Australian Government
Australian Maritime Safety Authority

# A guide to fishing vessel stability

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# Introduction

This guide is for all fishing vessel owners, operators and crew. It helps you to better understand the key elements and the hazards that influence a vessel's stability.

Stability refers to the ability of a vessel to return to its upright position after being heeled over by wind, waves, or other forces. If your vessel does not have sufficient stability it may capsize.

Understanding the importance of stability to your unique vessel operations and each of the factors that reduce stability will help you make the right decisions and take corrective actions to keep your crew and vessel safe.

You may also like to consider working with a qualified naval architect to prepare a stability guide specific to your vessel operations that takes into account your vessel's design, unique fishing methods and areas where you fish.

# 1 The importance of stability

The stability of your fishing vessel is something you depend on, for both your livelihood and your life.

Even if your vessel complies with all the rules, environmental factors and how you respond to them can still cause the vessel to capsize.

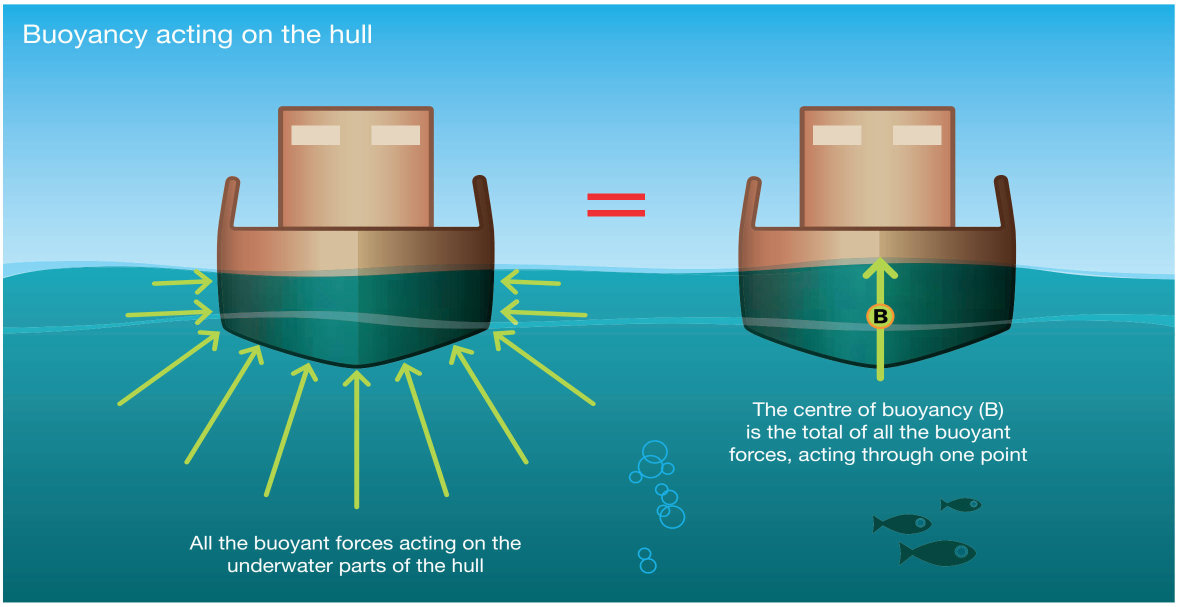
This guide will help you understand the key elements that influence vessel stability and the critical hazards that fishing vessels are exposed to.

Understanding each of the factors that reduce stability will help you make the right decisions and take the right actions to keep your vessel and crew safe.

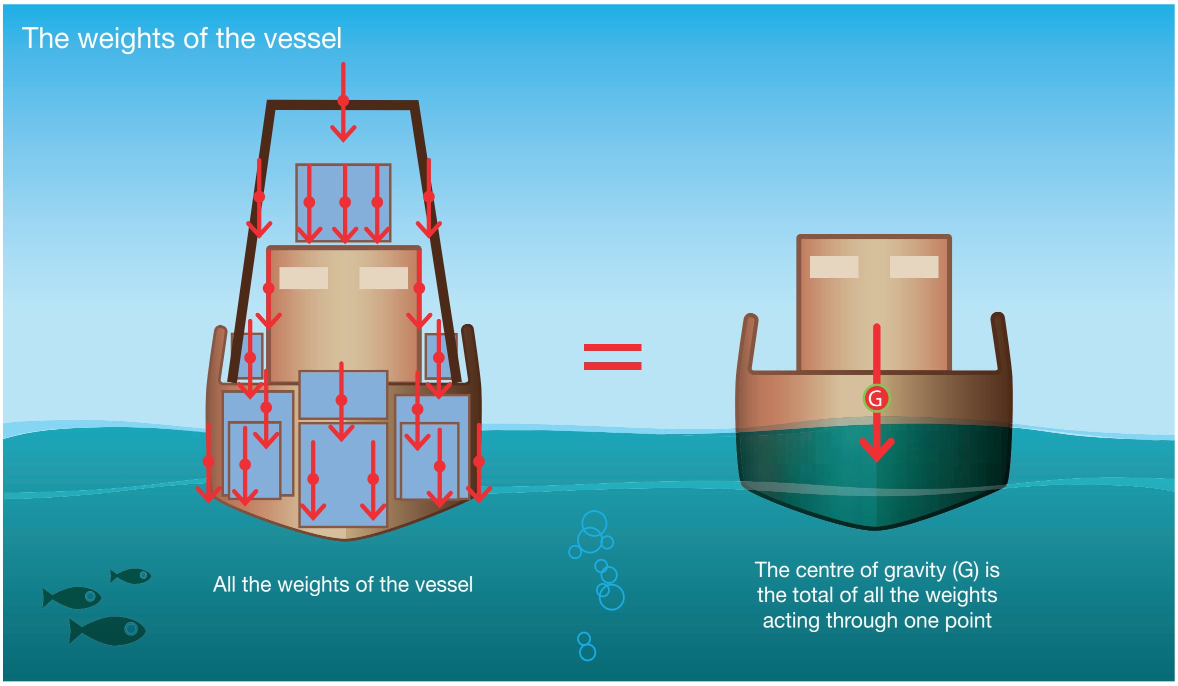
# The basics of stability: buoyancy and gravity

The buoyancy provided by the underwater parts of your vessel, coupled with the combined weight of its hull, equipment, fuel, stores and catch, determines the stability of your vessel.

## How the forces of buoyancy and weight are simplified

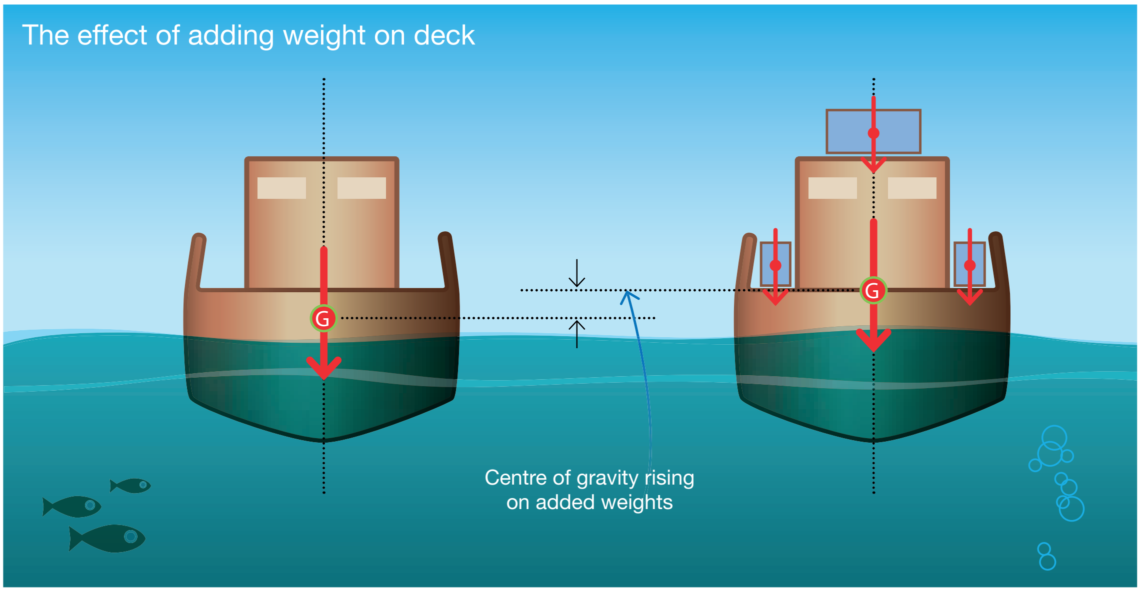



Buoyancy acts on all the underwater parts of the hull. The total of this buoyant upward force can be represented as acting through one point, the centre of buoyancy (B).




The total weight of the vessel, including all the stores, fuel, equipment and fishing gear, can be represented as acting through one point—the centre of gravity (G).

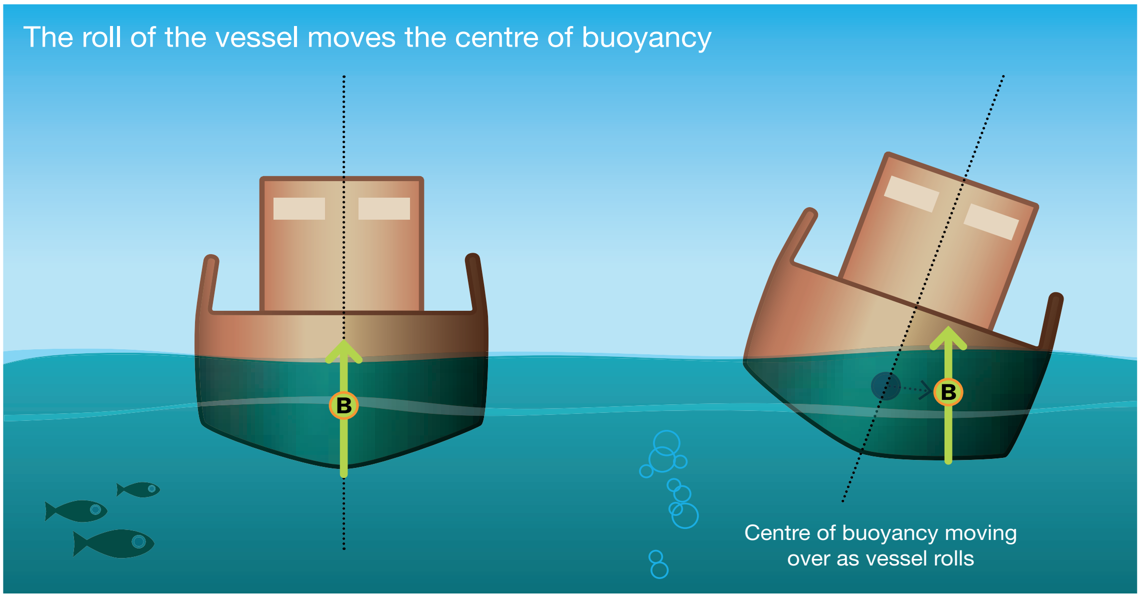
# How the centre of gravity moves




As a simple rule of thumb, the centre of gravity tends to move towards any added weights and away from any weights that are removed. If you add weight higher up on the vessel, the centre of gravity will rise and promote a top-heavy or 'soft' feeling. For example, if you add extra weight on deck or lift an object with a high derrick (crane), the centre of gravity moves up. Similarly, if you reduce weight from low in the vessel (such as using fuel from low down in the fuel tanks), the vessel will become more top heavy.

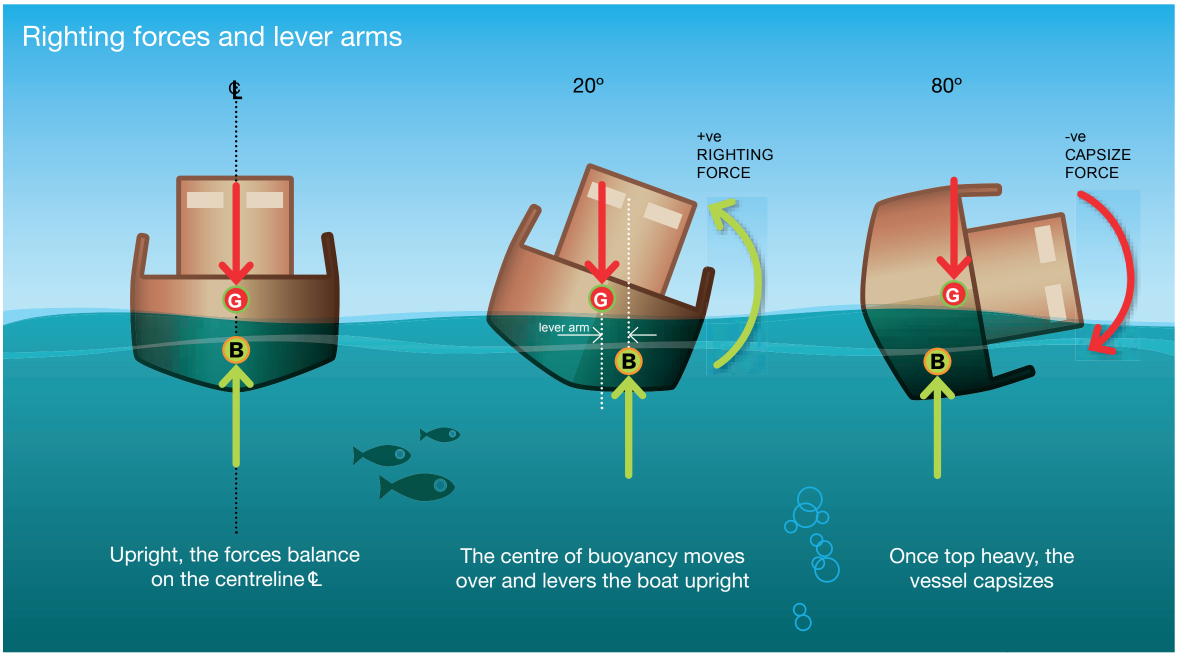
- for typical commercial fishing vessels at rest with no outside forces such as wind or waves, the center of gravity (G) is directly above the center of buoyancy (B)
- your vessel's centre of gravity moves in response to the weights you add and those you remove (or use).

# How the centre of buoyancy moves




The buoyancy force, acting through the centre of buoyancy (B), moves away from the centreline of the vessel as it rolls over on an angle. The parts of the hull entering the water add buoyant forces on one side, as those parts of the hull on the other side come out of the water. The centre of buoyancy moves to a new position towards one side of the vessel. This is where the buoyancy force will now act.

# How stability changes as a vessel rolls over




Upright in flat water, the forces at G and B balance each other on the centreline of the vessel.

When wind or a wave rolls the vessel over, the centre of buoyancy moves to one side and levers the vessel back upright. This horizontal distance, between the forces at G and B, is called the 'righting lever' (or GZ).

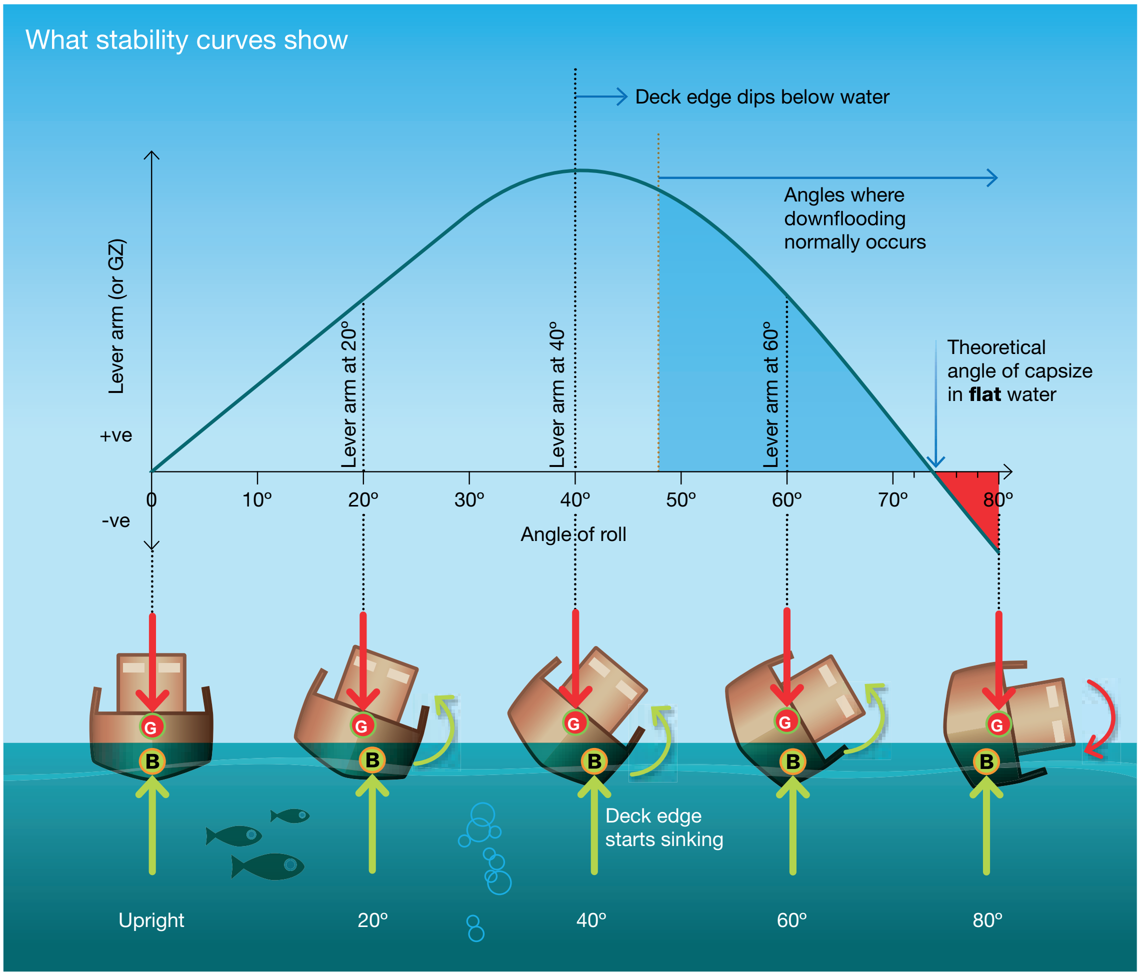
If the vessel rolls too far, the centre of buoyancy can't move over any more and the vessel becomes too top heavy and capsizes.

This tendency to capsize happens much sooner if the centre of gravity is moved higher.

As a vessel rolls, the shape of its hull limits how far the centre of buoyancy can move. The beam of the vessel's hull and the height of the deck's edge above the water determine how much buoyant force is available and how large the righting lever can be.

Normally, when the edge of the deck rolls below the water, the angle of roll with the largest possible righting lever has passed.

If the vessel gets lower in the water from loading too much weight or catch, the freeboard (the distance from the water to the deck edge) is reduced. In this condition, when the vessel then rolls, the deck edge goes underwater sooner and reduces the righting lever more quickly. The vessel will capsize sooner and at a smaller angle of roll.




The graph shown above is a stability curve, sometimes called a righting-lever curve or a GZ curve. You will find some of these for your vessel in your stability book if you have one. The small vessels that sit underneath the graph illustrate the corresponding angles of roll and how the forces acting on the vessel move.

The graph shows the righting lever arm for a stationary vessel in flat water, at increasing angles of roll. This righting lever curve will be different depending on how the ship is loaded with fuel, stores and catch.

For each angle of roll, the position of the centre of gravity and the changing position of the centre of buoyancy determine how big the righting lever (or distance GZ) is. This is what the curved line of the graph shows.

As the vessel's roll increases, the righting lever gets larger and then—beyond a certain angle—it starts reducing. Eventually the lever reduces to zero, and beyond that angle it starts working to capsize the vessel.

The area under the curve can be thought of as the 'stability safety envelope' for the vessel. The larger the area under the curve, the more stability is available. Some stability standards that apply to commercial fishing vessels specify how much area there must be under the different parts of the curve in order to verify sufficient stability.

The curve has a maximum, at the top, after which the righting lever starts reducing. For most fishing vessels, this is the angle of roll just before the edge of the deck goes underwater.

As the vessel continues to roll, taking on water or downflooding becomes likely. Once downflooding starts, through openings and hatches, stability is lost very quickly.

It is important to note that these curves are calculated for a stationary vessel in completely calm water. This snapshot does not fully represent the vessel's real dynamic stability when subject to waves, wind and operations such as lifting and trawling. Due to these ever-changing conditions, the real-life situation will have negative effects on the vessel stability compared to the assessment in calm conditions.

Stability curves are a tool and a guide. It is important to realise the limitations of the static stability assessment, especially beyond the angle of downflooding and deck edge immersion.

# 2 Stability hazards to look out for

Fishing vessel owners, operators, skippers and crew should become familiar with each of the stability hazards outlined in this section, and understand how they are caused.

Any significant hazard should be identified in the vessel's safety management system and measures should be in place to avoid or reduce their risk to the vessel and your crew.

# Modifying a vessel or installing new fishing gear

Additional new or heavier equipment installed in the vessel may be detrimental to stability and invalidate any previous stability assessment conducted.

New equipment or heavier replacements installed high in the vessel may make the motions feel more comfortable for the crew by making the roll more 'gentle'. However, this may also mean the vessel will capsize earlier and at a lower angle of heel to one side. It will also mean that less catch can safely be loaded, and that the wind and wave conditions that the vessel may capsize in will be less severe. Keeping weights as low down as possible is really important.

Any changes to a vessel's load-carrying capacity are critical to your vessel's stability safety and the reserves of buoyancy it will have at larger angles of roll. If you modify the vessel to make the fish hold bigger, the weight of a larger catch will reduce the distance from sea level to the deck edge (the vessel's freeboard). This, in turn, is likely to reduce the 'stability range' of the vessel (the vessel will capsize at a smaller angle of heel).

If you wish to install new fishing gear that is heavier (or in a higher position), or want to install a new structure on your vessel, you need to contact AMSA, your recognised organisation or accredited marine surveyor. They will help you determine how much this will affect your stability and whether adjustments need to be made or new stability calculations undertaken.


Keep an eye on how much extra weight you put on board your vessel as stores and equipment. Increases in weight take your vessel lower in the water, limiting both its range of stability and the catch you can safely carry. The slow accumulation of stores and equipment over the years can end up making a big difference to how stable your vessel is. Think about having a clean-out, and always consider carefully where you are storing heavy items.

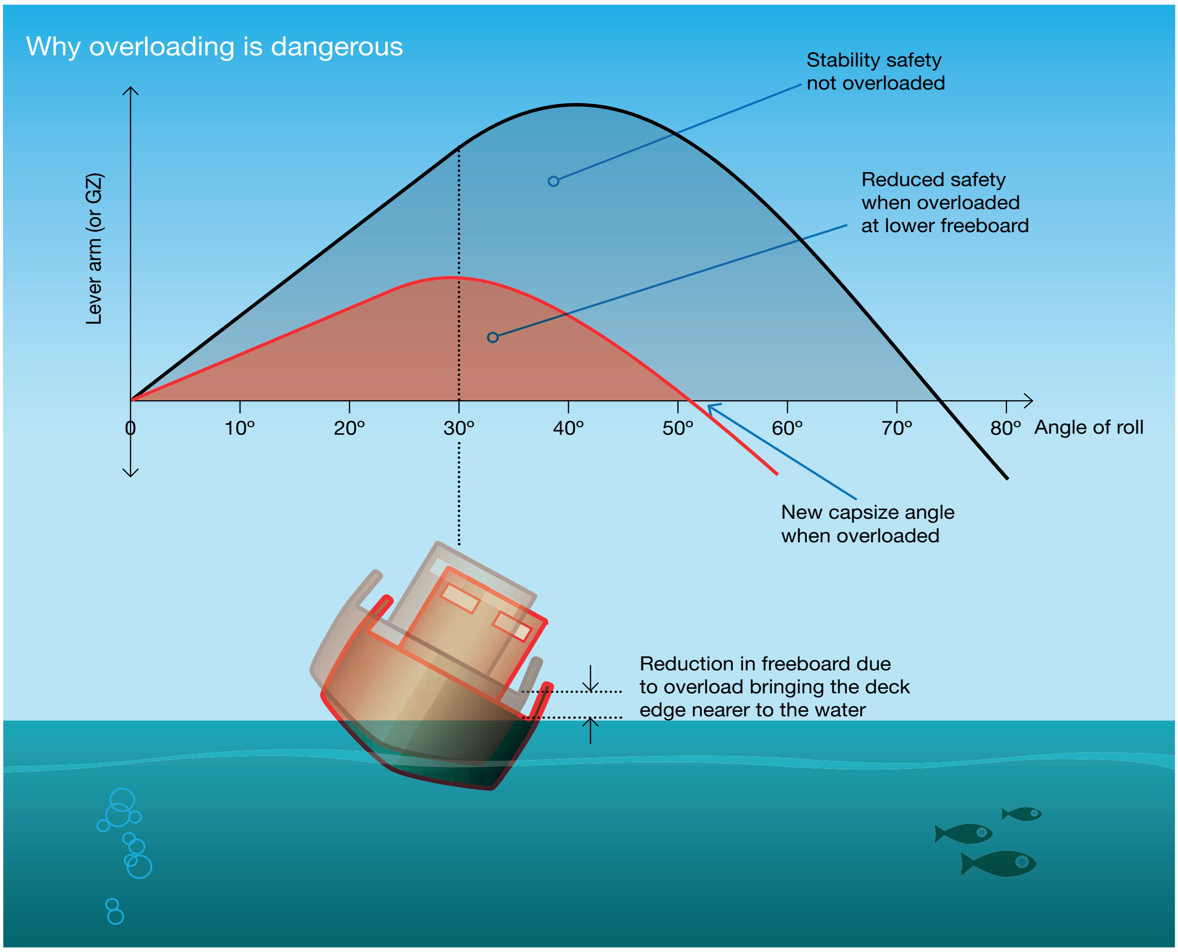
# Overloading leading to capsize

Loading too much catch in the hold, loading extra catch on the deck, or carrying too much fishing equipment will overload your vessel.

Overloading causes two dangerous stability hazards:

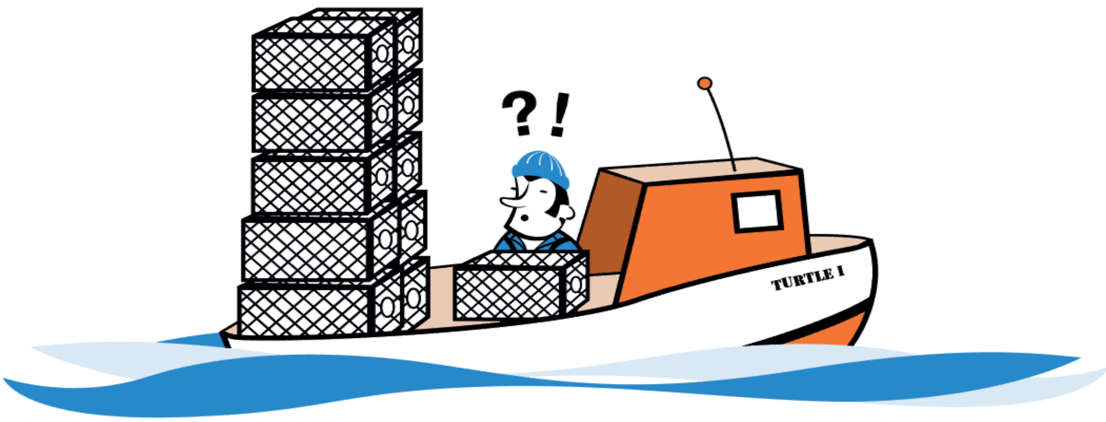
- The heavier the load in the hold, the lower the freeboard of the vessel, the nearer the water level is to the deck edge, and the more limited the range of stability becomes.
- Loading extra catch higher up on deck lowers the freeboard, and it also lifts the centre of gravity dangerously. This limits the range of stability and brings the vessel much closer to a capsize condition.

When you load too much catch in the hold, the vessel gets lower in the water and the extra weight eats into the buoyancy reserves. This means that when the vessel rolls, the deck edge is nearer to water, the stability safety is reduced and the strong righting forces are lost earlier. The vessel will capsize sooner and at lower angles of roll.



Loading too much catch on the deck has two significant negative effects. Firstly, it overloads the vessel (as described) and reduces the freeboard (and range of stability). Secondly, it lifts the average of all the weight on board (lifts the centre of gravity) and makes the vessel more top heavy. This combined effect is important to remember, as it can be dangerous and needs to be guarded against.

Overloading the vessel above decks, whilst also consuming fuel and liquids in the tanks below, can be extremely detrimental to a vessel's stability, especially when subject to rough weather conditions. Work out how much catch you can safely carry using your stability documentation, and leave plenty of safety margin for bad weather, decreasing fuel levels and, if applicable, the need to cross the bar in order to return to port. Plan your stability and don't overload the vessel, so that you can make it home safely.



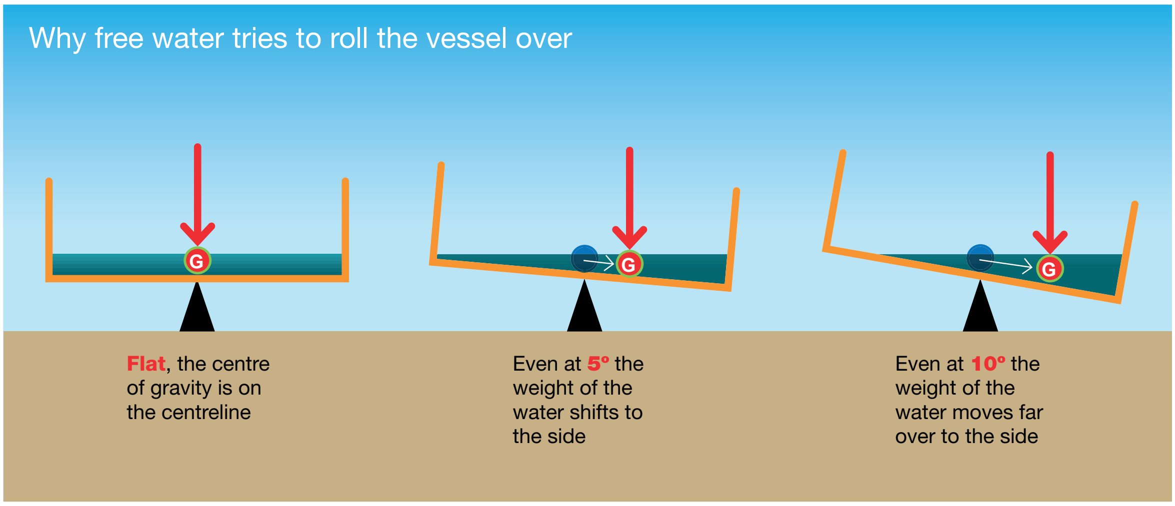

If you have a stability book, look at the 'loading conditions' prepared for your vessel. Loading conditions have been calculated for your vessel for specific amounts of fuel, stores and catch. Each scenario is designed to help you plan your trip and to highlight when the quantities of catch and/or fuel become a hazard. They should be thought of as useful guides to help you operate your vessel safely.

If your stability book is no longer current because you have installed new equipment or made modifications to your vessel, contact AMSA, a recognised organisation or accredited marine surveyor to prepare an update.

## Swamping of the deck and 'free-surface effects'

Water on deck is a serious stability hazard. A wave on deck can introduce many tonnes of water-weight and then add a strong rolling force from what are known as 'free-surface effects'. This combined effect is alarming from a stability point of view, because the extra weight drastically lowers your freeboard, the vessel's centre of gravity is raised, and then the water shifts and tries to roll the vessel over.

This is why it is critical to move water off the deck as quickly as possible. Freeing ports in the bulwark must be big enough for the task and should never be closed or blocked, especially during critical fishing operations and bad weather.




The diagram shows how the free-surface effect tries to roll the vessel over. It applies to water on deck, fuel and ballast in tanks, bilge water and melted ice in the fish holds.

- Avoid conditions where breaking waves or following seas could cause the decks to be swamped. A deck full of water is often the first stage in a capsize.
- Always keep freeing ports open while at sea and ensure they are clear of obstructions. Make sure the freeing ports comply with the standards and regulations.
- Keep all bilges and melted ice to a minimum.
- Keep fuel and ballast tanks either full or empty, to minimise the free-surface effect on board.

# Water ingress and downflooding

Accidental flooding of the vessel—through valves and leaks in the engine space or downflooding through hatches, doors and vents—can introduce a hazard that no one notices.

When taking on water in the bilges or downflooding, the vessel sinks lower in the water, which eats into its buoyancy reserves. The loose water then introduces a free-surface effect that tries to roll the vessel over.

A heavy roll or a breaking wave that results in downflooding will make the vessel less stable and multiply the problems the vessel experiences next.

Take these measures to avoid this hazard:

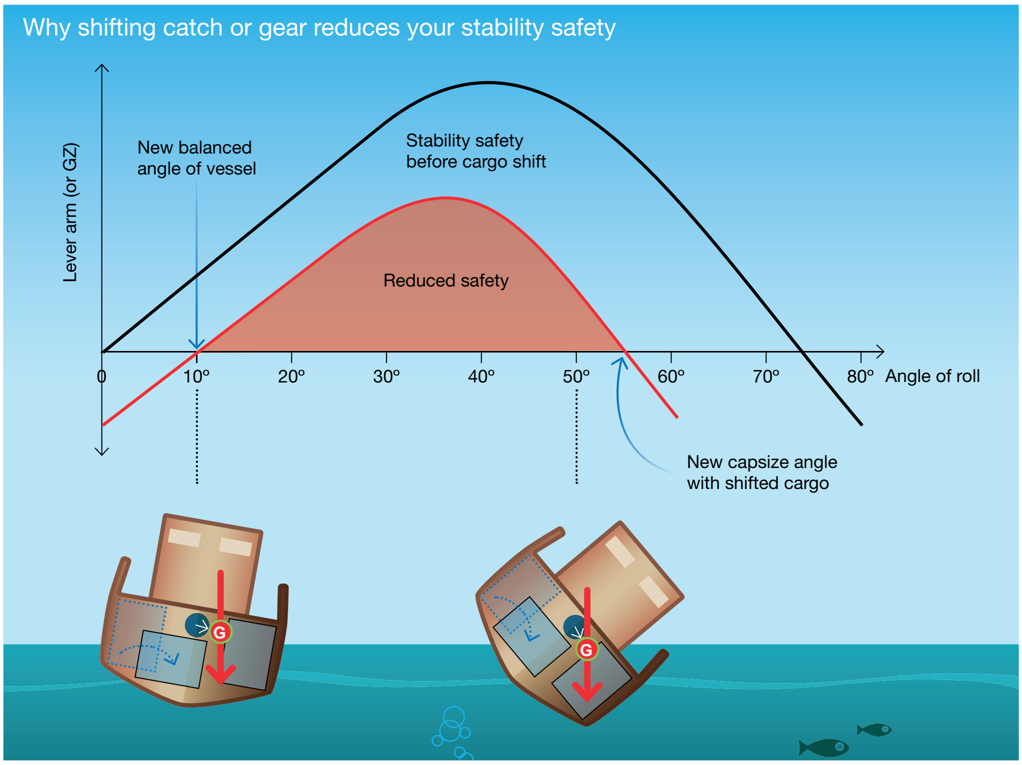
- Ensure your bilge alarms and bilge pump are working.
- Test them every trip.
- Never silence a bilge alarm without fixing the problem.
- During fishing operations, keep closed any doors and hatches that do not need to be open.
- Keep all doors and hatches free of lines, wires and obstructions.
- Ensure all hatches are fully secured and dogged down when they need to be.

# Shifting catch or fishing gear

## Shifting catch

If your catch shifts—whether it is bulk, boxed or while it is being loaded on board—it can significantly reduce your stability. It must be kept on the centreline, or balanced port and starboard. Fish in bulk can also act like water and slide with the roll to produce a free-surface effect. Secured pound boards are essential to keep the catch adequately stowed.

A shift to one side of boxed catch (or a stack of pots or cages) can also cause a list to port or starboard, which will reduce the vessel's stability and the angle of roll it can survive. In all weather conditions, you must ensure the catch is safely secured. Sorting it out in bad weather, or while crossing a bar, is dangerous.



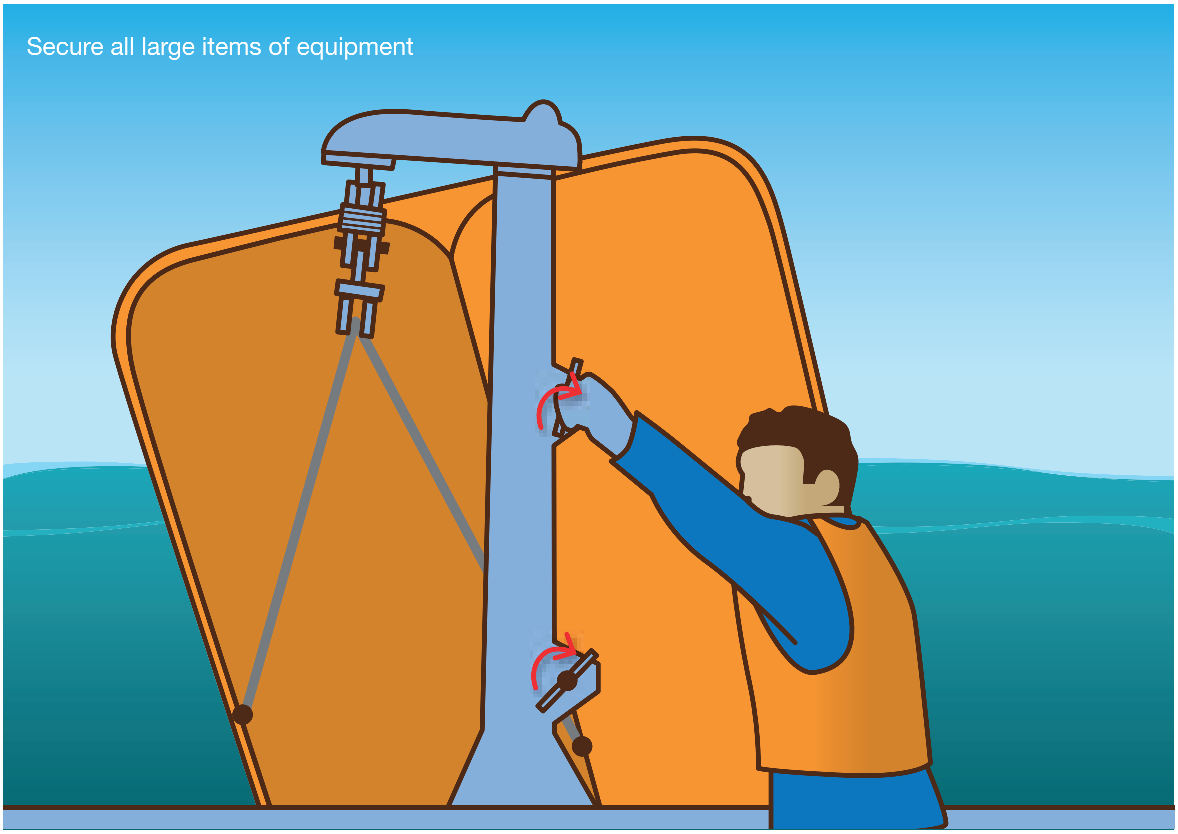
## Shifting fishing gear

Fishing gear must also be well secured. Any loose gear will be dangerous on deck and dangerous to the stability of the vessel.

Cages, pots and other gear stored on deck must be kept as low as possible and secured to withstand wave impact, rolling and wind loading. Any shifting gear is a major hazard for the crew and the safety of the vessel.

Trawl doors, spare equipment and other heavy items stored in exposed high positions must be secured. Keep the stowed positions as low as possible and avoid the weight of heavy items being taken by high blocks or pulleys, as this transfers the weight higher.

Ensure heavy items are secured with fastenings that are strong enough to withstand the loads they are exposed to in heavy weather. Swinging derricks and stabiliser boom arms must all be made fast to prevent movement.



## Stabilisers

Stabilisers are structures that swing out or lower down from the side of a vessel and deploy plates or lifting surfaces (often called 'birds') into the water to dampen the vessel's roll response. This damping effect is common with bilge keels and other surfaces deployed at the bulwark to slow the vessel's rolling.

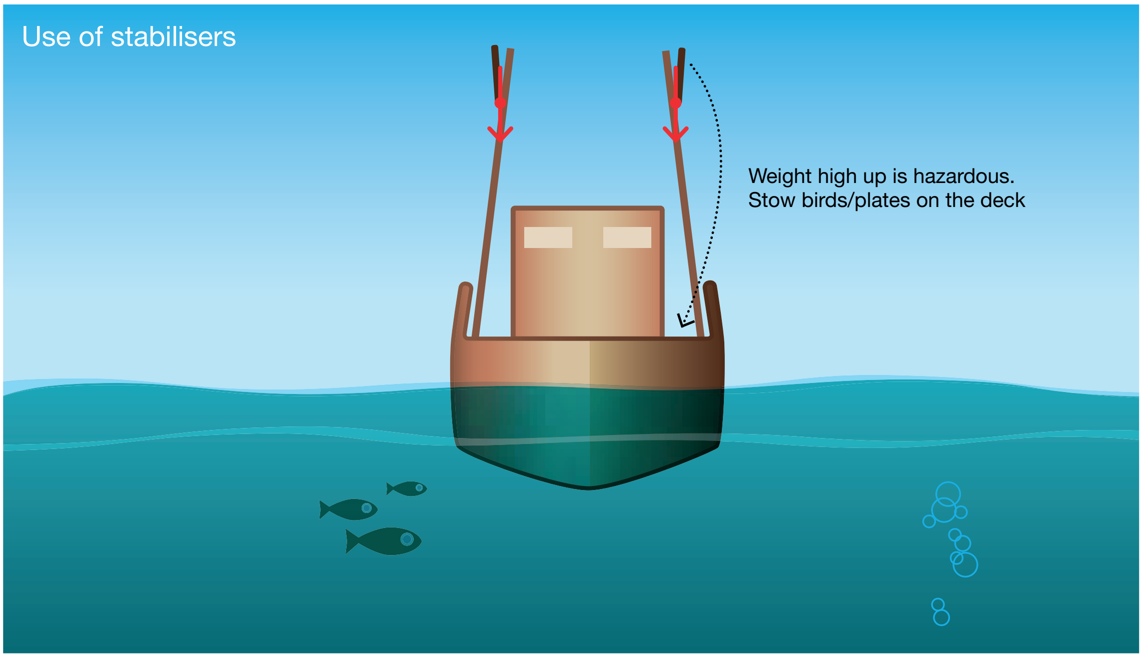
These structures make the vessel feel more stable because when they are deployed, the vessel's roll accelerations are significantly reduced. However, stabilisers do not provide stability—they only slow the rolling motion of the vessel.

Stabilisers pose significant hazards when:

- lowering the arms, or swinging them into position, and recovering them afterwards
- deploying and recovering the plate, lifting surface or 'bird'
- the arms and plates are lifted, which raises the vessel's centre of gravity
- the vessel is caught with the stabilisers deployed in a bad and worsening sea-state—where recovering them will compromise the vessel's stability.

Each of these hazards should be considered and planned for in the vessel's safety management system.

Raising the stabiliser arms (with the weight of the plates) at the end of fishing operations can be critical to a vessel's stability. This operation must be planned for, to ensure sufficient stability is kept in reserve to allow for the negative effect that raising the arms will have.



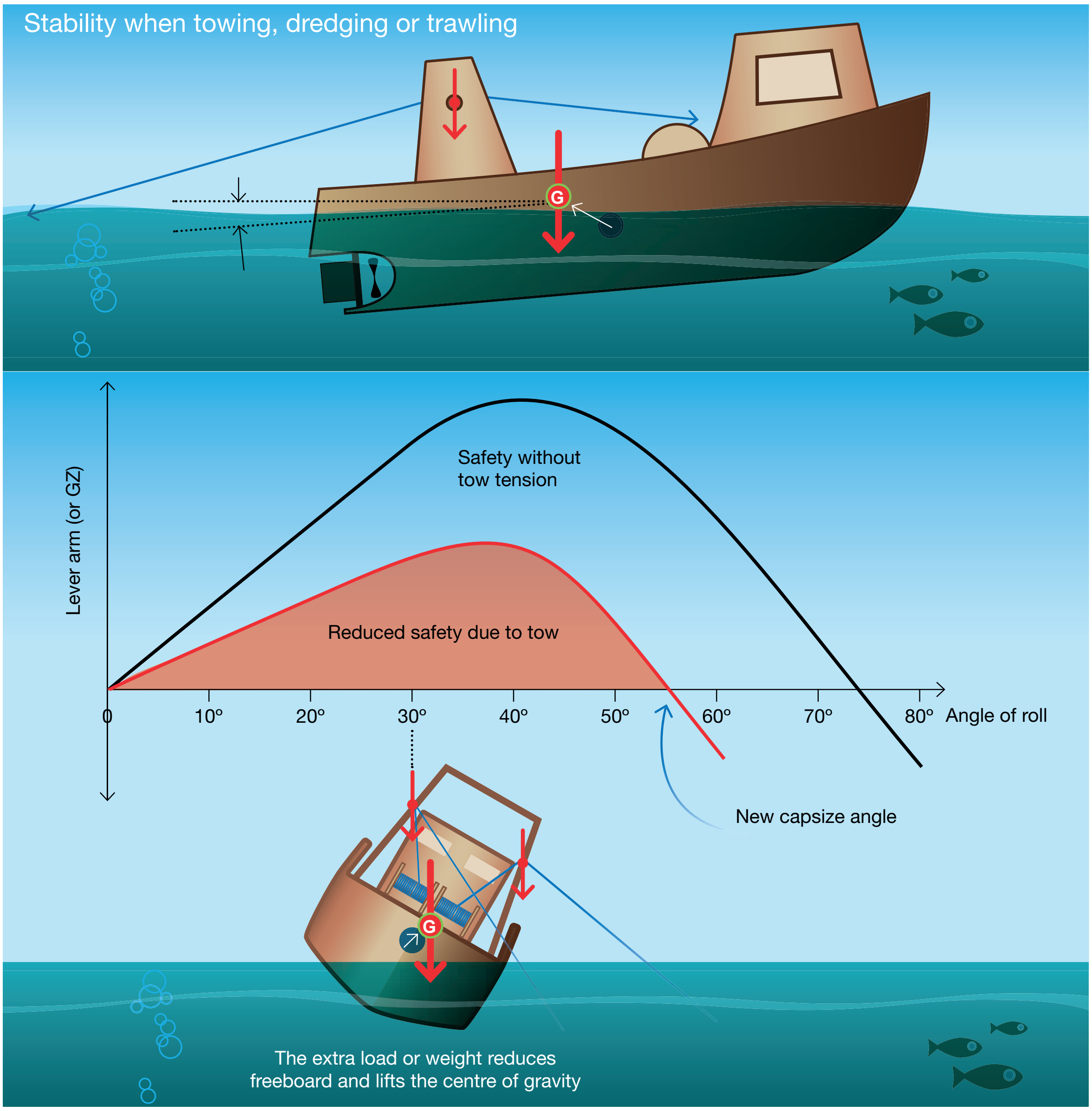

The plates, lifting surfaces or 'birds' must always be stowed on deck while they are not in use. They can weigh more than 100 kg, and leaving them at the top of the arms will significantly reduce a vessel's stability.

Maintaining the shackles, hanging eyes, pins, chains and all connectors is essential for safe operation with stabilisers. The failure of any of these during adverse weather could put the vessel in a critical situation. The vessel's maintenance plan should detail the required intervals for checks and replacements for these items of equipment.

# Trawling, dredging and towing

People often forget that the load on the lines while trawling has a significant negative impact on the vessel's stability:

- the tow line's load pulls the stern lower in the water, reducing the freeboard aft
- the downward weight of the load brings the vessel lower in the water
- the load from the tow line is transferred to the vessel through the point at which the line leads from the vessel. This may be a cleat, fairlead, or block attached to the vessel structure, referred to as the tow point. The position of this tow point may dramatically effect stability by raising the vessel's centre of gravity.



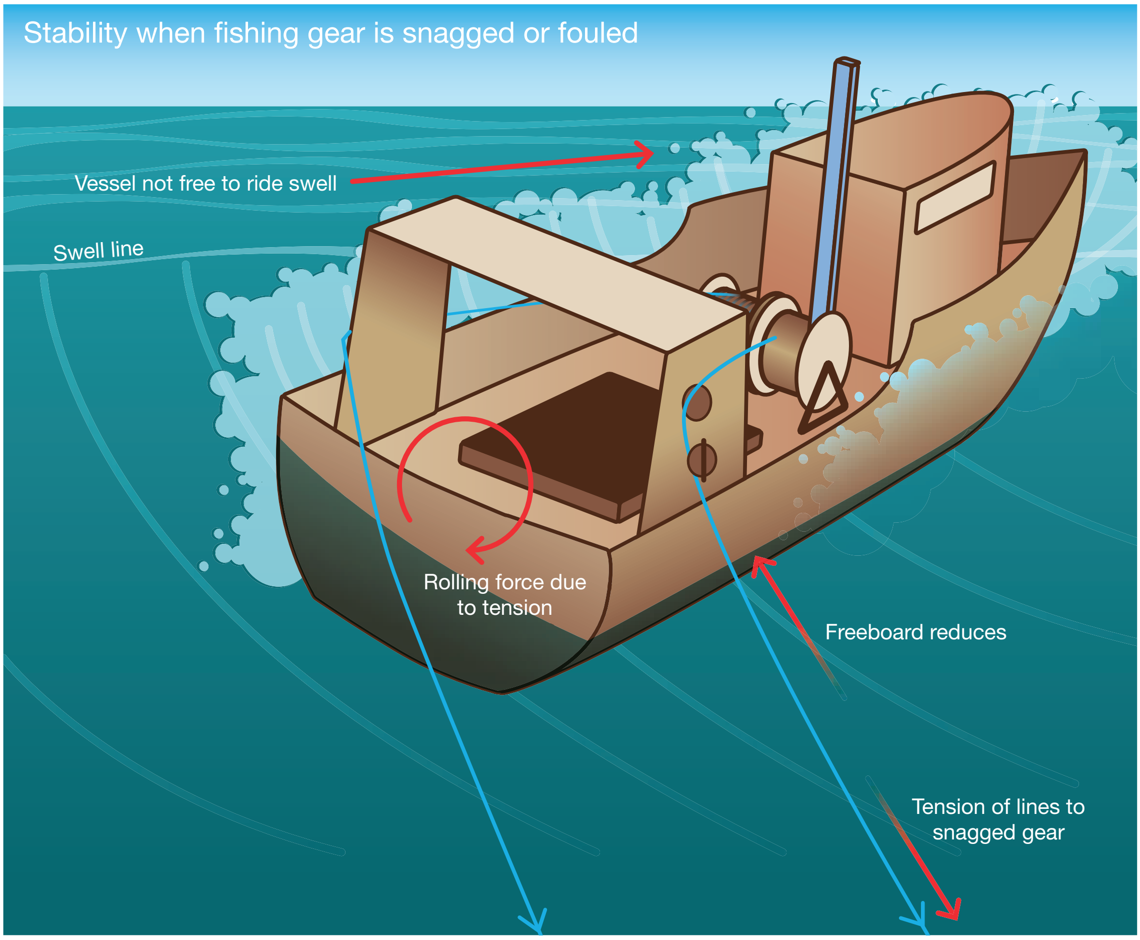

All these factors reduce the stability of the vessel. If the sea-state is rough, or if the vessel is already heavily loaded, the combined effect may be dangerous.

A heavy roll when towing may also cause the vessel to turn and roll to the load on lines. It is critical to pay attention to the direction of the swell in order to minimise rolling and safeguard overall stability of the vessel during tow or trawling operations.

- Before starting each tow or trawl, consider the sea-state and swell direction.
- Ensure the tow point of the vessel is as low as possible.
- Consult with AMSA, a recognised organisation or accredited marine surveyor prior to modifying the tow-point position.

## Fouling or snagging of fishing gear

For all fishing vessels, fouling or snagging their fishing gear is not just an inconvenience, it is a very dangerous stability hazard.




With any gear stuck on the seabed, the vessel is extremely vulnerable:

- The sea conditions, direction of the vessel compared to that of the waves and swell, and the angle of the tow lines compared to the vessel direction are all critical to ensuring the stability is maintained.
- The vessel may stop riding the swell, causing waves to wash over the deck and entrapping water within the bulwarks.
- The more load there is on the lines, the more the freeboard is reduced.
- A sideways load caused by a snagged tow line will increase the heel of the vessel to that side.
- The effects of wind and waves on the vessel will cause the snagged line to slacken and tighten. This occurrence will subject the vessel to large forces, increasing heel and roll, which are very dangerous to stability.
- Steep angles on the lines will worsen the stability hazard.

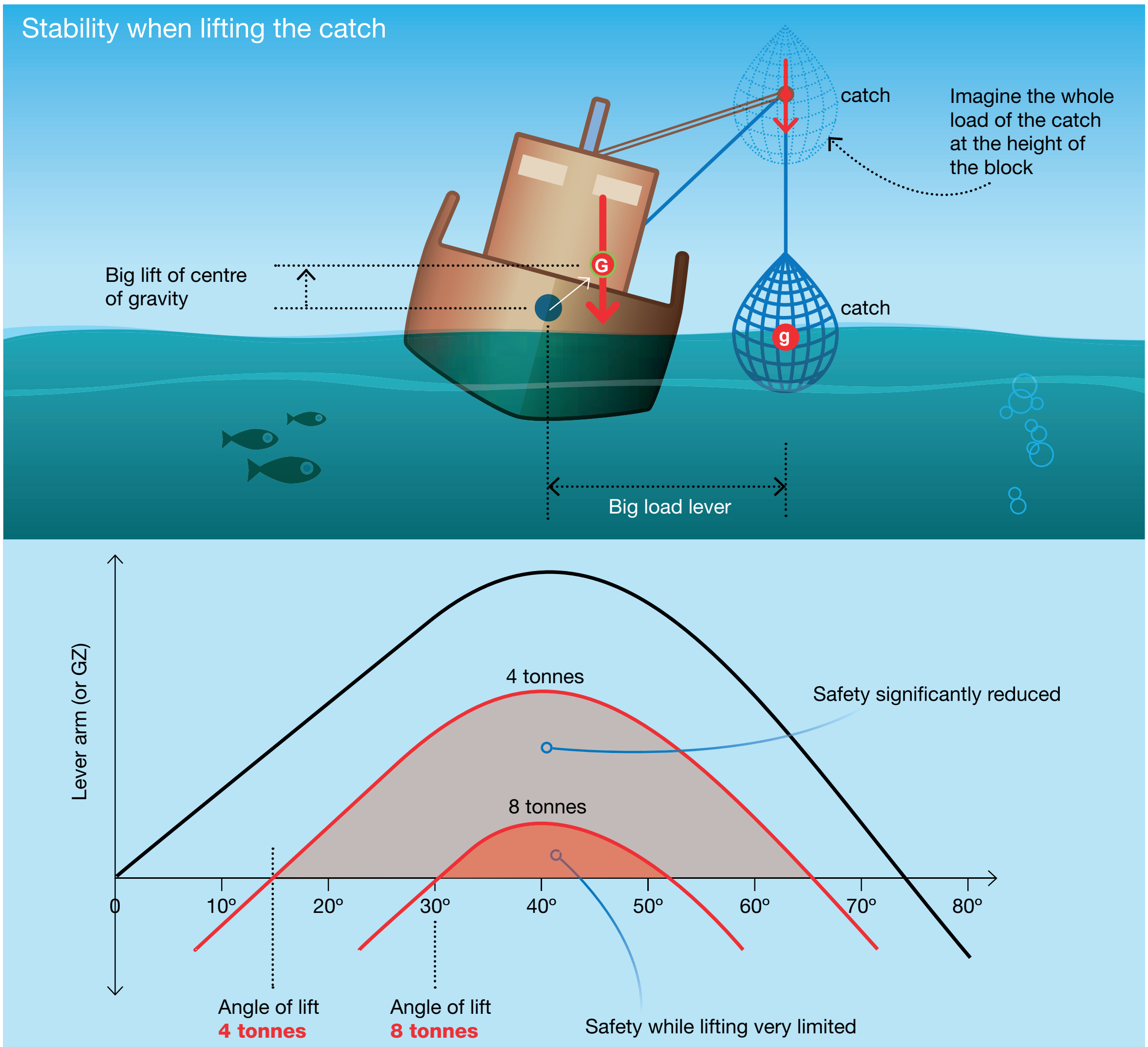
Operations to free the gear must only be undertaken with close attention to the effects of any actions on the vessel's stability, given the extra loads that will be needed to free the gear.

- Carefully assess the risks associated with fouled or snagged fishing gear to ensure there is sufficient resources and crew to deal with such events.
- Employ quick release or weak links in the tow or trawl lines so that a snagged load can be quickly released to ensure the vessel stability is not compromised.
- Seek professional advice from naval architects, accredited marine surveyors or recognised organisations if you are unsure whether your vessel is designed to withstand the forces induced from snagged or fouled fishing gear.

## Lifting, pulling on board or splitting the catch

People do not always realise that the centre of gravity and weight of any lifted object acts through the highest point of the blocks, pulley or winch line holding the weight.

What this means is that if you are lifting a catch, its weight is acting not where the object is, but at the top of the lifting point, block or winch that is lifting it. If you imagine the object up-high at this point, then this is where the vessel feels the weight.




Lifting fishing gear or a catch out of the sea into the air shifts the full weight to the highest point of the wire, usually just above the blocks on a derrick or A-frame. This sudden jump in the vessel's centre of gravity can be very dangerous. By the time you notice the vessel feels 'soft', it may be too late!

If the object then starts swinging in the swell, you may be in serious trouble. **Before you lift**, think about the condition of the vessel, the sea-state and how much you are going to lift.

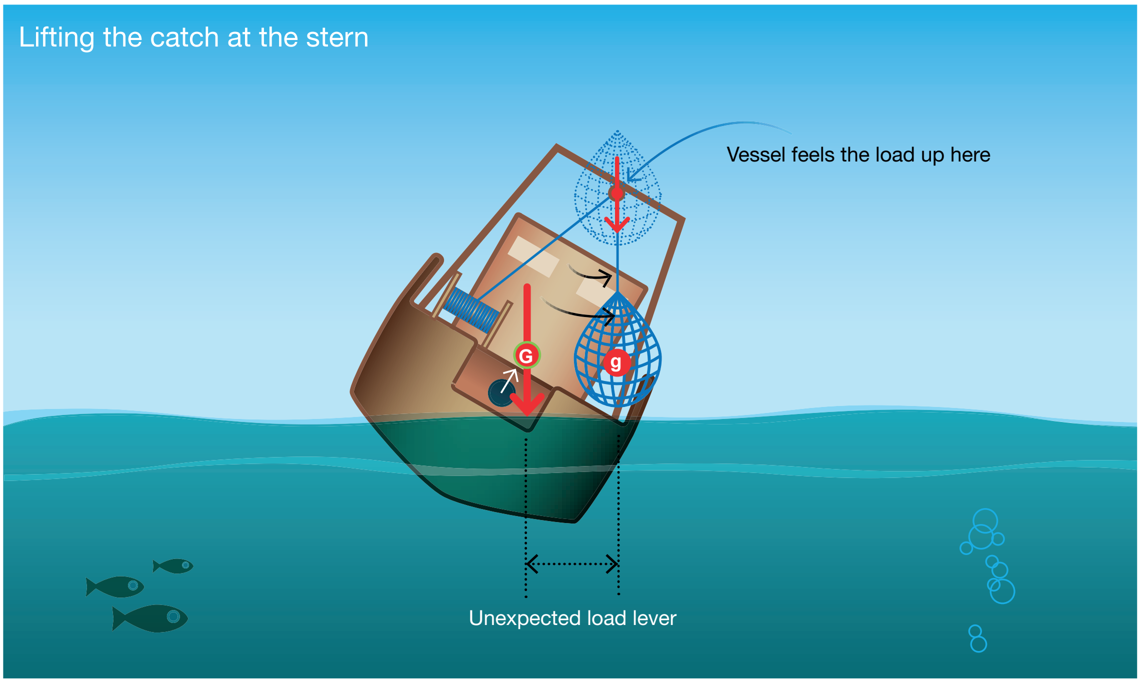
In the above example of a trawler lifting with a derrick, you can see that even the 4 tonne lift is dangerously reducing the stability, and with an 8 tonne lift the vessel is very close to capsize. Remember that these graphs only show the stability in completely flat water—and, as you know, the sea is seldom flat.

# Lifting the catch at the stern with an A-frame

This shifting of the centre of gravity due to the weight of the catch applies to stern lifters, too.

Any winch, block, wheel or lifting point used on an A-frame at the stern of the vessel will transfer some or all of the weight of the catch to that point. Any lifting or dragging of the gear or catch will have this effect.

The weight of the catch at the height of the deck has a big enough impact, but when it is lifted by blocks the centre of gravity of the catch shifts, partly or fully up to that height.




Visualise the gear and full catch at that height—that is how it feels to the vessel.

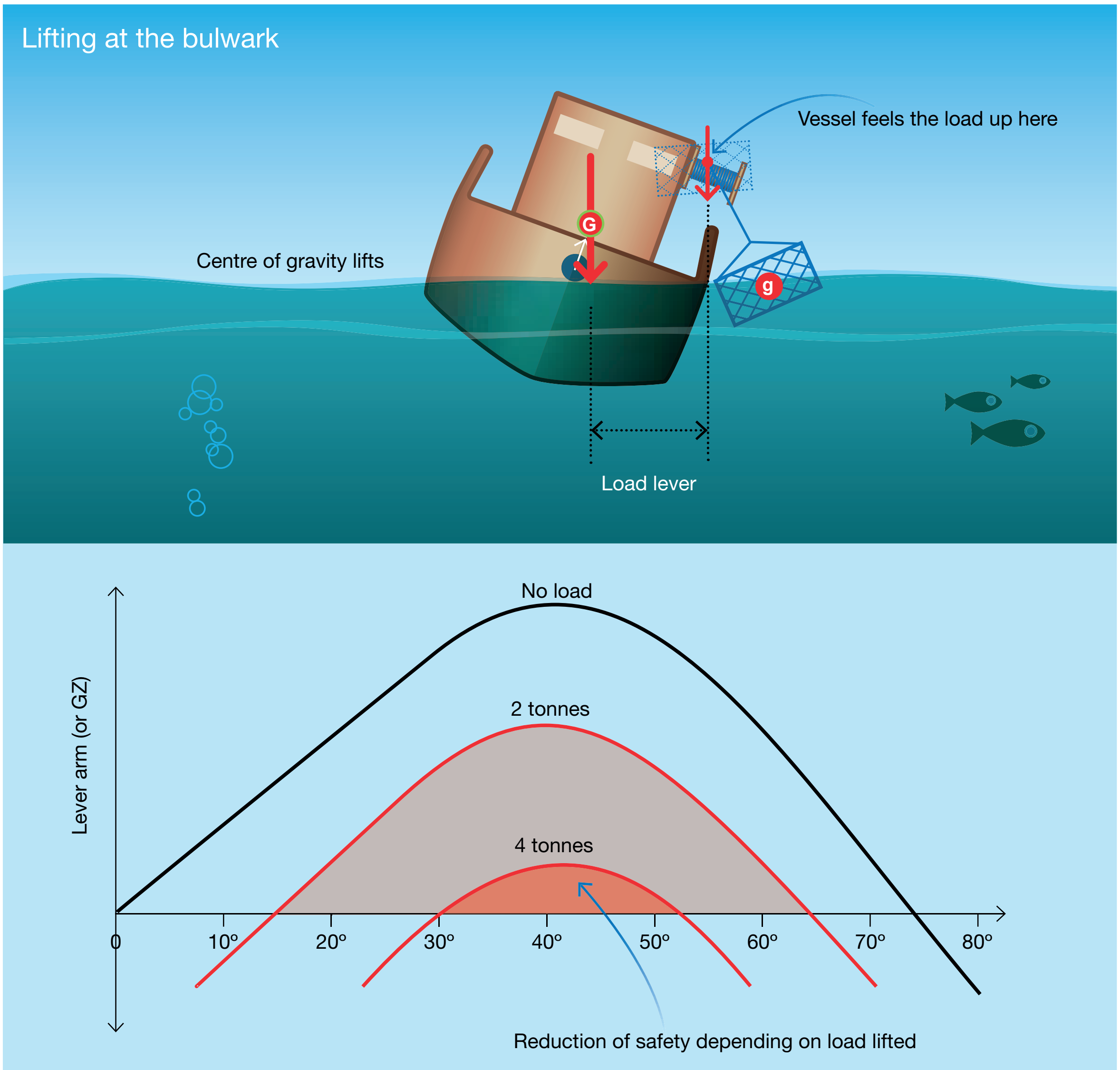
The effect on the vessel's stability reserves and the reduction in the range of roll before capsize is significant.

**Before you lift**, think about the condition of the vessel, the sea-state, and how much you are going to lift.

# Lifting or winching at the side

Lifting is also an issue for vessels lifting catch at the side. Any dredger, crayboat, side loader or seiner lifting loads at the side is taking large chunks of safety out of its stability curve every time it lifts.

Again, the weight acts at the point of lifting. On a crayboat, this point is the top of the winch.



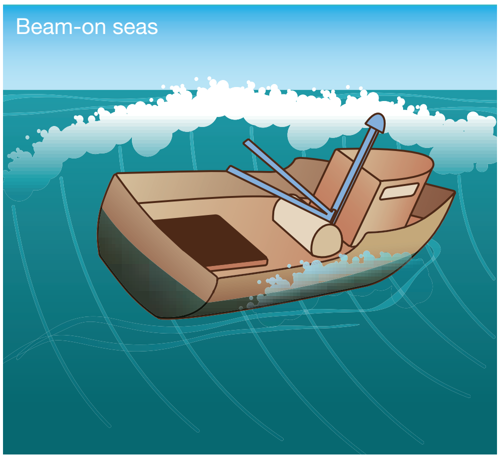

How much the stability safety is reduced, depends on the load lifted and whether a derrick is being used.

A lift at the side of the bulwark is safer than using a derrick (which is normally higher and reaches out further).

The example above of a fishing vessel lifting at the side, illustrates how much each of the loads reduces the stability safety while working (shown as the area under the curve). Every lift is only as safe as the load lifted, the condition of the vessel at that time, and the sea-state, size and direction.

# Risks from heavy seas, breaking waves and broaching

## Beam-on seas—a hazard



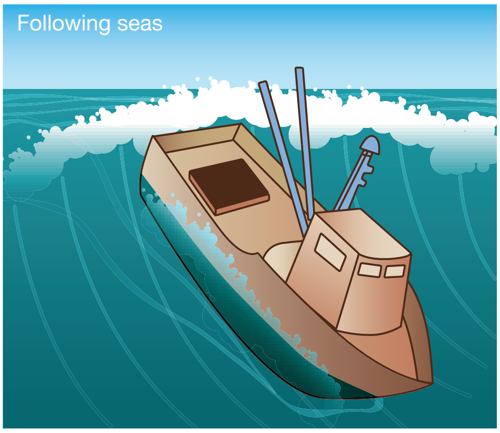

In beam-on seas, there is a high risk of a vessel taking large rolls. If the vessel is also overloaded or subject to another stability hazard, large rolls can lead to capsize.

The rolling caused by a beam-on sea may be quite violent, and crew members may have difficulty just staying on their feet, let alone being able to work effectively.

The large forces within breaking seas are highly dangerous for fishing vessels, especially if they are already overloaded or taking water. There is also a danger of the vessel being swamped and the working deck filling with water, exaggerating the rolling and further lowering stability levels.

As with all bad weather, the risk of shifting gear and catch is high, and all items need to be safely secured.

## Following seas—a significant hazard



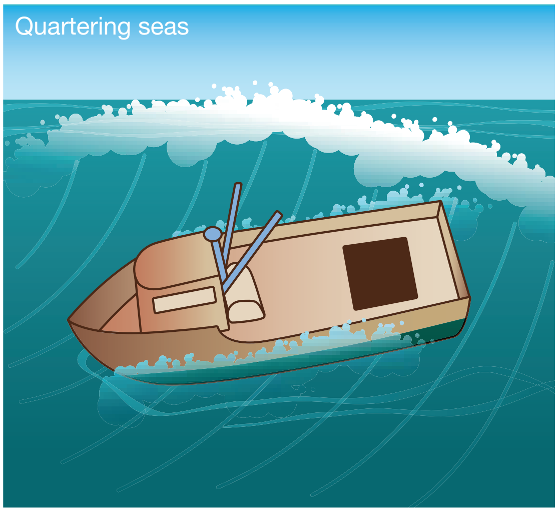

When steering a course with a following sea, great care is needed to avoid broaching. Running in the same direction as large waves makes steering extremely difficult, and the danger of yawing into a broach is always present.

The passing of a wave slows and then significantly accelerates the vessel, with the effects of surfing giving the vessel extra speed on the wave face. The burying of the nose and deceleration that follows, as the wave crest passes, throws the dynamic forces forward and often combines with the curvature of the hull trying to turn the vessel. At the same time, the rudder often has a loss of control due to the motion of the following wave and being raised near the surface as the stern lifts.

The combination of the next surge of the vessel being off course due to the broaching forces, and the vessel rolling on the next wave face makes a safe course very hard to steer.

In addition to the threat of broaching, the danger from being swamped is extreme. The extra weight and loss of stability from the deck being filled with water is frequently the cause of a full broach and potential capsize.

## Quartering seas—an extreme hazard




Quartering seas are even more prone to broaches, wave attack and swamping than following seas. On every wave, the vessel is partially broached on the wave face, increasing the chances of a full broach. The quarter is exposed to breaking waves and the deck exposed to swamping.

On the back side of the wave, the vessel often rolls back toward the trough of the wave with a corkscrew motion that rolls through to an even more dynamic motion with the next wave. This progression can often lead to a loss of steerage and broaching, especially if the vessel starts surfing on the wave face.

On this course, the underside of the stern is exposed to being picked up by a following breaking wave, causing the vessel to turn hard and roll on the leading slope of the wave. This is highly dangerous. Breaking waves can only safely be taken square on the transom, or head on with the bow into the sea.

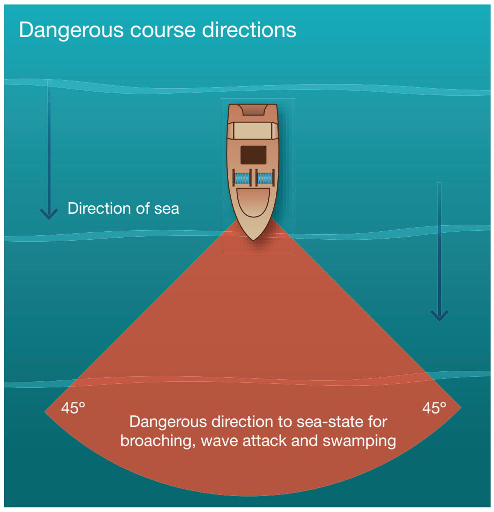
This course direction in a large sea-state with breaking waves is very dangerous, even if the vessel has good reserves of stability. Any decision to take a course of this nature in such a sea-state should only be taken with a sound understanding of the vessel's stability reserves and experience of its handling.

The hazards that are generated by both quartering and following seas are particularly relevant to safety when returning to port over a river or harbour sand bar.

## Direction of chosen course

A skipper normally has a choice about the course to steer while at sea. Running at angles between 45 degrees either side of the sea-state direction, are the most dangerous for surfing, broaching and wave attack.

In severe conditions, it may not be possible to continue in the direction of the waves and avoid the serious risk of capsize. It may then become necessary for the skipper to wait for an opportunity to turn the bow into the seas and head slowly upwind until conditions improve.




**Recommendation:**

- Avoid operating with waves coming from the beam in severe sea conditions, change course to put the bow into the seas. If the vessel must run with the seas, riding on the backside of the preceding wave minimizes the dangers.
- Consult with a naval architect and ensure your fishing vessel is constructed and arranged so it has adequate reserves of stability to withstand the perils of riding on crests in short and steep wave conditions.
- Ensure equipment, stores, cargo and fishing gear is appropriately secured to prevent their movement in the vessel should large angles of heel occur.

## Planning your stability for the whole trip

The stability of your vessel is not something that is set in stone—it changes constantly throughout your trip.

The factors that provide good positive stability forces, such as full fuel tanks normally being low down in a vessel, are initially present and then reduce during a trip as fuel is burnt. Having some catch loaded in your hold can also help your positive stability forces.

The conditions that have a negative impact on stability safety are not constant either. Fuel reductions and fishing operations steal margins of safety from the vessel's stability. The weather and sea-state can also negatively affect your stability safety.

AMSA encourages all fishing vessel operators and skippers to have—and become familiar with—a stability book or simplified stability data.

If you have one, your stability book can help with this planning. It helps you prepare for and check loading conditions at certain stages of your trip.

The different stages may include:

- leaving port with full fuel and stores but no fish
- being at the fishing field with a full catch
- coming home with a full catch and not much fuel and stores
- coming home with a small catch and not much fuel and stores
- any other actual operating conditions (such as fishing operation).

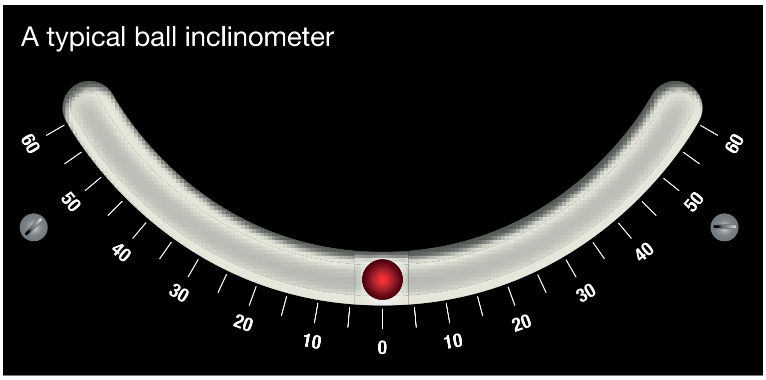
The loading conditions are useful descriptions of the boundaries for a vessel's stability safety. If you want them explained, please contact the naval architect who calculated them for your vessel.

## Inclinometers and how they help

Bubble and ball inclinometers are like spirit levels on a curve that tell you the angle the vessel rolls to, port and starboard. Regularly noting extremes in the logbook can help build an accurate picture of the vessel's motions in different conditions or when lifting.

AMSA strongly recommends each vessel is fitted with an inclinometer, mounted athwartships (at right angles to the keel) in a position visible from the helm. In this way, the angle of the vessel's roll can be monitored during fishing or loading operations, bad weather or adverse sea-states.

Inclinometers are not expensive and help raise awareness of stability issues for all people on board.



A typical ball inclinometer

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