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Homeland Security

United States
Coast Guard

BOAT CREW SEAMANSHIP MANUAL

"Train, Maintain, Operate"

COMDTINST M16114.5C
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Chapter 10 Only

Chapter 10
Boat Handling

Introduction

This chapter covers handling vessels under power. Vessels under sail and personal watercraft are not addressed. Topics include:

- Forces that move or control a vessel.
- Basic maneuvering and boat operating.
- Maneuvering techniques for general categories of vessels.
- Purpose-based boat handling evolutions and procedures.

Boat handling requires an understanding of many variables. The coxswain must understand how to balance those forces they have control over (power, steering, etc.) and those they don't have control over (wind, waves, etc.) to complete the mission. Though boat handling skills can only be developed through hands-on experience, the information in this chapter provides a basic description of principles and practices.

The Best Coxswains

Though good coxswains are familiar with the characteristics of their boat and how it operates, the best coxswains are knowledgeable in the operation of all types of small craft, including sailboats and personal watercraft. They know how varying weather and sea conditions affect the operation of not just their vessel, but are also keenly aware of the limitations that the weather and sea impose on other vessels. They have a thorough knowledge of navigation, piloting and characteristics of their operating area. Above all, the best coxswains understand how to mesh the capabilities of their vessel to weather and sea conditions to conduct the safest possible boat operations.

In this chapter

This chapter contains the following sections:

Section A. Forces

Introduction

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

In this section

This section contains the following information:

Environmental Forces

A.1. Safe Boat Handling

Environmental forces that affect the horizontal motion of a vessel are wind, seas, and current. The coxswain has no control over them and must take the time to observe how the wind, seas, and current, alone and together, affect the vessel. The coxswain should also determine how these forces cause the vessel to drift, and at what speed and angle. Coxswains must use environmental forces to their advantage and use propulsion and steering to overcome the environmental forces. Usually, a good mix of using and overcoming environmental forces results in smooth, safe boat handling.

A.2. Winds

The wind acts upon any portion of the vessel that is above the waterline. This includes the hull, superstructure, and on smaller boats, the crew. The amount of surface upon which the wind acts is called sail area. The vessel will make "leeway" (drift downwind) at a speed proportional to the wind velocity and the amount of sail area. The "aspect" or angle the vessel takes due to the wind will depend on where the sail area is centered compared to the underwater hull's center of lateral resistance. A vessel with a high cabin near the bow and low freeboard aft (see **Figure 10-1**) would tend to ride stern to the wind. If a vessel's draft were shallower forward than aft, the wind would affect the bow more than the stern. A sudden gust of wind from abeam when mooring a vessel like this might quickly set the bow down on a pier.

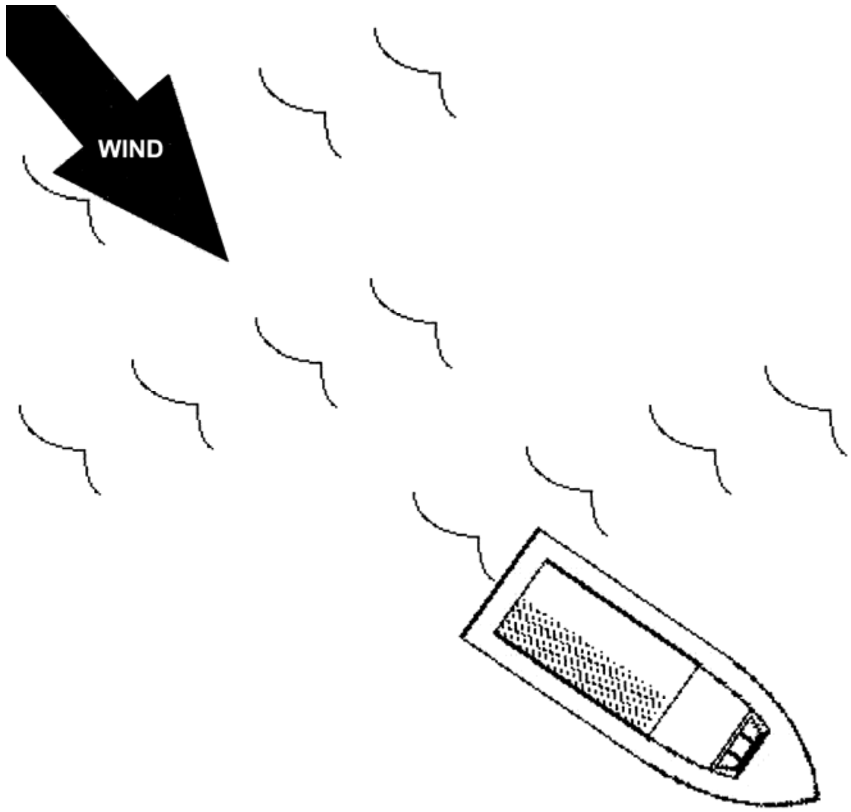


Figure 10-1
High Cabin Near Bow, Low Freeboard Aft

A.3. Close Quarters

Knowledge of how the wind affects a vessel is very important in all close quarters situations, such as mooring, recovery of an object in the water, or maneuvering close aboard another vessel. If maneuvering from a downwind or leeward side of a vessel or pier, the coxswain should look for any wind shadow the vessel or pier makes by blocking the wind. (see **Figure 10-2**) The coxswain should also account for the change in wind by planning maneuvers with this wind shadow in mind.

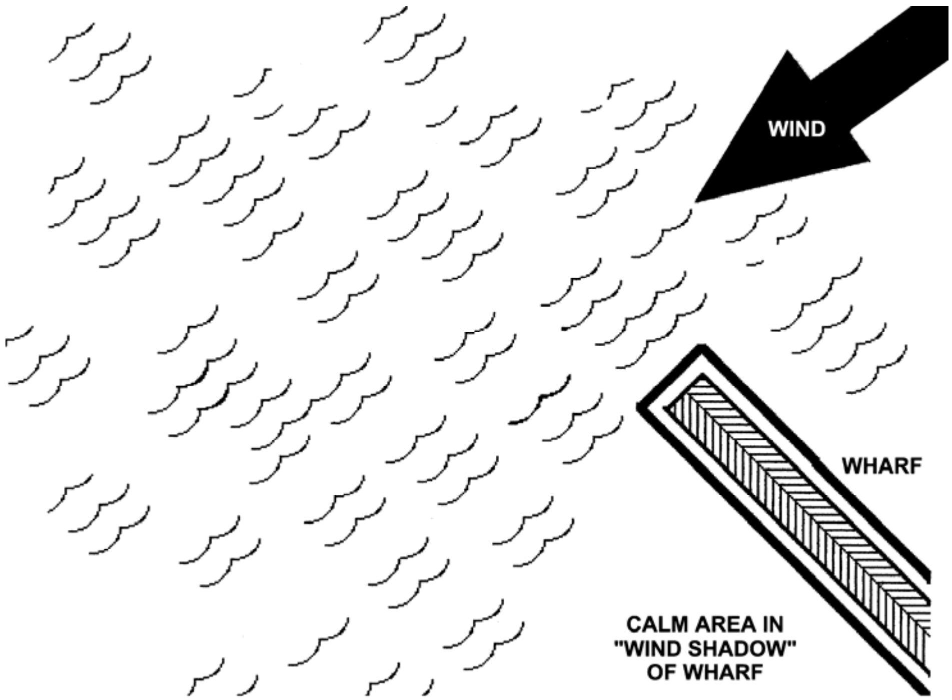


Figure 10-2
Wind Shadow

A.4. Seas

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

Relatively large seas have the effect of making a temporary wind shadow for smaller vessels. In the trough between two crests, the wind may be substantially less than the wind at the wave crest. Very small vessels may need to make corrective maneuvers in the trough before approaching the next crest.

A.5. Current

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

The coxswain should learn to look for the signs of current flow so as to be prepared when current affects the vessel, and should be particularly aware of instances where current shear is present. As with wind, a large, stationary object like a breakwater or jetty will cause major changes in the amount and direction of current. (see **Figure 10-3**) Crewmembers should note the amount of current around floating moorings or those with open pile supports. Caution should be used when maneuvering in close quarters to buoys and anchored vessels. Crewmembers should observe the effect of current by looking for current wake or flow patterns around buoys or piers and should watch how currents affect other vessels.

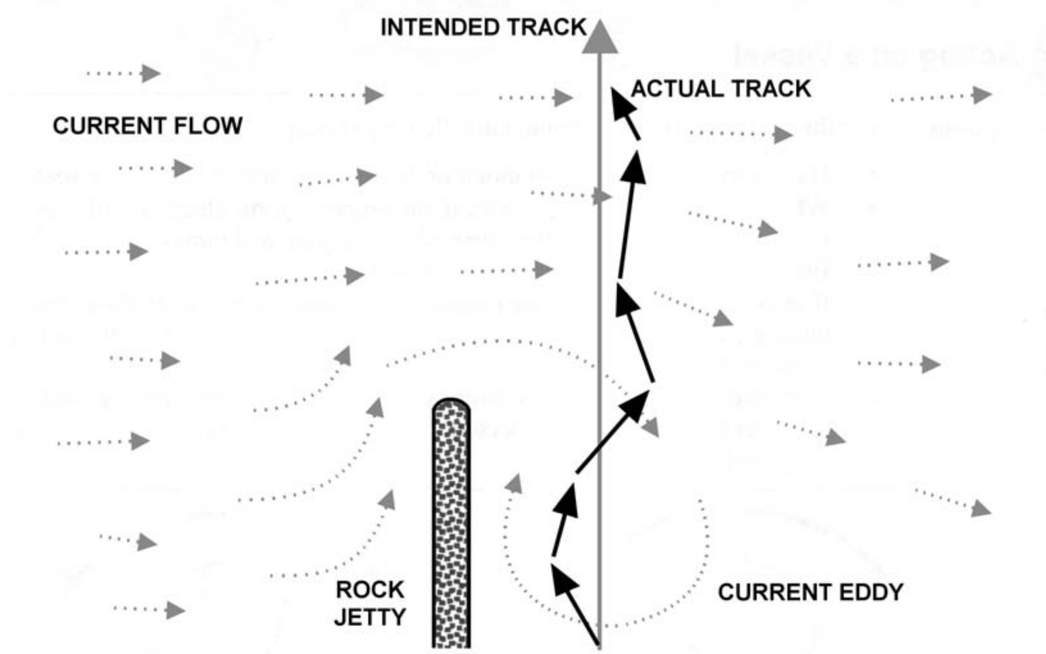


Figure 10-3
Effects of Current

A.6. Combined Environmental Forces

Environmental conditions can range from perfectly calm and absolutely no current to a howling gale and spring tides. Chances are that even if operation does not occur at either extreme, some degree of environmental forces will be in action.

A.7. Knowing the Vessel's Response

The coxswain should know how the vessel responds to combinations of wind and current, and should determine which one has the greatest effect on the vessel. It may be that up to a certain wind speed, current has more control over a given vessel, but above that certain wind speed, the boat sails like a kite. The coxswain should know what will happen if a sudden gust of wind is encountered; will the boat immediately veer, or will it take a sustained wind to start it turning?

When current goes against the wind, the wave patterns will be steeper and closer together. The coxswain should be particularly cautious where current or wind is funneled against the other. Tide rips, breaking bars, or gorge conditions frequently occur in these types of areas and may present a challenge to even the most proficient coxswain.

On the other hand, making leeway while drifting downstream (down current) requires a change in approach to prevent overshooting the landing.

NOTE Stay constantly aware of conditions, how they may be changing, and how they affect the vessel.

Forces Acting on a Vessel

A.8. Assumptions

For this discussion of propulsion, the following assumptions are made:

- If a vessel has a single-shaft motor or drive unit, it is mounted on the vessel's centerline.
- When applying thrust to go forward, the propeller turns clockwise (the top to the right or a "right-handed" propeller), viewed from astern, and turns counterclockwise viewed from astern when making thrust to go astern.
- If twin propulsion is used, the propeller to starboard operates as above (right-hand turning), while the port unit turns counterclockwise when making thrust to go forward when viewed from astern (left-hand turning). (see **Figure 10-4**)
- Be aware that some propeller drive units rotate in only one direction, and changing the propeller blade angle of attack controls ahead or astern thrust (controllable pitch propeller).

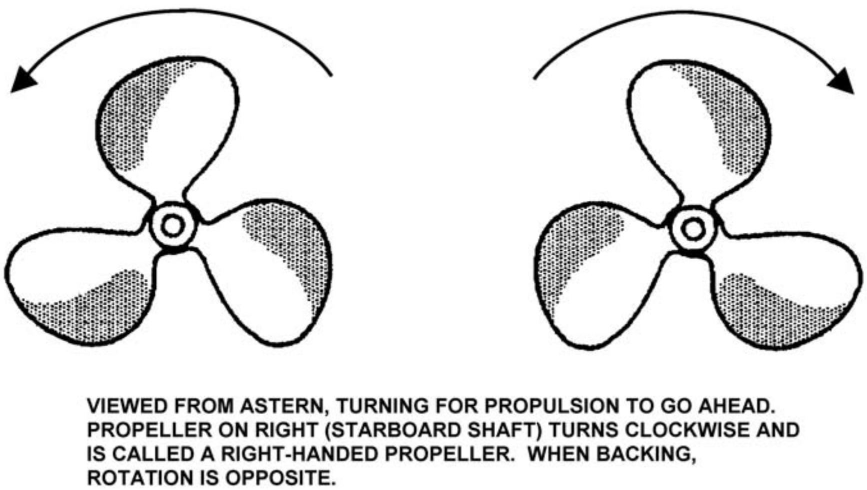


Figure 10-4
Twin Propulsion

A.9. Propulsion and Steering

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

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

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

- Rotating shaft and propeller with separate rudder.
- A movable (steerable) combination as an outboard motor or stern drive.
- An engine-driven pump mechanism with directional control, called a waterjet.

All three arrangements have their advantages and disadvantages from the standpoint of mechanical efficiency, ease of maintenance, and vessel control. Using one type of propulsion instead of another is often a matter of vessel design and use parameters, operating area limitations, life cycle cost and frequently, personal preference. There is no single "best choice" for all applications. Regardless of which type you use, become familiar with how each operates and how the differences in operation affect vessel movement.

NOTE

On almost every boat, propulsion and steering arrangement is designed to operate more efficiently and effectively when going ahead than when going astern. Also, every vessel rotates in a transverse direction about a vertical axis on its pivot point. (see **Figure 10-5**) The fore and aft location of the pivot point varies from boat to boat, but is generally just forward of amidships when the boat is at rest. As a hull moves either ahead or astern, the effective position of the pivot point moves either forward or aft, respectively.

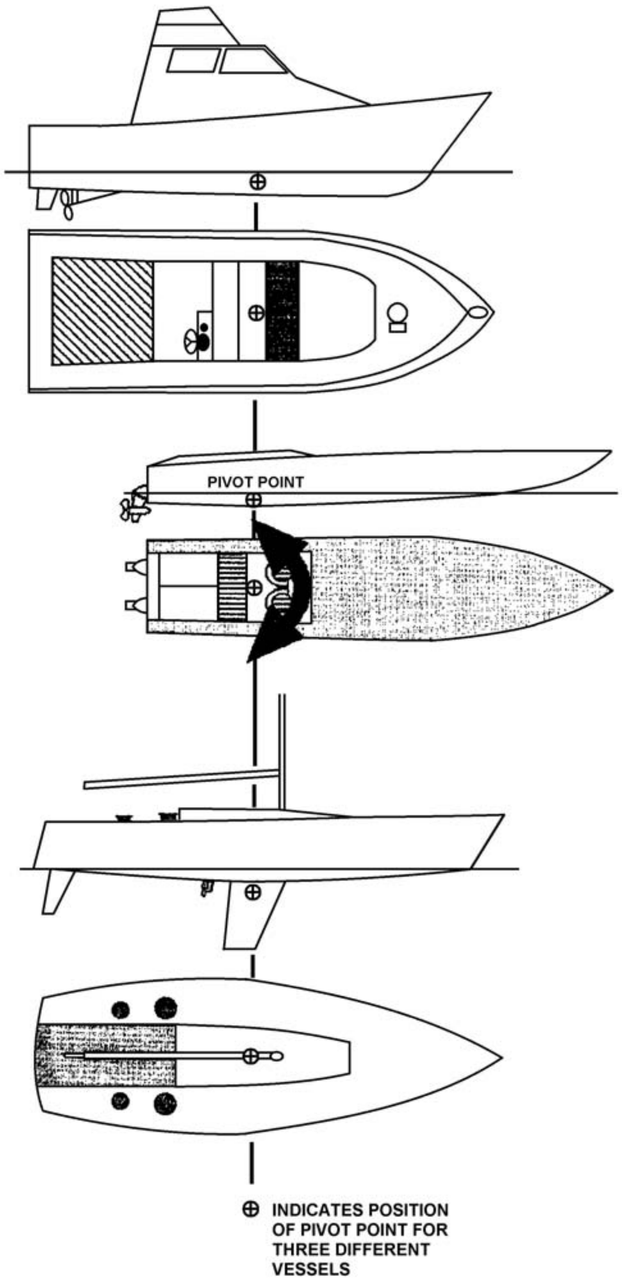


Figure 10-5
Pivot Point

Shaft, Propeller, and Rudder

A.10. Shaft

In small craft installations, the propeller shaft usually penetrates the bottom of the hull at an angle to the vessel's designed waterline and true horizontal. The practical reason for this is because the engine or marine gear must be inside the hull while the diameter of the propeller must be outside and beneath the hull. Additionally, there must be a space between the propeller blade arc of rotation and the bottom of the hull. For single-screw vessels, the shaft is generally aligned to the centerline of the vessel. However, in some installations, a slight offset (approximately 1°) is used to compensate for shaft torque. To finish the installation, the rudder is usually mounted directly astern of the propeller.

For twin-screw vessels, both shafts are parallel to the vessel's centerline (or nearly so), rudders are mounted astern of the propellers, and the rudders turn on vertical rudder posts.

A.11. Propeller Action

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

A.11.a. Screw Current

Regardless of whether the propeller is turning to go ahead or astern, the water flow pattern into the propeller's arc of rotation is called suction screw current, and the thrust flow pattern out of the propeller is called discharge screw current. (see **Figure 10-6**) The discharge screw current will always be stronger and more concentrated than the suction screw current.

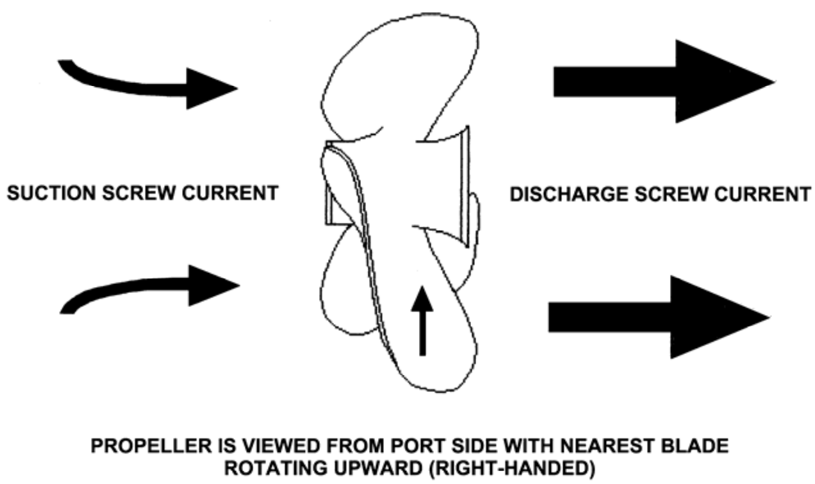


Figure 10-6
Screw Current

A.11.b. Side Force

In addition to the thrust along the shaft axis, another effect of propeller rotation is side force. Explanations for side force include:

- How the propeller reacts to interference from the vessel hull as the hull drags a layer of water along with it (the propeller encounters boundary layer "frictional wake").
- How the discharge screw current acts on the rudder.
- The propeller blade at the top of the arc transfers some energy to the water surface (prop wash) or to the hull (noise) and that the blade at the top of the arc either entrains air or encounters aerated water.

Due to the angle of the propeller shaft, the effective pitch angle is different for ascending and descending propeller blades, resulting in an unequal blade thrust. (The descending blade has a higher effective pitch angle and causes more thrust.) This net effect is sometimes referred to as sideways blade pressure.

The important facts to know: for a right-handed screw turning ahead, the stern will tend to move to starboard (see **Figure 10-7**), and for a right-handed screw when backing, the stern will tend to move to port. For a left-handed screw (normally the port shaft on a twin-screw boat), the action is the opposite.

An easy way to remember how side force will push the stern is to think of the propeller as a wheel on the ground. As the wheel rolls clockwise, it moves to the right. As a propeller turns clockwise when viewed from astern, the stern moves to starboard.

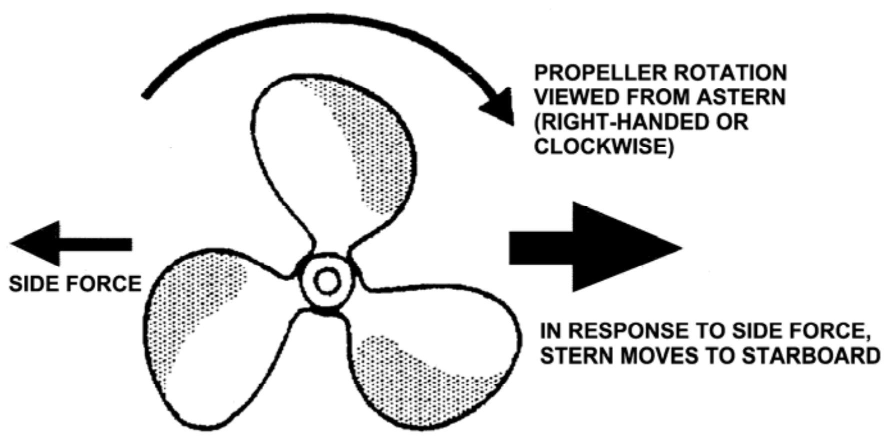


Figure 10-7
Side Force

A.11.c. Cavitation

Cavitation usually occurs when the propeller rotates at very high speed and a partial vacuum forms air bubbles at the tips of the propeller blades. Cavitation can also occur when trying to get a stopped propeller to spin at maximum speed, rapidly going from ahead to astern (or vice-versa), or by operating in aerated water where bubbles are dragged into the propeller flow.

Cavitation occurs more readily when trying to back, as the suction screw current draws water from behind the transom, and air at the waterline mixes with the water and is drawn into the propeller. Cavitation frequently occurs when backing with outboard motors. In this case, through-hub exhaust gas bubbles are also drawn forward into the propeller blade arc.

NOTE

A small degree of cavitation is normal and defined as when effective thrust is lost and the propeller just spins and makes bubbles. The easiest way to regain thrust is to reduce propeller revolutions and as the bubbles subside, gradually increase RPMs.

A.12. Rudder Action

When a vessel moves through the water (even without propulsion), the rudder is normally used to change the vessel's heading. As a hull moves forward and the rudder is held steady, amidships, pressure on either side of the rudder is relatively equal and the vessel will usually keep a straight track. When turning the rudder to port or starboard, pressure decreases on one side of the rudder and increases on the other. This force causes the vessel's stern to move to one side or the other. As noted above, because a vessel rotates about its pivot point, as the stern moves in one direction, the bow moves in the other direction. (see **Figure 10-8** (a) and (b))

The speed of the water flowing past the rudder greatly enhances the rudder's force. The thrust or screw discharge current from a propeller while operating ahead increases the water flow speed past the rudder. Also, while turning the rudder to a side, it directs about one-half of the propeller's thrust to that side, adding a major component of force to move the stern. (see **Figure 10-8** (c) and (d))

When operating astern, the rudder is in the screw suction current. The rudder cannot direct any propeller thrust, and since the screw suction current is neither as strong nor as concentrated as the screw discharge current, water flow past the rudder does not increase as much. The combined effects of screw current and rudder force when operating astern are not nearly as effective as when operating ahead.

As rudder force is determined by water flow along it, a rudder loses some of its effectiveness if the propeller cavitates and aerated water flows along the rudder.

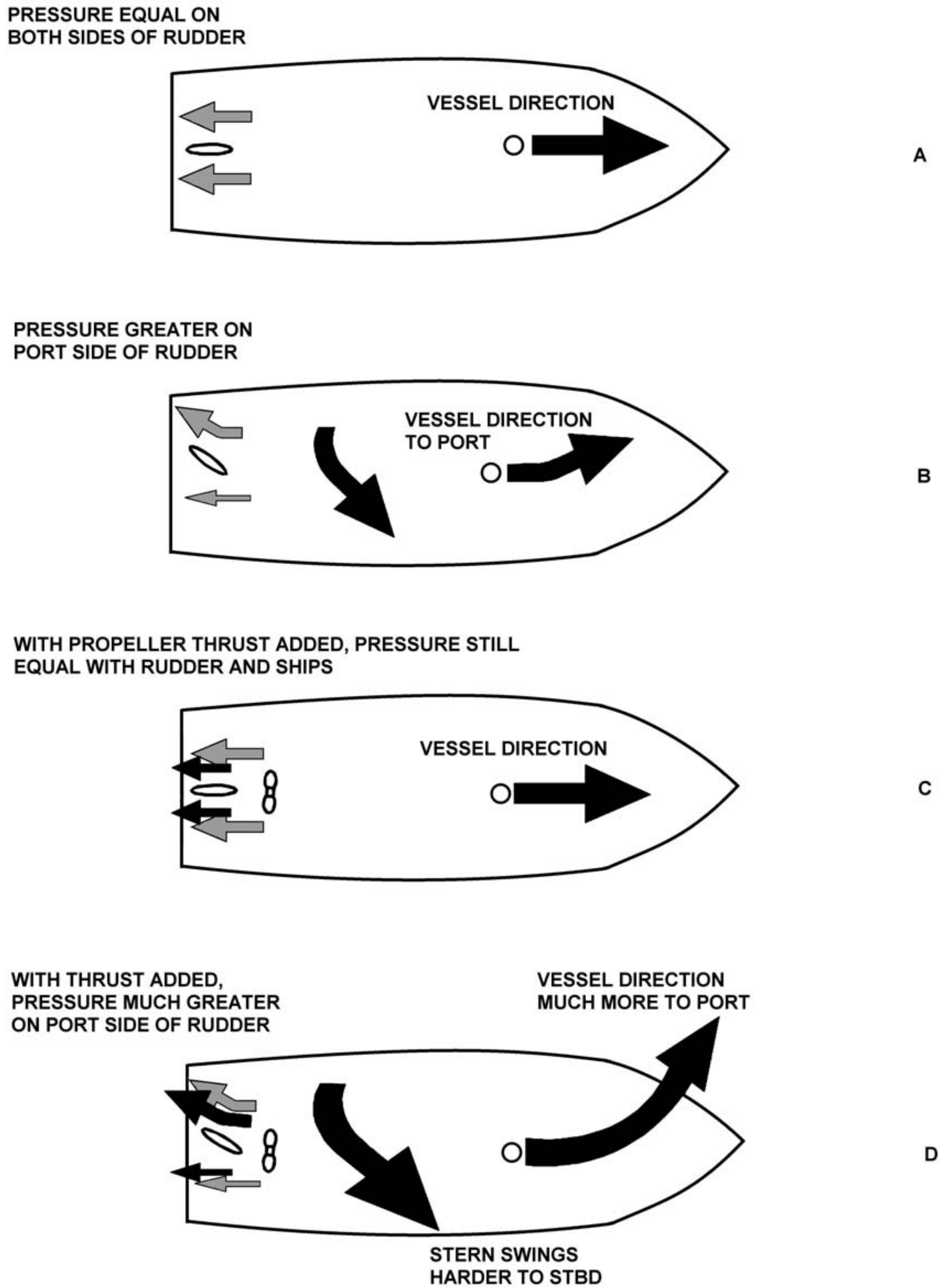


Figure 10-8
Effect of Rudder Action

Outboard Motors and Stern Drives

A.13. Major Differences

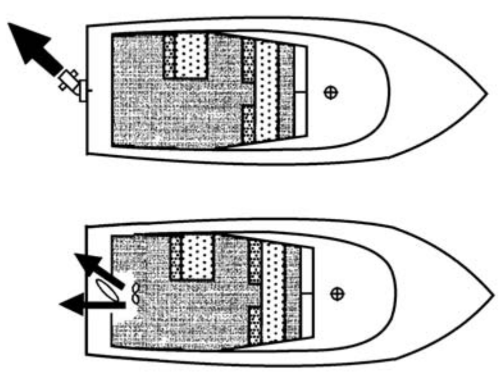
Outboard motors and stern drives will be considered together, as both include a pivoting gear case and propeller drive unit (called a lower unit on an outboard). The difference between these drive arrangements and the shaft/propeller/rudder arrangement is that the screw currents and thrust from an outboard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

The lower unit contains drive gears, a spline connection, and on many set-ups, through-the-propeller hub exhaust. Many lower unit gear housings are over six inches in diameter. Where an inboard engine powers the stern drive attached through the transom to the drive unit (the outdrive) and is commonly referred to as an inboard/outdrive or I/O. The outboard "powerhead" (engine) is mounted directly above the lower unit. Both outboards and stern drives can usually direct thrust at up to 35° to 40° off the vessel centerline. Also, both types generally allow the coxswain some amount of trim control. Trim control adjusts the propeller axis angle with the horizontal or surface of the water.

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

A.14. Thrust and Directional Control

Outboards and stern drives have a small steering vane or skeg below the propeller. The housing above the gearcase (below the waterline) is generally foil shaped. Though these features help directional control, particularly at speed, the larger amount of steering force from an outboard or stern drive is based upon the ability to direct the screw discharge current thrust at an angle to the vessel's centerline. (see **Figure 10-9**) This directed thrust provides extremely effective directional control when powering ahead. When making way with no propeller RPMs, the lower unit and skeg are not as effective as a rudder in providing directional control.



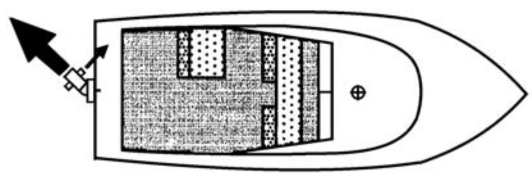
THE OUTBOARD OR OUTDRIVE (TOP) DIRECTS ALL THE THRUST IN THE DIRECTION THE HELM IS TURNED WHERE THE INBOARD, WITH SEPARATE PROPELLER AND RUDDER (BOTTOM), DIRECTS ONLY 60-70% OF THE THRUST TO THE SIDE.

Figure 10-9
Lower Unit/Outdrive Directed Thrust

NOTE ☞ The propeller forces discussed above in A.11 also apply to the propellers on outboards or outdrives. However, because these drives can be directed, side force can be countered. The steering vane/skeg angle is usually adjustable, also assisting in countering side force.

A.15. Propeller Side Force

When backing, it is possible to direct outboard/outdrive thrust to move the stern to port or starboard. When backing with the unit hard over to port, propeller side force introduces an element of forward motion (see **Figure 10-10**), but can be countered through less helm. When backing to starboard, the side force tends to cause an element of astern motion and also tries to offset the initial starboard movement. Many lower units are fitted with a small vertical vane, slightly offset from centerline, directly above and astern of the propeller. This vane also acts to counter side force, particularly at higher speeds.



WITH HELM OVER, THE PROPELLER SIDE FORCE (SMALL ARROW) HAS A FORE AND AFT COMPONENT.
THIS EXAMPLE SHOWS THE EFFECT OF SIDE FORCE WHEN BACKING WITH AN OUTDRIVE.
WITH HELM TO PORT, THE BOAT'S TRANSOM WILL MOVE BOTH TO PORT AND FORWARD (SMALL ARROW).

Figure 10-10
Lower Unit/Outdrive Side Force

A.16. Vertical Thrust

Outboards and stern drive usually allow a level of vertical thrust control. Trim controls the angle of attack between the propeller's axis of rotation and both the vessel waterline and the surface of the water. Vertical thrust control, especially applied aft of the transom, changes the attitude the vessel hull will take to the water. (see **Figure 10-11**) Small amounts of trim should be used to offset for extreme loading conditions or to adjust how the vessel goes through chop.

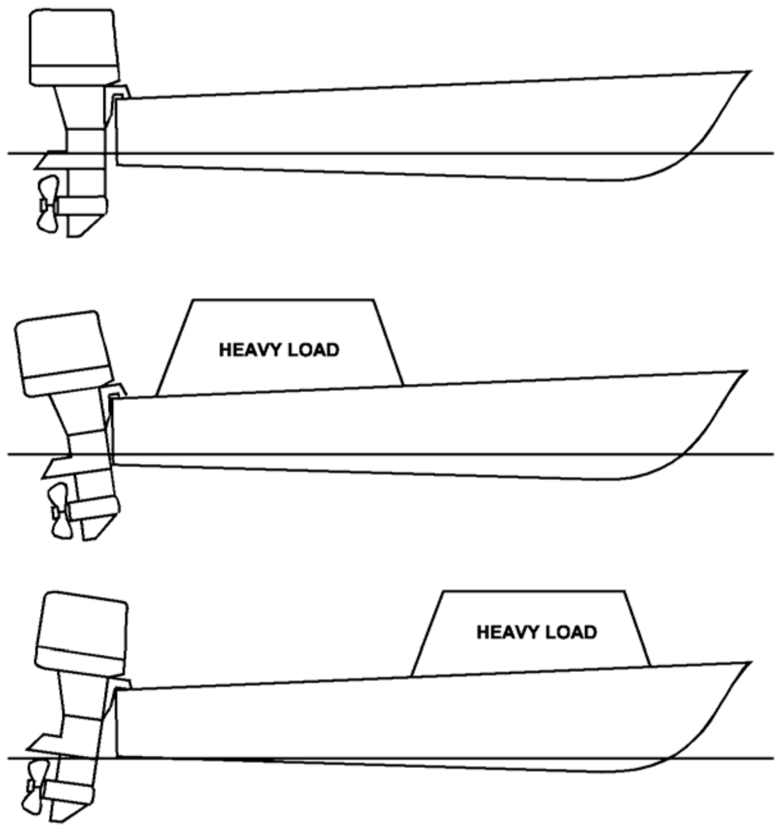


Figure 10-11
Trim to Offset Loading Condition

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

WARNING ✋

> In lightweight or highly buoyant outboard powered boats, use of full power in tight turns can cause loss of control or ejection of crew, coxswain or both. It is mandatory that the helmsmen attach the engine kill switch lanyard to themselves.

A.17. Cavitation

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

Waterjets

A.18. Operation

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

A.19. Thrust and Directional Control

Vessel control is through the nozzle-directed thrust. To attain forward motion, the thrust exits directly astern. For turning, the nozzle pivots (as a stern drive) to provide a transverse thrust component that moves the stern. For astern motion, a bucket-like deflector drops down behind the nozzle and directs the thrust forward. Some waterjet applications include trim control as with a stern drive or outboard. With this, thrust can be directed slightly upward or downward to offset vessel loading or improve ride.

In most cases the only vessel control is by the nozzle-directed thrust, but occasionally a waterjet with a small steering vane will be seen. If a waterjet craft is proceeding at high speed, power brought down quickly to neutral, and the helm put over, no turning action will occur. Of the three drive arrangements discussed; the waterjet alone has no directional control when there is no power.

A.20. No Side Force

Since the waterjet impeller is fully enclosed in the pump-drive housing, no propeller side force is generated. The only way to move the stern to port or starboard is by using the directed thrust.

A.21. Cavitation

Waterjet impeller blades revolve at an extremely high speed. A much higher degree of cavitation normally occurs than associated with external propellers without a loss of effective thrust. In fact, a telltale indicator of waterjet propulsion is a pronounced aerated, water discharge frequently seen as a rooster tail astern of such craft.

As the impeller rotation does not change with thrust direction, frequent shifting from ahead to astern motion does not induce cavitation. However, as the thrust to make astern motion reaches the waterjet inlet, the aerated water is drawn into the jet, causing some reduction of effective thrust. As with all types of propulsion, slowing the impeller until clear of the aerated water reduces cavitation effects.

Section B. Basic Maneuvering

Introduction

To learn the basic handling and maneuvering characteristics of a vessel, a trainee must first observe a skilled coxswain. Also, one must first learn to operate the vessel in relatively open water, away from fixed piers and moored vessels.

In this section

This section contains the following information:

Learning the Controls

B.1. Description

When stepping up to the controls of any vessel for the first time, the coxswain should immediately become familiar with any physical constraints or limitations of the helm and engine controls. Ideally, controls should be designed and mounted to allow for a wide range of operators of different arm length and hand size, though this is not always so.

B.1. Obstructions/ Hazards

The coxswain should determine if anything obstructs hand or arm movement for helm and throttle control. Checks should be made for the following obstructions and hazards:

- A firm grasp of the wheel through 360°.
- Anything that prevents use of the spokes.
- Awkward position of throttle/gear selector.
- Layout that prevents use of heavy gloves.
- Inaccessible engine shutdown handles.
- An easily fouled outboard kill-switch lanyard.
- Other commonsense items.

The coxswain should also learn where all the controls are and know their function before snagging a sleeve while maneuvering in close quarters or banging a knee or elbow in choppy seas.

NOTE

Check control operation while moored with engines secured. Some larger vessels require engine operation to operate controls, such as engine-assisted hydraulic steering. If so, check throttle controls with engines secured.

B.3. Helm Limits

The following are some guidelines for determining the helm limits:

Step	Procedure
1	Determine the amount of helm from full right rudder to full left rudder.
2	Check for any binding, play, or slop in the helm and rudder control, and at what angle it occurs.
3	Ensure that the helm indicates rudder amidships.
4	Ensure that a rudder angle indicator accurately matches rudder position and matches a centered helm.

B.4. Engine Control Action Check

The following are some items to check when checking engine control action:

Step	Procedure
1	Is throttle separate from shifting/direction mechanism?
2	Any detent, notch, or stops that separate *neutral*, *ahead* and *astern*.
3	Force required to shift from *neutral* to *ahead* or *astern*.
4	Binding or excessive looseness at any stage of the throttle control.
5	Is NEUTRAL easily found without looking at the control handle?
6	Do the controls stay put or do they tend to slide back?
7	Does the kill-switch lanyard allow adequate but not excessive range of motion?
8	Does an engine shut down handle work properly?
9	Is idle speed adjusted properly?

NOTE Perform these steps as part of every getting-underway check.

WARNING Smooth, positive operation of helm and engine controls is absolutely necessary for safe boat operation. Do not accept improper control configuration, mismatched equipment, or improper maintenance as a reason for poorly operating controls. Poor control operation causes unsafe boat operations.

B.5. Engine Control Recheck

After checking all controls while moored with engines secured, the coxswain should recheck their operation with engines running while securely moored. It may not be safe to apply full ahead to astern throttle, however, a note should be made anytime there is a lag between throttle shift and propulsion, from *neutral* to *ahead*, *neutral* to *astern*, *ahead* to *astern*, and *astern* to *ahead*.

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

When training, an experienced individual should get the vessel underway and into open water before turning control over to anyone not familiar with the particular boat's operation. Once in open water, control may be turned over to the new coxswain who should recheck helm and engine control operation at clutch speed.

Moving Forward in a Straight Line

B.6. Description

When moving forward in a straight line, throttle should be advanced gradually and firmly. If the vessel is single-screw, outboard, or outdrive, propeller side force will tend to move the stern slightly to starboard. (see **Figure 10-12**) The side force should be offset with slight starboard helm. If twin-engine, throttles should be advanced together. The vessel should not yaw in either direction if power is applied evenly. Engine RPMs should be checked so both engines turn at the same speed. Some vessels have a separate indicator to show if engine RPMs match, but also compare tachometer readings.

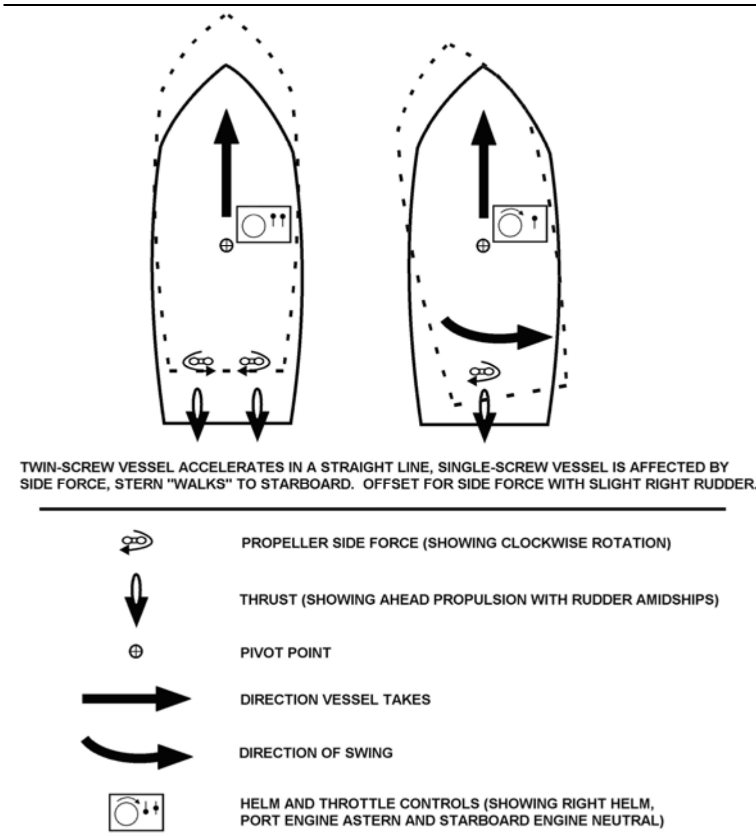


Figure 10-12
Accelerated Ahead

NOTE

Do not ram throttles forward when starting up. As the engines try to transfer the excessive power, the stern will squat, raising the bow and decreasing visibility (see **Figure 10-13**), and propellers or impellers may cavitate.

CH-1

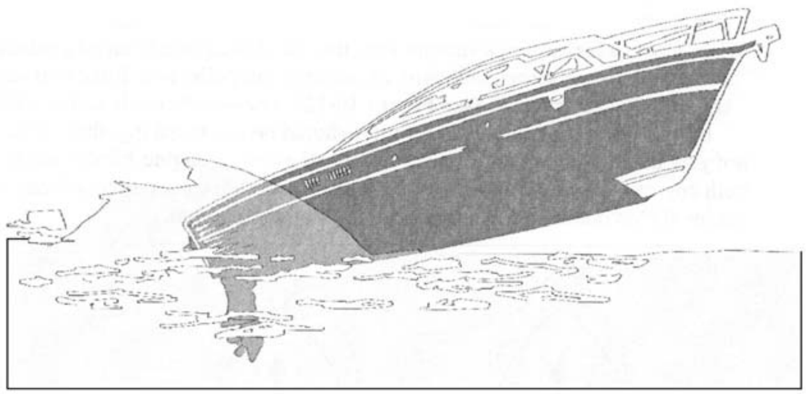


Figure 10-13
Pronounced Squat on Acceleration

B.7. Direction Control

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

B.8. Planing

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

B.9. Appropriate Speed

Running at full speed all of the time should be avoided. This wastes fuel and can cause excessive wear on the boat and crew. Many vessels will not exceed or will only marginally exceed a given speed, regardless of the power applied. At some point, the only effect of applying additional throttle is increased fuel consumption with no speed increase. Finding a speed that offers a comfortable ride as well as allows mission completion is advised.

B.9.a. Margin of Power

A margin of power should always be left available for emergencies. The best speed for the vessel should be determined. A good normal operating limit for semi-displacement vessels is usually 80 percent maximum power, allowing the remaining 20 percent for emergency use.

B.9.b. Safe Speed

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

- High seas: Slow down as winds and seas increase; the boat will handle more easily. Pounding or becoming airborne fatigues the hull and could injure the crew or cause them chronic skeletal problems. If it takes tremendous effort just to hang on, the crew will be spent and not able to perform their jobs. Minimize taking spray and water on deck.

NOTE

> Find the most comfortable, secure location for the entire crew. For many vessels, this means in the immediate vicinity of the helm.

WARNING

> Being "on plane" will not allow crossing a shoal that would ground the vessel in the displacement mode. At high planing speed, the stern will squat as it gets in shallow water, possibly grounding at a very damaging speed.

- Traffic density: Do not use high speed in high traffic density areas. A safe speed allows response to developing situations and minimizes risk of collision, not only with the nearest approaching vessel, but with others around it.
- Visibility: If conditions make it difficult to see, slow down. Fog, rain, and snow are obvious limits to visibility, but there are others. Geographic features and obstructions (river bends, piers, bridges and causeways), along with heavy vessel traffic, can limit the view of "the big picture." Darkness or steering directly into the sun lessens ability to see objects or judge distances. Prevent spray on the windscreen (particularly salt spray or freezing spray) as much as possible and clean it regularly. Spray build-up on the windscreen is particularly hazardous in darkness or in glare.
- Shoal waters: In shallow water, the bottom has an effect on the movement of the vessel. Slow down in shallow water. In extremely shallow water, the vessel's stern tends to "squat" and actually moves closer to the bottom.

CAUTION !

> Do not overcompensate for bank cushion and bank suction. Too much helm in the direction of the bank could cause the bow to veer into the bank. Then, a subsequent large helm movement to turn the bow away from the bank may cause the stern to swing into the bank.

B.10. Bank Cushion and Bank Suction

In extremely narrow channels, a vessel moving through the water will cause the "wedge" of water between the bow and the nearer bank to build up higher than on the other side. This bank cushion tends to push the bow away from the edge of the channel.

As the stern moves along, screw suction and the movement of water to "fill-in" where the boat was creates bank suction. This causes the stern to move towards the bank. The combined effect of momentary bank cushion and bank suction may cause a sudden shear toward the opposite bank. Bank cushion and bank suction are strongest when the bank of a channel is steep. They are weakest when the edge of the channel shoals gradually and extends in a large shallow area. When possible, a trainee should stay exactly in the center of an extremely narrow channel to avoid these forces. (see **Figure 10-14**) Slower speed also reduces the amount of cushion and suction. Some rudder offset towards the closer bank will help to avoid continuous cushion and suction effects by.

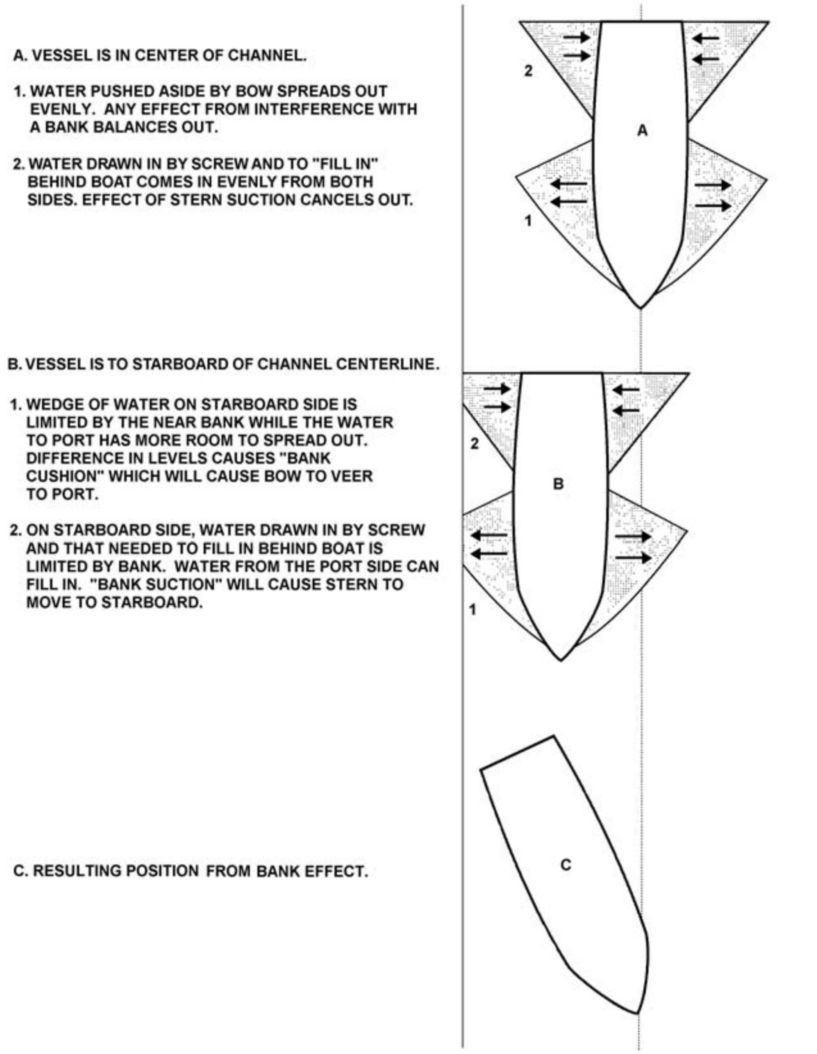


Figure 10-14
Bank Cushion and Bank Suction

B.11. Bow Cushion and Stern Suction

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

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

NOTE

The following bow cushion and stern suction considerations apply when meeting another vessel in a narrow channel and when operating near a bank:

- The deeper the vessel's draft, the greater the cushion and suction effect, particularly if draft approaches water depth.
- The closer to a bank or another vessel, the greater the cushion and suction.
- In very narrow waterways, slow down to decrease cushion and suction effects, but not to the point of losing adequate steerage.

When meeting another vessel in a narrow channel, the bow cushion and stern suction effects caused by the other vessel should be balanced with the bank cushion and suction effects due to the channel.

WARNING

While maneuvering, keep the crew informed, especially if rapidly accelerating, turning or slowing. A quick warning shout could prevent injury.

B.12. Wake Awareness

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

All vessels are responsible for their wake and any injury or damage it might cause. Only an unaware coxswain trails a large wake through a mooring area or shallows, tossing vessels and straining moorings. "Get-home-itis" and a false sense of urgency are two reasons coxswains forget to watch their wake. A large, unnecessary wake, particularly in enclosed waters or near other smaller vessels, ruins the credibility of a professional image.

Turning the Boat with the Helm

B.13. Description

To move in a straight line, small, frequent, momentary helm inputs adjust the position of the stern and bow to head in the desired direction. To intentionally change the vessel heading, larger, more sustained helm movement should be used.

B.14. Pivot Point

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

B.15. Propulsion Type and Turning

Because outboards, stern drives, and waterjets use propulsion thrust for directional control, they can make a much tighter turn (using helm alone) with a given hull shape than if the same hull had shaft, propeller, and rudder. With extended outboard mounting brackets, the directed, lower-unit thrust is farthest aft of the pivot point compared to the other configurations. Some brackets move the thrust three to four feet aft of the hull. The location aft of the pivot point, along with the amount of directed thrust determines how much the stern will kick away from the direction of the turn. With directed thrust, the stern will usually skid outward more than with shaft, propeller and rudder, making the bow describe a very tight arc. (see **Figure 10-15**)

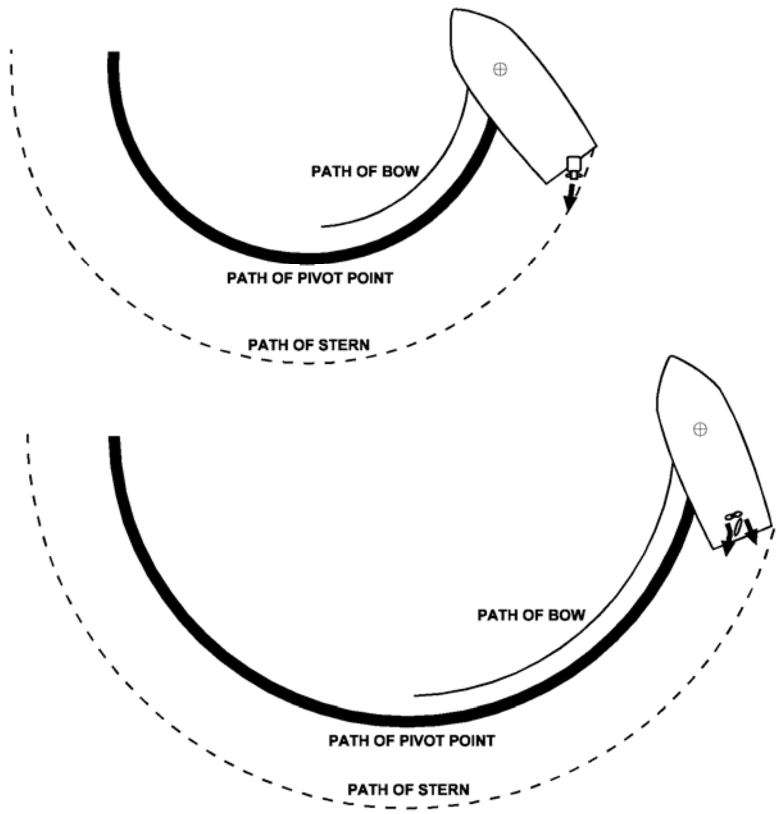


Figure 10-15
Pivot Point, Skid, Kick, Inboard vs. Outboard

B.16. Vessel's Turning Characteristics

When proceeding on a steady heading, putting the helm over to one side or the other, begins to turn the boat. Up to the time the boat turns through 90°, the boat has continued to advance in the original direction. By the time the boat has turned through 90°, it is well off to the side of the original track. This distance is transfer. As the boat continues through 180°, its path has defined its tactical diameter. If the vessel holds the turn through 360°, the distance it takes to reach the point where it first put the helm is referred to as its final diameter. For a particular vessel, these values vary for speed and rudder angle. (see **Figure 10-16**)

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

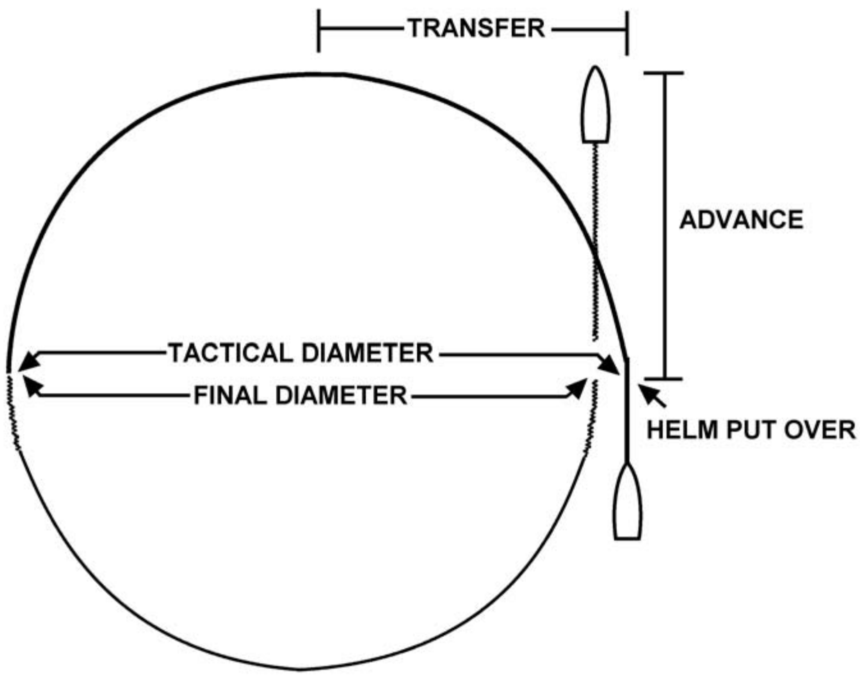


Figure 10-16
Turning Characteristics

WARNING

With light-displacement, high-powered craft, maximum helm at high speed will quickly stop a boat's progress in the original direction of movement. Though such a turning action is effective to avoid contact with an immediate hazard, the violent motion could eject unsuspecting crewmembers. Use this technique only as an emergency maneuver. Do not use this maneuver to demonstrate the boat's capability.

B.17. Loss of Speed

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

B.18. Making Course Changes and Turns in Channels

Bank suction, bank cushion (see B.10 above), and currents will all affect a boat navigating a sharp bend in a narrow channel. Where natural waterways have bends or turns, the water is always deepest and the current is always strongest on the outside of the bend. This is true for 15° jogs in a tidal estuary and for the "s" shaped meanders on the Mississippi River. This happens because the water flow has a great degree of momentum and resists having its direction changed. As it strikes the outside of the bank, it erodes the earth and carries the particles with it. The particles fall out farther downstream in areas of less current (the inside of a turn or bend) and cause shoaling. In some turns or bends, there may be circular currents (eddies) in either the deep outside of the bend or the shallow inside. Back currents also sometimes occur near eddies on the inside of the bend. When eddies or back currents occur, those near the shallows are much weaker than eddies or main current flow at the outside of the bend.

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

B.18.a. Countering a Head Current Through a Bend

The effect of a head current is minimized by steering along the inside quarter of the channel, making sure to avoid shoaling. If the bow gets into the area of greater current, it may begin to sheer towards the outside of the bend. It can be countered through helm towards the inside of the bend and by getting the stern directly down current from the bow. The vessel can then be gradually worked back to the inside quarter of the channel.

If the starting point is the outside of the bend, the full force of the current will be encountered. Bank cushion should keep the bow from the outside edge, but the stern is limited in its movement by bank suction. Initial helm towards the inside of the turn may allow the current to cause the bow to rapidly sheer away from the outside, but this is immediately offset with power and helm to keep the bow pointed upstream. Gradual helm with constant power should be used to get out of the main force of the current, and work across to the inside quarter of the channel.

B.18.b. Navigating a Turn with a Following Current

The turn on a course should be approached just to the outside of the middle of the channel. This will avoid the strongest currents at the outside edge while still getting a reasonable push. While turning, the strongest current will accentuate the swing of the stern quarter to the outside of the channel. Because of this, and because the following current tends to carry the boat toward the outside, the turn should begin early in the bend. The amount of sideways movement or if the boat tends to "crab" in the channel should be constantly monitored. If the boat starts to move too close to the outside of a bend, more helm and power should be constantly monitored to maneuver the boat back into the middle. Once through the turn, the vessel can be gradually worked back to the inside quarter of the channel.

- If the boat stays too far to the outside of the bend, timing the turn is difficult. Turning too early with stern suction on one quarter with the strongest current on the other quarter may cause an extreme veer to the inside of the turn. Any bow cushion will accentuate the sheer. Turning too late with stern suction and the quartering current could cause grounding.
- If trying to hug the inside of the turn, both current and bank effect will be lessened. Use a small amount of rudder toward the inside bank to enter the turn. As the channel begins to bend, use less rudder while the boat starts to move from the inside bank. Use caution as the current under the quarter affects the stern, giving it an increase in sheer towards the inside bank. Slack water or an eddy down current on the inside will increase this sheer while bow cushion may not be enough to prevent grounding.

Stopping the Boat

B.19. Description

Pulling back the throttle to *neutral* will cause the vessel to begin to lose forward motion. For a heavy-displacement vessel, once propulsion is stopped, the vessel will continue to move forward for some distance. The vessel carries its momentum without propulsion. For a semi-displacement hull or planing hull, retarding the throttle and reduce power will cause the boat to quickly come off plane. As the vessel reverts to displacement mode, the resistance of the hull going through the water instead of on top of the water slows the boat. The vessel still carries some way, but at only a fraction of the original speed. The coxswain should experiment with the vessel and see how rapidly the boat slows after going from cruising speed to *neutral* throttle. Knowing the distance the vessel will travel when stopping (also known as head reach) from different speeds is very important when maneuvering.

WARNING

The crash stop is an emergency maneuver. It may damage the drive train and stall the engine(s). In most cases, with high levels of crew professionalism, skill and situational awareness, it is not necessary.

B.20. Using Astern Propulsion to Stop the Vessel

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

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

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

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

WARNING

As with the crash stop, a full-helm, high-speed stop is an emergency maneuver. The violent motion could eject crewmembers. Do not use this maneuver in choppy waters as a chine could "trip" and cause the vessel to snap-roll and capsize.

B.21. Using Full Helm to Stop Forward Way

As noted above, with light-displacement, high-powered craft, maximum helm at high speed will quickly stop a boat's progress in the original direction of movement. To fully stop, the throttle should be placed down to *neutral* after entering the skid. If done properly, no astern propulsion is required.

NOTE

With a jet drive, no directional control will be available without thrust. The boat must be in a skid before reducing power. If thrust is reduced before trying to turn, the boat will slow on the original heading.

Backing the Vessel

CAUTION !

Do not back in a way that allows water to ship over the transom. Be careful with boats of very low freeboard aft. Outboard powered vessels, with low cut-out for motor mounting and a large portion of weight aft are susceptible to shipping water while backing, particularly in a chop. If shipped water does not immediately drain, it jeopardizes stability.

CAUTION !

Most inboard engines exhaust through the transom. Outboard motors exhaust astern. Backing could subject the crew and cabin spaces to a large amount of exhaust fumes. Limit exposure to exhaust fumes. If training, frequently change vessel aspect to the wind to clear fumes. After backing, ventilate interior spaces.

B.22. Description

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

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

B.23. Screw and Rudder

While backing, the rudders are in the weaker, less concentrated screw suction current, and most steering control comes from flow across the rudder due to sternway.

B.23.a. Single-Engine Vessels

Propeller side force presents a major obstacle to backing in the direction desired. The rudder does not have much effect until sternway occurs, and even then, many boats will back into the wind despite a best effort to do otherwise. If backing to the wind, the coxswain should know at what wind speed the boat will back into the wind without backing to port.

- Before starting to back, apply right full rudder to get any advantage available.
- A quick burst of power astern will cause the stern to swing to port, but use it to get the boat moving.
- Once moving, reduce power somewhat to reduce propeller side force and steer with the rudder. As sternway increases, less rudder will be needed to maintain a straight track astern.
- If more sternway is needed to improve steerage, increase power gradually. A strong burst astern will quickly swing the stern to port.
- If stern swing to port cannot be controlled by the rudder alone, use a burst of power ahead for propeller side force to swing the stern to starboard. Do not apply so much power as to stop sternway or to set up a screw discharge current that would cause the stern to swing farther to port. (As the vessel backs, it uses sternway water flow across the rudder to steer).
- If this fails, use a larger burst of power ahead, with helm to port. Sternway will probably stop, but propeller side force and discharge current across the shifted rudder will move the stern to starboard. Now try backing, again.

B.23.b. Twin-Engine Vessels

Both engines should be backed evenly to offset propeller side force. Using asymmetric power (one engine at higher RPM than the other) will help steer the stern. Asymmetric power will also give unequal propeller side force that will help steer.

- Apply astern power evenly, keeping rudders amidships.
- If the stern tends to one side, first try to control direction with slight helm adjustment. If not effective, either increase backing power on the side toward the direction of veer or decrease power on the opposite side.

B.24. Stern Drives and Outboards

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

B.24.a. Single-Outboard/ Outdrive

For single-outboard/outdrive, propeller side force is offset by turning the helm slightly to the right. Astern power is then applied gradually, but care should be taken not to cause propeller cavitation.

B.24.b. Twin-Outboard/ Outdrive

If astern power is matched, propeller side forces will cancel. As with twin inboards, offsetting any stern swing with helm should be attempted before using asymmetric power.

If less thrust than that provided by both drives at clutch speed is needed, one motor or engine should be used. This will keep speed low but will keep thrust available for steering, rather than shifting one or both engines from *reverse* to *neutral*. If using one unit, compensate with helm for propeller side force and the increased, off-centered drag caused by the other lower unit.

B.25. Waterjets

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

Bursts of power astern when backing should be avoided. Bursts of power when making astern thrust will excessively aerate the waterjet intake flow ahead of the transom.

Using Asymmetric or Opposed Propulsion (Twin-Screw Theory)

B.26. Description

Asymmetric propulsion while backing was covered in previous paragraphs. The techniques presented here are additional methods of maneuvering that capitalize on twin-engine vessel capability to differ the amount or direction of thrust produced by the two engines. Any difference in thrust affects the boat's heading. The amount of this difference can vary from that needed to hold a course at cruising speed to turning a boat 360° in its own length by opposing propulsion (splitting throttles). The concept of asymmetric or opposed propulsion can be likened to "twisting" the boat, but the forces and fundamentals discussed earlier still apply and affect vessel response. Pivot point, propeller side force, and turning characteristics remain important. Because the drives are offset from vessel centerline on a twin-engine vessel, they apply a turning moment to the hull. Twin outboard motors on a bracket apply this twist aft of the hull (and well aft of the hull pivot point), while twin inboards apply most of this twist to the hull at the first thrust-bearing member of the drive train (usually the reduction gear or v-drive, much closer to the pivot point). With inboards, propeller side force is transferred through a strut and stern tube to the hull.

Up to a point, the greater the difference in RPMs, the greater the effect on the change in heading. Above that point, specific for each boat, type of propulsion, sea conditions and operating speed, cavitation or aeration will occur, and propulsion efficiency will decrease, at least on one drive.

NOTE

As with all boat handling techniques, learn these first in calm weather, in open water, and at low speeds.

B.27. Holding a Course

Depending on a vessel's topside profile, wind conditions might make the bow continually fall off to leeward. Though the helmsman can compensate for this by steering with constant pressure to hold desired course, a less taxing way is to adjust the throttles so the leeward engine turns at more RPMs than the windward engine. The difference in RPMs can be fine-tuned until pressure is off the helm.

B.28. Changing Vessel Heading

The following techniques cause a faster change in heading by increasing both skid and kick, reducing advance and transfer, and if the heading change is held long enough, the overall tactical diameter.

B.28.a. Rotating about the Pivot Point

Rotating about the pivot point is a low-speed maneuver. It is important because situations will occur when the boat's heading needs to be changed (to the weather or another vessel) or the bow or stern moved in a limited area. The engines should be opposed to turn in an extremely tight space. This maneuver is first performed at *clutch* speed in calm conditions to learn how the vessel reacts and what type of arcs the bow and stern describe. With no way on, there is no initial advance and transfer, so depending on the boat; this maneuver might yield a tactical diameter of zero if the heading is changed 360° (rotating the vessel in its own length).

The forces involved should be considered. Vessels with propellers will develop side force from both drives during this maneuver. The rudder, where equipped, can use screw discharge current from the ahead engine to help pivot the stern. Because boats operate more efficiently ahead, some headway may develop.

B.28.a.1. Helm Amidships

With helm amidships, perform the following procedures:

Step	Procedure
1	At dead-in-the-water and throttles in *neutral*, simultaneously *clutch ahead* with starboard engine, and *clutch astern* with port engine (keep both engine RPMs the same, though in opposite direction).
2	Note the arcs described by bow and stern as the vessel swings through 360° to determine vessel pivot point.
3	If vessel moved forward (along its centerline) during the rotation, slightly increase astern RPM to compensate.
4	Now, simultaneously shift throttles so port is *clutch ahead* and starboard is *clutch astern*; note how long it takes to stop and reverse direction of swing.
5	Again, check bow and stern arcs as vessel swings through 360°, and then stop the swing.

B.28.a.2. Helm Over Hard-to-Port

Put the helm over hard-to-port by performing the following procedures:

Step	Procedure
1	Perform the same procedures as with helm amidships. When stopping and reversing direction of swing, shift the helm to starboard.
2	In addition to the observations made with helm amidships, note whether the sizes of the arcs were smaller (due to directed thrust by lower unit or rudder).

CAUTION ! All crewmembers must pay close attention to throttle changes and vessel movements. Firmly hold onto the vessel during these maneuvers.

B.28.a.3. Developing Skills

With the basic skill in hand, practice controlling the amount of swing by performing the following procedures:

Step	Procedure
1	Use the compass and gradually limit the degree of rotation down to 30° each side of the original heading.
2	Increase amount of throttle applied.
3	Note the effect on vessel movement especially as to the rate of swing.
4	Develop boat handling knowledge and skills to know the degree of throttle splitting or asymmetric thrust for best effect in any situation. Maneuvering near the face of a breaking wave may require opposing engines at one-third or more of their available RPM, while maneuvering near the pier might only require a short, small burst on one engine to bring the bow through the wind.

NOTE

Experiment with the vessel.
- Though rudder use should help increase the rate of swing, the increase in turn rate might not be worth the workload increase (stop-to-stop helm use). Due to rudder swing rate, full helm use may not be as effective as leaving the helm centered.
- At some level of power for each vessel and drive train arrangement, cavitation will occur with split throttles. Know at what throttle settings cavitation occurs. More power will not increase turning ability and might cause temporary loss of maneuverability until cavitation subsides. In critical situations, loss of effective power could leave a vessel vulnerable.

B.28.b. Reducing Tactical Diameter at Speed

An emergency maneuver at cruising speed may require a turn with reduced tactical diameter.

B.28.b.1. Turn and Drag Propeller

An effective technique for a twin-propeller boat is to have one propeller act as a brake. This creates drag on the side with that propeller and reduces the turning diameter.

Step	Procedure
1	Put helm hard over.
2	Bring throttle on the engine in the direction of the turn to *clutch ahead*.

NOTE

Do not put throttle to *neutral* position. In *neutral*, the propeller will "free-wheel" and rotate without any resistance. Keeping the engine in *clutch ahead* will keep the propeller from spinning freely and start "braking" the vessel on the inboard side.

WARNING

As with the crash stop, this maneuver is extremely hard on the engine and drive train. The backing engine's power must be higher than that available at clutch speed to prevent engine stall.

B.28.b.2. Turn and Split Throttles

This practice is also more effective with shaft, propeller, and rudder arrangement than with directed thrust drives. One propeller will still be providing forward thrust while the other will be backing. As with opposing thrust in low speed maneuvering, propeller side force is multiplied. Cavitation will be pronounced on the backing screw, but the vessel's forward motion keeps advancing this screw into relatively undisturbed (or non-aerated) water.

Step	Procedure
1	Put helm hard over.
2	Bring throttle on the engine in the direction of the turn firmly to and through *neutral*, then past the *clutch astern position*, and gradually increase astern RPM.

Performing Single-Screw Compound Maneuvering (Single-Screw Theory)

B.29. Description

Basic maneuvering techniques should be applied in combination with a single propeller at low speed to further boat handling skills. Practice these maneuvers in calm, no-current situations before learning to overcome environmental forces.

A single-screw vessel never has the ability to use asymmetric or opposed propulsion, and its coxswain must develop boat handling skills with this in mind. The operator of a twin-engine vessel could easily become limited to use of one drive due to engine failure or fouling a screw, and must also become a proficient, single-screw boat handler.

For the discussion here, the case of a single-engine propeller vessel with right-hand turning screw is used. When maneuvering a twin-engine vessel on one drive, the coxswain must account for the propeller rotation and side force for the particular drive used (normally starboard: right-hand turning, port: left-hand turning), and the offset of the drive from centerline.

B.30. Back and Fill (Casting)

The back and fill technique, also known as casting, provides a method to turn a vessel in little more than its own length. At some point, anyone who operates a single-screw vessel will need to rely on these concepts when they operate a boat, particularly in close-quarters maneuvering. To back and fill, the coxswain should rely on the tendency of a vessel to back to port, and then use the rudder to direct thrust when powering ahead to starboard. The coxswain should also decide the radius of the circle in which to keep the vessel (at most, 25 to 35 percent larger than the vessel's overall length), and the intended change in direction (usually no more than 180°) before starting. For initial training, the vessel should be turned through at least 360°.

From dead-in-the-water position, perform the following procedures to back and fill:

Step	Procedure
1	Put helm at right full and momentarily throttle ahead, being careful not to make much headway. (Rudder directs screw discharge current thrust to starboard, more than offsetting propeller side force and moves stern to port).
2	Before gaining much headway, quickly throttle astern and shift helm to left full. (With throttle astern, side force is much stronger than screw suction, rudder to port takes advantage of any sternway).
3	Once sternway begins, simultaneously shift helm to full right and throttle ahead as in step 1.
4	Repeat procedures until vessel has come to desired heading, then put helm amidships and apply appropriate propulsion.

NOTE

- A firm grasp of the vessel's maneuvering characteristics is necessary to know whether to back and fill rather than just maneuver at full rudder.
- The amount of steps used will depend on size of the turning area and the desired change in heading. The smaller the area, the more backing and filling required.
- Winds will play a factor in casting. If the vessel's bow is easily blown off course, the vessel probably has a tendency to back into the wind. Set up the maneuver (including direction of turn) to take advantage of this in getting the bow to change direction. Strong winds will offset both propeller side force and any rudder effect.
- A quick helm hand is a prerequisite for casting with an outboard or stern drive. To get full advantage of the lower unit's directed thrust, fully shift the helm before applying propulsion. With helm at left full, the propeller side force when backing will have an element that tries to move the stern "forward" around the pivot point.

Section C. Maneuvering Near Other Objects

Introduction

This section applies basic maneuvering principles to control a vessel with respect to other objects. Later sections will cover mooring, unmooring, and coming alongside other vessels or objects.

This section covers maneuvering your vessel near, but not next to, another object.

C.1. Station Keeping

Coxswains must learn to manage the effects of environmental forces by using power and helm to maintain their position next to an object. Station keeping is defined as maintaining distance, position and aspect to or from an object. With twin propulsion, coxswains need to develop the skills required to maintain any aspect to an object during most conditions. Though many single-drive boats are thought to be less maneuverable, coxswains should fully develop single-drive station keeping skills should the need arise. Station keeping should be practiced during various levels of wind, seas, and current.

NOTE

All coxswains of twin-drive vessels must frequently train for single-drive operation. This includes station keeping.

C.1.a. Maneuvering Zone

Each situation requires a safe maneuvering zone to reach an optimal position near the object so an evolution can safely occur and can be done effectively (i.e., equipment transfer, object recovery, surveillance, etc.)

Before station keeping perform the following procedures to determine a safe and effective maneuvering zone:

CAUTION ! When station keeping, always have a safe escape route to get clear of the object or any hazard. While station keeping, ensure the escape route stays clear. This may require changing position to establish a new escape route.

Step	Procedure
1	Evaluate environmental conditions and how they affect the situation.
2	Determine if obstructions on the object or in and above the water limit your safe maneuvering zone.
3	Account for these obstructions and keep the environmental forces in mind.
4	Avoid vessel outriggers, hull protrusions, loose pier camels, broken pilings, ice guards, shoals, low overhead cables, bridge spans, and rocks or other submerged obstructions.
5	Define the maneuvering zone by distance, position, and aspect. Put limits on each element and maneuver to stay within those limits.

C.1.b Distance

The coxswain should station keep close enough to complete a mission or evolution, yet far enough to prevent collision or allision. Minimum distance to the object will probably vary around the object or along its length. Environmental conditions and boat maneuverability play a major role in determining distance. The coxswain should perform the following procedures:

Step	Procedure
1	Use a practiced eye and ranging techniques to keep distance.
2	When able, use identifiable keys, such as a boat length. Unless well practiced, each crewmember will probably differ in how they view 25 feet or 25 yards.
3	Use knowledge of the vessel. If it has a twelve-foot beam at the transom, transpose that measurement to the gap between the boat and an object.
4	If the coxswain station does not allow a clear view of the object, use points on the vessel (windscreen brackets, antennae, or fittings) to set up range-keeping clues.
5	Position the angle from the object to the vessel (or the reciprocal). To keep station on another vessel, particularly one that is disabled and adrift, determine the angle from the other vessel’s centerline; on a moored or fixed object, use a geographic or compass bearing.
6	Aspect: the relative angle the vessel makes to the other object (bow, beam, quarter, etc.). It may be necessary to keep the object at a certain aspect to pass equipment or a towline, or to maintain surveillance or to train a fire hose.

C.1.c. Differences in Objects

Differences in objects determine the maneuvering situation. The coxswain should become fully capable of station keeping in a variety of situations with both different types of objects and different environmental conditions.

C.1.c.1. Free-Drifting Object

Object type and size ranges from small items floating in the water to other vessels. No two items will drift at the same speed through the water. Free-drifting objects will present a different drift rate from the vessel. The coxswain should develop station keeping techniques by first comparing your drift rate to the object, and then overcoming the difference.

While another vessel maintains a steady course at low speed, the coxswain should pace his/her vessel to the other vessel and then maneuver around it. Pacing movement to the other vessel is critical before safely going alongside. The following are procedures for station keeping on a free-drifting object:

Drift Rate	Procedure
No Leeway	Practice with a floating (but ballasted) item that does not drift with the wind. A weighted mannequin with PFD or weighted duffel bag with a float in one end will work. The object's drift will be limited to the surface current, while vessel will respond to currents and winds. This type of object simulates a person-in-the-water.
Leeway	Wind-drift is the main consideration here. Practice with paired fenders, a partially filled 6-gallon bucket or a small skiff. Though wind will have a measurable effect on object drift, current will play little role. As above, the vessel will be subject to both wind and current.
Other Vessel	Become proficient at station keeping on a variety of vessel types. Different vessels react differently to environmental forces. Learn how other vessels drift, see how other vessels lie to the wind, and then maneuver the vessel to an optimal position for observation, coming alongside or passing a tow rig.

C.1.c.2. Anchored Object

Station keeping on an anchored object limits much of the object's movement due to wind and current, but the object will often surge and swing. A vessel will react freely to the wind and current. The object will ride with its moored end into the strongest environmental force affecting it, while the combination of forces on a vessel may cause it to take a different aspect.

Station keeping on an anchored object helps determine where to and where not to maneuver. Upstream of a buoy, strong current could easily carry the vessel. On the other hand, the only safe approach to a disabled vessel, anchored off a lee shore, may be from dead-to-weather. The following are procedures for station keeping on an anchored object:

Object	Procedure
Buoy or Float	In general, approach a moored buoy or float from down current or downwind, bow to the object. If servicing a floating aid to navigation, the approach may require centering the stern on the buoy. To train, keep station at various distances and angles to an object. Pick something totally surrounded by safe water. Next, maneuver up current or upwind.
A Vessel at Anchor	Surveillance, personnel or equipment transfer, or fire fighting may require station keeping on an anchored vessel. Develop skills to keep station at all distances and angles. Different sizes and types of vessels will ride their anchors differently. Deep draft or a large underbody will make a vessel ride with the current, while high freeboard and superstructure may make the vessel tend downwind. Evaluate the combination of forces while station keeping.
Note vessel interaction.	If close aboard and upwind, a small, light vessel may ride the anchor differently than if another vessel were not there. A larger vessel may affect the forces of a smaller vessel by making a lee. Watch a vessel's motions while it "rides" anchor. Some vessels don't "steady out," but veer back and forth. Observe and plan accordingly.
Fixed Object	Keep station on a pier, seawall, or breakwater. View this as a step before mooring. Also, these skills may be necessary to transfer someone to a fixed aids to navigation or to remove a person stranded on rocks. Station keeping on fixed objects makes the coxswain deal with forces that affect him/her and not the object. Often, the fixed object affects the environmental forces by funneling, blocking, or changing direction of the current or wind.

C.2. Maneuvering

Station keeping will usually require frequent to near-continuous applications of power and helm to stay in the safe maneuvering zone. While station keeping and trying to stay within the maneuvering zone limits, adjusting for one of the parameters (distance, position, aspect) will almost always involve a change to one or both of the other two. While using power and helm to compensate for and to overcome wind and current, the wind and current should be used to the fullest extent.

C.2.a. Stem the Forces

To stem the forces means to keep the current or wind directly on the bow or stern and hold position by setting boat speed to equally oppose the speed of drift.

C.2.b. Crab the Boat Sideways

To crab the boat sideways, environmental forces should be used to move the boat at a right angle to the forces. The coxswain should put the bow at a shallow angle (20° to 30°) to the prevailing force and use ahead propulsion and helm to keep from getting set backward, while staying at the shallow angle to the prevailing environmental force.

C.2.e. Open and Close

Make a vessel "open" and "close" the distance on the object at various angles, both to leeward and to weather. With an object on the bow or stern, directly up-drift or down-drift from you, opening and closing requires only to compensate for the fore and aft drift rate and to maintain a steady heading. A combination of control and environmental forces should be used:

- Side force.
- Ahead and astern thrust.
- Rudder force.
- Leeway.
- Current.
- Drift.

The more difficult scenario is opening or closing distance abeam.

Section D. Maneuvering to or from a Dock

Introduction

The most challenging and probably most frequent maneuvering encountered is that associated with getting in and out of slips, dock areas, piers, boat basins or marinas.

D.1. General Considerations

When maneuvering to or from a dock, the coxswain should keep the following points in mind and brief the crew on procedures to be used especially when mooring at a new location.

Step	Procedure
1	Check the conditions before maneuvering. Always take advantage of wind and current when docking or mooring. To maintain best control, approach against the wind and current and moor on the leeward side of a mooring when possible. Chances are that when mooring, conditions are not the same as when getting underway.
2	Rig and lead mooring lines and fenders well before the approach. Have everything ready on deck before the coxswain must concentrate and maneuver to the dock. Though common practice is to leave mooring lines attached to the home pier, always have a spare mooring line and moveable fender on the boat and at the ready while approaching any dock, including the home pier.
3	Emphasize control, not speed, when docking. Keep just enough headway or sternway to counteract the winds and currents and allow steerage while making progress to the dock. Keep an eye on the amount of stern or bow swing. With a high foredeck, the wind can cause the bow to swing much easier, making it harder to control. In higher winds, a greater amount of maneuvering speed may be needed to lessen the time exposed to the winds and currents, but be careful not to overdo it.
4	Line handling is extremely important when docking. Coxswains must give specific line-handling instructions in a loud, clear voice. If mooring at a different location, brief the crew before starting the approach to where the lines will be secured. Avoid using civilians to handle lines on the dock since their knowledge of line handling is not known and they may not be wearing the appropriate safety equipment.

D.2. Basic Maneuvers

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

This section covers some basic examples of mooring and unmooring. Again, actual hands-on practice of different approach styles and maneuvers during different weather conditions with different boat styles are highly recommended.

D.2.a. Clearing a Slip

Clearing a slip assumes that there is no wind or current, and that the vessel is a single-screw. (see **Figure 10-17**)

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

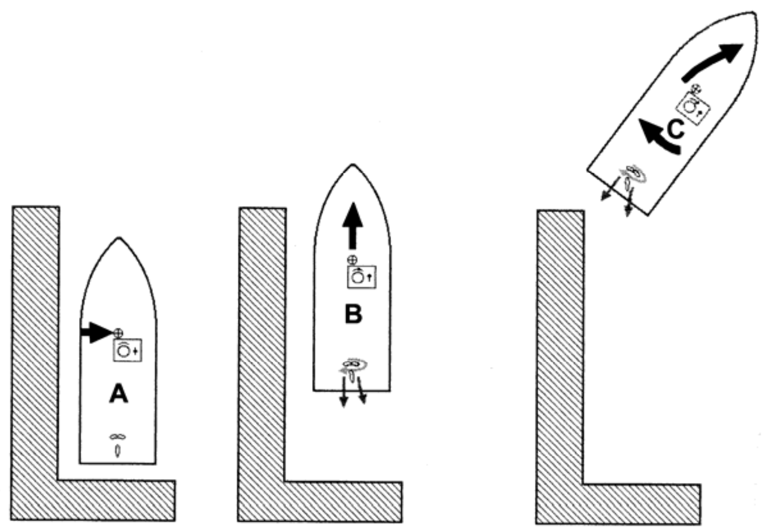


Figure 10-17
Clearing a Slip (No Wind or Current, Single-Screw)

D.2.b. Backing into a Slip

Backing into a slip assumes that there is no wind or current and the vessel is a single-screw, outboard or I/O. (see **Figure 10-18**)

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

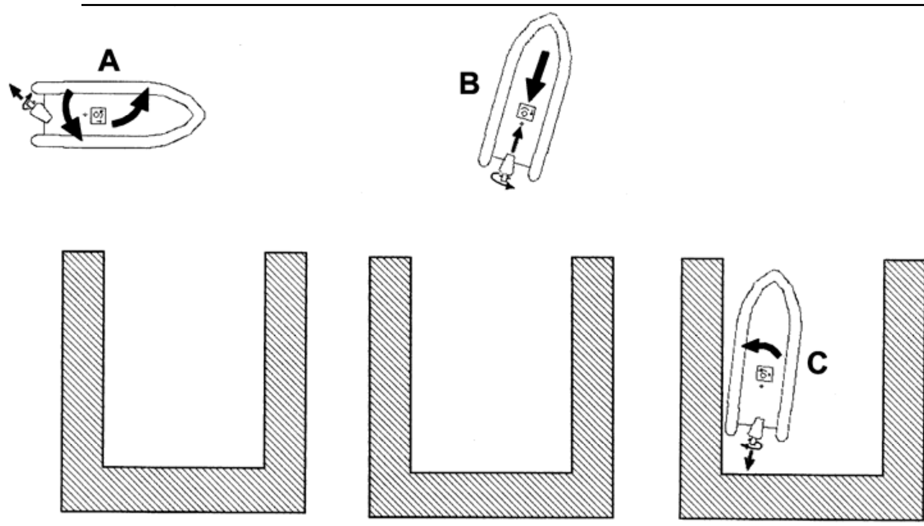


Figure 10-18
Backing Into a Slip (No Wind or Current, Single Outboard/Stern Drive)

D.2.c. Identifying Mooring Lines

Before using mooring lines to help maneuver at the dock, crewmembers need to first know their names and what they do (see **Figure 10-19**):

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

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

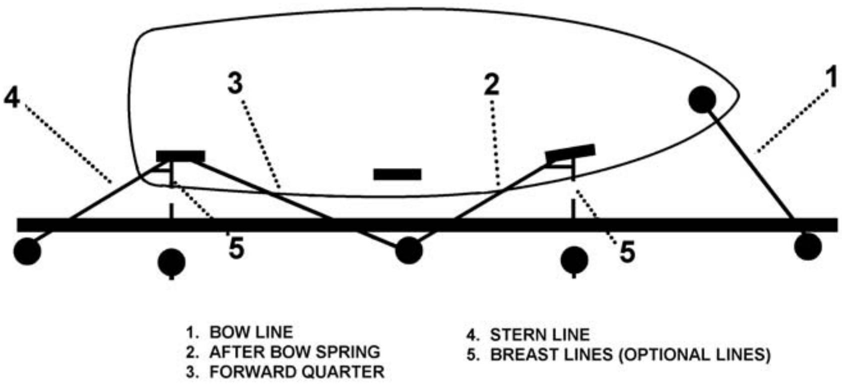


Figure 10-19
Mooring Lines

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

D.2.d. Using Spring Lines

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

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

The after bow spring, or bow spring (#2) should be used to "spring out" or move the stern away from the dock. The stern will move away with the rudder full toward the dock and the engines ahead. With the rudder turned the other direction or away from the dock, the stern will move towards the dock or "spring in". (see **Figure 10-20**)

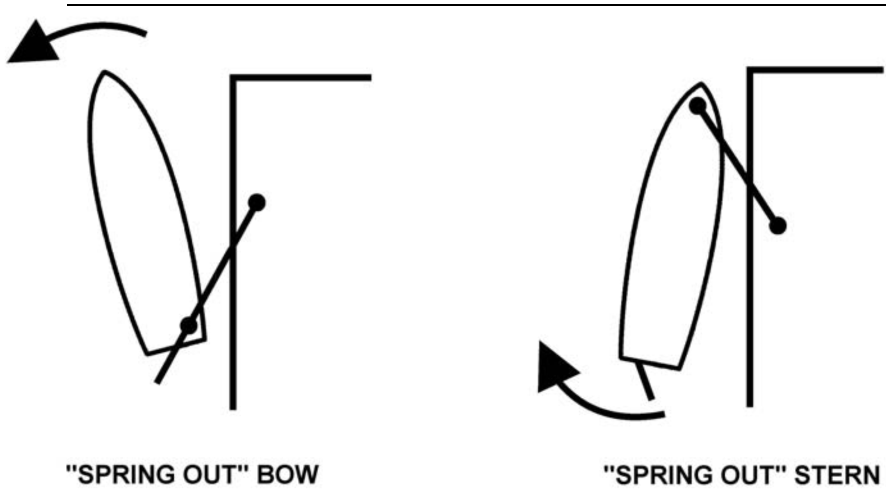


Figure 10-20
Basic Spring Line Maneuvers

D.2.e. Rigging Mooring Lines to "Slip"

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

D.3. Rules of Thumb

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

D.3.a. Responsibility

The coxswain is always responsible for the boat regardless of the existing environmental conditions and situations. Care must be exercised before assigning newly qualified coxswains to missions in extreme weather conditions.

D.3.b. Slow Speeds

On single-screw vessels maneuvering at slow speeds alongside another object, the coxswain should use full left (or right) rudders for better maneuverability. On twin-screw boats, the coxswain should leave the rudders amidships and use the engines at *clutch* (*idle*) speed to maneuver.

D.3.c. Alongside

When maneuvering alongside, speed should be kept to a minimum. Power should be applied in short bursts (with rudder at left or right full for single-screw boats) to get changes in heading; but the bursts should be kept short enough so as not to increase speed.

D.3.d. Port Side

Port side moorings are the easiest for single-screw boats with "right-hand" props (see *Section A* of this chapter for information regarding forces acting on a vessel).

D.3.e. Backing and Filling

Slow speed maneuvers to starboard are best for single-screw boats with "right-hand" props in restricted areas. The procedures for backing and filling are covered in *Section B* of this chapter.

D.3.f. Precise Control

When requiring precise control, the boat's heading should be kept into the predominate wind or current, or as close as possible. The boat should be maneuvered so that the set from the wind or current is either on the starboard or port bow allowing the boat to "crab" (move sideways) in the opposite direction.

D.3.g. Wind and Current

Wind and current are the most important forces to consider in maneuvering. The operator should use them to their advantage, if possible, rather than attempting to fight the elements.

D.3.h. Spring Lines

Spring lines are very useful when mooring with an off-dock set or when unmooring with an on-dock set. The spring lines should be used to spring either the bow or stern in or out. (see **Figure 10-21** and **Figure 10-22**).

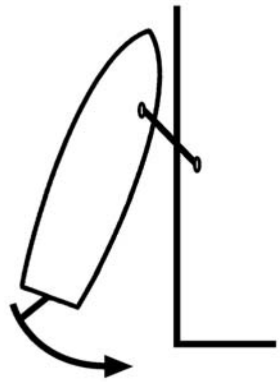


Figure 10-21
Going Ahead With Left Rudder Use of Spring Line

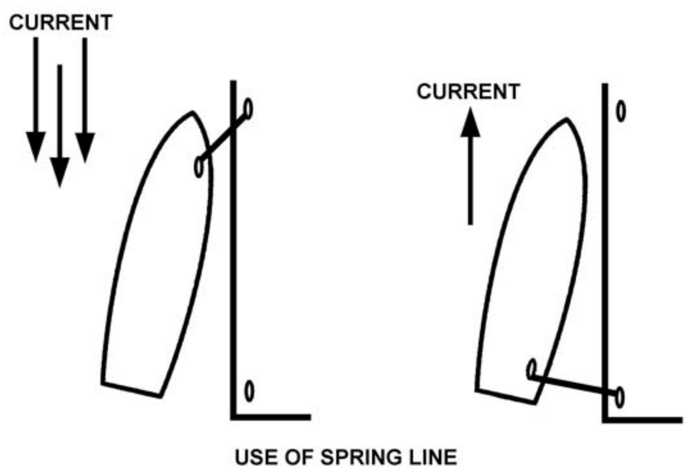


Figure 10-22
Making Use of Current

D.3.i. Thrusting Away from Another Boat	To thrust away from another boat, a camel, or a ship, the coxswain should use the prop wash or “screw knuckle.” By applying full power astern in a short burst then returning to *neutral*, the prop wash will move forward between the boat and the surface alongside, pushing the boat away.
D.3.j. Fenders	The coxswain should never attempt to fend a boat off a pier, float, etc., by hand or by foot, but should always use a fender. The proper sized fenders should be kept at hand.
D.3.k. Mooring/ Off-Dock Wind	When mooring with an off-dock wind, the approach should be made at a sharp angle - 45° or more.
D.3.l. Mooring/On-Dock Wind	When mooring with an on-dock wind, the approach should be made parallel with the intended berth and the fender should be rigged in appropriate positions. The coxswain should ensure that the boat has no fore and aft movement when contacting the dock.

D.3.m. Tying Down

Except for using the forward quarter spring, (see **Figure 10-19**) the stern of a boat should never be tied down while maneuvering beside a dock. This restricts maneuverability.

D.3.n. Pivot Point

The pivot point of a boat is approximately one-third of the way aft of the bow when the boat is underway at standard speed. This point moves forward as speed is increased and aft as speed is decreased.

D.3.o. Protecting the Stern

The stern should be kept away from danger. If propellers and rudder become damaged, the boat is crippled. If the stern is free to maneuver, usually the boat can be worked out of trouble.

D.3.p. Controlling the Boat

The greatest amount of control over the boat is gained by maneuvering into the prevailing face of the wind or sea. Boats turn more slowly into the wind and sea than away from them. A single-screw boat will generally back into the wind when the boat has more "sail" area forward of the boat's pivot point than aft.

D.3.q. The Wake

Coxswains are responsible for their boat's wake.

D.3.r. Informing the Crew

The coxswain must keep the crew informed. The coxswain should never assume the crew knows everything he or she is thinking.

D.3.s. Sea Conditions

All coxswains should know the sea conditions in which they can and cannot operate. All coxswains should immediately notify their Operational Commander if they are approaching their comfortable operating limits. It is better to return to the Station for a more suitable platform or a more experienced coxswain/crew than push the limits and possibly injure someone or cause damage to property.

D.3.t. Forethought

Coxswains should always think ahead and not take chances.

Section E. Maneuvering Alongside Another Vessel

Introduction

Many missions will require going alongside and making contact with another vessel. Activity can vary from a RIB going alongside a large merchant vessel to a large twin-screw boat going alongside a small canoe. Comparative vessel size, mission requirements, and prevailing conditions all dictate maneuvering practices. For many recreational and commercial mariners, maneuvering alongside their vessel is often the first; "up close and personal" look they get of the Coast Guard.

In this section

This section contains the following information:

Determining Approach

CAUTION ! Do not approach from leeward if it will put the vessel and crew in jeopardy, whether from shoal water or obstructions farther to leeward, or from smoke or hazardous fumes.

E.1. Conditions

When determining approach, the following conditions should be considered:

- Prevailing weather.
- Currents.
- Location.
- Vessel conditions.
- Vessel sizes.
- Traffic density.

The coxswain should discuss intentions with the other vessel's master.

NOTE If going alongside a disabled vessel or one that is underway but dead-in-the water, compare relative drift rates. When approaching a larger vessel with a low drift rate, approach from leeward. If approaching a smaller vessel, determine if vessel makes a wind shadow that will slow the other vessel's drift. In this case, an approach from windward may be better, and the smaller vessel will then be protected from winds and waves by the larger vessel. See *Chapter 17, Towing*, for more information.

E.2. Course and Speed

If possible and prudent, the vessel should maintain a course and speed to make the approach as smooth as possible for both vessels.

E.2.a. Large Vessels

Most large vessels will not be able to alter course significantly in a limited area to provide ideal alongside conditions. If it is not practical for the large vessel to change course, the coxswain should request that it reduce speed so the effects of bow and stern waves are reduced.

E.2.b. Small Vessels

Small vessels do not ride well when not making way in any kind of winds or seas. Unless the weather is perfectly calm or the vessel is disabled, a small vessel should maintain a course and speed that makes for safe, comfortable navigation while allowing mission completion. Speed should be slow enough to safely come alongside, but fast enough for both vessels to maintain steerageway when alongside one another.

CAUTION ! Make sure the other vessel does not change course while approaching or coming alongside. If this happens, break off and start the approach over again once the other vessel is on a steady course. Inform the master to maintain course and speed until the transfer is complete.

E.2.c. Stability

Many sailing vessels are much more stable while under sail than when powering or drifting. The coxswain should consider coming alongside while the other vessel is under sail, but should ensure that spars, standing or running rigging, or control lines do not foul either vessel. The situation should be discussed with the other vessel's master.

E.3. Approach From Leeward and Astern

A large vessel will create a wind shadow and block most of the seas allowing a smoother approach on the leeward side of a vessel. Coxswains should take advantage of this as in mooring to the leeward side of a pier.

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

NOTE If an approach from leeward is not possible (due to sea room or other condition like smoke or hazardous vapors), use caution during a windward approach to prevent being pinned up against the side of another vessel. If approaching on the windward side is a must, a bow-in approach might provide the most maneuverability.

E.4. Line and Fenders

Lines and fenders should be rigged as needed. Remember that with fenders, too many is much better than too few.

Going Alongside

WARNING Pick a contact point well clear of a larger vessel's propeller (including in the area of suction screw current), rudder, and quarter wave. Forces from these could cause loss of control.

E.5. Contacting and Closing In

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

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

NOTE If initial heading was parallel to the other vessel, increase speed slightly when starting to close at an angle.

E.6. Using a Sea Painter

In some instances, a sea painter may be used in coming alongside a larger vessel underway. The sea painter is a line used to sheer a boat clear of a ship's side when underway or to hold a boat in position under shipboard hoisting davits and occasionally to hold the boat alongside a ship in order to embark or disembark personnel. It leads from the larger vessel's deck well forward of where the boat will come alongside.

Perform the following procedures when securing a sea painter to the boat:

Step	Procedure
1	Choose a position for attachment of the painter just aft of the bow on the side of the boat that will be alongside the larger vessel. Normally, the first deck fitting aft of the bull nose works well.
2	Lead it outboard of handrails, stanchions, and fittings. It makes a pivoting point on the "inboard" bow of the boat.
3	Never secure the sea painter to the boat's stem nor to the side of the boat away from the ship. If secured to the "outboard" side of the boat, capsizing could result.

As both the boat and ship have headway, the pressure of water on the boat's bow will cause it to sheer away from the ship. The coxswain should use this force by a touch of the helm to control sheer, in or out or, by catching the current on one side of the bow or the other. Riding a sea painter helps maintain position and control of the boat.

Perform the following procedures if using a sea painter:

NOTE When sheering in or out, apply rudder slowly and be prepared to counteract the tendency of the boat to close or open quickly.

Step	Procedure
1	Go alongside of the vessel, matching its course and speed. When close aboard the larger vessel, and forward of the desired contact point, ask the ship to pass the sea painter.
2	The sea painter is usually passed by use of a heaving line. Quickly haul in the heaving line and adjust the boat's heading and speed to control slack in the sea painter so that these lines do not get into the boat's propeller.
3	Once the sea painter is onboard, secure it to an inboard cleat just aft of the bow.
4	Reduce speed slowly and drift back on the painter (ride the painter).
5	Use helm to hold the boat at the desired position alongside or at some distance off the ship.
6	If set toward the ship, apply rudder to sheer the bow out. If too far away, apply rudder to sheer the bow in. The forward strain on the painter will pull the boat and provide steerage.

NOTE If approaching a vessel anchored in a strong current, the sea painter can be used to provide a means to lie alongside. Procedures are the same as if the vessel is making way. Approach from leeward, against the current.

E.7. Making and Holding Contact

Perform the following procedures to make and hold contact with a vessel:

Step	Procedure
1	Make contact with the forward sections of the boat (about halfway between the bow and amidships).
2	Use helm and power (if not on a sea painter) to hold the bow into the other vessel, at the same forward speed.
3	Do not use so much helm or power that the other vessel is caused to change course.

E.8. Conducting the Mission

When alongside and conducting the intended missions, the coxswain should:

Step	Procedure
1	Minimize time alongside.
2	If necessary, "make-up" to the other vessel rather than relying on helm and power to maintain contact.

CAUTION !

Never back down when clearing alongside. Always pull away parallel to the other vessel that is making way.

E.9. Clearing

Getting set toward the side or stern of the vessel should be avoided. Perform the following procedures to clear the side of a vessel:

Step	Procedure
1	Sheer the stern in with helm to get the bow out.
2	Apply gradual power to gain slight relative speed.
3	Slowly steer away from the vessel while applying gradual power.
4	Ensure stern is clear of the other vessel before applying a large amount of rudder.

NOTE

If on a sea painter, use enough speed to get slack in the line, then cast off once clear. Ensure the sea painter is hauled back aboard the larger vessel immediately to prevent it from catching in the screws.

If operating a twin-screw boat, go ahead slowly on the inboard engine. This also helps to keep the boat clear of the ship's side.

Section F. Maneuvering in Rough Weather

WARNING ☝

> Do not exceed any vessel's operating limits as specified in the Specific Boat Operator's Handbooks, COMDTINST M16114 (series) or through district-use guidelines for other vessels.

Introduction

At some time, every boat and crew will encounter wind or sea conditions that challenge safe, successful boat operation. Due to size and design differences, extreme weather for one vessel is not necessarily challenging for another. Also, crew training, experience, and skill more often than not make the difference between safety and danger, regardless of the vessel.

Size, stability, and power are vessel characteristics that enhance safety and allow some forgiveness in large waves and high winds or due to the occasional lapse in skill or judgment. On the other hand, lightweight, speed, and agility give a means to avoid or to outrun conditions, but offer little protection or forgiveness for the slightest miscalculation.

The coxswain should learn to operate a vessel through the full range of conditions possible, beginning in light winds and small waves and working up to varied conditions that build knowledge and confidence.

In this section

This section contains the following information:

Using Caution

F.1. Description

Caution should be used at all times. The power of winds and waves and what they can do to a vessel or crew should never be underestimated. The following concepts will increase the level of safety of operation.

F.2. Vessel Operating Characteristics and Limitations

Crewmembers should be familiar with the vessel's operating characteristics and limitations to safely and confidently handle conditions that approach those limits including:

- Learning the vessel's motions and peculiarities.
- Knowing the vessel's limits.
- Ensuring proper operational readiness.
- Utilizing only capable vessels.

F.2.a. Learning Vessel Motions and Peculiarities

Operate the vessel frequently and develop a working knowledge of its response to waves and winds. Excessive boat motion is very fatiguing and could cause motion sickness.

- Learn the motions the boat makes in response to varying sea conditions. Find out if the vessel has any distinctive tendencies, for instance, attaining a dangerous heel while cresting a wave in high winds, burying the bow in all but the longest swells, or "lightness" to the stern in quartering conditions.
- Learn and develop techniques to minimize vessel motion in all conditions. A small tweak of the throttle or a smooth helm-hand can make the ride much smoother and less fatiguing.
- On smaller vessels, keep crew weight centered around the helm position. This is usually near the boat's center of gravity. It will make the ride more comfortable for the crew and will allow the hull to ride as designed.

Common Motions	Description
Pitch	Pitch is the up and down motion of the bow (and stern). In small waves at high speeds, pitch can be very small and barely noticeable. As seas increase, the bow might rise up when it meets a wave, and fully clear the water. As it comes back down, it immerses to a point on the hull above the designed waterline, sometimes with a heavy slam. Pitch is usually experienced when heading into the seas. Reduce pitch by reducing speed or by taking head seas at more of an angle.
Roll	Roll is the side-to-side motion as each side goes up and down. This is associated with beam seas. A round-bottomed vessel will roll even in near-calm conditions. Reduce roll by setting a course that does not have the seas directly on the beam.
Heave	Heave is the vertical motion the entire boat makes. Though frequently hidden by combined pitch and roll, it is felt as a boat encounters large waves or a heavy swell.

F.2.b. Vessel Limits

Knowing the maximum wind speed and wave height in which the vessel is allowed to operate is a must. Every attempt should be made to avoid exceeding these conditions. However, learning how to ride out the worst winds or seas is recommended before the need arises.

F.2.c. Operational Readiness

A vessel must not be used in rough weather when it is not operationally ready. A small discrepancy can lead to serious consequences. All required gear should be properly stowed and everything else should be removed.

F.2.d. Capable Vessel

When conditions exceed a particular vessel's limits, a more capable vessel should be used. If one is not available, OPCON must be notified and a waiver granted before launching on the mission.

- Do not use the wrong vessel or tool for a job.
- Always apply risk assessment.

F.3. Knowledge of Area Conditions

Operators should learn to handle the vessel in the types of winds and seas found in their specific area and learn their interaction with local geography and hydrography.

F.3.a. Area Conditions

Learn the area's tide rips, bars, gorges, coastal currents, and local waters before maneuvering there in rough weather by performing the following procedures:

Step	Procedure
1	Find out where wind funnels between headlands or in a river constriction.
2	Get the "big picture," if possible. Spend time in a watch tower or on an overlook, map the patterns of waves, where and when they break.
3	Follow the tracks of severe storms or squall lines. Learn how local geography affects their motion, winds or intensity.
4	Pay attention to forecasts, then frequently compare to actual conditions in the area.
5	Know location of points, capes, bars, hazards to navigation (i.e., piers, wrecks, submerged piles, etc.)

F.3.b. On-Scene Conditions

Evaluate on-scene conditions before committing to a maneuver by performing the following procedures:

Step	Procedure
1	Time the series of waves. Note relative lulls between large waves, any place where the waves do not curl and break with intensity, or where they seem to peak and break continuously.
2	Note if an approaching thunderstorm has a wall cloud or if a "downburst" is visible.
3	Determine the best way to lessen the effect of a sudden, extreme gust of wind.

F.4. Crew Limitations

Knowing the crew limitations as well as being aware of the human factors and clues associated with risk management is essential. False bravado or over-confidence in rough weather will not compensate for inexperience or fear. The following are common sense guidelines to follow:

- When in doubt, DON'T. Experience helps hone good judgment in risk assessment.
- Understand responsibility. Rough weather is not a game or a sport.
- Know when to end an evolution. This is particularly true in training. Damage or injury during training removes resources and people from operational availability.
- Perform as a team. While the coxswain concentrates on the detailed maneuvering, the crew must act as additional eyes and ears.

Negotiating Head Seas

F.5. Description

The operator should use the vessel's inherent capabilities. Bow flare provides additional buoyancy to help lift the bow, but larger seas must be met much slower than smaller ones. A slower speed of approach gives the bow time to rise and meet the waves.

NOTE

> The following information on maneuvering is general in nature. Remember that each specific boat type will perform differently.

NOTE

Keep in mind that aerated, broken, sloughing, or "white" water will not provide as much buoyancy as "green" water. Also, propulsion and helm response will be sluggish. Aerated water favors cavitation.

F.6. Maneuvering Constantly

Operators should always look and drive for the path of least resistance. The best way to get through waves is to avoid as many as possible. Anticipating patterns and taking advantage of them is key.

F.6.a. Breaking Waves

Pick ways around breaking waves as follows:

- Take advantage of any lulls between the higher series of waves.
- Look for gaps or windows in the breaking waves, but watch them to see if they close out before the vessel approaches.
- Do not try to steer a perfectly straight course; steer the smoothest course if navigation allows.

F.6.b. Crests

Operators should avoid the highest crests, staying away from waves that begin to peak in a triangular fashion. A "square" wave leaves no room to maneuver, and the trough behind is much deeper than others.

WARNING

If the vessel is a single-screw, do not attempt this if originally planning to take the wave on the port bow. Backing down will throw the stern to port and the vessel could end up beam-to the crashing wave.

CAUTION !

Do not use so much power to cause cavitation when backing away from a wave. If cavitation occurs, all thrust and maneuverability will be lost.

F.7. Working Over Waves

Operators should work over each wave individually, varying speed and angle of approach to account for differences in each wave. The following procedures apply:

NOTE

If going through a breaking wave, keep headway. Just as the breaking sea hits the bow, increase power to lift the bow so the sea will not spill on deck, then immediately reduce power.

Step	Procedure
1	Slow down, approach at an angle. Too much speed could "launch" a boat as it leaves a crest and result in a severe drop. Approach at a 10° to 25° angle to the wave rather than straight into it. Cross the crest at this angle to stay in the water and keep the propellers and rudders working.
2	Stay ready to maneuver. It may be necessary to straighten out quickly or to "fall off" to avoid a forming break.
3	Continually adjust boat speed. Increase speed to keep the screw and rudder or drive in the water and working, but then immediately reduce it to minimize wave impact.
4	Do not drive the bow into the wave.

NOTE

If the sea is about to break directly ahead and plunge onto the bow, back down squarely and quickly to avoid the plunging water. The boat will settle as the aerated froth passes, and propulsion and steering will lose some effectiveness until the white water passes.

F.8. Managing Power

Operators should always keep one hand constantly on the throttle control(s).

F.8.a. Heavier Vessels

Use the following procedures when managing the power of heavier vessels:

Step	Procedure
1	Use only enough power to get the bow sections safely over or through the crest.
2	Let momentum carry, and cut back power to let the boat slide down the backside of the swell. When the stern is high, gravity pulls the boat downward and the engines may race somewhat, but stay in gear. Do not decrease RPMs to the point where the engines need time to "spool up" to regain enough power to deal with the next wave.
3	Increase speed in the trough to counteract the reversed water flow and maintain directional control as the next wave approaches.
4	Slow down again and approach the next wave.

F.8.b. Lighter Craft (Including RIBs)

Use the following procedures when managing the power of light craft:

Step	Procedure
1	Use enough power to get the entire boat safely over or through the crest. Lighter craft will not carry momentum so constant application of power is necessary.
2	Keep a slight, bow-up angle at all times.
3	Once through the crest, a slight, bow-up angle, will let the after sections provide a good contact surface if the boat clears the water. A bow up attitude will help to approach the next wave.
4	Increase speed in the trough to counteract the reversed water flow and maintain directional control as the next wave approaches.
5	Slow down again and approach the next wave.

F.9. Staying in the Water

"Flying through" the crest should be avoided at all costs.

- If a large vessel becomes airborne at the top of a wave, the crew is threatened with serious injury and could damage the vessel when it lands.
- With lighter craft, ensure the after sections stay in contact with the water, but do not let the bow sections get too high. If the bow sections get too high while going through a crest, the apparent wind or the break can carry the bow over backward. On the other hand, if forward way is lost with the stern at the crest, the bow might fall downward, requiring to redeveloping speed and bow-up attitude before the next wave approaches.

F.10. Holding On

Crewmembers should keep a firm grasp on controls or hand holds, but should not brace rigidly. Staying rigid and tense will quickly sap strength. If standing, the knees should be kept flexed.

Running Before a Sea

F.11. Description

A following sea does not present the high relative closure rate of head seas, but keeping vessel control and stability is more challenging.

Operation in a following sea, especially a breaking sea, involves the risk of having the stern lifted up and forced forward by the onrushing swell or breaker. Surfing down the face of a wave is extremely dangerous and nearly impossible to control. Quite often, surfing will force the boat to "broach" and capsize or to "pitchpole" end over end. Through proper boat handling, a skilled coxswain may be able to keep a vessel ahead of breaking seas while maintaining control of both direction and speed. Only specially designed vessels, like motor lifeboats, have balanced buoyancy and sea keeping abilities to handle extremely rough weather, including large, breaking, following seas. Motor lifeboats also have the ability to quickly re-right themselves after capsizing.

F.12. Using Extreme Caution

Coxswains should be very careful when running in a large following sea. Some boats slip down the back of seas and heel strongly. In large stern seas, the rudder may get sluggish. Depending on the vessel, down-swell heading should be made anywhere from directly down-swell to a 15° angle to the swells.

NOTE

> A great deal of skill is needed to maintain a heading in large, quartering seas (30-45 degrees off the stern), especially in restricted waters. In addition to the action from astern, the forces from abeam will set up a rolling action that causes large changes in the vessel's underwater hull shape (on anything except a round-bottomed, displacement hull). This causes asymmetric forces that increase steering difficulty, could set up "chine-riding," loss of effective helm, and a pronounced veer to the side as the vessel begins to surf along the face of the wave. Even in open water, quartering seas present a challenge.

CAUTION !

> Avoid letting waves break over the transom of the boat. Be extremely careful in small craft with outboard motors, the relatively low transom-well offers little protection from even a small, breaking wave. A wave that breaks over the transom could fill the cockpit with water and swamp the boat. Without self-bailing, the vessel is vulnerable to capsize.

F.13. Riding the Backs of the Swells

In waves with a wide regular pattern, coxswains should ride the back of the swell, never riding on the front of a wave. On most vessels, wider and flatter after-hull sections are more buoyant than the bow. On the front of a wave, the boat may begin to surf, pushed along by the wave. As the bow nears the wave trough, it will tend to "dig in" while the stern continues to be pushed. This sets up either a broadside "broach" or an end-for-end "pitchpole" as the breaking crest acts on the boat.

F.13.a. Where to Look

The coxswain should keep an eye both ahead and astern. If the coxswain concentrates completely on the wave ahead, he/she will not be aware of waves from astern. Since larger waves travel faster than smaller ones, one much larger than the present wave may move up quickly from astern and catch the crew unaware.

WARNING

> Many small craft can travel faster than the largest waves. Do not keep climbing the back of a large wave ahead to its crest. The boat could go over the crest just as it breaks and fall into the trough under the plunging water.

F.13.b. Speed

The coxswain should adjust the speed to stay on the back of the swell and pay extremely close attention to the way the crest ahead breaks. If the vessel keeps gaining on the crest ahead, the coxswain should slow down.

F.14. Reserve Power

Large seas run at over 20 knots. If the boat is being pulled back towards a following sea, the coxswain should open the throttle. If the boat is still being pulled back, the coxswain should watch for "mushy" helm response and engine racing. If either happens, reducing throttle, then applying full throttle will help to kick out of the wave.

WARNING

Coming about in large seas can be dangerous. It puts the boat beam-to the seas. Do not try this unless well trained and experienced. Any close, steep swells will test all skills. Sluggish rudder, sail area, and irregular waves may cause the stern to slew off and result in a broach.

CAUTION !

If it is necessary to come about before a wave, use judicious helm and throttle. Too much throttle, especially when splitting throttles, could easily result in cavitation and leave no positive control in the face of the oncoming sea.

F.15. Slow, Back or Come About

If running with the seas and a wave is gaining astern, avoid it breaking on the transom by using the following procedures:

Step	Procedure
1	Slow Down: With a well-found vessel, it may be possible to just slow enough so the crest passes by before it breaks. This will cause some loss of positive steering and propulsion control as the crest passes because the water in the crest will be moving forward faster than the boat.
2	Back Down: It may be necessary to back and gain sternway to steer before the crest reaches the screws and rudder, particularly if the wave breaks and aerated water will slough past.
3	Come About: The safest point for most vessels to take a breaking sea is nearly bow-on. Always stay aware of the time and distance between crests. If time and distance allow, come about and present the bow to the sea with headway.

Traversing Beam Seas

F.16. Description

In large beam seas, the wave action will cause the boat to roll. The rolling will cause asymmetric hydrodynamic forces and will affect steering. If this occurs, drive and rudder should be kept immersed.

F.17. Breaking Waves

The number of breaking waves encountered should be minimized. If traversing near a surf zone, going into deeper water will help to avoid breaking waves.

F.18. Using Local Knowledge

Avoid areas that break when no other areas do. Offset your transit from areas of shifting bars.

NOTE

If it is necessary to operate in the surf zone, complete wave avoidance is not possible. The coxswain must be totally involved in operating the boat while the crew carries out the details of the mission (search, recovery, etc.).

F.19. Keeping a Weather-Eye to the Waves

As with head seas and following seas, the boat will be pulled towards the next, oncoming wave while in the trough, and set down-swell by the crest. Perform the following procedures to keep a weather-eye to the waves:

Step	Procedure
1	Look for a lull in the series to cross-seas. If necessary, slow to allow a large series of waves to cross ahead.
2	Use caution to avoid a forming break. Watch how the waves break. Plan to cross an oncoming wave well before it begins to break. Do not get caught racing a break to cross at a particular point. Use procedures for negotiating head seas to cross oncoming waves. As with head seas, cross them at the lowest part.
3	Never get caught broadside to a breaking sea. A breaking swell taken on the beam can easily capsize the vessel.
4	Do not get trapped. If the boat gets into seas that are spaced closer together, look for an out. If shallow water or a current against the seas is on one side, work toward the other direction.

Transiting Harbor Entrances, Inlets, or River Entrances

F.20. Description

When transiting harbor entrances, inlets, or river entrances in rough weather, there will be times when the vessel must either leave or enter port in challenging conditions. Though certain locations have extreme conditions much more often than others, learning how rough weather affects the various harbors and entrances throughout the local area is essential. Methods covered above for maneuvering in head, following, and beam seas still apply, but the entrance areas add additional consideration.

F.21. Knowing the Entrance

Though mentioned above, local knowledge is key. Knowing as much as possible before transiting an entrance in rough weather will help guard against potential problems. Utilize the following procedures and considerations to assess entrances areas:

Step	Procedure
1	Watch where waves break. Know how far out into the channel, whether near jetties or shoals, or directly across the entrance the waves break.
2	Pay close attention to how the entrance affects wave patterns. A jettied entrance may reflect waves back across an entrance where they combine with the original waves.
3	Some entrances have an outer bar that breaks, and then additional breaks farther in. Others are susceptible to a large, heaving motion that creates a heavy surge as it hits rocks or structures.
4	Know where the channel actually is. If shoaling has occurred, room to maneuver may be significantly reduced.
5	Know the actual depths of the water. Account for any difference between actual and charted depth due to water stage, height of tide, recent rainfall, or atmospheric pressure effects.

F.22. Transiting When Current Opposes the Seas

Transiting when the current opposed the seas presents the most challenging situation near an entrance. In opposition to the seas, a current has the effect of shortening the wavelength, and increasing the wave height. This makes waves much more unstable and much closer together. Utilize the following procedures and considerations to transit when the current opposes the seas:

Step	Procedure
1	When going into the seas, the current behind will push the boat into them, at a relatively higher speed.
2	Reduce the effect (which will also give more time to react between waves) by slowing, but because the current is behind, keep enough headway to ensure effective steering.
3	Do not let the current push the boat into a large cresting wave or combined waves peaking together. In an entrance, maneuvering room is often limited. The only safe water may be the area just left. Be ready to back down and avoid a breaking crest.
4	The situation can be critical in following seas and a head current. The waves will overtake at a higher rate; they become unstable more quickly, and will break more often. The current reduces the boat's progress over the ground, subjecting the vessel to more waves.
5	As with all following seas, stay on the back of the wave ahead. Because the waves become unstable and break more quickly, use extra caution to not go over the crest ahead. Concentrate both on the crest ahead and the waves behind.
6	Keep a hand on the throttle and adjust power continuously. In many entrances, there is not enough room to come about and take a breaking wave bow-on. Anticipate. If a wave looks to break, the only out may be to back down before it gets to the vessel.
7	Stay extremely aware of any wave combinations and avoid spots ahead where they tend to peak. If they peak ahead in the same place, chances are they will peak there when the vessel is closer. However, do not let a slightly different wave or wave combination catch the crew by surprise.
8	The crew must keep an eye on the situation and pass information freely.

F.23. Transiting When Current and Seas Coincide

In a situation of transiting when current and seas coincide, a current has the effect of lengthening the waves. Longer waves are more stable, with the crests farther apart, but caution is still needed. Utilize the following procedures and considerations to transit when current and seas collide:

Step	Procedure
1	When going into the seas and current, progress over the ground will be lessened, so more time will be spent in the entrance. Increasing boat speed may be warranted.
2	Do not increase boat speed so that negotiating waves becomes hazardous. The waves are just as high, so if overall speed was increased, reduce speed to negotiate each crest individually.
3	With following seas and current, speed over the ground will be increased. Because the waves are farther apart, the task of riding the back of the wave ahead should be easier. Because the current is behind, more forward way will be required to maintain steering control.
4	As with all following seas, stay on the back of the wave ahead. Do not be lulled into a false sense of security. With higher speed over the ground and less maneuverability due to the following current, there is not as much time to avoid a situation ahead.
5	Keep a hand on the throttle and adjust power continuously.
6	Because less time will be spent in the entrance, stay extremely aware of any spots ahead to avoid. Maneuver early, as the current will carry the boat.
7	The crew must keep an eye on the situation and pass information freely.

Coping with High Winds

F.24. Description

Though preceding discussions dealt with encountering severe wave action, high winds do not always accompany large swells. Also, there will be instances when extreme winds occur without sufficient duration to make large waves. Much of the time, though, high winds and building seas will coincide.

F.25. Crabbing Through Steady Winds

Depending on the vessel's sail area, it may be necessary to steadily apply helm or asymmetric propulsion to hold a course in high winds. Coxswains should learn to "read" the water for stronger gusts. The amount of chop on the surface will increase in gusts, and extremely powerful gusts may even blow the tops off waves. The effect of a gust should be anticipated before it hits the vessel.

NOTE

Boats that show extreme motion and minimal control in high winds and seas, regardless of size and power, are not well-suited for missions in these conditions. If caught in marginal conditions, safety of the vessel and crew must be the only concern. Other, more capable resources must conduct the mission.

Utilize the following procedures and considerations when crabbing through steady winds:

Step	Procedure
1	In large waves, the wave crest will block much of the wind when the boat is in the trough. Plan to offset its full force at the crest. The force of the wind may accentuate a breaking crest, and require steering into the wind when near the crest in head seas. Depending on the vessel, winds may force the bow off to one side while crossing the crest.
2	For light vessels, the force of the wind at the wave crest could easily get under the bow sections (or sponson on a RIB), lift the bow to an unsafe angle, or force it sideways. Though a light vessel must keep some speed to get over or through the crest of a large wave, do not use so much speed that the vessel clears the crest, most of the bottom is exposed to a high wind. Be particularly cautious in gusty conditions and stay ready for a sudden large gust when clearing a wave.
3	With twin-engined craft, be ready to use asymmetric propulsion to get the bow into or through the wind. As with all other maneuvers, early and steady application of power is much more effective than a "catch-up" burst of power.
4	Vessels with large sail area and superstructures will develop an almost constant heel during high winds. In a gust, sudden heel, at times becoming extreme, may develop. This could cause handling difficulties at the crest of high waves. If the vessel exhibits theses tendencies, exercise extreme caution when cresting waves. Learn to safely balance available power and steering against the effects of winds and waves.

F.26. Avoiding Severe Weather

Thunderstorms, downbursts, squalls, and waterspouts should be avoided. Many areas regularly get severe weather with localized winds in excess of 50 knots. As these conditions often arise at peak times in the recreational boating season, chances are that the crew may find themselves underway in them. Since numerous cells can occur in one thunderstorm, the crew may be faced with maneuvering among many different storms, and therefore, should keep an eye on what is approaching.

NOTE

If faced with a severe storm while on the water, reduce as much sail area as possible. Lower bimini tops, dodgers, outriggers, antennas, flags and ensigns. This significantly improves vessel stability and response to high winds. Also, stow all loose gear, close hatches and doors, and stay low.

F.26.a. Gusts

Coxswains should try to avoid the highest gusts. Some storm cells have their own gust fronts that precede them. These gust fronts appear as a layer of steam on the water. A 50-knot gust front will actually turn the surface of the water into spray, with the highest gusts mixing with the relative heat of the water to lift the spray vertically.

NOTE

If sea room permits, move away from (perpendicular to) the direction of the gust.

F.26.b. Drifting Stern-To the Winds

Coxswains should consider drifting stern-to the winds. At the speed these gusts move, they often do not have time to develop much of a sea. If so, it may be possible to lie safely, stern-to the wind, engines in *neutral*. This way, it will not be necessary to fight the overpowering force to keep the bow directly into the wind.

CAUTION !

Laying stern-to is not safe if an approaching storm has enough open water to develop fetch and build seas. A strong thunderstorm needs as few as five miles of open water to build a three- to four-foot chop. In combination with 50-knot winds, this chop can easily swamp small vessels.

F.26.c. Getting Between a Storm and Shore

Getting between a severe storm and a near, lee shore should be avoided. The coxswain should attempt to move across a gust front, before it arrives, as best as possible to safe haven or open water.

Heaving-To

F.27. Description

If unable to reach safe haven in extreme weather, heaving-to might be the only option to ride out the foul weather while waiting for conditions to improve. Basically, heaving-to is putting the bow into the wind or seas, and holding it there with helm and throttle. For vessels with a large sail area or superstructure, this might not be possible. If the conditions are strong enough, large waves or strong gusts of wind may cause the vessel to “fall-off” and lay beam-to or stern-to the wind or seas.

WARNING

Only heave-to when there is adequate sea room to leeward. Drift will be downwind and down sea.

F.28. Maneuvering

Coxswains should maneuver only to keep a bow-on aspect to the weather. Heave-to only when the vessel cannot safely make progress in a desired direction, utilizing the following procedures:

Step	Procedure
1	Offset for the strongest force. Wind and seas might not be from the same direction.
2	Try to keep seas between 10° and 25° off the bow as if negotiating head seas and note the compass heading. Negotiate the seas will still occur, but no progress will be made. If the wind allows holding this angle, it will give the best ride. Determine a mix of helm and throttle to hold the heading. Try not to use full rudder or throttle as it leaves no reserve for an emergency maneuver.
3	If the winds are gusty and have frequent shifts, they can easily force the bow off the desired heading. Listen for signs of an approaching gust and start to counteract its effect before it actually strikes the boat.
4	If seas are not the strongest force, keep the bow directly into the wind.

F.29. Sea Anchor

Utilize the following procedures to employ a sea anchor, if necessary, to hold the vessel into the weather:

Step	Procedure
1	If unable to hold a heading, use a drogue as a sea anchor, made fast to the bow, to hold it into the weather.
2	Use as much scope as available up to 300 feet.
3	Let the rode pay out and see if the vessel motions settle down.
4	The bow may continue to "sail" back and forth. Counteract this by using some forward power and helm to hold the bow at a constant compass angle.
5	Maneuver with caution, keeping the sea anchor rode off the bow.

Section G. Maneuvering in Rivers

Introduction

This section discusses the techniques and hazards of maneuvering in narrow rivers.

In this section

This section contains the following information:

Operating in a Narrow Channel

G.1. Bank Cushion

Bank cushion occurs only when operating in close proximity to the bank and refers to a boat being pushed away from the nearest riverbank. As the boat moves ahead in the river, the water between the bow and the near riverbank builds up high on the side of the boat, causing the bow to move away from the bank. The bank cushion affect is especially prevalent if the draft of the boat is nearly equal to the depth of the water, or in narrow channels with steep banks.

G.2. Bank Suction

Bank suction refers to the stern of a boat being pulled toward the bank. As the boat moves ahead while near the riverbank, the unbalanced pressure of water on the aft quarter lowers the water level between the boat and the bank, forcing the stern to move toward the bank. This suction effect occurs most notably with a twin-screw boat.

G.3. Combined Effect

The combined effect of bank cushion and bank suction may cause a boat to take a sudden sheer toward the opposite bank. (see **Figure 10-23**)

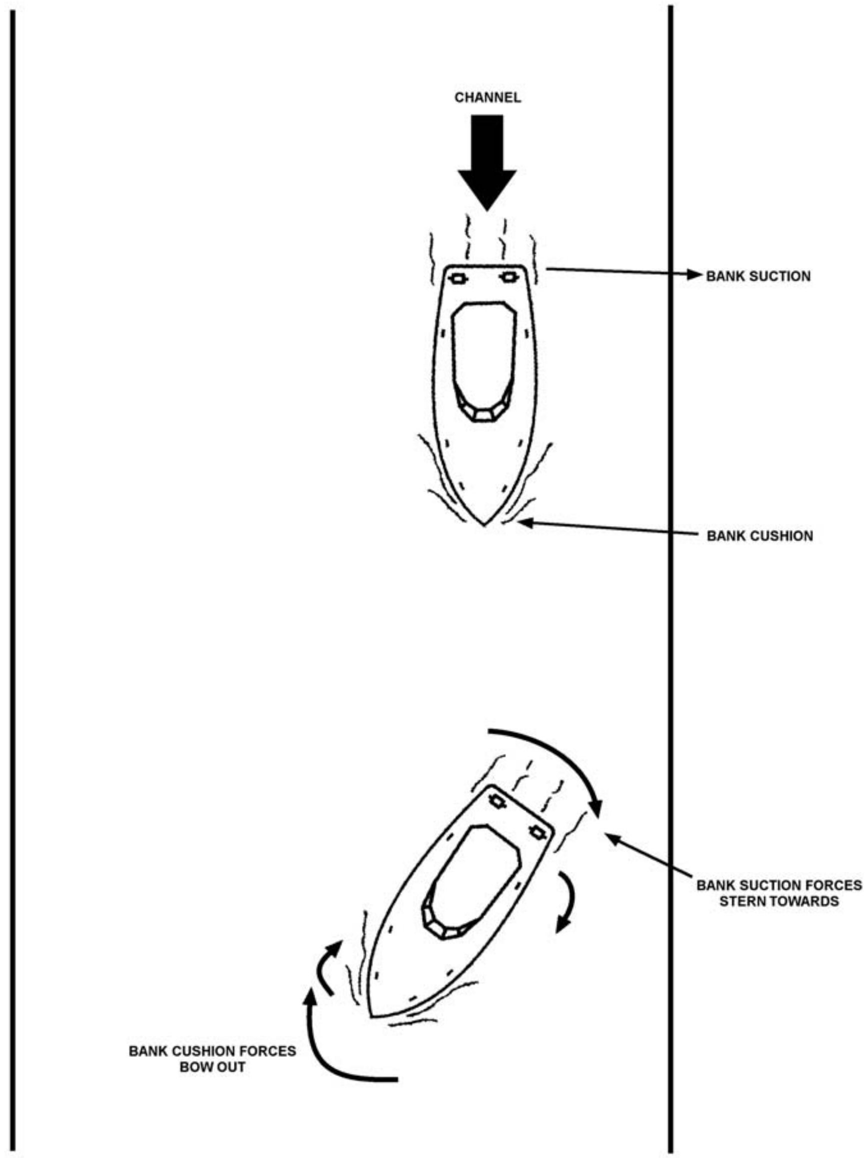


Figure 10-23
Bank Cushion and Bank Suction Affects in a Narrow Straight Channel

G.3.a. Single-Screw Boats

A single-screw boat going at a very slow speed with its port side near the left bank may lose control if sheer occurs. Increasing speed and adding a small amount of left rudder will bring the boat under control.

G.3.b. Twin-Screw Boats

A twin-screw boat, with its port side near the left bank, usually recovers from this sheer by increasing speed on the starboard engine, and adding left rudder.

G.4. Current

Current is the horizontal flow or movement of water in a river. Maximum current occurs during runoff and/or high water and the greatest velocity is in the area of the channel. Restricted or narrow channels tend to have a venturi effect, in that rushing water squeezes into a passage and accelerates. Current in a bend will tend to flow away from the inside point (to the outside), creating eddies, counter currents, and slack water immediately past the point. This effect will build shoals at the point or inside a bend. The prudent operator will be alert to the changing current within a waterway.

G.5. Extremely Narrow Channels

In extremely narrow channels where bank cushion and bank suction are expected, the coxswain should proceed at a very slow speed, keeping near the middle of the channel and passing other boats closer than normal. In a meeting situation in a narrow channel, headway should be reduced but not enough to lose steerage. On approaching the boat, a small amount of right rudder should be applied to head slightly toward the bank. Shortly after passing the other boat, the coxswain should reverse the rudder and straighten up. A little right rudder may be needed to hold course against the bank cushion effect. Because of wash from passing boats, extreme caution should be used.

Turning in a Bend

G.6. Strengths and Weaknesses

Bank suction, bank cushion, currents and wind are factors that affect a boat's turn in a sharp bend in a narrow channel. Bank cushion and bank suction are strongest when the bank of a channel is steep. They are weakest when the edge of a channel shoals gradually and extends into a large area. Bank suction and bank cushion increase with the boat's speed. Channel currents are usually strongest in the bend with eddies or counter-currents and shoaling on the lee side of the point. Speed of the current is greater in deeper water than in shallow water.

G.7. Following Current

In a following current, the boat makes good speed with little help from the engines. When making a sharp turn with a following current, it is possible to make the following maneuvers:

- Hugging the point.
- Staying in the bend.
- Proceeding on the bend side, middle of the channel.

An experienced operator can accomplish any of the three; however, the third choice, called the "bend side, middle of the channel," is the safest, and therefore, the preferred choice.

G.7.a. Hugging the Point

The operator carries a small amount of rudder toward the near bank to steer a straight course. As the channel begins to bend and the boat moves from the bank, less rudder will be necessary. This condition is a signal that it is time to begin the turn. However, slack water or eddies may be around the bend, making it difficult to prevent a sheer toward the near bank, especially in shallow water. The current under the quarter may affect the stern, and result in an increase in sheer. (see **Figure 10-24**) To correct for this, the coxswain should apply additional power and rudder to steer back towards the center of the channel, keeping the stern in the middle of the channel.

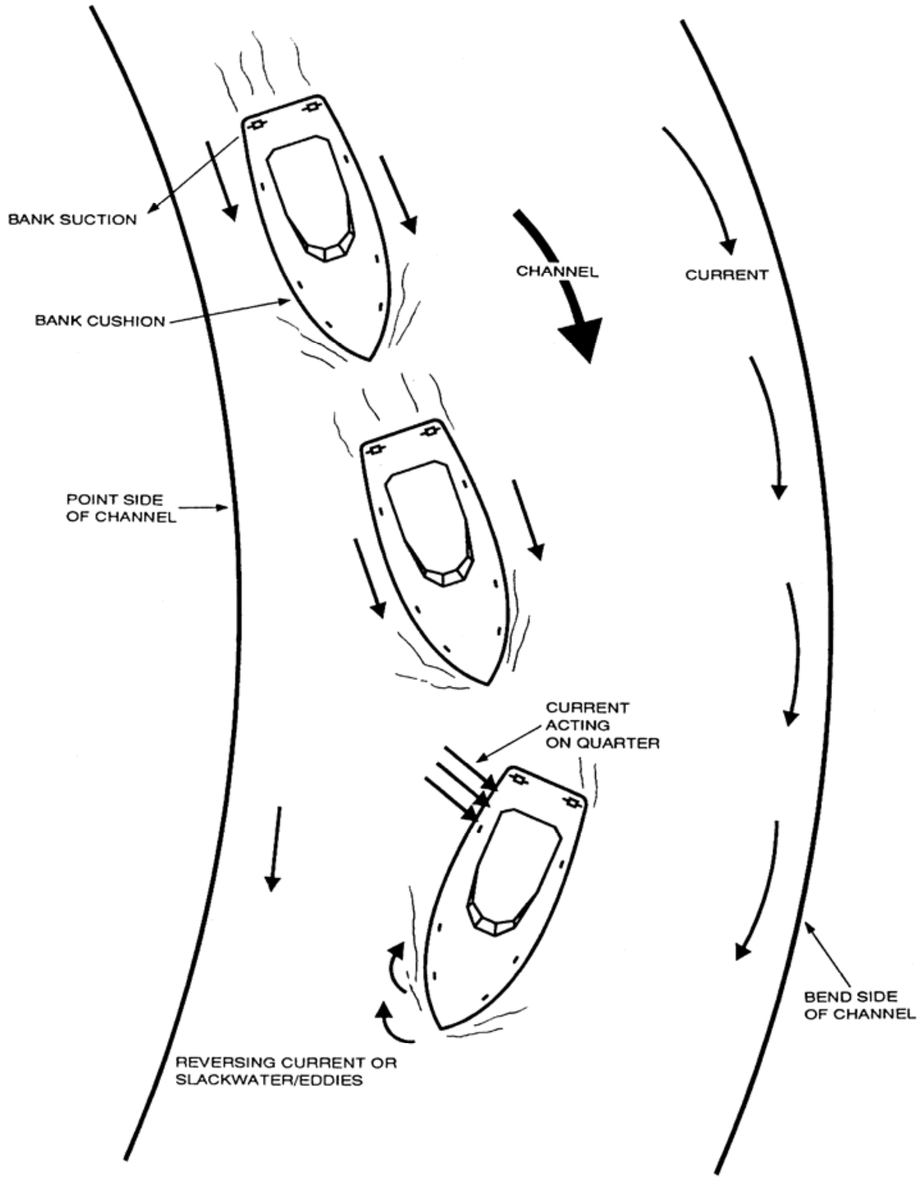


Figure 10-24
Hug the Point: Current Astern

G.7.b. Staying in the Bend

Staying in the bend is a turn in the bend away from the point that takes precise timing. If done too late, the boat may ground on the bank in the bend. If done too soon, there is extreme danger that a strong and sudden sheer will occur. The bank suction on one quarter combines with the current on the other quarter to give the boat the sheer. Also, the bank cushion under the bow will increase the sheer. (see **Figure 10-25**) Again, to correct for this situation, additional power and rudder should be applied to steer back towards the center of the channel.

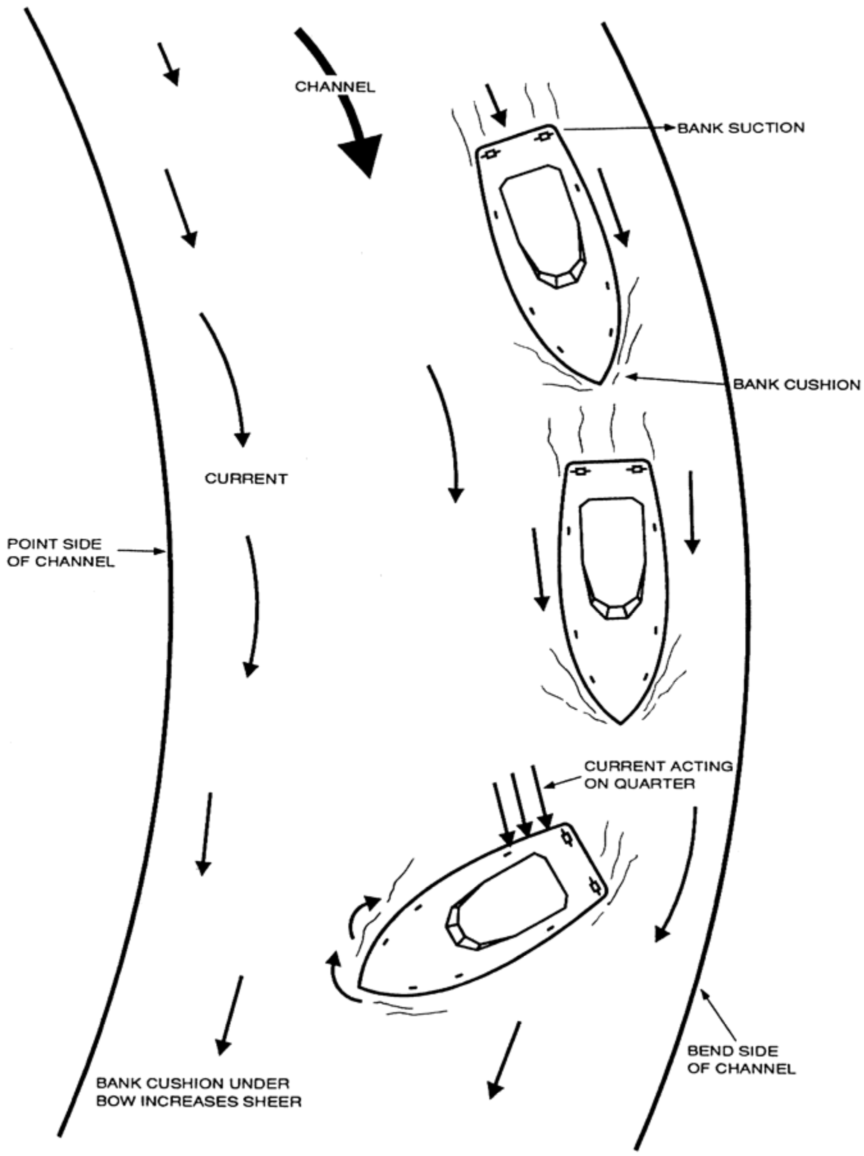


Figure 10-25
Stay in the Bend: Current Astern

G.7.c. Bend Side, Middle of the Channel

Approaching the turn steering a course toward the bend side of the middle of the channel is the safest method when the current is following. By doing this, the boat avoids any eddies under the point and the increase in currents in the bend. The operator can also use the force of the current against the quarter to help in the turn. A following current will force a boat toward the bend side; consequently, the turn should be commenced early in the bend. Additional power and rudder should be applied as needed to stay in the middle of the channel. (see **Figure 10-26**).

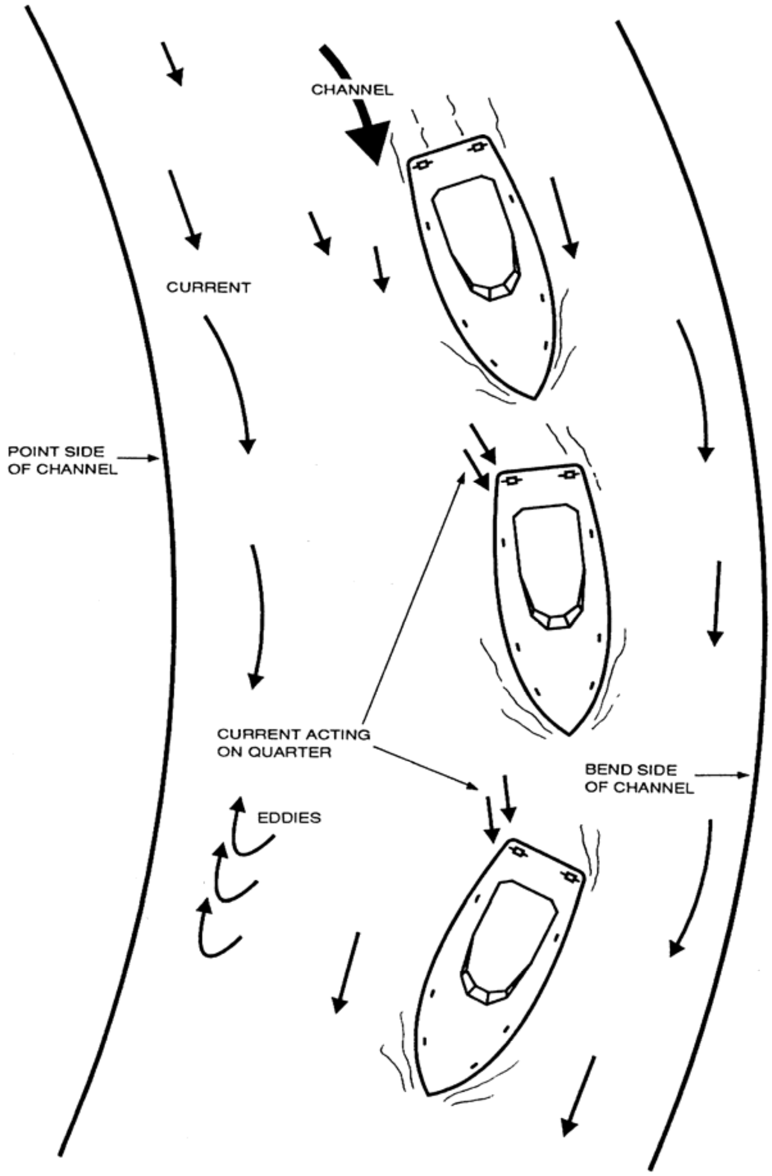


Figure 10-26
Approaching Slightly on the Bend Side, Middle of the Channel: Current Astern

G.7.d. Head Current

It is always easier to pilot the vessel into the current rather than have the current off the stern. When making a turn into a head current, the coxswain should apply power and rudder as needed to stay in the middle of the channel. Caution should be used when starting a turn. If started too soon, the head current could catch the bow and force the vessel down on the point side of the channel. If this happens, the coxswain should apply power and steer back towards the center of the channel and wait until later in the bend to commence the turn. Care should be taken not to wait too long before starting the turn. If the turn is started too late, the current could catch the bow and push the vessel towards the bend side of the channel. The stern should always be kept in the middle of the channel. (see **Figure 10-27**)

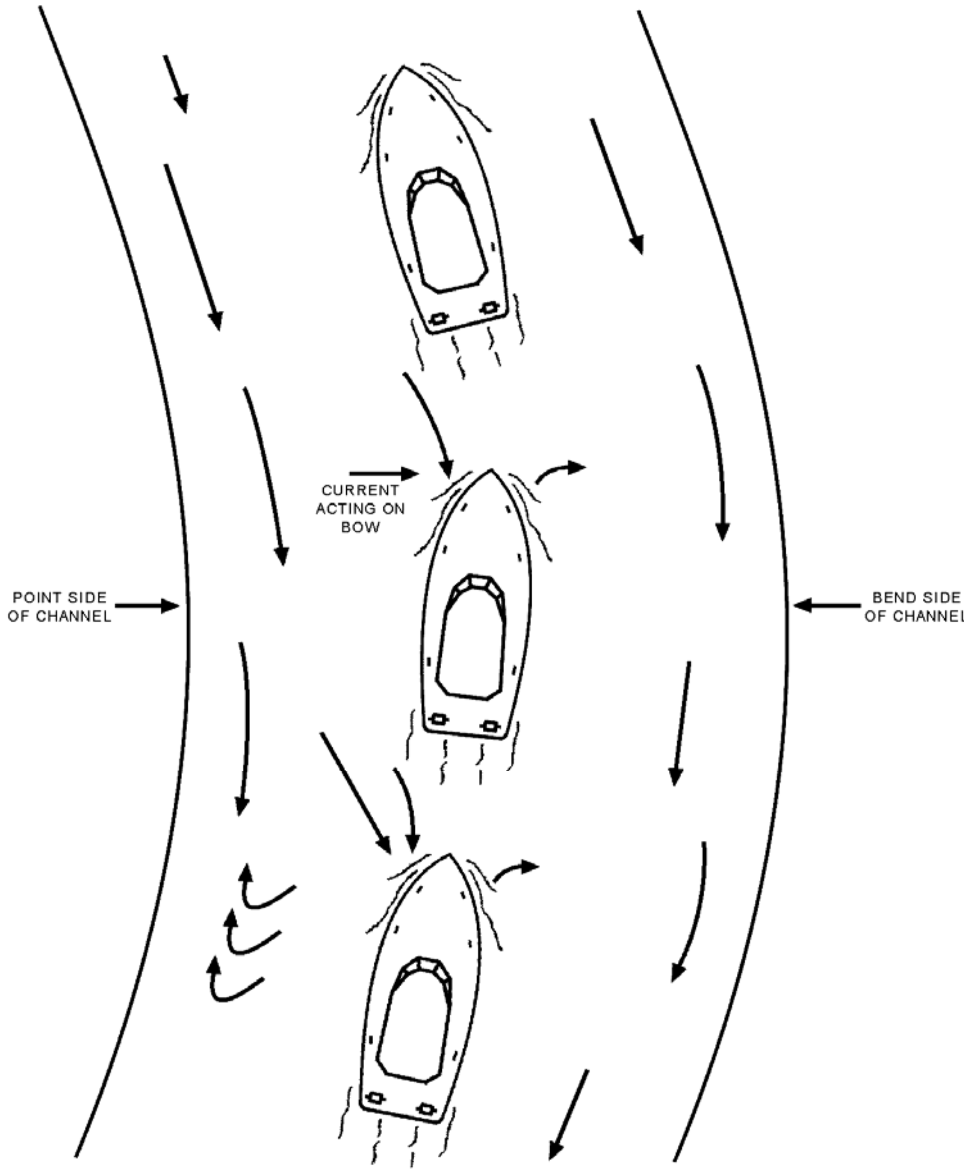


Figure 10-27
Heading into Current

Section H. Anchoring

Introduction

Anchoring must be performed correctly in order to be effective. This section discusses the techniques necessary to properly anchor a boat.

In this section

This section contains the following information:

Proper Anchoring

H.1. Elements

The basic elements of proper anchoring include:

- Proper equipment availability.
- Knowledge to use that equipment.
- Ability to select good anchoring areas.

H.2. Terms and Definitions

The anchoring system is all the gear used in conjunction with the anchor. The table below defines several of the terms used to describe the different parts of most modern types of anchors.

Term	Definition
Anchor	A device designed to engage the bottom of a waterway and through its resistance to drag maintain a vessel within a given radius.
Anchor chocks	Fittings on the deck of a vessel used to stow an anchor when it is not in use.
Bow chocks	Fittings, usually on the rail of a vessel near its stem, having jaws that serve as fairleads for anchor rodes and other lines.
Ground tackle	A general term for the anchor, anchor rodes, fittings, etc., used for securing a vessel at anchor.
Hawspipe	A cylindrical or elliptical pipe or casting in a vessel's hull through which the anchor rode runs.
Horizontal load	The horizontal force placed on an anchoring device by the vessel to which it is connected.
Mooring bitt	A post or cleat through or on the deck of a vessel used to secure an anchor rode or other line to the vessel.

Term	Definition
Rode	The line connecting an anchor with a vessel.
Scope	The ratio of the length of the anchor rode to the vertical distance from the bow chocks to the bottom (depth plus height of bow chocks above water).
Vertical load	The lifting force placed on the bow of the vessel by its anchor rode.

H.3. Reasons for Anchoring

There are many reasons to anchor; the most important is for safety. Other reasons for anchoring are:

- Engine failure.
- Need to stay outside of a breaking inlet or bar.
- To weather a storm.
- To hold position while passing gear to a disabled vessel.

H.4. Anchor Types

There are different types of anchors with specific advantages of each type. The type of anchor and size (weight) of anchor a boat uses depends upon the size of the boat. It is advisable for each boat to carry at least two anchors (see **Table 10-1**).

- A working, or service anchor should have the holding power to equal to approximately 6% of the boat's displacement.
- A storm anchor should be at least 150-200% as effective as the service anchor.

Table 10-1
Suggested Anchor Weights for Danforth Anchors

Maximum Boat Length	Working Anchor	Storm Anchor
20 feet (approx. 7 meters)	5 lbs.	12 lbs.
30 feet (approx. 10 meters)	12 lbs.	18 lbs

H.5. Danforth Anchor

Since most small boats use a Danforth type anchor because of their excellent holding strength compared to their overall weight, it is described below (see **Figure 10-28):**

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

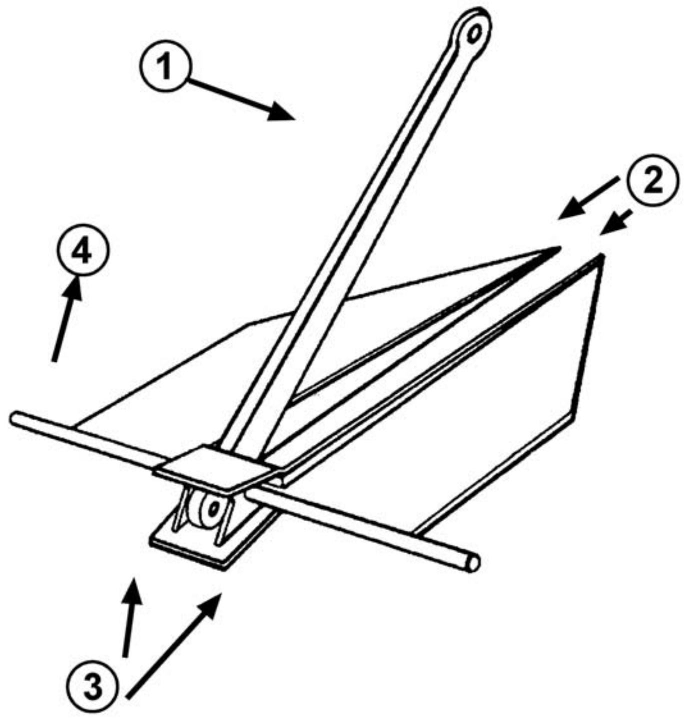


Figure 10-28
Main Parts of a Danforth Anchor

Ground Tackle

H.6. Anchor System	The complete anchor system consists of the anchor, the rode, and the various fittings connecting the rode to the anchor.
H.7. Anchor Rode	The rode is the line from the boat to the anchor and is usually made up of a length of line plus a short length of chain. Large vessels may use an all-chain rode. Each element of the system must be connected to its neighbor in a strong and dependable manner.
H.7.a. Line Type	The most commonly used line for rode is nylon. The line may be either cable laid or braided, and must be free of cuts and abrasions. Foot or fathom markers may be placed in the line to aid in paying out the proper amount of anchor rode.
H.7.b. Nylon and Chain	Chain added with the rode has several advantages: • Lowers the angle of pull (the chain tends to lie on the bottom). • Helps to prevent chafing of the line on a coral or rocky bottom. • Sand has less chance to penetrate strands of the fiber line higher up. • Sand does not stick to the chain. • Mud is easily washed off (without the chain, nylon gets very dirty in mud). The chain should be galvanized to protect against rust.

Fittings

H.8. Securing the Rode

There are various methods for securing the rode to the anchor ring. With fiber line, the preferred practice is to place an eye splice with thimble and swivel at the end of the line. If the thimble does not allow the swivel to be attached before the splice, a shackle is used to attach the swivel to the thimble. Then shackles are used to attach the swivel to one end of the chain and the other end of the chain to the anchor's shank. (see **Figure 10-29**)

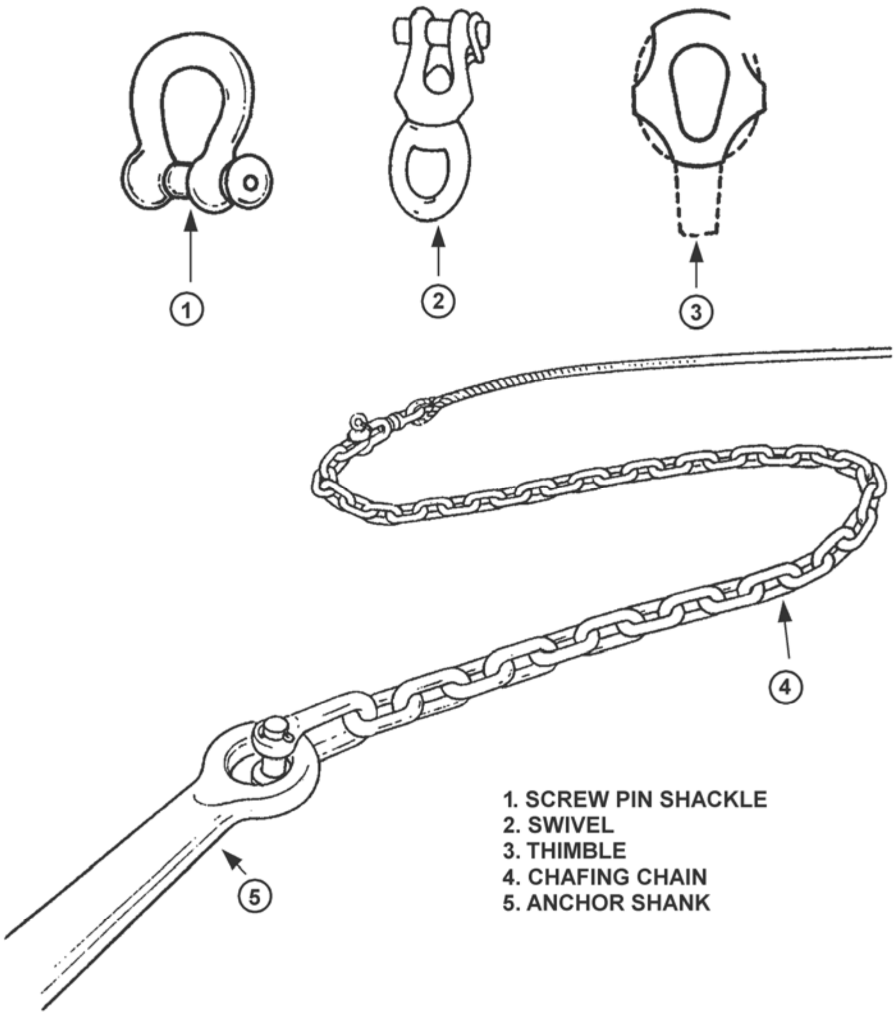


Figure 10-29
Anchor Fittings

H.9. Description

The following describes the different fittings used to connect the rode to the anchor:

Part	Description
Shackle	Bends the length of chafing chain to the shank of the anchor. Can also be used to connect other pieces of ground tackle together (swivels, thimbles, etc.).
Swivel	Allows the vessel to rotate around the anchor without twisting the line/chain.
Thimble	Protects the anchor line from chafing at the connection point. Use synthetic line thimbles for lines 2¾" in circumference (⅞" diameter) and larger.
Chafing chain	Tends to lower the angle of pull of the anchor and assists in preventing chafing of the anchor line on the bottom.
Detachable link	Attaches the anchor and associated ground tackle to the anchor line (not mandatory).
Eye splice	Used at the end of the line to permanently attach the thimble.

Anchoring Techniques

H.10. Procedure

Before the need arises, the coxswain should brief the crewmembers on procedures for anchoring.

Anchoring involves good communication between the coxswain and the crew. With noise from the engine(s) and the wind, it is difficult to hear voice communication. The coxswain should ensure a pre-arranged set of hand signals that the crew understands. Keep the signals as simple as possible.

NOTE

PFDs must be worn during the anchoring evolution.

CAUTION !

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

H.11. Precautions for Selecting Anchorage Area

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

- Check charts to ensure that the anchorage area avoids any submerged cables or other obstructions.
- If other boats are in the same area, be careful not to anchor too close to another vessel.
- Never drop within the swing area of another boat. (see **Figure 10-30**)
- Always approach the anchorage into the wind or current. (see **Figure 10-31**)

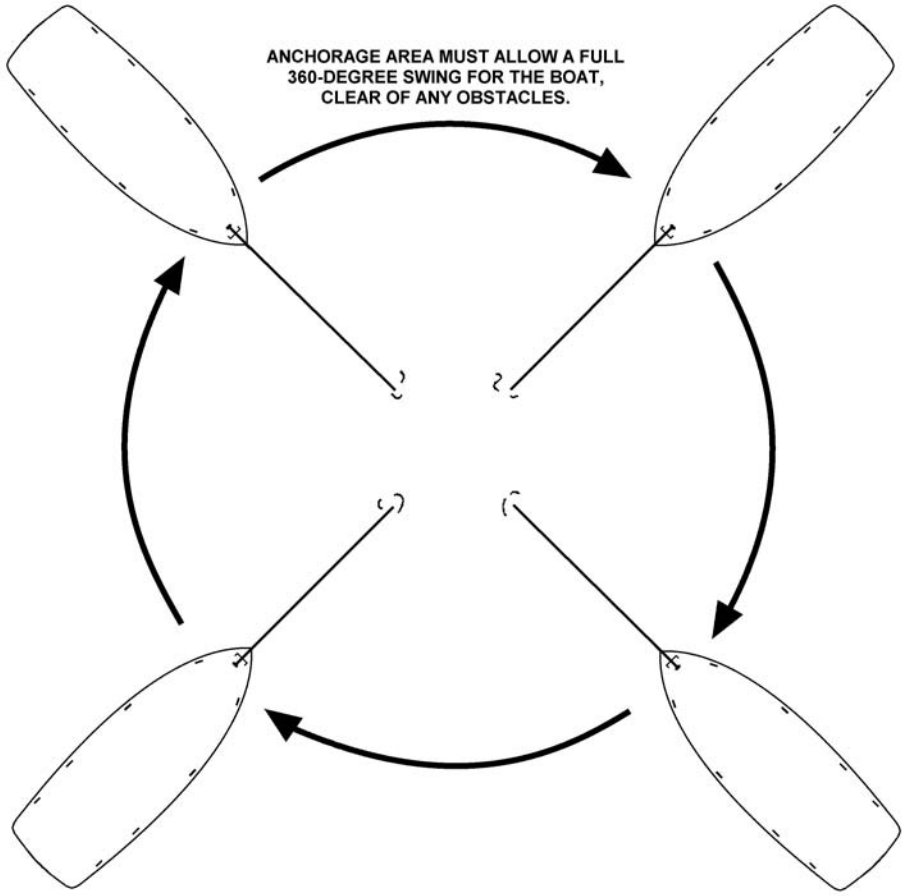


Figure 10-30
Anchorage Swing Area

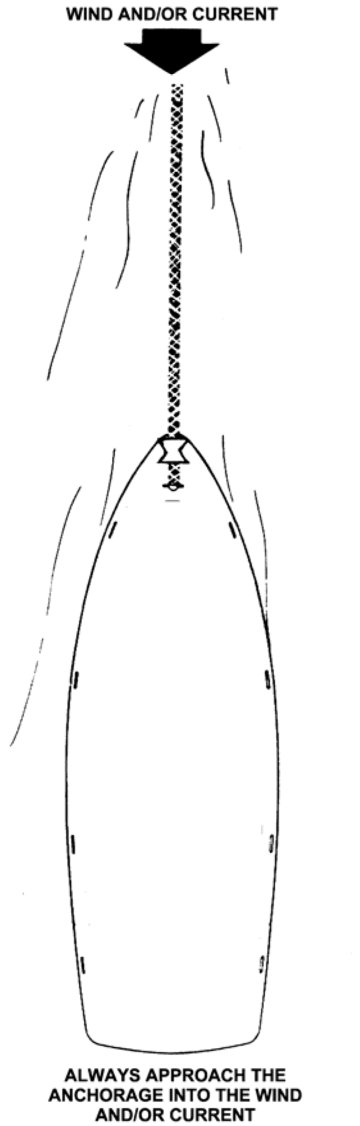


Figure 10-31
Approaching an Anchorage

H.12. Approaching the Anchorage

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

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

Type	Description
Firm sand	Excellent holding quality and is consistent.
Clay	Excellent holding quality if quite dense, and sufficiently pliable to allow good anchor engagement.
Mud	Varies greatly from sticky, which holds well, to soft or silt that has questionable holding power.
Loose sand	Fair, if the anchor engages deeply.
Rock and coral	Less desirable for holding an anchor unless the anchor becomes hooked in a crevice.
Grass	Often prevents the anchor from digging into the bottom, and so provides very questionable holding for most anchors.

H.13. Lowering the Anchor

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

NOTE

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

Step	Procedure
1	Station two persons on the forward deck (if available).
2	Haul out enough line from the locker and fake it on deck so as to run freely without kinking or fouling. If previously detached, the line must be shackled to the ring, and the stock set up (if of the stock type) and keyed.
3	On the coxswain's command, lower the anchor over the side hand-over-hand until it reaches bottom.
4	Once the anchor is on the bottom, take a working turn on the forward bitt to control how fast and how much anchor rode is released.
5	Once the desired length is paid out, make up the anchor rode to the forward bitt.

Many an anchor has been lost for failure to attach the rode properly. If anchoring for an extended period, the pin should be seized on all shackles to prevent the pin from coming out. Rodes as well, have gone with the anchor when not secured properly to the vessel.

Lightweight anchors are always ready for use and do not have to be set up, but a check should always be made to see that the shackle is properly fastened.

H.13.a. Length of Rode (Scope)

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

NOTE

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

H.13.b. Markers

Markers along the line, show the amount of rode that is out. It also helps to decide the scope necessary for good holding of the anchor.

H.14. Setting the Anchor

An anchor must be set properly if it is to yield its full holding power. The best techniques for setting an anchor will vary from type to type; only general guidelines can be given here. Experimenting will help determine the best procedures for the boat, the anchors, and the cruising waters.

Step	Procedure
1	With the anchor on the bottom and the boat backing down slowly, pay out line as the boat takes it with a turn around the bitt or cleat.
2	When the predetermined scope has been paid out, hold the line quickly and the anchor will probably get a quick bite into the bottom.
3	If the anchor becomes shod with mud or bottom grass adhering to the flukes, lift it, wash it off by dunking at the surface, and try again.

H.15. After Anchor is Set

After the anchor is set, perform the following procedures:

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

H.16. Checking the Anchor Holding

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

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

H.17. Making Fast

After the anchor has gotten a good bite and the proper scope has been paid out, the line should be made fast to the connection fitting (bitt, cleat, etc.). A check should be made to ensure the vessel is not dragging anchor before shutting off the motor. The fundamental idea in making fast is to secure in such a manner that the line can neither slip nor jam.

H.17.a. Forward Bitt

On boats with a forward bitt (sampson post), the best way to secure the anchor line is with one full round turn followed by three figure eights around the pin. The final figure eight can finish off with a weather hitch around the pin.

H.17.b. Stout Cleat

Where a stout cleat is used to make fast, a full turn is taken around the base, followed by three figure eights around the horns. The final figure eight can finish off with a weather hitch around one horn.

H.18. Anchor Watch

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

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

See *Chapter 1, Section C, Watchstanding Responsibilities* for a complete description of the anchor watch.

H.19. Weighing Anchor

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

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

H.20. Clearing a Fouled Anchor

If the anchor refuses to break free, perform the following procedures:

Step	Procedure
1	Snub the anchor line around the forward bitt or cleat and advance the boat a few feet.
2	Sometimes even this will not free the anchor, and the operator should run in a wide circle, slowly, to change the angle of pull.
3	Take extreme care to ensure the anchor line does not tangle in the screws during this operation. (see **Figure 10-32**)

Another way to break out an anchor is with a "trip line" (if one was rigged before anchoring). A trip line is a line strong enough to stand the pull of a snagged anchor (a ⅜-inch line is a typical size). Perform the following procedures if a trip line is needed:

Step	Procedure
1	Attach one end of the trip line to the crown of the anchor (some anchors have a hole for this purpose). The trip line should be long enough to reach the surface in normal anchoring waters, with allowance for tidal changes.
2	Secure the other end of the trip line to a float that can be retrieved with a boathook.
3	If the anchor does not trip in the normal manner, pick up the trip line and haul the anchor up crown first.

Besides helping recover a fouled anchor, a trip line helps determine where the anchor is on the bottom in relation to the vessel. This may help prevent other boaters from anchoring in the area as well as help make the approach back to the anchor during recovery.

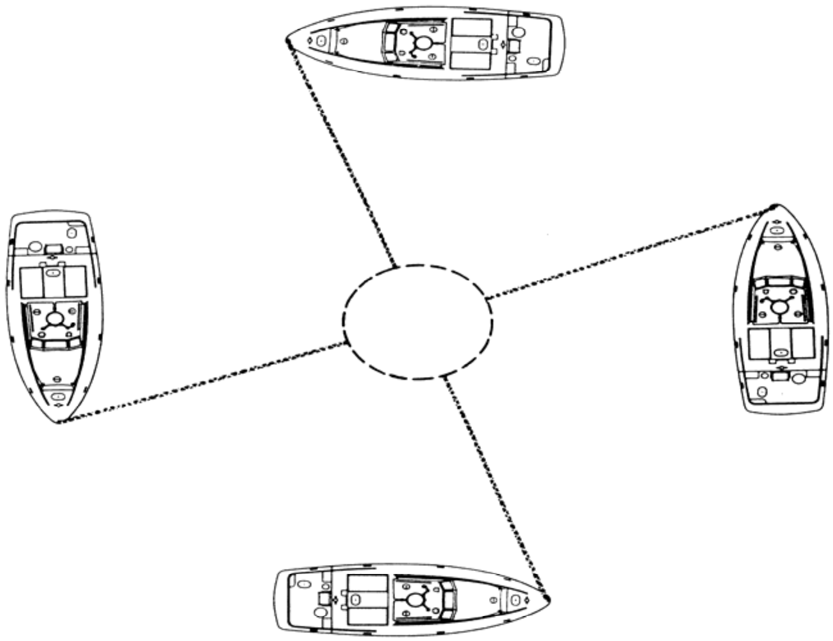


Figure 10-32
Freeing a Fouled Anchor

H.21. Cleaning the Anchor

The anchor should be cleaned before bringing it onboard, as it may have some “bottom” on it. Perform the following procedures to clean the anchor:

Step	Procedure
1	Either dunk the anchor up and down in the water or make the rode off to your connection point so that the anchor is just below the surface of the water.
2	Back down slowly and drag the anchor through the water till clean.
3	Check the condition of the equipment and, before departure from the area, be sure the anchor is adequately secured to prevent shifting and damage to the boat.

Anchor Stowage

H.22. Boat Size

Stowage of ground tackle depends upon the size of the boat. In smaller boats, it may be on deck, with the anchor secured in chocks to prevent shifting as waves cause the boat to roll. Some boats have the working anchor attached to a pulpit and the rode in a forward locker. The ground tackle should always be ready for use when the boat is underway.

H.23. Maintenance

After anchoring in salt water, ground tackle should be rinsed off with fresh water before stowing it, if possible.

- Nylon: Nylon rode dries quickly and can be stowed while damp.
- All-chain rode: If using an all-chain rode, drying on deck before stowing will help to prevent rust.
- Natural fiber: A natural fiber, like manila, must be thoroughly dried before stowage to prevent rot.

H.24. Second Anchor

Some boats carry a second anchor to use as a storm anchor. It is stowed securely, but in a readily accessible place with a rode nearby. The second anchor should be inspected from time to time to make sure it is in good condition.

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