12 BOAT HANDLING & HEAVY WEATHER

Overview

Heavy-weather handling skills rely on an appreciation of vessel performance, and on practical experience.

The widespread use of planing and semi displacement hull designs for CRV's offers many benefits in terms of overall speed, acceleration, and manoeuvrability.

It is often stated that a fast vessel can aid its crew to get out of a dangerous situation due to the vessel's potential speed of response. This is certainly true; however, this very speed of response can also get the vessel into the dangerous situation in the first place.

Any Helmsman of a fast vessel, whatever its type or role, must have good anticipation, as well as quick reactions.

CRV's are very strongly built, and the greatest danger in heavy weather is usually the potential for damage to the crew, not the vessel.

Small Vessel Design

It is important to understand how variations of design affect a vessel's handling characteristics. In general terms, yachts with fixed keels cope well in rough seas if properly handled; most will capsize only in extreme conditions, and providing all hatches remain secured, are virtually unsinkable. This is not so true of most power vessels (CRV's included): in extreme weather they are particularly vulnerable, and are subject to the possibility of swamping or capsize.

Hull Design

The hull is the main body of a vessel, consisting of a structural internal framework and its external covering. There are many different skin types but the most common are wood, fibreglass, steel, and aluminium.

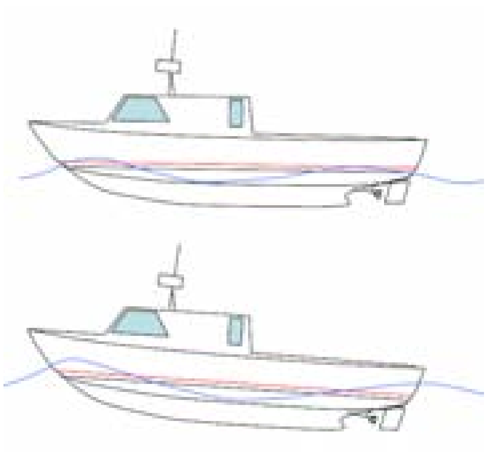
There are three basic types of hulls:

- Displacement.
- Planing.
- Semi-displacement.

Displacement Hull

As the name suggests, this hull design displaces the surrounding water. As the vessel makes way, the water parts at the bow and closes in again at the stern. When making way and as speed increases, the vessel's stern will ride lower in the water. At maximum speed, the vessel will exhibit a distinct bow and stern wave.

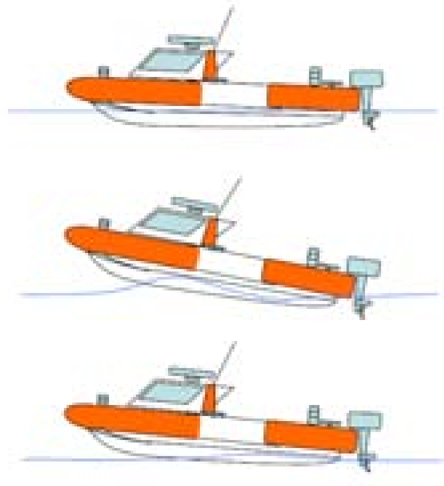
The vessel's maximum speed is determined by its underwater profile and waterline length, and is known as hull speed. When a displacement vessel reaches its maximum speed it develops a wave with a crest at the bow and at the stern. At this point the vessel cannot displace any more water as it moves forward. Care must be taken when towing a displacement vessel not to exceed this speed. (See Module Towing Techniques)



Planing Hull

At rest and slow speed, the planing hull and the displacement hull are very similar. Both displace the water around them, and a planing hull reacts in the same fashion as a displacement hull when it initially gets underway.

However, at a certain speed (dependant on the hull design), the external force of water running against the hull acts on the hull shape and causes it to lift up onto the water's surface. At planing speed only a minimal amount of the hull is in contact with the water.



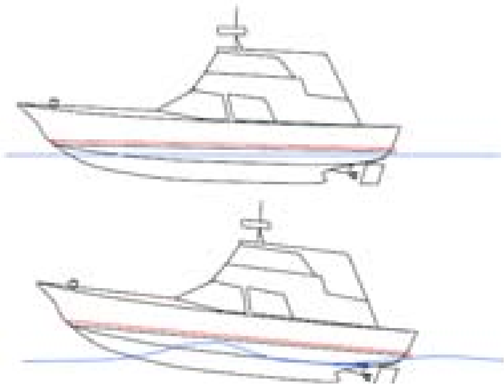
The planing hull skims over the water surface. In this state, small increases in power result in larger increases in speed.

Just as the gradual and smooth application of power is required to move from displacement to planing mode, so the reverse is true. If the power is cut suddenly, the hull will slap to the water's surface, causing rapid deceleration, and risk of injury to the crew.

Semi Displacement Hull

A semi-displacement hull is a combination of the characteristics of both displacement and planing hulls. That is, up to certain speeds the hull remains fully in the water in displacement mode. Beyond this point the hull is raised to a partial plane.

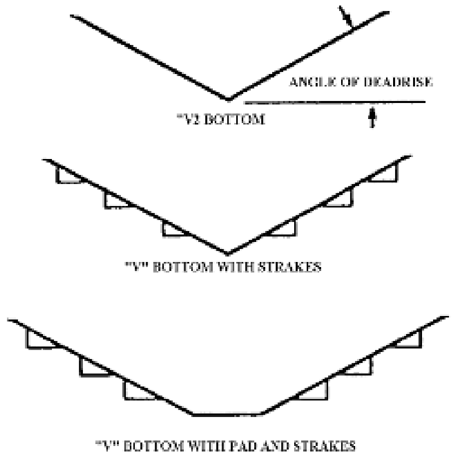
The semi-displacement hull remains in the water and never gets on top, like a planing hull does. It gives more effective responses to increased power than a displacement hull, but the vessels top speed is nowhere near that of the planing hull.



Basic Hull Forms (planing)

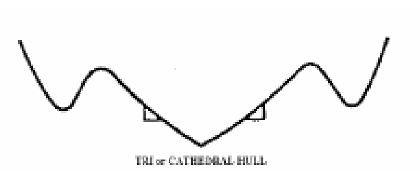
V Hull

Most CRV mono-hull designs are based on a “V” bottom hull form. The V hull generally offers good speed with a soft ride. Softness of ride and increase or decrease of speed can all be varied by the angle of the "V" (called deadrise), the use of strakes and / or the incorporation of a small flat at the very bottom called a "pad. Pads on the aft keel area allow the vessel to have certain surf board like characteristics that are, in some circumstances an advantage. The addition of these pads does however tend give a harder ride in choppy seas.



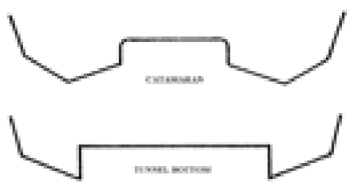
Tri-Hull and Cathedral Hull

Based on the principal of a central “V” hull, with some degree of extra V added on the outside edge of the hull (often most predominant near the bow). This hull form provides a stable platform, particularly at rest. The penalty however is a significantly rougher ride in choppy seas.



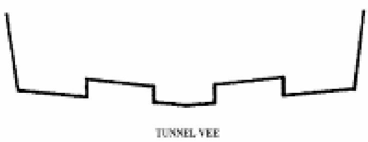
Tunnel Bottom

This design differs from the older catamaran bottom in that the inside corners (between the bottom and the tunnel) are quite sharp. This allows very tight high-speed turns, and a very soft ride. Some of these hulls have experienced handling problems at low speeds.



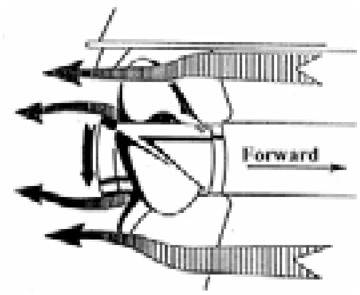
Tunnel “V”

Combines a shallow "V" bottom with twin tunnels, and provides a far higher level of top speed performance, but rough water handling characteristics are significantly reduced.

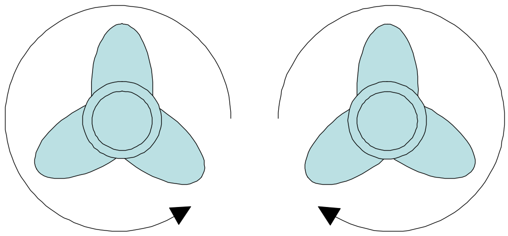


Propulsion Systems

Propeller Drive



As the propeller spins, water accelerates through it, creating a slightly smaller jet stream of higher-pressure water behind the propeller; this creates the thrust which drives the vessel forward.

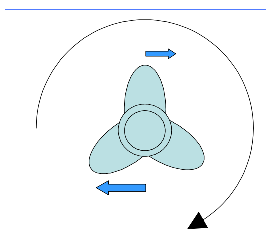


There are right-hand rotating (RH)) and left-hand rotating (LH) propellers. Most propellers on single engine vessels are RH rotation. Viewed from astern when going ahead, a right hand propeller rotates clockwise, and a left hand propeller rotates counter clockwise.

Transverse Thrust

Transverse thrust is a sideways force that is generated as a propeller rotates (also known as ‘prop walk’ or ‘paddle wheel’ effect).’

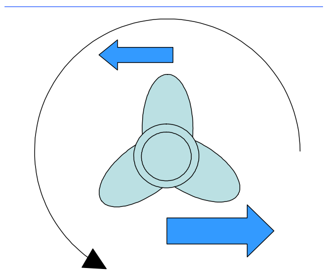
Although the propeller is designed to concentrate the water into a jet, a certain amount is thrown off sideways. When a propeller rotates, the blades at the bottom of the rotation are in water of a slightly greater pressure, this will result in slightly more sideways thrust at the bottom of the rotation compared to the top.

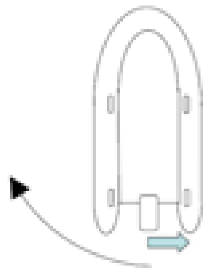


In a RH prop this will tend to turn the vessel to port when going ahead. The effect while going ahead is so small, and easily corrected by the helm that it is hardly noticed.

Every propeller will produce transverse thrust, but the effect is usually more pronounced on fixed shaft / inboard engine vessels. This is mainly because of the deeper and larger propellers, and hence greater proportional difference in water pressure between the top and bottom of the propellers blades.

In reverse the effect is far more pronounced simply because the shape of the blades are not as efficient when going astern, and more water is thrown off sideways. (Diagram below left) Single engine vessels (if they are RH props) will inevitable swing their stern to port when the engine is put astern (Below right).

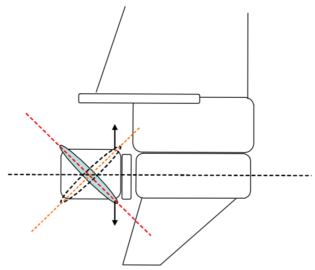




Torque (Unequal Blade Pressure)

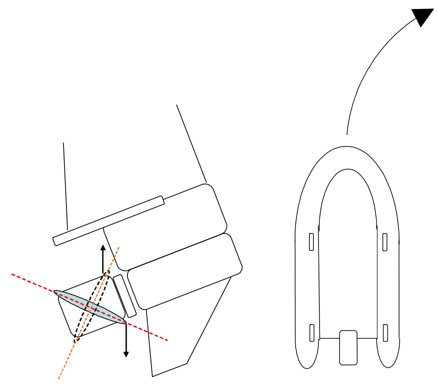
Depending on the angle of the propeller drive shaft, another form of sideways thrust can develop. This is when there is unequal blade pressure, and is of particular significance in vessels with outboard engines because of their ability to change the trim of the engines.

If the engine is trimmed in or out the angle of the propeller blades in the water will alter. In the diagram opposite a RH engine is in ahead with neutral trim. The angle at which the downward moving blades are moving through the water is equal to the angle of the upward moving blades.

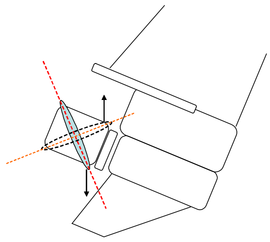


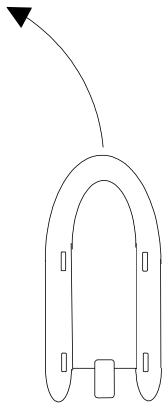
When the engine is trimmed in, the downward rotating blades angle to the water has changed. Its pitch has increased while the upward rotating blades pitch has decreased. This results in unequal blade pressure or torque. This effectively tries to twist the vessel, pulling the starboard side down.

In this case with a single RH engine the vessel will be forced to starboard.



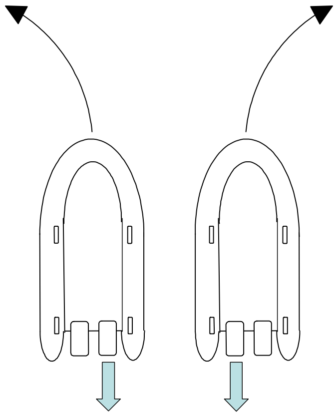
With the engine trimmed out the opposite happens and the vessel is now pushed to port.





With twin counter rotating engines this effect is cancelled out as each engine (if trimmed equally) will produce equal torque in opposing directions.

When operating with only one engine the effect can be very pronounced, so while engaged in close quarter manoeuvres it is usually preferable to have neutral trim rather than the engines trimmed in.

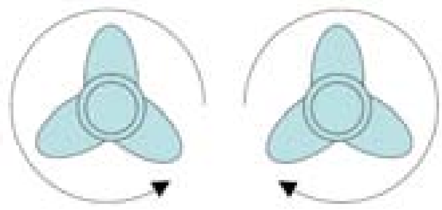


If the depth of water is such that the engines need to be trimmed out / up then at least the torque produced will help to move the vessel in the direction you would expect when using a single engine.

With engines trimmed out, going ahead on the starboard engine will produce torque that turns the vessel to port. Going ahead on the port engine will produce torque which turns the vessel to starboard. (Diagram opposite)

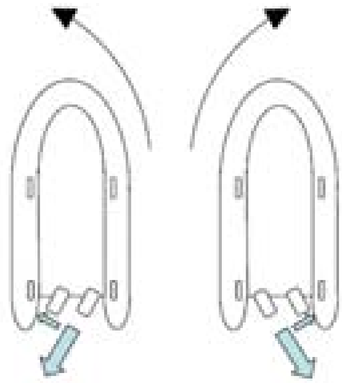
Transverse Thrust and Torque are factors to be taken into consideration when manoeuvring. Each vessel will be different, and the only way to fully understand and appreciate these effects is to experiment & practice.

Twin Engines



Vessels with twin engines will normally be counter rotating with the starboard engine RH and the port engine LH. This balances the transverse thrust from each engine and ensures it works to advantage when turning the vessel in a tight circle or in small / enclosed areas.

Turning – Using the 'Outside' Engine

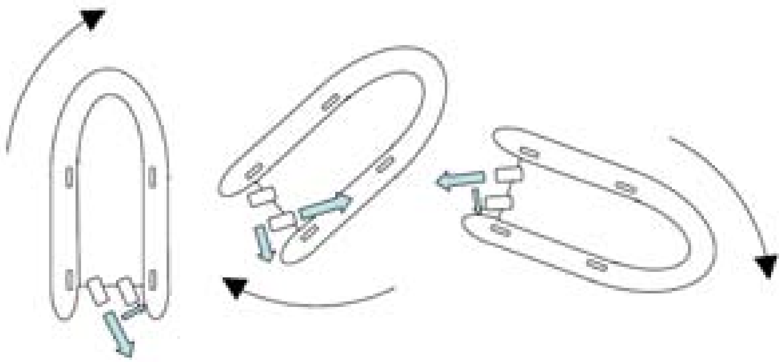


Twin engine vessels will develop a smaller turning circle by ' favouring' (increasing the throttle) or only using the engine on the outside of the turn. For manoeuvring in close quarters to other vessels / objects this is far more effective than simply turning the wheel and keeping both engines at the same throttle setting and direction of drive.

When turning while going ahead, using the outside engine the transverse thrust (although small) also helps to turn the vessel in the desired direction.

Turning – Using Alternate Engines

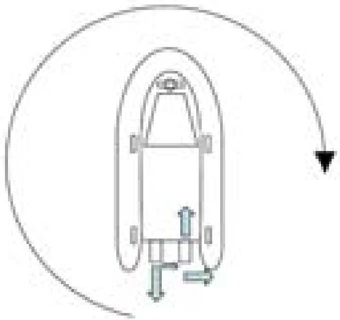
To turn in a very tight circle, the engines can be used alternatively – first in ahead then astern. In both ahead and astern, the transverse thrust is working to advantage. In the diagram below the pictures of the vessel have been separated for clarity; in reality with this method the vessel can be turned in space little more than its own length.



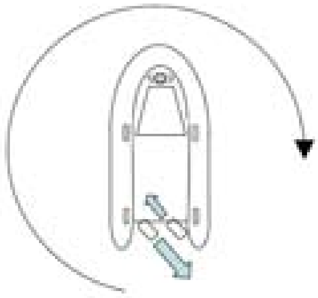
Turning – Using Both Engines (canting)

Another method is to use both engines simultaneously, one in ahead, one in astern, and the helm central. This is a slow method compared to using alternate engines and on many vessels not a very effective method either. The outboard engines are often so close to each other that they develop very little 'turning' motion.

In the diagram opposite the port engine (LH) is in ahead which produces a small amount of transverse thrust to starboard. The starboard engine is in astern also producing (far greater) transverse thrust to starboard.



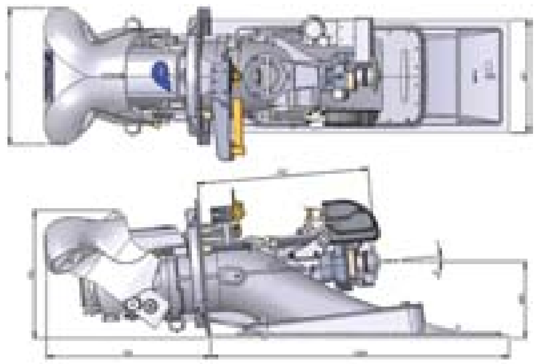
A slight variation to this method can produce a far quicker and more positive turn. This time the helm is used to turn. In the diagram opposite the helm is to starboard, starboard engine in astern, and port engine in ahead. The speed and size of turning circle can be further controlled by 'pulsing' (giving short bursts of ahead) the port engine instead of constant throttle.



Both the above methods have limited practical application. The main reason for this is in real life situations a vessel is turned / manoeuvred using the available space (in tight situations may need to use **all** the available space). Pivoting around by canting engines often leads to the vessel running out of space, because while turning the wind or tide is pushing it towards a hazard or obstruction.

Using alternate 'outside' engines and steering is generally a much more effective and flexible method to use in close quarter manoeuvres.

Jet Drive

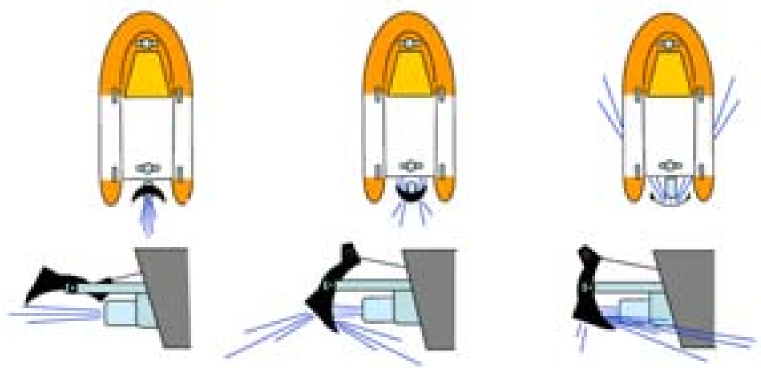


Essentially, a water jet is like an aircraft jet engine, except that it uses water not air. Water from beneath the vessel is fed through an inlet to an inboard pump (the impeller) which accelerates the water flow and then directs it to an outlet nozzle. This acceleration creates the thrust of the water jet.

Unlike propellers drives, jets do not have any form of transverse thrust or torque.

Steering is controlled by angling the outlet nozzle (or less commonly) by directional deflectors, that direct the water jet to one side or another.

- In ahead the reverse deflector or bucket (diagram below left - shaded in black) is raised to allow the jet to push the vessel forward.
- When the bucket is put in a neutral position, the jet is forced down and to each side. Ahead and astern thrust is equal, so the vessel stays in the same position (below middle).
- Astern is achieved by lowering the bucket even further, which deflects the jet forwards (below right).

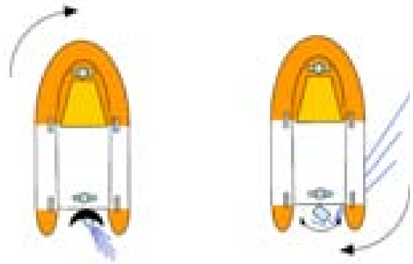


Jet drives give a high level manoeuvrability, and very quick response to any change of helm or selection of ahead / astern thrust. The engine can be running at full throttle and producing a correspondingly powerful jet of water, but with the bucket in neutral the vessel is stationary. Raising or lowering the bucket will give near instant full power in ahead or astern.

When it comes to close quarter manoeuvres, the throttle control on a jet drive is essentially adjusted to select the sensitivity of the controls, and speed at which the vessel will react and manoeuvre.

Turning

Turning a jet drive vessel while going ahead, (bucket raised) is no different to a conventional propeller drive. Turn the wheel to starboard and the jet is deflected to starboard (diagram below left).

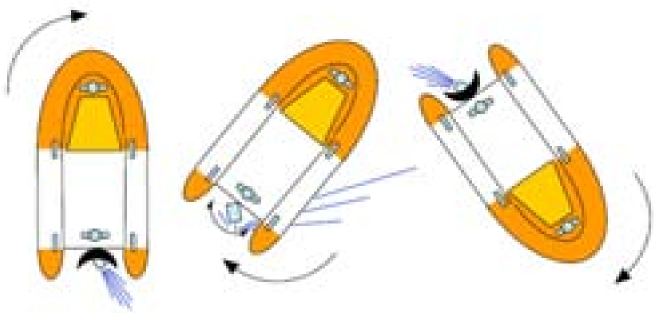


The difference with jet drives is when astern is selected. On almost all jet drives the bucket remains fixed so that it can go up and down, but it does not angle from side to side with the nozzle.

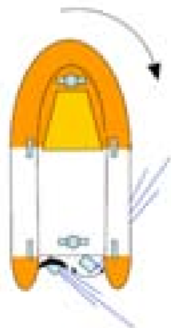
When astern is selected on the bucket, the jet is deflected in the completely opposite direction to thrust of a propeller (opposite right).

Jets drive the completely opposite way to propeller drives when in astern.

This means that for turning in a tight circle a vessel with a single jet drive can be alternately put in ahead and then astern and turned without having to adjust the steering.



For vessel with twin jets turning in a tight circle can be as simple as putting the wheel over in the direction you wish to turn and then going ahead on the 'outside' engine and astern on the 'inside' engine. With jets this can be completed far more effectively than equivalent manoeuvres using propeller drive (opposite).



Jet drives have the ability to turn very quickly, in very tight circles and can give full power in an instant. With an experienced helmsman they easily carry out manoeuvres that are extremely difficult if not impossible with most propeller drives.

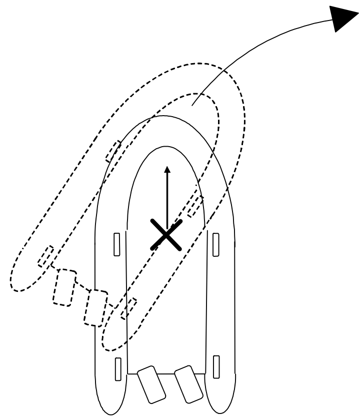
This speed of response also means that an inexperienced helmsman can get themselves into trouble very quickly.

Pivot Points

At displacement speed all vessels whether displacement, planing or semi displacement exhibit similar handling characteristics regarding their pivot point. The pivot point of any vessel is dependent on the position of the thrust from the drive units (propeller or jet) and the underwater profile of the hull (how much 'grip' it has in the water).

Going Ahead

When going ahead, a vessel has 'rear wheel steering' just like a forklift. For most propeller drive vessels the pivot is located approximately 1/3 of the vessels waterline length abaft the bow.



Jet drive vessels often have a relatively shallow draft (with no props or rudders below the hull they are very suited to operate in shallow water). They also may have a fairly shallow dead rise and very flat aft section, to allow an uninterrupted flow of water to the jet inlet. With less grip in the water their manoeuvrability is greatly increased, and their pivot point is often further aft than a comparable propeller drive vessel.

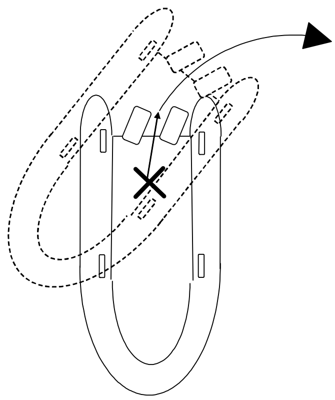
Knowing the location of the pivot point is vital in close quarter manoeuvring.

When going ahead;

- The bow cannot be turned unless there is room for the stern to move in the opposite direction.
- To move the bow sideways will usually require a larger movement of the stern in the opposite direction.

Going Astern

This time the vessel has front wheel steering, so when the vessel is in astern the pivot point moves aft. For most propeller drive vessels this is usually to a point approximately 1/3 or less of the vessels waterline length forward of the stern. For many jet drive vessels the pivot point is even further aft. As with turning while going ahead, when going astern the majority of the vessel swings in the opposite direction to the turn.



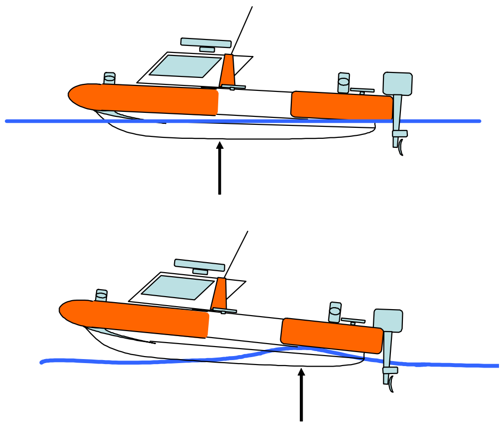
When going astern

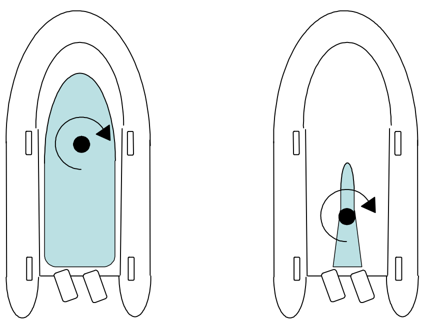
- The stern cannot be turned unless there is room for the bow to move in the opposite direction.
- To move the stern sideways will usually require a larger movement of the bow in the opposite direction.

Failure to appreciate and make allowance for the location of a vessels pivot point is one of the most common mistakes made in close quarter manoeuvres.

The pivot points (in ahead or astern) of a displacement vessel remain fixed (unless the trim and hence underwater profile is altered appreciably). The pivot point of a planing or semi displacement vessel can change considerably.

As a vessel moves from displacement to planing mode the amount of hull in contact with the water reduces and moves aft, as a result the pivot point also moves aft.





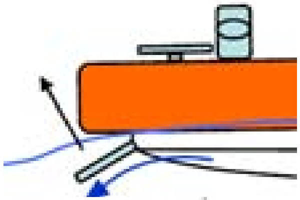
Trim

How a vessel is trimmed can have a marked effect on its handling characteristics.

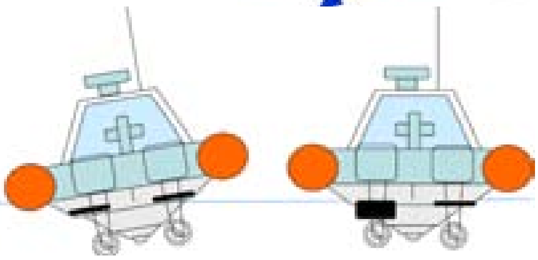
A vessel trimmed down by the bow will not be able to ride the waves in a head sea as easily, but will tend to bury the bow into the waves. It will also be more prone to broach in following seas. Broaching is where the bow buries itself in the face or trough of a wave but the momentum of the stern results in the vessel slewing sideways and ending up lying across the face of the wave. This can leave the vessel at high risk of capsize.

The trim of a displacement vessel is altered by the distribution of weights within / on the vessel and as such is not usually easily changed. Planing and semi displacement boats often have the ability to alter their trim by altering the trim of the engines, or by the use of trim tabs (picture opposite).

Trim tabs act in a similar way to horizontal rudders. When the trim tab is pushed down it directs water downwards, and the force of the water on the trim tab generates a lifting force which will raise the stern and depress the bow.

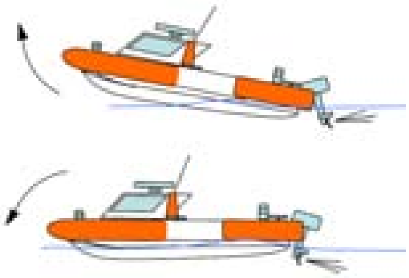


In the diagram opposite the vessel is heeled to port, by using the port trim tab only it can be brought back to an upright position.



As mentioned previously the vessels trim can also be altered by trimming the engines. Trimming the engines out will raise the bow, while trimming them in will depress the bow.

The engines can be trimmed individually to adjust the angle of heel just like trim tabs. Equally trim tabs can be used together to trim the vessels bow up or down. As a general rule engine trim would be the primary choice for altering a vessel's trim bow up / bow down, and the tabs used to correct any heel / list. .



The best general guideline as to whether a vessel is trimmed correctly is usually by the 'feel' of its steering. ***Trimmed well with a smooth flow of water around and past the hull the steering will be light and responsive. Trimmed badly and the steering will be heavy.***

Stability

A vessel has two principle types of stability, longitudinal and transverse.

Longitudinal (fore-and-aft)

- Longitudinal stability tends to keep the vessel from pitching. Poor longitudinal stability characteristics may cause discomfort because of excessive pitching and make for a very wet ride.

Transverse (athwartship)

- Transverse stability tends to keeps the vessel from capsizing. Knowledge of the transverse stability of any vessel is important in order to determine the amount of roll allowable without the danger of capsizing.

The two principle forces that affect stability are static and dynamic forces.

- Static Forces caused by placement of weight within the hull - adding weight on one side of the vessel's centreline or above its centre of gravity usually reduces stability.
- Dynamic Forces caused by actions outside the hull - wind and waves are dynamic forces.

Centre of Gravity

The centre of gravity is the point that represents the sum of all weights of, and in the vessel. In other words, the vessel acts as though all of its weight was concentrated at this point. The centre of gravity of a vessel does not move unless weight is added, subtracted, or moved.

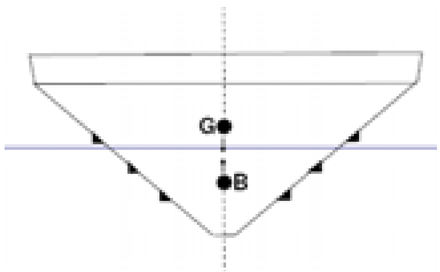
When weight is added, the centre of gravity moves toward the added weight. When the weight is removed the centre of gravity moves in the opposite direction.

Centre of Buoyancy

The force of buoyancy that keeps a vessel afloat, acts vertically upwards through the centre of buoyancy. This is the point on which all upward / vertical force is considered to act. It lies in the centre of the underwater form of the hull.

Equilibrium

When the centre of buoyancy acting vertically upwards is in line with the centre of gravity acting vertically downwards, the vessel is considered to be in equilibrium.

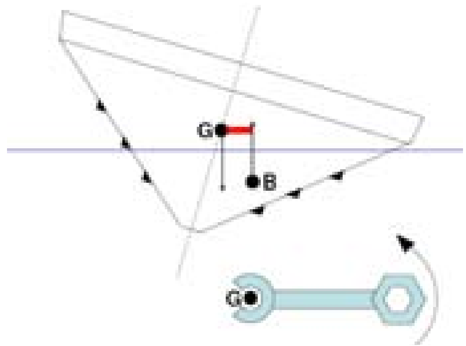


Transverse Stability

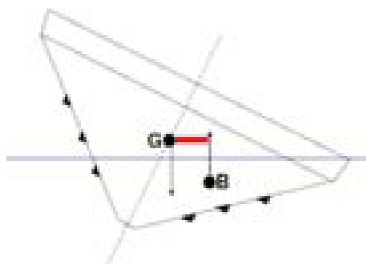
When a vessel heels, the underwater shape changes which causes the centre of buoyancy to move.

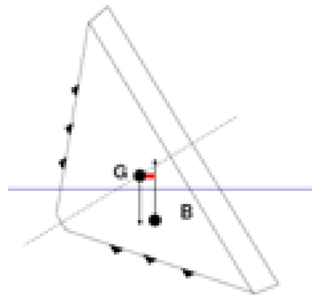
The centre of buoyancy will always move toward that part of the hull that is more deeply immersed, so that the force of buoyancy acting upwards brings the vessel back to an even keel.

This force acting to push the vessel back upright is often referred to as the righting lever (diagram opposite indicated in red). Like any lever the longer it is the more force exerted.



As the vessel continues to heel, this lever gradually increases up to a point at which the deck edge is awash (immersed). At this point the centre of buoyancy ceases to move any further from the centre of gravity. (Opposite left) Beyond this point the vessels heels righting lever begins to decrease. (Right)



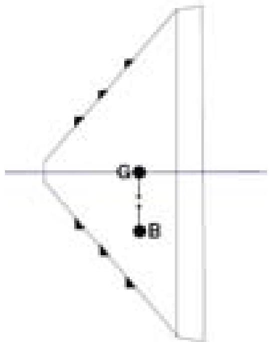


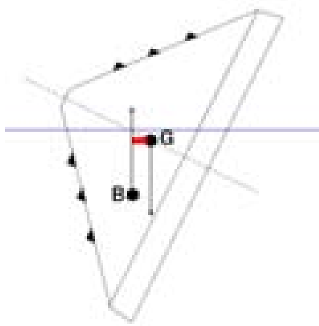
AVS (Angle of Vanishing Stability)

When the centre of gravity and centre of buoyancy are in a vertical line there is no righting lever left, and the vessel has reached the Angle of Vanishing Stability or AVS. (Below left)

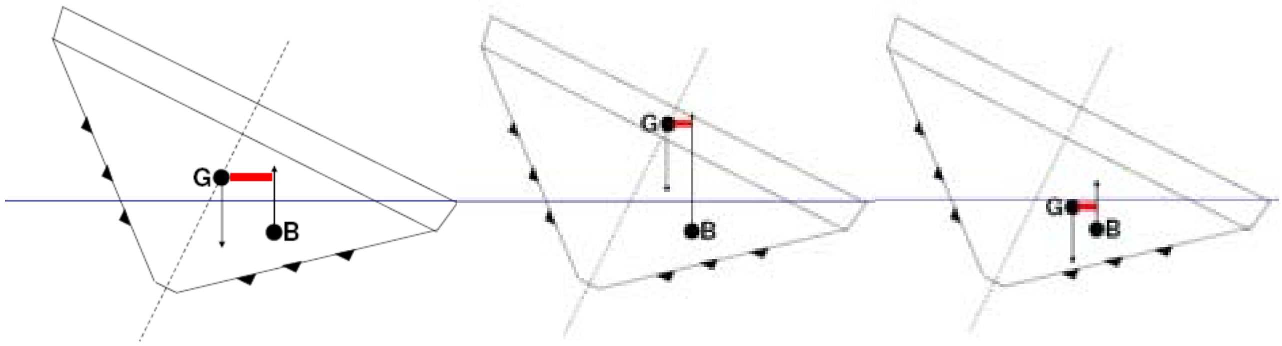
Any further movement will take the vessel beyond its AVS, producing a lever that will act to ***capsize*** the vessel not right it (opposite right).

Any weights added, subtracted, or moved will affect vessels stability.





In the diagrams below the vessel is heeled at equal angles, but if the centre of gravity is higher the righting lever is much smaller (diagram middle). If the centre of gravity were to move (due to unsecured equipment or crew), then again the righting lever is reduced, and the vessel will reach its AVS far sooner (diagram right).



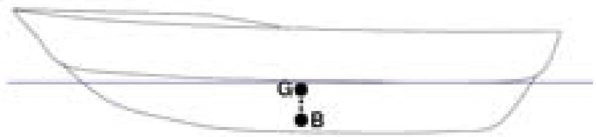
Rolling Characteristics

The rolling characteristics of a vessel depend on the hull shape. For example a round hull will roll easily since no water has to be displaced to alter the angle of the keel. For whatever type of vessel;

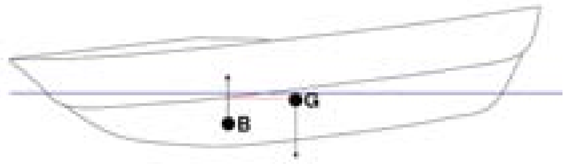
Watch the period of time required for a complete roll from side to side. The period should remain approximately the same regardless of the severity of the angle or roll.

Should the period increase appreciably or the vessel appears to hesitate at the end of the roll before coming back, the vessel is approaching or past the maximum righting lever. Immediate steps should be taken to decrease the roll by changing course, speed or both.

Longitudinal Stability



Works in the same way as transverse stability, and because vessels are usually much longer than they are wide they will have far greater longitudinal stability compared to their transverse stability.



Two of the primary characteristics affecting longitudinal stability of a vessel are the design of its bow and stern.

The Bow

The bow of a vessel must be designed with sufficient buoyancy so that it lifts with the waves and does not cut through them too easily. When a vessel is heading into a wave, the bow will initially start to cut into it. Not enough buoyancy can cause the bow to continue cutting into the wave and become immersed in it. The extra weight of the water will then shift the centre of gravity forward and further diminish the righting lever.

Vessels intended for operating in rough seas and heavy weather generally have fuller bows than those designed to operate in slight to moderate seas.

The Stern

The design of the stern is as important as the design of the bow. Ideally a vessel should possess the same type of bow and stern. For example, a full bow should be balanced by a full stern. However this is not easily possible in planing hulls as there needs to be a sharp edge between the aft section of the CRV's hull sides and the transom, to prevent water flow dissipating around the stern causing turbulence and drag.

The design of the stern is not too critical when operating in head seas; it is, however, of great importance in following seas, travelling at speeds slower than the waves, when the stern is the first part of the vessel to meet the waves. For instance, if the stern is lifted too high by following waves and the bow is fine, it may bury itself in the sea. Such a position permits the stern to pivot towards the bow. If this is not controlled it can result in the vessel broaching or pitch poling.

Weather Forecasts

A weather forecast for any given area is only an estimated average of wind speed, direction and wave / swell heights, and it must be realised that the weather that you experience locally may differ greatly from the actual forecast.

Wind Speed

Wind speed is described in multiples of 5 knots. A given wind speed implies a 10-knot range; for example, if the wind speed is forecast to be 15 knots, wind speeds between 10 and 20 knots should be expected.

Gusts can be up to 50% higher than the average wind speed, and local affects caused by valleys or hills can alter the wind speed by + / - 100%

In other words the forecast may be for 15kts, but locally the average may be 20 gusting 30kts. Coupled with the influence of a ravine or valley that accelerates the wind you might encounter an average wind speed of 40 gusting 60kts.

Wind Directions

Wind directions are again an estimated average, e.g. for the Recreational Marine forecast issued by the Met service. Wind directions given are the eight points of the compass (that is, north, northeast, east, southeast, etc)

If a forecast is for a Southerly wind (180°) then realistically the direction you might experience is between South Southwest to South Southeast, or even between Southwest to Southeast. In the recreational forecasts only changes in direction of 45 degrees or more are mentioned.

A change of up to 45° in the wind direction could have a significant bearing on what might be considered a safe route or even a safe haven for a towed vessel.

Wind direction can also be greatly affected by local terrain, and any CRV crew must be aware of local affects on wind speed and direction in their area.

Swell Heights

Swell waves are waves which have moved away from their area of generation. They may have little or no relationship to local wind conditions. Swells generated over the eastern Pacific regularly arrive on the eastern coasts of New Zealand. Thus, a part of the New Zealand coast may have little or no wind but a large swell, or winds and swells which are in opposing directions.

Swells are only included in forecasts when they are expected to be 1 metre or greater. Their direction is given as one of the eight points of the compass.

Swells are described in terms of ***significant height***. Significant height is defined as the average height, from trough to crest, of the highest third of the waves. This means that some swell or sea waves will be notably larger than the significant height. For example, if the forecast is for 4 metre swells, then the occasional 6 metre (50% +) wave should be expected, and there is a high probability that you will encounter an 8 metre (100% +) swell.

Waves

Broad, rounded waves associated with deep water and choppy waves frequently found in shallow water and confined areas of bays and inland lakes cause few problems for the well handled CRV. It is not necessarily the size of a wave that poses a danger to a vessel, but its gradient (how steep it is) or whether the wave is breaking.

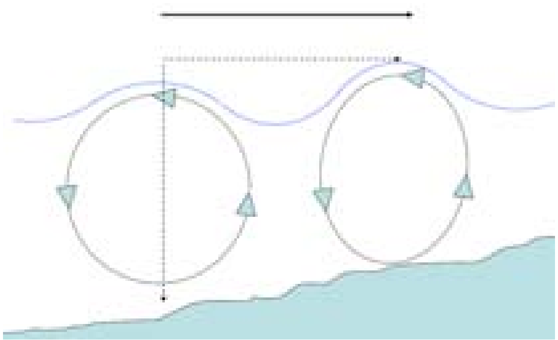
Wave Gradient

The ratio of wave height to length determines how dangerous a wave is. The steeper the gradient the more likely it is to break. The gradient of the wave also affects the ability of the vessel to safely ride up or down the wave without loosing control.

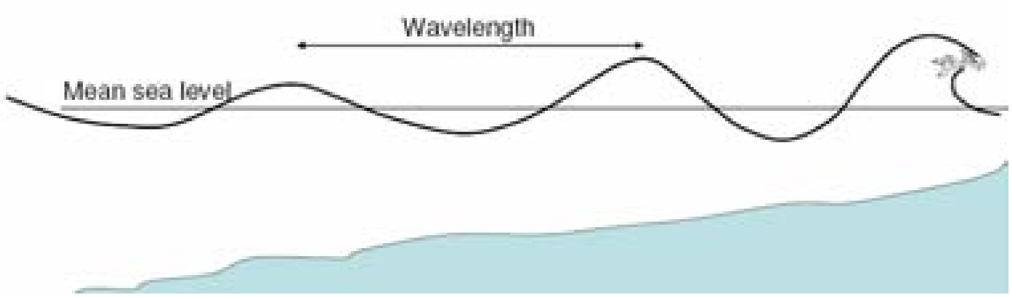
Breaking Waves

Breaking waves are the most dangerous kind of waves encountered in any small vessel operations. Sea water weighs just over 1 tonne per cubic meter, and a breaking wave has the potential to drop several tonnes onto a vessel and its crew.

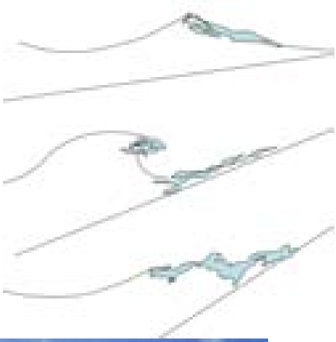
Effects of Shallow Water



In deep water waves are circular in motion, as the waves get to shallow coastal water changes take place both in speed and shape. They become shorter and steeper as they come into contact with the sea bed. This happens at a point where the water is approximately one half as deep as the wave's length. Breakers will normally form when the swells reach water that is a little deeper than their height. But waves can crest and break at a depth twice their height, if there is a strong pushing wind and if the tide is flowing against the swells.



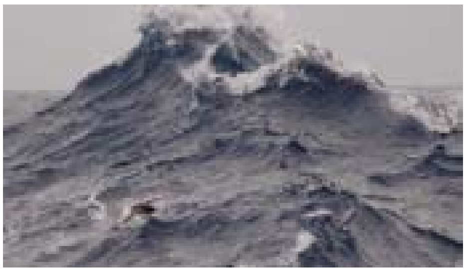
Waves breaking on the shore may exhibit quite different characteristics depending on the gradient of the shoreline.



- A shallow gradient will produce spilling breakers.
- A steeper gradient will produce plunging breakers.
- A very steep gradient will produce surging breakers.

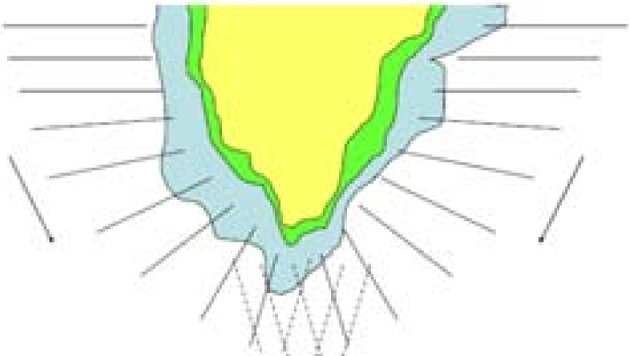
Reflected Waves

Reflected waves (for example rebounding off steep cliffs or breakwaters) can be extremely dangerous. The effect of waves from different directions meeting can produce extremely confused seas with individual waves which suddenly 'explode' upwards.



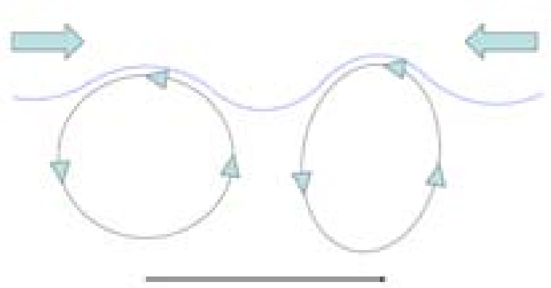
Refracted Waves

Wave patterns can be refracted or bent by land masses or shallow water. As the waves move into shallower water it will slow down. The part of the wave still in deeper water continues at the same speed. This will cause the part of the wave in shallower water to bend in towards the land. In the example below the waves either side of the land mass are being refracted inwards to meet at the end of the headland / island. This can produce similar conditions to those of reflected waves.



Tide / Current

Over falls



The gradient of a wave can be affected by the influence of tide or current. When the wind and tide / current are in the same direction the waves are to an extent flattened. With wind and tide / current in opposition the waves become steeper. This can lead to short choppy waves much higher than those formed by wind alone.

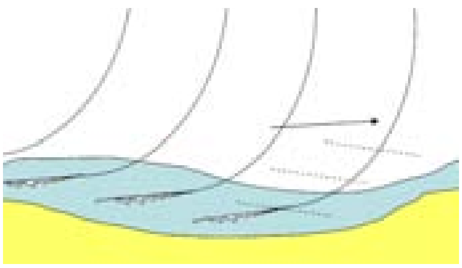
As a general guideline;

The additional wave height is equivalent to 10 knots of wind for every knot of tidal / current against the wind.

For example; the sea conditions you might expect when you have 2kts of tide against a 20kt wind may be more like the conditions normally experienced in 40 kts of wind.

This guideline is for deep open water, areas around the coast prone to strong tides such as head lands, will probably also be subject to shallow water, refraction and reflection affects. All of which can combine to produce extremely dangerous conditions. These areas are known as over falls.

Long Shore Currents



When a wave pattern is refracted due to shallow water it will often result in the waves breaking directly onto the shore, while the waves in deeper water are running at an angle or parallel to the shore. The water reflected back out to sea after breaking on shore is carried along by the wave pattern in deeper water. The result is that although the waves are breaking directly on to the shore, there is a strong movement of water along the shore line in the direction of the waves in deeper water. This is known as a Long Shore current.

Rip Currents

A rip current is where the long shore current has been deflected (by changes in the depth and contour of the sea bed) out to deeper water rather than running parallel to the shore. Rip currents will often create a deep channel in a beach. The increase in depth often results in fewer breakers within the rip. Rip currents can often be easily identifiable because of the significantly 'calmer' water.

While a rip current may present problems to a swimmer – a vessel can use it to its advantage. The reduced amount of breakers and deeper water can make a much safer area to use in approaching the shore.

Bars

A bar is an 'underwater hill' caused when silt is washed out and deposited at the entrance of a river mouth or harbour. As waves or swell move in from the sea, they meet the rising seabed causing seas to break. A strong outgoing current can also create standing waves and a confused pattern of breaking seas.

Preparation

- Before crossing any bar, it is prudent to seek advice from someone who is familiar with its current state, especially if you have any doubts about the condition or location of the best transit area.
- A visual check of the bar from any vantage point is highly recommended.
- The weather forecast and tide times will also have a bearing on likely bar conditions. High tide gives maximum water over the 'hill' which will reduce the height of any wave formation.
- The vessel should be rigged for such conditions with all moveable objects secured.

Before You Cross

- If possible, run the vessel for five to ten minutes before you cross in order to observe the bar and to ensure your motor is running without fault.
- Perform some tight turns to test the steering.
- Accelerate and decelerate to test the throttle performance.
- Approach the bar with caution and study the nature of any breaking seas. At this point you need to assess whether a bar crossing is possible, based on your knowledge of the capabilities of both your vessel and crew, and, if so, the best route to take.
- A trip report (T/R) must be made on VHF radio immediately prior to, and following a bar crossing (this applies both to going out and coming back in).
- Once you have committed your vessel to cross a bar you should not turn back. Trying to turn around will almost inevitably result in disaster.

Going Out

Use your most experienced helmsman when crossing in difficult or hazardous conditions. Initial crew training trips should only be conducted when the bar is considered safe.

- Slowly approach the bar, and then hold station for as long as it takes to get your bearings and to pick up the rhythm of the wave sets. When the window of opportunity comes, take it.
- If a big wave does unexpectedly rear up, present the vessel's bow to the wave and hit the wave at about 0 - 10° off head-on, with good throttle.
- Once through, back off the throttle so as not to power off the back of the wave. This will enable an assessment of the next and subsequent waves to be made before continuing.
- Always look and try for the lowest point of the wave and be prepared to alter course early to cross at that point. Remember the correct angle of approach.
- Be careful of applying too much throttle in the frothy residue of the breaking waves as ventilation and loss of power may occur when it is most needed.

Units based at a harbour with a bar or where crossing bars are likely should conduct extensive training in crossing bars. Dangerous bars should not be attempted in darkness.

Coming Back

- A trip report (T/R) must be made on VHF radio immediately prior to, and following a bar crossing. It is far more difficult to assess bar conditions from out at sea.
- If possible communicate with a shore base or other vessels that have recently made the return trip, to ascertain the current conditions.
- Crew should be suitably briefed for their roles which should include a stern lookout for the duration of the crossing.
- Extreme care should be exercised if towing another vessel over a bar, due to decreased manoeuvrability and speed.
- Plan ahead for the time when the return trip is not possible.

Due to the risk of broaching / capsize coming back in is usually far more hazardous than going out.

Preparation for Heavy Weather

If you are knowingly heading out to seas expected to be rough, a few additional checks should be made beforehand to ensure that your vessel is primed for the experience:

- Weights in a boat should be stowed uniformly on both sides of the hull, and stowed as low as possible to keep the centre of gravity low.
- All loose items must be securely lashed.
- Fuel and water tanks should ideally be topped up to minimise ‘free surface’ effect, as liquids moving within a tank can dramatically alter the centre of gravity.
- All hatches and anchors should be secured.

CRV Handling in Heavy Weather

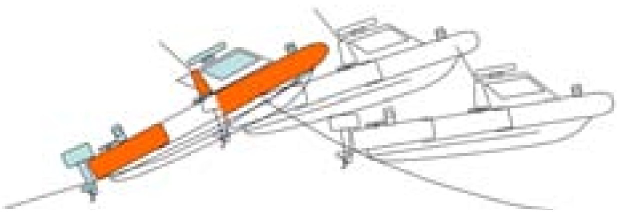
The following text applies equally to a planing or semi displacement vessel.

Head Seas

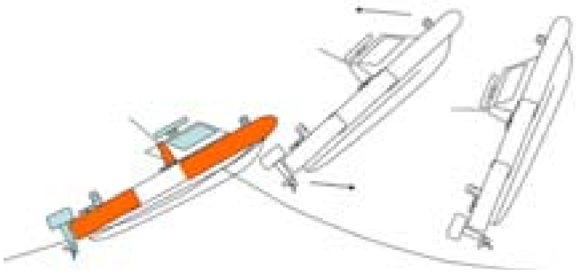
The helmsman should present the CRV to oncoming waves at a speed which allows the vessel to maintain a slight bow up angle. This ensures that after passing the crest of the wave, the CRV after possibly jumping partially or completely out of the water, will land in a relatively comfortable manner, and also in the best position for the next wave. The vessel should be driven so that it maintains an upright position at all times with no tendency to land on either of its shoulders or its side. It must be stressed that the speed of the vessel is critical and the correct speed required may vary greatly according to the circumstances and sea state.

Slight to moderate conditions generally present few problems to a CRV. Good speed can be maintained without the vessels head being thrown up and jumping occurring. In such conditions the helmsman should maintain a speed which allows the vessel to keep contact with the water surface and does not induce jumping.

In more adverse conditions, it may be impossible for the helmsman to prevent jumping when travelling at speed, but a good angle of re-entry should be aimed for. Ideally, this angle should not exceed approx 30°off the horizontal.

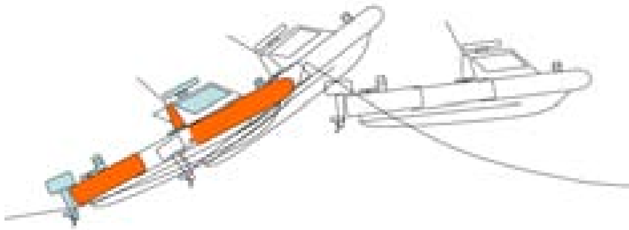


It is normally high winds with broken seas that cause most concern. In such conditions, the helmsman must ensure that the vessel's bow does not rear up too violently. The danger is that the CRV jumps the top of the wave at such an angle that the windage on the hull and the weight (and hence momentum) of the engines combine to push the CRV into a vertical or near vertical position with disastrous consequences on landing.



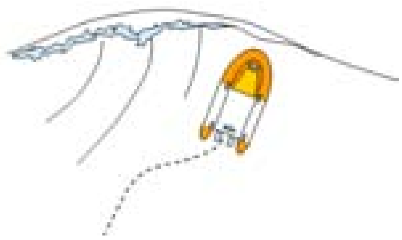
If the CRV does become airborne **do not throttle back**, the vessel will just slam into the trough even harder. Keeping the power on will also help to prevent water being forced back up the exhaust and stalling the engine(s).

When a CRV is presented to a wave which has a curling, unbroken crest, it is essential that it is given enough speed and power to break through this wave, but not with so much speed as to cause a very steep angle of re-entry. It is also important to accelerate into the crest at the right time to bring the bow up; if the bow is allowed to drop and then accelerated into the sea it is possible for it to dig in as the curling water passes over the bow. The vessel may easily get caught up in the wave and either be held stationary or even be dragged along inside the wave.



The most direct course to the destination may not be the best course to follow (diagram opposite). Angling the CRV to the line of the waves has the effect of lengthening the distance between crests. This can produce a much more comfortable ride.

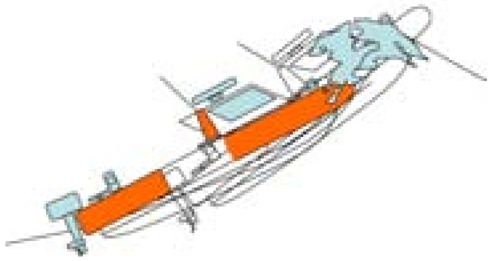
Every effort must be made to anticipate and react to the on coming waves. Wherever possible the CRV should be steered to the low side of the breaking sea, thereby protecting the vessel from the full hazard of the wave (diagram opposite).



The most dangerous type of wave that may have to be negotiated is a heavy, breaking sea. This occurs when a large, curling unbroken crest forms, then becomes unstable. The crest accelerates and crashes down the face of the still curling wave. These waves present an almost vertical wall of dense water with broken surf falling in front.

If the helmsman is unable to avoid the breaking wave, they must maintain enough way on the CRV to keep its bow into the wave (approximately 0 - 10 ° off head on).

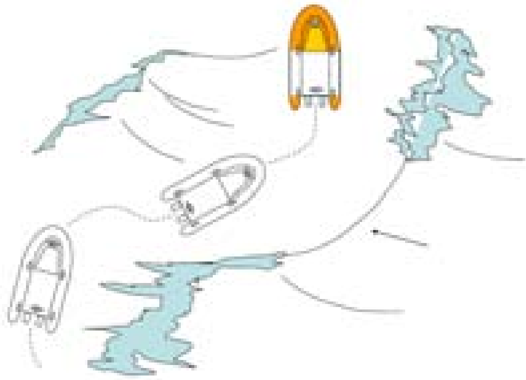
If the helmsman cannot keep the CRV head into the sea and allows it to go beyond 15 - 25° off, there is a distinct possibility of capsize occurring



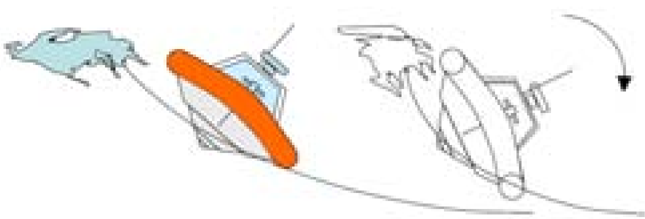
Beam Seas

The helmsman should avoid crossing the path of waves near to the face of their crests. The normal practice either is to run round the back of the bigger waves, or run clear down the face of the wave before altering back onto course.

If crossing a line of crests, wait until a wave to windward breaks, and then drive through the smooth patch left by the broken wave. The helmsman must judge the speed and formation of the waves, and then adjust the speed and course of the CRV to best advantage.



If the CRV starts to take a list away from the wave face either immediately turn to run directly before the wave or turn directly into the wave. Under no circumstance must the helmsman allow the CRV to maintain a list down the face of the wave, as very rapidly the vessel will dip its deck edge, which may lead to capsize.

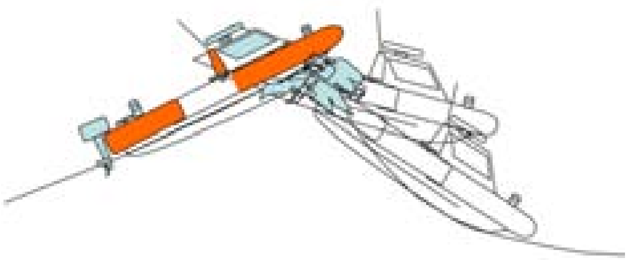


Following Seas

Oceanographic studies have shown that normal maximum wave speed in gale to storm conditions is approximately 24 knots. This is for open water, and closer to the coast the waves will slow down due to the shallow water affect. This means that a CRV, with speeds in excess of 30 knots, should (theoretically) be able to outrun most normal adverse sea conditions.

In slight to moderate conditions, the helmsman can maintain almost full speed, but must be careful to make sure that they allow the vessels bow to rise prior to accelerating up the back of the wave ahead. If the helmsman decides to jump the wave ahead, the re-entry point into the water may be further away than expected. Unless the helmsman has been very careful with the angle of the CRV passing over the crest; it may be presented with a flat landing or worse “stuff the bow’ into the trough or back of the wave ahead.

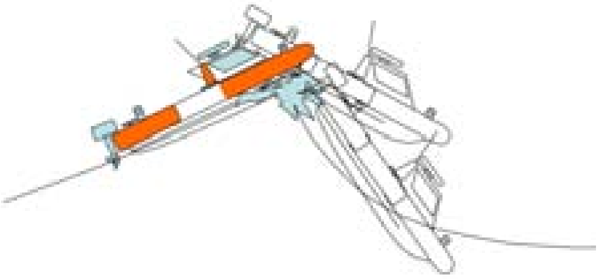
Once the wave size increases, the CRV tends only to negotiate the crest and then re-enter the water still on the face of the same wave. It now becomes necessary for the helmsman to allow the CRV to regain the correct bow up attitude before accelerating into the back of the next wave.



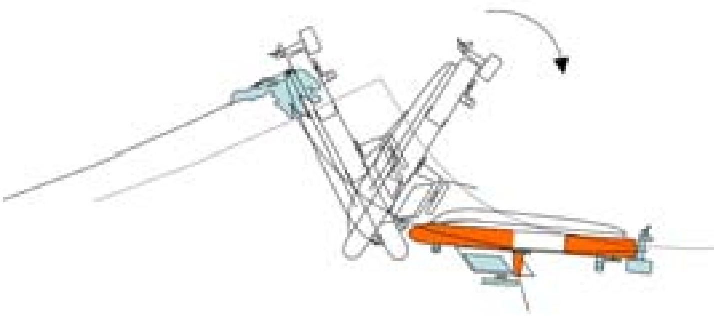
If the vessels bow is not kept at a good angle it can again “stuff its bow” - into the face of the wave just negotiated or its trough. This can be dangerous if the “stuffing” is violent enough to decelerate the CRV to the point where the crest of the wave just negotiated catches up with the now stalled vessel. This can cause a broach and subsequent capsize.

As the sea state increases it may well be too risky to attempt jumping the crest in front or even allowing the craft to be positioned close to the wave crest.

This area of water near the crest is often highly aerated, and can drastically affect the performance of the vessel. It is also possible that the wave crest may collapse, and if the CRV is positioned too near the crest, it may well fall below the 'dumping' sea.

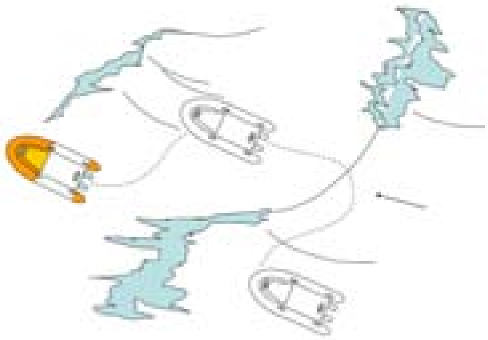


If the CRV does fall down the face of such well formed waves, it can easily be pitch poled by the sheer speed and weight of the following wave. As the vessel accelerates down the face of the crest, the bow will dig in because of the extreme angle of descent. This will act as a brake. The stern is held in the fast moving water adjacent to the wave crest and in extreme circumstances, the force of water on the stern will roll the vessel stern over bow.



It is essential that the CRV's speed and manoeuvrability are used to the full when running in heavy weather. Ideally the CRV should be positioned on the back of the wave, away from the possible area of aeration, but in front of the base of the trough.

This position allows a greater view of the surrounding area. The helmsman will vary the engine revs to allow the position to be maintained, and it is often possible to cover a considerable distance on the back of one wave before it is spent. As each wave begins to spend, the helmsman should manoeuvre the CRV diagonally across the sea to pick up another suitable wave.



Ventilation

Ventilation is when air is drawn down from the waters surface into the propellers. This results in the engine 'racing' (increased noise and apparent revs) and a sudden loss of power. Outboard engines are fitted with anti ventilation plates (picture opposite) to help prevent this, but it may still occur for the following reasons;

- Too tight a turn at speed will raise the bottom of the engine close enough to the surface to suck air into the props.
- The engines are trimmed out / up too much.
- The vessel is in aerated water (such as the disturbed water left by a broken wave.
- The engines themselves are mounted too high on the vessels transom - or the engines are not 'long' enough (props are not deep enough in the water) for the vessels design.

If ventilation occurs, ease the throttle right back to idle, pause then reapply power smoothly.

Ventilation is not the same as Cavitation (although the symptoms are very similar). Cavitation is the result of a propeller which has unsuitable pitch (angle of propeller blades) or the blades have been damaged. Either way the propeller will have to be replaced or repaired. (Refer CBES Outboard Engine Maintenance course)

Jet drives can suffer their own form of ventilation particularly when aerated water is drawn into the jet inlets.

Guidelines for Heavy Weather

The greatest skill required by any helmsman is the ability to anticipate and read the waves, assess their affect on the CRV, and make early adjustment for these factors.

The skill of a Helmsman shouldn't be judged by the amount of physical action in handling the conditions - constantly throttling engines, and adjusting the helm. It is demonstrated more by the lack of big waves the CRV is made to take, and the minimum amount of throttle and helm changes that have to be made.

- Fastest speed is not always best speed.
- The direct route is not always the fastest or safest route.
- Once you are airborne – you have no control.
- If you become airborne do not back off the throttle (slowing the engine isn't going to slow the boat down if you're in mid air)
- Ventilation - back off the throttle until it stops, and then reapply power smoothly & gradually.
- Always have power in reserve.
- Always have helm in reserve.
- Always prepare and make alterations early rather than late.

General Rules on Trim

Altering the trim of a planing or semi displacement vessel can have a huge effect on its handling characteristics. The actual angle of trim needed depends on the vessel and the sea conditions. When going into a head sea the bow should be trimmed to allow the bow to lift to oncoming waves, but not so much as to induce flying off the top of them. How much trim is needed is individual to every vessel and the conditions at the time. In a following sea the bow can usually be trimmed up far more to avoid the possibility of 'stuffing'. In a beam sea the CRV may need to alternatively turn both down and up sea, so the trim of the vessel should be a compromise between the position for head or following seas.

Following sea	***Vessel trimmed bow up the most.***
Head sea	***Vessel trimmed so bow can rise but not fly off the waves.***
Beam sea	***Vessel trimmed half way between the above***