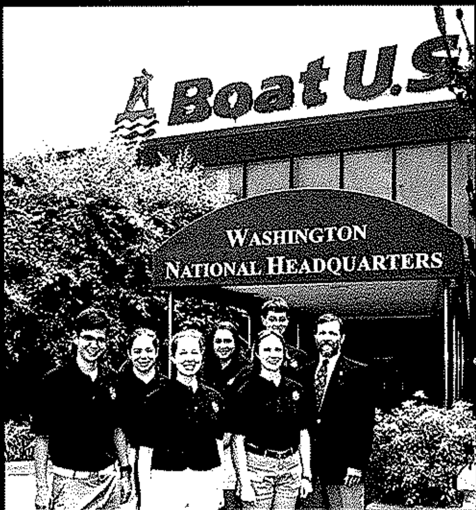
SEAMANSHIP AND BOATING SAFETY



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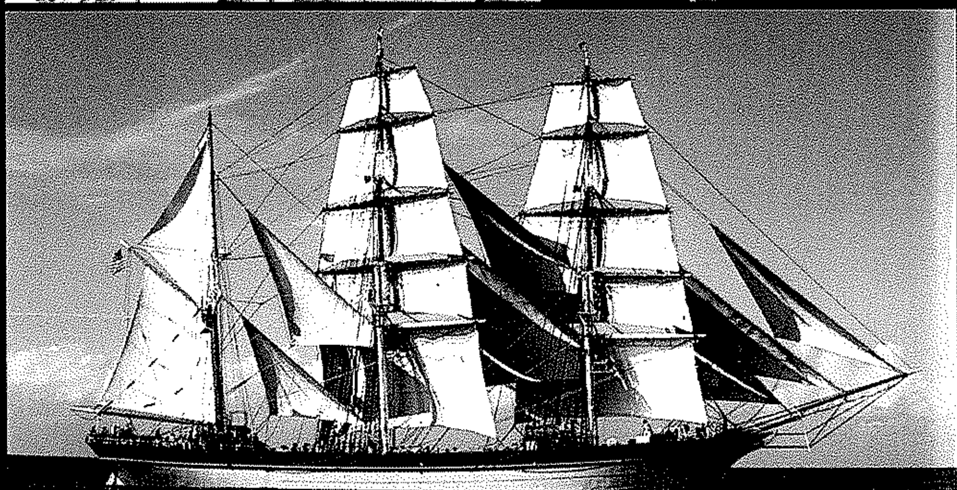
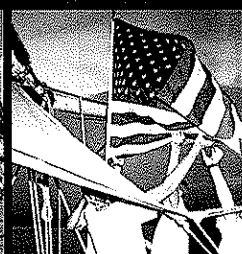
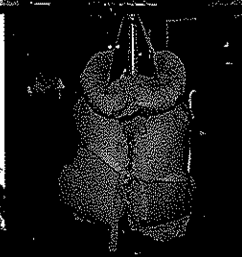






SEAMANSHIP AND BOATING SAFETY

Chapter 4

Marlinspike seamanship is the care, handling, knotting, splicing, and use of fiber and wire rope. A marlinspike is a pointed metal tool (or its wooden equivalent, the fid) used in marling or in separating rope strands for splicing.

In the days when sailing vessels ruled the seas, every sailor had to be an expert in this field. They developed marlinspike seamanship into a leisure-time art that produced hundreds of knots, hitches, bends, and splices. Today, however, only about a dozen are of any regular use to the sailor of small boats.

Rope

Rope is perhaps one of the oldest and most useful tools of man. In small boats, it is used for mooring, anchoring, towing, and general utility. Sailboats, in particular, have many uses for rope, including standing rigging (wire), halyards (wire and/or rope), sheets, etc. All rope aboard a vessel is referred to as line unless it has a specific name such as a halyard, sheet, etc.

Generally speaking, rope is made from three types of material—vegetable fibers, synthetic materials, and wire. In the early days, rope was made from whatever material was available, such as vines or strips of animal hides, but these crude materials were gradually replaced by stronger fibers like flax, cotton, and ramie. These products were replaced by jute, sisal, and Manila hemp. The last two are still widely used for certain applications.

During World War II, the scarcity of sisal and Manila hemp prompted scientists to develop a substitute. As a result many synthetic ropemaking materials were produced. Some of these new products proved superior to the vegetable fibers used for so many years.

Dacron and nylon have proved particularly effective, and polyethylene and polypropylene have many uses in rope manufacture. Sometimes two synthetic materials are used together such as a polyethylene cover over a Dacron center.

Although braided synthetic lines are proving to be increasingly popular, laid rope of either a natural or synthetic fiber is still most widely used. It is made in diameters from $^3/_{16}$ to 4 inches. The manufacture of laid rope involves four principal steps:

1. Clean fibers, lubricated to withstand internal friction, are laid parallel and drawn into continuous "slivers." (This first step is not necessary with synthetic fibers.)
2. The slivers are spun into yarns of uniform size, twisted in one direction. Synthetic fibers are spun directly into yarns.
3. The yarns are twisted in opposite directions to form strands.
4. The strands are laid, again in opposite directions, to form finished rope. Reversing the direction of the twist twice makes the three elements work against each other; otherwise the rope would come apart quite easily. Rope is laid normally with three strands but sometimes with four. Except for several special purpose ropes, it is laid right-handed, i.e., spiraling upward to the right if the rope is held vertically.

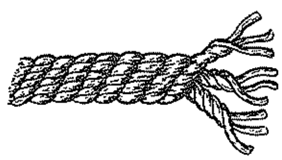
The Various Lays

Plain-laid rope is three-stranded, right or left. The most common lay is right-handed.

Plain-laid

Cable-laid rope consists of three ropes, laid together into a larger rope. In laying any rope, plain or cable, the component strands or ropes are given an extra twist, or a fore turn as ropemakers call it. This is taken out when the rope is laid, the back turn of the laying counterbalances the fore turn of the forming. Think this over and examine a rope.

Cable-laid



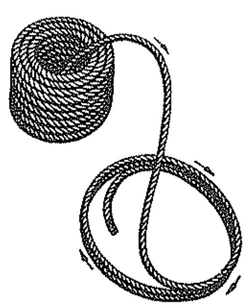
Four-stranded rope is plain-laid, but consists of four strands. As four strands will not lie together without a hole in the center, this center space is filled in by a small rope known as the heart. Therefore, four-stranded rope is stronger than three-stranded rope of the same size.

Four-stranded, plain-laid with heart

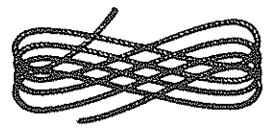
A hawser is any rope 5 inches or more in circumference. Such ropes are used for towing vessels, making fast alongside wharves, warping, etc.

A coil is the standard method of preparing rope for shipment. It is usually 200 fathoms in length (1,200 feet).

Taking line from a new coil, reach down inside and take inner fag end from bottom. Coil clockwise if rope is right-handed.



Line flaked down, ready to run out rapidly. Coils, in practice, would lie closer together.



Uncoiling Rope

Great care must be exercised in taking rope out of a coil. First, determine the lay, whether right or left. If right-laid, proceed as follows:

- Loosen the burlap cover, lay the coil on the flat side with the inside end nearest the deck.
- Reach down through the center of the coil and draw the inside up and out of the coil. Never uncoil from the outside since extra turns are put into the rope by doing so, and kinks are liable to form.
- Coil down loosely, right-handed, or clockwise.

To Thoroughfoot a Rope

Suppose a rope gets full of turns and kinks are forming. Suddenly, you get the order "Thoroughfoot that rope!"

Take the end and coil down against the lay, that is left-handed for a right-handed rope. Then bring the lower end, where you started coiling, up through the center of the coil, and coil down again with the lay. If there are many turns in your rope, coil small; if a few, coil large.

When we are about to thoroughfoot a rope where one end is fast, as the hauling part of a halyard or boat fall, begin coiling left-handed with the part off the pin, or where belayed. Then, when the left-handed coil is finished, dip the end down through the coil, capsize the coil, and proceed as before.

Facts About Rope

Rope sizes are sometimes measured by circumference, but the diameter is more commonly used. The strength of rope is measured by the load that it will support without breaking. Different kinds of ropes vary considerably in their strength characteristics.

In any strenuous boating use, the minimum safe tensile strength under normal conditions is five times the weight of the object attached to the rope. Thus, a water-skier weighing 175 pounds needs a towing line of about 875-pound tensile strength. This 5-to-1 safety factor allows for sudden strains and for normal deterioration.

The size of rope is proportional to its strength, other things being equal. However, the best rope for a given purpose is not always the size indicated by the tensile strength specification.

Another important factor is the use of the rope. This is particularly important in rope used to run through blocks. If the diameter is too small, the rope will tend to slip and roll in the sheave, wearing out quickly. A rope that is too large for a particular block will chafe against the sides of the block and also wear out before it should.

The stretching quality or elasticity is an important consideration in choosing rope. Two elements are involved in determining this—permanent elongation and working elasticity.

Permanent elongation refers to the permanent increase in length the first time a load is put on a rope. Under normal conditions, Manila stretches approximately 1.5 percent; Dacron, 0.5 percent; and nylon, 4 percent.

Rope Weight and Strength Specifications

Nominal Size in Inches		Tensile Strength in Pounds			
		Federal Spec. Minimum	Approximate Average		
Cir.	Dia.	Manila	Polyethylene	Dacron	Nylon
3/4	1/4	600	1,200	1,750	1,950
1	5/16	1,000	1,750	2,650	2,950
1 1/8	3/8	1,350	2,500	3,600	4,200
1 1/4	7/16	1,750	3,400	4,800	5,500
1 1/2	1/2	2,650	4,100	6,100	7,200
2	5/8	4,400	5,700	9,000	11,000
2 1/4	3/4	5,400	7,800	12,500	15,300
2 3/4	7/8	7,700	11,000	16,000	21,000
3	1	9,000	13,300	20,000	26,500

Nominal Size in Inches		Weight in Pounds per 100 Feet			
		Federal Spec. Minimum	Approximate Average		
Cir.	Dia.	Manila	Polyethylene	Dacron	Nylon
3/4	1/4	1.96	1.25	2.45	1.74
1	5/16	2.84	1.88	3.60	2.65
1 1/8	3/8	4.02	2.94	5.00	3.85
1 1/4	7/16	5.15	4.00	6.60	5.25
1 1/2	1/2	7.35	5.00	8.40	6.95
2	5/8	13.10	8.10	12.80	10.60
2 1/4	3/4	16.30	11.50	18.00	15.50
2 3/4	7/8	22.00	16.20	23.50	20.80
3	1	26.50	19.60	30.00	27.50

Working elasticity measures the amount that rope can be stretched and recover while in use. This quality varies considerably in types of rope materials as well as the load applied and how long the rope might be free of strain between use. Under a normal (20 percent) load and relaxation period, working elasticity varies from 7 percent in Manila and 9 percent in Dacron to 22 percent in nylon.

These stretching qualities make nylon well suited to mooring and anchor lines, where it can act as a shock absorber. On the other hand, nylon is much too elastic for use on sailboat halyards or sheets. Dacron or Manila rope are best for this.

The Care of Rope

Always dry rope out well before stowing it after use. In salt water, wet it down with fresh water before drying and stowing. Keep rope free from sand and grit and avoid any contact with acids.

To examine rope, open up the lay and look at the inside strands. If the rope is powdery, fibers broken, use it with care. The inside yarns of a rope break first. Sometimes, when a rope has been overstressed, many of the inside yarns are broken while the cover yarns appear good and sound. It may break with a small load.

Synthetic rope fibers are not attacked by the fungi that cause rot and mildew to Manila rope. Synthetic rope absorbs little water, so it does not need to be dried after use, like Manila.

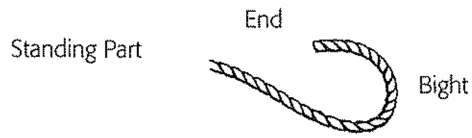
Rope Terminology

Old-time seamen made quite a point of the difference between a knot, a hitch, and a bend. A knot is used to close or stopper something (reef knot, overhand knot, etc.) A hitch is used to attach a line to an object (clove hitch, rolling hitch, etc.) A bend is used to connect two pieces of rope (sheet bend, carrick bend, etc.) Over the years these definitions have become blurred and the general term "knot" is commonly used today.

The end of a rope is what you work with in tying a knot. (If passing through a block, it is called the fall.)

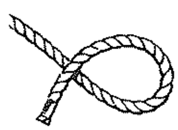
The standing part is the long unused or belayed end of a rope.

The bight is the loop or half loop formed by turning the rope back on itself.



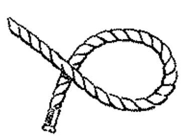
An overhand loop is made by crossing the end over the standing part.

Overhand Loop

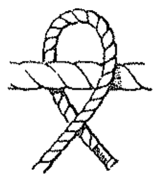


An underhand loop is made by crossing the end under the standing part.

Underhand Loop



A turn is one loop around an object such as a pile. A round turn is two loops around an object.

Turn  Round Turn 

There are three additional points to remember in knot tying:

1. Every knot requires passing rope either over or under itself or both. If this is not done carefully, the wrong knot, or no knot at all, will result.
2. A knot must be tightened slowly and evenly with all elements of the knot in proper relationship. If this is not done, an embarrassing snarl may result.
3. In joining two lengths of rope, you can reduce the rope's strength up to 50 percent by using a knot.

A well-made splice, however, retains about 90 percent of the rope's strength. Therefore, a carefully made splice is preferable to a knot, when strength is important.

Knots

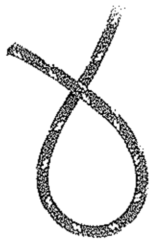
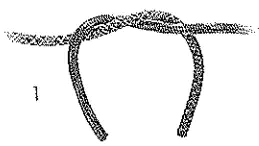
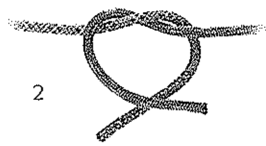
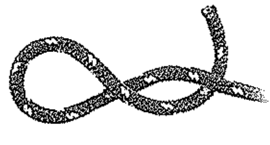
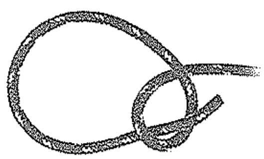
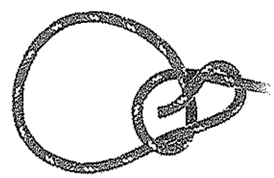
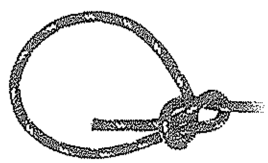
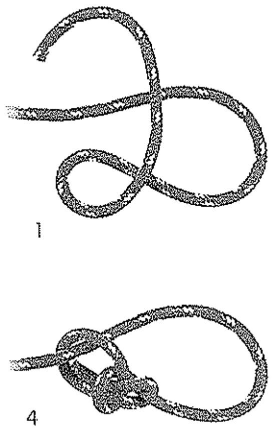
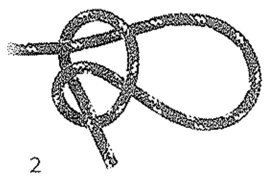
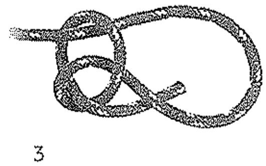
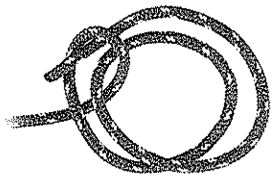
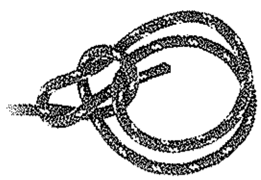
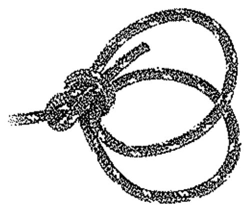
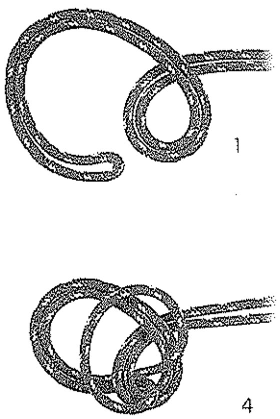
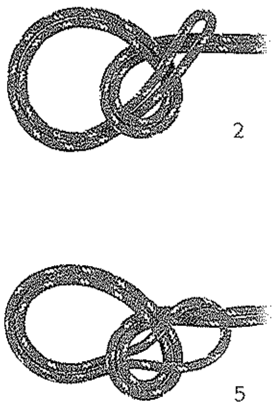
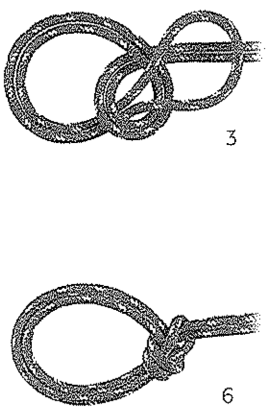
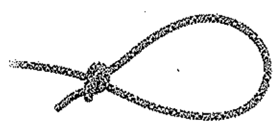
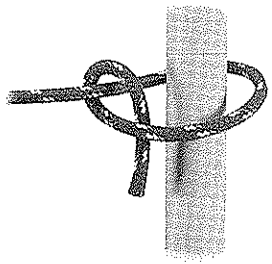
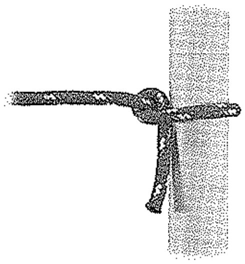
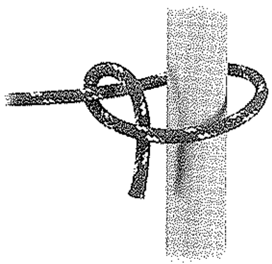
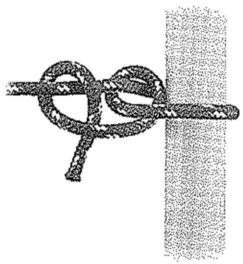
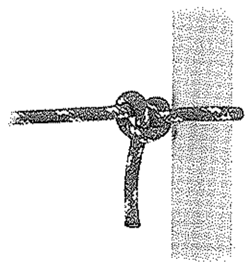
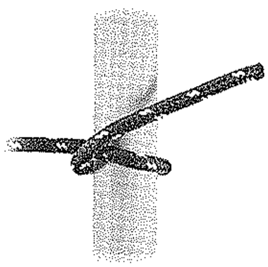
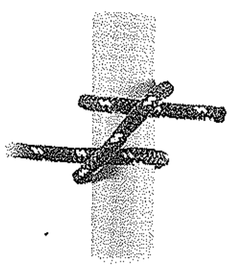
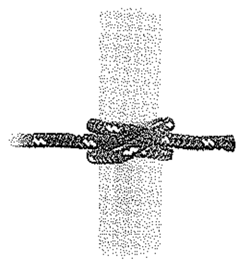
OVERHAND KNOT. The overhand knot is the smallest and simplest of knots and the start of bigger ones. It can be an effective stopper, but will jam when pulled too tight. To make an overhand knot, make an overhand loop and pass the end under and up through it.			
REEF OR SQUARE KNOT. This knot is used to tie the reef points when reefing a sail. The knot is often tied as a slipped hitch to permit a rapid release. Never use this knot to bend two lines. It would be unreliable. Unless this knot is tied carefully, you will come up with a worthless granny knot.	1  4 	2 	3 

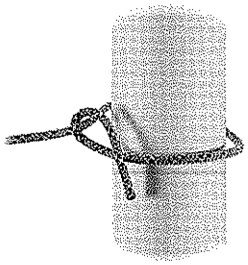
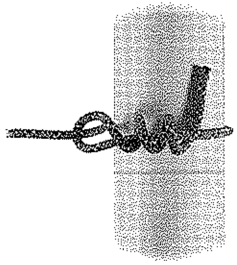
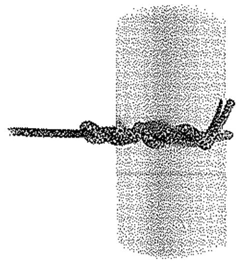
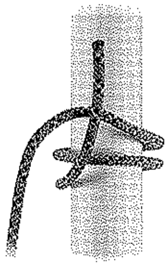
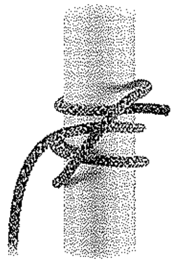
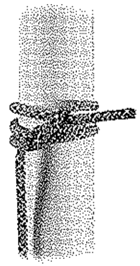
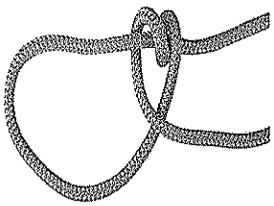
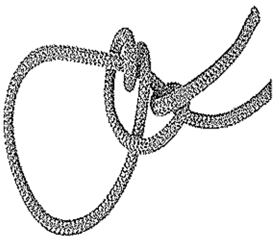
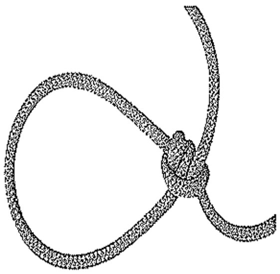
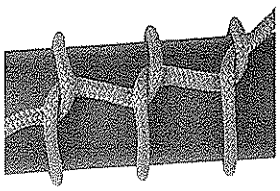
FIGURE EIGHT KNOT. This knot is easily untied and gentle to fiber. It is the best knot for keeping a rope end from running through a fairlead or block. To make this knot, make an underhand loop; then bring the end around and over the standing part, under and up through the loop.			
STEVEDORE'S KNOT. The stevedore's knot is used to prevent the end of a fall from running through the large swallow of a cargo block.			
BOWLINE. This has been called the king of knots. Nothing can jam it. It will never slip if properly made. It can be tied in the hand and dropped over a cleat, bitt, or piling or formed around a mooring ring. To tie a bowline, make an overhand loop with the end held toward you, pass the end under and up through the loop, then behind the standing part and down through the loop again, adjust the bight carefully, and draw tight. This is a knot you can both trust and be proud of. By the way, the bowline as a knot has no particular connection with the bow line used to tie up the bow of your boat. The bowline was first described by Thomas Bowling. In usage, "Bowling's knot" became the "bowline."			

RUNNING BOWLINE. The running bowline is simply a bowline with the loop first passed about the standing part before the bowline is formed. The illustration shows the result, but it is more easily understood when you see it tied.			
FRENCH BOWLINE. The French bowline provides two nonslip loops used for hoisting, lowering, etc. To tie this knot, start with an overhand loop as on a regular bowline, but pass the end through twice to form two larger loops; finish as on a regular bowline by passing the line behind the standing part and down through the original loop.			
BOWLINE ON A BIGHT. The bowline on a bight increases the strength of a bowline and makes several loops for various purposes. It is formed in the same way as a bowline using the bight instead of the end, the parts being double. When the bight is brought up through the gooseneck, it is passed down around the loop and up behind the standing part. The illustration shows this.			
SLIPKNOT. This knot with a sliding noose is useful for various purposes. When pulled tight, it may be hard to break free. To tie, make an overhand knot around the standing part.			

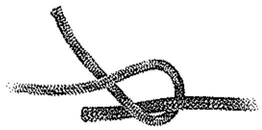
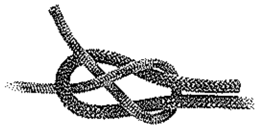
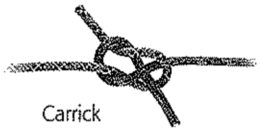
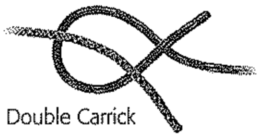
FISHERMAN'S KNOT. This is an excellent way to join lengths of small line together, such as a fishing line. Lay end portions of two lines side by side. Tie overhand knots around opposite strands and pull the knots together. When drawn tight, this will not slip.			

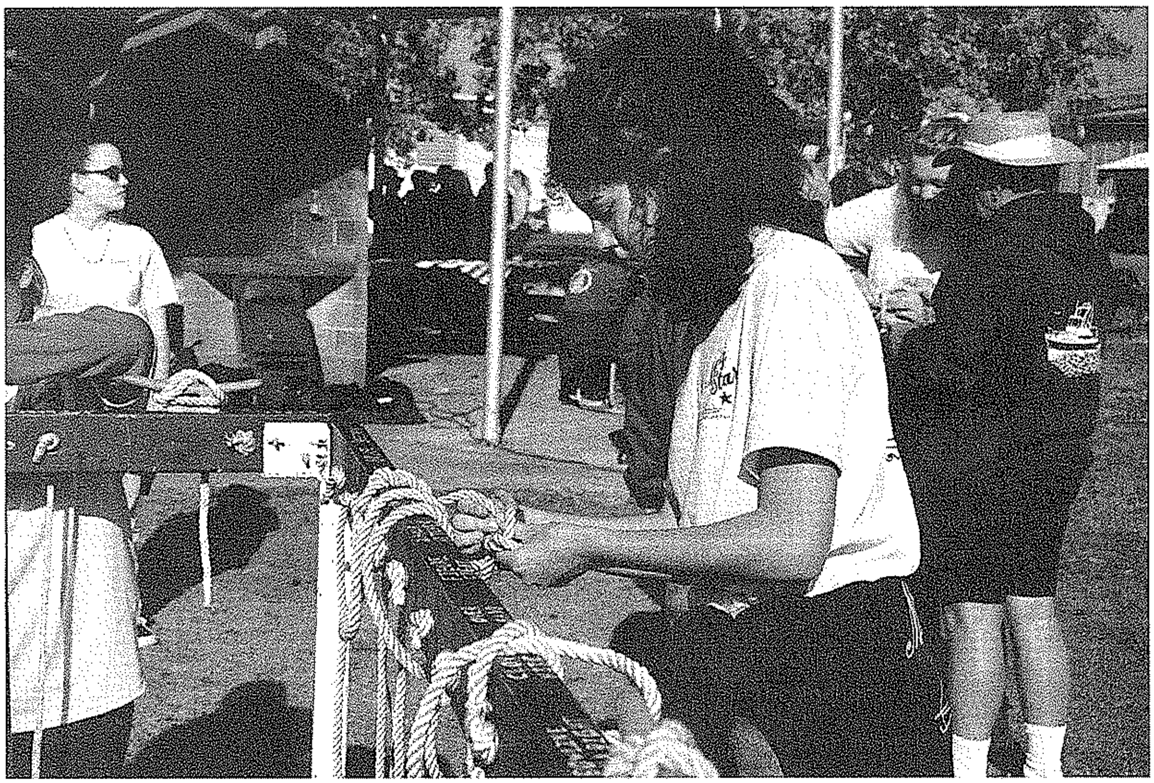
Hitches

HALF HITCH. This is the smallest and simplest of all hitches and the start of others. It may be used to fasten to an object with only a right-hand pull, but quickly slips if not reinforced. To tie, pass the end of the rope around the object and tie an overhand knot to the standing part.			
TWO HALF HITCHES. This is a quick and very reliable knot employed when making lines fast at a mooring. To tie, make a half hitch and then add another next to it. Additional half hitches will add strength.			
CLOVE HITCH. The clove hitch is a simple, handy way to fasten a rope temporarily around a pile or spar. To tie a clove hitch, take a turn around the object, bringing the end of the rope over itself from below; then, take a second turn with the end under itself. This knot consists of two half hitches in opposite directions.			

TIMBER HITCH. The timber hitch is useful when lowering or hoisting a spar or pole. To tie, pass the rope around the spar and take a turn on the standing part; twist the end back on itself for at least three turns, following the lay of the rope. Adding a half hitch enables one to tow a spar end first on a straight course.			
ROLLING HITCH. This is a very effective hitch when a pull is to be resisted along the length of a spar. However, it is only effective for a steady pull. Slacking and jerking are liable to loosen it.			
MIDSHIPMAN'S OR TAUTLINE HITCH. This hitch is used to keep a line taut. It is similar to two half hitches with the first half hitch doubled. It is easy to untie if the second half hitch is slippery. Frequently used for tent guy lines.			
MARLINE HITCH. This is a very simple hitch, used in lashing hammocks, marling down canvas chafing gear on large ropes, etc. It is often made wrong. The ends of the rope, coming out of the hitch, should always come out from underneath.			

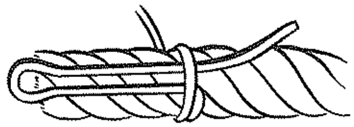
Bends

SHEET BEND OR BECKET BEND. This is used for securing a small rope to the bight of a larger rope. It is very much like the bowline, but uses two ropes rather than one. To tie a sheet bend, make an overhand loop with the end of one rope; pass the end of the other rope under and up through this loop, behind the first loop's standing part and down through the loop again.			
CARRICK BEND. The carrick bend and double carrick bend are used in bending together hawsers, as in towing. The last gives an easy connection, distributing the stress along the fibers of the rope.	 Carrick  Double Carrick		

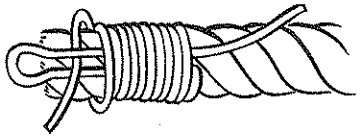


Whipping

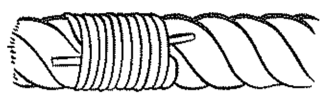
All ropes should be whipped to prevent the ends from unraveling. On Manila rope this may be done with small stuff (marline, spun yarn, etc., for larger rope, waxed cord for smaller). For the most common way, place the end of the yarn at the end of the rope, lay a loop of it along the rope.



Then wind the yarn tightly around both rope and loop for a distance about equal to the rope's diameter.



To finish, put the winding end through the loop and pull the original end to draw the loop under the whipping. Trim both ends. This method is also recommended for synthetic rope. As an alternative, you may "whip" the end of synthetic rope by applying heat (as from a match). This fuses the strands.

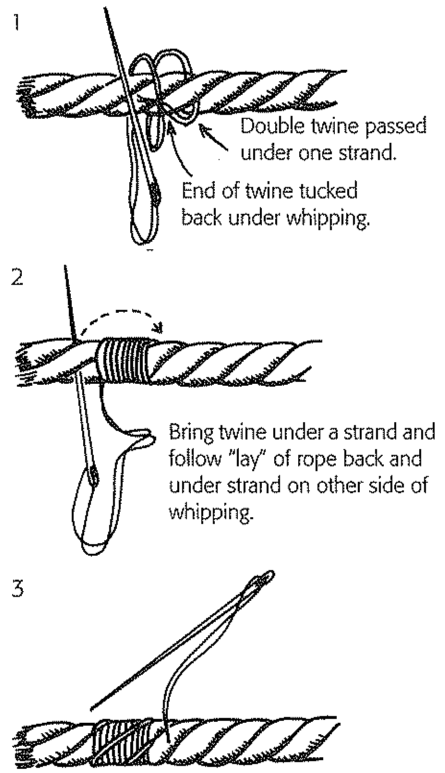


The second method of whipping the end of a rope is needle-whipping. The advantage of this method over the first is that the end turns never become unwound.

The whipping should be started "inboard" and wound to the end of the rope. Then, put on the binding turns in the lay, as shown. If you were to start the binding from the end of the rope and work in, your last binding turn would come "outboard" and the whole thing would loosen.

In an emergency, use tape as a temporary whipping.

Needle-Whipping



Having followed the three lays back and forth over the whipping, finish by bringing twine up through the center of strand.

Splicing

Splicing is the sailor's art of joining any two parts of rope together permanently. The most important step in splicing is the start. Marry the strands correctly, and the remaining steps follow easily.

To prepare a rope for splicing, unlay the end adequately and whip each strand with a temporary whipping of small stuff. Extra care is needed with nylon as the strands do not retain their set and will quickly unlay into a tassel.

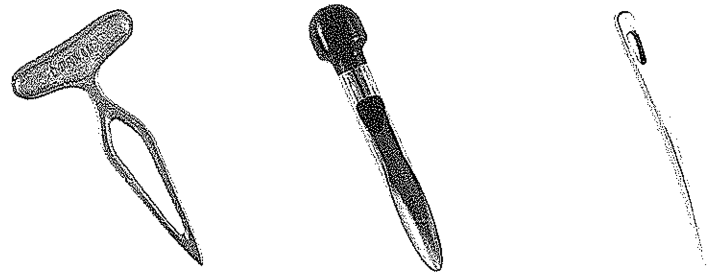
Before beginning to splice fiber rope, you need several tools. The first is a knife. The second is a fid. A rigging knife is also handy, since it combines a blade and a small marlinspike in one tool.

Fid

The fid is1 ½ to 2 inches in diameter at the butt and tapered—usually more than a foot long. It should be smooth.

The fid is used to aid in opening the lay of rope at the point where a strand is to be introduced.

Four tucks will hold any splice in normal fiber rope, providing they are full strands, i.e., not tapered off. Tapering off is made after the fourth tuck and is done by reducing each of the strands by one-third; tucking, reducing by another third; and finally, tucking and trimming off close. Six tucks are advised for more slippery synthetic rope.



Eye Splice

The eye splice is the strongest type of rope loop and may be formed around a thimble. Unlay the rope for a distance of about 12 times the rope's diameter. If you are a beginner in the art of splicing, it is a good idea to put on a temporary whipping at the point where the strands begin to unlay or at the crotch. This whipping should be cut off after the splice is formed.

Now use a fid or marlinspike to lift one strand of the standing part. Tuck one of the unlaid strands under it and draw it taut (see fig. 1). The other two strands are to lie on each side of this middle strand. Have the eye toward you and the strands and standing part of the rope away from you.

Then take the left strand, tuck it from right to left under the next strand of the rope, and haul firmly taut (see fig. 2). Then the last strand is to be tucked to the right. Give it an extra turn and tuck from right to left (see fig. 3).

Now make certain the three strands are properly taut (all equally so) and each under its proper strand of rope. Also, make certain that the eye thus formed is the required size, and the eye itself is not distorted in any way.

Figure 1

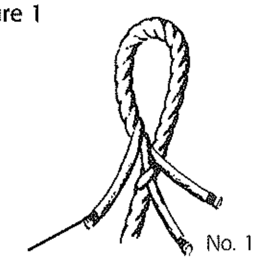


Figure 2

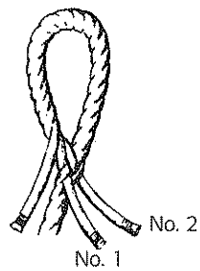


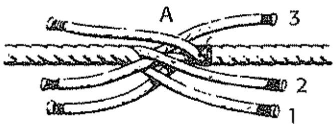
Figure 3

Now repeat the tucks in the same order until the end strands are too short to work. You can "fair" the splice to some extent by rolling it under your shoe or pounding it gently with a wooden or rubber mallet.

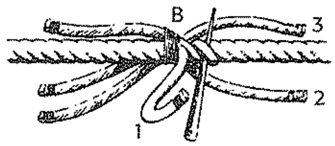
Short Splice

The short splice joins two ropes or two ends of the same rope. It is the strongest of splices, but because it increases the diameter, it cannot run through a correctly sized block. Its bulk can be reduced by tapering the strands toward the end of the splice, but this tends to weaken it somewhat.

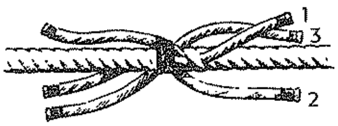
Both ends should be unlaid for about a distance equal to 12 times the rope's diameter. Temporarily, whip the crotch at A and the ends of the strands of each rope. Bring the two ends together as shown, alternating the strands, and pull them taut.



Temporarily, tie down the unlaid strands of the right-hand rope at B (in cut). Remove the lashing from that rope. Using a fid, raise one strand of it as shown so that strand 1 from the left-hand rope can be tucked under it.



Pass strand 1 over the intervening strand and under the raised one. Tuck it against the lay of the rope and pull it taut.



Raise the next strand and tuck left-hand strand 2 under it. Do the same with strand 3. This completes one full tuck. Continue tucking the strands in sequence until you have at least three tucks.

Remove the temporary tie B and the lashing A from the other rope. Tuck the strands one after the other as with the first rope.

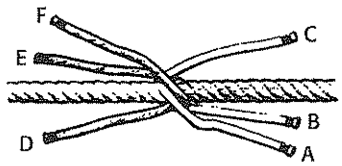
To taper the splice, finish several complete tucks; then, remove the whipping from each of the strands. With a sharp razor, cut about one-third of the yarn from each strand. Retwist the yarns, whip as before, and make another full tuck. Again, untwist and slice about half of the remaining yarn on each strand for the remaining tuck.

For synthetic rope, follow the same methods as mentioned above but allow two additional tucks (with or without tapering).

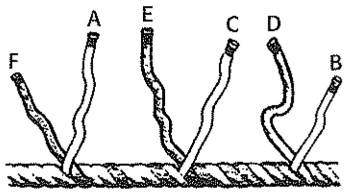
Long Splice

To do this splice, the sailor must show his skill. Properly made, the splice is hard to detect and will run over the sheaves of a block without trouble. It uses considerable rope, but does not affect the rope's strength to any great extent, although it is not quite as strong as the short splice.

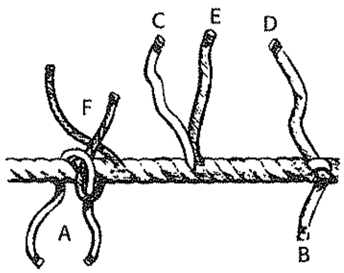
Unlay the ends of each rope about 15 turns (six times the circumference) and whip the ends of the strands. Bring the two ends together as shown in the illustration, with the strands alternating: A, D, B, E, C, F.



Start with any opposite pair of strands, A and F, and unlay A enough farther so that F can be laid in its place. Do the same with another pair, B and D, in the opposite direction. Leave the third pair, C and E, protruding from between the strands, as shown.

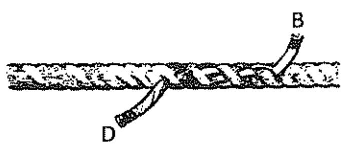


Tie each pair of strands with an overhand knot, as shown with B and D. To reduce the diameter of the finished splice, untwist the strands, separate them lengthwise into half strands, retwist them, and again whip or tape before knotting, as shown with A and F.



This is a kind of compromise between splicing and tapering. It sacrifices some strength, though less than tapering alone.

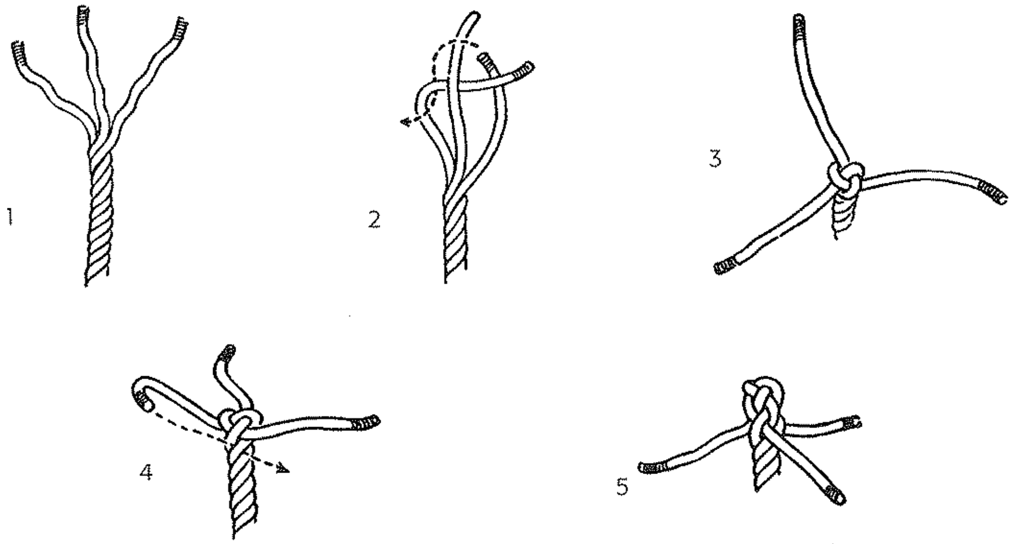
After knotting each pair of strands, tuck them under alternate strands as above. Two tucks are enough. Finish by rolling or pounding the splice well and trimming the ends of the strands.



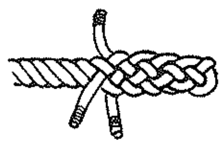
To produce a neat and strong splice requires patience and practice, but it is a job that you can be proud of. It is an easy splice to make if you take your time about it and have an understanding of the essential structure of rope. Take pride in your work.

Back Splice

This is merely a method of preventing the end of a rope from unlaying. The ends are first laid over each other or crowned. The drawing illustrates this. Then the ends, sticking out of the crown point back along the standing part of the rope, are tucked in a short splice.



A neat whipping at the ends of the splice helps make it more durable. If the strands are tucked back without tapering, it forms a bit of a knob on the end of the rope that may be useful.


6

Splicing Braided Rope

Splicing nylon or Dacron double-braided rope is a complex process needing special tools. Splicing kits are available for a variety of sizes of double-braided rope. Follow the instructions packed with the kit.

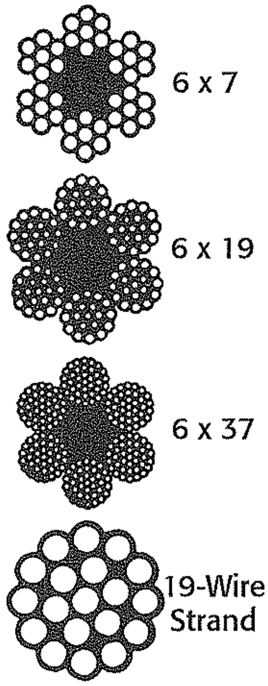
Polyethylene and polypropylene braided rope is easy to splice since it seldom has a core. Heat the end with a flame and shape it into a point. Be careful not to burn your fingers. Form a loop and open the braid at the desired point by "pushing" the rope. Work the pointed end down into the opened braid 5 or 6 inches. Now pull the rope and the braid will close around the end. A whipping at the base of the loop will keep the braid from opening and releasing the end.

Wire Rope

Rope that is formed from wire strands rather than fiber yarn is wire rope. As with fiber, the wires are twisted into strands and the strands are then twisted the opposite way around a center strand to make the finished wire rope.

There are many variations that give wire rope great versatility. Wires are made from a number of metals, including galvanized iron, cast steel, plow steel, stainless steel, and sometimes copper, bronze, or phosphor bronze.

The coppers are generally not as strong as iron wire of the same diameter. For yacht and small boat use, long-lasting wire is made of stainless steel and other alloys that make it nonrusting and much stronger than ordinary steel wire.



Wire rope is almost universally preferred for standing rigging and halyards on sailboats (sometimes spliced to fiber rope). It also is often used on both sailboats and powerboats for tiller and steering cables, handrails, mooring pennants, and similar applications.

Wire rope is often coated with plastic materials, usually nylon or vinyl, which make it tough, flexible, smooth running, and easier to handle. This coated rope is used for steering lines or handrails.

Wire rope is made in diameters from $^1/_{16}$ to 1 $^1/_2$ inches or larger and is designated always by the diameter of the rope, not the circumference as sometimes with fiber rope. Wire sizes above 1 inch are called cable. It is also classified by the number of strands.

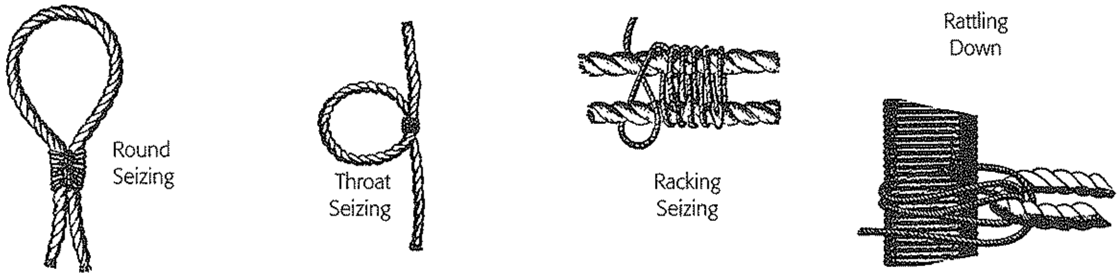
Wire rope cannot be knotted like fiber rope but, if made of flexible material, will run through blocks, sheaves, or fairleads. In handling wire rope, use leather palm gloves to protect your hands against frayed ends or splinters.

The ends of wire rope should be whipped with seizing or serving wire, just as fiber rope should be whipped with small stuff. Wire rope can also be spliced end to end using a long splice, or to form an eye, either plain or around a thimble. In most cases a rigger's screw is used to hold the eye. Then the strands are opened up with a steel marlinspike for tucking.

Today, most eyes in wire are "swagged" by fitting a metal sleeve, or ferrule, around the standing part and the end of the wire just below the eye and squeezing with a hand or power press. Wire rope requires special tools and equipment and is not easy to handle by the inexperienced.

Seizings

These are really small lashings that bind or fasten together two lines or a line to a spar. They are often of a permanent character and should be carefully made. The seizing is made with small stuff, such as marline or other tarred material, if it is to be exposed to the elements.



Canvas Work and Sail Repair

The sewing of canvas is an art acquired only by practice as in ropework. Canvas-sewing equipment consists of the following:

SAIL NEEDLES. Long spur needles, triangular in shape, rounded at the eye end for general sewing. The No. 15, which is 2 $^1/_2$ inches long, is the needle most generally used.

TWINE. Use cotton twine of 4 to 8 ply for general canvas work, the heavier ply for heavier canvas. Cotton twine comes in a ball of 1/2 pound. Heavier roping is done with 9- to 12-ply twine. Synthetic line equal to what is being sewn can also be used; nylon to nylon, rayon to rayon, etc., will control shrinkage. This is also for added strength. Twine should be threaded through the eye of the needle, doubled, and well waxed for extended life.

PALM. A heavy leather half-glove worn over the hand. The palm has a lead casting sewn in, and this is used to push the needle through the canvas or rope. Palms are either right- or left-handed.

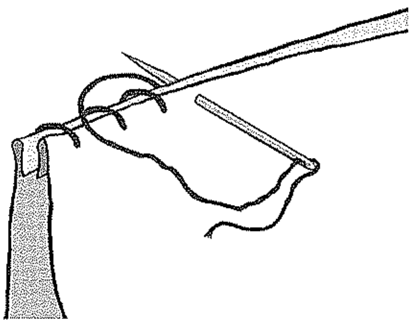
PRICKER. A long, sharp, steel-pointed tool used to puncture a needle hole through several thicknesses of canvas.

CREASING STICK. A tool, having a slot at one end, used to crease the seams in preparing the sewing of seams.

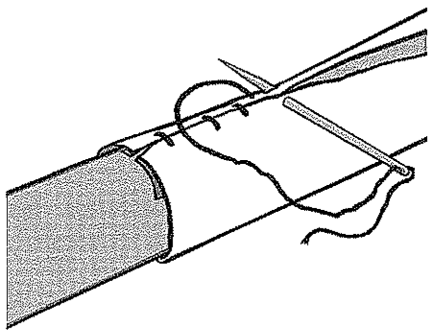
BEESWAX. A small cake of pure beeswax is used for waxing twine.

Canvas Seams

Round seams are used to cover lines, especially in places where wear is likely to occur. The only difference between the two types shown is the direction of the needle thrust. The covering will be firmer if the stitch is passed through the line.

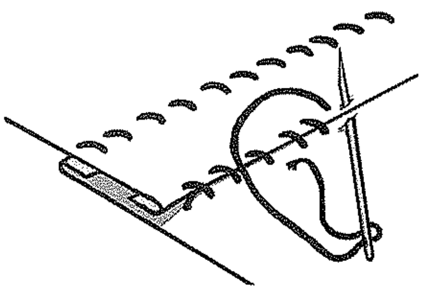


Round Seam



Flat seams are really two seams. They are commonly used to join two pieces of canvas. To sew a flat seam, lay the two pieces of canvas on a flat surface, only overlapping the edges that you want to fasten together. You can mark the overlap with a pencil. Arrange the two cloths with the raw edge toward you and the folded edge behind it. Sew away from you. When finished, open and rub the seam flat using a creasing stick.

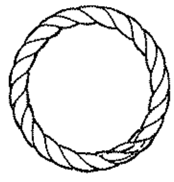
Fold back the second cloth and sew the edge to the doubled part of the second cloth. Rub the seam smooth. If done right, it will lie flat.



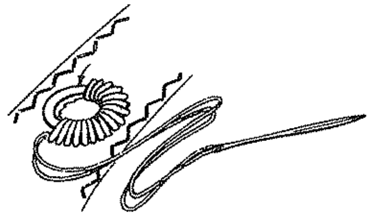
Flat Seam

Grommets

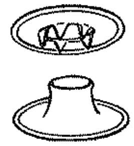
These are sail fittings that should be very carefully made. Making a seagoing grommet eye takes practice. It is done as follows:



Spliced Rope Grommet



Metal Grommet Ring



Toothed Metal Grommet

Cut a hole, somewhat smaller than that of the finished eye. This hole must be cut out of the canvas and not punched by a spike. Then, lay a brass or galvanized iron ring over the edge of the hole or, if you have no ring and wish to make a good eyelet, form a strong grommet of marline, and lay this over the hole. Then take some stout roping twine, 9- or 10-ply, wax it well, and having hitched the end around the side of the grommet away from the point of stress, work around the grommet and through the canvas, about 1/8 inch away from the grommet, making your stitches even and hauling them taut.

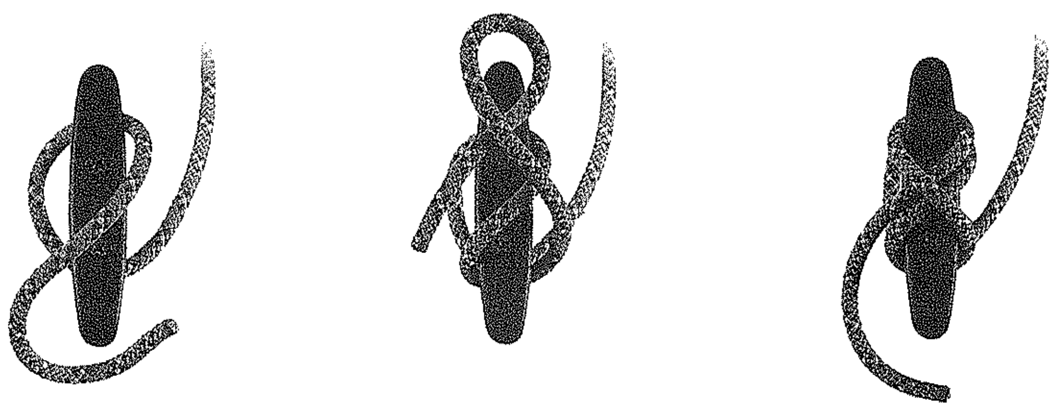
Then follow around again, stitching a bit further away, and riding your turns between those stitched first. Follow this by one or two more rings of stitchings, all evenly disposed and hauled taut. Finish off by hitching the end securely under the grommet ring with a few cross-stitches.

Such a grommet eye, properly made, will not pull out or tear the canvas under any reasonable stress. It takes practice, but is worth doing well.

Belaying

There is a right way and wrong way to belay a rope. Do not tie or knot sheets and halyards to cleats. When rope gets wet, as it often does, it shrinks in length and swells in diameter. This means that knots get so tight and stiff that they cannot be untied quickly.

The illustration shows the correct method of making fast to a cleat. The half hitch that completes the fastening is taken with the free part of the line. The line can then be freed without taking up slack in the standing part.



Blocks and Tackles

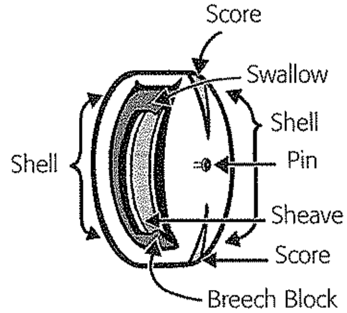
A block is a mechanical device made up of one or more scored wheels called sheaves (pulleys) over which a rope or ropes are worked. The sheaves are mounted in a shell that is fitted with a hookeye, shackle, or other means of attaching it to an object.

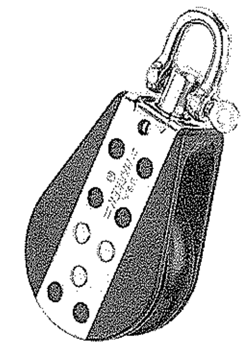
Blocks are single, double, treble, etc., according to the number of sheaves. They are also spoken of as single, twofold, threefold, etc.

Snatch blocks are fitted with an opening by which the bight of a line may be snatched into the block without going to the trouble of reeving (passing) thought the end. These particular blocks are very useful on board ship for snatching boat falls, to give them a proper lead along the deck.

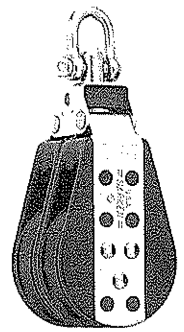
The block to which the standing part of a fall is made fast has a becket worked into its heel. A becket is an eye designed to take the hook of a block.

In choosing a block, use the block manufacturer's rating of the load the block will carry safely. Of secondary importance is the rated strength of the rope being used, as this is normally greater than that of the block.

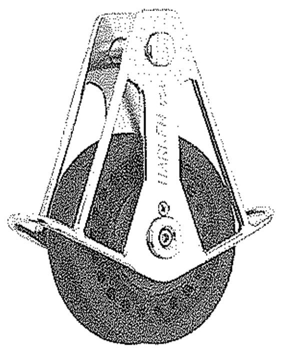




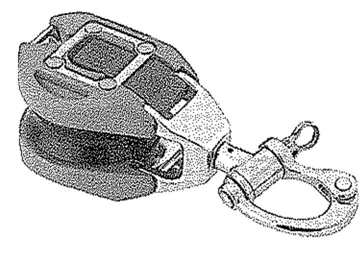
Single Block



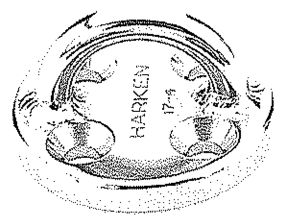
Double Block



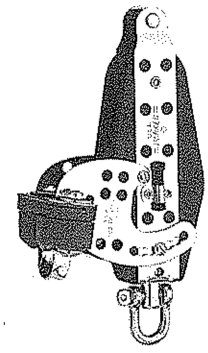
Runner Block



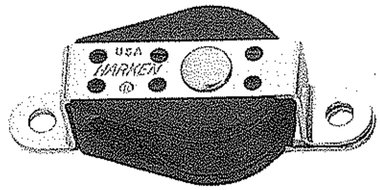
Snatch Block



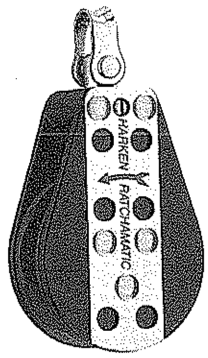
Pad Eye



Fiddle with Cam and Becket



Cheek Block



Ratchet Block

Table 7: Table of Block Sizes

Length Shell (Inches)	Size Sheave (Inches)	For Diameter Rope (Inches)
3	1 3/4 x 1/2 x 3/8	3/8
4	2 1/4 x 5/8 x 3/8	1/2
5	3 x 3/4 x 3/8	5/8
6	3 1/2 x 1 x 1/2	5/8 – 3/4
7	4 1/4 x 1 x 1/2	7/8
8	4 3/4 x 1 1/8 x 5/8	1
9	5 1/2 x 1 1/8 x 5/8	1

Tackle

When a block or blocks and rope are combined to multiply power, it is called a tackle. The following terms are used in connection with tackle:

- **Falls**. That part of the tackle made of rope (wire or fiber).
- **Standing part**. That part of the fall to which the power is applied.

- **Hauling part**. The end of the fall to which power is applied.
- **Round in**. To bring the two blocks together.
- **Overhaul**. To separate the two blocks.
- **Reeve**. To pass the rope through the block and over the sheave.

The tackle is a mechanical device for applying power and gaining added power at the expense of distance. That is, by applying a comparatively small force to the end of the fall and hauling it 10 feet, the movable block of the tackle will be lifted about a foot, but will do so with a considerable increase in power.

The tackle then consists of a certain fixed block on some solid fixture, like a mast, and a movable block on the object to be moved. The rope or fall is rove through the blocks and the amount of power gained (ignoring the loss by friction) is equal to the number of parts of the fall leading from the movable block.

Types of Tackles

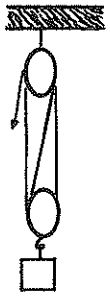
LUFF TACKLE. This consists of a single and double block. The standing part of the fall is made fast to the becket of a single block and rove back again through the second sheave of the double block. When the double block is attached to the object to be moved, the power gained is four times (disregarding friction).

When the object to be moved is attached to the single block, the power gained is three times the pull (again disregarding friction).

Here we see the rule: Count the number of rope parts leading from the movable block and you have the theoretical number of times the power is increased.

The luff tackle is one of the most useful tackles.

Luff



$\frac{P}{W} = \frac{1}{2}$ } No Friction

$\frac{P}{W} = \frac{13}{30}$ } With Friction

GUN TACKLE. This consists of two single blocks with the standing and hauling parts of the fall leading from the same block. The diagram shows the method of reeving the fall. The power gained is two or three, according to the block attached to the movable object.

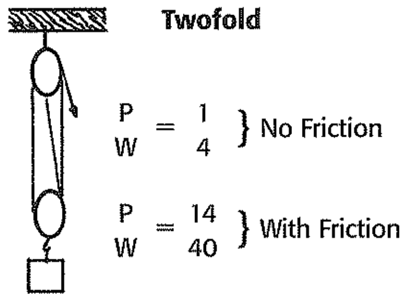
These tackles were attached to the gun carriages in the old days of smoothbore cannons and were used to train the guns. This tackle is a handy one and has many uses.

Gun Tackle

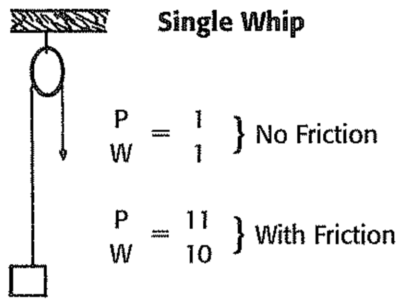
$\frac{P}{W} = \frac{1}{2}$ } No Friction

$\frac{P}{W} = \frac{12}{20}$ } With Friction

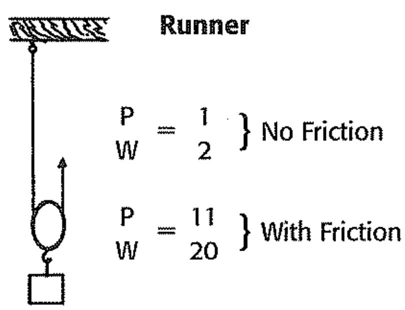
TWOFOLD OR DOUBLE PURCHASE TACKLE. The twofold tackle consists of a tackle rove off with two double blocks. The diagram shows that the power gained is either four or five, depending on which is the movable block. A point to note is that when the hauling part of the fall is leading from the movable block, when you are pulling directly from the object moved, the power is always greater by one.



SINGLE WHIP. This is simply a rope rove through a single block. If the block is stationary, no power is gained. If the block is attached to the object to be moved, the power gained is two.



RUNNER. The runner is simply the whip with the block at the movable object. These combinations of a single block and rope, whip, or runner are found in many parts of the rigging of ships. In modern vessels, the cargo whip is a good example of its use.



REEVING TACKLES. This should be done as follows: We assume that the rope to be rove as a fall is right-handed. Place the two blocks to be used on the deck, hooks up. Take the end you intend for the starting part.

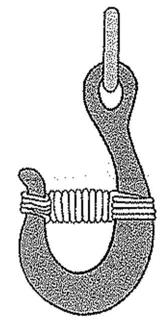
Enter this into the sheave you intend to lead the hauling part out of and reeve off the tackle from right to left, against the sun, or counterclockwise. When your standing part comes to an end, splice or hitch it using a thimble into the becket of the block to which it is to be made fast.

Place the blocks about three feet apart for an ordinary watch tackle, hooks pointing up, and coil down with the sun, coiling the fall around the blocks. With the end of the fall, clove hitch about the coil between the blocks. When about to use, cast off the hitch, laying the tackle on the deck in the same position as when being made up, lift the coil clear and then capsize it.

To Make Up a Tackle

Take hold of the blocks, two men running apart with them, and fleet the tackle. Fleeting is the pulling apart of the blocks, so they will be ready for use. When a tackle is in use and the blocks come together, the tackle is said to be "two blocked."

The power loss, due to friction, in a tackle is variable, about one-fourth is normal. With well-designed blocks, wide swallows, and large sheaves, the power loss will be less than when a heavy rope is rove through small blocks.


Mousing a Hook

MOUSING HOOKS. When tackles are to be used where there is a chance of unhooking, the hooks should be moused.

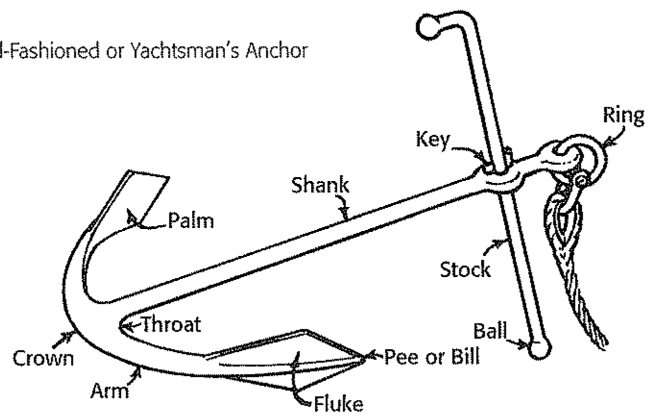
Ground Tackle

Ground tackle is a general term for the anchors, cables, warps, springs, etc., used for securing a vessel at anchor.

Anchor Parts

Let us consider the parts of the old-fashioned anchor or its very close relative, the yachtsman's stock anchor in general use today. First, today's anchors are forged. The ***shank***, which is the main stem of the anchor, is its most important part. The ***arms***, branching off from the bottom of the shank, form the holding element. They are slightly curved and branch upward at an angle. Where they join the shank is the ***crown***. At the upper side, on either side of the shank, is the ***throat***. When a buoy rope is hitched about an anchor, it is attached here.

Old-Fashioned or Yachtsman's Anchor



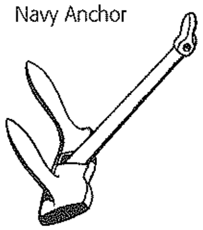
The arms are tipped by the ***flukes*** or ***palms*** and these in turn by the ***bill*** or ***pee***. The metal shod boards on the bow of ships are called ***billboards***, where the bill of the anchor touches the side when hoisted inboard.

The outside of the palm, where the fluke fines down and acts as a support, is called the ***blade***.

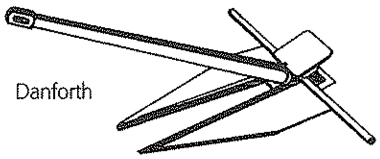
The ***stock*** is the part of the anchor which is straight and at right angles to the plane of the arms. Just above the stock the upper end of the shank carries a large eye where the anchor shackle is attached. This is where the anchor cable is joined to the anchor.

Types of Anchors

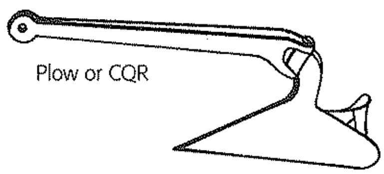
Navy Anchor



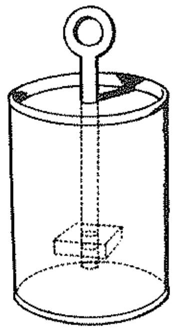
Danforth



Plow or CQR

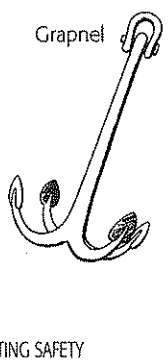


Mushroom



Homemade Anchor

Grapnel



YACHTSMAN'S OR OLD-FASHIONED ANCHOR. The yachtsman's anchor is very similar to the anchor used for centuries that had a wooden stock. In suitable weight, it has excellent holding power. The stock, running across the shank, is designed to make the anchor lie on the bottom so that when a horizontal pull comes from the boat, the fluke digs into the bottom.

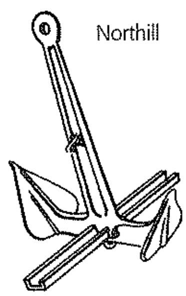
The yachtsman's anchor in general use today is constructed so that the stock slides through the shank and folds down alongside it for convenience in stowage. The one disadvantage of the yachtsman's anchor is that it can easily be fouled by the protruding fluke as the boat swings or "walks" while anchored.

NAVY ANCHOR. The stockless or navy anchor, sometimes called patent, has no stock and, therefore, is free of the danger of fouling the cable. Its effectiveness depends on its weight and the bottom conditions that enable the flukes and heavy crown to dig in.

The crown is pivoted on the end of the shank and this allows the flukes to turn down into the bottom. This type of anchor is used on large ships that can handle and stow it efficiently. The navy anchor is not effective in small craft.

LIGHTWEIGHT ANCHORS. The most widely used anchors for small craft today are the lightweight type. Developed by R. S. Danforth in 1939, this design produces strong holding power because of thin large flukes that heavy strains bury deeply. Instead of a stock through the head of the anchor, the Danforth has a round rod through the crown that prevents the anchor from rolling. This type of anchor has the unique feature of being equally adaptable to large or small craft.

Another comparable model is the Northill. This anchor is light and relatively efficient. The Northill has a stock at the crown instead of at the ring end, adding to the anchor's holding power when the flukes are buried. The arms are at right angles to the shank, and the broad flukes are set at a carefully engineered angle to ensure a quick bite into the bottom.



Northill

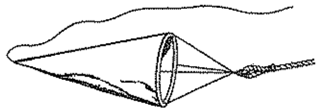
Another efficient anchor is the CQR, or plow, of English design. As it does not have a stock, it rarely fouls. It has the ability to dig in again promptly even after a 180-degree change of direction of a boat at anchor caused by changes in the wind or tide. This type of anchor is not stowed as easily as some of the other lightweight anchors.

MUSHROOM ANCHOR. The mushroom anchor is standard for permanent moorings. In heavy weights, it has excellent holding power. It has a cast-iron bowl at the end of the shank.

HOMEMADE ANCHOR. You can fashion a simple anchor by placing a large bolt in a No. 10 can and then filling the can with concrete. This is suitable only for a very small boat in calm waters.

GRAPNELS. The grapnel is frequently used by small craft for temporary use. It has five or more flukes uplifted around the shank. It is a handy piece of equipment for retrieving gear lost overboard by dragging along the bottom.

SEA ANCHOR. The sea anchor is a canvas cone that can be used to keep the boat's head into heavy seas.



Sea Anchor

Anchor Selection

Choosing the proper anchor or anchors for any given boat depends on several factors: the load that the boat may place on an anchor, the types of bottom in which a particular anchor may be used, and the type of anchor rode and anchoring materials. All of these are interrelated.

The load that a particular boat may place on its ground tackle depends upon its weight and several external conditions such as the force created by the wind above the waterline, the currents below the waterline, and the wave action at any particular time.

A good rule of thumb for cruising sailboats calls for a working anchor weighing about 1 pound per foot of the boat's overall length, plus a "storm" anchor of about twice that weight for bad weather. A "lunch hook" of about 1/2 pound per foot may be satisfactory for temporary anchoring. Motorboats and centerboard sailboats may use smaller anchors.

All of these weights may be reduced for the more efficient lightweight anchors, but increased for the navy-type ones. Check with the anchor manufacturer's recommendations before trusting the holding power of any anchor.

The holding power of an anchor varies greatly with the type of bottom. An anchor that might develop 1,500 pounds of holding power in hard sand may only be able to hold a 500-pound load in a soft bottom. You cannot always tell in advance where you might anchor your ship, so you must have ground tackle available for the most difficult anchoring conditions you might face.

The horizontal pull generated by a particular boat will determine the type of anchor rode. To be effective, the rode must be long and strong enough. The length of the rode—or scope—must be so that the pull on the anchor shank is almost horizontal. A scope of at least 7 to 1, seven times as long as the vertical distance at high tide from the bow chock to the bottom, is considered safe.

For example: If you are anchoring in 12 feet of water and the distance from your bow chock to the water is 3 feet, you should pay out seven times the total of 15 feet or 105 feet of anchor rode. Any scope less than 5 to 1 would be considered unsafe in anything but very calm weather.

Small-craft anchor rodes are usually made of rope. Until the newly developed synthetic ropes came onto the market, Manila had been the traditional rope for anchor rodes. Manila is weaker than the synthetic materials and does not have the elasticity of synthetic fibers, particularly nylon.

Nylon is particularly effective to minimize shock loads caused by winds and tides. The synthetic materials dry quicker and are more durable than Manila.

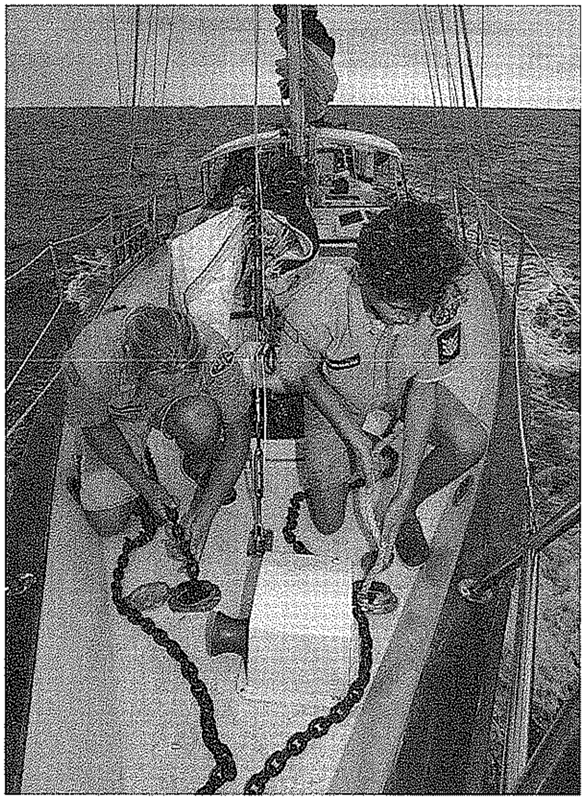
A short chain between the end of the rope line and the anchor is effective. It tends to lie on the bottom and further lessens the shock by adding weight to help maintain the important horizontal pull.

All components of the anchoring materials should be joined with good-quality galvanized shackles and the line should have an eye with a thimble where it meets the chain to reduce as much abrasion as possible.

In constructing a proper anchor rode, limit the working load to one-fifth of the rated breaking strength of the rope and one-half of the proof test of the chain used. Thus, a boat developing a load of some 2,000 pounds should have a rode in which the rope is rated at 10,000 pounds.

Stowage of Ground Tackle

Though some small boats carry only a single anchor, this is by no means adequate. Even if you discount the possibility of fouling an anchor so that it cannot be retrieved, there are many occasions when it is desirable to lay two anchors. Also, having just one anchor heavy enough for heavy-weather conditions would be a nuisance in ordinary conditions.



Many boats carry three anchors. Two are kept on deck, ready for use. A light one is used for brief stops while someone is aboard. A medium-weight anchor is used for ordinary service, including overnight anchorage in a harbor. The third anchor might be considered a spare that has been chosen for extreme holding conditions. It is usually carried below.

To prevent deck anchors from coming adrift when the boat rolls and pitches, carry them in chocks and be sure they are securely lashed.

Except for very small craft that carry their line coiled forward on the deck or in an open cockpit, the usual practice in boat manufacture is to provide rope and chain lockers in the forepeak. Chain dries quickly as it comes from the water and can be fed down through a deck pipe as it comes off the winch or is hauled by hand.

Manila rope should be thoroughly dried before it is stowed in the chain locker. Some boats have gratings on the deck as an aid in drying rope. The chain lockers should be well ventilated to permit circulation of air. A dark, wet locker is a likely place for dry rot to happen.

Anchors and chain often become foul from the muddy bottom of harbors and should be washed before stowage. Manila requires care if it is to give good service as an anchor rode. It is subject to chafe and deterioration and should be inspected often.

Anchor Cable

The link of large anchor chain is somewhat different from that of ordinary chain. It has a crosspiece called a ***stud***. This crosspiece strengthens the chain, prevents kinking, and adds to its weight.

Chain is made into shots of 15 fathoms (1 fathom is 6 feet). These shots are shackled together to form the entire chain cable.

Chain cables range in size up to 4 inches—the diameter of the metal in a link. This is, of course, a very large chain. The heaviest chain used in the U.S. Navy is 3⁵⁄₈ inches. It is attached to the heaviest anchors. Each such link weighs 112 pounds!

Table 8: Markings

The markings of chain are on the shackles separating the shots as follows.		
Fathoms	**Merchant**	**Navy and Coast Guard**
15	One turn wire on first stud from each side of shackle	One white link on each side of the detachable link, detachable link red, one turn of wire around the stud on each white link
30	Two turns wire on second stud each side of shackle	Two white links on each side of the detachable link, detachable link white also, two turns of wire around the stud of the second link each side of the detachable link
45	Three turns wire on third stud each side of shackle	Three white links on each side of the detachable link, detachable link blue, three turns of wire around the stud of the third link each side of the detachable link
60	Four turns wire on fourth stud each side of shackle	Four white links on each side of the detachable link, detachable link red, four turns of wire around the stud of the fourth link each side of the detachable link
75	Five turns wire on fifth stud each side of shackle	Five white links on each side of the detachable link, detachable link also white, five turns of wire around the stud of the fifth link each side of the detachable link
90	Six turns wire on sixth stud each side of shackle	Six white links on each side of the detachable link, detachable link blue, six turns of wire around the stud of the sixth link each side of the detachable link, and so on
• The entire next-to-last shot shall be painted yellow • The entire last shot shall be painted red • A "weak" link shall be used to attach the end of the chain to the vessel		

Anchor Cable Parts

The following are parts of an anchor cable, beginning at the anchor.

Bending or anchor shackle: The bow or rounded end is away from the anchor. This is to prevent the shoulder of the shackle from catching on the hawsepipe when heaving in.

Extra heavy open link (without a stud): This is necessary because the anchor shackle is so heavy that the stud-link opening would not be large enough to go around the shackle.

Note: The combination of links and swivel between the anchor shackle and the first-joiner shackle is called the swivel.

- **Stud link**. Sometimes called an open link.
- **Swivel**. Bow toward the anchor, swivel eye inboard.
- **Stud link**. Also called an open link.
- **Joiner shackle**. Used to attach the first shot of chain.

The shots of chain in the merchant service are all 15 fathoms. In the Navy it has been the practice to have the first shot of 5 fathoms, then a long shot of 40 fathoms, and after that the regular 15 fathom shots. However, since the Navy has adopted the cast steel as standard, all shots are 15 fathoms except the anchor shot (or swivel shot), which is 5 fathoms.

Anchoring

There are certain basic steps to be taken in anchoring small boats under normal conditions.

APPROACHING THE ANCHORAGE. Do not anchor where it is so shallow that there is a possibility of being aground at low water. Conversely, you need not anchor in 50 feet of water if you can find 20 feet a little closer to shore.

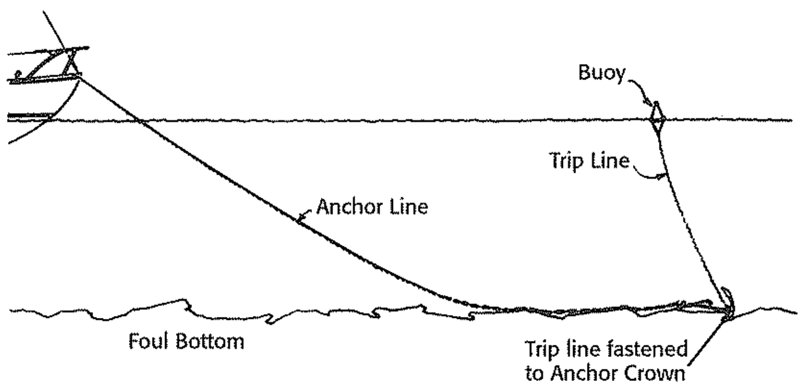
One prudent rule in strange waters is to check the depth of the water in the area of any possible swing of the boat with a lead line or suitable measuring device. Note the location of other boats or empty moorings so that you will not anchor so close to boats that you swing into others with shifts of tide or wind.

Hard sand is the first choice for the bottom. Soft mud is the last. A rocky bottom is generally between these two. However, you cannot know just what the bottom is until after the anchor is down.

DROPPING ANCHOR. Under either power or sail, come up to your chosen anchorage into the wind or tidal current (whichever is stronger). Under power, bring the boat to a dead stop and then reverse very slowly. At this point a crew member already stationed forward lowers the anchor gently, always maintaining control of the rode. ***Never throw an anchor.***

Reverse the boat slowly as the rode is paid out to keep the anchor from getting fouled. Keep reversing until it takes hold and ample scope has been paid out. If the anchor drags at this point, it is usually because it has been fouled or is resting on poor holding ground at the bottom.

Using a Trip Line



If it does drag, then you must raise the anchor and try it again. Once the anchor takes hold, check to be certain you are clear of the shore and other boats before shutting off the engine. Under sail, of course, you cannot reverse your boat to help you take hold. However, you can use the tide or wind as a natural reversing power.

At the moment you come to a standstill, drop the anchor quickly, but smoothly, and pay out ample scope. Then belay the rode to the bitt or a cleat and wait until you are certain the anchor is not dragging.

LEAVING THE BOAT. If you go ashore after properly anchoring, note carefully the boat's relative bearing to other boats, or better still, to nearby shore objects. By doing this, you can spot a change in your ship's position caused by the anchor dragging.

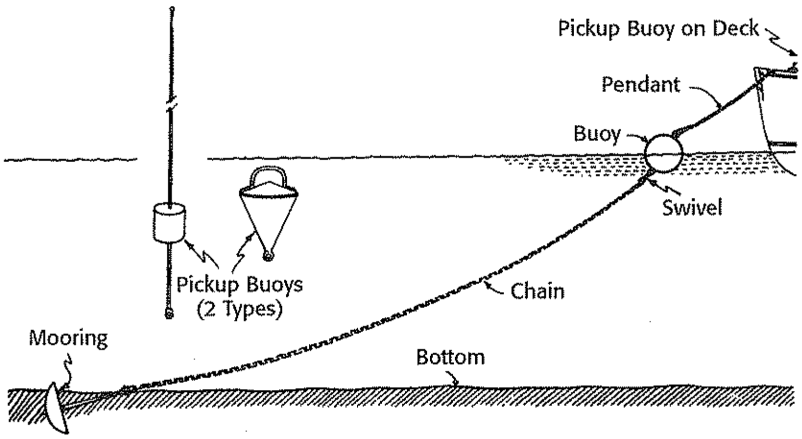
If a boat stays at anchor during a change of tide or wind shift, she may swing through a 180-degree arc. This movement can foul the rode of some types of anchors, twisting it around an arm or stock, causing the fluke to be easily pulled from the bottom. Under these conditions it is wise not to leave a boat unattended.

WEIGHING ANCHOR. When under power, move slowly toward the anchor while a crewman forward hauls in the slack of the rode. When the anchor breaks loose, come to a stop while you bring it in. This must be done carefully to avoid gouging the boat. If your boat is allowed much headway while bringing in the anchor, there is a good possibility of damaging it with the anchor.

When the anchor is brought aboard, it should be secured at once. The wet line should be allowed to dry before stowing.

If the anchor does not break loose easily, bring the boat carefully up to the approximate position of the anchor and belay the rode to the foredeck bitt. After this, apply just enough power to give steerageway and run the boat past the anchor. If it does not work the first time, try this maneuver again.

Mooring Tackle



Under sail you can usually sail right up to the anchor, while a crewman takes in slack slowly, and raises the anchor as described above. If the anchor is firmly embedded in the bottom, you may have to sail forward to put added strain on the rope in the opposite direction to the anchoring pull.

If you know beforehand that the bottom where you plan to anchor your boat is likely to be foul, use a trip line. This is merely a light but strong line secured to the crown of the anchor long enough to reach a pickup buoy that is left floating on the surface. When the time comes to weigh anchor, the buoy is retrieved and the trip line pulled to haul the anchor out crown first.

Sometimes it is necessary to carry the anchor away from the ship in a small boat. The ship is then pulled to it by means of capstans or winches. This is called kedging. Grounded vessels may sometimes pull themselves clear in this manner.

When a boat lies mostly at her home port, it is best to set a permanent mooring. This would make her more secure than being at anchor. A safe permanent mooring must be able to hold in any weather condition. It must be as antifouling as possible.

A ***mooring anchor*** should be of the mushroom type in muddy or sandy bottoms. There should be a bulb on the upper end of the shank to help keep the anchor down in a digging position.

A common rule of thumb for mushroom anchor weights is about 10 pounds for every foot of the boat's overall length. This may be lessened somewhat for small, lightweight racing sailboats, but should be increased for larger cruising craft, both power and sail.

In hard or rocky bottoms, other types of moorings with sufficient weight would be adequate. Discarded railroad wheels, concrete blocks, old engine blocks, etc., might make adequate permanent mooring anchors, but in really bad storms, the mushroom anchor is the most effective anchor.

The ***chain*** used in permanent moorings is standard link steel chain that is usually galvanized to resist corrosion. The diameter should be large enough for a holding power consistent with the strain that will be placed on it.

Some two-thirds of the total length of chain to be used should be of heavy chain ($^3/_4$ to 1 inch in diameter). The balance should be lighter. The chain and all fittings should be checked annually for any possible looseness or worn links.

The mooring buoy that the light chain connects to is often a steel sphere, although often wooden spars or Styrofoam buoys are used. If a metal buoy is used, it should have some form of a bumper to cushion any possible striking against the boat's hull.

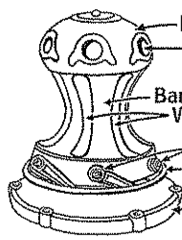
The pendant should be about the same strength as the chain and often is made of Manila or nylon. Nylon is good for several seasons; Manila should be replaced each year. Braided line does not have hackles as severe as laid line when used where twisting may occur.

As the pendant will run through the bow chock at angles depending upon the swinging of the boat, the edges of the chock should be smooth to minimize any abrasions. The pendant itself should be protected by tape, cloth, canvas, or a hose tied around it to protect it from chafing where it rubs along the chock.

The pickup buoy can be made of many things. Whatever the material, it should have a ring or handle on top to aid in picking it up.

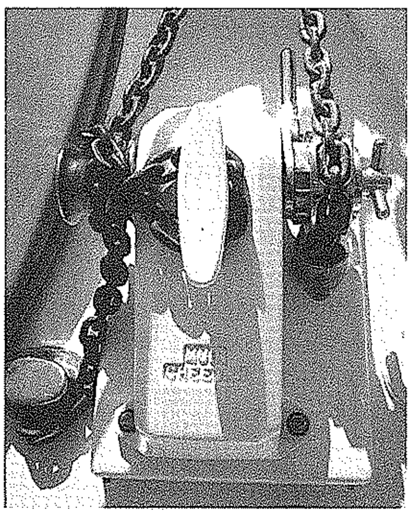
The Capstan

The capstan is a rotating device, operated by power or by hand, employed on board ship for the application of extreme power to ropes and wires in the hauling in of heavy objects. The main element of a capstan is its upright drum or barrel, which distinguishes it from a windlass.



Windlass

A windlass is a powerful winch on which a rope can be taken in or paid out.



In the old days the windlass consisted of a horizontal barrel of wood around which a cable was wound. This was mounted on a windlass frame and revolved, the barrel being fitted with pawls, and with a brake arm and driving gear working with rachets.

The modern windlass embodies these same principles. It is driven by a steam engine or a motor but can be worked by hand. Usually, there is a capstan on the forecastle head which works the windlass by means of a screw running in the driving gear.

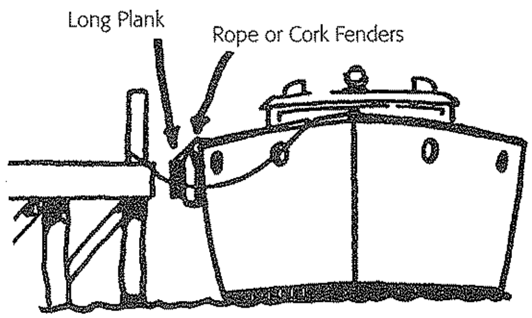
Mooring to a Pier

Closely akin to the art of anchoring is that of making fast to a wharf or pier. Sufficient and proper lines must be run out, fenders placed, and provisions made to protect the ship in case of change of tide or wind, or against the wash of passing vessels.

For a short stay, bow and stern lines are adequate, and someone should remain on board to fend off if necessary. The sketch shows the proper way to moor for a long stay. Note the diagonal lines. These are to gradually check slight movements of the vessel away from the wharf so that sudden strain will not snap the lines. They also prevent any motion ahead or astern.

Fenders are hung over the side but are never allowed to rub against the wharf or pier, which is usually tarred and in no time would streak up the topsides. A timber is hung outboard from the fenders as indicated.

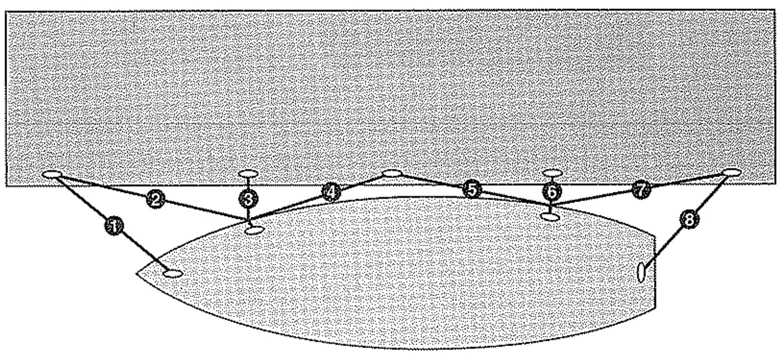
Using Fenders Properly



A good way to moor to a pier, especially when there is considerable current, is to set an anchor astern, leaving plenty of extra line coiled up on the after deck. Then pass a bowline to the pier. Now, by slacking off on the stern line and hauling in on the bowline, the vessel can be brought on the dock. Of course, this is only practical on a small boat, up to 40 feet.

Mooring to a Pier

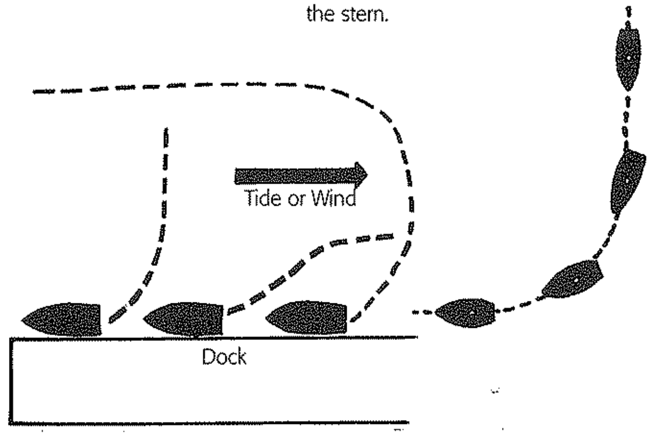
1. Bowline
2. Bowline
3. Breast Line
4. Spring Line
5. Spring Line
6. Breast Line
7. Stern Line
8. Stern Line



Sometimes the vessel can be layed between bow and stern anchors, off the wharf or pier, and a gangplank rigged for passage between ship and shore. A sailboat will sometimes lay to a dock with a single line and the mizzen set or the mainsail sheeted in flat. The wind, of course, must be offshore to do this.

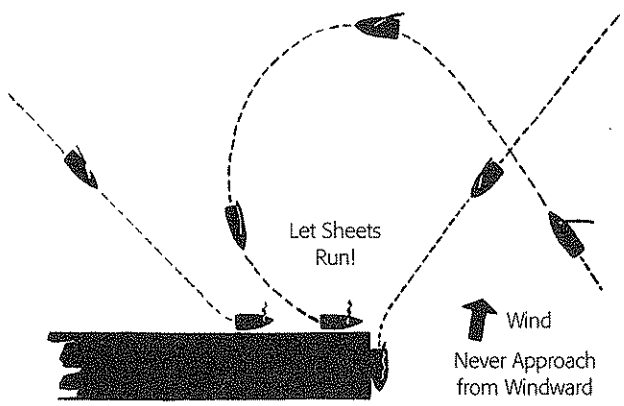
Mooring a Powerboat

In bringing a powerboat to a dock, take careful notice of wind and tide direction. Remember also that a powerboat steers by the stern. Her point of pivoting is near midships, on a center line. When the bow is directed to the right, the stern will swing to the left. This must be allowed for in any close maneuvering.



Mooring a Sailboat

Bringing a sailboat to a dock is a ticklish job. With wind in the right direction, of course, the boat is simply luffed, that is pointed directly into the wind so that the sails slat idly, and a line is passed to the pier. Under other conditions, however, much practice and a thorough understanding of the art of sailing and the boat itself is necessary.



Heaving a Line

Proper heaving of a docking line separates the experienced boatman from the novice. The novice often coils the line wrong, and the end usually falls short of its mark.

A few preparations and practice will give you the ability to handle a line properly. There are four things to remember.

1. The line must be considerably longer than the distance it is to be thrown or it will probably fall short of the target.
2. The line must be coiled carefully and evenly with the draw of the loops toward the free end; the loops should be smaller than those made for other purposes.
3. Hold the shipboard end of the line in one hand and the coil to be thrown in the other.

4. The coil must be thrown properly—in an underhand motion with a strong, swinging motion. Release it when the arm is well above the shoulders and at not too great a distance. Always aim at the head and shoulders of the person receiving it. Otherwise, the throw is apt to be low. If necessary, a weight can be used to help carry the line a greater distance, but in small-boat handling this is seldom necessary.

Orders to the Crew

On larger vessels there are specific orders used in connection with the handling of lines at a dock.

When docking, the order STAND BY TO DOCK puts the crew at readiness, each standing by his or her station with his or her line coiled, ready to heave. If no one is available at the dock to receive lines, other crew members stand ready to step ashore to receive the lines.

At the command HEAVE THE BOW LINE (or whatever line is to be used), the deckhand assigned to this line heaves it to the dock.

TAKE IN SLACK means that deckhands are to pull in the slack and take a turn on the cleat or bitt.

TAKE A STRAIN means that deckhands are to pull on the line named, taking a turn on the cleat or bitt but allowing it to slip.

EASE OFF means that the line is to be allowed to slip off more freely.

HOLD means to check the line temporarily.

SECURE LINES means to make fast permanently, adjusting to proper length.

On leaving a dock the order STAND BY THE LINES tells the people on the wharf or pier to be ready to cast off the lines and the people on the deck to be ready to take them in. This is followed by the order CAST OFF THE LINES at which time the dockmen clear the lines from the bollards and toss them to the deckmen, keeping them clear of the water if possible.

On a small boat, the procedures explained above are greatly simplified. Docking may involve one person stepping ashore for the bow and stern lines with simple instructions from the Skipper.

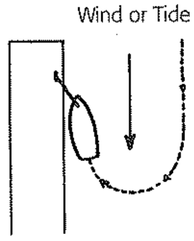
One mistake made by inexperienced crewmen is that in their eagerness to be helpful they snub lines at once. The lines should merely be tended and left slack until the boat is in the proper position. Then they should be secured.

Warning: Never allow docking lines, or any other lines, to go over the side where they can be sucked down into the propeller and wrapped around the shaft.

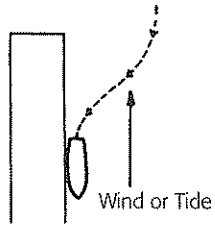
Maneuvering at a Dock

The possibilities of maneuvering a boat around docks and moorings are almost infinite in number. The boat's characteristics, the wind and tide, and types of rudders and propellers are all considerations. You should think out the maneuver in advance, step by step, to keep the boat under control at all times. Here are a few situations that may confront you.

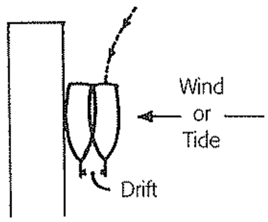
APPROACHING THE WIND: Turn to face the wind or tide, get a bowline out first, let the stern drift alongside.



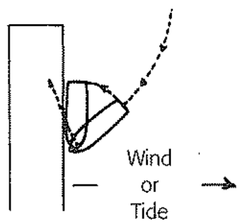
APPROACHING AGAINST THE WIND: Maneuver alongside the dock, get a bowline out first, let the stern drift alongside.



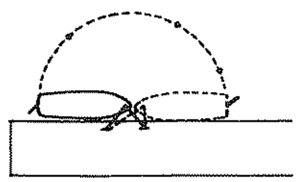
APPROACHING THE WINDWARD SIDE: Stop alongside and parallel, drift into the dock. The bow will probably touch first.



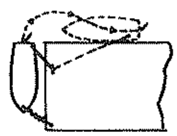
APPROACHING THE LEEWARD SIDE: Touch with the bow, put a bow spring line out. Go forward under power with the rudder away from the dock to swing the stern in.



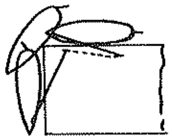
TO REVERSE HEADING WHILE AT DOCK: Put out double bowlines, swing the rudder toward the dock, go forward under engine power. When halfway around, stop the engine, reverse; then, as the bow strains against the opposite line, proceed as before.



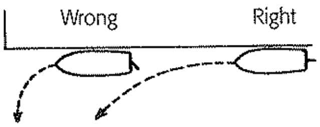
TO WARP FROM A PIERHEAD TO ALONGSIDE: Put out the stern spring line, rudder toward dock and reverse on the engine, tending the bowline. As the boat swings alongside, slack and tend the spring line.



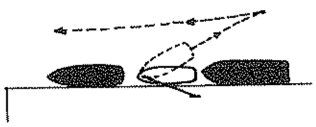
TO WARP FROM ALONGSIDE TO A PIERHEAD: Put out a bow spring line. Go forward with the rudder amidships, until pivot point is beyond the pierhead. Then put the rudder toward the dock and, as the boat comes around, put the rudder away from the dock.



RIGHT AND WRONG MANNER TO LEAVE A DOCK: Go forward with the rudder amidships and, as speed is picked up, move away from the dock slightly, increasing the angle as the boat slowly clears the dock. To set the rudder sharply away from the dock, as the boat leaves, will swing the stern into the wharf with force that may damage the boat.



CLEARING A DOCK WHEN BETWEEN TWO BOATS: Put out a bow spring line and, with the rudder toward the wharf or pier, go forward on the engine. When clear, cast off and reverse; then go forward.



WHARFS, PIERS, DOCKS, AND SLIPS: Even experienced seamen sometimes don't know the difference between a wharf, pier, dock, and slip. A wharf is a structure parallel to the shore (and usually attached to it) to which boats and ships are tied. A pier is a structure perpendicular to the shore. Vessels can be tied along either side. A dock is the space alongside a wharf or pier that the boat occupies. You cannot tie a boat to a dock since the dock is the space the boat occupies. A slip is the docking space between two piers. A marina usually contains many slips in a row. In common usage the slip can include both the docking space, piers, and other structures.

Boat Maintenance and Engines

In general, boats are fragile. Whether a canoe or an ocean liner, they have been designed to travel under skillful direction in an element that could be overwhelming. The best design and the sturdiest construction won't amount to much if the craft has been allowed to deteriorate through neglect or ignorance.

The real seaman is always alert for signs of trouble—a strained hull, evidence of dry rot, corrosion, worn gear, frayed lines, sluggish performance of hull or engine, worn stitching on the seams of a sail. Flaking finish or crazed varnish can mean impending trouble. The knowledgeable boatman keeps his vessel shipshape.

First and foremost, the safety of the ship and her passengers can be seriously jeopardized by neglecting the hull, fittings, sail, rigging, power plant, or gear. The continuing value of the boat depends almost entirely on its care and upkeep. The true seafarer takes pride in the sparkling appearance of his or her ship.

There are boats today that are 30 to 50 years old that retain their full seaworthiness and original appearance because they have been kept up. There are boats only a few years old that literally are worthless hulks through simple neglect. Sun, rain, salt water, acids, and fumes are considered the great enemies of finish, appearance, and integrity. But the real enemy is neglect.

WORK SCHEDULE—2
Outfitting Checklist

ITEM	TO BE DONE BY	DATE TO BE DONE	MATERIAL	COST
Remove cover—store	Skipper—mate	Apr. 1	—	—
Inspect boat	Crew leaders	—		
Develop checklist	Committeeman	—		
Scrub and clean				
Inside	Crew #1	Apr. 8	—	—
Outside	Crew #2			
Clean and check seams, fittings, etc., for leaks—recaulk	Crew #1 on deck Crew #2 on hill	Apr. 8	Compound	$3.50
Remove and replace plank—portside	Crew #3 mate	Apr. 15	Plank	$16.00
Install sisterframe starboard amidships	Skipper, consultant	Apr. 15	Frame Fastenings	$14.25 $16.18
Cut away and install new section of coaming	Crew #4 committeeman	Apr. 15	Parts and labor	$28.95

Fitting Out and Laying Up

Normally the overall condition of the boat is analyzed and necessary corrective action is taken two times per year, in the spring and the fall. Spring is the traditional fitting-out time. Winter covers come off, the hull is carefully inspected inside and out, the power plant or sails and rigging are checked, all equipment is looked over, and repairs are made. Small boats are included in the work schedule.

The development of a checklist is the first step. From it can be determined the jobs to be done and their priority, the materials and tools required, and the costs and time that the fitting out will take. Another question that must be answered is who is to do the work: the crew, volunteers, a shipyard, or special technicians.

If it is a small sailboat or powerboat up to 20 feet, usually the work can be done quickly and simply by the Sea Scouts at little cost. If it is a larger boat, fitting out can be time-consuming, difficult, and if professional services are needed, very expensive.

The sample checklist can be tailored to meet your needs—but have a checklist, set up a time schedule, and assign people to the work to be done. The plan should involve all hands, including the Skipper, mates, committee members, consultants, and specialists.

Remember, you can save repair and maintenance costs by careful selection of the boat in the first place. Then by employing good workmanship with quality materials, you can avoid many problems.

Lay Up

This is a procedure to be followed when a boat is to be stored for the winter. In preparation, much equipment should be removed. Cushions, blankets, mattresses (and other fabrics), charts, books, navigation gear, fire extinguishers, anchor lines, running rigging, food and liquids, etc., should be placed ashore for storage in a safe, dry place.

The hauling-out process is important. If the boat is a small one that can be hauled and stored on a trailer, the problem is relatively simple. If the boat needs to be hauled on a railway and is to be stored in a cradle or shored up with blocks and poppets, attention must be given to hull support at four points at least to prevent the boat from hogging or sagging.

The boat should be thoroughly cleaned. The bottom in particular should be washed and scrubbed clean of all marine growth and slime. The bilges should be cleaned and thoroughly drained. Rock salt may be sprinkled into the bilges to absorb moisture.

The engine should be cleaned, the oil drained, the exterior sprayed with light oil to prevent corrosion, the spark plugs should be removed and oil injected into the cylinder heads. Spars should be removed and stored.

The great enemies of a boat in storage are rot, mildew, and corrosion. Ventilation must be adequate. Remove all floorboards and open all hatches, skylights, drawers, and locker doors.

Unless stored inside, make a frame and cover the boat with canvas, allowing for ample ventilation. The battery or batteries should be removed and stored, preferably on a low (trickle) charge. Here again, a checklist and work schedule should be developed and the costs estimated.

Tools

Every boat, large or small, should have a supply of common hand tools. The tool locker should contain the following tools and equipment: wrenches (end, socket, stillson, crescent, and allen), pliers, screwdrivers, hammer, ignition tools, oil sump pump, oil in a squirt can, grease, packing, spare parts, etc.

For woodworking, you'll need saws, hammers (ball peen and claw), screwdrivers (regular and Phillips), chisels, planes, nail sets, rivet blocks, scrapers, clamps, files, drills, bit brace and bits, putty knife, spirit level, and rule.

On-deck tools should include wire cutters (of a size to cut any diameter wire aboard), hacksaw, routing iron, fid, needles, palm, wax, twine, wire brush, electrician's tape, Mystik tape, sail repair tape, knife, hand ax, tin snips, sandpaper, putty, caulking compound, sealer, etc. A good extension light should be included.

Paint and Varnish

The protection of marine surfaces covers a wide and specialized field. Surface protection must be related to the material to be covered—wood or plywood, metal, fiberglass, plastic, etc., and whether it is an exterior or interior and above or below the water's surface.

Also, it is important whether your boat operates in salt or fresh water. In any case, obtain products designed for marine use. Marine paints fall into many categories, each designed to inhibit staining, marine growth, surface erosion and corrosion, dry rot, abrasion, and the effects of oil and gasoline. They provide for stress as well as high temperatures and other weather conditions. And, finally, they reduce friction to a minimum.

Paints may be oil base, lead base, or any of the modern resin and synthetic bases. They may be hard finish (enamel) or self-flaking (flat). They may be glossy, as in a racing bottom finish, or defoliating, as in a copper or other toxic metal compound designed to kill or prevent underwater marine growth.

Paint and Varnish Types

Common to all types of paint are three ingredients: pigment, solvents, and film formers. Varnishes and shellac contain no pigments.

- **Alkyds**. This is the most common and most versatile paint.
- **Vinyls**. An antifouling finish for underwater surfaces.
- **Epoxies**. A synthetic for use on plastic and fiberglass.
- **Polyurethanes**. A hard finish that is abrasion- and friction-resistant.
- **Acrylics**. Hull and metal protection.
- **Phenolics**. Clear finishes such as varnish.
- **Lacquer Hard Finish**. A varnish or enamel base used clear to waterproof surfaces such as wiring.
- **Shellac**. Used as a varnish base or a sealant, frequently used to coat engine or pump gaskets.

The secret of lasting protection is the care taken in preparing the surface before applying the finish.

For a new surface, sand the area smooth and clean it carefully to remove any residue. On wood or plywood, use a sealer to set the grain. Then apply a surfacing compound to fill any dents or scratches, and a primer or undercoat to provide a smooth surface and a tight bond for the final finish. Use a primer on metal surfaces, also.

On previously finished surfaces, remove the old finish by scraping, burning, chemical removers, or sanding to the point where the remaining surface offers a sound bond. If the surface is exposed, touch it up as you would a new surface. A rule of thumb is to take off as much of the old finish as you plan to put on (to prevent a heavy buildup of finish).

On wood surfaces that are to be varnished to show the grain and beauty of the wood, sand smooth, remove any discoloration with a bleach, apply stain if desired, and apply at least five coats of good marine varnish. On previously varnished surfaces, sand carefully and apply at least two coats. The secret of a good varnish job is to sand lightly between coats.

Paint should always be thoroughly agitated and mixed before applying. Never mix or agitate varnish. It will form air bubbles that are almost impossible to work out.

Painting and varnishing should be done on clear days with a temperature range between 60° and 85°F. Never apply finish to damp or rotted surfaces.

Paints and varnishes should be kept in tightly sealed containers in well-ventilated lockers, but not aboard your vessel. Brushes should be cleaned carefully in a solvent or thinner and soap and warm water. Wrap in cloth or foil and hang up by the handles or lay flat (never on end on the bristles) between periods of use.

Engines

The vast majority of boaters today operate craft that are powered by marine internal combustion engines, either outboard or inboard.

The information here is aimed at giving Sea Scouts and officers a general understanding of engines. It is hoped that this in turn will lead them to more comprehensive publications. The information here, though brief, is broad enough in scope to satisfy the needs of a Sea Scout seeking to qualify for the Quartermaster elective on engines.

Since outboard engines account for about 70 percent of total engine production, let's consider them first.

Outboard

This is a basic, internal combustion engine consisting of an aluminum alloy block containing a crankshaft with a flywheel on top which is rotated by a rope or an electric starter. The crankshaft is rotated by pistons that move up and down within cylinders. They are driven by the expanding force of a mixture of fuel (gasoline) and air, ignited by an electric spark from spark plugs that protrude into the cylinders through the cylinder head. These spark plugs get current from a magneto. As the crankshaft is forced to rotate by the driving action of pistons, this rotation is transmitted through a drive shaft, vertically mounted, through bevel gears to a short, horizontal propeller shaft on which the propeller is mounted.

The basic engine is a two-cycle engine normally using gasoline mixed with oil. The oil lubricates the internal working parts and surfaces. The oil and gas enter a carburetor where air is mixed with the fuel. This mixture enters the crankcase through an intake valve and on into a combustion chamber. The fuel ignites at the maximum compression caused by the rising piston and the explosion forces the piston down.

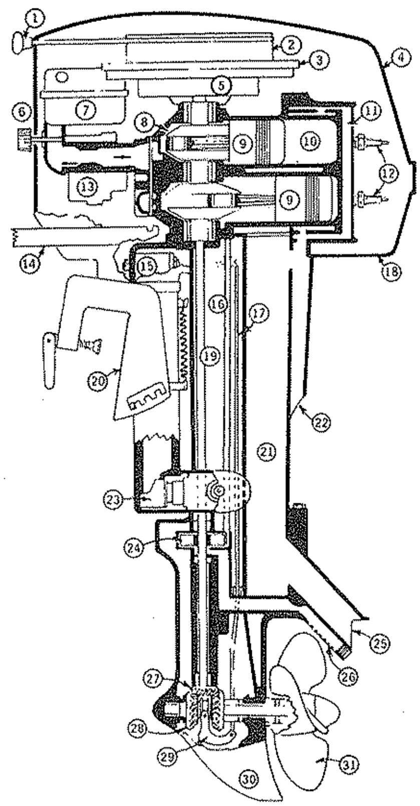
Each piston goes through a cycle of two strokes. The down or power stroke rotates the drive shaft and exposes the exhaust and intake ports in the wall of the cylinder. Exhaust gases escape on one side and fresh fuel enters on the other. The upstroke covers these ports and compresses the fuel for ignition. Exhaust valves are not required.

The source of the igniting spark is the magneto mounted within the flywheel, which requires no outside power. (Normally, batteries are used for starting, lights, etc., not for ignition.)

The motor is cooled by water picked up by a forward facing scoop just behind the propeller. It is forced through passages around the motor by a pump and is expelled through an underwater outlet—as are the exhaust fumes.

The outboard motor is entirely self-contained, is secured by clamps, and should be protected by a safety chain to the stern of the boat or attached as an auxiliary by means of a bracket. Outboard motors may have two, four,

Outboard—Basic Engine, Two Cycle



1. Manual starter handle
2. Manual starter pulley
3. Flywheel
4. Upper Cover
5. Magneto assembly
6. Low-speed control
7. Carburetor silencer
8. Crankcase
9. Piston
10. Cylinder
11. Head jacket
12. Spark plugs
13. Carburetor
14. Steering handle and throttle control
15. Upper motor control
16. Water intake pipe to engine
17. Shift rod
18. Lower cover
19. Driveshaft
20. Stern mounting bracket
21. Exhaust gallery
22. Water outlet
23. Lower motor mount
24. Water pump
25. Exhaust outlet
26. Water intake
27. Driveshaft pinion gear
28. Propeller-shaft gears
29. Shift lever
30. Skeg
31. Propeller

or six cylinders. Their power output ranges from 3 hp to 100 hp and although intended to be portable, these removable engines range in weight from 17 to 300 lbs.

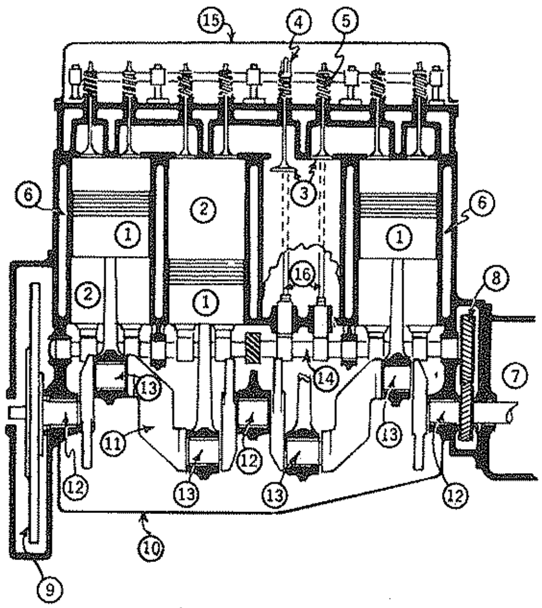
Small outboard engines (up to 18 hp) usually are hand-started and hand-controlled. Some have an integral fuel tank. Outboard motors generally have electric starters, equipped for remote starting, control, and steering, and have separate fuel tanks, etc.

Inboard

The inboard engine (so called because it is located entirely inside the hull, mounted on stringers or a bed) is an internal combustion engine which develops its power by pistons driving a crankshaft. It includes a cast-iron block containing pistons, crankshaft, and other moving parts.

Marine engines are ruggedly built for heavy duty. Automobile engines though identical in principle make satisfactory marine conversions only through extensive structural changes to exhaust and cooling systems and the addition of a marine clutch and reverse gear.

Attached to the block are various accessories for starting, ignition, cooling, lubricating, exhaust gas removal, fuel injection, etc. Fuel may be either gasoline (most common) or diesel fuel—a less expensive fuel less likely to explode.

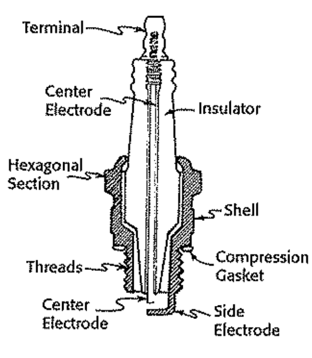


Four-Cycle Inboard Engine
(Gasoline, 4 Cylinders)

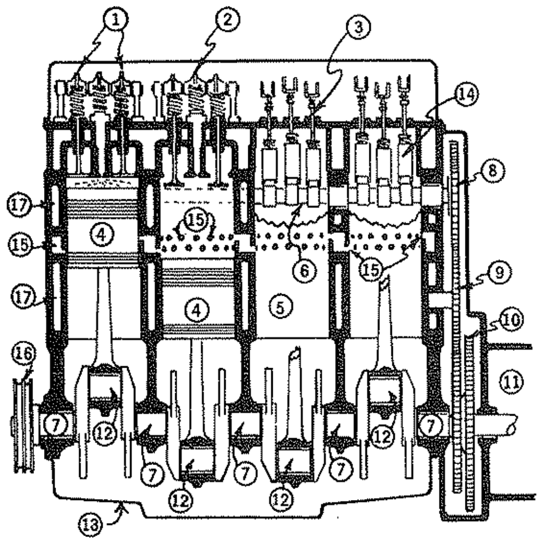
1. Piston
2. Cylinder
3. Valve
4. Rocker arm
5. Valve spring
6. Water jacket
7. Reverse gear
8. Timing gear
9. Flywheel
10. Crankcase
11. Crankshaft
12. Main bearings
13. Rod bearings
14. Camshaft
15. Valve cover
16. Valve push rods

Normally, marine engines have two, three, four, six, or eight cylinders usually mounted in line or, as in the V-6 and V-8 engines, in two parallel banks. The combustion principle is the same as discussed in outboard engines, except for diesel engines. Here the fuel is ignited by the heat of air compression caused by the upstroke of the piston, thus eliminating the need for spark plugs or an ignition system.

Spark Plug Components



Most inboard engines are of the four-stroke-cycle type, commonly called four-cycle, requiring two valves for each cylinder—intake and exhaust—to admit fuel and dispose of burned gases. These valves are acti-



Four-Cycle Diesel Marine Engine

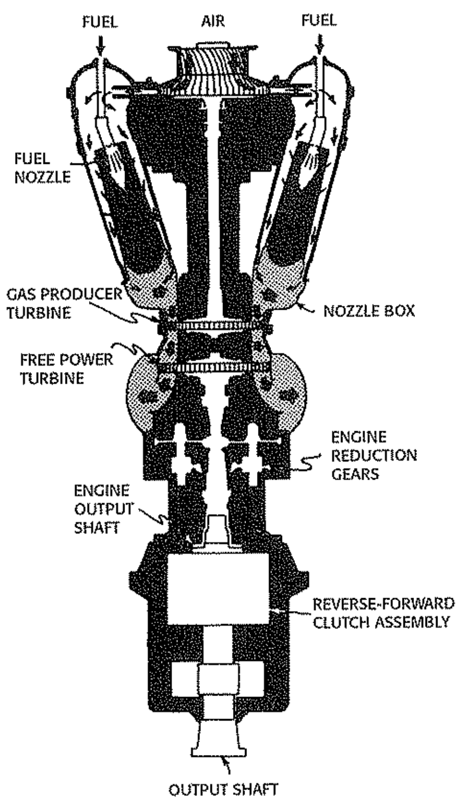
1. Rocker arms; valves, exhaust
2. Rocker arms; injectors
3. Push rods
4. Piston
5. Cylinder
6. Camshaft
7. Main bearings
8. Timing gear, camshaft
9. Timing gear, idler
10. Flywheel
11. Gearbox
12. Rod bearings
13. Crankcase
14. Cam followers
15. Air intake ports
16. Accessory pulley wheel
17. Water jacket

vated by a camshaft which is geared to the crankshaft.

In the complete cycle, four strokes of the piston are involved. The crankshaft makes one revolution on each two strokes. Two crankshaft revolutions equal one cycle of four piston strokes: intake, compression, power, and exhaust.

Power is related from the crankshaft to the drive shaft through the transmission in order to enable neutral, forward, or reverse drive. In addition, some engines are equipped with a reduction gear to reduce crankshaft speed to a lower speed on the drive shaft to enable both the engine and the propeller to operate at their most efficient rates.

GAS TURBINE ENGINE



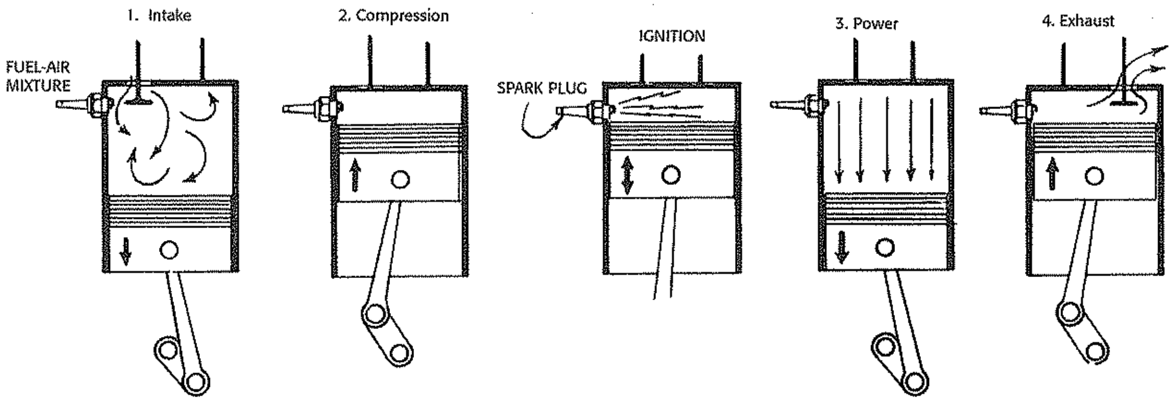
The inboard-outboard motor combines an inboard engine connected through the transom with an outboard stern-drive unit. This gives the ease of maneuvering of an outboard engine and the greater horsepower of an inboard engine more conveniently located aboard the boat.

Other Types of Propulsion

Although the internal combustion engine is by far the most widely used today, there are other types.

There are variations of the internal combustion type such as the multifuel engine, using a hydrocarbon fuel developed by the U.S. Army. This operates like a two-cycle diesel engine, requiring no valves and equipped with air cooling.

FOUR-STROKE CYCLE, GASOLINE ENGINE



The N.S.U. Wankel rotary engine replaces cylinders and pistons with an eccentric mounted rotor. A single spark plug ignites compressed fuel in a specially-shaped chamber containing the rotor, keeping it turning. The gas turbine engine consists of a gas producer where gasoline and air are vaporized under enormous pressure and a turbine converts the burning expanding gas into rotating shaft power.

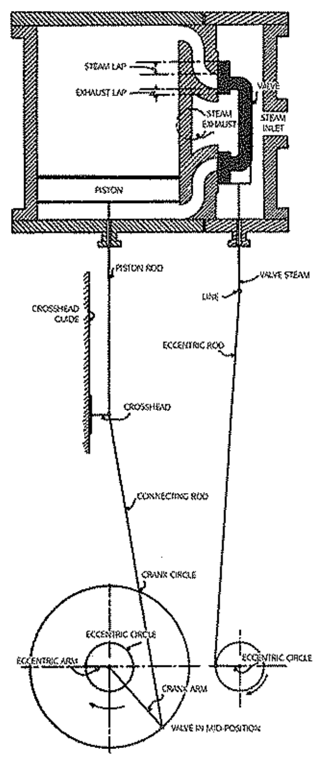
Steam Expansion Engines

The source of steam power is the coal or oil-fired furnace, which heats water in a boiler to produce steam under pressure. This high-pressure steam is conducted through pipes to the cylinders of a reciprocating piston engine where steam expansion provides the driving force that activates the pistons. A sliding valve admits steam alternately to the top and bottom surfaces of the piston, providing up and down strokes in sequence. Piston action rotates the engine's crankshaft.

In a double-expansion engine, the cylinders are mounted in pairs. A small-diameter pair operates first and then feeds steam into the larger one under less pressure. The steam provides driving force by continuing expansion before being drawn off into a condenser that converts it back to water. The water is returned to the boiler through a preheating system.

Triple- and quadruple-expansion engines are an extension of connected cylinders with each of the companion cylinders increasing in size according to a precise ratio.

DIAGRAM OF A RECIPROCATING STEAM ENGINE



Turboelectric Drive

This propulsion system is based on a steam-driven turbine wherein steam under pressure is the force that strikes the turbine blades, causing them to rotate. The blades are small at the front of the turbine and become larger toward the rear to utilize decreasing steam pressure as it moves through the turbine. This rotation is connected by a shaft to an AC or DC generator or alternator, which in turn provides power for the main, electric-propulsion engine.

Diesel-Electric Drive

The basic power unit is a diesel-fueled engine that provides the driving action for an electric generator or alternator, which in turn provides electric power for an AC or DC electric-propulsion motor that provides the propeller shaft driving power directly or through a system of gears.

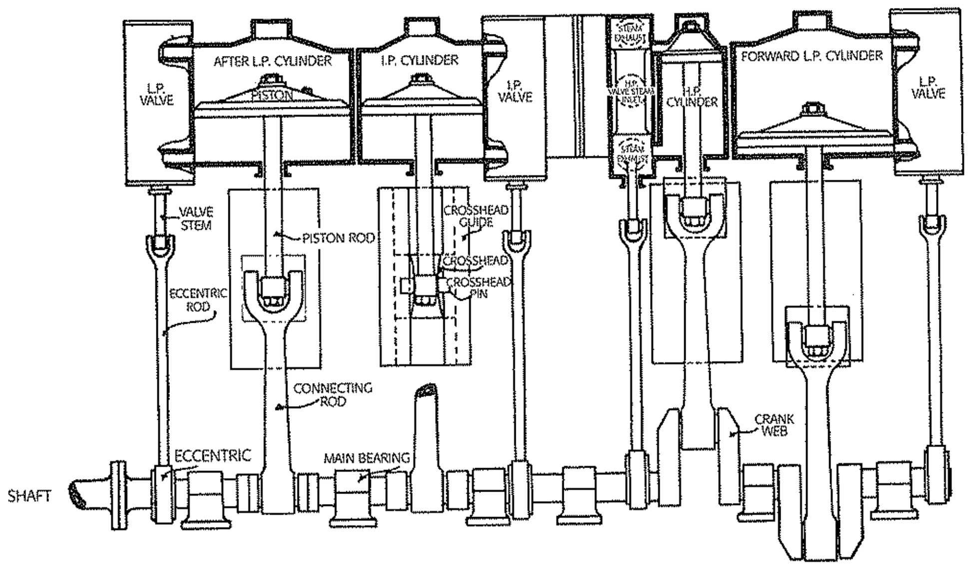
To reverse a turboelectric or diesel-electric drive, if the electric motor is operated on DC, polarity is reversed. If the motor is operating on AC, two of its three phases are reversed.

Direct Reversing Diesel

In this installation, a standard, heavy-duty, diesel-fueled, internal combustion engine is the basic power unit. In the reversing process, the engine is completely stopped, a camshaft device is activated which, when the engine is restarted, causes the crankshaft to operate in reverse. In other words, the engine itself reverses its rotation, as, of course, does the drive shaft and propeller.

To achieve a neutral position, a clutch action separates the drive shaft, permitting the engine to continue to operate. This is a fairly standard installation on harbor tugs, river towboats, commercial, and military auxiliary vessels.

FOUR-CYLINDER, TRIPLE-EXPANSION STEAM ENGINE



Nuclear Power

To date, the application of relatively small, nuclear-power reactors for ship propulsion has been developed chiefly for submarines, aircraft carriers, and other naval vessels. Only one commercial ship, the freight-passenger vessel *Savannah*, was equipped with nuclear power. Its keel was laid in 1958 and the vessel was retired in 1970. The *Savannah* was used mostly as a goodwill promotional vessel, demonstrating a peaceful use of nuclear power. The ship actually transported cargo between 1965 and 1970.

The former Soviet Union (and now the Russian Federation) has built eight nuclear-powered icebreakers, all still in service. They are the *Tamyr* (1989), *Vaygach* (1990), *Arktika* (1974), *Sibir* (1977), *Rossiya* (1986) *Sovetskiy Soyuz* (1990), *Yamal* (1992), and *Ural* (1996).

Without going into the complex fission process, whereby the splitting of atoms releases fantastic amounts of energy (heat), we will simply consider its application. The power reactor consists of a heavily shielded container (cement-lead insulated to protect personnel from radiation) containing "heavy water" as a moderator. It utilizes enriched uranium or plutonium. The reactor also contains the fuel, which is an enriched solution of uranium salt.

The moderator and fuel are intimately mixed. Heat generated by the resulting fission process goes into a water-filled heat exchanger where it is converted to steam. The steam thus produced is piped into a steam turbine which rotates the drive shaft. The steam residue goes into a condenser and returns as water to the heat exchanger. In this case, uranium is substituted for conventional fuel as the energy source.

From 2.2 pounds of uranium comes a power output equal to 5 million pounds of coal (2,500 tons). Unquestionably, this type of power source for ship propulsion will increase in the years ahead.

Engine Operation

The proper function, dependability, and long life of any power plant depends to a large degree on the care and maintenance it gets. Safety is the first consideration.

Proper safety practices include having the tanks vented overboard; being sure there are no fuel fumes in the bilge; equipping the engine with a drip pan and the carburetors with a flame arrestor; sparkproofing the electric switches; and checking for tight fuel tanks and lines and adequate engine compartment ventilation, as well as tight electrical connections, etc.

Your prestarting check should include careful attention to the following.

- No fumes in engine compartment
- Oil level in crankcase at proper level (add proper grade oil, if necessary)
- Water level in battery (plates should be covered)
- Grease cups on water pump, transmission, etc., filled and tightened down
- Distributor wiring and spark plugs free of dirt, corrosion, and moisture
- All wiring with good connections
- Water intake open
- Fuel valves open
- Lines tight and clean
- Reverse gear operates freely
- No stung box leak
- Ventilation exhaust blower running a full five minutes before starting

While in operation, the engine should be periodically checked to be sure the oil pressure and engine temperature are normal, the electric-charging rate is proper, the fuel supply is adequate, and the engine is running smoothly.

Before securing the engine, slow down its operating speed to allow it to cool. Turn off the fuel valves and run all fuel out of the lines. Shut off the ignition. Recheck the engine compartment for fuel or water leaks. Consult manufacturers' specifications for engines that may not require that fuel lines be drained.

All engines come with an operation manual provided by the manufacturer. If you don't have one, contact the manufacturer for another copy. It includes all specifications, operating instructions, and maintenance and repair data for the engine and its accessories.

Familiarize yourself with this manual and develop a checklist for prestarting, operating, winter care, lay up, and outfitting.

Always keep an engine log that records the hours of operation, oil changes, repairs and adjustments made, most efficient rpms, the best operating temperature and charging rate, etc.

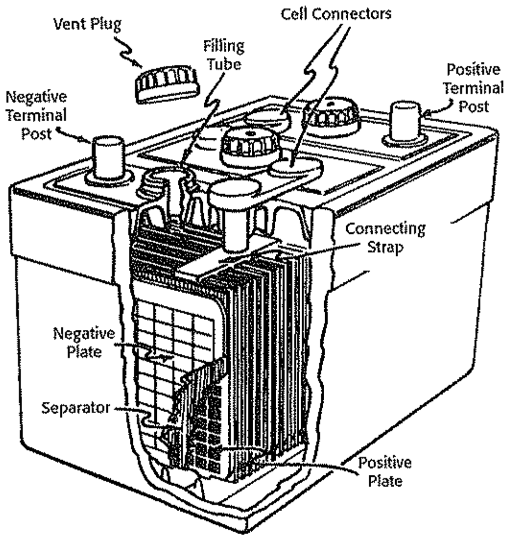
Obviously, it makes good sense to carry a kit of tools as recommended by the manufacturer. Similarly, an adequate supply of spare parts should be aboard.

Electrical Systems

For the most part, electrical systems on small boats are entirely self-contained. Even on the smallest powerboats and auxiliaries, electricity is needed for engine operation, running lights, etc.

The source of electrical power is usually the wet cell or lead-acid battery, which is made up of a series of cells in a plastic or hard-rubber container, electrically connected in series. Each cell is made up of a number of positive (lead sulfate) and negative (spongy lead) plates separated by glass, wood, or rubber inserts.

Battery Components Are Shown in Standard 3-Cell, 6-Volt Type



Three such cells make up a 6 V battery and six cells make up a 12 V battery. They are submerged in a sulfuric acid solution. The resulting chemical reaction produces electrical energy released through positive and negative terminals to which the engine and other circuits are attached by wires.

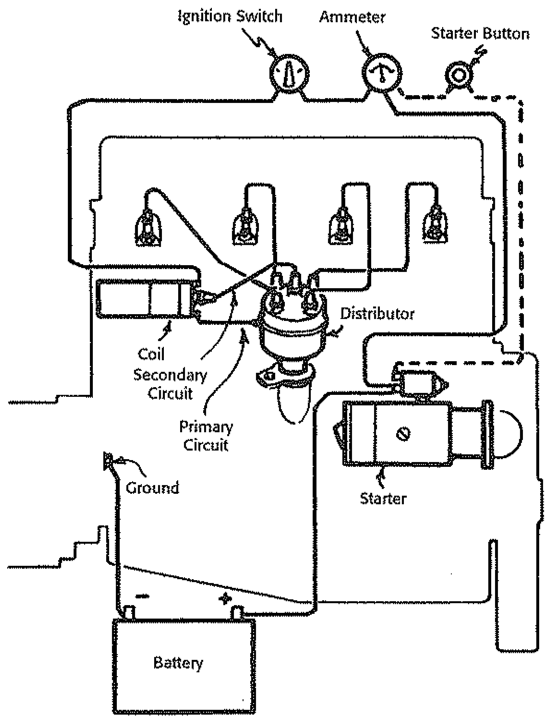
Battery care calls for careful maintenance of the electrolyte (liquid level) in the battery by the addition of distilled water as necessary. The battery's ability to deliver electrical energy should be checked periodically with a hydrometer, which measures the specific gravity of the electrolyte.

The battery and, particularly, its terminals should be kept clean and free from corrosion with a solution of sodium bicarbonate and coated with Vaseline. Maintaining a battery at or near full charge (normally a reading between 1.220 and 1.280 on the hydrometer) will protect it from freezing, and prolong its life. Batteries in boats should be firmly secured and provided with a ventilated plastic cover.

On many boats, a dual battery system is used, with one battery used for cabin lights, radios, etc., and the other reserved for engine starting, ignition, and equipment that is used only when the engine is in operation such as running lights, etc.

If you arrive at your vessel and find that the battery(ies) is dead, first take the battery out of your car and replace one of the dead batteries with it. Then move

Inboard Ignition System



the battery selector switch to either "Both" or "All." Run the engine blower before trying to start the engine. After turning off the blower, try to start the engine. If nothing else is wrong, the engine will start and will charge both batteries. While sailing, don't turn the engine off, but instead, take it out of gear and keep it throttled down. This will continue to charge the battery. You will not be able to start the engine and run the blower at the same time since the car battery is different from a marine battery.

To understand the wiring of your boat and galvanic action, you will need an expert.

Outboard Motors

Outboard motors for boats have been around for a good many years, but they are still temperamental and must be handled with tender loving care. Most of them are of two-cycle stroke but a few are four-cycle. It is the two-cycle that requires the most care and is the more popular. Such engines in the lower horsepower ranges may be either air or water cooled. They are very expensive and easily damaged. Owners of such engines are reluctant to loan them out for fear of damage. Never violate any of the following rules.

1. Never run an outboard engine in salt water without flushing it in fresh water immediately after.
2. Never connect a starting battery, if required, to the wrong polarity of the electrical system. One spark and you have a very expensive repair bill.
3. Never start an outboard unless the safety chain is secured to the transom.
4. Make sure your tanks are full of the proper oil-gas mixture (from table 9) before casting off.

5. As soon as the engine is started, ascertain that enough cooling water is being discharged for water-cooled engines. If no discharge is seen, shut the engine down immediately. Investigate.
6. Never leave an engine with gas in the carburetor for more than 24 hours. If you do not need it sooner, disconnect the fuel line at the motor while it is running and let it run dry. You may want to consult the manufacturer's specifications.
7. Periodically, check the lower transmission oil level and replenish it.
8. Use oil as specified for two-cycle engines; others create excess carbon.
9. Store engines in a vertical position to keep water pumps drained.
10. Take a spare starter rope, spark plug, propeller shear pin, and cotter key, and the minimum tools for such repairs on board at all times.

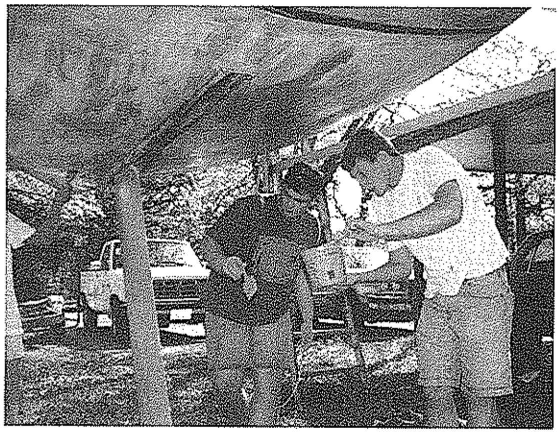
Accidents can happen to outboard motors. If you are cruising along and come to a sudden stop by hitting a submerged object or sandbar your outboard engine may be "pooped," or swamped by your own backwash. In such cases you may be able to start it again. Remove the hood and use a dry towel to wipe clean all electrical systems. You may have to remove the plugs and also dry them, depending on how long the engine ran submerged. Since the carburetor is under pressure very little water should be in it. A few squeezes on the fuel priming bulb will take care of that. On the other hand, if your engine falls overboard, for whatever reason, and can be salvaged within a few hours, it can be disassembled and restored with no great trouble by a reliable marine motor shop. Even saltwater-immersed engines may have such damage alleviated by emptying the cylinders of water and refilling them with a light oil, until you can get the engine back to a shop.

A little practice in changing shear pins from inside a boat will reward you later if you operate very much in obstructed waterways.

Table 9: Oil–Gas Mixtures

50-to-1 Mixture	
Gasoline	Oil
U.S. Measure	
1 gallon	1/6 pint or 3 oz.
3 gallons	1/2 pint or 9 oz.
5 gallons	13/16 pint or 15 oz.
6 gallons	1 pint or 16 oz.
Metric Measure	
1 liter	0.02 liter or 20 cc
5 liters	0.10 liter or 100 cc
10 liters	0.20 liter or 200 cc
20 liters	0.40 liter or 400 cc

Fiberglass Repairs



As most of the contemporary boats used by Sea Scouts are constructed of fiberglass, the repair of damage to such boats should be known to all. Fiberglass is available in cloth, mats, ribbon, and powdered form. Exercise caution when working around this material as it floats in the air and is a hazard to your nose, eyes, and skin. Irritation is marked. Wear nose masks, goggles, and long-sleeve shirts.

Fiberglass is molded into a hull in a permanent mold which has been lined first with a parting compound and a layer of gel-coat. A layer of activated resin is applied followed by a layer of fiberglass cloth. Then another layer of resin and fiberglass until the desired thickness is obtained. Upon curing, by time, the hull is removed from the mold for further processing.

To repair a hole in the hull of such a vessel, secure a patching kit from any hardware store and follow directions for activating the resin and note that mixing must be done in a glass or metal container using a disposable wooden stick. The activator will eat right through most paper cups. Depending on the ratio of activator to resin in your mix, you have about three minutes to use it before it becomes stiff.

Prepare edges of the hole to be repaired by sanding a clean surface at least two inches all around. Next apply a coat of activated resin and let it dry until tacky. Then cut (with scissors) a patch of cloth equal to the cleaned area. Soak this patch in a fresh batch of activated resin using a stick or putty knife. Do not use your hands if at all possible. Apply the patch to the opening and smooth down with a broad putty knife—from the middle outward. Smooth out wrinkles and bubbles and feather the edges. Allow to cure before application of successive layers, if needed. Complete with one or more coats of activated resin and allow to cure thoroughly.

Use #240 wet-or-dry sandpaper to smooth and feather edges. Finish with #400 paper; use plenty of water in each case. Let dry and paint, if required. Hands and tools may be cleaned with acetone, but use it sparingly.

On occasion it may be possible to repair the gel-coat if the hole is not too large. Gel-coat repair kits are available in most marine supply stores together with instructions.

It is impractical to gel-coat an entire boat unless you have had years of experience using a two-line spray gun and materials at elevated temperatures.

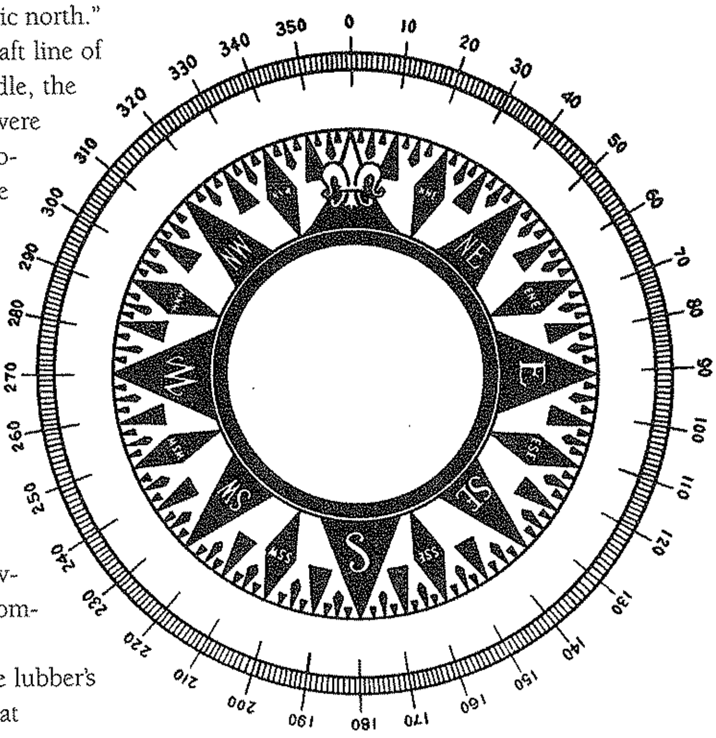
Piloting and Rules of the Road

Though piloting and navigation are closely related, the seaman considers piloting the art of finding his way along a shore or in and out of harbors and rivers. Navigation, then, is piloting offshore but without the many aids to navigation close to land. The pilot can actually see the shore and lighthouses, ranges and buoys. He can read the depth under him and listen to various radio aids, foghorns, and bells. The navigator must proceed without these aids. He or she must rely on the story told by the celestial bodies, the speed of his ship, and his or her knowledge of the currents, tides, and the vast ocean that he or she sails.

Mariner's Compass

Without the mariner's compass, both piloting and navigation would not be possible. It is the basis for all navigation. The magnetic compass has been changed only by minor refinements since Columbus used it in his epic voyage of 1492. The Chinese had learned much earlier how to magnetize a needle, which is the principle involved.

A simple compass consists of a magnetized needle or pointer mounted on a card that is graduated in points. This needle swings on its pivot so that it always points in a northerly direction. This position is called "magnetic north."



If the compass were placed in your boat and the fore-and-aft line of the boat were lined up parallel with the direction of the needle, the boat would be heading in a northerly direction. If the boat were steered 90 degrees to the right of this heading, it would be proceeding easterly; 90 degrees to the left of north would place the boat on a westerly course; and 180 degrees from the north heading of the needle would bring the boat around to a southerly heading. There are 360 degrees in a complete revolution of the compass needle. A heading would be called 000 for the north, 090 for the east, 180 for south, and 270 for west. All points are called with three digits.

The point marked north, or 000 on the compass card, is aligned with the north-seeking end of the magnetized needle. The needle, with the compass card fastened to it, is mounted on a pivot in a sealed container called the compass bowl. In actual practice, on a truly accurate boat compass, several magnetized needles are grouped together beneath the compass card rather than a single needle.

On the forward part of the compass bowl a line called the lubber's line is scribed. The man at the wheel or tiller, looking down at the compass, uses this lubber's line as a reference point for reading the boat's heading.

The compass bowl is filled with liquid to reduce the weight on the compass card by flotation and to enable it to turn freely on its pivot. The liquid also acts as a brake or dampener to slow down gyrations of the card as the course is changed. Refined petroleum products or other fluids which do not freeze at low temperatures are used in the bowl.

The compass bowl itself is mounted on an arrangement of brackets called gimbals, which allow the bowl to remain level regardless of the motion of the boat. Many marine compasses are further protected by a housing called a binnacle, which may be illuminated for night reading.

The compass card is marked in several ways, two of which are in common use today. The illustration shows the inner card, which was formerly used and was accurate enough for the constant changes of course by sailing vessels. The outer card, marked in degrees, is the one generally used today.

The standard compass card is divided into 360 degrees starting from zero (north) and proceeding clockwise to 360° or 0° again. It is the most precise card and makes accurate courses possible. This is the steering compass card used by commercial vessels and by the U.S. Navy. However, because wind and current directions sometimes are referred to in relation to the compass points, the card is marked in points in an additional circle.

Points

The division of the compass card according to points is an interesting one. The seaman should be familiar with both the degree system and the point system as clearly shown in the illustration and table.

POINTS OF THE COMPASS

See if you can box the compass by naming each of the 32 compass points in sequence.

1.	North	17.	South
2.	North by east	18.	South by west
3.	North-northeast	19.	South-southwest
4.	Northeast by north	20.	Southwest by south
5.	Northeast	21.	Southwest
6.	Northeast by east	22.	Southwest by west
7.	East-northeast	23.	West-southwest
8.	East by north	24.	West by south
9.	East	25.	West
10.	East by south	26.	West by north
11.	East-southeast	27.	West-northwest
12.	Southeast by east	28.	Northwest by west
13.	Southeast	29.	Northwest
14.	Southeast by south	30.	Northwest by north
15.	South-southeast	31.	North-northwest
16.	South by east	32.	North by west

There are 32 principal points on a compass card, and each point has a specific name. The four cardinal points are north, east, south, and west.

The intercardinal points are those midway between the cardinal points. Their names are a combination of those points they bisect. Thus, the point midway between north and east is northeast. This will give us eight divisions.

We now subdivide these eight divisions. Once again give the eight new points names which are combinations of the two points between them. The point midway between north and northeast is north-northeast.

To locate the additional 16 points, divide the points already found and proceed as before. Here again the new points have names corresponding to their adjacent points. The word "by" is used in all of these additional 16 points. For instance, the point between north and north-northeast is north by east because it is adjacent to north and is in an easterly direction from north.

The 32-point system has historic value but is no longer used in small boat navigation, having been abandoned in favor of the standard 360-degree compass. Most modern compasses are marked for the eight-point system and references to wind direction commonly use the eight-point system.

Duties of a Lookout

The rules of the road require a vessel to keep a proper lookout. In fog, at least one lookout should be forward and one aft. A lookout aft is also required when backing out of a slip, and a lookout is required even at anchor.

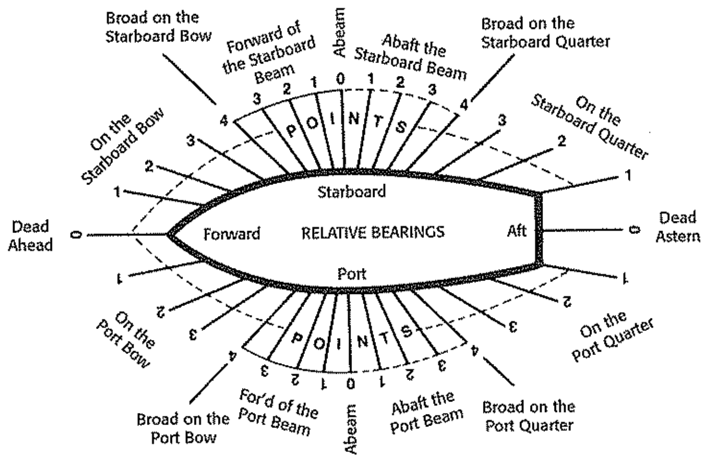
The lookout must be able to report accurately the bearing of any vessels, aids to navigation, and objects that he or she sights (or hears) to the officer in charge of the vessel. The lookout should relate any other pertinent information that is evident, such as their distance, course, and speed. The lookout must be vigilant, have no other duties, and be in a position to see and hear best.

Relative Bearings

The bearing of an object with respect to the fore-and-aft line of the ship is a relative bearing. Relative bearings take their names from the ship itself and are divided, as the compass is, into 32 points. They are also given in degrees.

Relative bearings have an indirect relation to compass bearings (true bearings). A Sea Scout should be able to translate from one to the other easily by having the entire picture in mind.

Let us assume, for an easy illustration, that your vessel is heading due south (on a true course of 180°). You sight a ship on your starboard beam. The relative bearing is 090°; the true bearing is 270°. Adding the relative bearing of an object you have observed to that true heading of your vessel will give you the true bearing of the object.



Compass Variation and Deviation

Unfortunately the magnetic compass always points to magnetic north, the center of magnetic energy which draws and holds the needle. It does not point to true or geographic north. The geographic North Pole, as we commonly understand it, is the northern end of the axis upon which the earth rotates. All charts and maps are oriented to geographic or true north. The difference between true and magnetic north is called variation and is expressed in degrees.

Magnetic north is not a fixed spot. Its general location is in northern Canada, but its exact location is subject to some annual change. This motion is predictable and by simple computations the correct local variation and annual change are noted upon each compass rose on all charts. The mariner converts his magnetic compass reading to true reading to conform to his charts.

Because waves of magnetic energy flow in irregular paths between the northern and southern magnetic poles, variation is easterly or westerly, or as the mariner faces the North Pole, the compass needle is too far to the right or to the left. The charts indicate which it is. Only when a compass happens to be located on a line south of the magnetic North Pole is there no variation. Only then does the needle actually point to geographic north.

Variation is expressed in degrees and minutes, east or west of true north.

Deviation

Deviation of the compass is caused by the inherent magnetism of iron and steel in a boat and in the boat's equipment such as auxiliary machinery, generators, radios, and batteries. Deviation, too, is expressed in degrees, either east or west, depending upon its effect on the compass. Unlike variation, however, deviation does not vary with changes in location but depends upon the amount and placement of magnetic metal on the vessel itself. Deviation will be different for each heading. Therefore, in order to have a record of the corrections to be applied, the deviation must be measured and recorded on a card located always in sight, for reference at any change of course.

Deviation is determined by running the ship over known courses, or "swinging ship" to bear on different known range marks found in most harbors.

Plot 12 range lines on your chart, at approximately 30-degree intervals, and compute the magnetic heading for each range line. Steer a course along each range line, and note your compass heading. The difference between your compass heading and the magnetic heading is your deviation for that compass heading.

If the deviations change by 3 degrees or less between any two entries, your table is satisfactory; if they change by more than 3 but less than 6 degrees, repeat the exercise using 15-degree intervals; if they change by more than 6 degrees, repeat using 10-degree intervals. (For easier interpolation, aim for a maximum difference of 2 degrees, or even 1 degree, rather than 3.)

Your headings will rarely be exactly a multiple of your interval; for convenience in the pilot house, interpolate your table to align with your intervals.

You can use the same methods to check the accuracy of the course reported by a gyrocompass or by Loran or GPS navigation systems.

Deviation is reduced by placing magnetized iron bars called flinders bars near the compass to pull it back to a nearly correct reading. Steel vessels must also use soft iron spheres for compensation. Compass correction, called compensating, is done by expert compass adjusters.

Freighter compasses must often be adjusted whenever they carry magnetic materials as cargo. A ship carrying wool or paper on one trip would need an entirely new deviation card if she were carrying automobiles on the next trip. So delicate is the compass that the helmsman can commit no greater shipboard crime than to tend the wheel with battery-operated watch or a knife, marlinspike, or other magnetic metallic object on his or her person which might affect the compensated deviation.

Compass Error

The combination of errors resulting from variation and deviation is known as compass error. The navigator must consider this on every course he or she lays down and adjust his or her compass heading to compensate for the error.

DEVIATION TABLE
Vessel: S.S.S. Queequeg
Location: Pilot House

Compass Heading		
000	4.0 W	7.0 E
030	3.5 W	5.5 E
060	2.5 W	2.5 E
090	2.0 W	1.0 W
120	2.0 W	3.5 W
150	0.5 W	4.0 W
180	4.5 E	

Thus, when the variation is westerly, the compass needle is drawn to the left of the true course. To compensate, the navigator brings the compass course to the right the proper number of degrees (adding degrees).

When the variation is easterly, the compass needle will be to the right of the true course. The navigator adjusts by coming to the left (subtracting degrees).

Magnetic compasses are carried on all craft regardless of size. Vessels built of steel are usually equipped with gyrocompasses and use their magnetic compasses only for standby. The gyrocompass is independent of magnetic influence. It is a complicated, motor-driven device in gimbals in which a shaft spun at high speed continuously maintains a position parallel to the earth's axis. This position, translated mechanically to a compass card, causes the north point on the card always to point to geographic (true) north.

Thus no correction for variation need be made, and as no magnetism is involved, there will be no deviation to apply. A gyrocompass costs many thousands of dollars and requires a reliable and unfluctuating source of electric current for its operation. The invention of the gyrocompass made possible the accurate navigation of submarines.

Rules of the Road

With the story of the compass in mind, let's turn to piloting a ship. When driving a car, we must know traffic laws and rules of the road. When piloting a ship we must know maritime laws and rules of the nautical road.

There are two sets of rules, international and inland. With a few exceptions, international and inland rules are identical. International rules are in effect on the ocean beyond a line of demarcation usually at the harbor entrance. Inland rules apply to harbors, rivers, and inland lakes. A few additional rules are in effect for the Great Lakes and western rivers, and mariners cruising these waters should note them.

The rules of the road are found in the book *Navigation Rules, International and Inland* (COMDTINSTR M16672.2 [latest edition]) published by the U.S. Coast Guard. On the subject of legal requirements for motorboats, the standard references are:

- Federal Requirements and Safety Tips for Recreational Boats
- *Pleasure Craft*, 33CFR Subchapter S, Parts 173-183
- *Rules and Regulations for Uninspected Vessels*, 46CFR Subchapter C, Parts 24-26
- *Aids to Marine Navigation of the United States*, 33CFR Subchapter C, Parts 62-76

All of these publications may be purchased from the Superintendent of Documents, U.S. Government Printing Offices in most major metropolitan centers. Check the blue pages of your telephone directory for the address and phone number. Publications are ordered by title. Mail or phone-in orders are welcome. There is a fee for each publication. Payment can be made by check, money order, or major credit card.

For reference on legal requirements for motorboats, refer to the pamphlet Federal Requirements and Safety Tips for Recreational Boats. This publication may be obtained in limited quantities from: Commandant, U.S. Coast Guard; Auxiliary, Boating & Consumer Branch; 2100 2nd Street, SW; Washington, DC 20593-0001, or your local USCG station or USCG Auxiliary flotilla.

Every vessel is governed by the rules applying to the waters she is on. It is very important that the Skipper and crew be familiar with all pertinent boating laws.

Courtesy and common sense dictate that small boats stay clear of larger vessels. However, if there is any risk of collision whatever, the rules clearly apply to large and small vessels alike. Only strict observance of all rules by all vessels can ensure the minimum danger. Every Sea Scout ship should have a copy of *Navigation Rules* on board.

When the rules refer to a power-driven vessel, they mean any vessel propelled by machinery, including steam, electricity, gasoline, and diesel, whether the vessel is also under sail or not. A sailing vessel is any vessel proceeding under sail only, though she may be equipped with power. A vessel is under way when she is not at anchor, or made fast to the shore, or aground. It is not necessary to be moving through the water to be "under way."

Dangerous situations requiring quick decisions are often as numerous for the person at the helm of a boat as for the person behind the wheel of an auto, but are usually far more complex. Therefore, the person at the helm must know the rules well to be able to analyze a situation quickly and apply the applicable rule correctly. Not every situation can be discussed here, but the following describes the rudiments.

Risk of Collision—All Vessels

Every vessel shall use all available means appropriate to the prevailing circumstances and conditions to determine if risk of collision exists, including the use of radar equipment if installed and operational. If there is any doubt, such risk shall be deemed to exist. Assumptions shall not be made on the basis of scanty information, especially scanty radar information.

In determining if risk of collision exists, the following considerations shall be among those taken into account

(a) Such risk shall be deemed to exist if the compass bearing of an approaching vessel does not appreciably change; and
(b) Such risk may sometimes exist even when an appreciable bearing change is evident, particularly when approaching a very large vessel, a tow, or when approaching a vessel at close range.

Conduct of Vessels

Rules 5 and 6 (from *Navigation Rules*)

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

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

(a) The state of the visibility
(b) The amount of other vessel traffic in the area
(c) The maneuverability of your vessel
(d) At night, the presence of background lighting
(e) The state of the wind, sea, and current
(f) The draft of your vessel in relation to the available depth of water

Responsibility Between Vessels

Rule 18 (Inland and International)

Except where (Navigation) Rules 9, 10, and 13 otherwise require:

(a) A power-driven vessel under way shall keep out of the way of:
 (i) A vessel not under command;
 (ii) A vessel restricted in her ability to maneuver;
 (iii) A vessel engaged in fishing; and
 (iv) A sailing vessel
(b) A sailing vessel under way shall keep out of the way of:
 (i) A vessel not under command;
 (ii) A vessel restricted in her ability to maneuver; and
 (iii) A vessel engaged in fishing
(c) A vessel engaged in fishing when under way shall, so far as possible, keep out of the way of:
 (i) A vessel not under command;
 (ii) A vessel restricted in her ability to maneuver
(d) A seaplane on the water shall, in general, keep clear of all vessels and avoid impeding their navigation. In circumstances, however, where risk of collision exists, she shall comply with the rules of this part.

Risk of Collision—Sailing Vessels

These rules apply to sailing vessels except vessels racing among themselves. These rules do apply to racing vessels encountering others not in the race. Study them carefully.

Rule 12—Sailing Vessels (from *Navigation Rules*)

(a) When two sailing vessels are approaching one another so as to involve risk of collision, one of them shall keep out of the way of the other as follows:

(i) When each has the wind on a different side, the vessel that has the wind on the port side shall keep out of the way of the other.
(ii) When both have the wind on the same side, the vessel that is to windward shall keep out of the way of the vessel which is to leeward; and
(iii) If a vessel with the wind on the port side sees a vessel to windward and cannot determine with certainty whether the other vessel has the wind on the port or on the starboard side, she shall keep out of the way of the other.

(b) For the purpose of this rule, the windward side is the side opposite to that on which the mainsail is carried.

Situations for Proper Maneuvering

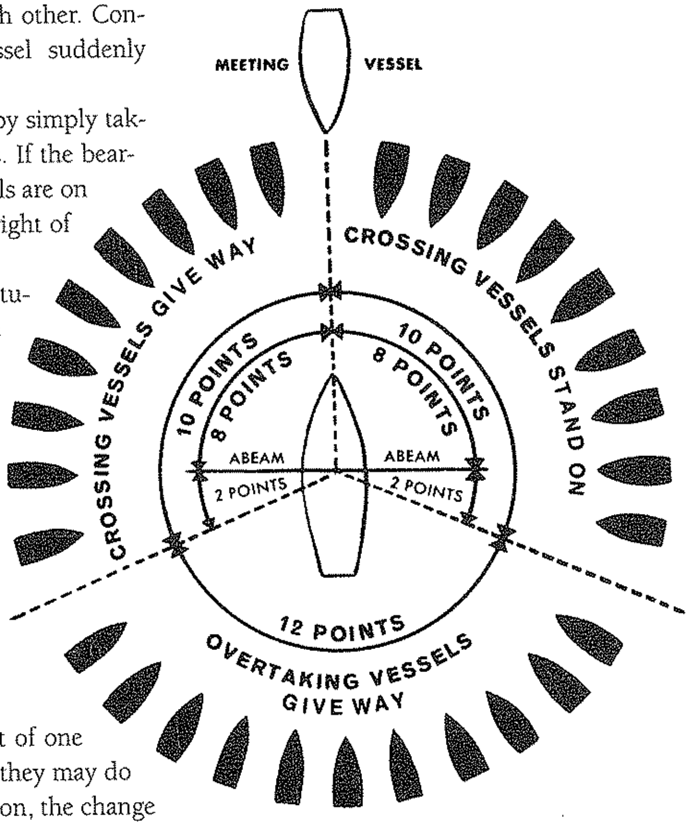
There are three basic situations that can lead to collision afloat—and an inevitable lawsuit ashore: The meeting situation, the crossing situation, and the overtaking situation.

All of these situations are shown in the diagram. None of the situations actually exists until two or more vessels are in sight or sound of each other. Consider how quickly a situation might arise with another vessel suddenly appearing out of a fog bank or around a river bend.

Normally, all of the situations can be observed in the making by simply taking a series of bearings on the other vessel or, at night, her lights. If the bearings do not change substantially from sight to sight, the two vessels are on a collision course. The give-way vessel—the one not having the right of way—is therefore required to change course or speed or both.

Common sense is one of the best rules. It is better to avoid a situation that might lead to a collision than to try to remember the exact rule to get you out of trouble.

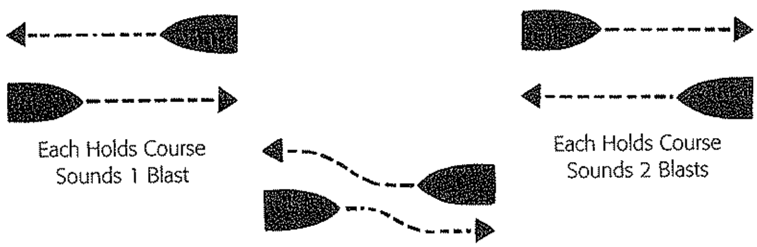
Pretend you are the skipper of the vessel in the center of the diagram. You must keep out of the way of any vessel approaching you in the arc from dead ahead of you to $22^{1}/_{2}$ degrees (two points) abaft your starboard beam. All the other vessels in the diagram—except the meeting vessel—must keep clear of you. Both you and a meeting vessel (one which is head-on or nearly so) must alter course to starboard as necessary to pass clear of each other.



Rule 14—Head-On Situation

Neither vessel may turn to port. If they are already so far left of one another that they may pass safely without changing course, then they may do so. But if any change of course is necessary to avoid risk of collision, the change must be to starboard.

MEETING



Each Holds Course
Sounds 1 Blast

Each Turns Right
Sounds 1 Blast

Each Holds Course
Sounds 2 Blasts

Rule 15—Crossing Situation

The vessel that has the other on her starboard is required to keep out of the way by altering course to starboard, slowing, stopping, or reversing. She may not turn to port. The appropriate action will cause each vessel to pass the other port side to port side. Hence the one short blast.

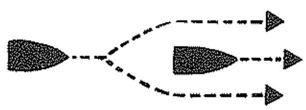
Crossing

Each Sounds 1 Blast

Rule 13—Overtaking

The overtaking vessel is required to keep out of the way of the vessel being overtaken. Power-driven vessels should keep to the starboard side of narrow channels.

Overtaking



Overtaking Vessel Stays Clear

Rule 2—Responsibility

"Nothing in these rules shall exonerate any vessel, or the owner or master or crew thereof, from the consequences of any neglect to comply with these rules or of the neglect of any precaution that may be required by the ordinary practice of seamen or by the special circumstances of the case."

"In construing and obeying these rules, due regard shall be had to all dangers of navigation and collision and to any special circumstances, including the limitations of the vessels involved, which may make a departure from these rules necessary to avoid immediate dangers."

A rule may be departed from—that is, it may be disobeyed—only when circumstances of the case make it necessary to avoid immediate danger. For example, when obeying the rule would run your vessel aground or into collision with a third vessel, or when the vessel that is supposed to keep out of the way cannot do her duty and collision is imminent, the responsibility rule allows you to take whatever action is necessary. Such a situation might be caused by a disabled steering gear or sudden loss of power.

Rule 35—Sound Signals in Restricted Visibility

All vessels in or near an area of restricted visibility, whether by day or by night, must sound fog signals at intervals of not more than two minutes. They may sound no other signal. Whistle signals for passing may not be sounded until vessels are within sight of each other. A prolonged blast is four to six seconds in duration. A short blast is about one second.

The fog signals are as follows:

- Power-driven vessels making way, one prolonged blast
- Power-driven vessels under way but stopped and making no way, two prolonged blasts with an interval of about two seconds between them

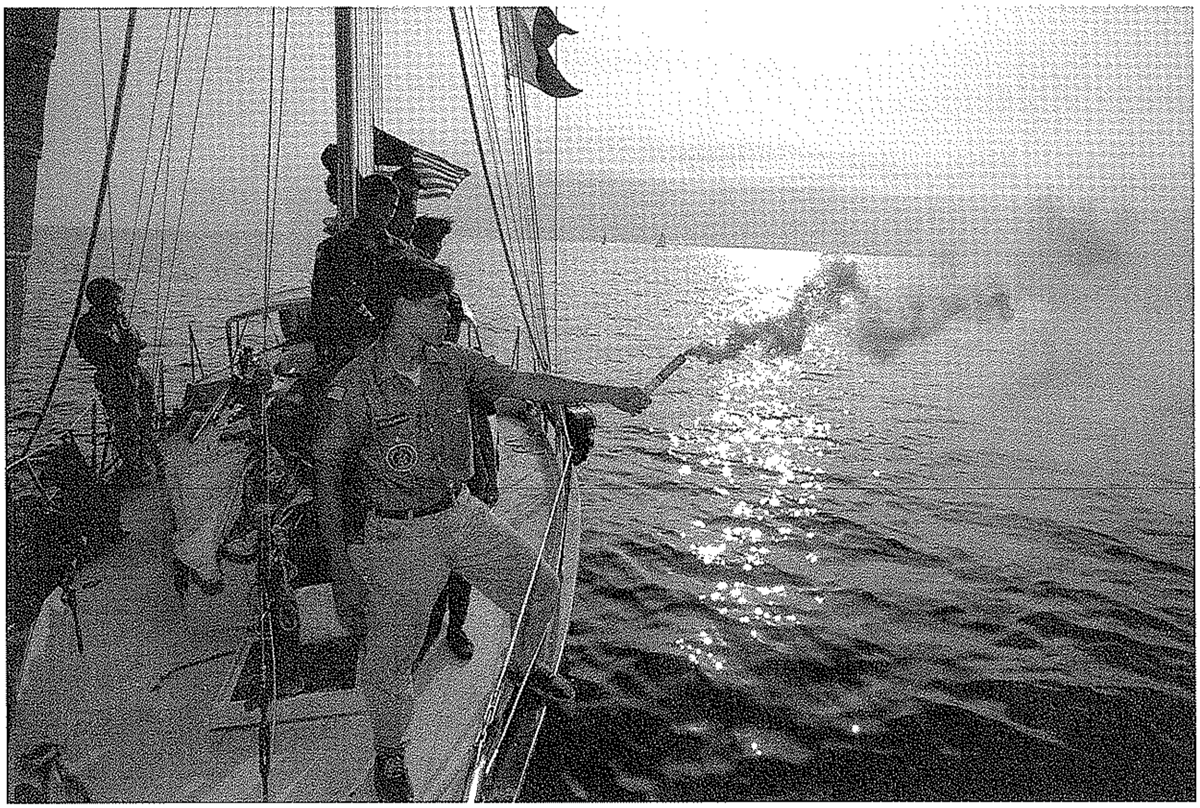
- A vessel not under command; a vessel restricted in her ability to maneuver, whether under way or at anchor; a sailing vessel; a vessel engaged in fishing, whether under way or at anchor; and a vessel engaged in towing or pushing another vessel, one prolonged blast followed by two short blasts
- A vessel towed (if manned), one prolonged blast followed by three short blasts. When practical, this signal shall be made immediately after the signal made by the towing vessel.
- A vessel at anchor, bell rung rapidly for five seconds

Rule 34—Maneuvering and Warning Signals—Inland Rules

When power-driven vessels are in sight of one another and meeting or crossing at a distance within half a mile of each other, each vessel under way, when maneuvering, shall indicate that maneuver by the following signals on her whistle:

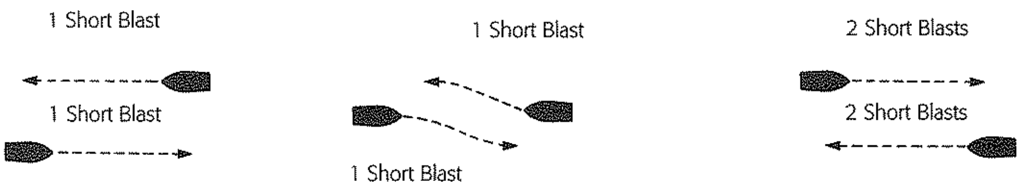
- One short blast: "I intend to leave you on my port side."
- Two short blasts: "I intend to leave you on my starboard side."
- Three short blasts: "I am operating astern propulsion."

Upon hearing the one- or two-blast signal of the other vessel, if in agreement, you shall respond with the same signal and take the necessary steps to effect a safe passing. If, however, from any cause, either vessel fails to understand the intentions of the other, or doubts the safety of a proposed maneuver, she shall immediately sound the danger signal of at least five short and rapid blasts on the whistle and each vessel shall take appropriate precautionary action until a safe passing agreement is made.

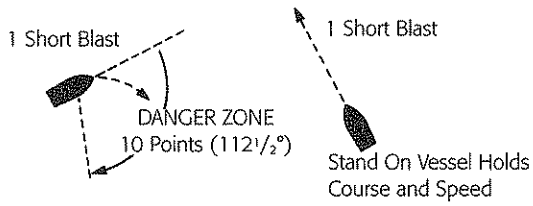


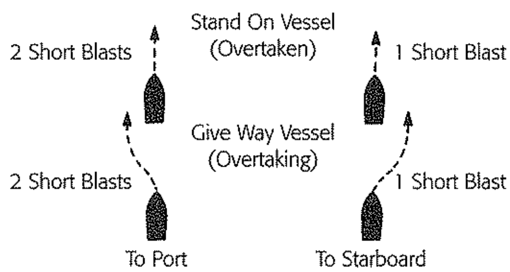
Vessels leaving a dock or berth, or nearing a river bend or similar blind spot, shall sound one prolonged blast.

PORT TO PORT **STARBOARD TO STARBOARD**



GIVE WAY VESSEL GIVES WAY





Lights and Shapes

By day, a vessel's course or a change in her course is fairly obvious to the lookout. By night, however, little can be determined about the direction of another vessel unless that vessel is lighted as required by the rules. The provisions for lights vary according to the place, the size of the vessel, and her use.

The diagrams that follow indicate precisely the proper lights for all small vessels under way in specified waters. These regulations must be followed exactly, and the lights readily identified by all persons handling boats at night.

Large vessels display certain lights at night and "day shapes" during daylight hours to indicate that they are involved in special activities or situations. For a more complete listing, consult U.S. Coast Guard publications. Some important lights and day shapes are:

	Night	Day
Ship **NOT UNDER COMMAND.** Due to unusual circumstances the ship is out of control.	Two 360-degree red lights displayed in a vertical line.*	Two black balls displayed in a vertical line.
Ship **RESTRICTED IN ABILITY TO MANEUVER.** Ship cannot maneuver due to the type of work being performed aboard such as diver down or dredging.	Three 360-degree red over white over red lights displayed in a vertical line.*	Black ball over black diamond over black ball displayed in a vertical line.
Vessel **CONSTRAINED BY DRAFT.** Vessel cannot maneuver out of the channel due to draft.	Three 360-degree red lights displayed in a vertical line.*	Black cylinder in rigging.
FISHING. Boats fishing with nets and trawling (dragging nets).	360-degree green light over white light.	Two black cones apex to apex.
NOT TRAWLING. Boat fishing other than trawling.	360-degree red light over white light.	Two black cones apex to apex; if less than 20 meters may display basket in rigging.
SAILING VESSELS UNDER POWER.	Lights prescribed for power-driven vessel.	Conical shape in rigging with apex pointing down.

*If the vessel is not anchored or aground, it shall *also* show side lights and a stern light.

International Waters—Power-Driven

1. A power-driven vessel less than 20 meters (65 feet, 6 inches) shall exhibit navigation lights as shown in either figure 1 or 2. If you choose figure 1, the aft masthead light must be higher than the forward one; if figure 2 is selected, for a vessel less than 12 meters (39 feet, 4 inches), the masthead light must be 1 meter (3 feet, 3 inches) higher than the colored lights. If the vessel is 12 meters (39 feet, 4 inches) or more in length and less than 20 meters (65 feet, 6 inches), the masthead light must be 2.5 meters (8 feet, 2 inches) higher than the gunwale.
2. A power-driven vessel less than 7 meters (22 feet, 10 inches) in length and whose maximum speed cannot exceed 7 knots may, in lieu of the lights prescribed above, exhibit an all-round white light. Such vessel shall, if practicable, also exhibit side lights.
3. A power-driven vessel, when operating on the Great Lakes, may carry an all-round white light as displayed in figure 4, in lieu of the second masthead light as shown in figure 1.

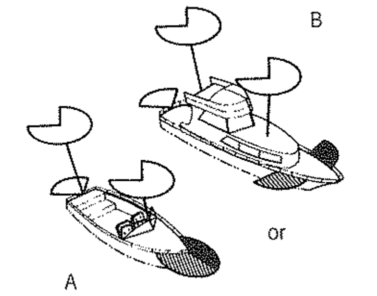


Figure 1

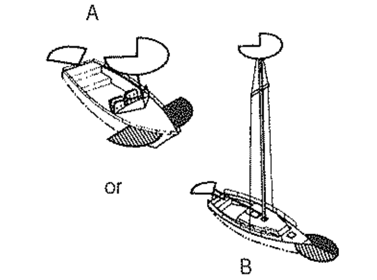


Figure 2

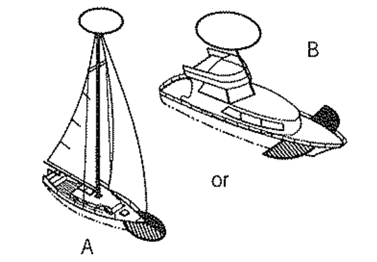


Figure 3

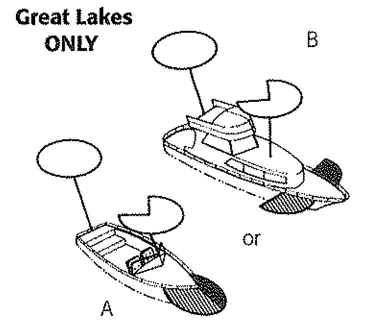


Figure 4

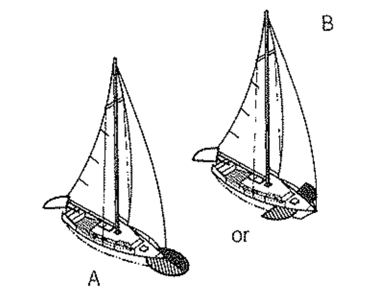


Figure 5

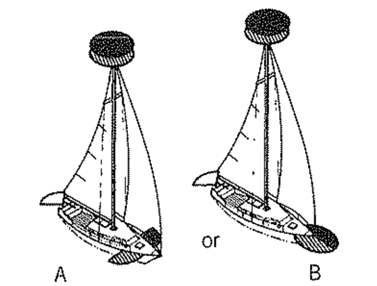


Figure 6

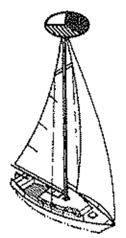


Figure 7

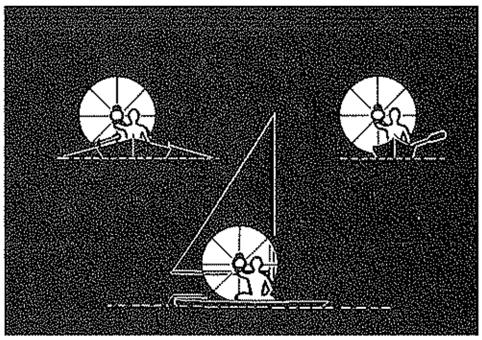


Figure 8

*Some exemptions may apply to vessels on which construction was started prior to December 25, 1981. See Rule 38 for details.

White

Red

Green

Inland Waters—Power-Driven

1. A power-driven vessel 50 meters (165 feet) or over shall exhibit navigation lights as shown in figure 1B.
2. A power-driven vessel 12 meters (39 feet, 4 inches) or more in length and less than 20 meters (65 feet, 6 inches) shall exhibit navigation lights as displayed in either figure 1 or 2.
3. A power-driven vessel less than 12 meters (39 feet, 4 inches) may exhibit those lights shown in figure 1, 2, or 3.
4. A power-driven vessel, when operating on the Great Lakes, may carry an all-round white light as displayed in figure 4, in lieu of the second masthead light as shown in figure 1.

International—Sailing Vessels and Vessels Under Oars

1. A sailing vessel of less than 20 meters (65 feet, 6 inches) in length shall exhibit navigation lights shown in either figure 5, 6, or 7.
2. A sailing vessel of 20 meters (65 feet, 6 inches) or more in length shall exhibit navigation lights shown in either figure 5B or 6A.
3. A sailing vessel of less than 7 meters (22 feet, 10 inches) in length shall, if practicable, exhibit those lights prescribed for sailing vessels less than 20 meters, but if she does not, she shall have available an electric torch or lighted lantern showing a white light that shall be exhibited in sufficient time to prevent collision (see figure 8).
4. A vessel under oars may display those lights prescribed for sailing vessels, but if she does not, she shall have available an electric torch or lighted lantern showing a white light that shall be exhibited in sufficient time to prevent collision (see figure 8).

Inland—Sailing Vessels and Vessels Under Oars

1. A sailing vessel under sail alone shall exhibit navigation lights as displayed in either figure 5, 6, or 7.
2. A sailing vessel of less than 7 meters (22 feet, 10 inches) shall, if practicable, exhibit the lights prescribed in number 1 of this section, but if she does not, she shall have available an electric torch or lighted lantern showing a white light that shall be exhibited in sufficient time to prevent collision (see figure 8).
3. A vessel under oars may exhibit the lights prescribed in this section for sailing vessels, but if she does not, she shall have available an electric torch or lighted lantern showing a white light that shall be exhibited in sufficient time to prevent collision (see figure 8).

Range and Degree of Visibility of Lights—Inland and International

Less than 12 meters/12 meters or more but less than 20 meters

	Location	Visible Range (Miles)	Degrees
	Masthead light	2/3	225/225
	All-round light	2/2	360/360
or	Side lights	1/2	112.5/112.5
	Stern light	2/2	135/135

Lights Used When Anchored—International

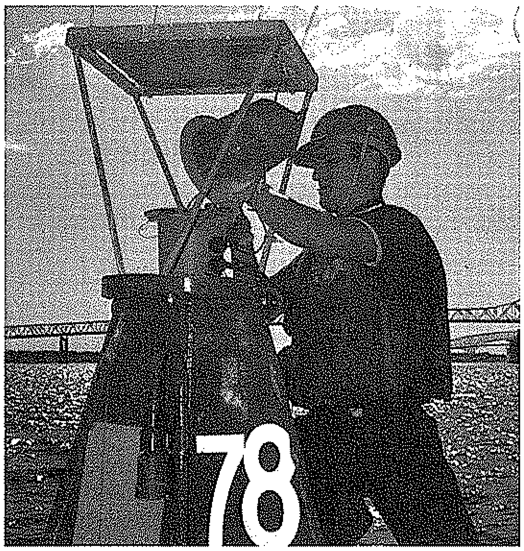
Power-driven vessels and sailing vessels less than 50 meters in length at anchor must display anchor lights. Vessels less than 7 meters in length shall not be required to display anchor lights unless anchored in or near a narrow channel, fairway, or anchorage, or where other vessels normally navigate. An anchor light is an all-round white light, visible for two miles, displayed where it can best be seen.

Lights Used When Anchored—Inland

Power-driven vessels and sailing vessels less than 50 meters in length at anchor must display anchor lights. Vessels less than 7 meters in length shall not be required to display anchor lights unless anchored in or near a narrow channel, fairway, or anchorage, or where other vessels normally navigate. An anchor light is an all-round white light, visible for two miles, displayed where it can best be seen. A vessel less than 20 meters in inland waters, when at anchor in a special anchorage area designated by the secretary of transportation, shall not be required to exhibit an anchor light.

Aids to Navigation

Along the length of the coasts and navigable waters of the United States and its possessions, there are many aids to navigation to assist the mariner in determining the position of his or her vessel. These aids range from steel, concrete, or wood structures such as lighthouses, buoys, and beacons, to electronic navigation aids such as LORAN (LOng RAnge Navigation), radiobeacons, and GPS (Global Positioning System).



The U.S. Coast Guard has responsibility for designing, establishing, and maintaining more than 40,000 navigational aids in the waters of the United States. The Coast Guard also monitors thousands of state and privately maintained aids to navigation. Today our nation has the biggest and best aids-to-navigation system in the world. In comparison, Great Britain, a seafaring nation, maintains fewer than 550 aids to navigation.

This system, evolved through the years, has many variations. They are as follows:

- U.S. Navigation System
- Western River System
- Uniform State Waterway Marking System
- Private Aids to Navigation

The navigational devices used in these different systems vary in shape and size, depending upon the job they have to do and the location. A lighthouse may be built where the light must be visible for many miles at sea, while a lighted buoy is designed to be placed where visibility over a distance is not as critical.

Light List

A complete listing of aids to navigation is found in the five-volume *Light List* published yearly by the U.S. Coast Guard. Volume I covers the Atlantic Coast to Little River, South Carolina; Volume II, the balance of the Atlantic and Gulf coasts; Volume III, the Pacific coasts and islands; Volume IV, the Great Lakes; and Volume V, the Mississippi River system. The Light List and all charts should

STANDARD MARINE DISTRESS SIGNALS

Search and Rescue

RADIO

RADIOTELEPHONE
CALL: Mayday
GIVE: Name and position

GMDSS
(General Marine Distress Signalling System)

USE:
156.8 MHz — Channel 16; 2182 kHz; or use alarm signal
CB: Ch 9

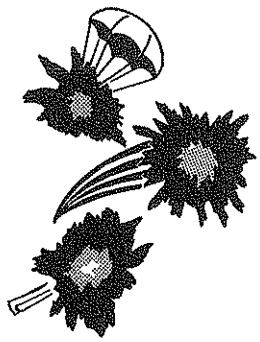
Emergency position indicating radio beacon

FLARES

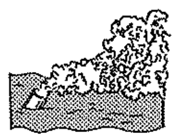
TYPE A:
Parachute rocket

TYPE B:
Multistar rocket

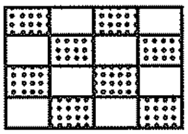
TYPE C:
Hand-held



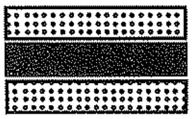
TYPE D:
Buoyant or hand-held orange smoke



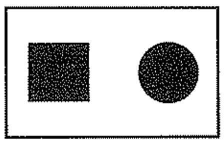
CODE FLAGS



N
OVER
C

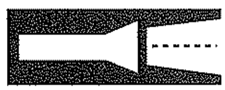


DISTRESS CLOTH



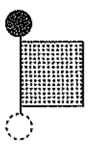
FLASHLIGHT

(SOS) . . . _ _ _ . . .



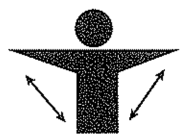
SHAPES

BALL
over or under
SQUARE



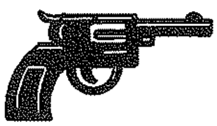
ARM SIGNAL

Do not use near helicopter
(different meaning)



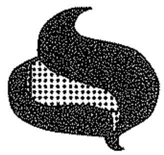
SOUND SIGNALS

Continuous:
Foghorn, bell, whistle
One-minute Intervals:
Gun or any explosive

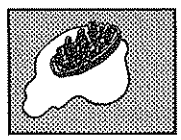


FLAME ON VESSEL

As from burning tar, oil in barrel, etc.



DYE MARKER



be corrected regularly from Notice to Mariners as changes in aids to navigation are made.

Lighthouses

Lighthouses are important aids to seafarers and have been in use for centuries.

Lighthouses in our country have an interesting history. Many legends have been built on the exciting lives led by early lighthouse keepers and their families. Often the stories were of rescues they accomplished.

Modern lighthouses differ little in principle from the famous old lighthouses, although many of them today function automatically. The life of the keeper is far different from what it once was.

The big change has been in the method of illumination. Lighthouses progressively over the years have been lighted by bonfires, whale oil, kerosene, acetylene gas, and finally by electricity.

Lighthouses differ markedly in their external characteristics. Each structure is built to meet the specific demands of its location. Most have recognizable profiles. Each is so colored to be easily identified by day. Each has its own characteristic light sequence for identification at night.

The color of the light may be white, green, red, or a combination of each. The structure itself may be painted a solid color or patterned with other colors. By using all of the characteristics of a given lighthouse—light, shape, materials, and color—a mariner can quickly identify it by day or night and plot bearings from it.

The distance a light can be seen at sea in clear weather depends upon three things: the height of the light itself above sea (which is noted on the chart), the height of the observer above the sea, and the candlepower of the light. Because of the curvature of the earth's surface, the higher a light is located above sea level, the farther it can be seen.

When a vessel approaches on a clear night from seaward, the first indication the navigator may have of a lighthouse is a glare reflected in the sky while the source is still below the horizon. As the vessel closes the distance to it, the light and then the tower slowly rise above the horizon.

In addition to the welcoming light, a lighthouse and its available equipment provide other important aids to the mariner. The light may be so designed to show red over a sector of its lighted arc to warn of shoals or rocks in that specific area. The red sectors of a lighthouse are marked on all charts to give the mariner warning that he or she is in dangerous waters.

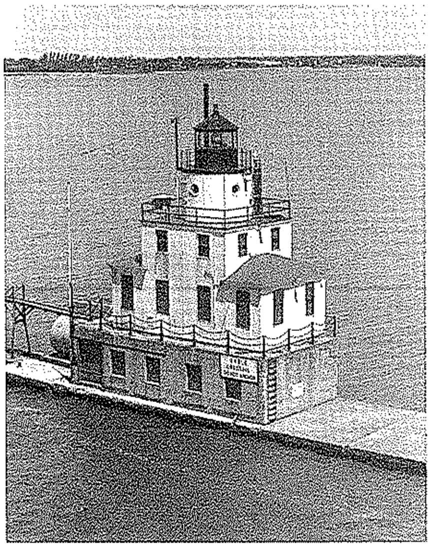
Many lighthouses are equipped with signals that serve as warnings during foggy weather or other periods of poor visibility. Regularly timed blasts of a horn, siren, or other signal identify most lighthouses. As a further navigational aid, in recent years marine radio beacons have been installed at strategically located lighthouses.

Visibility of Lights

The distances at which lights may be seen are shown on charts and in the light list as the nominal range. This is the distance the light can be seen under normal conditions for the area. Haze and fog can reduce this range; unusually clear conditions can increase it. So the light's luminous range is the distance it can be seen under current conditions without considering the curvature of the earth. But the earth does curve, so the geographic range is the distance a light could be seen under perfect viewing conditions, limited only by the earth's curvature, and assuming that the observer's eye were at sea level.

The higher a light is above the water, the greater its geographic range. The height of the observer's eye above water adds to this range. The table shows the distance, in nautical miles, to the horizon for each eight feet above sea level.

To find the actual distance of visibility of a light, you must add the distance to the horizon of the light (based on its height above the water) to the distance to the horizon of your eyes (based on their height above the water). For example, if the light is 55 feet above the water, its distance to the horizon is 8.5 nautical miles. If your eyes are 8 feet above the water, your distance to the horizon is 3.2 miles. Add the two distances (8.5 + 3.2). You should be able to see the light at a distance of 11.7 nautical miles in perfectly clear weather.



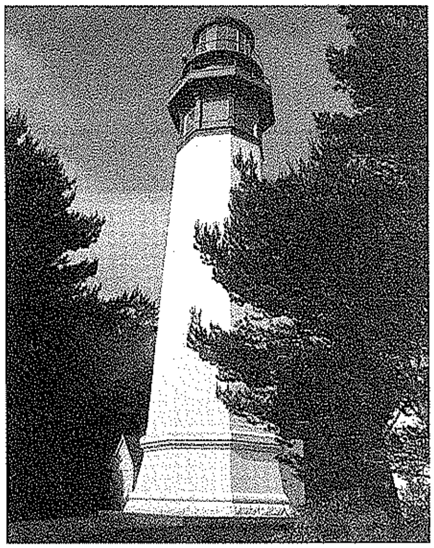


Table 10: Distance to Horizon

Height (Feet)	Distance (Nautical Miles)	Height (Feet)	Distance (Nautical Miles)
1	1.1	35	6.8
2	1.6	40	7.2
3	2.0	45	7.7
4	2.3	50	8.1
5	2.6	55	8.5
6	2.8	60	8.9
7	3.0	65	9.2
8	3.2	70	9.6
9	3.4	75	9.9
10	3.6	80	10.2
15	4.4	85	10.5
20	5.1	90	10.9
25	5.7	95	11.2
30	6.3	100	11.4
Distance (D) to the horizon based on the formula: $D = 1.14 \sqrt{h}$			

Lightships

Lightships once served the same purpose to mariners as do lighthouses and often were equipped with the same devices. They were used in locations where it was impractical to build a permanent structure to support the light. They were moored at important stations such as harbor approaches, entrances to bays, and where warning of dangerous shoals was necessary.

The U.S. Coast Guard has completed a program to replace lightships with offshore towers or large buoys. The *Nantucket* was the last lightship still in service.

The Lateral System

Buoys were used in our waters 200 years ago. In 1767, on the Delaware River, crude logs or staves were used to build wooden buoys up into barrel shapes. Iron buoys were first used in 1850. The present steel nun and can buoys were placed in service in 1900.

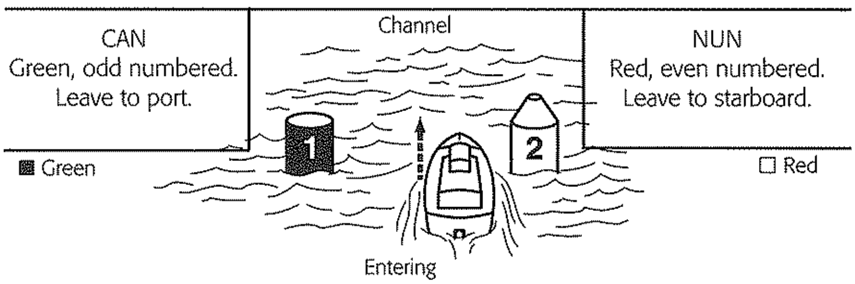
Buoys lighted by compressed acetylene gas stored inside the buoy were first introduced in 1910. The electric battery now generally has supplanted acetylene gas. On many buoys, the batteries are kept charged with solar cells. Whistle buoys date back to the late 1800s. The motion of the sea actuates an air pump which sounds the whistle. Bell buoys were introduced in the latter part of the last century.

The buoyage system may appear confusing with the many odd shapes, varied colors, odd sounds, and complicated lights, but there is a system. It is called the lateral system and is very cleverly devised to operate with a high degree of efficiency. Buoys are located to warn of dangers and obstructions and to mark channels. The lateral system determines the distinguishing shape, color, number, and light characteristics of buoys to indicate the side on which each should be passed by vessels proceeding from seaward toward the head of navigation.

But not all channels lead directly from seaward, so in certain places arbitrary rules have been established to make the lateral system consistent. Thus a vessel is considered to be proceeding from seaward when proceeding in a northerly and westerly direction along the coast of the Gulf of Mexico, a southerly direction along the Atlantic coast, and a northerly direction along the Pacific coast.

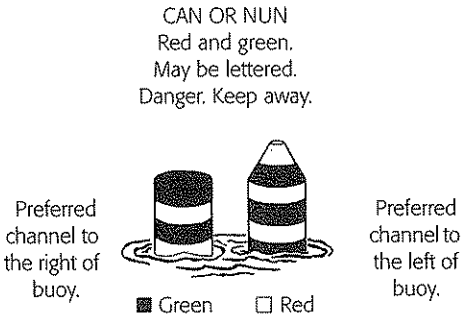
On the Great Lakes, the arbitrary direction from seaward is northerly and westerly. On the Mississippi and Ohio Rivers and their tributaries, from seaward is upstream toward the river sources. Aids on the Mississippi River and its tributaries are numbered according to mileage distances upstream from references points.

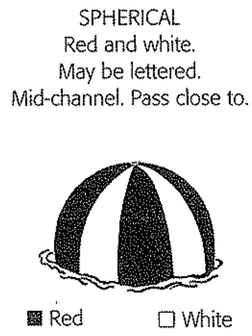
Green buoys mark the left side of the channel when returning from seaward and must be passed by keeping them on the port or left hand. Red buoys mark the right side of the channel and must be passed by keeping them on the right or starboard hand when returning from seaward. An old adage is: "Red right returning." Buoys on the left side of a channel are painted green and have odd numbers. Buoys on the right side are painted red and have even numbers. A look at a chart will readily explain this.



Red and green horizontally striped buoys mark wrecks or obstructions that may be passed on either side, but not close to. If the top stripe is red, the preferred channel will keep the buoy on the right hand. If the top stripe is green, the preferred channel will keep the buoy on the left hand. The chart should always be consulted. Red and white vertically striped buoys are located in a fairway or in mid-channel and may be passed close to on either side. These fairway buoys are spherical in shape or lighted buoys with a red spherical topmark.

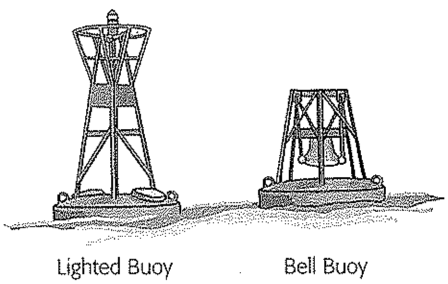
The different shapes of unlighted buoys make identification easy. Conically shaped buoys, called nuns, are used for red buoys and for red and green horizontally banded buoys on which the top band is red. Cylindrically shaped buoys, called cans, are used for green buoys and for red and green horizontally banded buoys when the top band is green. Red spar buoys are pointed on top (like nun buoys). Green spar buoys are cut off square across the top like can buoys for easy identification.

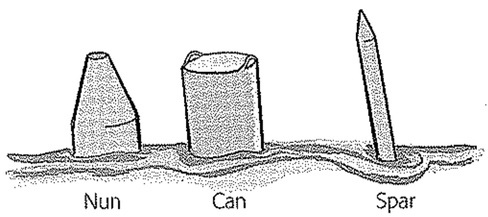




No particular significance is attached to the shape of bell buoys, gong buoys, whistle buoys, lighted buoys, or combination buoys. Their purpose is indicated only by their coloring, numbering, or light characteristic. Solid red and solid green buoys have conspicuous numbers to indicate which side of the channel the particular buoy marks. Also they are so identified on the chart. Even-numbered buoys mark the right-hand side of the channel and odd-numbered buoys mark the left-hand side of the channel when proceeding from seaward. The numbers increase from seaward and are kept in approximate sequence on the two sides of the channel by omitting numbers when needed.

Many unlighted buoys are fitted with reflectors. These may be reflecting disks mounted on the buoy or consist of fabric coated with a reflecting substance. Some have large metal plates attached to them to serve as radar reflectors.





Lighted Buoys

Buoys that are of special importance must be useful at night. Therefore, they are equipped with lights. Lighted buoys may be used in place of either can or nun buoys. Green lights are used only on green buoys, or on green and red horizontally striped buoys where the topmost band is green. Red lights are used only on red buoys, or on green and red buoys where the topmost band is red. White lights may be used only as a crossing aid (Western River System, including the Mississippi River above Baton Rouge). They are visible for greater distances than colored lights.

Sound Buoys

Buoys equipped with sound signals are effective in fog or whenever visibility is limited. These are classed as bell buoys, gong buoys, whistle buoys, or horn buoys. Each is easily recognizable by its distinctive sound.

Bell buoys have four clappers hung loosely around the bell so that the slightest motion of the buoy causes a clapper to strike the bell. Gong buoys have three or four gongs of different tones, each with a separate clapper rung in turn by the motion of the buoy in the sea. The air used in whistle buoys is compressed and released by the rise and fall of the buoy from the movement of the sea. Buoys of this type are usually placed only where there is sufficient motion to activate them. A horn buoy is sounded at regular intervals by mechanical means.

Characteristics of Lights

To permit ready identification and to avoid confusion with other lights, most lighted buoys have distinct flashing characteristics. These characteristics are in the form of a variety of flashes (light periods) and eclipses (dark periods). These characteristics are indicated on charts and in the light lists by the following abbreviations:

F	Fixed	I Qk Fl	Interrupted Quick Flashing
Fl	Flashing	S-L Fl	Short-Long Flashing
Gp Fl	Group Flashing	E Int	Equal Interval Flashing
Qk Fl	Quick Flashing	Mo (A)	Morse Code Letter A
Occ	Occulting		

Additional symbols used in the light list to describe lights and their characteristics are: R (red), G (green), W (white), s (seconds), fl (flash), and ec (eclipse). For example, the symbols Fl. G., 2.5s (0.5s fl) show in the light list just below the name of the aid and indicate that this light exhibits a flashing green light every 2.5 seconds, the flash being 0.5 seconds duration followed by an eclipse (period of darkness) of 2.0 seconds.

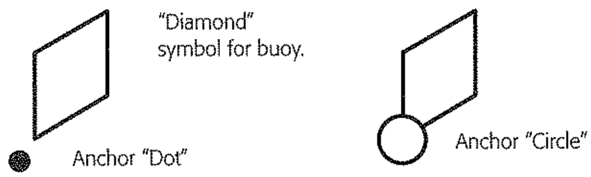
The light rhythms on lighted buoys follow a pattern that helps the navigator identify the light and its meaning. Mid-channel buoys will always show a white light flashing the Morse code letter A. A preferred channel aid will show a red or green light depending on which channel is preferred and have a composite group flashing light (2 + 1). Port and starboard side buoys will show a green light to port and a red light to starboard. Their light rhythms will vary from buoy to buoy in such a way that buoys will not be easily confused. The lighting pattern will be marked on the chart.

Dependence on Buoys

Although every care is given by the U.S. Coast Guard in maintaining all navigational aids, the navigator must not rely entirely on the placement and lighted characteristic of a buoy. Buoys may be carried away, sunk, shifted, or lights extinguished by nature, collision, or mechanical failure.

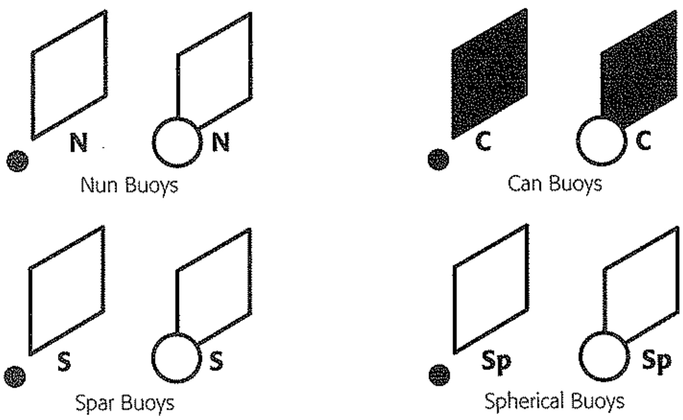
Symbols for Buoys

The basic symbol for a buoy is a diamond and a small circle (a dot will be shown instead of the circle on older charts). The circle denotes the position of the buoy. The diamond is used primarily to draw attention to the position of the circle, and it also may partially describe the aid in question.

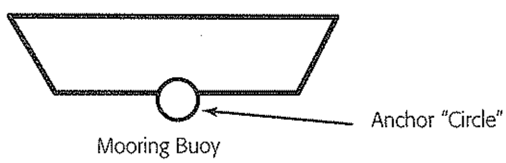


The position of the diamond with reference to the circle is of no significance. The diamond may be placed in any attitude relative to the circle to suit the situation and to afford the least amount of interference with other local features or conditions on the chart. (If the diamond is below the circle on the chart, it does not mean that the buoy is upside down!)

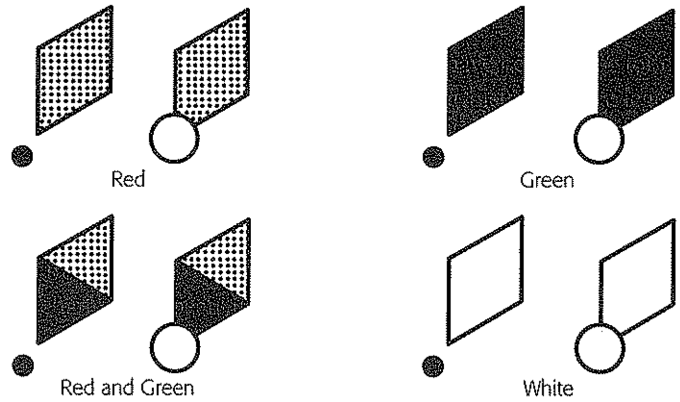
The shape of the buoy will be indicated by initials if the shape is of significance.



A mooring buoy is the only buoy that is depicted by a symbol other than the diamond and circle. This symbol is a quadrangle with the circle at the bottom.

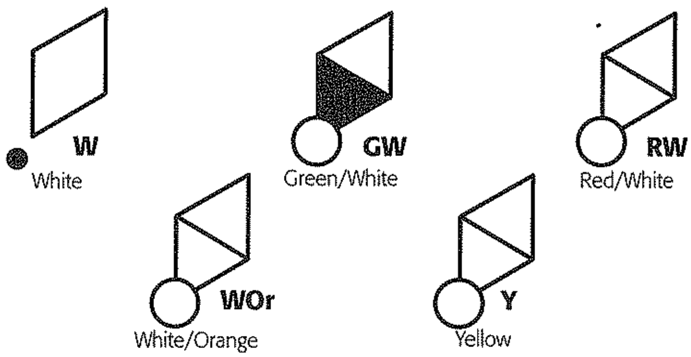


If the buoy is painted red, the diamond will generally be colored red; if the buoy is painted green, the diamond will be green. If the buoy is red and green horizontally banded, the diamond will be red and green. If the buoy is white and green vertically striped, the diamond will have a line drawn through its long dimension.



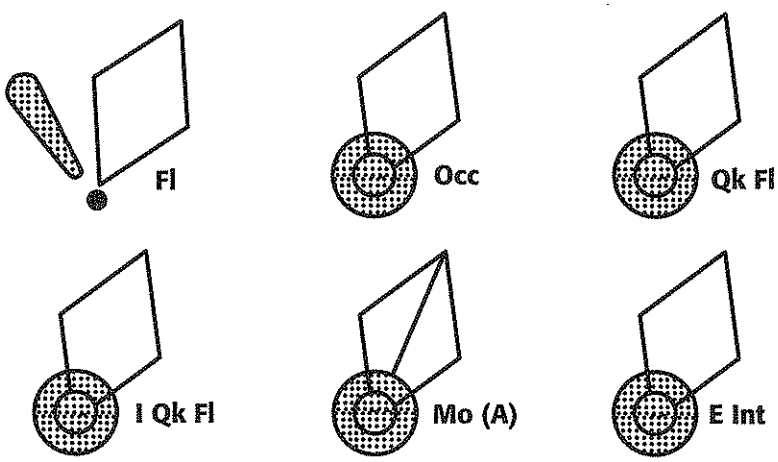
The five color patterns used on buoys which have no lateral significance are shown as follows. (In each case below, the buoy is cylindrical in shape.)

Can Buoys



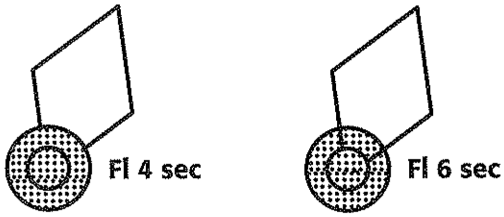
If a buoy is lighted, a magenta-colored disc will be overprinted on the circle. The characterictic of the light will be described briefly. This is done by the use of abbreviations. These are as follows:

Lighted Buoy Symbols



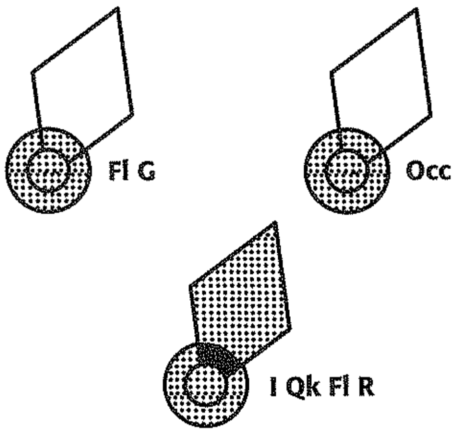
Flashing lights may be further identified according to their timed characteristics.

Time Characteristics of Flashing Buoys



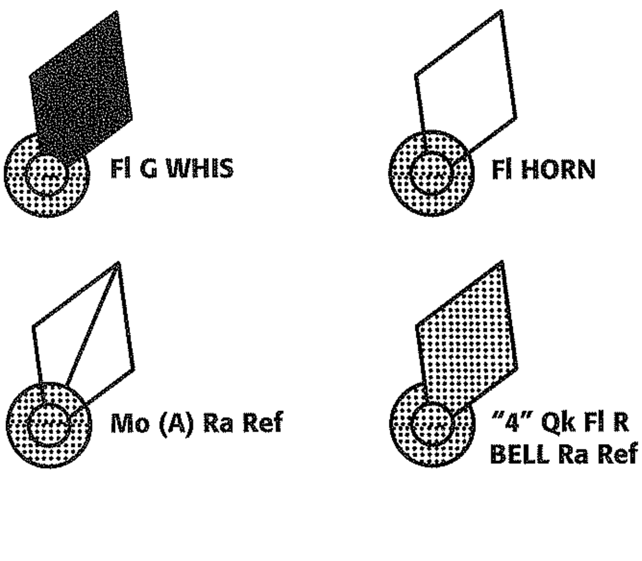
The color of the light is also indicated on the chart. Colors of lights on buoys are either red, green, or white. For red or green lights, the initials R or G are used. If the color of the light is not identified on the chart, it is assumed that the light is white.

Colored Lights on Buoys



Other features may also be on the buoy. These are sound signals, radar reflectors, numbers or letters, or any combination of these features. Bells and horns are spelled out, radar reflectors are abbreviated, and numbers or letters which are painted on the aid are shown in quotation marks.

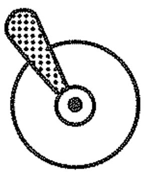
Other Features on Buoys



The Rule of Lettering

On all charts, lettering is printed in both vertical and slanted type. The rule is that if an object is afloat, or it covers and uncovers with tidal action of the water, the descriptive wording or abbreviation is printed in slanted type. If the object is not afloat, or if it does not cover and uncover with the tide, the descriptive wording is printed in vertical type. Thus a mariner can tell at a glance if ALPHA ROCK is an islet or a reef. If the wording is printed in slanted type, it can at times be under water and thus may not be seen. All descriptive lettering for floating aids to navigation is found in slanted type, while descriptions of lighthouses, ranges, and other objects not afloat are found in vertical type.

Symbols for Lighthouses



The basic symbol for a lighthouse is a circle with an overprinted magenta disc and an "exclamation mark." Major lights are named and described while minor lights are described only. The characteristics of the light are shown, the height of the focal plane of the lantern above mean high water is also shown. The nominal range is shown (approximately) in miles, and other equipment on the station is listed.

The symbol at left describes a minor light (not named). The light is fixed white and the lantern is 20 feet above mean high water and visible nine miles.

If the lighthouse has a radio beacon, the magenta disc is surrounded by a magenta circle and the radio frequency and identifying signal are described.

If the radio beacon shared a frequency with other stations, the sequence within the group would be indicated by a Roman numeral. Each station is assigned a minute in its proper sequence. If this station were fourth in its group, the Roman numeral IV would appear behind the RBN frequency. (Normally, the stations operate in groups of six.)

Certain lights are not visible through the 360-degree arc of the horizon, because of interference by land masses. When a light is observed through a portion of its arc, the symbol for the light on the chart is shown with an obscured sector.

Some lights contain a red sector to warn of special dangers within the arc of visibility of the sector. When a light contains such a sector, it is shown on the chart.

Daybeacons

Daybeacons are another type of navigational aid. These structures are built of wood, metal, or masonry. Generally, they are painted to contrast with their surroundings. When a daybeacon is used to mark the side of a channel, the lateral system of coloring and numbering is used. Daybeacons often have reflectors for spotting at night by searchlight.

Intracoastal Waterway

The Intracoastal Waterway is the protected, shallow, inland water route along the Atlantic seaboard from New Jersey to the waterways of south Texas. Pleasure boats and shallow-draft commercial vessels use this waterway to avoid the more hazardous outside passage in the open sea. Its system of buoys to navigation is basically the same as the lateral system, but different distinctive shapes and colors of buoys are used.

All buoys to navigation along the Intracoastal Waterway are, in part, painted yellow in addition to the red and green of the lateral system. Yellow is the indentifying color of this system. On the Intracoastal Waterway, it is considered to be proceeding from seaward when proceeding south along the east coast, and west along the Gulf Coast.

Numbers on buoys going south increase consecutively—odd numbers on the left, even numbers on the right. However, numbers stop at specific points caused by natural dividing lines and start over again.

Western River (Mississippi River) System

Navigational aids on the western rivers consist of many types: unlighted buoys, lighted buoys, shore lights, daybeacons, river gauges, and lights on bridges and locks. These aids are shown on river charts and also tabulated in the light list. Certain tributary rivers also have safety harbor and landing markers and direction boards.

In the Western River System, as a result of custom and usage, all aids are considered with reference to the flow of the river. Red buoys are on the left-hand bank and green buoys are on the right-hand bank as seen from a vessel bound downstream.

This arrangement enables a radio-equipped vessel to communicate with an approaching craft some distance away to report the exact position of any obstruction, misplaced aid, or other hazard.

Types of Buoys

The shapes and coloring of aids on the Western River System are much the same as elsewhere in the lateral system. The red (nun) buoys are located on the left-hand side of the navigable channel and the green (can) buoys are located on the right-hand side as seen from a vessel bound downstream. Unlighted buoys are equipped with reflectors as an aid at night: nuns with red reflectors, cans with green reflectors. Unlighted red and green buoy tops are painted white to increase their visibility at all times. In this case white is not considered a directional characteristic. Red and green horizontal striped buoys marking junctions of the river, wrecks, or other obstructions do not have white tops. Quarantine, anchorage, dredging, and special purpose buoys have the same color and markings as those in the basic lateral system.

In the Western River System, unlighted buoys are not numbered. Numbers on lighted buoys indicate only the number of miles from a given starting point.

Lighted Buoys

The colors and characteristics of all regular channel lighted buoys are as follows:

From the right side of the channel looking downstream:

Flashing Green, 2s (0.2-1.8)

From the left side of the channel looking downstream:

Group Flashing Green or Group Flashing Red 4s (0.2-0.6-0.2-3.0)

Channel Marker Shore Lights

Another type of navigational aid is the channel-marker shore light, mounted on a wood structure, painted white. These lights are now operated electrically.

Many shore lights show the same characteristics as the lighted buoys. Looking downstream they show a flashing white or green from the right bank and flashing white or red from the left bank. Sometimes the light is fixed or occulting.

The channel is buoyed where it is narrow or makes a sharp bend. Where it is straight for a considerable distance, channel shore lights are used as a guide. Each light is visible from the one preceding it.

Range Lights

These aids in separated pairs, one higher than the other, are usually small, skeleton-type structures. They are visible from one direction only. When they are in line, you know you are on a safe course.

By steering a course that keeps these lights in line, you will remain in the channel. But you must consult your charts to know where to leave the range course. Proceeding too far might ground your vessel.

The range lights may be white, red, or green and may be fixed or flashing.

Reflectors

All light structures and daybeacons in the Western River System are equipped with reflectors. As seen from a vessel bound downstream, they are red and white on the left bank, green and white on the right bank. All reflectors are white unless shown as red or green in the light list.

River Gauges

There are signboards at intervals along the riverbanks in the Western River System. Each bears a single number to enable the experienced pilot to estimate the depth of the water at a particular point. These river gauges appear on all river charts. The numbers are changed to conform to the seasonal level of the river.

River Charts and Light Lists

There are two printed aids to navigation that every river pilot should have available for instant use: the light list and the river chart. They are prepared and sold by the Corps of Engineers. The charts show the sailing line or channel, around and between islands in the river, as well as the mileage from a given point to the head of navigation.

Range Lights

Range lights are separated into pairs, one higher than the other, usually mounted on skeleton tower structures. Each of the two rectangle-shaped daymarks are vertically divided into thirds and equally colored with two contrasting colors. They usually are lighted.

The two daymarks or lights, if placed in a vertical line, will mark the center of the channel. By steering a course that keeps the daymarks or lights in line, you will remain in the channel. If your vessel wanders to the right or left in the channel, the range markers will "split" or "open." It is important to consult your navigation chart to know where to leave the range course. Proceeding too close might cause your vessel to ground.

Range lights may be red, green, white, or yellow. Their characteristics vary. Consult your chart to confirm the range characteristics.

Retroreflective Materials

All buoys, daymarks, and light structures in the Western River System are equipped with retroreflective materials. As seen from a vessel bound downstream, they are red on the left bank, green on the right bank, and white or yellow on aids having no lateral significance.

River Gauges

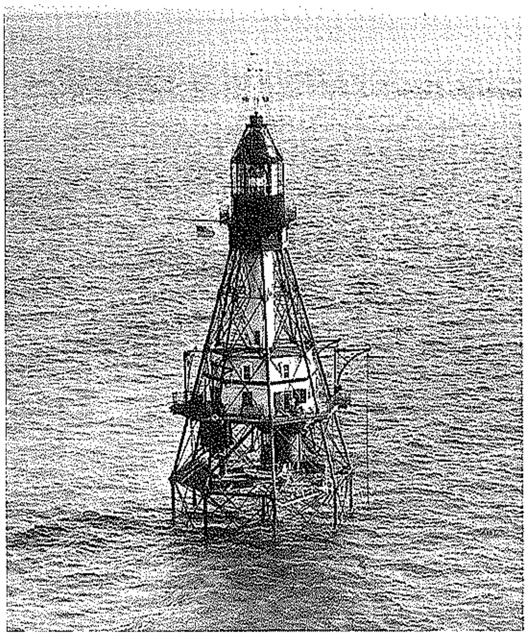
Signboards located at intervals along the riverbanks in the Western River System assist the mariner in determining the level of the river. These river gauges will be listed on the river chart. The numbers are changed to conform to the seasonal levels of the rivers. This information is provided by the U.S. Army Corps of Engineers.

Lights on Locks and Bridges

Colored lights guide the pilot through the many locks on the Western River System and locate the channel beneath bridges.

Radiotelephone Aboard Ship

The use of radiotelephones aboard small craft is becoming increasingly important. All ships' stations are licensed primarily for the safety of life and property. Therefore, any distress or safety communication sent out on the airwaves has absolute priority over any other calls. These calls are transmitted only on specific frequencies. There are, however, other frequencies available to ships that may be used for radiotelephone calls to shore or other ships.



Three types of radiotelephone equipment are common for marine use. The first is single sideband (SSB) and covers long-range communication requirements from 150 to 10,000 miles. This equipment usually is found on oceangoing ships, is relatively expensive, and not normally used aboard Sea Scout vessels. SSB use requires both a station and operator's license.

A more practical type of radiotelephone for Sea Scouting use is very high frequency-frequency modulated (VHF-FM). The VHF radiotelephone has a line-of-sight range and is practical to 20 miles—farther with a tall antenna. As more recreational boaters install VHF equipment, the prices are coming down and it is becoming a practical investment for Sea Scout ships. Neither a station license nor operator's permit is required for VHF-FM radios while in U.S. inland waters. Both, on the other hand, are required in international waters or other territorial waters, such as Canadian or Mexican.

The third type of radiotelephone is citizens' band (CB). Its range is short, discipline is almost nonexistent in its use, and it is not monitored on a regular basis by the U.S. Coast Guard or other agencies. While units are inexpensive, they are not recommended for Sea Scout use. Neither a station license nor operator's permit is required for CB radio use while in U.S. or Canadian inland waters. Both may be required in the territorial waters of other countries, or in international waters.

All radio transmitters aboard ships must be licensed by the Federal Communications Commission. Every licensee is responsible at all times for the lawful and proper operation of the station. Licenses are granted only to United States citizens.

The use of all marine transmitting radios is governed by the Communications Act of 1934, as amended. Generally speaking, there are two kinds of licenses for radiotelephones that may be operated by Sea Scout ships. Before installing a transmitter, consult the nearest FCC field engineering office.

Vessels with six or more passengers for hire must have on duty a radio operator with an FCC Marine Radio Operator Permit.

Radiotelephone Procedures

Citizens' band radio unfortunately has deteriorated to the status of a plaything. Careful discipline is to be maintained, however, in using SSB or VHF marine equipment. The use of "handles," "10 codes," CB jargon, and idle chitchat have no place in marine radiotelephone communication. The Federal Communications Commission monitors transmissions and will issue citations for repeated violations of the rules. Even more effective control can come from other operators. They'll have a few choice words for those who fail to follow the rules. A marine radiotelephone is not a plaything, and operators resent those who misuse it. It can—and has—saved many lives.

Prowords

Marine radiotelephone conversations are terse, efficient, and to the point. A number of procedure words, or "prowords," have become common usage:

OVER. It is your turn to talk.

OUT. I have finished talking and no reply is expected.

ROGER. I understand.

WILCO. I will comply.

SAY AGAIN. Please repeat your last transmission.

I SPELL. I am spelling in phonetic words.

There are other prowords, but these are the most common.

The Alphabet

Letters of the alphabet often sound alike. B, C, D, E, G, P, T, V, and Z can easily be confused. There is no doubt, however, when one hears Bravo, Charlie, Delta, Echo, Golf, Papa, Tango, Victor, and Zulu. So all letters of the alphabet are transmitted by voice using the following words:

A — Alpha	**J** — Juliet	**S** — Sierra
B — Bravo	**K** — Kilo	**T** — Tango
C — Charlie	**L** — Lima	**U** — Uniform
D — Delta	**M** — Mike	**V** — Victor
E — Echo	**N** — November	**W** — Whiskey
F — Foxtrot	**O** — Oscar	**X** — X-Ray
G — Golf	**P** — Papa	**Y** — Yankee
H — Hotel	**Q** — Quebec	**Z** — Zulu
I — India	**R** — Romeo	

So, a radiotelephone call sign WLB 4321 is stated on the air as Whiskey Lima Bravo 4321. To spell the name of the vessel Aeolus, the radiotelephone operator would say, "I spell: Alpha, Echo, Oscar, Lima, Uniform, Sierra."

Using the Radiotelephone

Specific frequencies have been set aside for calling and emergency traffic on SSB and VHF radiotelephones. These are 2182 kHz on SSB and channel 16 on VHF. Each vessel is required by law to monitor the emergency and calling channel unless actively speaking on another channel designated for the type of transmission being sent. VHF radios are required to have channel 6 (safety messages), channel 16 (calling and emergency), and at least one other working channel. Most station operators select channel 9 or 68 for recreational use. Channel 22 is important as it is used to talk to the Coast Guard, channels 26 and 28 are used to place telephone calls, and WX1 and WX2 will receive the weather reports. Care must be taken that channels are used only for their designated purposes.

There is a prescribed format used to initiate a call on a marine radiotelephone. All calls are made on channel 16 when VHF is used, 2182 kHz for SSB. Once contact is established, both stations shift to a working frequency to transact their business. Here's an example of the procedure:

1. Check to be sure that the calling and desired working channels are free of traffic.
2. Place the call, being sure to identify who you are calling and who is making the call:
   "*Callner*, *Callner*, *Callner*. This is *Columbia*, Whiskey Tango Bravo 9876. Over."

If not immediately answered, the call may be repeated. If there is no answer within 30 seconds, two minutes must elapse before calling again.

3. The vessel being called answers:
   "*Columbia*, this is *Callner*, Whiskey Romeo Zulu 4321. Over."
4. The two stations agree on the working channel:
   "*Callner*, *Columbia*; shift and answer six eight."
   "Six eight; wilco."
   Both stations now shift to channel 68.
5. The called station speaks next:
   "*Columbia*. *Callner*, Whiskey Romeo Zulu 4321. Over."
   This identifies the stations now on channel 68.
6. The vessel that originated the call now identifies itself and the conversation proceeds:
   "*Callner*. *Columbia*, Whiskey Tango Bravo 9876." (The message now follows.)

Each vessel's radio operator takes turn speaking. Each message ends with "over" to let the other party know that a reply is desired.

7. When the business has been concluded, both stations sign off and shift back to channel 16:
   "*Callner*, Whiskey Romeo Zulu 4321, out."
   "*Columbia*, Whiskey Tango Bravo 9876, out."

The most misused prowords are "over" and "out." "Over" means, "It's your turn to talk." "Out" means, "I've finished this transmission." If you say "Over and out," you're saying, "It's your turn to talk, but I'm not listening."

Marine radiotelephone messages should be brief, clear, and concise. Each transmission may last no more than five minutes. Each station spends as little time as possible on channel 16, clearing it for emergency and other use.

RADIOTELEPHONE

MARINE DISTRESS COMMUNICATIONS FORM

Instructions: Complete this form now (except for items 6 through 9) and post near your radiotelephone for use if you are in DISTRESS.

SPEAK: SLOWLY—CLEARLY—CALMLY

1. Make sure your radiotelephone is on.
2. Select either VHF channel 16 (156.8 MHz) or 2182 kHz.
3. Press microphone button and say: "MAYDAY—MAYDAY—MAYDAY."
4. Say: "THIS IS ________ ________ ________"
   Your call sign/boat name repeated three times
5. Say: "MAYDAY ________"
   Your boat name
6. Tell where you are (What navigational aids or landmarks are near?).
7. State the nature of your distress.
8. Give number of persons aboard and conditions of any injured.
9. Estimate present seaworthiness of your boat.
10. Briefly describe your boat: ________ feet; ________; ________ hull;
    Length / Type / Color
    ________ trim; ________ masts; ________
    Color / Number / Anything else you think will help rescuers find you
11. Say: "I WILL BE LISTENING ON **CHANNEL 16/2182**."
    Cross out one which does not apply.
12. End message by saying: "THIS IS ________. OVER."
    Your boat name and call sign
13. Release microphone button and listen; someone should answer.

    IF THEY DO NOT, REPEAT CALL, BEGINNING AT ITEM NO. 3 ABOVE.

    If there is still no answer, switch to another channel and begin again.

RADIOTELEPHONE REMINDERS

- Post station license and have operator license available.
- Whenever the radio is turned on, keep the receiver tuned to the distress frequency (2182 kHz or 156.8 MHz).
- Use 2182 kHz and 156.8 MHz for calling, distress, urgency, or safety only.
- Listen before transmitting on any frequency to avoid interfering with other communications.
- If you hear a MAYDAY, talk only if you can help. Be prepared to render assistance or relay the distress message if necessary.
- Identify by call sign at the beginning and end of each communication.
- Keep all communications as brief as possible.
- Keep your radio equipment shipshape. Have it checked periodically by a qualified, licensed technician.
- Notify the FCC of changes to mailing address, licensee's name, and vessel name.
- False distress signals are prohibited.
- Radiocommunications are private, and divulgence of content without permission is prohibited.
- Don't use profane or indecent language.

Emergency Messages

The principal purpose of the marine radiotelephone is to handle emergencies. Three types of emergency messages are used and all are transmitted on channel 16 or 2182 kHz:

MAYDAY: Distress—Loss of life, serious illness or injury, or loss of the vessel is possible.

PAN (pronounced pahn): Urgent—Safety of the vessel or person is in jeopardy. Loss of life or property is not likely but help is needed.

SECURITY (pronounced say-curitay): Safety message—Used to report hazard to navigation, buoy off station, extreme weather, etc.

As soon as a MAYDAY, PAN, or SECURITY message is heard, all other traffic on channel 16 must stop. If someone tries to transmit on any other subject, the command SEELONCE (silence) may be given. Normally the entire MAYDAY or PAN situation is handled on channel 16. If another channel is to be used, this will be ordered by the search and rescue authority, usually the Coast Guard.

Since SECURITY messages do not involve a threat to life or property, all traffic beyond the initial call shifts to a working channel. If a situation is spotted, boaters are usually advised to report it to the Coast Guard and let them evaluate the situation and issue the SECURITY message. Their taller antenna will give better coverage.

If your vessel is in distress, use the format on page 200 to place a MAYDAY or PAN call. These messages must be used only in the event of a real emergency.

Speed Logs

A log is a device for measuring the speed or distance covered by a vessel. Various types of logs have been used at one time or another, but most have been superseded by the marine speedometer.

A simple method for determining speed is called the Dutchman's log. This is simply a method of noting the time it takes a chip, paper, or other floating object to pass from a marked point at the bow to a mark at the stern. The distance in feet is to feet per hour as the time in seconds is to the hour in seconds (3,600 seconds in one hour).

For example, the distance between the marks is 20 feet. The time between the marks is four seconds.

$$(20 \times 3{,}600) \div 4 = 18{,}000 \text{ feet per hour}$$

Multiply the distance (20 feet) by seconds per hour (3,600). This is 72,000. Then divide by the seconds (4), which equals the feet per hour (18,000).

There are 6,080 feet in a nautical mile, so divide the feet per hour by 6,080. This is approximately 2.9 knots. (A knot is one nautical mile per hour—a rate of speed, not a distance.)

If the distances between the marks vary (30 or 40 feet for example) but the time is constant, at four seconds the speeds would be 4.4 knots and 5.9 knots, respectively. Try this formula several times; then work out a chart for your boat similar to the following:

Table 11: Speed Table for S.S.T.V. *Callner*

TIME (seconds)	SPEED (knots)
2	7.4
3	4.9
4	3.7
5	2.9
6	2.5
(Distance bow to stern: 25 feet)	

Great care must be taken to sight down to the water vertically and to mark the time accurately, preferably using a stopwatch.

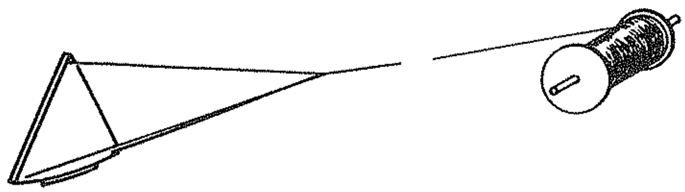
The chip log is well suited for small-boat use, especially at speeds from 2 to 10 miles an hour. The old-time chip log had three parts: chip, line, and 28-second sandglass. The chip was a thin wooden quadrant weighted on the curved edge so that it would float upright. One end of a line was attached to the point of the chip. Lines went from each corner of the chip to a peg-and-socket attached to the line. A sharp tug pulled out the peg and the chip collapsed for easy retrieval. The other end was wound on a small reel.

The line was knotted at intervals of 47 feet, 3 inches. When the chip was thrown overboard, the glass was inverted and the line ran out. The number of knots leaving the reel in the 28 seconds the glass took to empty was approximately equal to the boat's speed in knots. Here is where we get the sea term "knot."

Although fairly accurate up to 10 knots, the chip log has been almost entirely replaced today by the patent log or the speedometer. A chip log is rarely available for sale but can be made easily. We don't use a 28-second sandglass much any more, so a stopwatch, sweep second hand, or digital watch that displays seconds can be used. A 15-second interval is easier to read on a watch, and for this time, the knots are tied 24 feet, 4 inches apart.

A ground log is a simple form of log for showing a boat's approximate speed and direction in shoal water. It consists merely of a weight on one end of a hand line. The weight is thrown overboard and allowed to rest on the bottom. The direction of the line and the amount paid out in a given time as the boat moves indicates the boat's course and speed.

A patent log is any one of various mechanical devices designed to measure a ship's speed, distance, or both. They have three parts: (1) a metal rotator that is drawn through the water with blades that vary its speed of rotation depending on the speed of the boat towing it; (2) a line several hundred feet long attached at one end to the rotator and at the other end to a wheel on the instrument on the boat; and (3) a dial that registers the speed of rotation of the wheel to which



Chip Log

the log line is attached reading in knots and/or accumulated distance in nautical miles. The best-known type of patent log is called a taffrail log.

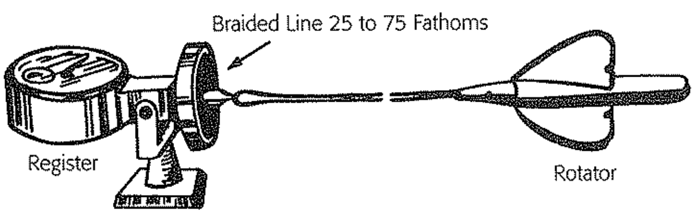
A speedometer is often called a log. It differs from a tachometer, which measures only engine revolutions. Many speedometers utilize the pressure of water rising in a small tube (called a pitot tube) attached outside the hull with a special fitting and connected by tubing to a small dial mounted on an instrument panel. Changes of pressures within the pitot tube are registered on a dial that is calibrated in miles per hour or knots.

Some speedometers are designed specifically for outboards, inboards, or sailboat use. Others operate on the drag of a movable strut that projects into the water from a hull fitting. Under way, the pressure on the strut moves a small piston against hydraulic fluid in a tube, which moves a needle on a dial calibrated to record knots.

Any boat speedometer shows only approximate velocity through the water. The effects of wind and current must be considered to get an accurate reading of speed over the bottom.

A speedometer also gives a check on the performance of the boat. A drop in speed over a period of time could indicate that something on the boat needs attention. Perhaps the engine is not performing as it should, the propeller is damaged, the boat needs trimming, or there is a bottom drag as the result of excessive marine growth.

Taffrail Log



Speed by revolutions is another reliable way of recording distance and speed. Make calibrations at various engine speeds over a course between two marks of known distance. It is preferable to make these tests in relatively calm water and to recheck them often. Compute the speeds for each run at a given rpm, then average the speeds—not the times. Average the runs in both directions to account for wind and current. Then develop a conversion card:

Table 12: Conversion Card S.S.T.V. *Callner*

rpm	knots	mph
600	5.5	6.3
700	6.0	6.9
800	6.6	7.6
900	7.2	8.3
1,000	8.2	9.4
1,100	9.2	10.6

If the distance run is in statute miles, the speed is expressed in mph; if in nautical miles, the speed is in knots. Some conversion cards show both.

This ratio should be periodically checked; many factors can affect the actual speeds.

Remember that hull speed is equal to the square root of the waterline length times 1.34.

The Lead

The lead is one of the most useful instruments aboard ship. The hand lead, or "blue pigeon," as sailors call it, is usually 7 or 14 pounds in weight, although 4-, 6-, 8-, and 10-pound leads are made. A marked line attached to the lead completes the device used for measuring water depths and for bringing up a sample of the bottom. The latter is done by arming or filling a hollow in the bottom of the lead with grease to which the sample adheres.

The lead line is usually 60 fathoms long and is made of well-stretched or untarred American or Italian hemp. Traditionally, there are bits of leather, cloth, etc., fastened to the line at specific fathom intervals. These are called marks. The unmarked intervals between the marks are called deeps.

Today, however, numbered plastics tabs, available in many marine supply stores, can be used to mark the line.

Taking soundings with the lead is done when the vessel has moderate headway. The leadsman casts the lead forward, getting the depth as the vessel passes over the lead as it rests on the bottom.

He or she grasps the lead line about 1 fathom (6 feet) from the end where a small wooden toggle is sometimes seized into the lay of the line. He or she swings the lead back and forth parallel with the side of the ship, from a stand that projects over the side. After making two full circles, he or she releases it at the bottom of its swing to fly forward almost parallel with the surface of the water. With a right-hand throw from the starboard side, the leadsman holds the coils of the line in his or her left hand so the line can run out without hindrance.

As the line flows out and the lead reaches bottom, he or she grasps the running line with the right hand and pulls it rapidly, plunging it up and down to feel if it is resting on the bottom. Feeling bottom, the leadsman plumbs the line up and down as the ship passes by the lead. He or she feels whether the bottom is hard, soft, or sticky and notes the mark above the water.

As a succession of soundings are taken, the leadsman sings out the marks and deeps sharp and clear. Years ago on the Mississippi River, the familiar cry of "By the mark twain," indicating a safe depth, produced the pen name of the famous author Samuel Clemens.

A lead line can be necessary when entering an unknown inlet or channel, in unfamiliar waters at night, in fog, or when anchoring. Not only will these soundings tell you how much water there is under the keel, but by comparing successive soundings with those shown on the chart you can check your boat's position.

Electronic Depth Sounder

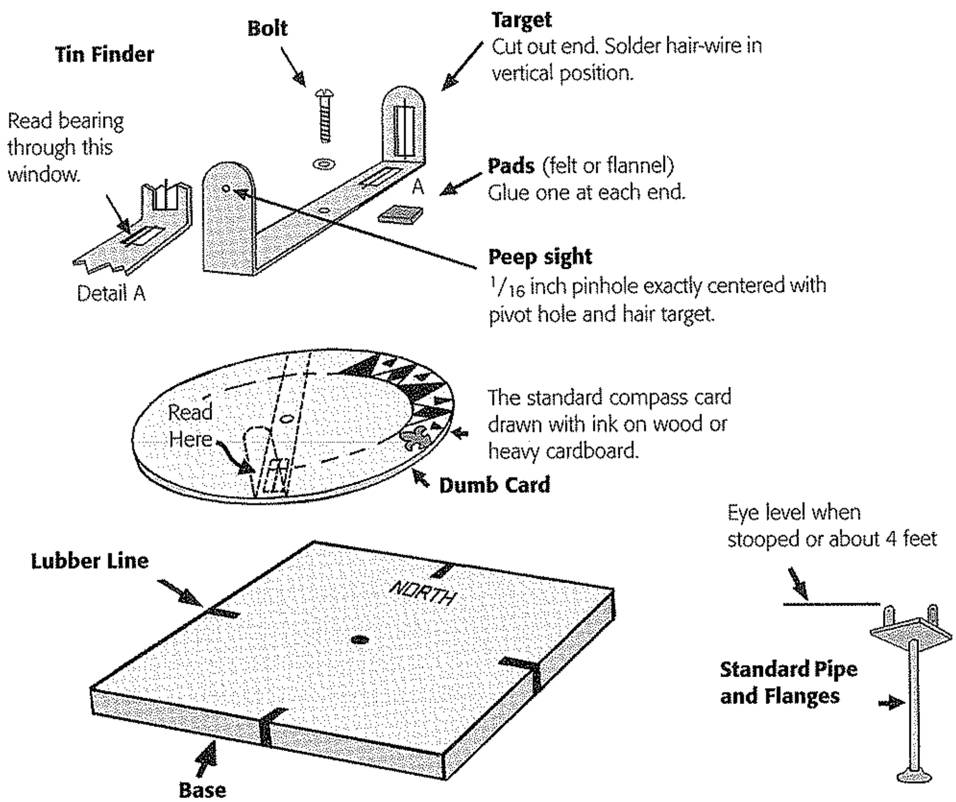
This is an instrument for determining the depth of water under a boat's hull by measuring the time required for a transmitted electronic impulse to reach the bottom and return by echo to the boat. These instruments are called sonic depth finders, echo sounders, depth finders, depth indicators, depth meters, depth sounders, or fathometers.

A depth sounder consists of two elements, an indicator and a transducer. The transducer is a combined transmitter and receiver, installed in the hull. It is small and compact. A cable inside the hull runs from the transducer to the indicator. Electronic pulses are sent and received by the transducer. A unit in the indicator times their travel and converts the result into depth-the distance from the transducer to the bottom. Indicators may be powered either by the boat's batteries or by self-contained batteries.

Pelorus

The pelorus is simply a movable compass card, swung in gimbals and with a sighting apparatus through which the observer may sight an object. The card of the pelorus is set to match the card of the ship's compass so both indicate the same heading. While the ship is held on a steady course to which the pelorus card has been set, the observer swings the sighting apparatus of the pelorus until he or she sees an object on which he or she wishes to take a bearing. He or she reads the pointer, thus determining the angle of the object in relation to the ship's course. This bearing is then plotted on the chart to cross the line of the courses. The pelorus is an interesting and useful instrument that can be made easily.

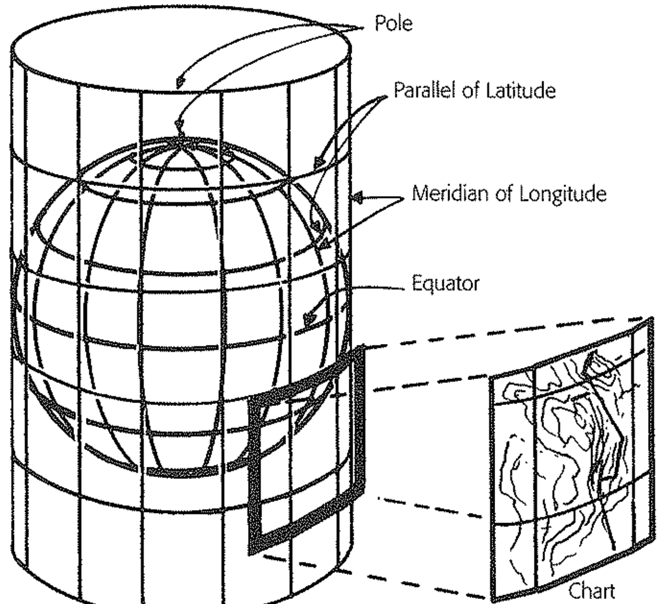
Construction Plans for a Pelorus



Charts

A chart is a detailed scale print or representation (in indelible ink on waterproof paper) of navigable waters. All charts are projected to overcome the curvature of the earth's surface. You would find it impractical to carry a globe of sufficient size for actual navigation. Therefore, for convenience, the round globe is projected onto a flat chart. This transfer is made without loss of accuracy by what is called Mercator projection. The value of this is that a straight course appears as a straight line on a chart. Distances can be measured with a pair of dividers on the latitude scale which is on the east and west sides of the chart. A minute of latitude on the scale is equal to a nautical mile.

A Mercator Projection



A chart is a small section "peeled" from the cylinder or projection.

The longitude scale at the top and bottom of the chart must not be used for measuring distances because in examining the meridians of longitude on a globe one will see that they converge at the poles. It follows, therefore, that for any distance either above or below the equator a degree of longitude becomes progressively smaller, thus giving an incorrect measurement.

Polyconic projection is used on charts of the Great Lakes. This projection is made more nearly to correspond to the earth's true surface. Here both parallels and meridians are curved and are projected to their true length within the area of the chart.

Reading and Using Charts

Some charts print a legend defining specifically the symbols and the abbreviations used. A complete list of symbols and abbreviations is found in the pamphlet Chart No. 1, published by the National Ocean Survey. One should learn and recognize these before actually attempting to use them.

It's important to know the scale to which the chart is drawn. This is given as a fraction just below the chart's title. Harbor charts that show lots of detail may have a scale of 1:10,000 or 1:20,000. This means that one inch on the chart equals 10,000 or 20,000 inches (a little more than 1/8 or 1/4 nautical mile). Ocean charts can have a scale of 1:1,000,000. Here one inch represents 13.7 miles. A small-scale chart has less detailed features; a large-scale chart has greater detail. Remember that the scale is a fraction and that one ten-thousandth is larger than one-millionth.

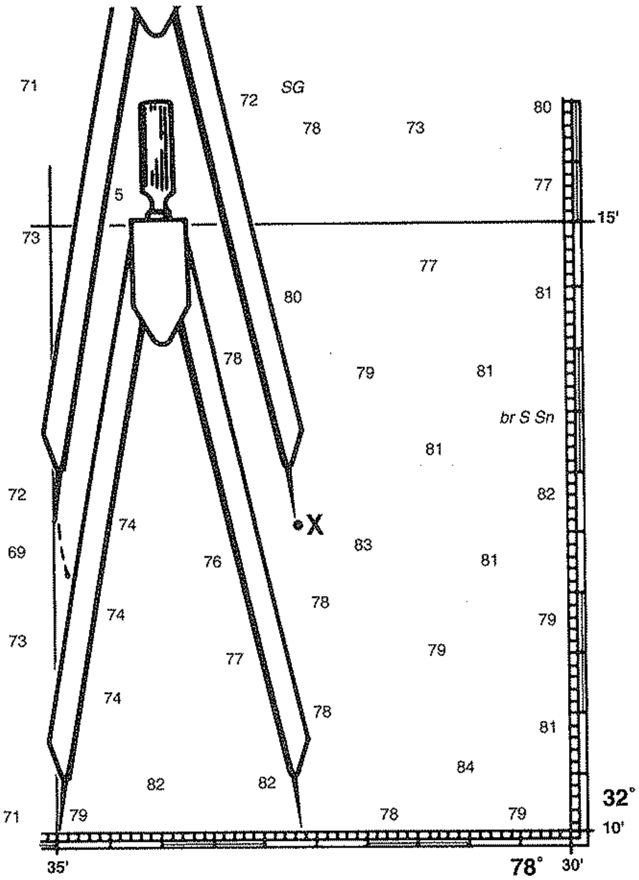
A coastal chart is concerned with varying depths of water and shows soundings in fathoms or feet, depth curves, and shoal and rocky areas. The river chart omits these things because depths are relatively consistent in the main channel. The coastal chart gives the depth of water at mean low tide, while the river chart tells how high the water is at that particular season. Both charts show contours, landmarks, and shore installations.

Both the coastal and the lake sailor need accurate compass courses so the specific chart is made accordingly. Meridians and parallels are shown, with appropriate scales along the chart's east and west edges. There is at least one compass rose with two circles: the outer degrees with zero at true north, the inner in points and degrees with zero at magnetic north.

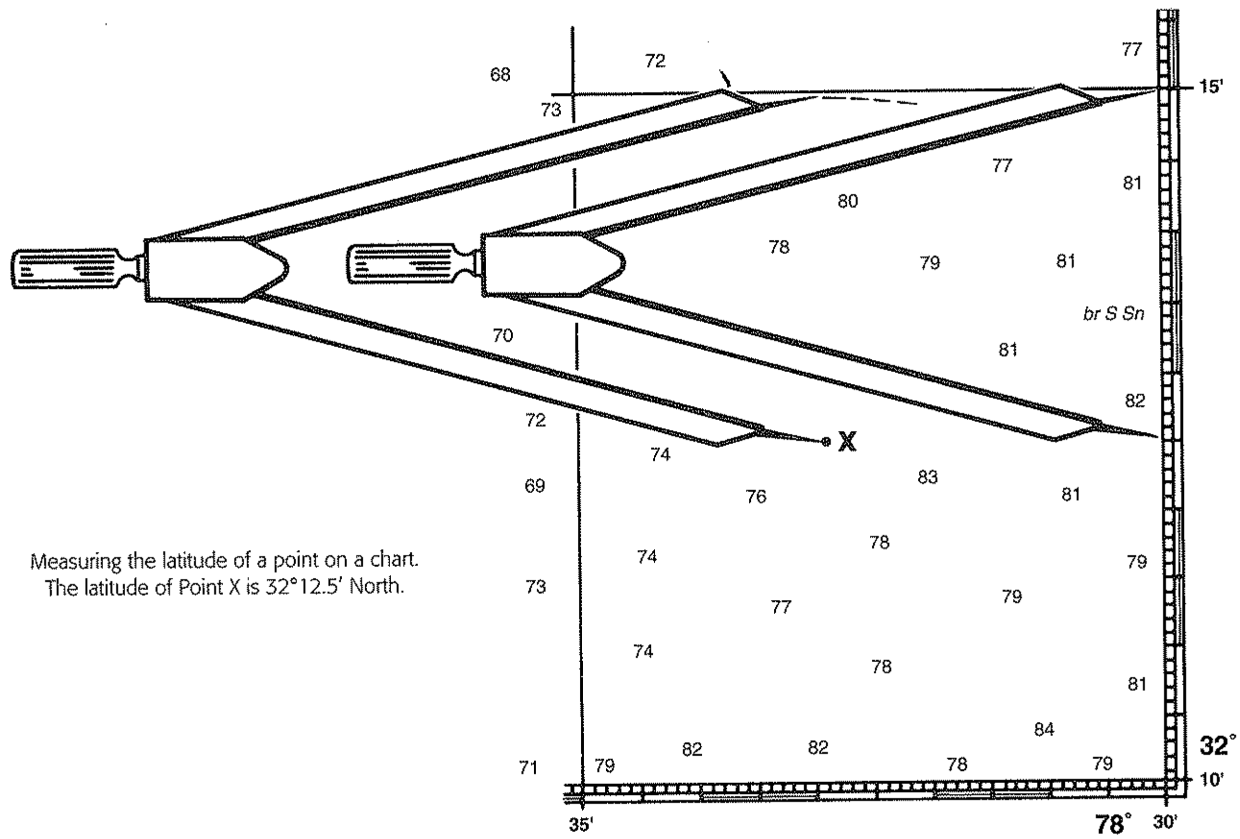
The river sailor needs none of this, so his or her chart simply follows the direction of the stream, and north may be at any angle relative to the sheet. Latitude and longitude may be shown on river charts, but the scales are omitted as are the compass roses.

The coastal chart is measured in nautical miles, and the river chart in statute miles. Mileages on the river itself are normally marked and numbered from a base point.

In using a chart, start by comparing the information on the chart with whatever can be seen. The shore outline, navigational aids, or landmarks will help to locate your



Measuring the longitude of a point on a chart.
The longitude is 78°32.7′ West.



Measuring the latitude of a point on a chart.
The latitude of Point X is 32°12.5′ North.

position on the chart. A course protractor or parallel rules, dividers, and a sharp pencil are necessary for simple chart work.

To determine the direction of any given line on the chart, you can use the course protractor to measure the angle the line makes with a meridian or parallel, then add or subtract accordingly. Or, by using parallel rules, you can "walk" these rules across the chart, without changing direction, to the nearest compass rose. The center of the rose is marked with a small cross. By walking the rules until the leading edge of the rule passes through this cross, the line's direction in degrees as marked on the rose will become evident. You can use or mark either true or magnetic north.

To determine the distance of a line or course on the chart, spread the dividers to the length of the line. Then place the points of the dividers on the distance scale to read the distance in nautical miles or set the dividers for a given number of miles and walk off the distance. On Mercator projection scale charts, the distance can be read from the latitudes scale: one minute of latitude equals one nautical mile.

To describe a position on the chart, note either the latitude and longitude or its distance and direction from some specific point. Latitude and longitude can be determined by using the dividers to measure the distance of the position to the nearest printed parallel and meridian. This distance is then pricked off with the dividers on the latitude and longitude scales on the chart borders. To describe your position relative to another point, find the direction and distance as described and note them: "3.7 miles, 180 degrees true from Cape X Light."

In using any chart, always be certain that you have the latest edition or revision since changes frequently occur. For ease in plotting, obtain the chart with the maximum scale available. Charts can be kept up-to-date by noting changes published in Notices to Mariners, available from the local district headquarters of the U.S. Coast Guard.

Navigation charts for North America are produced largely by three U.S. government departments and one Canadian agency. U.S. National Ocean Survey charts cover all coastal waters in the United States, including tidal rivers. The U.S. Army Corps of Engineers is responsible for important inland waters that include the Mississippi system and the Gulf Intracoastal Waterway. Its U.S. Lake Survey covers the Great Lakes and connecting waters. The U.S. Naval Oceanographic Office produces offshore charts and republishes foreign charts of navigable waters around the world. The Canadian Hydrographic Service charts the dominion's important navigable waters.

Note: Obtain and refer to a chart of your local waters as you study the information in this chapter. Catalogs of charts are available at no charge from National Ocean Survey, Riverdale, MD 20840.

The Practice of Piloting

Piloting in clear weather is relatively simple, but what happens in thick weather? Often in snow, fog, or blinding rain, colors cannot be identified or numbers read.

This is when the shapes of navigational aids help the mariner. A nun-shaped buoy is red; a can is green or black. If you run close to the buoy, you can read the number. If you miss the No. 1 can, for example, in approaching a harbor and you spot No. 3, you are not lost. You can locate your position on the chart and then make your way into the harbor.

Fog is, of course, difficult for all pilots. The methods for locating a ship's position in fog are still somewhat primitive, even with our modern electronic devices, and many small craft do not have modern equipment. At sea, you must always be aware of your exact position. If you encounter fog, you must be able to take a departure to lay a safe course back to port.

If you do not have a radio direction finder aboard, you must depend upon old reliable warnings such as bells, whistle buoys, and lighthouses. However, sounds often play pranks in fog, and wide silent areas are sometimes found near a foghorn itself. Be most cautious: never neglect the lead or depth sounder, go slow, and keep the proper sound signals going as required by the rules of the road. Most helpful to the pilot when listening for sound signals is the illustrated table of the speed of sound.

Speed of Sound

At 40 degrees Fahrenheit, sound travels 1,100 feet per second or one mile in 4.8 seconds.

DEGREES	FEET	SECONDS
50	1,110	4.78
60	1,120	4.73
70	1,130	4.68
80	1,140	4.63
90	1,150	4.59

Modern lighthouses and sea buoys are equipped to transmit an identical sound signal simultaneously with the radio signal. The interval between the reception of the radio signal and sound signal is converted into distance.

Many of the famous river pilots were able to navigate their vessels up and down our rivers by timing the return of echoes made by their ships' sounding devices. It is often wiser to anchor and wait for fog to lift than to attempt a dangerous passage to some unfamiliar harbor or inlet.

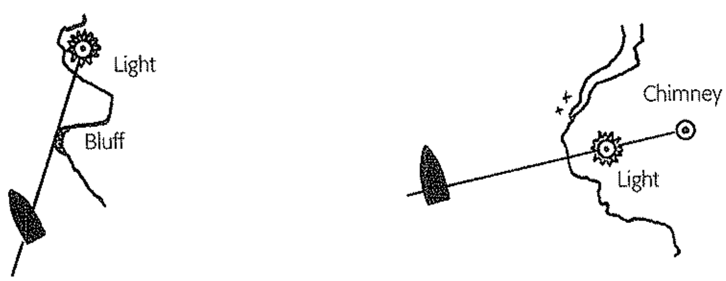
Dead Reckoning

By knowing your speed, the wind, the tide, and the elapsed time you can estimate or "dead reckon" your position after running along known compass courses. As a further check, you can sound for depth. After comparing soundings with your chart, you can calculate a fairly accurate position.

Lines of Position

A line of position (LOP) is drawn on a chart from a bearing or range that shows you are somewhere along that line. The simplest line of position is taken from a range. Sight down two charted objects you can see from the water. Draw a pencil line seaward from them. You are somewhere along that line.

Line of Position From Ranges



It is more common to draw a line of position from a bearing. Take a bearing on a charted object. Correct for variation and the deviation of your boat's heading and draw a line seaward from the object on the reciprocal bearing of the one you observed from the boat. You are somewhere along that line.

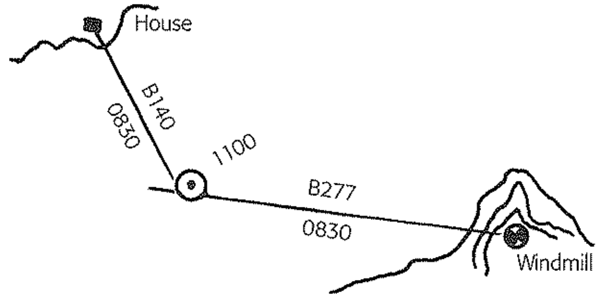
There is some debate over whether bearings should be labeled. Novice navigators are advised to label bearings as this makes it easier to check your plotting. The time goes above the line of position, the bearing from the boat to the object goes below the line.

Fix by Cross Bearings

If you have two or more lines of position taken at the same time, your position is at the intersection of the two lines. This is a fix.

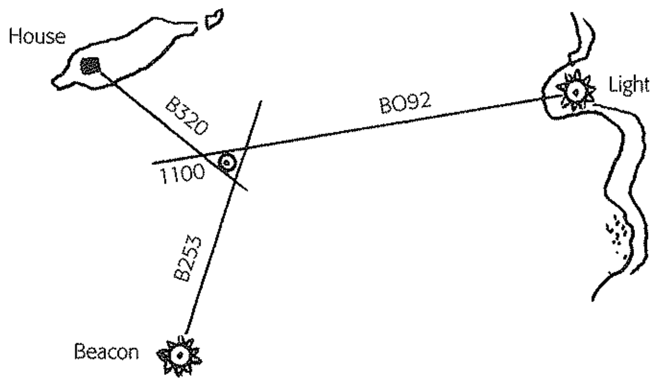
Two crossed bearings provide a reasonably accurate fix. It should be noted that the narrower the angle of intersection of the two lines, the greater the likelihood of error.

Fix by Two Cross Bearings



A fix by three bearings is preferable, whenever possible. Any error is averaged by locating the fix in the center of the small resulting triangle. Sailors call this a "cocked hat." The smaller the triangle, the more accurate the fix. Repeat the bearings if necessary.

Fix by Three Bearings

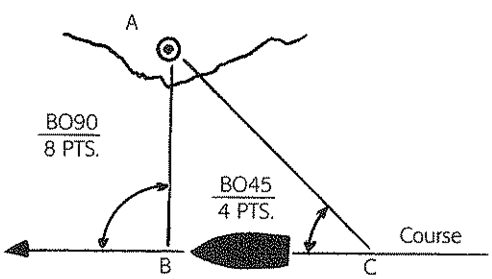


Bow and Beam Bearings

Bow and beam bearings may be taken from the compass, considering the compass as a protractor. When the object bears 45 degrees, or four points, read the log. When the object bears 90 degrees, or eight points, read the log again.

The distance away from the object on the line of position A—B is equal to the distance run B—C.

Bow and Beam Bearings



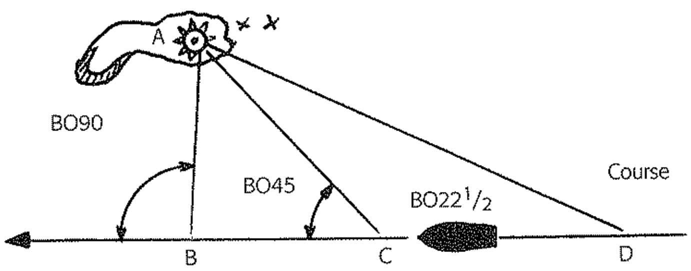
Doubling the Angle on the Bow

Another method of finding distance off is called doubling the angle on the bow. Take bearings as before. Read the log when the object bears 22½ degrees, two points. The distance run between C–D equals C–A or the distance off.

Distance off A–B will equal 7/10 the distance run between C–D. This method is valuable in that it predicts in advance distance off when abeam.

The above problem is merely an example. Any angle observed from D to A may be doubled and logged to obtain C–A. For example, if D is 30 degrees, C would be 60 degrees. However, the 7/10 rule holds good only for the 22½ degree through 45-degree bearings.

Doubling the Angle on the Bow

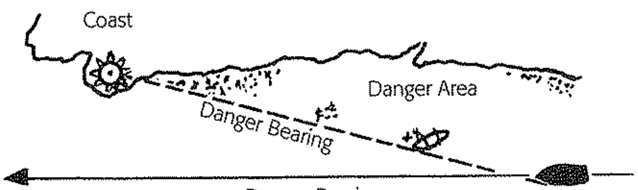


Danger Bearings

A bearing is the direction of an object from a boat while its reciprocal is the direction from an object to the boat. The difference is 180°. For example, the reciprocal of 45° is 225°.

A danger bearing is a convenient way to keep clear of hidden dangers such as shoals, reefs, wrecked vessels, etc., without frequent fixes or reliance on dead reckoning alone.

As illustrated, draw a line from some prominent landmark well ahead so as to clear all dangers and note its direction by compass rose. Take frequent bearings on the object as your vessel proceeds. As long as the bearings are to the right of the dotted lines' bearings, your ship is to the left and safe side of the danger bearing.



Danger Bearings

The Effect of Tides and Currents

All courses, fixes, and lines of position are drawn on the chart in relation to the bottom. The water through which a ship moves is not fixed but moves as a mass in accord with tidal and current forces. Obviously, the course must be corrected by the amount of movement of either or both of these forces.

Currents

The tides and currents of the entire coast have been studied and diagrammed, so mariners may use them to help them along their course. Even when stemming an adverse tide or current, certain areas may be found where the current is lighter.

Information is found in two publications of the National Ocean Survey—the Tide Table and Current Tables. By referring to certain key points where high and low water is given for each day of the year, the navigator may then refer to a table of corrections for his own locale.

For example, high water at New London, Connecticut, may occur at 11 A.M. on January 14. To find the time of high water at any of the several smaller ports nearby or at various points in the river, the tables say: "For Noank, add 50 minutes to time of H.W. at New London" or "For West Harbor, add 31 minutes" or "For Money Pond, subtract 13 minutes." In this way almost every mile of the seacoast is covered with a tidal prediction.

Tides

Ocean tides are caused chiefly by the moon's attraction on the waters of the earth. The pull on the waters nearest the moon creates a daily tide. These tides follow the moon around the earth. The sun is millions of times the moon's weight, but it is so much farther away that its tide-making force is only $4/9$ as great.

When the moon and sun pull together or in opposite directions, there are spring tides, when the high tides are highest and the low tides are lowest. When the sun pulls at right angles to the moon, there are neap tides with less difference between high tides and low tides. The moon travels around the earth about 13 times a year. This means 26 spring tides and 26 neap tides a year.

Tidal currents, depending upon the range of the tide, are greatest during spring tides and least during neap tides.

High water is, of course, that state of the tide when the water is highest. Low water is the time between successive high waters when the tide is lowest.

Slack water may also be designated slack water high and slack water low. It is the period of rest or sluggish current when the tide has flooded or ebbed and is about to turn.

Flood tide is when the water is approaching. The tide rises during flood. Ebb tide is the flowing out of the water. The tide lowers during ebb.

The rise of the tide is the amount it rises above the datum plane of mean low water, the point at which all soundings are shown on charts.

The range of the tide is the extreme difference in tidal level between the lowest low water and the highest high water. In some places, as in the Bay of Fundy, this is as much as 40 feet.

The set of a tidal current is the direction in which it flows. The drift of a tidal current is the speed at which it sets, generally indicated in knots.

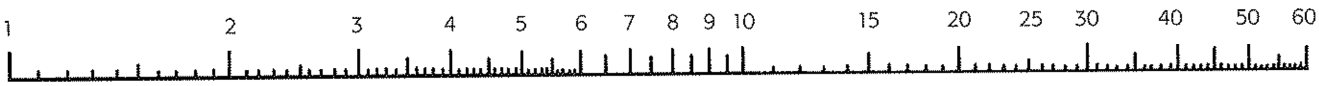
The swiftest current in straight portions of tidal streams is usually in the middle. In curved portions, it is toward the outer edge of the curve. Remember this when bucking the current in a river.

Table for Finding Height of Tide Above Low Water at Any Hour of the Ebb or Flood

Falling Tide Hours after high water	**Rising Tide** Hours after low water	**Constant** Ebb or Flood
0	6	1.0
1/2	5 1/2	0.98
1	5	0.92
1 1/2	4 1/2	0.84
2	4	0.75
2 1/2	3 1/2	0.63
3	3	0.50
3 1/2	2 1/2	0.38
4	2	0.26
4 1/2	1 1/2	0.16
5	1	0.08
5 1/2	1/2	0.025

1. Find rise of tide for given day in the tide tables (difference between heights of nearest high and low tides.)
2. Enter column 1 or 2 on the line corresponding to the time for which height of tide is to be calculated.
3. In column 3, find the constant given for that time.
4. Multiply the constant obtained in (3) by the total rise of the tide (1).

Logarithmic Speed Scale



To find SPEED, place one point of dividers on distance run (in any unit) and the other on minutes run. Without changing divider spread, place right point on 60 and left point will then indicate speed in units per hour. Example: with 4.0 nautical miles run in 15 minutes, the speed is 16.0 knots.

Speed, Time, and Distance

Computing speed, time, and distance is an important part of dead reckoning. Speed is the distance traveled in a unit of time expressed as miles per hour. Speed (S) is distance (D) divided by time (T):

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

Speed is measured in knots or miles per hour, but it's easier to measure time in minutes rather than hundredths of an hour. Therefore, the time in hours is divided by 60 minutes to get the following speed, time, and distance formulas:

$$S = \frac{60 \times D}{T} \qquad T = \frac{60 \times D}{S} \qquad D = \frac{S \times T}{60}$$

Most charts have a logarithmic speed scale located on the upper or lower margin. This is an aid in avoiding the arithmetic, as you can tick off time, speed, or distance with your dividers. Few modern navigators are without a pocket calculator, and this is probably the easiest method to use.

Time is expressed in hours and minutes and the 24-hour clock is used. Thus, 1:20 A.M. is written 0120 and 4:35 P.M. is 1635. Adding and subtracting time can be confusing. The first two digits are hours, the second two digits are minutes, and there are 60 minutes in an hour. If you set out on a cruise at 0845 and have traveled 2 hours, 35 minutes, you would add 0235 to 0845 to arrive at a current time of 1080. Of course, there is no such time so you must remove 60 minutes from the last two digits and add that hour to the first two. The result is 1120, a quite proper time.

Subtracting time can be a problem. If it is now 1605 and you've been traveling for 3 hours, 22 minutes, you'll be tempted to subtract 0322 from 1605 to find out your departure time. The answer of 1283, or 1323, obviously isn't correct. Remember that there are 60 minutes in the hour. If 1605 is written as 1565 (borrowing 60 minutes from the 16 hours), 0322 subtracted from 1565 results in 1243, the correct starting time.

The Dead Reckoning Plot

The skilled navigator takes pride in a neat and accurate dead reckoning plot. Complete details on dead reckoning are beyond the scope of this manual, but an outline of the general principles will help Sea Scouts get started in this important skill. For more complete information, consult any good text on the subject. *Piloting and Dead Reckoning* by Stufeldt and Dunlap is one of the best and most practical.

A dead reckoning plot is the record of your boat's progress based on course steered and speed made through the water. It does not consider wind or current so it does not show your true position at any point—only your "reckoned" position. Your true position is found by fixes from charted features, radionavigation aids, or celestial observations. So, your dead reckoning plot must always start from a known point, a fix. It tracks your progress until the next fix, where you start a new dead reckoning plot.

Some tools are needed for dead reckoning. The minimum will be an up-to-date chart, sharp pencil, pair of dividers, good eraser, and parallel rules, or one of the many plotters available. It is assumed that your boat has a good compass with a deviation table. A pelorus or a hand bearing compass is helpful but not required.

To lay out an accurate plot you must understand variation and deviation to correct a compass course or bearing to a true course or bearing, and how to uncorrect from true to compass. The time-speed-distance formula will be used regularly. You will also need to know how the lines are drawn and labeled. Here are some general rules.

- Always start a DR plot from a known position—a fix.
- All lines on the chart are labeled as soon as they are drawn.
- Numbers are rounded off to the nearest value. If the number is exactly midway between two values, it is rounded to the even value. Thus, 1.44 is rounded to 1.4, 1.46 to 1.5, and 1.45 to 1.4, while 1.55 is rounded to 1.6.
- Time is always expressed in military time: 1:30 A.M. is written 0130, 4:18 P.M. is written 1618. The time of a fix is written parallel to the bottom of the chart, time of a DR position is written at an angle to the bottom of the chart, and if lines of position are labeled, the time is above the line. Time is rounded off to the nearest minute.
- Courses and bearings are always plotted as true directions using three digits. The course is drawn above the course line: a course of 45° is written C 045; 282° is written C 282. If bearings are labeled on lines of position, they are written below the line: a bearing of 185° is written B 185. The degree symbol is not used, as three-digit numbers are always degrees.
- Speed is expressed in knots on oceans and harbors, statute miles per hour on inland waters. The speed used must agree with the chart's usage. Speed is written below the course line and rounded off to the nearest 10th. A speed of 6.27 knots is written S 6.3.
- Distance is rounded off to the nearest $^1/_{10}$ mile. If distance is plotted on a course line, it is written below the line following the speed.
- Dead reckoning positions are indicated by a dot on the course line with a semicircle. DR positions are plotted whenever there is a change in course or speed, as well as every hour, on the hour. The time of all DR positions is noted.
- A fix is marked with a dot surrounded by a circle. The time of the fix is noted and this starts a new DR plot.
- An estimated position is marked with a dot surrounded by a square. The time is not noted, as it will be the same as its accompanying DR position. A new DR plot is never started from an estimated position.
- Latitude and longitude are never marked on the chart. When they are logged, however, they are rounded off to the nearest 10th of a minute or six seconds. Latitude is written first, then longitude. Latitude 42° 18'14" North is written L42° 18.2'N. The latitude scale is used to determine distance; the longitude scale is never used for this purpose.

In addition to plotting the DR course on the chart, the skilled navigator keeps an accurate set of notes on a deck log. A sample page from a deck log is shown on the next page.

A Day's Cruise

Let's see how all this comes together in a day's cruise. S.S.T.V. *Callner* left its slip at 0800 and took a departure from buoy C "1" at 0820. This is a known point, so it's a fix. A compass course of 095 was set for the radio tower, but the variation in these waters is 19° west (it's noted inside the compass rose on the chart) and the deviation at this heading is 1° west. So the true course is 075.

DECK LOG

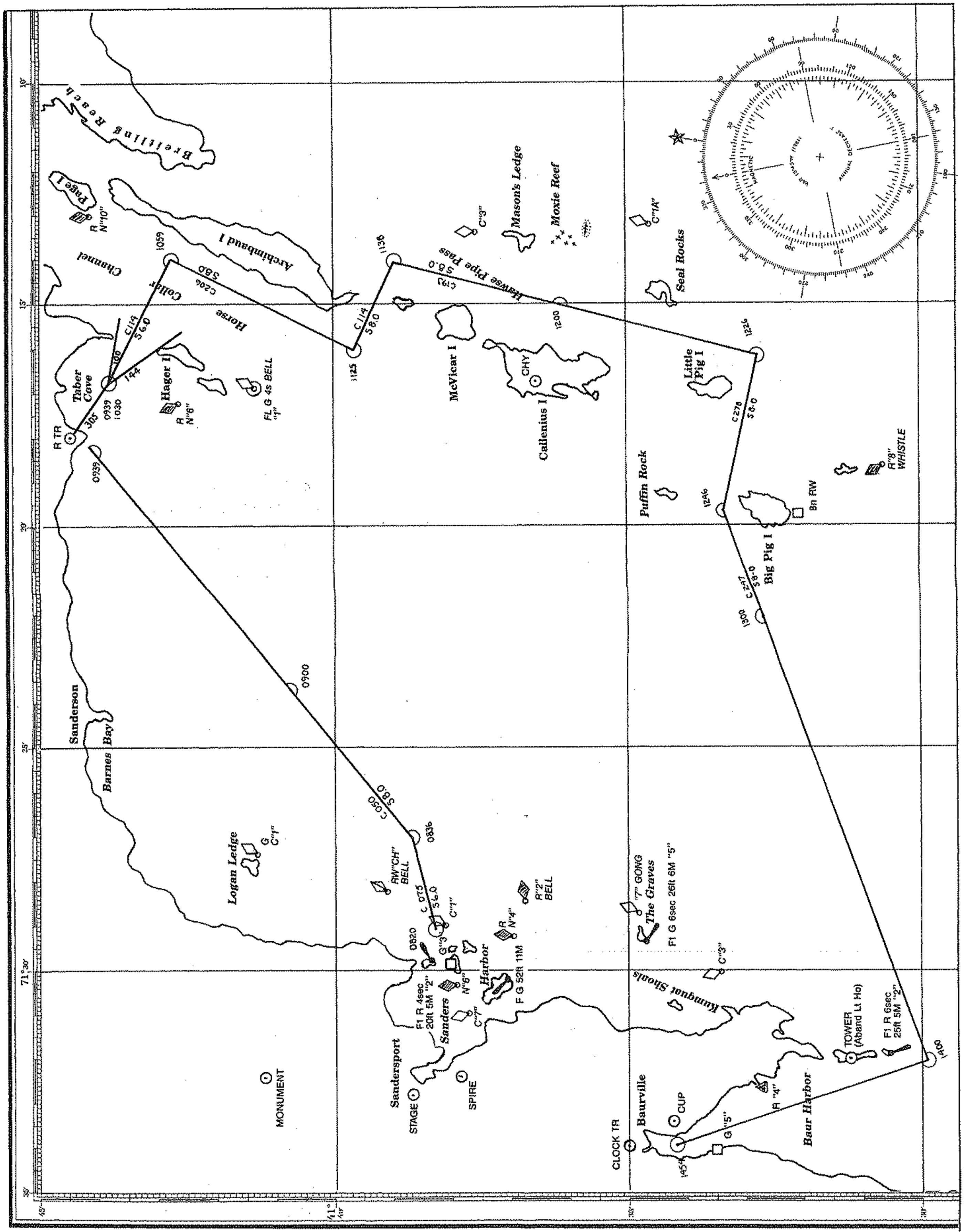
VESSEL ____________ **NAVIGATOR** ____________ **FROM** ________ **TO** ________

Time	Position	Latitude	Longitude	Course				Speed	Log Dist.	Remarks
				True	Var.	Dev.	Comp.			

DECK LOG

VESSEL S.S.T.V. CALLNER **NAVIGATOR** ______ **FROM** 8/1/99 **TO** ______

Time	Position	Latitude	Longitude	Course				Speed	Log Dist.	Remarks
				True	Var.	Dev.	Comp.			
0800										DEPART SLIP & UNDER WAY THRU SANDERS HARBOR FOR FISHING & SIGHTSEEING CRUISE
0820	FIX	41° 83–3' N	71° 29.1' W	075	19W	1W	095	6.0	1.6	TOOK DEPARTURE SANDERS HARBOR BODY C "1"—CLEAR-WIND WNW. 5–10 KT.
0836	DR			050	19W	1W	070	8.0	3.2	COURSE FOR TABER COVE RADIO TR INCREASE SPEED TO 8 KT.
0900	DR								5.2	COURSE & SPEED
0939	FIX	41° 43–9' N	71° 16.1' W							ANCHOR TABOR COVE TO FISH, BEARINGS TABOR PT-100; RTR-305; HAGER NO PT-144
1035	FIX	"	"	114	19W	2W	135	6.0	2.4	RAISED ANCHOR—COURSE FOR HORSE COLLAR CHANNEL—WIND CALM
1059	DR			206	19W	0	225	8.0	3.5	CHANGE COURSE & SPEED DOWN HORSE COLLAR CHANNEL
1125	DR			114	19W	0	135	8.0	1.7	PASS BETWEEN ARCHIMBAUD ISLAND AND MCVICAR ROCK
1138	DR			193	19W	0	212	8.0	2.9	CHANGE COURSE DOWN HAWSE PIPE PASS
1200	DR								3.5	COURSE & SPEED
1226	DR			278	19W	2E	295	8.0	2.7	COURSE TO PASS BETWEEN LITTLE PIG AND BIG PIG
1246	DR			247	19W	1E	265	8.0	1.9	COURSE FOR BAUR HARBOR ENTRANCE
1300	DR								8.0	COURSE & SPEED
1400	DR			341	19W	0	000	5.0	4.5	PASSED AT "2" REDUCED SPEED COURSE FOR BAURVILLE ANCHORAGE
1454	FIX	41° 34–2' N	71° 34–1' W							AT ANCHOR BAURVILLE
1520										CALLNER SECURED. ROWED ASHORE FOR ICE CREAM. M. STRAIN BOATKEEPER



Breitling Reach
Page I
Archimbaud I
Channel
Collar
Horse
Taber Cove
Hager I
FL G 4s BELL "1"
Mason's Ledge
Moxie Reef
Hawse Pipe Pass
Seal Rocks
McVicar I
Callenius I
CHY
Little Pig I
Puffin Rock
Big Pig I
R "8" WHISTLE
R TR
Sanderson
Barnes Bay
Logan Ledge
RW "CH" BELL
R "2" BELL
"7" GONG
The Graves
Fl G 6sec 26ft 6M "5"
Sanders Harbor
F G 52ft 11M
Fl R 4sec 20ft 5M "2"
Sandersport
STAGE
SPIRE
MONUMENT
CLOCK TR
Bauville
CUP
TOWER (Aband Lt Ho)
Fl R 6sec 25ft 5M "2"
Baur Harbor
C 050 S8.0
C 075 S6.0
C 114 S6.0
C 206 S8.0
C 114 S8.0
C 193 S5.0
C 278 S8.0
C 247 S8.0

That's what was plotted. Note that while they steered a course for the radio tower, they arrived at the anchorage in Taber Cove without a change in course. Probably the WNW wind blew them slightly off course. A fix was taken using three bearings to landmarks ashore. This fix not only spotted their position on the chart, but a change in the bearings would alert them to any drifting of the anchor.

By 1035 the wind had calmed down. They were cruising among easily spotted islands and no further fixes seemed necessary. Note that DR positions were plotted hourly and at every change of course or speed. Information that seemed important was listed in the "Remarks" section.

Let's hope that the Sea Scouts who rowed ashore brought some ice cream back to M. Strain, who stayed aboard as boatkeeper.

While it isn't plotted on the sample chart, *Callner* cruised back up to Sanders Harbor later that afternoon. What would have been the best course—a direct route west of the The Graves or a longer dogleg to the east?

Eyeball Piloting

Most boaters cruising coastal or inland waters do not regularly lay down a dead reckoning plot. Some don't know how. Others simply don't bother as they feel that drawing a dead reckoning plot is unnecessary in their situation. They prefer to practice the ancient art of "eyeball piloting."

Skilled eyeball pilots either have a good knowledge of the local waters or have carefully studied the chart. They have noted the buoys passed along the route, spotted charted landmarks likely to be useful, have checked the tide tables, and have a good mental picture of the route to follow. This could be called "mental dead reckoning" as the skipper can visualize the track on the chart and check off landmarks and aids to navigation as they are approached and passed. The skipper is sensitive to the set and drift of the current and adjusts the course to compensate for leeway made.

Sailboat skippers beating to weather keep a mental record of the time involved in each tack. If they do not have a knotmeter aboard, they are probably a good judge of the boat's speed through the water by the way she handles. They have learned from experience how close to sail to the wind and the rate of progress to weather compared to the speed through the water on each tack.

If you ask experienced eyeball pilots where they are, they will probably glance at the coastline, check their compass, look at the chart, and point to a spot that's remarkably close to the actual position. This comes from experience, sensitivity to the boat as it passes through the water, knowledge of the chart, and careful observation of aids to navigation and landmarks ashore.

As soon as fog or foul weather threatens, the truly skilled eyeball pilot gets a good fix and starts a dead reckoning plot. So, the knowledge of dead reckoning is vital even to the best seaman. Failure to keep an accurate track of your position either visually or by dead reckoning can result in becoming lost, going aground, collision, or perhaps loss of life.

Helmsmanship

One of the marks of a good seaman is the ability to steer well. This skill is developed not by study, but by a good deal of practice. Not all of the principles given for proper steering of a ship will always apply to small boats, but if you learn the fundamentals of steering a large vessel you will do a better job at the wheel of a small boat.

There are certain commands given to a helmsman that need explanation. The old expressions of PORT HELM and STARBOARD HELM have given way to RIGHT RUDDER and LEFT RUDDER. The latter expressions allow no possibility of confusion.

If the maximum available rudder arc is 35°, full rudder is likely to be only 30°, the remaining degrees being used only for emergencies. Rudder amidships, obviously, requires the helmsman to align the rudder exactly fore and aft. If the rudder is to be turned a specified number of degrees—10 degrees to port—the command is LEFT 10 DEGREES RUDDER. If the rudder angle is to be increased, the command is GIVE HER MORE RUDDER; decreased, EASE THE RUDDER. With the rudder at 15 degrees, EASE TO 10 would indicate to the helmsman exactly how much rudder is to be eased.

Handsomely means gradually or carefully. Therefore, if the command is RIGHT, then HANDSOMELY, would call for only a slight change to the right.

To check the swing of a ship without stopping it entirely is to MEET HER. STEADY or STEADY AS YOU GO or STEADY SO means to hold it on the course. If the command is given while the ship is still swinging, the helmsman notes the course when the command is given and steadies on that course.

When the course to be made good is a little to one side of the set course, the command may be NOTHING TO THE RIGHT or NOTHING TO THE LEFT. If the latter, the helmsman knows he or she must not let the ship go to the left of the ordered course.

In maneuvering, an officer may order SHIFT THE RUDDER. The ship, for example, might be turning to starboard with right rudder. As headway is checked, the rudder is changed from right to left.

MIND YOUR RUDDER means to stand by for an order or perhaps to pay better attention to the steering. However, if the ship is getting off her course too much—to the left, let us say—the command is MIND YOUR RIGHT RUDDER. This would mean, use your right rudder to counteract the tendency the ship has toward the left of her course.

Commands from the officer of the deck are repeated by the helmsman. Then, when the command has been executed, he reports, as an example, STEADY ON COURSE 192, SIR. The officer's acknowledgment may be VERY WELL if the report is correct or acceptable, or the reply may be KEEP HER SO if the helmsman is to continue to steer the course reported.

Steering

At sea, most steering is done by compass, requiring the helmsman to keep the lubber's line of the compass on that mark of the compass card which indicates the course to be steered. Remember that the card stands still while the ship swings.

As a vessel swings with a change in course, there is a tendency for the inexperienced helmsman to allow the vessel to swing too far. A crooked course, yawing side to side, is the result. When piloting a small boat, pick out a distant landmark or a star at night to steer by. When using a star as a mark, remember that stars, like the sun and moon, move across the sky so that every 15 minutes, you must pick out a new star and check constantly with the compass.

These things help to maintain a straight course; the compass on a small boat is more affected by pitching and rolling than a compass on a large vessel. Using a landmark by day or a star at night, the helmsman can steer a good course by dropping his eye occasionally to the compass to check that he or she is on course.

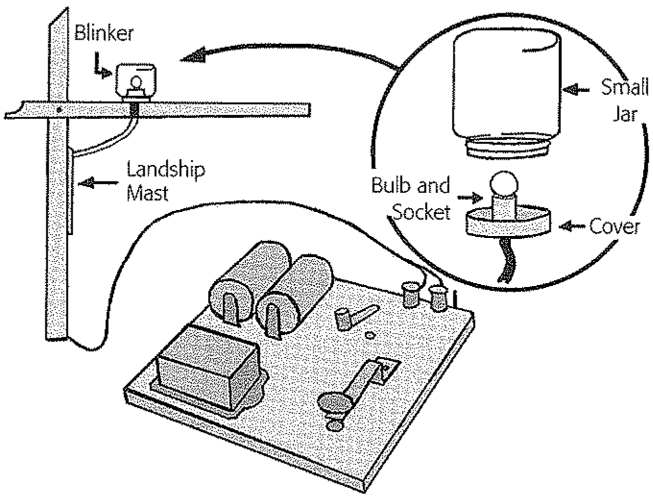
Communications Signaling

Signaling is carried out at sea in several ways. Some of the devices are the use of radio, Global Marine Distress Signalling System (GMDSS), International Code flags, signal flags, and blinker lights.

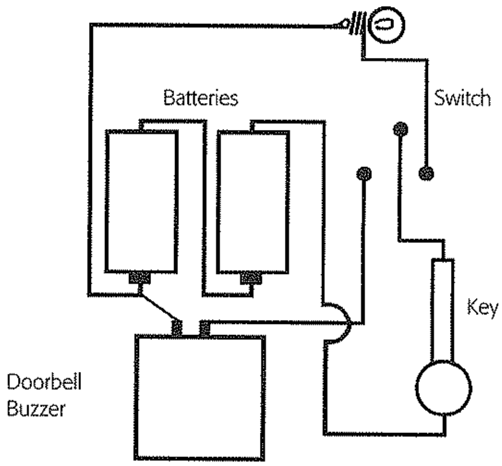
The International Morse Code

Until recently, the Morse code was the standard signaling means throughout the world. It is still frequently used in non-telegraphy signaling. It is possible to send Morse code by several different methods: it is easily simulated by a simple electric buzzer; it may be signaled by the ship's whistle, siren, or foghorn; or it may be transmitted by signal flag when the flag is held erect for a long interval

Practice Blinker/Buzzer



Wiring Diagram



INTERNATIONAL MORSE CODE

Letter	Code	Sound
A	• —	di-dah
B	— • • •	dah-di-di-dit
C	— • — •	dah-di-dah-dit
D	— • •	dah-di-dit
E	•	dit
F	• • — •	di-di-dah-dit
G	— — •	dah-dah-dit
H	• • • •	di-di-di-dit
I	• •	di-dit
J	• — — —	di-dah-dah-dah
K	— • —	dah-di-dah
L	• — • •	di-dah-di-dit
M	— —	dah-dah
N	— •	dah-dit
O	— — —	dah-dah-dah
P	• — — •	di-dah-dah-dit
Q	— — • —	dah-dah-di-dah
R	• — •	di-dah-dit
S	• • •	di-di-dit
T	—	dah
U	• • —	di-di-dah
V	• • • —	di-di-di-dah
W	• — —	di-dah-dah
X	— • • —	dah-di-di-dah
Y	— • — —	dah-di-dah-dah
Z	— — • •	dah-dah-di-dit

Number	Code	Sound
1	• — — — —	di-dah-dah-dah-dah
2	• • — — —	di-di-dah-dah-dah
3	• • • — —	di-di-di-dah-dah
4	• • • • —	di-di-di-di-dah
5	• • • • •	di-di-di-di-dit
6	— • • • •	dah-di-di-di-dit
7	— — • • •	dah-dah-di-di-dit
8	— — — • •	dah-dah-dah-di-dit
9	— — — — •	dah-dah-dah-dah-dit
0	— — — — —	dah-dah-dah-dah-dah

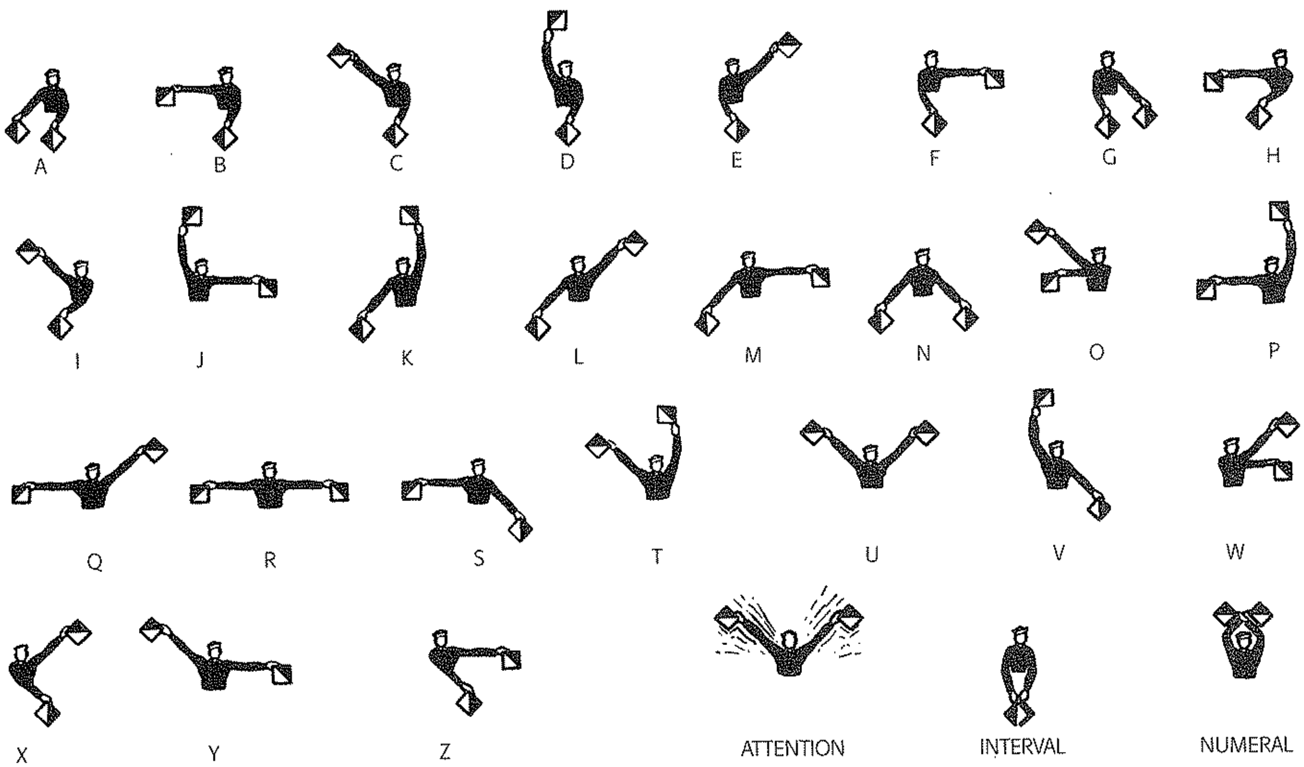
for dashes and a short one for dots, or, more commonly, swung to the sender's right for a dash and to the sender's left for a dot.

It is also sent with a blinker system. This method can be improvised in many ways, and every seaman should know them. A pocket flashlight, a lantern covered and uncovered by a piece of clothing or any opaque object, a porthole opened and closed, or any of the standard ship's lights can be adapted.

Semaphore

This method of signaling is an old favorite of the Navy and has much to recommend it. It is the fastest way of sending messages by flags. It can be used only in the daytime and at short distances. Form the letters by placing two flags at certain angles to each other. Hold each so that the staff is a continuation of your forearm. Keep your arms stiff.

Semaphore Signaling



Whenever you cross a flag in front of you to make a letter, twist your body slightly in the same direction.

To send a semaphore message, get the receiver's attention with the attention signal, made by waving both flags repeatedly overhead in a scissorlike motion. When the receiver sends the letter K, you can go ahead.

Send the letters of each word by going directly from the position of one letter, without stopping, into the position of the next, pausing in each. If you have to think of the next letter, hold the letter you are making until the next one comes to mind.

To indicate the end of a word, give the front signal by bringing the flags down in front of you, with the staffs crossing each other.

Procedure Signs

MEANING	EXPLANATION	MORSE			SEMAPHORE
		Radio	Blinker	Wigwag	
Attention	I have a message for you; make ready to receive.	Call or CQ	Call or AA	Call or Waving Overhead	Call or Waving J
Go ahead	I am ready to receive.	K			
Wait	Wait—I will be ready to receive you or to finish in a moment.	AS			
I cannot receive you	Radio: Your signals are too weak.	QRJ			
	Blinker: Your light not properly aimed.		W		
	Flags: Move up Move down Move right Move left			MU MD MR ML	
Break	Beginning of text of message.	BT			
End of word	End of word.	Space		Front	
End of sentence	Period.	AAA			
Error	I have made a mistake and will repeat.	EEEEEEEE			
Word received	Made by receiver after each word to indicate received.		T	T	C
Repeat	Repeat.	IMI			
Message received	Message is received completely.	R			
End of message	Signing off—no more traffic.	AR			

Whenever double letters appear in a word, use the front signal to separate them. Make the first letter, then front, and immediately, without pause, bring the flags again in position of the letter.

The receiver acknowledges each word by sending C. If he or she suddenly sends IMI, it means that he or she did not catch your last word. Repeat it and continue from there. If you have made an error yourself, send eight Es and start again from the beginning of that word. Finish the message with AR and wait for the receiver to make the letter R. This means the receiver has your message.

The International Code Flags

Any extensive use of the International Code flags will call for the use of *International Code of Signals*, published by the U.S. Naval Oceanographic Office. A few of the principal signals and the general method of making and answering signals are given here.

HOW TO MAKE A SIGNAL. If you want to make a signal, hoist your ensign with the code flag under it. If more than one vessel or signal station is in sight and your signal is intended for a particular vessel or signal station, indicate which vessel or signal station you are addressing by making the distinguishing signal (i.e., the signal letters) of the vessel or station with which you want to communicate. If you don't know the distinguishing signal, observe that ships will answer with their distinguishing signal hoists or answering pennant.

When you have been answered by the vessel you are addressing, proceed with your signal, first hauling down your code flag. It may be required for making or answering signals.

Signals should always be hoisted where they can be best seen, not necessarily at the masthead. Each hoist should be kept flying until the other ship hoists her answering pennant close up. When finished signaling, haul down your ensign.

HOW TO ANSWER A SIGNAL. On seeing a signal made by another ship, hoist your answering pennant at the dip. (A flag is at the dip when it is hoisted about three-quarters up its halyard.)

Always hoist the answering pennant where it can be seen best.

When the hoist has been recognized and is understood, hoist your answering pennant close up, and keep it there until the other ship hauls her hoist down. Then haul your answering pennant down to the dip and wait for the next hoist.

If the other ship's flags cannot be made out or the signal is not understood, keep your answering pennant at the dip, and make a signal to that effect. When she has repeated or clarified her signal, hoist your answering pennant close up.

The International Code flags (see appendix M, "International Flags and Pennants," for color illustrations) consist of:

- Two swallow-tailed burgees: A and B
- Twenty-four square flags: C, D, E, F, G, H, I, J, K, L, M, N, O, P, Q, R, S, T, U, V, W, X, Y, and Z
- Four repeater pennants
- Ten numeral pennants
- The code pennant

The code flags come in various sizes. The square flags, 3 by 3 feet, are handy for Sea Scouting.

The best method of practice is to rig up two widely separated masts or halyard hauls. Then have your instructor give a set of signals to one group, noting the time, speed, and accuracy in which they are transmitted. Then have the second group send some signals.

Signal flags should be properly bent, either with a sheet or signal halyard bend, or with snap hooks. The best way to stow and use flags for quick work is to have a signal rack and a signal bag made of canvas. Flags should never be stowed wet and should be kept in repair.

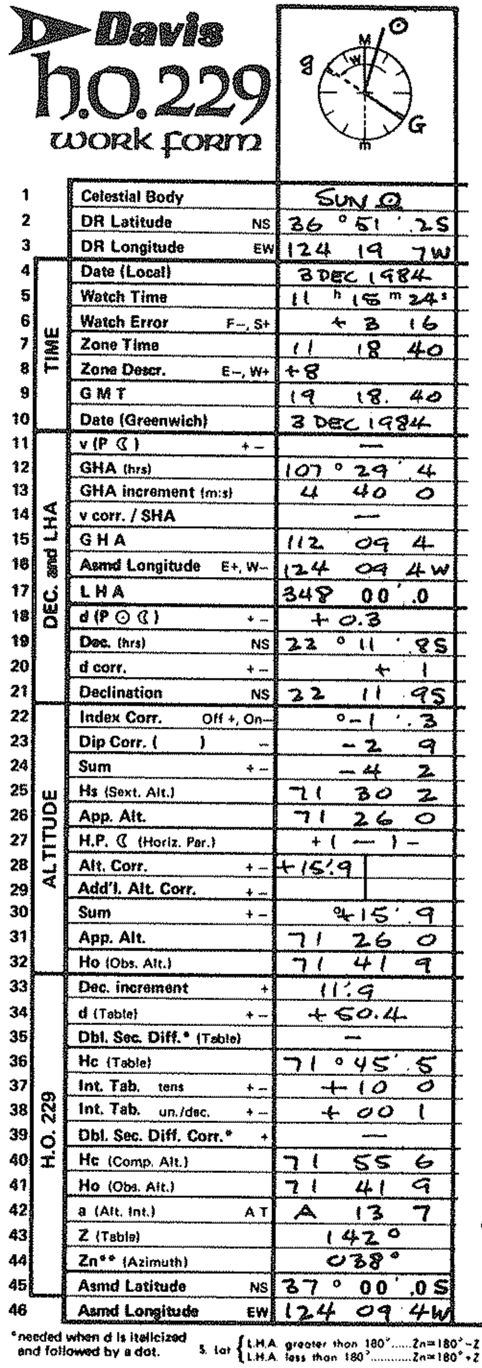
Navigation and Weather

Navigation today is an exact science that makes it possible for the mariner to take his or her ship anywhere in the world that can be reached by water. At any time, he or she can determine his or her precise position while at sea by celestial observations or through the use of electronic devices.

Piloting—an elementary form of navigation—utilizes visible and audible aids such as lighthouses, buoys, horns, bells, soundings, coastal-land features, etc., to aid in determining position and course headings.

Navigation requires a working knowledge of the "great chart of the sky" by day or night to determine position relative to the sun, moon, and stars by careful observation and measurement.

All pilots and navigators must have a thorough knowledge of charts and their meaning, as well as a thorough knowledge of latitude and longitude, on which all piloting and navigation are based.



Davis h.o.229 work form

1		Celestial Body	SUN ☉
2		DR Latitude NS	36° 51'.2S
3		DR Longitude EW	124 19 7W
4	TIME	Date (Local)	3 DEC 1984
5	TIME	Watch Time	11h 15m 24s
6	TIME	Watch Error F–, S+	+ 3 16
7	TIME	Zone Time	11 18 40
8	TIME	Zone Descr. E–, W+	+8
9	TIME	GMT	19 18. 40
10	TIME	Date (Greenwich)	3 DEC 1984
11	DEC. and LHA	v (P ☾) +–	—
12	DEC. and LHA	GHA (hrs)	107° 29'.4
13	DEC. and LHA	GHA increment (m:s)	4 40 0
14	DEC. and LHA	v corr. / SHA	—
15	DEC. and LHA	GHA	112 09 4
16	DEC. and LHA	Asmd Longitude E+, W–	124 09 4W
17	DEC. and LHA	LHA	348 00'.0
18	DEC. and LHA	d (P ☉ ☾) +–	+ 0.3
19	DEC. and LHA	Dec. (hrs) NS	22° 11'.8S
20	DEC. and LHA	d corr. +–	+ 1
21	DEC. and LHA	Declination NS	22 11 9S
22	ALTITUDE	Index Corr. Off +, On–	°– 1'.3
23	ALTITUDE	Dip Corr. ( ) –	– 2 9
24	ALTITUDE	Sum +–	– 4 2
25	ALTITUDE	Hs (Sext. Alt.)	71 30 2
26	ALTITUDE	App. Alt.	71 26 0
27	ALTITUDE	H.P. ☾ (Horiz. Par.)	+ (—) –
28	ALTITUDE	Alt. Corr. +–	+15'.9
29	ALTITUDE	Add'l. Alt. Corr. +–	
30	ALTITUDE	Sum +–	+15'.9
31	ALTITUDE	App. Alt.	71 26 0
32	ALTITUDE	Ho (Obs. Alt.)	71 41 9
33	H.O. 229	Dec. increment +	11'.9
34	H.O. 229	d (Table) +–	+ 60.4
35	H.O. 229	Dbl. Sec. Diff.* (Table)	—
36	H.O. 229	Hc (Table)	71° 45'.5
37	H.O. 229	Int. Tab. tens +–	+ 10 0
38	H.O. 229	Int. Tab. un./dec. +–	+ 00 1
39	H.O. 229	Dbl. Sec. Diff. Corr.* +	—
40	H.O. 229	Hc (Comp. Alt.)	71 55 6
41	H.O. 229	Ho (Obs. Alt.)	71 41 9
42	H.O. 229	a (Alt. Int.) A T	A 13 7
43	H.O. 229	Z (Table)	142°
44	H.O. 229	Zn** (Azimuth)	038°
45		Asmd Latitude NS	37° 00'.0S
46		Asmd Longitude EW	124 09 4W

*needed when d is italicized and followed by a dot.

S. Lat { L.H.A. greater than 180°.....Zn=180°–Z; L.H.A. less than 180°.....Zn=180°+Z }

Product No. 203

This work form shows only one work column; the full sheet has four.

Latitude and Longitude

Latitude is distance north or south of the equator. Parallels of latitude are small circles (a circle whose plane does not pass through the earth's center) equidistant north or south of the equator, diminishing in size as they approach the poles.

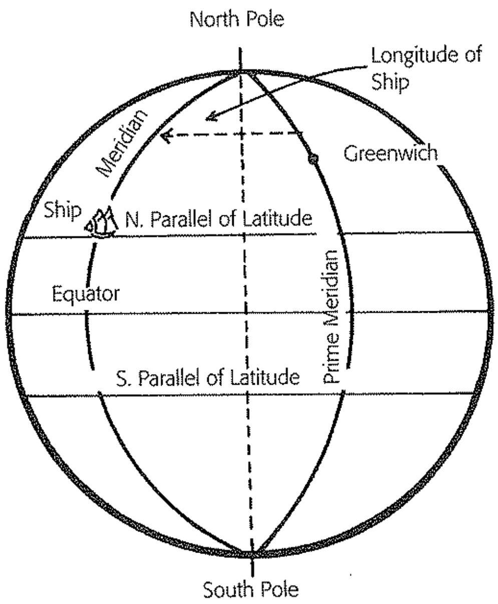
Longitude is distance east or west of the prime meridian which passes through the Royal Naval Observatory in Greenwich, United Kingdom. All meridians are great circles that pass through the North and South poles.

Keep in mind that the earth is a nearly spherical body slightly flattened at the poles. Its longer or equatorial diameter measures about 7,927 statute miles. Its axis (or polar diameter) is about 7,900 statute miles. Actually an oblate spheroid, for all practical navigational purposes, the earth may be considered a perfect sphere.

The equator divides the earth's surface into two hemispheres. It is the only latitude great circle. Therefore, its plane passes through the center of the earth.

The shortest distance between any two points on the earth's surface will be along the edge of a great circle.

Meridians are the great circles passing through the poles. These great circles intersect the equator at right angles. They are used to define longitude east or west of the prime meridian and are measured in degrees (°), minutes ('), and seconds (") from 0° to 180°. The angle at the poles between this prime meridian and the meridian passing through the ship is the ship's longitude.



Parallels of latitude are small circles parallel to the equator, measured along a meridian, numbered in degrees from north or south 0° at the equator to 90° at the poles.

Latitude and longitude enable a navigator to pinpoint his or her position at any spot on the earth. It is also used to describe the location of other ships, objects, and aids to navigation. The latitude is normally written first and identified as north or south, longitude is written next and labeled east or west. In practice, the coordinates are rounded off to the nearest 10th of a minute. Thus Ambrose Light at the entrance to New York Harbor, for example, is located at Lat. 40°27'5" N, Long. 73°49'9" W.

The difference of latitude between any two points on the earth's surface is the arc of a meridian intercepted between the parallels of latitude passing through the places. The difference of longitude between any two places is the arc of the equator intercepted between their meridians.

The nautical or sea mile is 6,076 feet—the statute or land mile is 5,280 feet. The nautical mile is the average length of one minute of arc on a great circle of the earth. A degree of latitude contains 60 minutes of arc and, therefore, is 60 nautical miles long.

A degree of longitude is 60 miles long only at the equator; so when degrees of longitude are figured north or south of the equator along any parallel of latitude, the degrees become shortened and the minutes become less than a nautical mile in length. This is why the measurement of distance is always taken along the latitude scale of a chart.

The blue-water navigator relies on five things: compass, sextant, taffrail or patent log, chronometer, and electronic receiving equipment—radio direction finder, radar, loran, GPS (Global Positioning System), and consolan. (*Note*: See page 235.)

If his or her ship is equipped, like most modern vessels, with an inertial navigation system (INS), complete with computers, he or she can achieve almost fantastic navigational accuracy. All this is a complex field and for the most part outside the scope of this manual.

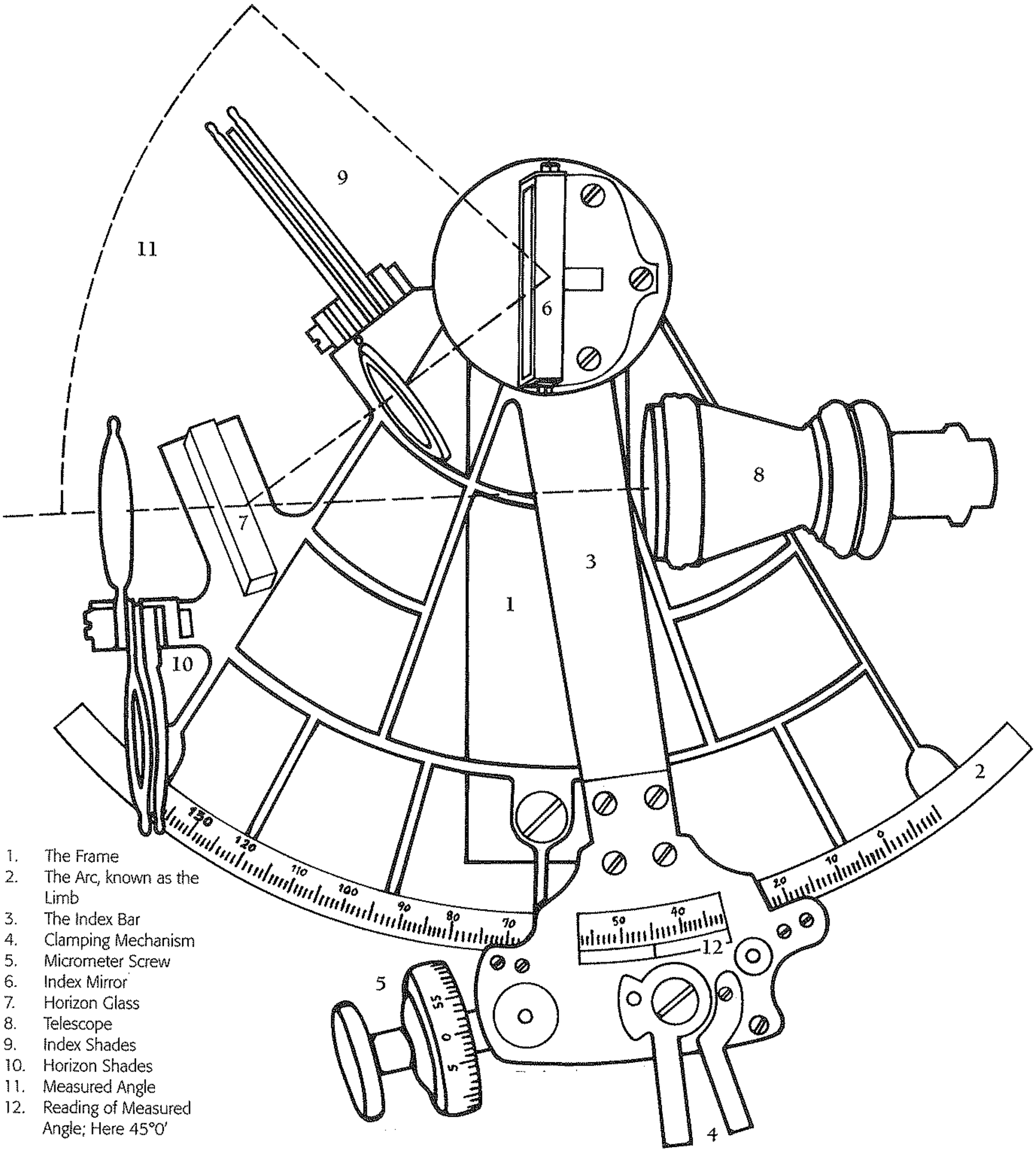
Textbooks covering the subject are listed at the end of this manual. We will, however, introduce you to the subject by discussing briefly some of the navigator's tools.

Celestial Navigation

Celestial navigation can be defined as determining a ship's position by the observation of celestial bodies (sun, moon, planets, and stars). It is a detailed subject far beyond the scope of this manual, but it is hoped that some general principles will inspire Sea Scouts to learn more about the navigator's art. While less complicated in practice than it appears in theory, celestial navigation is best learned with an instructor. The classical navigation textbook is Bowditch. It is far too complicated for the beginner, however. A number of excellent small books are now available with the general theme of "Celestial Navigation Made

Easy." Those that strip away the theory and deal with practical situations are recommended.

Celestial navigation begins with the geographical position or ground point (GP) of a celestial object. The ground point is that spot on the earth where the object is directly overhead. If we can find where we are in relation to a celestial object's ground point, we can draw a line of position. In the sections of this manual on piloting and dead reckoning, we learned that when two or more lines of position intersect, we have a fix. So, if we can draw two or more lines of position related to the ground points of two or more celestial bodies, we have a fix.



1. The Frame
2. The Arc, known as the Limb
3. The Index Bar
4. Clamping Mechanism
5. Micrometer Screw
6. Index Mirror
7. Horizon Glass
8. Telescope
9. Index Shades
10. Horizon Shades
11. Measured Angle
12. Reading of Measured Angle; Here 45°0'

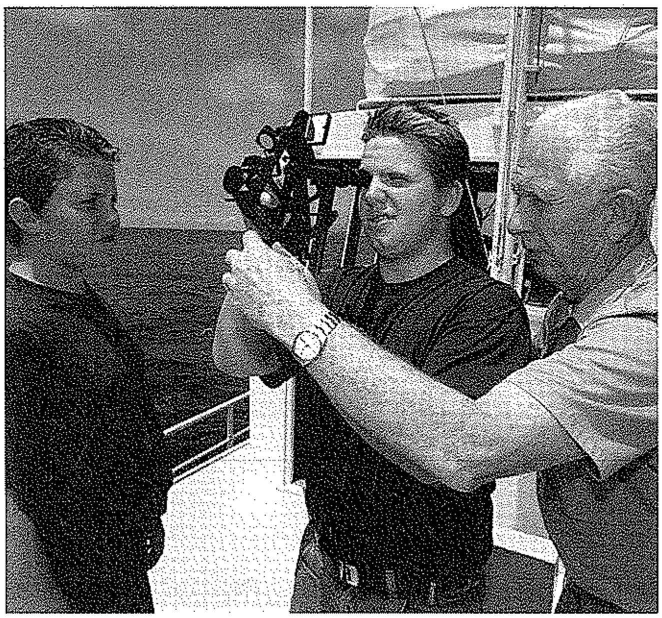
To achieve this, the navigator needs some information. First, he or she must measure the angular height of the celestial object above the horizon. For this he or she uses a sextant. Next, he or she must know the precise time of his or her observation. A very accurate clock, the chronometer, gives him or her the time to the nearest half second. Third, he or she must know the location of the ground point of the celestial object at the time of his or her observation. He or she looks this up in the current edition of the *Nautical Almanac*. Finally, he or she uses a set of sight reduction tables (where all the heavy mathematics have been done for him or her) to compute the azimuth (direction) and altitude (a function of distance) of the celestial body. He or she can now draw a line of position. Lines of position from one or two other stars gives him or her the fix at the time of the observations.

Most navigators use prepared worksheets to enter the data and compute the results. A number of factors must be considered such as the height of the observer above the water, parallax, instrument error, etc. A good worksheet has spaces for these entries, and the navigator is not likely to forget them. Sight reduction worksheets look complicated but, with practice, are no more difficult than reconciling a checkbook. The only arithmetic involved is addition and subtraction.

The Sextant

A sextant is the instrument chiefly used in celestial navigation. It is designed for sighting two objects at the same time (the horizon and the sun for example) and measuring the exact angle between them. It is a precision instrument shaped like a piece of pie. It is held on edge with one hand while sight adjustments are made with the other.

Its name, sextant, comes from its lower arc, which is one-sixth (60 degrees) of a circle. The arc is divided into degrees; minutes and 10ths are read by means of a vernier (a refinement in dividing) or a micrometer drum.



The sextant takes advantage of the principle that the angle made by the last direction of a ray of light, reflected twice in the same plane, is twice the angle made by the reflecting surfaces. That sounds complicated, but it means that the 60-degree sextant arc is able to measure angles up to 120 degrees.

Using a sextant takes practice. The easiest procedure for beginners is to move the index arm to zero and point the telescope to the desired celestial object. If you are observing the sun, do not forget to move one of the sun shades into position. Now, keeping the celestial object in the right-hand silver portion of the horizon glass, move the sextant down and swing the index arm out until the horizon appears in the left-hand unsilvered side of the horizon glass. Clamp the index arm and make fine adjustments with the micrometer drum or tangent screw until the split image shows the object exactly at the horizon. For the sun or moon, the upper or lower limb (or edge) of the object should be exactly at the horizon. For a star or planet, it should be centered on the horizon line. Now rock the sextant back and forth a few times to see that the object has been measured at its lowest point. This check will assure that the sextant is perfectly vertical. When you're satisfied with the sight, note the exact time and read the elevation from the arc and micrometer drum or vernier scale.

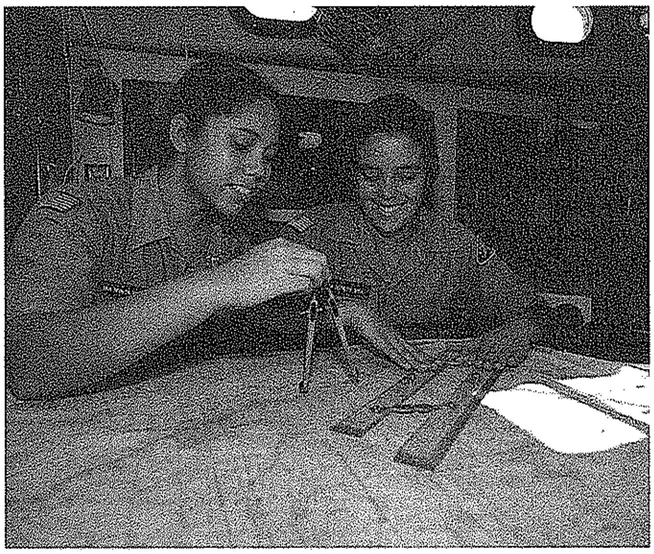
Since a sextant measures angles very accurately, it has uses other than in celestial navigation. It can be used to measure distances. The height of lighthouses and other visible landmarks are listed on charts. If you measure the angle between the top and bottom of a lighthouse whose height you know, a knowledge of simple trigonometry and a tangent table can give you your distance from the lighthouse (the distance equals the height divided by the tangent of the angle).

The sextant used by a professional navigator is a delicate and expensive instrument. A number of plastic sextants are now on the market that are surprisingly accurate and modestly priced. The old time navigator might be horrified at the notion of a plastic sextant but they have been used successfully on a number of occasions by yachtsmen in round-the-world cruises. In fact, a perfectly adequate beginner's sextant can be purchased at less cost than the almanac and reduction tables needed to use it.

Time

For accurate navigation, the exact time of an observation must be known. This was a serious problem for early navigators since accurate timepieces were not available that could withstand the constant motion and changes of temperature found on shipboard. After almost 30 years of development, John Harrison perfected the first practical chronometer. His device was too bulky and expensive for practical use. Pierre LeRoy, of France, and Thomas Earnshaw, of England, developed the first truly practical spring-wound chronometers for shipboard use. Their basic designs are used today.

The modern spring-wound chronometer is a timepiece of great accuracy and is carefully protected aboard ship. It is set in gimbals in a special box, wound daily with the same number of turns, and its rate of gain and loss is carefully noted. Many ships carry two chronometers and compare their corrected times for additional accuracy.

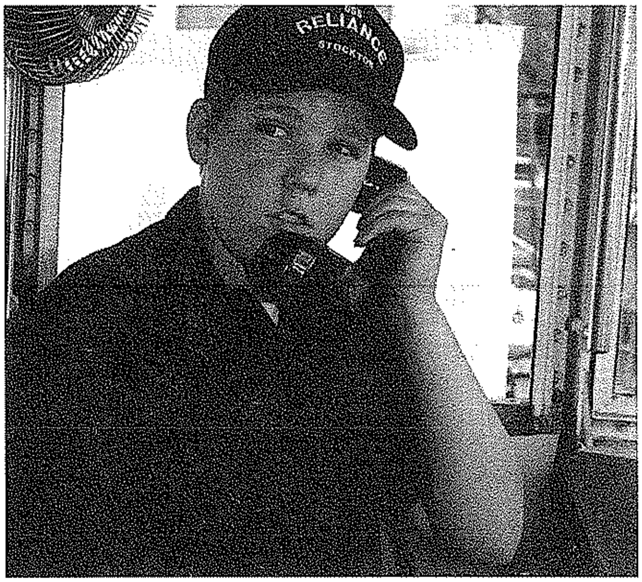


The battery-operated quartz movement has made a dramatic change in shipboard timepieces. Quartz chronometers are now available and are less expensive and probably more accurate than the older types. Some yachtsmen claim that a quality quartz wristwatch is accurate enough for serious navigation.

Navigators deal in several types of time. The principal time used in navigation is Greenwich mean time (GMT). This is the time at the prime meridian passing through the Royal Naval Observatory at Greenwich near London, United Kingdom. All chronometers are set to Greenwich mean time, also known as coordinated universal time.

Zone time (ZT) is the time we use in our daily activities. Our clocks are advanced by one hour for each 15 degrees of longitude we move east from Greenwich. Clocks are set back when moving west. On land, time zone lines usually follow political boundaries for the convenience of the citizens but closely approximate the 15-degree intervals. We usually refer to zone time as standard time or daylight saving time.

Local mean time (LMT) is the actual time along the meridian where you are located. Local mean time and zone time are identical only along a meridian where the time zone changes. Local mean time is used to compute the time difference between your location and the prime meridian. This distance measured west from Greenwich is the Greenwich hour angle (GHA).



Navigators are so concerned with the correct time that they obtain a radio time signal, usually called a time tick, at least daily. Time ticks are broadcast by the National Bureau of Standards on stations WWV in Fort Collins, Colorado, and WWVH in Kauai, Hawaii. The broadcasts are on 2.5, 5.0, 10.0, 15.0, and 20.0 MHz. You can obtain a telephone time tick by dialing 303-499-7111. This is a toll call to Boulder, Colorado, but if your watch is ready to be set, the call takes less than one minute. The time will be reported as "coordinated universal time." For our purposes, that is the same as Greenwich mean time.

The Nautical Almanac

The *Nautical Almanac* is published annually by the U.S. Naval Observatory. It contains numerous tables, but the most important ones give the locations of celestial objects for each day of the year at hourly intervals. Essentially, these locate the ground points of Venus, Mars, Jupiter, Saturn, the sun, the moon, and 57 selected stars. The Greenwich hour angle (angular distance west from the prime meridian) and declination (angular distance north or south from the equator) are given for the sun, moon, and planets. The Greenwich hour angle is given for Aries, an imaginary spot in the Milky Way used as a reference point for locating stars. The sidereal hour angle (SHA—angular distance of a star west from Aries) and declinations are given for the 57 most popular stars used by navigators. In addition, tables for computing sunrise, sunset, twilight, moonrise, and moonset are provided.

Sight Reduction Tables

The Defense Mapping Agency Hydrographic Center publishes *Sight Reduction Tables for Marine Navigation*. These are published in six volumes, one for each 15 degrees of latitude. The navigator enters the tables with his corrected observations of the celestial body and the data obtained from the *Nautical Almanac*. The results give him the information needed to draw a line of position for each object observed.

The process of sight reduction sounds complicated but, with practice, can be done quite quickly. Printed worksheets provide a standard format and the beginner soon becomes familiar with the tables and learns to find the data he needs quickly and accurately.

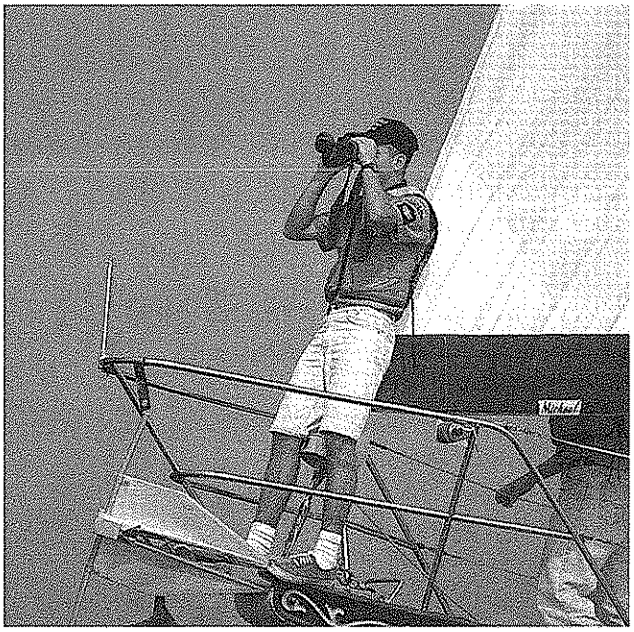
Fixing the Ship's Position

On naval ships celestial observations and fixes of a vessel's position are normally made three times a day. A similar practice is followed on well-ordered commercial ships.

Observations of stars, planets, and the moon (if above the horizon) are made in the twilight periods just before sunrise and just following sunset. During this time, the sky is dark enough for the stars to be visible but light enough for a sharp horizon. Before taking twilight sights, the navigator checks the *Nautical Almanac* and chooses the stars and planets he or she will observe. He or she checks the stars' predicted positions and consults a star finder to aid in identification. Most navigators have 10 or 12 "favorite" stars they prefer to use.

The third sight is taken at local apparent noon. Here the navigator finds the elevation of the sun when it is at its zenith or directly overhead. In addition, he may shoot the moon if it is above the horizon and in a good position, as well as the planet Venus if it is not too close to the sun. Landsmen are surprised to learn that in clear sea air, Venus is visible during the day if you know where to look.

Additional sights of the sun are normally taken in mid-morning and mid-afternoon. The morning sun line is usually advanced to confirm the noon position. The noon sun line is often advanced to the afternoon sun line as a position check but normally not logged as a fix.



Shooting the sun, moon, stars, and planets is easiest if the navigator has a helper. The helper has a comparing watch that has been set to exactly agree with the chronometer. Sometimes a stopwatch is started at a convenient chronometer time and the number of minutes and seconds that have elapsed at the time of the observation are noted. The helper carries a clipboard or notebook to record the star observed, the sextant reading of its height above the horizon, and the exact time of the observation. Simple worksheets are available for recording these data.

In shooting a sight, the navigator locates the object, swings it to the horizon, and calls out "mark" when he is satisfied that he has a good sight. The helper immediately notes the time. The navigator then reads aloud the angle from the sextant and the helper makes his notation. The process is repeated with each additional star until the navigator is satisfied that he has a good set of readings. Normally three or four sights are made for each star or planet, particularly if there is a heavy seaway and the ship is rolling and pitching. The observations that produce the most accurate fix are the ones that are used.

Taking sights without a helper presents some challenges. You will be juggling a sextant, comparing watch, clipboard, and pencil while trying to work quickly and accurately. Doing some advance planning and getting yourself organized can make this task easier.

First, know where your stars or planets are. For a morning sight, come on deck well before first light and identify the objects you will be shooting. Begin your observations as soon as there is a sharp horizon. For evening sights, study the star finder and almanac so you can predict the positions of your objects and be prepared to begin as soon as they appear.

If you use a wristwatch as a comparing timepiece, you will have one less item to juggle. A rubber band on the clipboard will keep the paper from blowing. Check to see that there is a secure place to set the sextant while you are noting the angle and time. Some mariners dangle the sextant from a lanyard around the neck. It looks strange but is better than having the sextant crash to the deck or—heaven forbid—go over the side.

Some beginners are so intent on getting a good sight and noting the time, they actually forget to read the sextant! That is embarrassing. Another problem is getting the sights and the objects mixed up—which series of sights go with which object? That is also embarrassing and can produce some startling results when the sights are reduced for the wrong star. Lots of practice taking imaginary sights and the use of prepared or homemade worksheets can help.

The navigator now returns to the navigation station, consults the *Nautical 231231* and sight reduction tables, and plots the lines of position. Since the various sights may be taken over a five- to 10-minute period, they are advanced or retired to the same instant of time. The navigator now reports the ship's position to the captain and begins a new dead reckoning plot. All worksheets are kept in a notebook and become a part of the ship's official records.

Dead Reckoning

Keeping track of a ship's position by celestial observation is accurate and precise. What does the navigator do, however, when storms, clouds, and fog fill the sky or mask the horizon? This is where dead reckoning becomes vital.

The ship's position is deduced by keeping a careful record of courses steered and distances sailed from the last known position and by a careful estimate of the effects of current, leeway, speed-log error, etc. Dead reckoning can be, and frequently is, used in coastal passages when fog or other conditions obscure the coastline or aids to navigation. It is an inexact method at best, but experience and careful plotting of all known factors can often produce surprisingly accurate results—even when long distances and several days are involved. It is a great relief to a navigator when he can confirm his "dead" (deduced) reckoning position by other, less-fallible means.

The Day's Work

A daily routine, called the day's work, is established for a vessel being navigated at sea. Details may vary with the navigator but a typical day's work involves the following:

- Plot of dead reckoning throughout the day.
- Observation and reduction of celestial observations for a fix during morning and evening twilights.
- Winding of chronometers and determining chronometer error. Chronometers are traditionally wound on naval vessels at 1130.
- Observation of the sun for a morning and afternoon sun line. This is often combined with an azimuth of the sun for a compass check.
- Observation of the sun at local apparent noon. This is crossed with a morning sun line that has been advanced or with an observation of the moon or Venus to obtain a noon position.
- Computation of the day's run, usually noon to noon.
- Computation of the time of sunset, sunrise, and twilight, and preparation of a list of stars and planets in a favorable position for observation during each twilight period.
- Computation of the time of moonrise and moonset (if required).
- Use of loran C and any other radionavigation aid on a regular schedule, usually every hour.

The results of the day's work are tabulated and kept as a part of the navigator's notebook. Some items such as the noon position and noon-to-noon run are entered in the ship's smooth log.

A day's work for a Sea Scout vessel cruising in coastal or inland waters obviously will not be as complex as the one described. A well-kept deck log of the type described in the section on dead reckoning is usually all the typical Sea Scout navigator will need.

Electronic Position Finding

The use of electronic devices is becoming much more common in navigation. Even on smaller vessels, radio direction finders, radar, and loran installations are to be found. Larger vessels may employ inertial navigation and satellite navigation systems.

These are detailed subjects, but a brief review of several systems may be of interest.

RADIO DIRECTION FINDER. This device is a radio receiver with a loop antenna that can be rotated so that the direction of the transmitting station can be determined. Locations of transmitting stations are charted and marked as "radio beacons." These stations transmit designated signals at stated intervals so they can be identified.

Two or more radio beacons can produce lines of position that intersect to give the ship's position or the ship can "home in" on a single beacon. Bearings so established may be subject to error due to local or atmospheric distortion. This means constant rechecking. The normal range is between 20 and 200 miles.

Radio direction finders are not uncommon on Sea Scout vessels. Like many other items of electronics, prices are dropping and "new and improved" models are appearing on the market. Some ships are obtaining direction finders from private or commercial vessel owners seeking to upgrade their equipment.

RADAR. Radar, or radio detecting and ranging, is an electronic device that "bounces" radio energy off objects (land masses, aids to navigation, other vessels, etc.) and measures the time required for the impulse to return to the point of transmission.

The returning impulses are translated into a maplike picture of the object on a radar scope. The image so produced may be interpreted to provide bearings and distances of the objects. It will function regardless of weather, darkness, etc., and is of great help to the navigator. The range is $^1/_2$ mile to 20 miles.

A surprising number of Sea Scout vessels are equipped with radar. Usually the source is a commercial vessel upgrading its equipment.

LORAN C. This long-range navigation system was developed by the Allies during World War II. It is a system using synchronized radio impulses transmitted from two shore stations acting as a pair (even though they may be hundreds of miles apart).

Vessels receiving these signals note the time difference of reception and are able to establish a line of position. A second line of position is established from another pair of transmitters. Where the two lines of position cross is the ship's position. Its range is up to 2,000 miles and it's accurate to within 500 yards of the actual position.

Modern loran units now display the vessel's latitude and longitude, saving the bother of comparing time differences and the use of a loran chart.

INERTIAL NAVIGATION SYSTEM (INS). This is found only on the most modern vessels. Briefly, this highly sophisticated multidevice equipment involves a complex computer that takes into account all the factors found in dead reckoning, such as speed, distance, courses, changes, current, wind, etc. Through interpretation, a vessel's position can be constantly known.

GLOBAL POSITIONING SYSTEM. GPS is a system that uses signals transmitted from three or more satellites that orbit the earth. As a result, GPS is not susceptible to outside interference (unlike loran) such as alternator noise, electrical storms, overhead rigging, TV, or fluorescent lights.

GPS has better absolute accuracy if you are going to a position for the first time. Part of its inability to return to the exact spot can be attributed to "selective availability." This is an error that has been intentionally introduced into the system by the military to protect the United States from use of the system by unfriendly forces. Selective availability is a program that inserts a random error into the satellite signal. This can affect your GPS with up to a 300-foot error when returning to a location.

When looking at GPS displays, you find the familiar latitude and longitude found on loran displays. GPS, however, works in real time, so as your boat increases or decreases in speed, the unit reacts immediately, unlike loran which has about a two-minute lag time.

GPS units that are "Differential ready" can be made highly accurate through the addition of a Differential-GPS unit. This unit accesses a radio beacon system (RBS) established by the Coast Guard that corrects the error created by selective availability. Using a GPS unit with a differential beacon receiver should make it accurate to within 30 feet. The federal government has announced plans to eliminate selective availability programs by the beginning of the 21st century.

In spite of the most sophisticated navigating devices, most good navigators still practice the arts of celestial navigation, piloting, and dead reckoning. His or her ship may have been on autopilot for a week with steering orders generated by inertial navigation, constantly checked by a loran display, but the old-time navigator will still be seen on a bridge wing taking morning, noon, and evening sights. As one captain explained, "The satellite can fail, the computer can dump, circuits can blow, and I can lose power. If all that happens, I still need to know where I am!"

In a practical sense, in Sea Scouting we will normally deal with more basic and simpler systems; our basic tools will continue to be charts, an accurate compass, and our constant friend—the sun.

SUN COMPASS. One of the devices that can be of great help to us is the sun compass. Sometimes called a "shadow pelorus," it is used to establish deviation with considerable accuracy. Its function is to determine the error in the ship's compass by an azimuth of the sun.

Essentially, it consists of a reverse compass card mounted in a box in such a way that it can be rotated around its center. A 3- or 4-inch length of wire is mounted vertically in the center. The box, which has a lubber line, is mounted so that this lubber line represents the bow of the vessel and is exactly in line with or parallel to the boat's keel.

As the sun's rays fall on this device, the vertical wire casts a shadow at a point on the card, indicating the boat's heading. Comparing this heading with the heading indicated on the ship's compass, deviation can be determined at a glance. Correction tables show the correct point at which to set the sun compass card on the lubber line at any time of day.

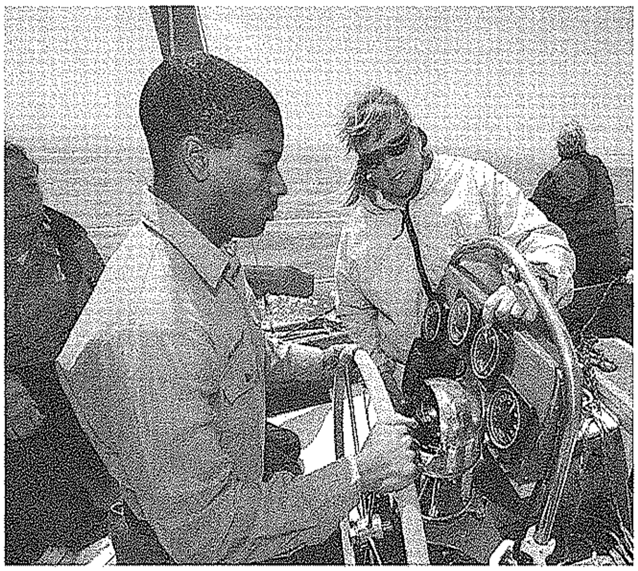
The practical application of this device is a fairly complex procedure when true or magnetic courses are to be computed. A full explanation, tables and examples can be found in *Piloting Seamanship and Small Boat Handling*, by Charles F. Chapman, chapter XIV.

The Sailings

As a navigator plans a voyage, he or she must decide on a route to be followed and courses to be steered so his or her ship will arrive at its destination in minimum time, at lowest operating cost, and with maximum safety. In some ocean crossings, the North Atlantic for example, he or she can count on long periods of overcast skies and stormy weather that make celestial observations all but impossible. While he or she keeps a detailed dead reckoning plot, it's sometimes desirable to compute his or her position using traverse tables. The several methods of laying out a course and computing the position are called the "sailings."

PLANE SAILING. This method assumes that the earth is flat so should not be used for distances of more than a few hundred miles. It involves a single course and distance. Using traverse tables (found in Volume II of *Bowditch*) the latitude (progress made in a north-south direction) and departure (progress made in an east-west direction) are determined. The course traveled is along a rhumb line—a course line that makes the same angle with all meridians and appears as a straight line on a Mercator chart.

TRAVERSE SAILING. This combines plane sailing solutions when there are two or more courses. This sailing is a method of determining the equivalent course and distance made good by a vessel steaming along a series of rhumb lines. In years past this was a common problem for sailing ships beating to weather or making course changes to catch the best wind. Early seamen kept track of courses sailed and time run on a "traverse board." This was a thin slab of wood with lines radiating from the center in 32 compass directions. Regularly spaced along the lines were small holes into which pegs were fitted to show the time on a particular course. The traverse board kept an accurate record but the navigator still was faced with solving a series of plane triangle problems. Traverse tables now do all this work for him or her.



PARALLEL SAILING. Early navigators were able to determine their latitude by observing the height of a star above the horizon. Polaris was most frequently used for this in the northern hemisphere, as it remained in a fairly constant position in the sky. This led to the practice of sailing due east or west along a known parallel of latitude and computing longitude from a dead reckoning plot of the distance run. The Vikings' mastery of parallel sailing led to their discoveries in the New World. A check of a world map will show that Greenland, Iceland, and Newfoundland are on the same parallels of latitude the Vikings likely would have used as departure points from Scandinavia, England, or Ireland. In fact, this is how the term "departure" came to be used for distance traveled along a parallel.

MIDDLE-LATITUDE SAILING. The inaccuracies involved in plane sailing led to mid-latitude sailing in the early 17th century. Here the use of a parallel midway between those of the point of departure and arrival will reduce the errors in plane sailing that result from the converging meridians. It is still used by some modern navigators.

MERCATOR SAILING. This system provides a mathematical solution to a rhumb line course drawn on a Mercator chart. It is similar to plane sailing but uses parts of the meridian and differences in longitude rather than the difference in latitude and departure.

GREAT CIRCLE SAILING. For hundreds of years mathematicians knew that a great circle is the shortest distance between two points on the earth's surface. It wasn't until the 19th century, however, that navigators began to use this information. You can demonstrate how this works using a globe and a piece of string.

Stretch the string along the surface of the globe between two points—San Francisco and Yokohama, for example. Note how the string curves north almost to the 48th parallel and then curves south. If you transfer this route to a Mercator chart, the resulting course line will be a curve. Figuring out this curve is the principal problem in great circle sailing. Our old friend, the sight reduction tables, can help us solve this problem. We can compute the distance of the great circle route, the course angle at each end of the voyage, and course changes to be made at various points along the route. Laying out a great circle course on a Mercator chart presents some problems, as the track is curved. Special charts drawn on a gnomonic projection, usually called great circle charts, can be used. Here the great circle route can be plotted as a straight line.

Weather

Since the dawn of civilization, perhaps no single subject has more occupied people's minds than the weather. Think how important the weather can be. Virtually all great decisions are conditioned by it—the growth of crops, the outcome of battles, electoral results.

To the seafarer, knowledge of weather lore is absolutely vital. The progress and the safety of his or her vessel and the lives of its people are the constant stakes in the everlasting game of determining the weather.

If the vessel is a small sailboat on a weekend cruise or the world's largest ship on a trip around the world, she still must be able to endure every adverse condition that may arise, from the quick summer squall to the giant force of a hurricane.

The sailor must develop a sound working knowledge of weather conditions. He or she must know how to gauge them and how to predict change. He or she must know how to deal with every type of situation that may be encountered, from glassy calm to full gale, thick fog, drenching rain, or the fresh breeze that wings him or her on his or her way or veers and then faces him or her with an implacable assault.

Our ability to predict weather changes has progressed from the aching joint or twitching muscle to a broad, scientific approach. Meteorology, though still an inexact science, has made vast strides forward using a myriad of instruments to gauge and measure conditions and project change.

While the results of this application of scientific knowledge are constantly available to the boatman through regular reports from the National Weather Service, the U.S. Coast Guard, and other sources, they are no substitute for the sailor's ability to observe local conditions and make his or her own forecast.

The study of cloud appearance, wind direction (particularly as it changes) and force, visibility and its change, temperature, humidity, and changing atmospheric pressure all enable the sailor to arrive at a reasonable judgment of what conditions will be in his or her immediate area.

Weather Instruments

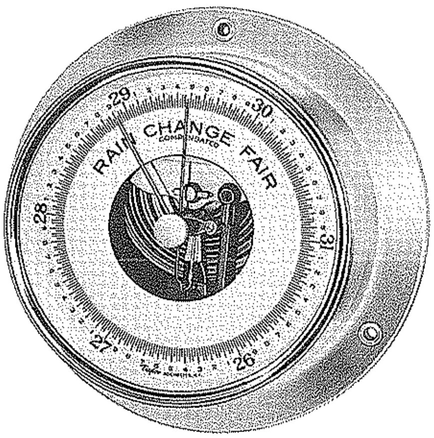
THE BAROMETER. This is an instrument designed to record atmospheric pressure—the key to weather forecasting. The standard is based on the height of a column of mercury in a tube sealed at one end, with its open end down in a small container of mercury.

If the tube is more than 30 inches in height, the mercury in the tube will measure about that height when balanced by normal air pressure. (The actual normal pressure is 29.92.)

It is a precise, costly, and fragile device, necessarily bulky. It is normally calibrated in inches, ranging from 27 to 31. It records changes in air pressure within this range on a precise scale. Scientifically, the measurements are in millibars, based on the metric force unit of dynes per square centimeter at sea level.

In more common use is the aneroid barometer, which is a small, thin, round metal can from which most of the air has been expelled. As atmospheric pressure increases, the two flat sides tend to move inward; when the pressure decreases, they move apart.

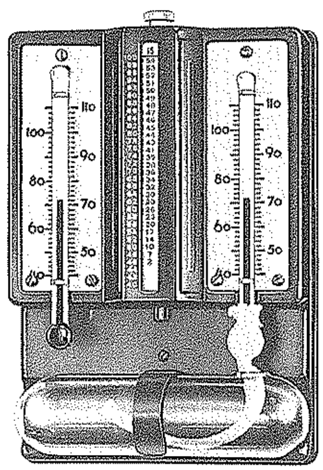
This movement is recorded by a pointer moving over a scale calibrated to heights of a mercury column in inches and fractions, with another scale calibrated in millibars. An adjustable pointer provides a reference point from which changes may be observed.

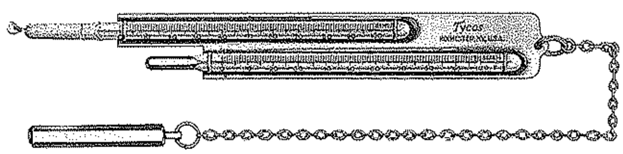


Aneroid Barometer

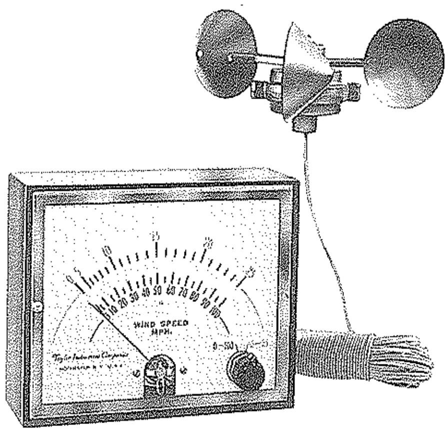
THERMOMETER. This is a well-known device for measuring the temperature. The Fahrenheit scale is commonly used, with the freezing point of water at 32° and the boiling point of water at 212° at sea level. The total scale is subdivided into 180 parts or degrees. As we move toward adoption of the metric system, the Celsius (formerly called centigrade) scale is also used. On this scale, the freezing point of water is 0° and the boiling point is 100°.

PSYCHROMETER. This is a combination of wet and dry thermometers for measuring relative humidity. These are either permanently mounted or can be portable like the sling psychrometer, which is more commonly used.


Psychrometer


Sling Psychrometer

ANEMOMETER. This is a device for measuring wind force in statute miles per hour or in knots. It may have rotating cups with a geared wheel that measures wind speed on a dial or it may be the tube type that measures velocity on a vertical scale according to the height a small ball rises in the tube.



Anemometer

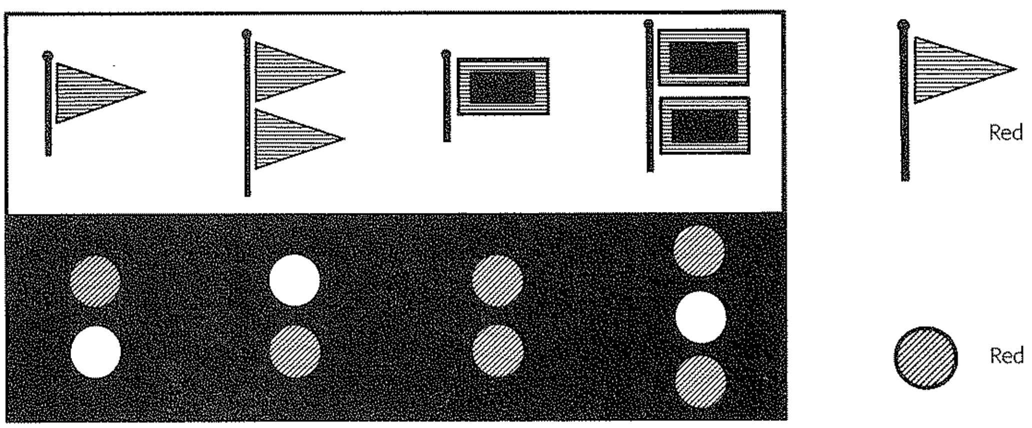
Day and Night Weather Signals

From information gathered by the National Weather Service and the U.S. Department of Commerce, weather signals are displayed from some U.S. Coast Guard shore installations and vessels. (No night signals are displayed on ships.)

In addition, regular and special weather information is broadcast on the radio by the Weather Service, Coast Guard stations, and by a large number of commercial radio and television stations.

Detailed schedules of weather information broadcast by American and foreign stations are listed in Radio Weather Aids to Navigation, the U.S. Hydrographic Office publication 206.

Storm Signals



Weather Reports and Bulletins

Responsibility for the collection and dissemination of weather information rests primarily with the National Weather Service, National Oceanographic and Atmospheric Administration. The service issues a daily surface weather map of the United States that can be found in most daily newspapers and is available by subscribing from the Superintendent of Documents, Government Printing Office, Washington, DC 20402.

The work of the Weather Service is vast and complex. It embraces the whole field of meteorology, from hurricane hunting, research, long-range, and world-wide data collection to detailed national, regional, and local forecasting. Space limitations preclude any discussion in depth, but weather is a fascinating study.

Beaufort Scale

Beaufort Force	Miles Per Hour	Weather Bureau Term	Condition of Sea
0	0–1	Light	Smooth; mirrorlike
1	1–3	Light	Ripples
2	4–7	Light	Small wavelets that do not break
3	8–12	Gentle	Wavelets; some whitecaps
4	13–18	Moderate	Small waves; many whitecaps
5	19–24	Fresh	Moderate waves; many whitecaps; some spray
6	25–31	Strong	Large waves; white foam crests everywhere; spray
7	32–38	Strong	Sea heaps up; spindrift
8	39–46	Gale	Higher, longer waves; spindrift
9	47–54	Gale	High waves; dense foam; spray
10	55–63	Storm	Very high waves; sea all white
11	64–72	Storm	Extremely high waves; low visibility
12	Above 73	Hurricane	Driving spray; low visibility

Fog

The curse of the coastwise boatman and the bane of the oceangoing shipmaster is the seafarer's ancient enemy—fog. Blotting out landmarks, concealing aids to navigation, hiding ships at sea in a sometimes-impenetrable blanket where visibility is reduced to 100 feet or less, it imposes the harshest conditions on the careless sailor and is a severe test of piloting skill.

Actually fog is, in effect, a sea-level cloud formed from minute water droplets in suspense when the temperature of the air drops to the dew point (the temperature at which air moisture condenses). It may be caused by advection, which is the movement of air over a surface of differing temperature such as water. It may be caused by radiation, which is the cooling of the surface of the earth or body of water below that of the surrounding air.

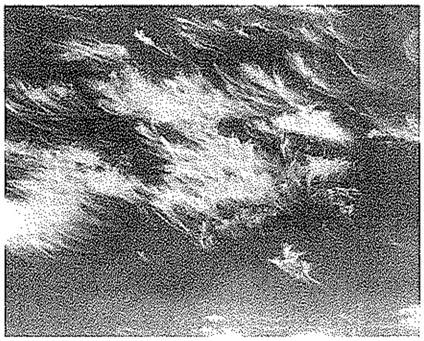
Its onslaught can be predicted by use of a psychrometer, which indicates the dew point. Successive readings will establish the difference between dry-bulb and wet-bulb readings. As this difference decreases, fog can be anticipated.

Fog conditions, which prevail when visibility is seven-tenths of a mile or less, require certain precautions:

1. The speed of a vessel should be reduced to the point where it maintains full maneuverability, usually within one-half of its circle of visibility.
2. Audible signals should be sounded to announce the vessel's presence.
3. The most careful determination must be made of the boat's position and continuing course.
4. A most careful watch must be set (doubling the regular watch) to search for aids to navigation, other vessels, etc., as well as to listen for the audible signals which either may employ. Caution is the watchword. Fog has the unnerving capacity to distort sound in terms of both volume and direction.
5. If the vessel is "on soundings," the crew must get out the lead line and check position by the charted depths. If worse comes to worst, they drop the hook and wait it out, regularly sounding the bell.

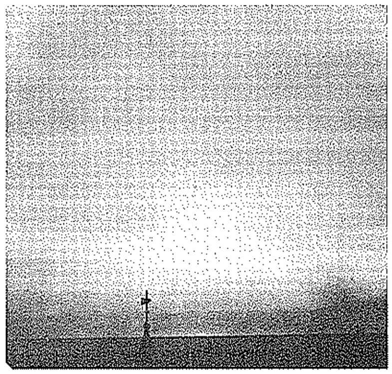
Cloud Formations

Cirrus clouds are detached, delicate, fibrous, with white filaments and white bands. They have a silky, hairlike appearance, tufts, and form lines across a clear sky. They are sometimes called "mares' tails," "painters' brushes," "hen feathers," or "spider webs." When they are low on the horizon, cirrus clouds can sometimes be mistaken for cirrostratus clouds. Cirrus clouds are composed of ice particles.

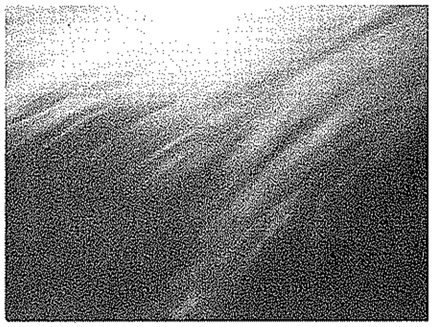


Cirrocumulus clouds are sheets or layers of small globular ice clouds, resembling ripples in sand, or fish scales, and without shading. Often, they give the appearance of a "mackerel sky."

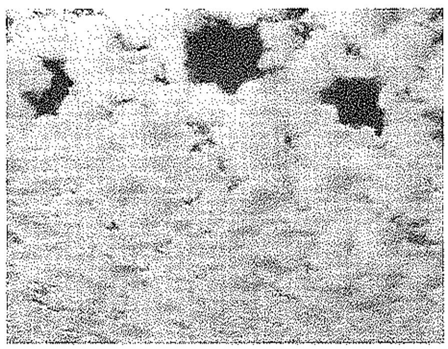
Cirrostratus clouds are transparent, white, and fibrous in appearance. They are composed of ice particles. They may be mistaken for stratus. These clouds give a milky look to the sky, not dense enough to blur or diffuse the outline of the sun or moon, but they may occasionally give them halos.



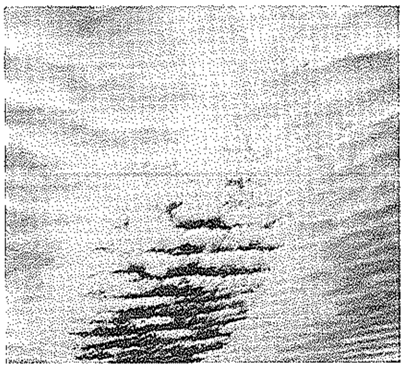
Cirrus and cirrostratus or "mares' tails," their popular name, are the cirrus clouds that thicken into cirrostratus. The probability of rain within 24 hours is increased when this type is followed by thickening lower clouds.



Altocumulus clouds are white, although there may be some light-gray parts in flattened layers, masses, or rolls; sometimes they appear in waves, their edges touching. They may be fibrous or diffuse, mostly in small elements. Altocumulus may be called water clouds, although the upper parts have ice particles. Because of their shapes, these clouds are often mistaken for cirrocumulus. Altocumulus are darker than cirrocumulus, although the shapes are similar.

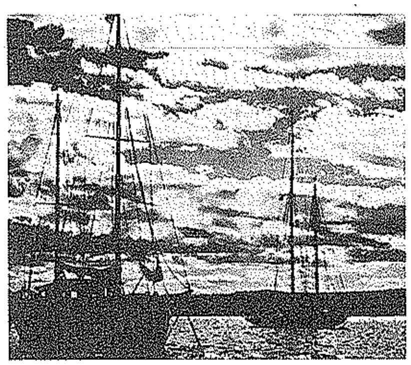


Altostratus clouds look like a gray or bluish fibrous veil often so dense that the sun and moon generally appear as they would through ground glass. Continuous rain or snow may follow thickening altostratus.

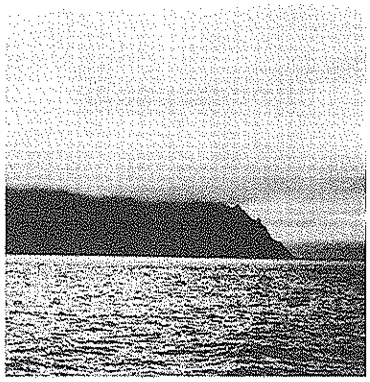


Cumulus clouds are the spectacular ones. Depending on their position relative to the sun, the edges stand out brilliantly or darkly. Their bases are usually flat or horizontal and are darker than the upper portions. Cumulus are termed water clouds and, like many other types, their tops have ice particles. Precipitation from them usually is in the form of brief showers. They can be distinguished from stratocumulus and altocumulus, because cumulus always are separate, in towering or dome shapes. Some suggest snowy cauliflowers.

Stratocumulus are water clouds. Precipitation from them can be either rain or snow. The upper parts contain some ice particles. Often this formation appears to be lighted from behind. They are seen mostly in waves, rolls, or a series of undulations, sometimes with spaces between the rolls. The most common type is the stratiformis, with masses of rolls which are wavy in extended sheets. This is often the leading edge of a cold front.



Stratus clouds are light to dark gray, usually uniform in appearance. They are frequently seen in ragged patches. The precipitation from stratus clouds is usually a drizzle, light rain, or snow and may last several days. Often the sun can be seen through these clouds. Their light-gray color, however, gives them an appearance different from other clouds, and they cannot produce halos. Stratus clouds at sunset can be gorgeous in dramatic color and sweep.



Cumulonimbus clouds are heavy and dark, towering like huge mountains. Their tops are usually smooth, sometimes shaped like anvils or vast plumes. These are water clouds, their tops having some ice particles, often with ragged cloud formations, or "scuds," beneath. The localized cumulonimbus cloud storm can develop in a short period, with rain or hail falling over relatively small areas. Local winds can be strong.

Boating Safety

Safety aboard a ship is made up of many things—rules, equipment, judgment, skill, preparation, foresight, and practice for the protection of yourself, your shipmates, and your vessel, as well as other people and ships.

Some safety equipment is required by law. This includes Coast Guard-approved personal flotation devices (PFDs), fire extinguishers, and flame backfire controls. Also, lights, ventilation systems, and sound-producing devices must satisfy Coast Guard safety requirements.

Approved for use on motorboats less than 40 feet in length are special purpose water safety buoyant devices. They may include waterski jump vests, racing vests, whitewater canoeing vests, buoyant duck-hunter-style jackets, etc.

Skill, knowledge, and judgment are the principal ingredients of safety: skill in handling the vessel under all conditions, knowledge of the equipment and its use, judgment that exercises caution in speed, bad weather, or rough sea.

The Coast Guard maintains an extremely useful boating safety Web site at www.uscgboating.org. Among other pieces of information, the Federal Requirements and Safety Tips for Recreational Boats pamphlet may be found there.

Coast Guard Boating Safety has also made a telephone Infoline available at 1-800-368-5647. Questions regarding boating safety, as well as hard copies of the Federal Requirements and Safety Tips for Recreational Boats, *Boating Safety*, and the *Boater's Source Directory* (Boat/U.S.), may be obtained through this source.

EQUIPMENT REQUIRED	**Length of Vessel:** Less than 16 feet	16 feet to less than 26 feet	26 feet to less than 40 feet	40 feet to not more than 65 feet
Backfire Flame Arrester	Required on each carburetor of all gasoline engines, except outboards			
Certificate or Documentation and Number	Required if propelled by machinery. Some states require for all watercraft			
Navigation Lights	Required if operating between sunset and sunrise			
Personal Flotation Devices*	One wearable (type I, II, III, or V) per person	Type I, II, III, or V for each person on board, plus one Type IV		
Pollution Prevention	Required on all vessels		Required on all vessels and placard must be posted	
Portable Fire Extinguishers**	One B–I type, except outboards with open fuel tanks		Two B–I's or one B–II	Three B–I's or one B–I and two B–II's
Sound-Producing Device	Not required	Efficient sound signal required		Whistle and bell required
Ventilation	Required for every closed engine or fuel tank compartment			
Visual Distress Signals***	Required between sunset and sunrise	Three day and night flares required in coastal waters and Great Lakes		

* Canoes and kayaks are required to carry one PFD of any type for each person on board, regardless of length.
** If an approved fixed system is installed, one less B–II is required.
*** You should carry three day and three night signals, or three each day and night signals in date (not expired). Not required on inland waters but strongly recommended.
Note: This list is a summary of the federal requirements and is not all-inclusive. Please refer to the USCG pamphlet Federal Requirements and Safety Tips for Recreational Boats for the complete list of requirements.

Recommended Optional Equipment

In addition to that required by law, the safety-conscious boater will consider having on board:

- VHF Radio
- Visual Distress Signals
- Spare Anchor
- Heaving Line
- Fenders
- First Aid Kit
- Flashlight
- Mirror
- Searchlight
- Sunburn Lotion
- Tool Kit
- Ring Buoy
- Chart and Compass
- Boat Hook
- Spare Propeller
- Mooring Line
- Food and Water
- Binoculars
- Spare Batteries
- Sunglasses
- Marine Hardware
- Extra Clothing
- Spare Parts
- Alternate Propulsion (Paddles)

Whistle or Horn	Dewatering Device (Pump or Bailer)
Fuel Tanks	Spare Fuel
	Anchor

The ability to swim can be vital to you and every person aboard your ship. A thorough knowledge of lifesaving and the use of lifesaving equipment also is important. The law requires that at least one wearable (type I, II, III, or V) Coast Guard–approved personal flotation device (PFD) for each person be on board where it is readily accessible. In addition, all powerboats and sailboats 16 feet in length or over must have at least one Coast Guard–approved throwable PFD (ring buoy or seat cushion) that is immediately available. See page 244 for requirements and Federal Requirements and Safety Tips for Recreational Boats for definitions of type I, II, III, and IV PFDs.

Life jackets currently approved for manufacture contain kapok, fibrous glass, and unicellular plastic foam as flotation material. They may be of the jacket-and-bib type. Buoyant vests made of compact kapok, fibrous glass, or plastic foam are acceptable on boats not carrying passengers for hire.

Coast Guard-approved type I and II lifesaving devices designed to be worn are required to float a person in an upright, slightly backward position to keep his or her face out of the water, in case he or she is unconscious.

New regulations outlaw lifesaving devices in which the fiber filler is not protected in a waterproof sealed plastic container to prevent absorption, which would reduce buoyancy.

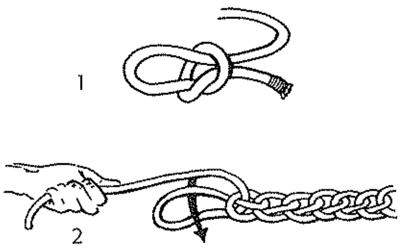
Personnel on military vessels always wear lifesaving devices when at action stations and in heavy weather when on deck duty. Small-boat people put them on at the approach of bad weather. Small children and people who are not strong swimmers should wear them aboard ship at all times.

Life rings or ring buoys are usually found on the rails and bridge wings of large vessels or inboard in the rigging or on an outside bulkhead on small boats. They are hung on quick-release clips and are principally used to be sent after a person who has fallen overboard (heave a cushion if no ring is at hand). They may have heaving lines attached and, for night rescue, they may have a self-activating electric light or chemical flare.

You can practice heaving a ring using wadded newspaper for the target. The object is to come as close to the target as possible without striking it. Hitting the victim with a heavy ring could stun and drown him.

Ashore, practice heaving the ring with a long length of line attached (a standard installation at swimming areas) for recovery of the buoy—and the victim. For surf or shore rescue, where a rescuer goes in after the victim, a chain-knotted rescue line is invaluable.

Chain Knotting for Rescue Lines



Drills and Practice

For hundreds of years safety has been a concern of all who are related to the sea. Today, safety drills are required by law on commercial vessels.

They are required of us, too. Drills should be held frequently in anticipation of any emergency so that any situation can be dealt with skillfully and quickly without confusion.

STATION BILL

				COLLISION	FIRE	ABANDON SHIP	
				General Alarm Word Passed—Piped	General Alarm Rapid Ring of Bell	General Alarm Bugle—Siren	
No.	Name	Rank	Billet	Stations	Duty	Boat	Will Provide

On large ships and small, everyone should know where he or she should be or report, and what action is expected of him or her. His or her station and duties must be clear.

STATION BILL. This is a printed list that defines everyone's station and duties in an emergency. Failure of anyone to carry out his assigned duties could jeopardize the ship and the people aboard. Look over the procedure and illustrated example as your ship prepares for an emergency.

MAN OVERBOARD. Here are the duties to be carried out when someone accidentally falls overboard.

1. Pass the word, fast, loud and clear.
2. Heave a life ring, cushion, or life jacket to the victim.
3. Keep him or her in sight at all times. This should be one person's sole responsibility.
4. Stop your engine and quickly turn so the stern and screw swing away from the victim.
5. Swing the ship around to pick up the victim. Take in any light sails and hoist all working sails.
6. Launch a small boat, if necessary, with two or more people in it if vessel is large enough.
7. Prepare to render first aid if necessary.
8. Stand by radio transmitter if an assistance call is ordered.

If you should fall overboard, swim quickly away from the ship to keep clear of the propeller and to enable the ship to pick you up upon its first return pass.

COLLISION. Here are some things that you can practice in case of a collision.

1. Sound the alarm, pass the word.
2. Get all hands on deck, wearing personal flotation devices—if on a small ship.
3. Get a collision mat rigged; on a small boat use canvas or materials at hand to stop inflow of water.
4. If your vessel is not in danger of sinking, stand by to render assistance to the other vessel.

5. If your vessel is in danger of sinking, it may be necessary to abandon her.
6. Stand by your radio transmitter.

Abandon Ship

Practice the following steps in order to avoid confusion and unnecessary bodily harm if you should have to abandon ship. But remember, stay with your craft unless it is sinking or there is an uncontrollable fire or the danger of an explosion.

1. Sound the alarm, pass the word, get everyone up from below decks and into personal flotation devices.
2. Swing out boats, check emergency water, provisions, and equipment.
3. Ship's papers, log, etc., go into the skipper's boat.
4. Charts, binoculars, tools, canvas, first aid gear, signaling devices, lights, matches, life belts, etc., are secured by persons responsible.
5. Radio transmission giving circumstances, position, etc., sent off and repeated until acknowledged.
6. Junior officers check each boat, its equipment, and personnel. Report to the skipper the course and distance to land.
7. Boats away, skipper's boat last, all colors left flying. Each officer assumes absolute command of his or her small boat.

LIFEBOAT DRILL. This should be conducted frequently to provide skill and practice for man overboard or abandon ship conditions. The lifeboats should be inspected and the crew assignments reviewed for this drill. Passenger-carrying vessels mobilize the passengers in life jackets at their assigned boats. Time yourselves on manning your stations.

FIRE. Fire aboard ship calls for fast action.

1. Sound the alarm; pass the word.
2. Pinpoint the location, the type, and the size of the fire.
3. Attack the fire at once with extinguishing equipment. Keep the skipper constantly informed: "under control," "holding," "spreading," "out of control," or "explosion danger."
4. Transmit a radio call for assistance.
5. Reduce your speed or stop. Adjust the ship's heading to minimize the wind effect.
6. Swing out all boats. Lower and tow them astern if necessary.
7. Prepare to abandon ship if necessary.

Fire Prevention

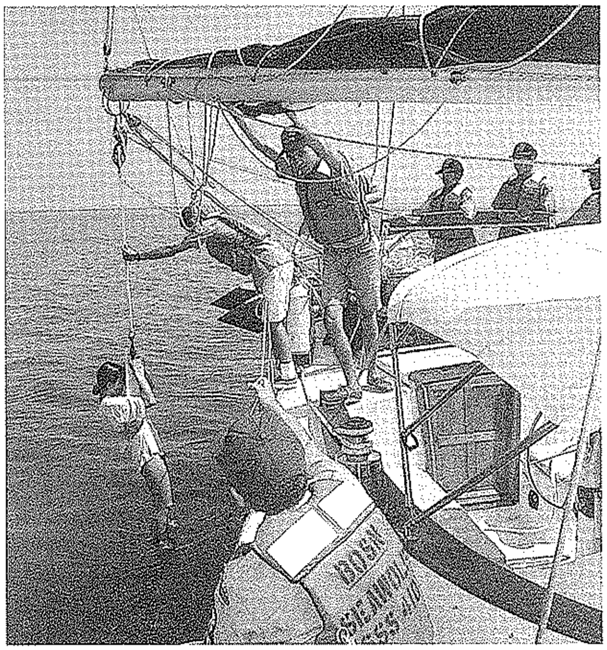
Fire constitutes such an extreme hazard on any vessel that every step to prevent it should be taken, and every technique to combat it should be understood. No boat is immune to fire, and the utmost care should be taken.

ENGINE ROOM. The engine room is most vulnerable. It should be kept spotlessly clean and well ventilated, with leakproof fuel tanks and tight fuel lines and fittings at fuel injection points. The law requires that carburetors be equipped with backfire traps. All electrical components should be kept clean, tight, and sparkproof.

Many small ships have fume detectors, power-ventilation systems, sparkproof switches, and built-in fire-suppression systems. Don't trust them. Before starting the engine, open the hatches and sniff the bilge for fumes. (Fanning the hatches will help dissipate fumes.)

Leave the hatches open when starting the engine. Run ventilation blowers a full five minutes before starting.

REFUELING. Special precautions should be taken when refueling. All open flames (stoves, etc.) must be put out. Close all hatches and ports. Never permit smoking in the area during refueling. Be sure fuel tanks are solidly in place with fill pipes tight to the deck plate and vents leading overside. See that fuel valves are shut off. The tanks should be grounded. Pump nozzles should be kept in constant contact with the fill pipe to prevent any spark. Spillage should be promptly swabbed up. After fueling, ventilate the engine compartment, open the hatches and sniff for fumes, and open hatches and ports to air out the boat below decks.



GALLEY. The galley is another vulnerable spot. Open flame is a routine matter. Gasoline stoves should never be used on boats. Stoves may be fueled by wood, coal, charcoal, kerosene, oil-fired jellied fuel, alcohol, bottled gas, or electricity. Alcohol is probably the safest liquid fuel, since it can be extinguished with water.

If possible, keep the fuel supply out of the galley. Bottled gas must be above deck. If in a special locker, it must be ventilated. Insulate all surrounding woodwork from the stove and smoke pipe. Stoves should be set on an insulated base. Make sure all liquid and gas lines are tight. Keep curtains, towels, and clothing away from the flame area.

ELECTRICAL SYSTEM. Any electrical system can be a fire hazard from overheating, short circuits, or sparks. Keep wiring out of bilges and up as high as possible. Wire should be of correct size to carry the load, should be properly insulated, and have tight connections. All circuits should have fuses or circuit breakers. The switches should be sparkproof, and the batteries secured in battery boxes to prevent shifting.

LOCKERS. Usually neglected, lockers are often hazardous. They should be kept clean, well ventilated, and orderly. Never stow oily rags in them and, if possible, avoid the stowage of paint, varnish, solvents, grease, and oil. A well-ventilated metal-lined locker is safest if flammables are carried at all.

Fire Fighting

If fire does break out, it must be quickly and properly suppressed. To do this you must know the three classes of fires and how to combat them.

CLASS A fires involve normally combustible materials such as wood, fabric, paper, etc. This class can be extinguished with water, foam, or soda acid, which cools and penetrates.

CLASS B fires involve liquids such as gasoline, oil, grease, etc. Water is dangerous to use as it spreads the fire. The oxygen that supports this type of fire must be cut off by foam, dry chemicals, halon, or carbon dioxide (CO_2).

CLASS C fires are electrical fires involving heated wire, arcing, etc., and are treated with dry chemicals, halon, or CO_2—never water, which is an electrical conductor.

Fires of any one class may involve materials of other classes, so more than one type of extinguisher should be carried.

Some extinguishers can be used on more than one type of fire. An example is a B–C extinguisher.

Because of the danger of lethal fumes, carbon tetrachloride (CCl_4) extinguishers are not approved for any purpose.

If fire breaks out, shut off all fuel lines (engine and stove), reduce ventilation as much as possible, and direct the extinguishing medium at the base of the fire. Use the extinguisher conservatively, as the contents are soon exhausted.

Inspect all extinguishers regularly to be sure they are fully charged. Refill immediately after use.

First Aid

A working knowledge of first aid is absolutely essential to the safe operation of a Sea Scout ship. Normally, there is no medical assistance immediately available—particularly on small boats.

A complete first aid kit is necessary. It should contain the following:

- Sterile absorbent cotton
- Small adhesive bandages
- Sterile gauze squares, various sizes
- Sunscreen (8 to 15 range)
- Sunburn lotion
- Aromatic spirit of ammonia
- Antiseasickness pills
- Safety pins, assorted
- Zinc oxide ointment
- Single-edged razor blades
- Small scissors
- Tongue depressors
- Antihistamine pills
- Liquid soap
- Elastic bandages, various widths
- Waterproof adhesive tape
- Gauze roller bandages
- Cotton-tipped swabs
- Burn ointment or petroleum jelly
- Pain-relieving tablets (aspirin or acetaminophen)
- Clinical thermometer
- Rust-resistant needles
- Tweezers or thumb forceps
- Toothache remedy (oil of cloves)
- Snakebite kit (inland)
- Laxative (mild)
- Bicarbonate of soda
- Tube of boric acid ophthalmic ointment
- Throat lozenges
- Throat spray
- Antidiarrheal
- Instant ice bags
- Small flashlight
- Hydrogen peroxide
- Sterile eye pads
- Alcohol swabs
- Meat tenderizer
- Disposable latex gloves or plastic wrap
- Mouth-barrier device
- Plastic safety goggles

Proficiency in the use of the above is vital.

Hurry Rescue Cases

All ship members should know how to deal with these emergencies, where fast action spells the difference between life and death.

1. **Severe Bleeding**. Severe bleeding can cause shock or death. First, stop the bleeding. The best way to control bleeding is with direct pressure over the site of the wound.
   a. Use a pad of sterile gauze, if available, or a clean handkerchief. For protection against blood-borne diseases, wear latex gloves or cover hands with several sterile dressings or a piece of plastic wrap.
   b. Use the flat part of the hand.
   c. Apply firm, steady, direct pressure for five to 15 minutes. Most bleeding will stop within a few minutes.
   d. If bleeding is from a foot, hand, leg, or arm, use gravity to help slow the flow of blood. Elevate the limb so it is higher than the victim's heart.
   e. After bleeding is stopped, put bandages or cloths against the wound and tie them in place with another cloth or wide tape.
   f. Send someone else to call EMS or an ambulance.
   g. Treat the victim for shock as soon as you take care of the bleeding.
   h. Do not apply pressure to head or neck wounds where there may be a fracture.
2. **Rescue Breathing**. A drowning person is pulled out of the water . . . a man is dragged out of a burning building . . . an auto mechanic is dragged from under a car with its motor running . . . a child is pulled away from an electric wire. In each of these cases, breathing may have stopped. Yet the victim's life may be saved.

   If you come upon an emergency, check if the victim is breathing. Look at his chest. Listen with an ear to his mouth. If he is not breathing, start giving him rescue breathing.

   In rescue breathing you breathe your own breath into the victim's lungs. The air in your breath has enough oxygen in it to save a life. For an adult you breathe through the victim's mouth. For a child you breathe into both nose and mouth.

   First Aid. Place the victim face up. Tilt his head far back, chin pointing up. Lift with the fingers of one hand under the chin. Press down with the other hand on the forehead. Pinch the nostrils shut with thumb and forefinger of this hand.

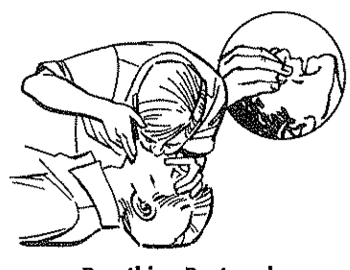
Airway Opened
by head-tilt method

   Then take a deep breath and give rescue breathing:
   - **Step 1**. Open your mouth wide and seal it over the victim's mouth. (For protection from airborne infectious diseases, use a mouth-barrier device.) Blow into the mouth to fill up the lungs. Look to see that the chest rises.
   - **Step 2**. Remove your mouth. Take a deep breath. Look to see that the victim's chest falls as the air escapes.

   Repeat steps 1 and 2 every five seconds for an adult, every three seconds for a child (1 to 8 years of age).

   When the victim's breathing starts, time your efforts to fit his efforts to breathe for himself. Then care for shock.

   If no air is getting into the victim's lungs move speedily to open the airways:
   - Place one of your hands on your other hand and press victim's abdomen with upward thrusts.



Breathing Restored
by mouth-to-mouth breathing

- Probe victim's mouth with two fingers for obstructions. Then quickly resume rescue breathing. Don't give up. Continue until a physician tells you to stop.

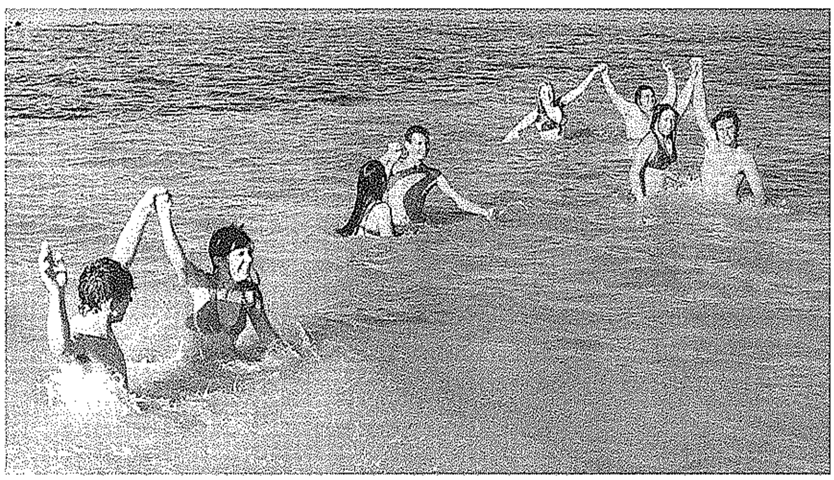
3. **Stopped Breathing—no pulse**. If the victim has stopped breathing and there is no pulse, his heart has stopped. Cardiopulmonary resuscitation (CPR) is the approved method to start the heart again.

CPR requires a trained person. Proper training by local Red Cross chapters or American Heart Association affiliates is essential, since CPR can cause damage, even when done correctly.

Safe Swim Defense

You can virtually eliminate the possibility of drowning tragedies on your ship by following all eight of these simple defenses.

1. **Qualified Supervision**. All swimming activity must be supervised by a mature and conscientious adult 21 years of age or older who understands and knowingly accepts responsibility for the well-being and safety of the children in his or her care, who is experienced in the water and confident of being able to respond in the event of an emergency, and who is trained in and committed to compliance with the eight points of BSA Safe Swim Defense. (It is strongly recommended that all units have at least one adult or older youth member currently trained as a BSA Lifeguard to assist in the planning and conduct of all swimming activity.)
2. **Physical Fitness**. Require evidence of fitness for swimming activity with a complete health history from physician, parent, or legal guardian. The adult supervisor should adjust all supervision, discipline, and protection to anticipate any potential risks associated with individual health conditions. In the event of any significant health conditions, an examination by a physician should be required by the adult supervisor.
3. **Safe Area**. When swimming in areas not regularly maintained and used for swimming activity, have lifeguards and swimmers systematically examine the swimming area to determine varying depths, currents, deep holes, rocks, and stumps. Mark the area for three groups: not more that 3 1/2 feet deep for nonswimmers; from shallow water to just over the head for beginners; deep water not over 12 feet for swimmers. A participant should not be permitted to swim in an area where he cannot readily recover and maintain his footing, or cannot maintain his position on the water, because of



swimming ability or water flow. When setting up a safe swimming area in natural waters, use poles stuck in the bottom, or plastic bottles, balloons, or sticks attached to rock anchors with twine for boundary markers. Enclose nonswimmer and beginner areas with buoy lines (twine and floats) between markers. Mark the outer bounds of the swimmer area with floats. Be sure that clear-water depth is at least 7 feet before allowing anyone to dive into the water. Diving is prohibited from any height more than 40 inches above the water surface; feet-first entry is prohibited from more than 60 inches above the water. For any entry from more than 18 inches above the water surface, clear-water depth must be 10 to 12 feet. Only surface swimming is permitted in turbid water. Swimming is not permitted in water over 12 feet deep, in turbid water where poor visibility and depth would interfere with emergency recognition or prompt rescue, or in whitewater, unless all participants wear appropriate personal flotation devices and the supervisor determines that swimming with personal flotation equipment is safe under the circumstances.

4. **Lifeguards on Duty**. Swim only where there are lifeguards on duty. For unit swims in areas where lifeguards are not provided by others, the supervisor should designate two capable swimmers as lifeguards. Station them ashore, equipped with a lifeline (a 100-foot length of 3/4-inch nylon cord). In an emergency, one carries out the line; the other feeds it out from shore, then pulls in his partner and the person being helped. In addition, if a boat is available, have two people, perferably capable swimmers, take it out—one rowing and the other equipped with a 10-foot pole or extra oar. Provide one guard for every 10 people in the water, and adjust the number and positioning of guards as needed to protect the particular area and activity.
5. **Lookout.** Station a lookout on the shore where he can see and hear everything in all areas. He may be the adult in charge of the swim and may give the buddy signals.
6. **Ability Groups**. Divide into three ability groups: Nonswimmers, beginners, and swimmers. Keep each group in its own area. *Nonswimmers* have not passed a swimming test. *Beginners* must pass this test: jump feet-first into water over the head in depth, level off, swim 25 feet on the surface. Stop, turn sharply, resume swimming as before and return to the starting place. *Swimmers* must pass this test: jump feet-first into water over the head in depth. Level off and swim 75 yards in a *strong* manner using one or more of the following strokes: sidestroke, breaststroke, trudgen, or crawl; then swim 25 yards using an easy resting backstroke. The 100 yards must be swum continuously and include at least one sharp turn. After completing the swim, rest by floating. *These classification tests should be renewed annually, preferably at the beginning of the season.*
7. **Buddy System**. Pair every youth with another in the same ability group. Buddies check in and out of the swimming area together. Emphasize that each buddy lifeguards his buddy. Check everyone in the water about every 10 minutes, or as needed to keep the buddies swimming and together. The adult in charge signals for a buddy check with a single blast of a whistle or a ring of a bell, calls, "Buddies!" He counts slowly to 10 while buddies join and raise hands and remain still and silent. Guards check all areas, count the pairs, and compare the total with the number known to be in the water. Signal two blasts or bells to resume swimming. Signal three blasts or bells for checkout.

8. **Discipline**. Be sure everyone understands and agrees that swimming is allowed only with proper supervision and use of the complete Safe Swim Defense. The applicable rules should be presented and learned prior to the outing, and should be reviewed for all participants at the water's edge just before the swimming activity begins. Swimmers should respect and follow all directions and rules of the adult supervisor. When people know the reason for rules and procedures they are more likely to follow them. Be strict and fair, showing no favoritism.

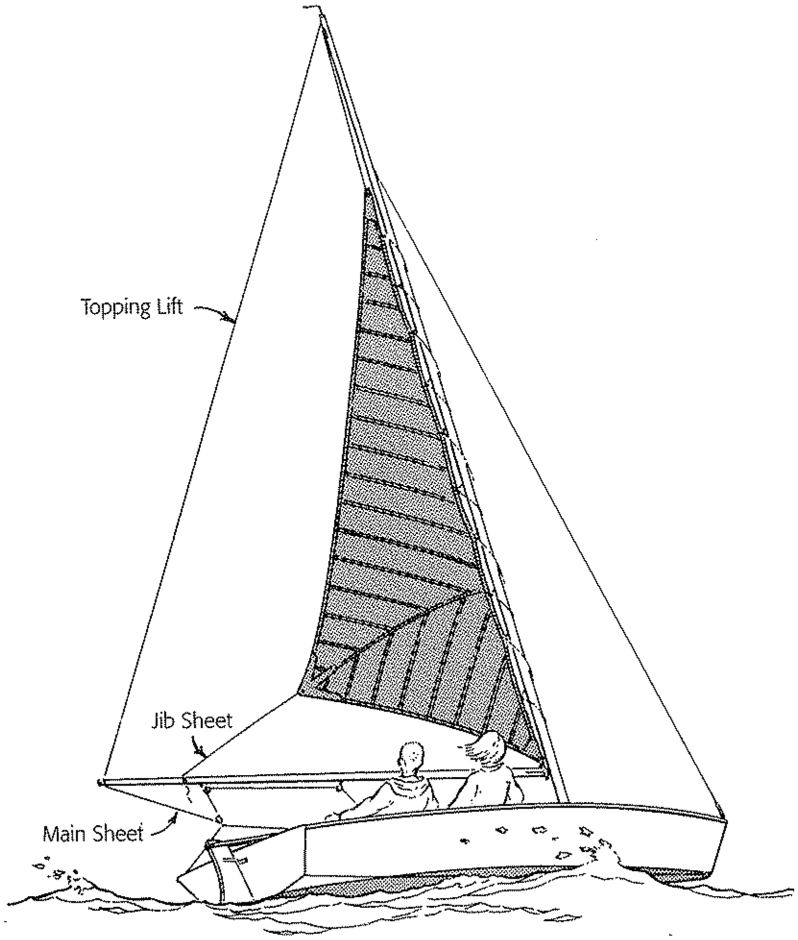
Heavy Weather

With the onset of heavy weather, certain precautions must be taken. If it can be done, seek a sheltered harbor, put out the proper ground tackle, and ride it out.

If caught in an exposed position, however, begin by securing all loose objects on deck and below. If the threat is a summer squall or thunderstorm, it could be quite violent and, usually, is of short duration. On all boats, have everyone on deck don life jackets. You should consider equipping each life jacket with a personal strobe, whistle, and reflective tape.

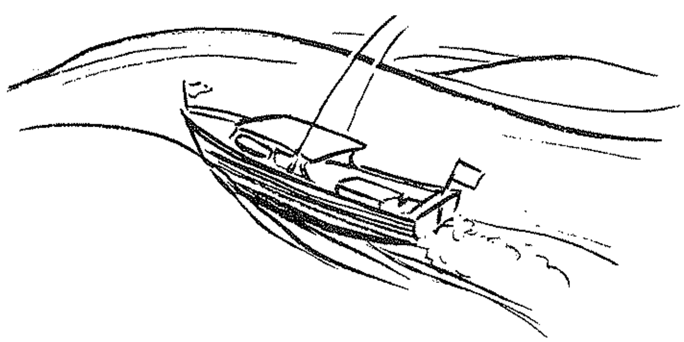
If you are in a powerboat, reduce your speed to steerage way and head into the storm. If you are in a sailboat, reduce the sail to the minimum (down to a small jib, a well-reefed main, or a storm trysail—the jib can be rigged as a trysail) or get all the sail off, rig a sea anchor, and ride it out under bare poles. In any case, it is important to keep the ship's head into the seas. Anyone leaving the cockpit for any reason must be harnessed and attached to a jackline. A jackline is a strong line attached fore and aft. It can be made of heavy ship's line in an emergency. The harness attaches to the line by a snaplink. The harness keeps you attached to the boat but not necessarily on the deck.

Jib Rigged as a Storm Trysail



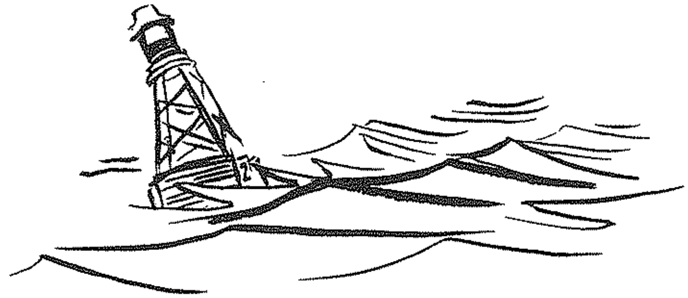
The greatest threat is from wave action. There are two kinds of waves. Long rolling trochoidal waves, which form in deep water where there are miles of open sea, seldom break (except in a whole gale), but they can strike a ship with enormous force.

Trochoidal Waves Form in Deep Water



Cycloidal waves, which form in shoal water, have sharp peaks, break easily and are most dangerous.

Cycloidal Waves Form in Shallow Water



If conditions become so bad the vessel cannot hold her own, she may have to heave to or lay to. Plenty of sea room is required. A sea anchor may be rigged to keep her head to the sea and an oil bag may be rigged on it to lay just ahead of the ship. It may be a canvas bag filled with motor oil or a tin of oil with very small holes pricked in it. The seeping oil creates a slick that prevents seas from breaking around the ship.

A sailing ship may lay to with the helm lashed down and a storm trysail rigged. This keeps her lung up into the wind and sea. She, too, may use a sea anchor and an oil bag.

Overloading or Improper Loading Equals Boating Accidents

Coast Guard statistics show the most common cause of boating accidents is overloading and improper loading of small boats. Most fatal accidents caused by a loading error involved boats under 26 feet in length. And half of these vessels had 10 horsepower or less.

The number of seats is not indicative of the number of passengers a boat can carry safely. A safe load capacity depends on the boat's construction and characteristics. Weather and sea conditions must also be considered.

There are several things to keep in mind before leaving the dock. First, when loading a boat, distribute the load evenly. Keep the load low.

Don't let anyone stand up in a small boat. A boat under 26 feet can be very unstable with just one person moving around. If moving is necessary, stop or slow the boat. Keep low and toward the centerline of the boat

Above all, don't overload your boat. An overloaded boat will easily swamp or capsize because it cannot react to waves and other actions properly.

Many manufacturers install a plate on their boats showing the recommended weight capacity. This usually indicates the number of persons as well as the number of pounds for persons, motor, fuel, and gear. Many states now require new boats to have a capacity plate. These recommendations are for fair weather, however, and do not relieve the operator of the responsibility for exercising his or her judgment. If weather and water conditions are adverse, the load should be reduced accordingly.

In the absence of a capacity plate, use some common sense. There may be times when you must decide that some of the people or some of the gear will have to be left behind. If this decision interferes with the fun of the occasion, the choice could be a difficult one, but leadership requires this kind of strength.

If there is doubt that the load is safe, it would be better to err on the side of safety rather than pleasure—and tragedy.

A detailed formula for figuring boat capacity—one currently used by the Coast Guard—is included in the Federal Requirements and Safety Tips for Recreational Boats pamphlet. The boating guide covers all aspects of pleasure boating.

Low Head Dams

Low head dams are defined as those dams whose overflow, or spillway, discharges water of a foot or more depth measured at the lip of the outfall in normal weather. The downstream portions of such dams should be treated with the greatest respect. A swimmer or boater caught in the boil, backwash, or eddy currents on such downstream side is in dire peril. Not only are they unable to swim out of such boils, falling water has such force they may be pitchpoled under water, like a shirt in a clothes dryer, until they drown. Rescue from shore is usually next to impossible unless two or three strong lifeguards and a length of strong rope are handy.

Victims of such boils have been rescued by a strong swimmer from shore, secured with an adequate line tended by others on shore. So much for the ideal rescue. More likely the rescuer will be alone, but if there is a rope handy the rescuer could secure it to a tree or post and swim out to the victim. Both rescuer and victim could then pull themselves shoreward with the rope until an eddy current sweeps them the rest of the way. This is a very hazardous procedure and care should be taken when attempting it. Some victims may be rescued with fishing poles or strong vines, depending on the size of both river and dam.

For those of you cruising rivers and canals in unfamiliar territory, your wisest investment is a topographical chart of your section of the river. There is nothing funny about going over a dam of any height either by swimming or boat or float. Know where your portages are and go ashore at least 100 yards upstream from any low head dam.

Power and Sail Small-Boat Handling

In recent years, the sport of recreational boating has grown enormously. More than 40 million people take part. It has become a $1 billion industry with great career opportunities. For many people, it is a way of life. It is a sport that can last a lifetime.

The interest usually begins with one particular boat. Boats used for pleasure range up to 100 feet in length, complete with professional crews. Ninety percent of all boats in use today—not counting rowboats and canoes—are small sailboats and powerboats of 20 feet or less, operated by amateur owners.

Many graduate to the larger boats, but the small boat offers the best opportunity to acquire the skills and knowledge that apply to the handling of all boats.

Become familiar with this manual, take advantage of the instruction provided by your officers and consultants. Participate in courses offered by the U.S. Power Squadrons, U.S. Coast Guard Auxiliary, and yacht clubs and schools. Learn all you can from the available opportunities. There is no substitute for practical experience.

If you've been active in Scouting, you may already have the Rowing, Canoeing, Swimming, and Lifesaving merit badges. If not, you should acquire proficiency in these related activities.

Sailboats

Using a sloop-rigged sailboat such as the 13-foot, 6-inch Bluejay as an example, the following are recommended steps to take when you arrive at your vessel.

If she has a cover, remove it, fold it up, and stow it in a bag or up forward out of the way. Bail or sponge out any water in the bilge. Drop the centerboard and attach the rudder and tiller. Remove the boom crutch and stow it.

Check all gear: life vests or cushions, bailer, oars or a paddle, anchor, lines, compass, sailor's knife, fenders, boathook, etc.

Check all halyards to make sure they are not fouled. Check the shrouds to make sure they are set up correctly (barely tight is enough).

Remove the sails from the sailbag. Bend on the mainsail first. Attach the main halyard to the sail's headboard. Attach slides to the track on the mast and boom. Secure the tack. Run the foot of the sail out on the boom and secure the clew with an outhaul tautly, but without too strenuous a pull.

Insert battens in the pockets in the mainsail. Put a loose furl in the main and secure a line around it to keep it from bellying out or falling into the cockpit while you turn your attention to the jib.

Attach the halyard to the head of the sail. Attach clips or hanks to the headstay. Secure the tack and rig the sheet.

Most small sloops have a divided jib sheet. Check to see if it should be led aft outside of the shrouds through a fairlead, snatch block, or cam action device both to port and starboard.

Now, hoist the mainsail first, making sure the boat is heading into the wind. Set the halyard just hand tight. Belay the halyard on a cleat by making a figure eight wrap, finishing off with a round turn set in tight.

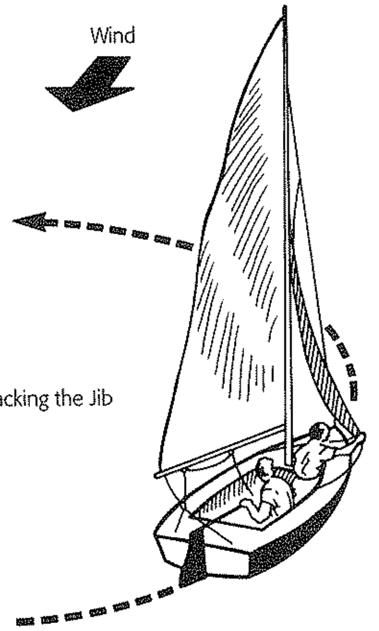
Never use a half hitch. Under strain or when it gets wet, it can jam and prevent the quick lowering of the sail. This applies to all halyards and sheets.

Now hoist the jib and set the halyard up tight. The leading edge should be perfectly smooth or it will interfere with the airflow in the sail. Coil and hang all halyards.

You're ready to get under way.

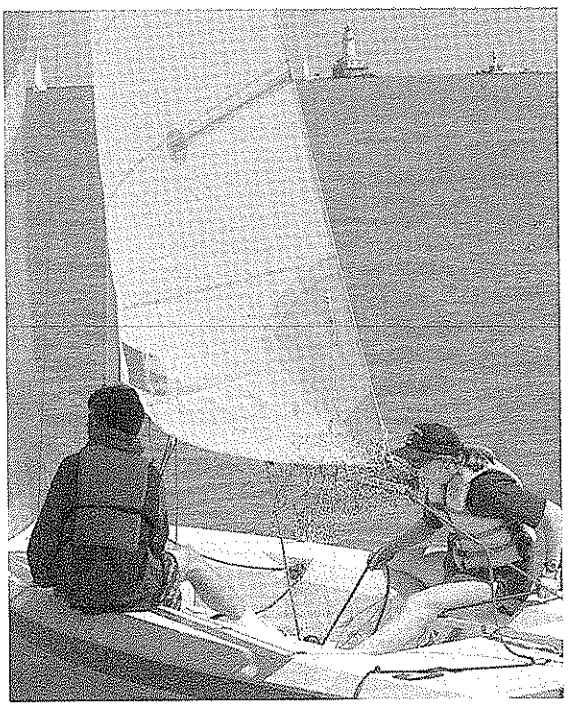
Getting Under Way From a Mooring

Look carefully at the direction you plan to travel to be sure you have room to maneuver. Cast the mooring from the deck fitting and draw it aft to give the boat some forward motion while putting the tiller over to get her clear.



As the bow falls off, trim in the main and jib sheets until the sails fill and the boat begins to move with the breeze. It is also possible to cast the mooring off and let the boat drop back. Point the end of the tiller in the direction opposite the one you wish to go and the stern will swing, letting the bow fall off, or have a crew member backwind the jib on the side opposite your proposed heading. The bow will fall off. Then trim the main and jib.

Be sure crew weight is properly distributed. Too much weight aft will cause the boat to squat. Too much weight forward will cause her to plow. Also, and most important, unless the breeze is very light, the crew weight should be on the windward side. In very light air, the crew weight can be amidships or to leeward to give her a slight heel, which helps keep the sail full. Experiment with weight distribution under various conditions to keep the boat sailing on her lines and properly balanced.



Make sure main and jib sheets are clear, not fouled on fittings or under your feet. You can take a turn on a cleat, but never put a hitch on a sheet.

Now move the tiller gently a few inches from side to side and note the effect on the boat's heading. You will see as you sit to windward, that pulling the tiller toward you causes the boat to swing off or away from the direction of the wind. Pushing the tiller away from you causes the boat to head up into the direction of the wind.

Now look at the sails. They should have a graceful curve to them caused by the pressure of the wind. This curve acts as an airfoil and the airflow in this curve exerts a forward pressure which causes the boat to move ahead. The correct trim of the sails is essential to their effectiveness and can be learned only by actually adjusting the trim and noting the effect.

By trimming in the jib and main as tight as possible, we get in close-hauled trim. Ease the tiller away from you (toward the sail) and bring the boat's bow more into the wind until the leading edge of the jib begins to lift or flutter. This is called lung. The mainsail's leading edge may also begin to luff. Ease the tiller toward you until the lung stops, then keep her steady as she goes.

If the jib is not lung but the mainsail is, try slacking the jib sheet a bit to improve the airflow through the slot between jib and mainsail. Too tight a trim on the jib can force the airflow off the jib to backwind the main, causing it to luff.

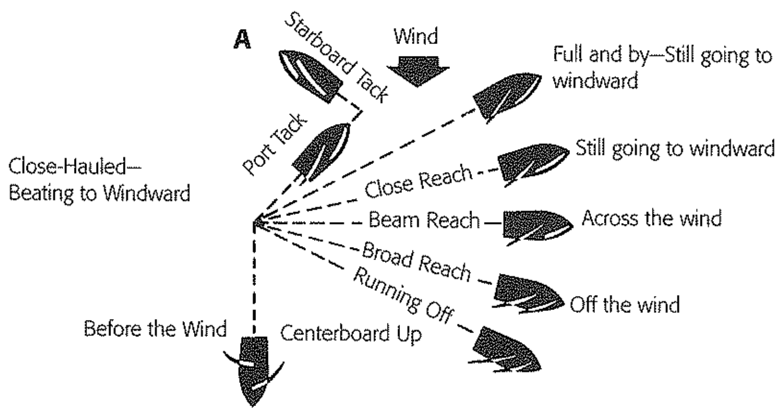
Tacking

Since it is impossible for a sailboat to sail directly into the wind, progress is made to windward in a series of tacks or zigzags, each tack being at about a 45-degree angle to the wind. To change tacks, it is necessary periodically to come about. To do this, the helmsman alerts the crew with the command READY ABOUT.

The crew checks the jib sheets to be sure they are clear. At the command HARD ALEE the helmsman eases the tiller away from him or her. He or she swings it to a point where it is at about 45° to the boat's centerline.

Never slam the tiller hard over as it will cause the rudder to act as a brake or drag, slowing the boat down and possibly putting her in irons as she fails to turn past the eye of the wind.

Points of Sailing

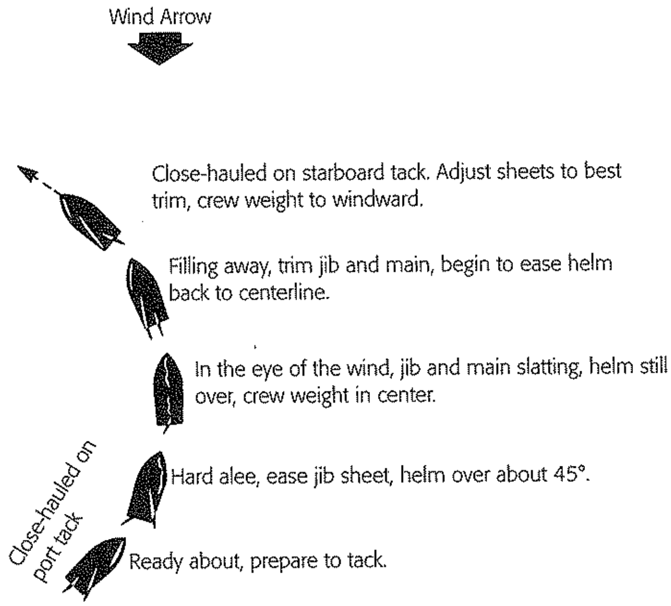


Jib and main trimmed on opposite sides (wing and wing)

All boats except A are on the port tack.

Now a crewman eases the jib sheet, and as the boat comes up into the wind, lets it fly and shifts his or her weight amidships. He or she ducks as the boom swings over the boat and then as the boat passes the eye of the wind trims in the other jib sheet as the boat fills away on the other tack.

Coming About

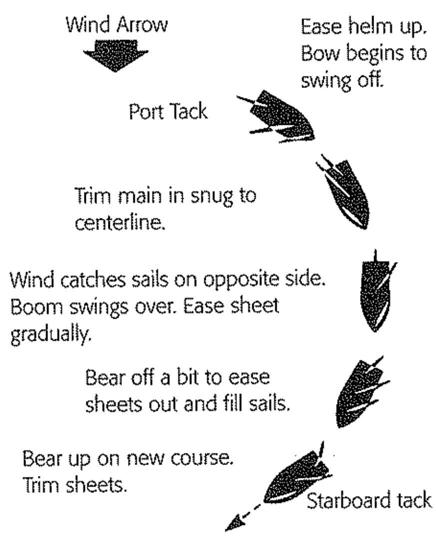


Moving his or her weight to windward as needed, the helmsman also shifts sides as the boat comes about, keeping the mainsheet in his or her hand. As on the new tack, the mainsheet trim should be about as it was on the previous tack.

Jibing

This maneuver involves changing tacks while sailing off or before the wind. It looks easy, but it can cause real trouble if not carefully controlled. It is the chief reason that boats capsize. It should be practiced in light air until cause and effect are clearly understood.

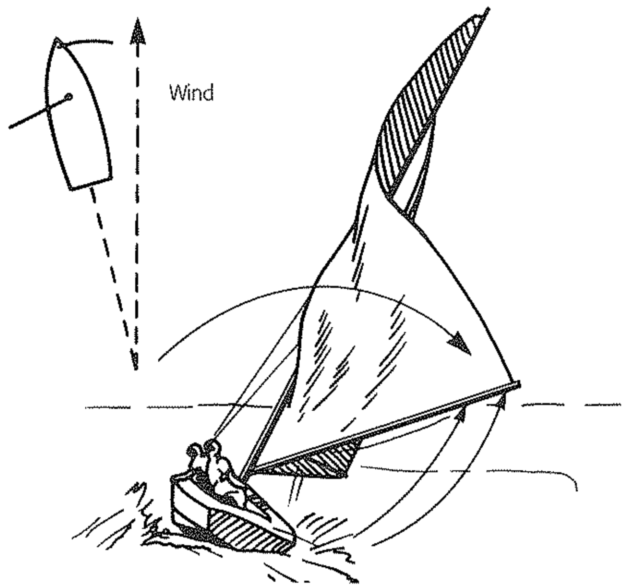
Jibing



As a jibe is planned the command is STAND BY TO JIBE. Check to be sure all sheets are clear. The helmsman eases the helm toward him or her (away from the sail), and the boat's head begins to fall off. At the order JIBE-O the helmsman trims the main in rapidly, while the jib sheet man moves his or her weight amidships and holds both jib sheets in his or her hands. As the boat's stern passes the eye of the wind, the mainsail catches it on the opposite side. Ease the sheet out rapidly. Swing the tiller off (away from the sail a bit to ease the strain). The helmsman shifts his or her weight to windward and adjusts the mainsheet to the new course.

As the jibe is executed, the jib sheet man eases on one sheet and trims on the other to keep the jib from flying out ahead and fouling on the forestay. He or she then trims the working sheet as needed, adjusting his or her weight to windward as needed. If it is a direct downwind jibe, the crew weight may be opposite that of the helmsman to keep the boat balanced.

A Goosewing Jibe



Beware the accidental jibe or a jibe in strong winds. The force of an uncontrolled 180-degree swing of the mainsail and boom can tear out deck fittings, rip the sail, snap the rigging or the mast, and almost surely capsize the boat.

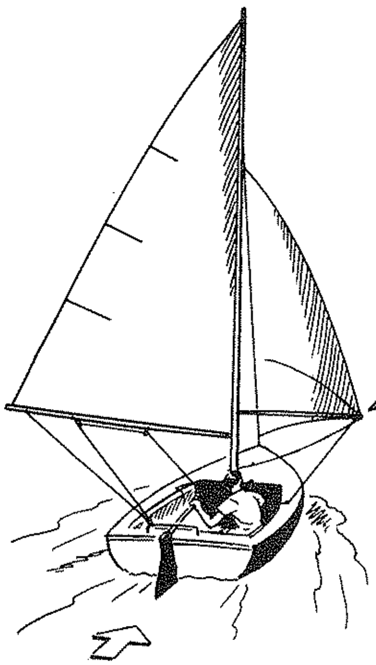
In fresh breezes it is better to come into the wind, trimming sheets to maintain speed until close-hauled, come about in the regular manner, and then bear off on the new course. By all means avoid what is known as a goosewing jibe. This occurs when the boom rises and the upper part of the sail wraps around one side of the upper portion of the mast while the boom and lower sail remain on the other side. This can happen if you are in a position to jibe and hold on too long. Using a boom vang can prevent this.

Running

Sailing on a close beam or broad reach poses no particular problems other than proper trim of the sails and crew weight distribution. The boom should be at, or nearly at, a right angle to the direction of the wind.

When running free (the most difficult aspect of sailing), many factors must be considered. Carelessness on the helm or a sudden wind shift could cause an accidental jibe with disastrous consequences. Keep a sharp eye on sea and wind conditions and take corrective action to meet any changes.

Wing and Wing



A Few Pointers

Sailboats are designed to sail on their lines. Don't permit them to heel too far over. In an open cockpit boat, putting her rail under may look exciting, but the margin of safety is very slim and the boat's actual speed is reduced. Keep the rail up by having crew weight as far to windward as possible and well distributed fore and aft.

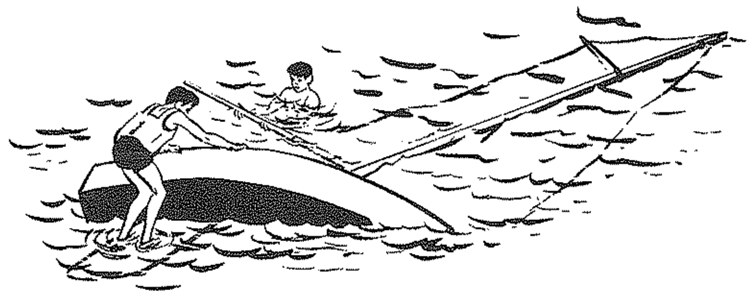
In fresh to strong breezes, tuck a reef in the mainsail or ease the mainsheet to let the sail luff and spill some of the wind.

In rough water, ease the bow off a bit to meet wave crests. Heading up into them could stop forward progress and make the boat subject to a knockdown. Keep the jib trimmed in flat. It will help maintain forward motion and at the same time backwind the mainsail. The jib sheet can be cleated with a couple of round turns but never the mainsheet. Keep it in your hand. Ease it off in heavy gusts; then trim it in enough to keep moving well.

Sooner or later, most small-boat sailors capsize or get knocked down. If it happens to you, don't panic. Stay with the boat.

First check to be sure all persons are accounted for. If not wearing one, slip on a life vest or get an arm through the straps of a buoyant cushion. Round up and secure all loose gear. Get the sails off by releasing the halyards. Draw them down into the boat and lash them.

Your boat can probably be righted by standing on the centerboard and pulling on the coaming. Bail the water out until it's safe to get aboard and finish the job. Otherwise, stay with the boat until help comes.



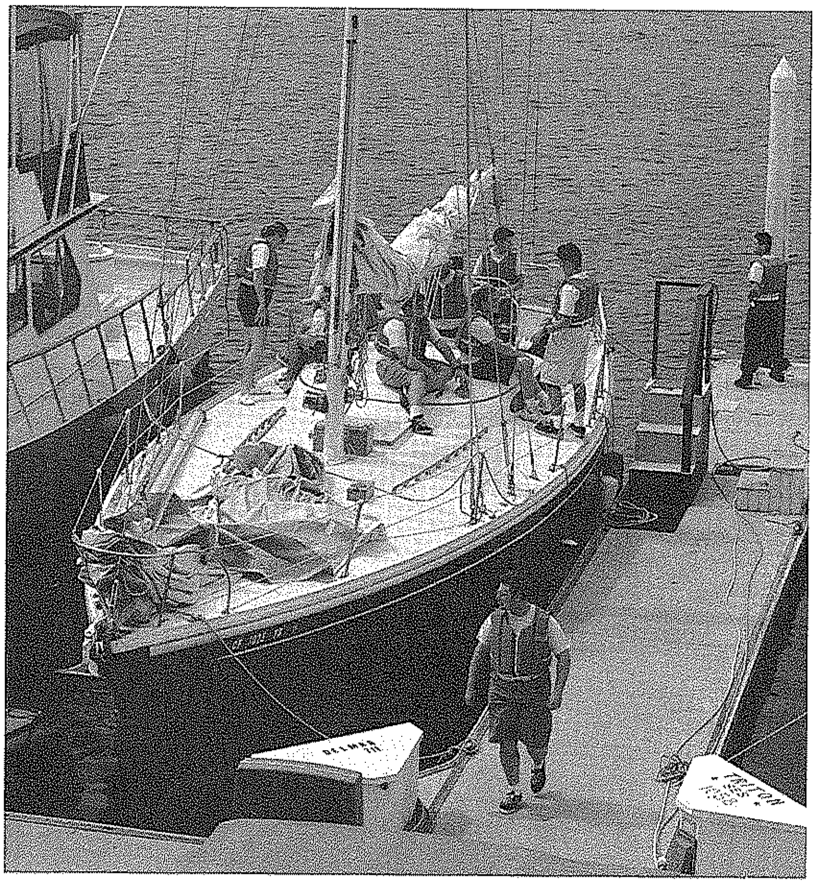
The sailor on the far side is getting the mainsail off the mast while his companion stands on the centerboard preparing to swing the boat upright.

Mooring and Docking

In a clear area, with room to maneuver, practice coming into the wind a few times to see how far your boat will shoot or coast into the wind. With this distance in mind, you can pick up a mooring or round up to a pier with some confidence.

When approaching a mooring, sail to leeward of it until you are within shooting distance. Let the jib fly, ease the tiller over, and coast up to it. If you come up on it too fast, go around and try again.

Picking up a mooring on the fly may cause the boat to come around with disastrous results. If you fall short, backwind the jib, get under way, and try again. If you have to approach the mooring from upwind, round up to windward, drop the sails, and drift down on it.

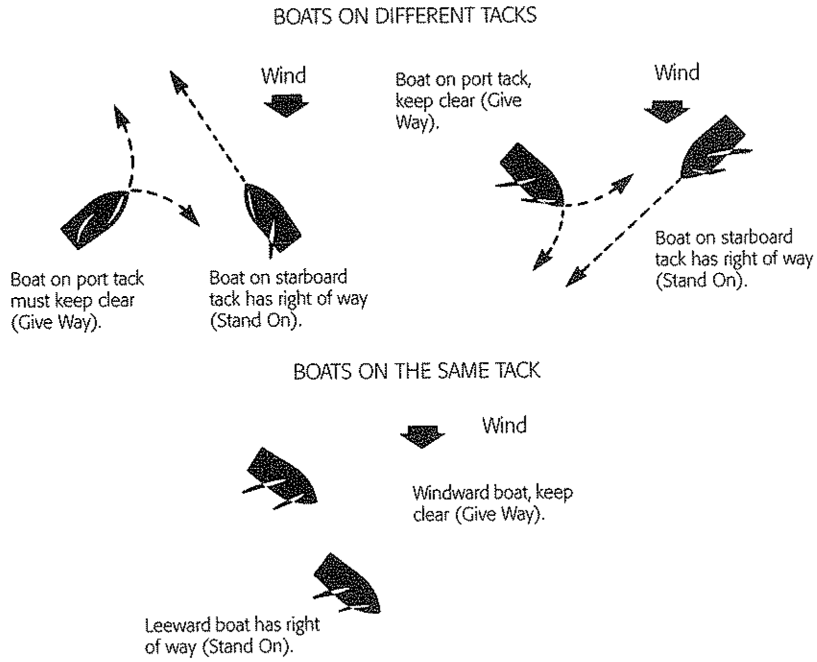


In approaching a dock the technique is similar, but the penalty for misjudgment can be more severe. Too much headway here can result in a damaged boat, a snapped mast, or a ripped sail. And not enough headway may leave you with no room to maneuver. It takes practice.

The Rights of Others

There are two main points involved here for small-boat sailors. (1) The rules of the road, which provide legal privileges and burdens, and (2) customs and courtesy, which have their roots in common sense and consideration.

Rules of the Road for Boats Under Sail



Rule: A vessel overtaking any other vessel (sail or power) shall keep clear of the overtaken vessel.
Statement: In obeying and construing these rules, any action taken should be positive, in ample time, with due regard for good seamanship.

Small Boat Courtesy

There are countless occasions when a sailboat has the right of way, but the rules of judgment and consideration are paramount. In a narrow channel or crowded anchorage, a small, easily maneuvered sailboat must keep clear of a larger one that is more difficult to handle. In fact, the rules of the road require small boats to keep clear of vessels 65 feet and over in crowded anchorages and channels.

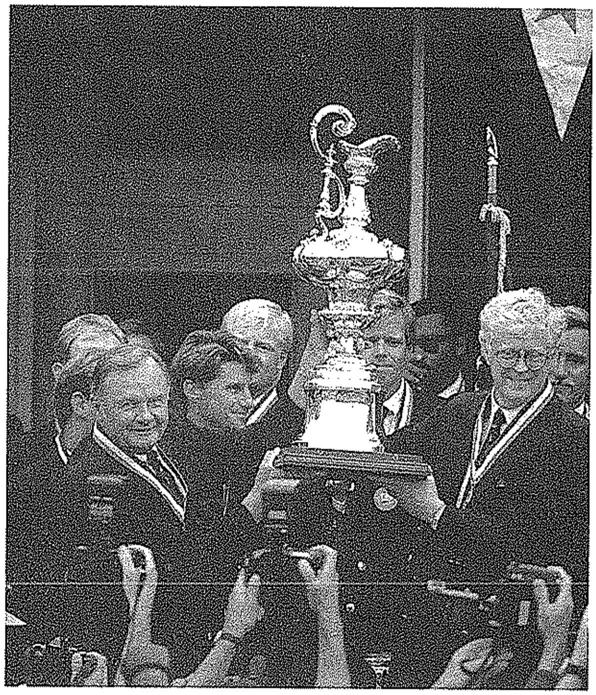
Keep well clear of commercial vessels and tugs with unwieldy tows. Always keep entirely clear of boats that are engaged in a race. Size up the other boat's problem and yield to him or her when it won't endanger you but will give him or her a break. Don't heave trash overboard in any waters. Always and immediately go to the assistance of anyone in trouble or distress or see to it that assistance is immediately available on the scene of the trouble.

Racing

Sooner or later you will find sailboat racing an irresistible challenge. This is a broad and complex sport involving rules, tactics, and advanced boat and sail handling. It involves the use of spinnakers, split-second timing, superlative seamanship, courtesy, and good judgment.

Become thoroughly familiar with the racing rules of the International Sailing Federation, available from the U.S. Sailing Association. There are about 70 such rules that set conditions and define everyone's rights and obligations.

The most famous sailboat race is the America's Cup. In this contest, another nation challenges the current holder of the America's Cup. This country successfully defended the cup since the schooner *America* won the first race in 1851, losing for the first time to Australia in 1983. The United States regained the cup in 1987, successfully defending it two more times before losing to New Zealand in 1995.



Buddy Melges (left) and Bill Koch (right), winners of the 1992 America's Cup and Sea Scouting volunteers, along with members of the winning crew.

Care of Boat and Sails

A boat is a thing of beauty, but it requires hard work to keep it that way. A sailboat needs care. Here are some pointers.

Clean up the boat when you leave it. Swab off the decks and cockpit. Keep the bottom clean and smooth. Scrub it off every couple of weeks to remove growth or slime. Keep the ends of your lines whipped, your standing rigging properly tuned. Stow gear properly. Keep life vests and cushions dry. Use a good cover to keep out rainwater.

Care of Sails

Modern sailboats use nearly all synthetic sailcloth—Dacron, nylon, Kevlar, or mylar. These materials have greatly improved characteristics over canvas, but they do require proper use and maintenance.

Care in Use

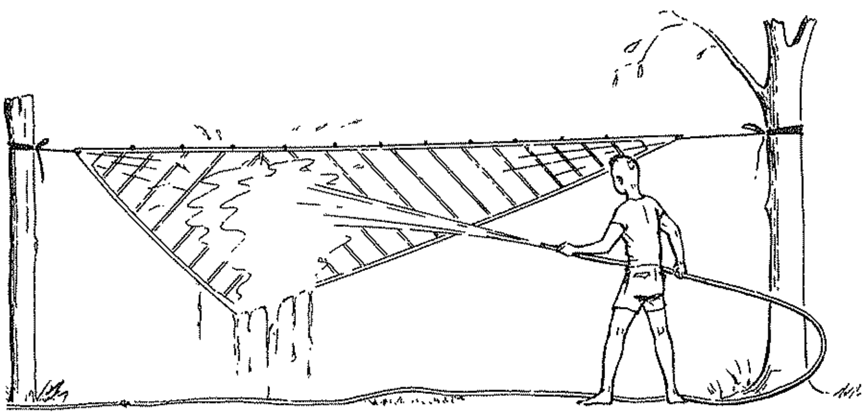
Protect sails from chafing—use wooden or rubber protectors over turnbuckles and at the tips of spreaders. Don't let sails slat needlessly; it wears the stitching and tears batten pockets. Use properly fitted battens and remove them when the sail is furled.

Care in Stowage

The greatest enemy of synthetic sailcloth is the sun. Excessive sunlight ultimately causes the material to break down and lose its strength. If sails are left on, they should be furled and covered. Water and moisture will not harm Dacron and nylon, so such sails can be stored damp if necessary. It is, however, advisable to dry them if you can, in order to avoid mildew and carrying moisture below decks.

Wash sails once or twice a season with pure water and soap—no detergents; and never use a washing machine. Hose off, spread to dry, and inspect before folding. Try to keep them as free from salt as possible.

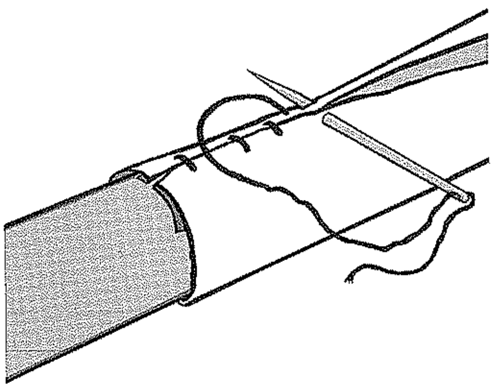
When storing for the winter wash, clean, and dry. In folding, lay out on the floor, fold lengthwise, accordion fashion. When you have a 2- to 3-foot-square bundle, fold head to foot, tie up and store safely or hang to protect from vermin.



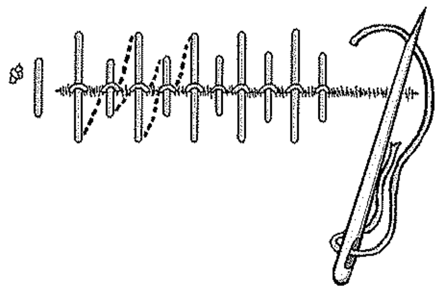
Sail Maintenance

Although any major repairs should be left to a professional sailmaker, every sailor should be familiar with four basic emergency repairs: the round stitch, the herringbone stitch, the patch, and sail repair tape.

ROUND STITCH. The round or overhand stitch is used particularly for light sails and in repairing minor tears, 1 to 4 inches long. Gather the two sides of the rip, starting about an inch above it. Secure the thread not by knotting, but by passing it under the first few stitches; then sew over it and continue round and round, ending about an inch below the tear. Finish your job in the same turn-under way.



HERRINGBONE STITCH. This is used for more serious repairs. Before placing the two sides of the rip together, fold under a narrow margin on each and "iron" it like a pair of pants by gently scraping the edge of the sailcloth with your knife. Then make alternate long and short stitches to avoid an even line, starting about $1/4$ inch from the end of the tear, and finish $1/4$ inch below it. Tuck the end of the twine under the final few stitches as in the round job, and cut it. This is a stitch that is best learned from someone who knows how.



PATCH. Cut your patch, if possible, from the same weight and type of material as the damaged sail. Allow about $1\frac{1}{2}$ inches of margin on either side of the tear and turn the patch under $\frac{1}{2}$ inch all the way round. "Iron" folds with knife treatment to keep them manageable, especially heavier weight cloths. Try to get the weave of the patching cloth to run identically with the sail being repaired. Measuring the approximate area and marking the patch material with pencil before cutting will help.

Miter corners of the patch and, pinning it to sail with extra needles, use the round or overhand stitch to sew your patch to the sail. Pound it into submission with a knife handle, turn the whole lot over, miter the corners of the torn sail itself, sew it to the back of the patch, and hoist away.

TAPE. Spinnaker and white rigging tape can be pressed into service swiftly and efficiently to help you finish—even win—a race, or perhaps withstand the wind in some cruising crisis until you reach port.

In making the repair, separate the sticky part from its guard which comes as part of the roll; then, as you unroll the ready tape, press with your fingers on both sides of the rip or seam. It should hold until you can get to it with needle and thread, or bring it ashore to the sailmaker.

Sail Repair Kit

Various sailmakers can supply emergency repair kits suitable for the sails used on your boat. These include sewing twine, needles, beeswax, a sewing palm, and other useful items, including a booklet of instructions on the care and repair of sails.

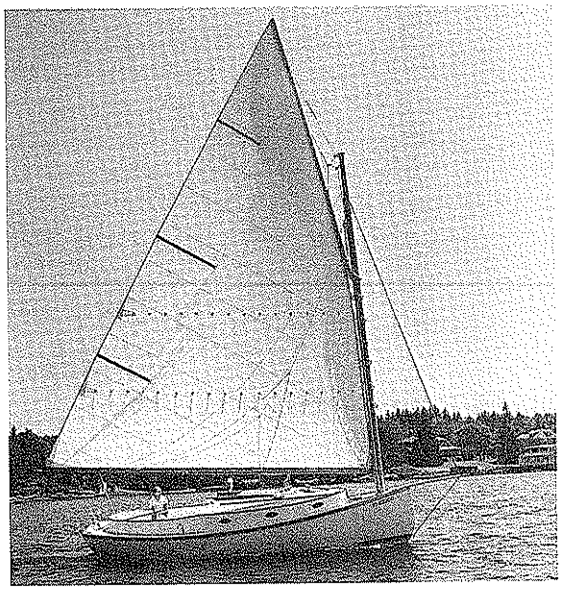
Larger Sailing Craft

Anyone with a bit of salt in his or her veins has a heart that beats faster when he or she sees a sail in the wind. Although he or she may specialize in small sailboats, he or she will also want to learn about larger sailing craft.

The photographs here should whet your nautical appetite and lead you to further investigation of these marine beauties. To cover all sailing craft here is both impractical and impossible. There is a vast range of makes and types. However, rigs fall into only a few basic types, described here.

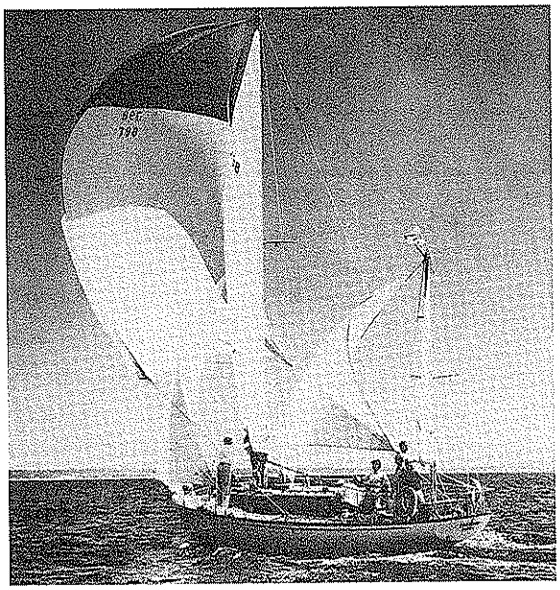
The Sunfish, with its pole mast straight up in the bow, carries a single sail and is both impressive and easily handled.

The sloop is a single-masted vessel with the mast far enough aft to enable it to carry one or more headsails—forestaysail, jib, or spinnaker.



Gaff-Headed

Racing Sloop, Marconi Rig With Genoa Jib

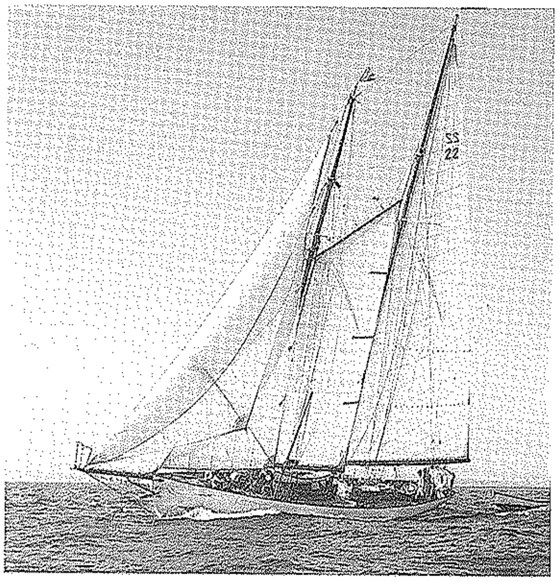


Yawl Carrying Spinnaker and Mizzen Staysail

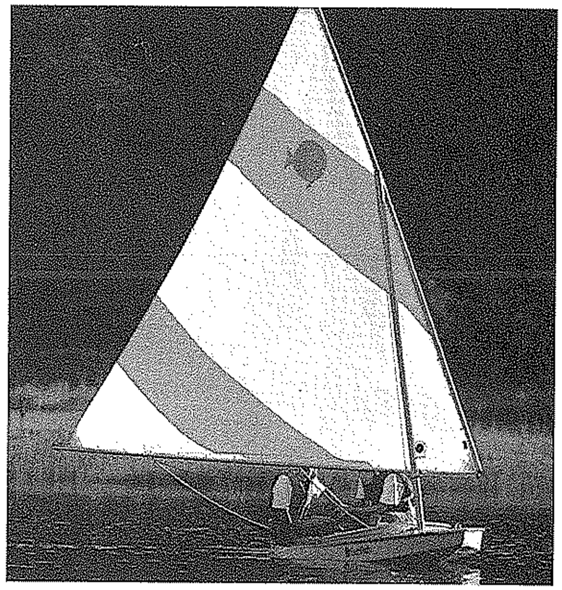
Ketch Rig

The yawl has two masts; the shorter is stepped aft of the rudder post or wheel. The smaller sail is called the mizzen or the jigger and aids in sailing balance. In heavy weather this boat can be sailed with a whole or reefed mainsail or do well under jib and jigger. The sail area of the mizzen or jigger is about one-fifth the area of the mainsail.

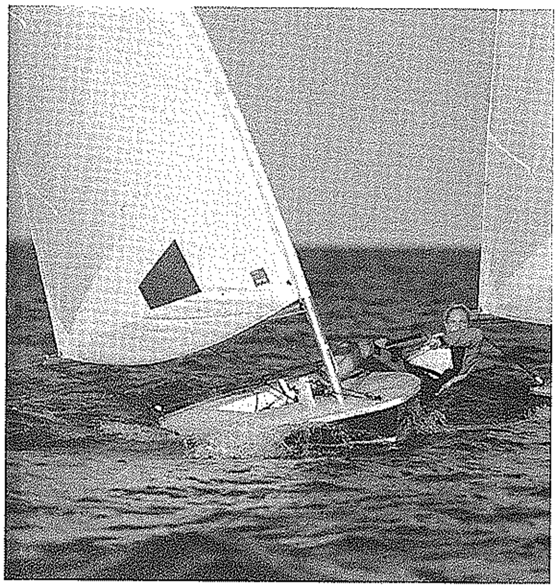
The ketch is somewhat similar to the yawl except that her aftermast is somewhat larger and is stepped forward of the rudderpost. This mast is also called the mizzen. The area of the mizzensail is one-third to three-fifths the area of the main. It, too, aids in sailing balance. Sail may be shortened to mizzen and a



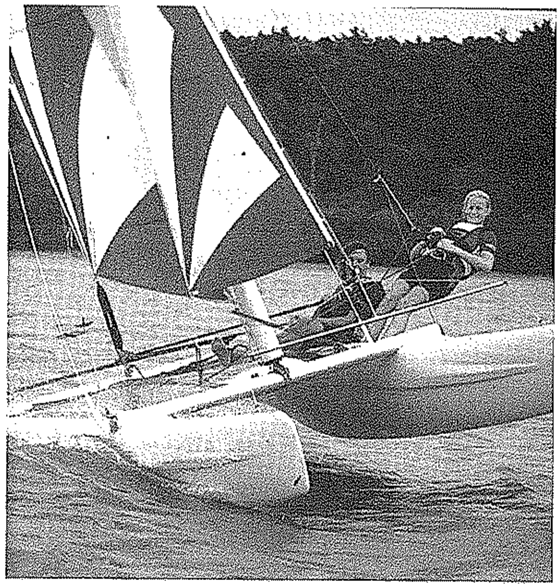
Schooner Gaff-Headed Foresail and Jib-Headed Main



Sunfish



Laser (Radial)



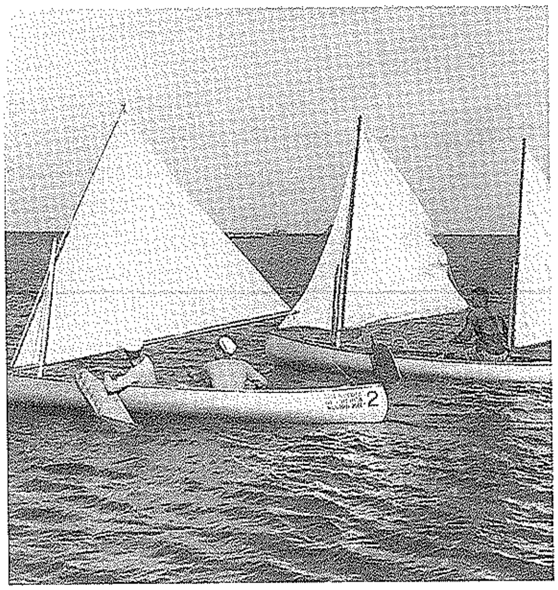
Laser Cat

large headsail. Or, as in a yawl, both may be taken off and the mainsail alone, whole or reefed, may be used.

The schooner is a traditional type, not so frequently seen today as are generally faster and more easily handled boats—the yawl, ketch, and sloop. The schooner's fore (forward) mast is the shorter of the two. (Schooners with more than two masts have all masts approximately the same height.)

The largest ever built was the seven-masted schooner *Thomas W. Lawson*. Its masts, starting forward, were named: fore, main, mizzen, jigger, driver, spanker, and pusher. Its headsails, starting from the foremast, were: forestaysail, jib, outer jib, flying jib, and jib topsail.

One-Design Sloop



Sailing Canoes
Lateen Sail (left), Marconi Ketch (right)

The most famous schooner-rigged yacht was the magnificent *Atlantic*, a 185-foot three-master. In 1905 she raced from Sandy Hook, New Jersey, to the Lizard Lighthouse in England in 12 days, 4 hours, 1 minute—a record never broken by a sailing vessel, yacht, or clipper ship.

There are many inexpensive kits available, from sailing dinghies to cruising auxiliaries, all in various stages of completion. Look in yachting magazines for boats that your ship might build.

Powerboats

Since about 85 percent of all small boats in common use are powered by outboard motors, let's take a look at a typical small outboard motorboat.

The boat we have selected is a 16½-foot open "day boat" powered by a 65-horsepower motor. It has a planing hull. This means that as its speed increases, the boat tends to lift up out of the water and plane along on the surface. The heavier round, or "vee"-bottom hulls that do not plane, but rather plow through the water are displacement boats.

Our boat has good freeboard, plenty of beam, built-in seating, and remote controls. Since she is more than 16 feet in length, she is included in the Federal Boating Safety Act of 1971. This act is described in the section on "Piloting."

You must be thoroughly familiar with its provisions, as well as the laws of your state affecting use of powerboats, including federal or state laws requiring all powerboats to be numbered. You can get this information from the U.S. Coast Guard, local law enforcement agencies, marine dealers, or boating organizations in your area.

Sea Scouts should know and observe the "Scout Boating Code" as stated in the *Motorboating* merit badge pamphlet.

Before getting under way from mooring or dock or before launching the boat from a trailer, make a careful check of the boat, motor, and equipment. Remove and stow the boat's cover, if she has one. Bail or sponge out any water that may have accumulated. Be sure the drain plug is in place.

Check all equipment that is required by law and by common sense. The law requires one approved lifesaving device for each person, a hand- or mouth-operated whistle, and at least one B-I fire extinguisher. (See "Fire Prevention" on page 248.)

If the boat is to be used after sunset or before dawn, federal law requires prescribed lights to be displayed. Federal and state laws also require the boat's certificate of numbering to be aboard.

Common sense calls for suitable anchors, anchor and dock lines, compass, chart of the area, fenders, boathook, paddle, tool kit, spare fuel, emergency light, bailer, first aid kit, spare engine parts, shear pins, flares or smoke signal kit, and possibly fresh water and emergency rations.

Motor Check and Starting

With all gear checked and properly stowed, turn to the motor. If it is necessary to install it, be sure the boat is secured to the dock or float with lines fore and aft. Check the mounting bracket to be sure it will slip easily onto the transom.

While one person can easily swing a light motor aboard (being careful to keep the weight centered in the boat), it will take two people to handle a large, heavy motor.

Make sure the transom bracket is set up tight and that a safety chain is well secured. Connect up all controls and fuel lines, if these are provided. Check the shaft angle of the motor (it should be vertical to the surface of the water at normal operating speed and trim). If the motor is already in place, release the tilt lock and drop the motor into operating position.

If the boat has electric starting and remote controls, starting is simple. However, before starting be sure all is ready and the passengers are aboard and seated. Never overload the boat. Allow 12 cubic feet of space for each 150-pound passenger, and distribute the weight of the passengers so the boat trims properly.

Follow the manufacturer's instructions for starting and setting the choke, throttle, and gear positions properly. Run the engine at low speed for a minute or two to warm it up.

Handling and Maneuvering

It is important to acquire the feel of your boat as quickly as possible. Steering is the same as for a car except—and this is important—the stern swings to bring the boat onto a different heading. Keep this in mind in close quarters or when approaching docks or floats.

Move out, with due regard for any speed regulations in anchorages and channels, to open or unrestricted waters, and spend some time checking the boat's performance. Adjust the trim if necessary. Try various speeds and steering reactions. Be sure that you have control of the boat before your speed is too great.

Warning: Don't cut the forward speed too rapidly or your wake may catch up with you and pour over the stern.

See how the boat handles in reverse. Practice maneuvering alongside an anchored boat cushion to judge stopping distances, steering, stern swing, etc. Practice allowing for the effects of the wind and current.

Leaving and Approaching Docks

Nothing identifies the lubber as quickly as sloppy boat handling at docks or floats. Skill comes from practice, knowing your boat and how she reacts in close quarters.

If you are leaving a pier from the windward side, cast off the stern line, snug in the bow line, and come slow ahead under power with the wheel hard over toward the dock. The thrust of the propeller will swing the stern out. When it is in the clear, release the bow line and back away far enough to then go forward without striking the pier or other boats.

On the lee side of a dock, cast off bow and stern lines, giving the bow a good shove off. When she is headed clear, move away slowly under power, watching the stern swing so as not to hit the dock or other boats.

In approaching docks or floats, speed should be reduced to provide steerage way only. If coming in on the windward side, approach with caution, stop parallel to your dock a few feet out, and let the wind set you down.

Approach the lee side at about a 30-degree angle, bow in, until a line can be secured on the pier. Then put the wheel hard over away from the dock, go slow ahead and the stern will swing in alongside. In either case, forward movement can be checked by putting the engine in reverse just long enough to stop her.

In making a landing on a beach or launching ramp, head straight for it at slow speed. Cut the motor when momentum will carry you in. Tilt the motor up to avoid propeller damage.

When leaving shore, pole or paddle the boat into deep water before starting the motor.

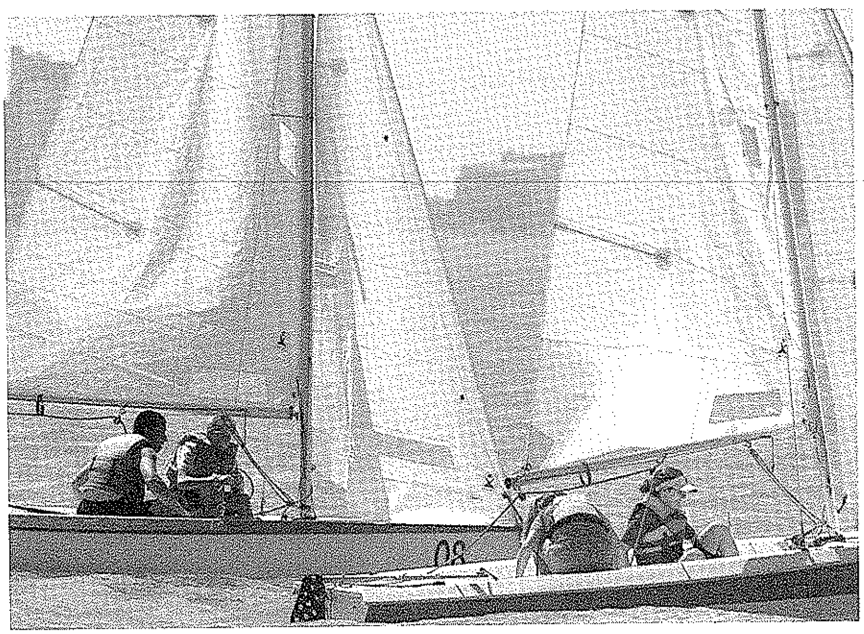
General Operation

As soon as you are afloat, you will find that you are engaging in an activity shared by a large number of people. As a result of the growing popularity of boating, congestion sometimes develops at launching areas, service docks, anchorages, and channels. Patience, courtesy, and consideration for others are important.

You should be familiar with boating's "traffic laws" or rules of the road. Always keep clear of larger boats that may be more difficult to maneuver. Keep clear of sailboats, rowboats, canoes, and people who may be fishing, swimming, or skin diving.

Observe speed rules in anchorages, channels, near docks and floats, or near boats that are anchored. Take a good look at the waves your boat creates when under way and keep in mind that you may be held liable for any injury to persons or damage that your wake may cause.

Familiarize yourself with the waters in which you will be operating. Consult a chart, if one is available, and learn the meanings of the buoys and other aids to navigation.



In inland or uncharted waters, watch for shallow water and hidden rocks or snags. Frequently, the color of the water is a useful guide: darker for deep water and lighter for shallow water. Breaking waves, eddies, or ripples reveal underwater obstructions.

On rivers, the deepest water is usually in the middle on straight stretches and on the outside of curves.

Safety

Boating is a safe activity if care and common sense are constantly exercised. Learn to judge the weather and sea conditions. Remember that what may be a fine sailing breeze for sailboats could produce some heavy and dangerous conditions for a small outboard boat.

Be very sure that all persons in the boat are competent swimmers and are instructed where to sit and how to conduct themselves.

Make sure that at least one other person in the boat knows how to operate it in case you should be taken ill or otherwise become disabled. Nonswimmers and beginners must wear life vests. Some states require that children below a certain age wear life vests regardless of their swimming ability.

Avoid sharp turns, particularly at high speeds.

Never anchor in a channel or fairway and never tie up to a buoy or channel marker—it is a federal offense.

Keep entirely away from beaches where there are swimmers. Even a slowly turning propeller can cause the loss of an arm or leg, or inflict other harm to a person.

Reduce speed in rough water or when crossing the wake of another boat. Head into large waves.

Fueling

When gassing up, exercise extreme caution. If your boat is equipped with a portable fuel tank, take the tank onto the pier or float to fill or refill it. Mix oil and gas alternately. Keep the gas nozzle grounded against the tank. Tighten the tank cap and close the vent when returning the tank to the boat. Connect the fuel line carefully, then open the tank vent. If the boat or motor compartment is decked over, be sure it is properly ventilated as required by law.

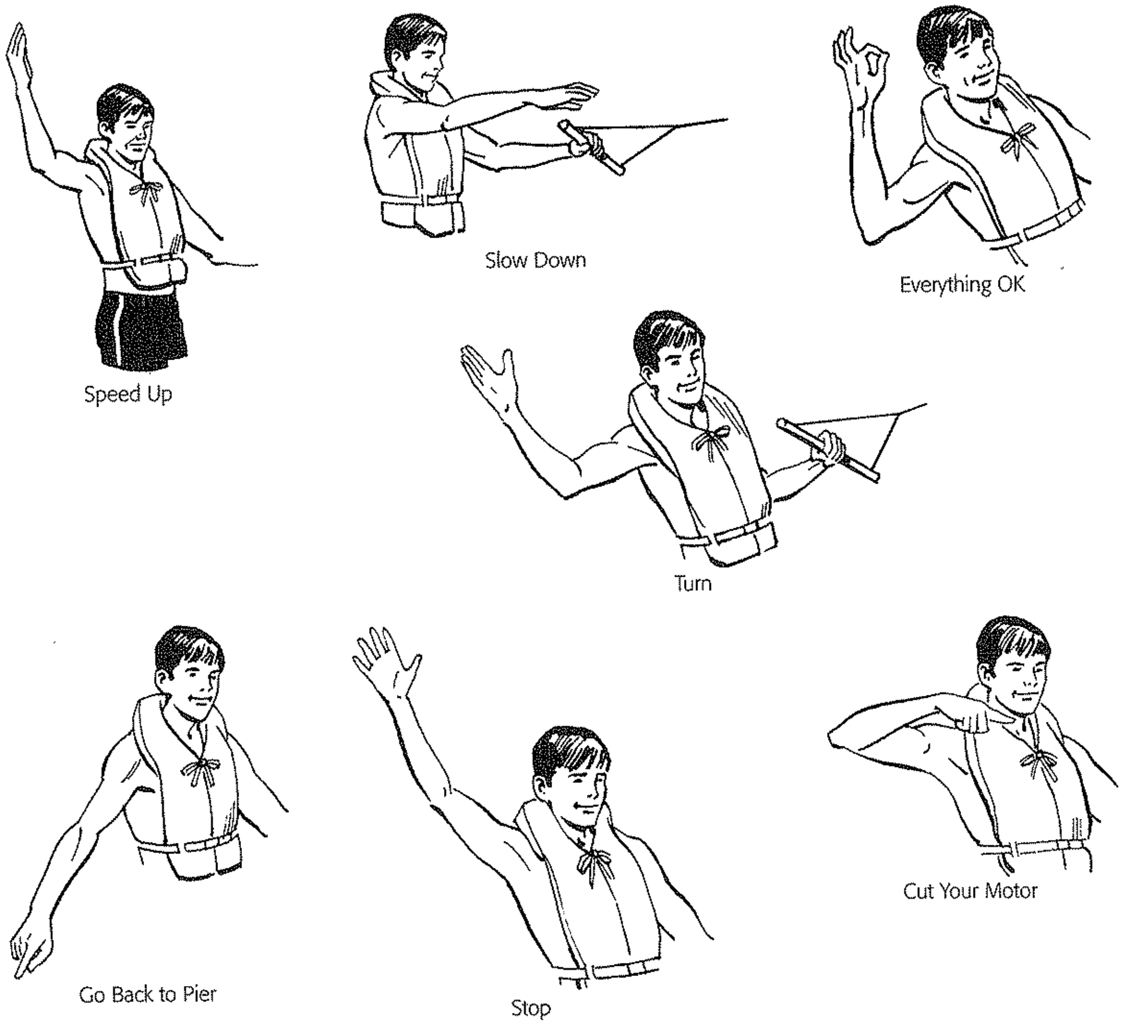
Waterskiing

This is a popular sport and a lot of fun, but it takes practice to acquire real skill. Like everything else connected with boating, it takes good judgment and consideration for others. Boatmen are infuriated when water-skiers violate the rules of common sense.

- Never waterski in an anchorage, channel, near a swimming beach, or anchored boats.
- Pick an open area where you will not interfere with anyone.
- There must always be two people in the towing boat—one to operate the boat, the other to observe the skier and tend the towline. Some states require a rearview mirror.

- Skiers should wear a life vest even if they are very strong swimmers. A wipe-out at high speed can stun and disorient the most experienced skier.
- Learn the standard signals for waterskiing and observe them. Have fun, but use good judgement.

Standard Hand Signals for Water-Skiers



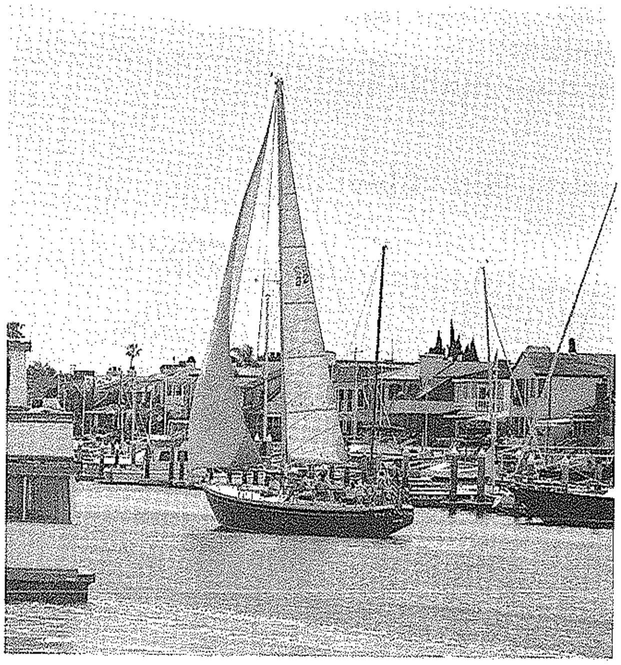
Trailering Your Boat

One of the great advantages of small boats is their mobility. With a good trailer, all kinds of new boating areas can be explored. You might want to consider renting a trailer for weekend or long-cruise trips. It is not expensive, and the rental fee normally provides for legally required equipment, insurance, license, hitch, etc.

A stout car hitch that is well secured is essential, and the trailer itself should be adequate for the load. Become familiar with the laws of your state regarding trailers, covering licenses, insurance, equipment, lights, safety chains, and restrictions on the overhang distance for masts, etc.

Be sure your boat is positioned properly on the trailer and that it is well supported at all contact points.

Proper balance is important. One person should be able to lift the loaded trailer easily to attach it to the car hitch. Always be sure the boat is tied down properly and secured against fore-and-aft slippage. Most trailers are equipped with loading winches, and many have tilting arrangements to facilitate loading and launching.



When ready to put your boat in the water, look for an established launching ramp. Otherwise, pick a gentle slope with a surface firm enough to support the wheels (deflating the tires a bit will help on sand). Be sure there is sufficient water depth to float your boat. Back down to the water at right angles. Avoid, if possible, backing the trailer in deeper than the wheel's hubcaps. Water—especially salt water—can ruin the wheel bearing lubricant. Do not launch while wheel bearings are hot.

Before launching, release all tiedowns, lock the motor in tilt position, release the bow winch, and rig a line to draw the boat back in when it floats free of the trailer. Disconnect the trailer lights to avoid burning out a bulb when you use the brakes.

When all is ready, push the boat off the trailer or tilt the trailer so the boat rolls off. Remove the car and trailer to a parking spot and draw the boat up to the beach. You are ready to get under way.

Travel Tips

Before starting a trailer trip, check the security of the boat on the trailer. If you load gear into the boat, distribute the load evenly to maintain balance. Do not exceed the load capacity of the trailer. Be sure all state requirements are observed.

Check the wheel bearing lubricant, tire air pressure, lights, and the hitch and safety chains (allow enough chain slack to make sharp turns.) Be sure the boat's motor is secure on the transom.

If you have a sailboat, place the mast so there is a minimum overhang, and attach a red cloth to the end of the mast. Check all points of boat and gear contact, and pad, if necessary, to avoid chafing. Be sure that the trailer tilt and winch locks are in place.

It is recommended that fuel tanks be empty when traveling. Fill them at your destination.

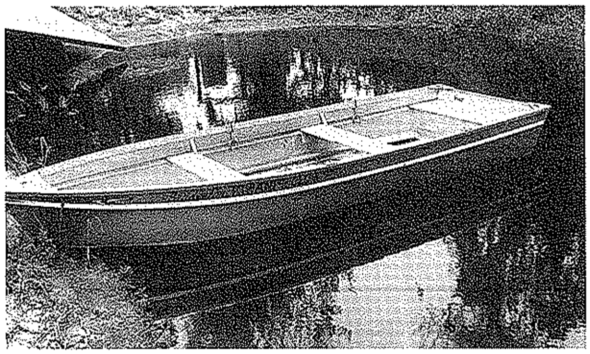
Careful attention to these details will make your trip a safe and successful experience both ashore and afloat. You will have more fun, too, when you play by the rules.

Types of Powerboats

There is, of course, an endless array of sizes and shapes of powerboats, all the way from the canoe (man-powered) to the mighty supertanker. Each type of powerboat is designed and built for a special purpose or to meet special conditions.

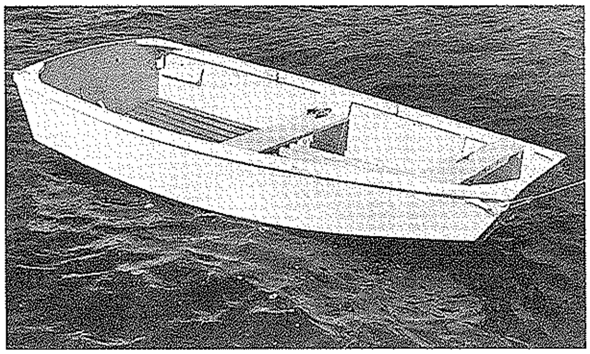
Before acquiring a boat, consult local boating experts. There is an important relationship between where and how the boat is to be used, the type of power, and the material of which the boat is constructed. Boats are made of wood, aluminum, cement, and fiberglass. Power choices include inboard engines, out-

Punt

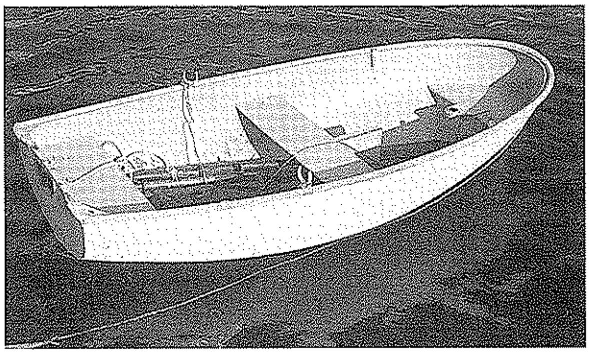


Skiff

Dory

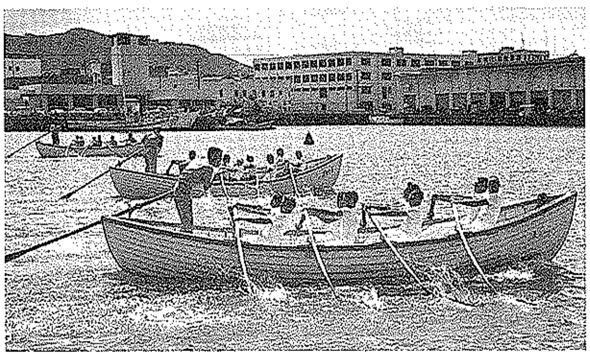


Pram



Dinghy

Self-Bailing Surfboat



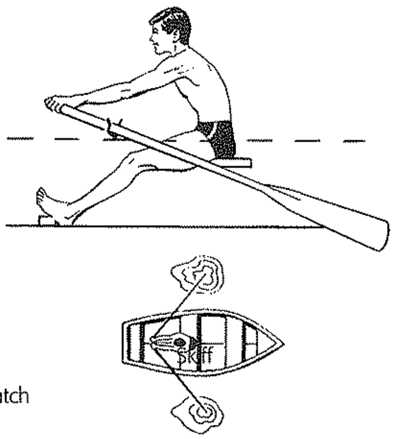
Whaleboat—Pulling Boat

board and inboard-outboard motors—either jet or propeller type.

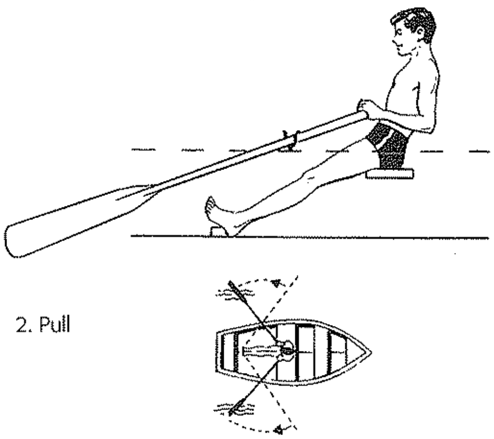
Punts and skiffs are designed for smooth, sheltered water. The dory is designed to meet conditions on the open sea.

The pram and the dinghy are designed to carry people and gear from shore to larger boats in sheltered anchorages. Light in weight, they can be carried on larger boats to serve as tenders, or they can be lashed on top of a car for fishing trips.

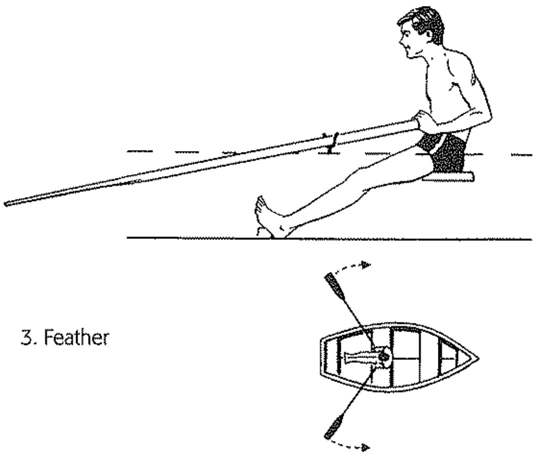
The cutter is a large pulling boat designed to carry a large number of people. Larger models, powered



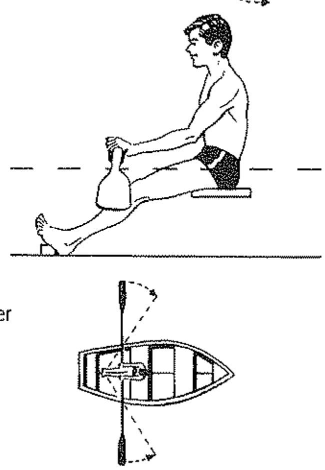
1. Catch



2. Pull



3. Feather



4. Recover

with diesel engines, are used for liberty and landing parties in the Navy. (Remember that a cutter is also a type of sailing rig.) Pulling and powered surfboats are used for saving lives in heavy seas or surf.

The canoe was the Native American Indian's mode of travel on quiet rivers and lakes. And, in skillful hands, it could run white water safely. It is still one of the most popular crafts on inland waters.

The catamaran with its two hulls has great speed and stability. The motor sailer combines the best features of the full-powered hull with the added security and economy of sails.

The owner of a small powerboat will find fun and excitement not only in his own boat, but in his ability to recognize and identify other powerboats—large and small.

Rowing

Rowing is a skill to be acquired by practice. However, a few hints may be of help.

First, before starting to row, be certain the oars are the right length. In a single-banked boat (whaler), twice the width of the thwart from which it is rowed plus the freeboard at the rowlock is the correct length. In other pulling boats, the correct length is twice the length of the thwart from which it is rowed.

Good oarsmen generally prefer to have the ends of the oar handles touch each other or overlap slightly, since this gives more power to the stroke.

The complete stroke is made up of four distinct movements:

1. **Catch**: placing the blades in the water ready to pull.
2. **Pull**: sweeping the blades aft to give headway.
3. **Feather**: raising the blades and turning them flat.
4. **Recover**: swinging the oars to the position of catch.

To give the stroke full power, keep the upper edge of the blades at the surface of the water, your hands as level as possible. They should move fore and aft in a smooth motion.

As the stroke is finished, give your wrists a smart flip so that the blades come out of the water at about a 45-degree angle. Keep your elbows close to the body and your back straight, chin up and in, and your feet against the stretcher or otherwise well braced. Your weight should be centered slightly abaft.

The pin-type rowlock will not permit proper rowing technique. This kind of oarlock is used principally on lakes for trolling where the oars are often trailed. A ring rowlock is better, and a preventer inboard of the oar is used so that the oar will not move overboard.

In rowing, learn to set a course making due allowance for tide or wind. Once your course has been determined, steer by the wake or by taking a range over some point off the quarter. It is tiresome to be turning continually after every few strokes to look forward.

Sculling

A single oar, properly handled, can move a boat almost as fast as a pair of oars used in the conventional manner. This maneuver is called sculling and is helpful in crowded waters.

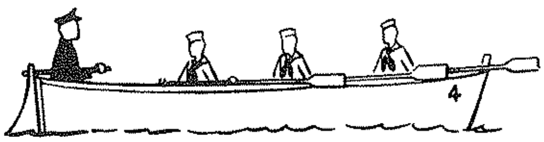
In sculling, the oar is shipped over the stern and placed in a grommet or rowlock in the transom. The sculler stands facing aft. Grasp the handle in your right hand, your knuckles down, and move the handle to the right. At the end of the stroke, turn your knuckles up and move the handle to the left—knuckles up, push left; knuckles down, push right. Continue this, keeping the oar blade pressing outboard. Steering is done by easing the motion either right or left.

An oar designed for sculling has a very narrow blade—almost half the overall length of the oar. The longer the oar, the easier it is to scull with. Therefore, a sculling oar is only slightly shorter than the boat in which it is used so that it can fit within the boat when not in use.

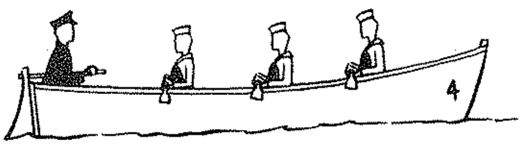
The notch in which the oar rests in the transom is on the starboard side if the sculler is right-handed, on the port side if he or she is left-handed.

Basic Rowing Commands

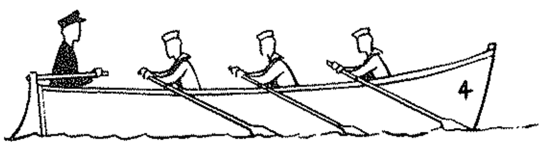
STAND BY THE OARS. Everyone except the bowman seizes his or her oar by its handle and sets the blade clear of the other oars. The oars should be shoved forward over the gunwale far enough to bring the handle in the proper position, but should be kept fore and aft.



OUT OARS. Given when the boat is clear of the ship's side. The oarsmen throw the blades of the oars horizontally outward, allowing the leathers to fall in the rowlocks. They place both hands on the handle, and quickly trim the blades flat and directly abeam.

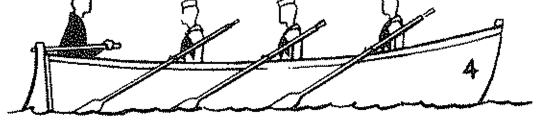


GIVE WAY TOGETHER (starboard or port). To commence pulling.



OARS. To stop pulling for any purpose, keeping the oars out horizontal and blades feathered.

TRAIL. Given when blades are in the water. They finish the stroke, then release the handle of the oar, allowing it to draw fore and aft and trail alongside.



HOLD WATER. To check headway or sternway. The oars of either side may hold water independently. If the boat has much headway, care is required.

STERN ALL. To acquire sternway. Should not be given when boat has much headway. When boat has headway, should be preceded by hold water.

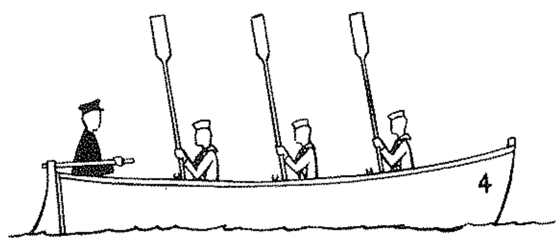
POINT THE OARS. To shove off a boat that has grounded, the oarsmen stand facing aft. They point the blades of the oars forward and downward at an angle of about 30 degrees, ready to shove off at the command. If waves lift the stern of the boat, the united effort to shove off should be made just as her stern lifts.

BACK STARBOARD (or port). To turn. Should hold water before backing, if boat has headway.

BACK STARBOARD, GIVE WAY PORT (or vice versa). To turn quickly when boat has no headway.

BOAT THE OARS. To get the oars into the boat blades forward. Given when lying on oars or when oars have been trailed.

TOSS OARS. Raise to a vertical position with the blades set fore and aft. Use this command when it is proper for your boat to salute a passing vessel.



LET FALL. To go from TOSS OARS to OARS.

Thwarts and oars are numbered from forward. Double-banked thwarts are designated by No. 1, starboard; No. 1, port; No. 2, starboard; No. 2, port; etc. The thwarts next to the bow and stroke are also properly designated as second bow and second stroke.

Rowing a boat takes practice. It is best to start slowly until a good rhythm is developed by the crew, then slowly increase the stroke as the crew's proficiency increases.