritime Administration
MARPOL	International Convention for the Prevention of Pollution from Ships
MARSEC	Marine Security Conditions
MDA	Maritime Domain Awareness
MEDEVAC	Medical Evacuation
METL	Mission Essential Task List
MISLE	Marine Information for Safety and Law Enforcement
MMD	Merchant Mariner Document
MMSI	Maritime Mobile Service Identity
MOA	Memorandum of Agreement
MOB	Man Overboard
MOU	Memorandum of Understanding
MSST	Maritime Safety and Security Team
NAVAIDS	Navigational Aids
NCW	Naval Coastal Warfare
NLT	No Later Than
NM	Nautical Miles

NMEA	National Marine Electronics Association
NOAA	National Oceanic and Atmospheric Administration
NOSC	Navy Operational Support Center
NTP	Naval Training Publication
NWP	Naval Warfare Publication
OEM	Office of Emergency Management
OIC	Officer-in-Charge
OJT	On-the-Job Training
OPAREA	Operational Area
OPCON	Operational Control
OPORD	Operations Order
ORM	Operational Risk Management
OS	Operations Specialist
OSC	On-Scene Commander
OSHA	Occupational Safety and Health Administration
PAO	Public Affairs Officer
PATCOM	Patrol Commander
PFD	Personal Flotation Device
PIW	Person-in-the-Water
PMS	Preventative/Planned Maintenance System
PO	Petty Officer
PPE	Personal Protective Equipment
PQS	Personnel Qualification Standard
PSU	Port Security Unit
PTO	Power Take-Off
RACON	Radar Beacon
RT	Receiver/Transmitter
SAR	Search and Rescue
SATCOM	Satellite Communication
SCUBA	Self-Contained Underwater Breathing Apparatus
SDB	Service Dress Blue
SEC BUFF	US Coast Guard Sector Buffalo
SEC LIS	US Coast Guard Sector Long Island Sound
SEC NNE	US Coast Guard Sector Northern New England
SEC NY	US Coast Guard Sector New York
SITREP	Situation Report

SOA	Speed of Advance
SOG	Speed Over Ground
SOLAS	Safety of Life at Sea
SOP	Standard Operating Procedure
SOPA	Senior Officer Present Afloat
SOS	Save Our Ship
SPF	Sun Protection Factor
SSB	Single Side Band
TACON	Tactical Control
U/W	Underway
UHF	Ultra High Frequency
UPS	United Parcel Service
USBP	US Border Patrol
USC	United States Code
USPS	US Power Squadron
	US Postal Service
UTC	Coordinated Universal Time
VHF	Very High Frequency
VRM	Variable Range Marker
VTS	Vessel Traffic Services
WAAS	Wide Area Augmentation System
XO	Executive Officer

MILITARY EMERGENCY BOAT SERVICE
SEAMANSHIP MANUAL

MEBS SEA-MAN