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Safety practices related to small fishing vessel stability

Cover photo:
Fishing port of Beruwala, Sri Lanka. FAO/A. Gudmundsson.

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by
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Preparation of this document

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Abstract

This document introduces some basic principles on the stability of small fishing vessels and provides simple guidance on what fishing vessel crews can do to maintain adequate stability for their vessels. It is not intended to be a complete course on fishing vessel stability

The publication is aimed at fishers and their families, fishing vessel owners, boatbuilders, competent authorities and others who are interested in the safety of fishing vessels and fishers. It may also serve as a guide for those concerned with training in matters of safety of fishing vessels. It is recommended to translate and adapt the content for each target audience, in order to be consistent with the local weather conditions, types of vessels, fishing gear being used, etc.

Gudmundsson, A.
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Contents

1. Introduction

Stability is one of the most important factors in every fishing vessel's overall safety. Without reducing the importance of life-saving equipment, every possible means should be used to prevent the capsizing of a vessel. The vessel itself is the best survival craft.

Stability is the ability of a vessel to return to its upright position after being heeled by an external force, such as the wind, a wave or the strain from its fishing gear. It is determined by the characteristics of the vessel, such as hull form and weight distribution and how the vessel is operated. The stability of a fishing vessel is not a constant condition; it undergoes continuous changes during each voyage and through the vessel's life. An originally stable fishing vessel may become unstable because of changes in weather, because of the way it is loaded and operated, or if the vessel's layout or equipment is changed.

It is stressed however, that whereas this document is not intended to be a complete training course, it does provide an insight to the stability of small fishing vessels. Thus it can be of use to competent authorities responsible for setting stability criteria, framing stability booklets and defining acceptable means to carry out stability tests. It would also be of use to boatbuilders during the construction of new vessels and following refitting or alterations to existing vessels. In addition, the contents could provide the basis for course material in relation to fishing vessel stability for the training of fishing vessel inspectors and in the training of fishers with particular reference to operational safety.

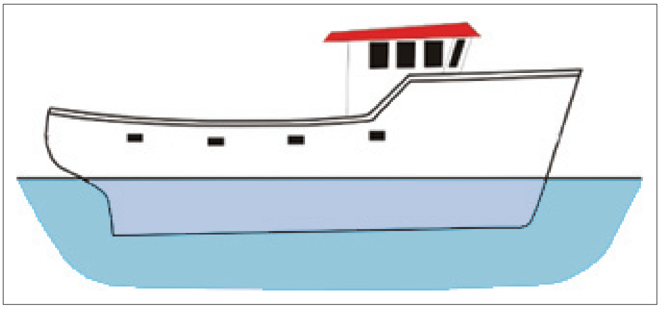
Furthermore, fishing vessel owners and potential owners making use of this document will have a better understanding on the importance of stability in relation to the design and operation of fishing vessels and would be of assistance in completing contractual arrangements for new construction, refitting and possible alterations to existing vessels. It would also be a useful reference to an owner when preparing operational safety procedures to be followed by the crew whether at sea or in harbour.

Finally, but by no means least, individual fishers, groups of fishers and their families will have a better understanding of the various factors that can affect the stability of a fishing vessel when preparing for sea, during fishing operations and when discharging the catch at sea or in harbour. The chapter on precautions may be of particular interest to many small-scale fishers, especially the section on crossing sand bars and beach landing; the latter often witnessed by the families of fishers.

2. Definitions

DISPLACEMENT

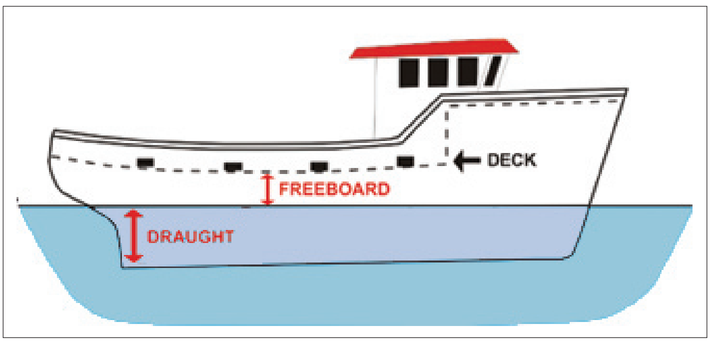
Archimedes principle: Every floating body displaces its own weight of the liquid in which it floats.



For a vessel to float freely in water, the weight of the vessel must be equal to the weight of the volume of water it displaces.

Displacement is the volume of water the vessel displaces.

DRAUGHT

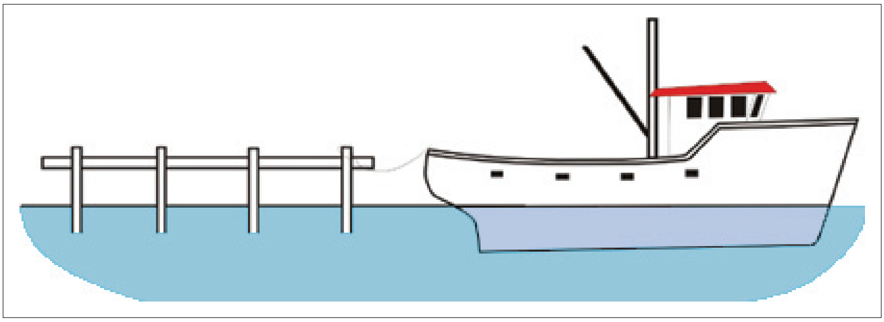


Draught relates to the depth of water required for a vessel to float freely and is measured vertically from the underneath side of the keel to the waterline.

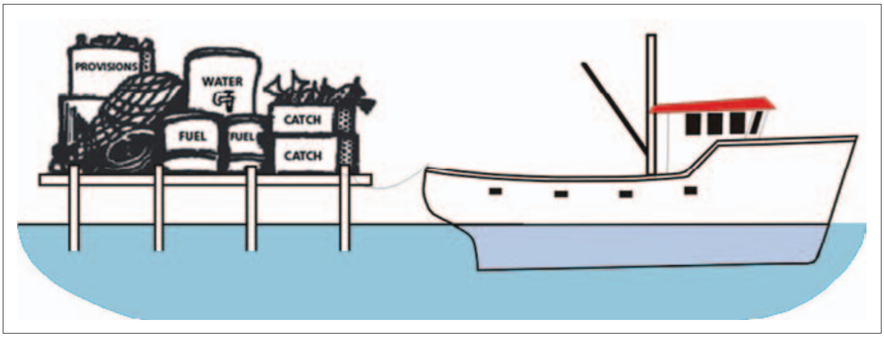
FREEBOARD

Freeboard is the vertical distance from the top of the lowest point of the working deck at the side of the vessel to the waterline.

LIGHT SHIP WEIGHT

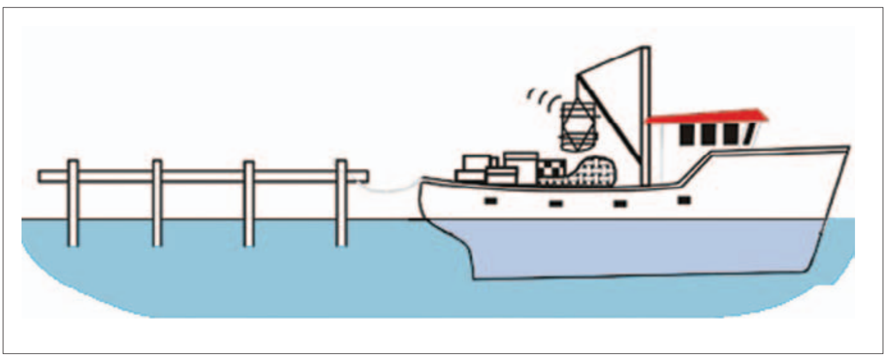


The light ship weight is the actual weight of a vessel when complete and ready for service but empty.



DEADWEIGHT

Deadweight is the actual amount of weight in tonnes that a vessel can carry when loaded to the maximum permissible draught (includes fuel, fresh water, gear supplies, catch and crew).



DISPLACEMENT MASS

Displacement mass is the total weight of the vessel, i.e.:

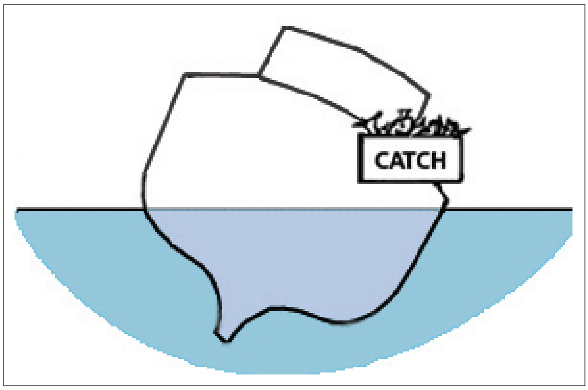
Lightship weight + deadweight = displacement mass

LIST

A vessel is said to be listed when it is inclined by forces within the vessel, e.g. movement of weight within the vessel.

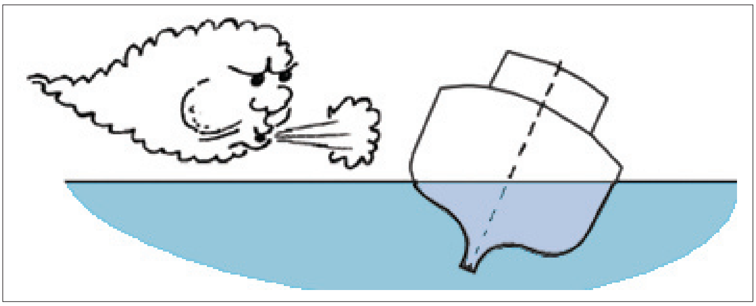
A list reduces the stability of the vessel.

When a list is corrected by increasing the displacement mass, the additional weight should be placed as low as possible in the vessel.



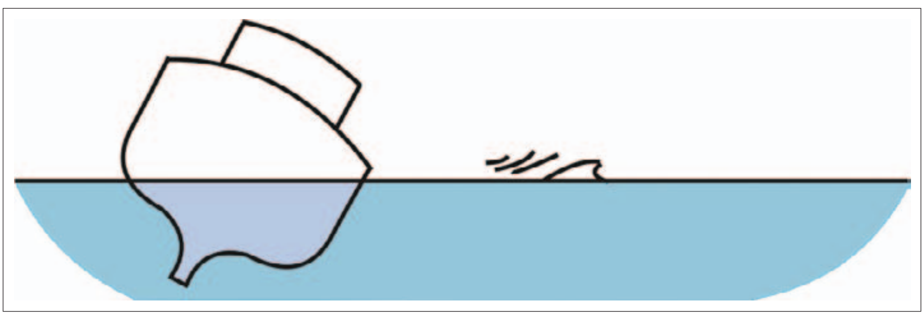
HEEL

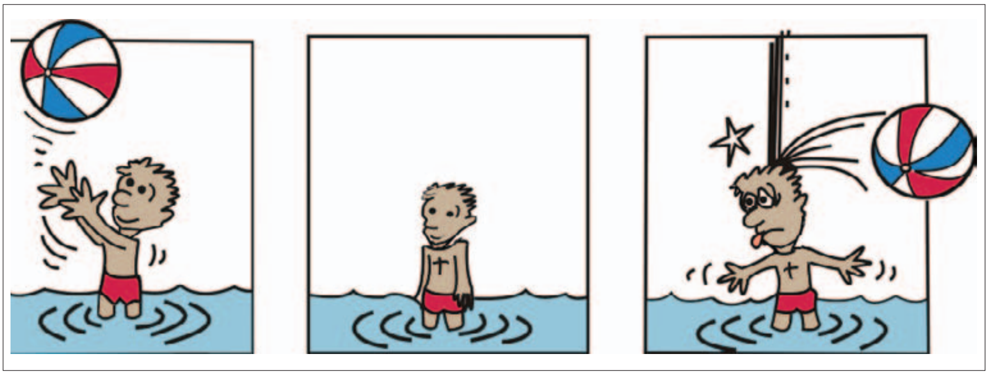
A vessel is said to be heeled when it is inclined by an external force, e.g. from waves or the wind.



LOLL

The term "loll" describes the state of a vessel which is unstable when upright and which floats at an angle from the upright to one side or the other. If an external force, e.g. a wave or wind, changes this state, the vessel will float at the same angle to the other side. Loll is quite different from list or heel as it is caused by different circumstances and requires different counter-measures to correct. It is, therefore, most important that fishermen are able to distinguish between these terms. (See also the section on unstable equilibrium on page 10.)

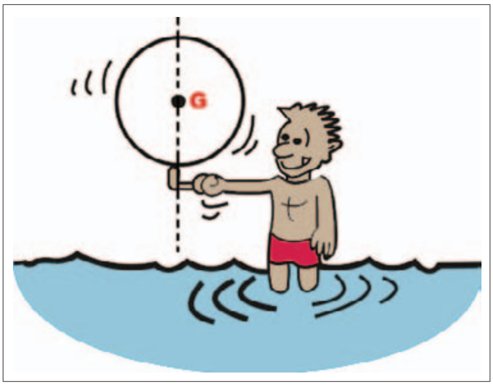




GRAVITY

"What goes up must come down".

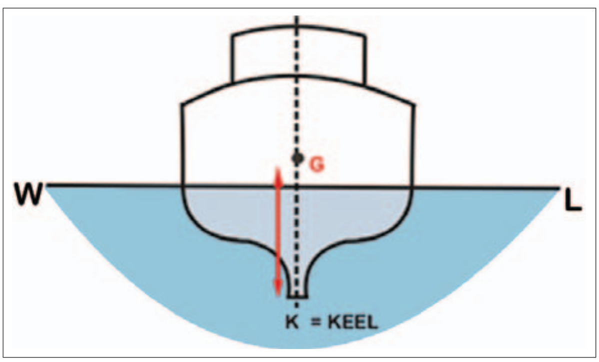
Throw a ball in the air. It soon comes back down in response to the earth's gravitational pull.



CENTRE OF GRAVITY

Centre of gravity is the point (**G**) at which the whole weight of a body can be said to act vertically downwards.

The centre of gravity depends upon weight distribution within the vessel and its position may be found by carrying out an inclining test or by calculation. The position of the centre of gravity (**G**) is measured vertically from a reference point, usually the keel of the vessel (**K**). This distance is called **KG**.



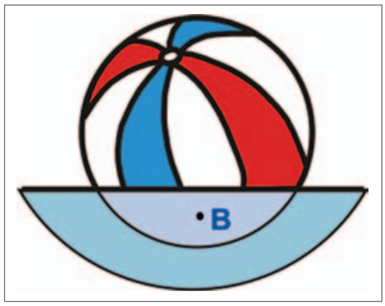
BUOYANCY

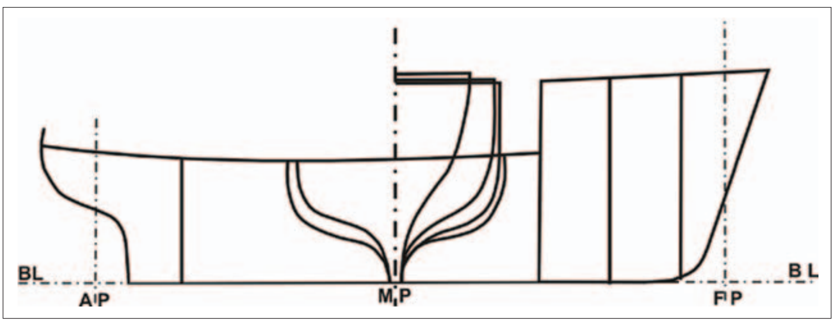
If a ball is pushed underwater it will soon bob up again. This force is called buoyancy.

When a vessel floats freely, its buoyancy is equal to its displacement mass (refer to Archimedes principle on page 3).

CENTRE OF BUOYANCY

The centre of buoyancy (**B**) is the point through which the force of buoyancy is considered to act vertically upwards. It is located at the geometric centre of the underwater section of the vessel.

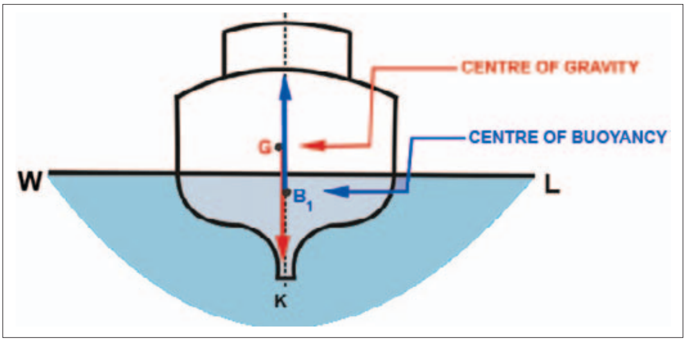


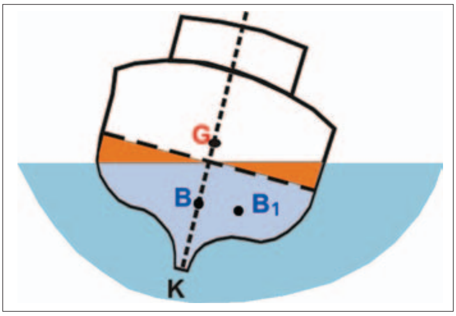


When the shape of the hull of a vessel is known, the designer, often a naval architect, can calculate the centre of buoyancy (**B**) for the various combinations of displacement, trim and heel.

TRANSVERSE STABILITY

When a vessel is floating upright (at equilibrium) in still water, the centre of buoyancy (upthrust) and the centre of gravity (downthrust) will be on the same line, vertically above the keel (**K**).

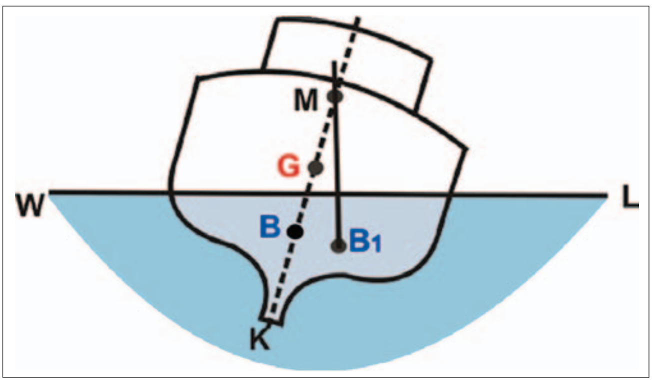




If the vessel is inclined by an external force (i.e. without moving internal weight) a wedge of buoyancy is brought out of the water on one side and a similar wedge of buoyancy is immersed on the other side. The centre of buoyancy being the centre of the underwater section of the vessel has now moved from point **B** to **B**$_1$.

METACENTRE

Vertical lines drawn from the centre of buoyancy at consecutive small angles of heel will intersect at a point called the metacentre (**M**). The metacentre can be considered as being similar to a pivot point when a vessel is inclined at small angles of heel.



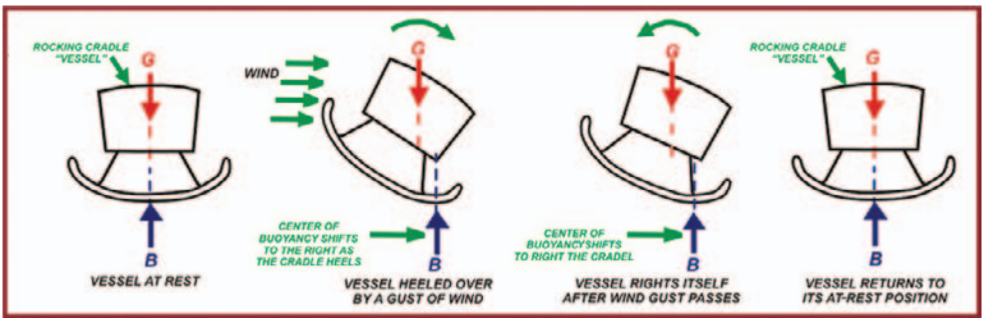
The height of the metacentre is measured from the reference point (**K**) and is, therefore, called **KM**.

WHY A FISHING VESSEL REMAINS UPRIGHT

Another way of understanding how a fishing vessel stays upright is to imagine the rocking of a baby cradle, as shown in the figure. The fishing vessel (weight) is represented by the cradle and its centre of gravity (**G**) is the near the centre of the cradle. The "buoyant force" supporting the cradle is represented by the rocker resting on the floor and the centre of buoyancy (**B**) is the point where rocker contacts the floor.

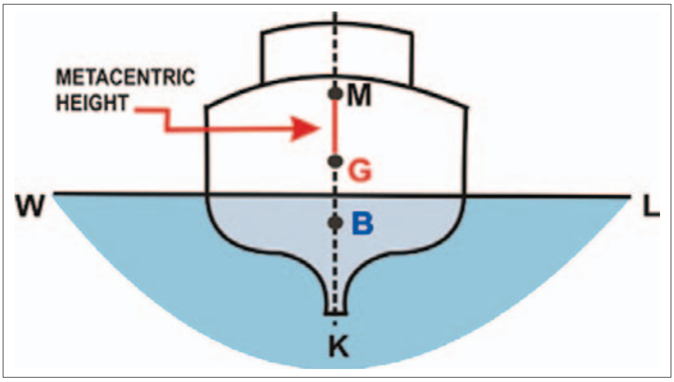
As with a fishing vessel, the cradle's (vessel's) centre of gravity (**G**) is above its rocker, the centre of buoyancy (**B**). The slightest disturbance (wind or waves) causes the cradle (vessel) to roll (heel) to one side.

As the cradle (vessel) rolls to one side, the point where the rocker touches the floor (the centre of buoyancy (**B**)) shifts outboard. To keep the cradle (vessel) upright, the point where the rocker touches the floor (the centre of buoyancy (**B**)) must shift outboard. It is this shifting of the centre of buoyancy (**B**) that allows a fishing vessel to return to upright after being heeled by an external force.



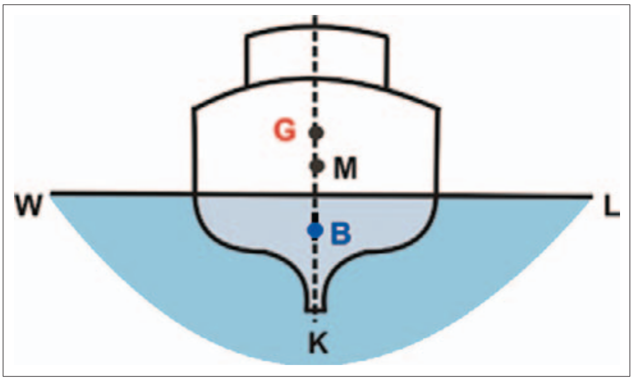
EQUILIBRIUM

A vessel is said to be in stable equilibrium if, when inclined, it tends to return to the upright. For this to occur the centre of gravity (**G**) must be below the metacentre (**M**).



METACENTRIC HEIGHT

The distance between **G** and **M** is known as the metacentric height (**GM**). A stable vessel when upright is said to have a positive metacentric height (**GM**), i.e. when the metacentre (**M**) is found to be above the centre of gravity (**G**). This is usually referred to as having a positive **GM** or a positive initial stability.



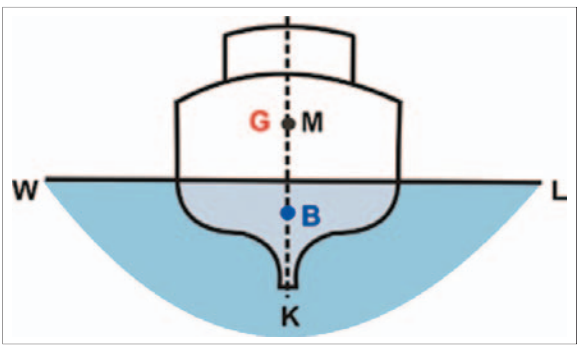
UNSTABLE EQUILIBRIUM

If the centre of gravity (**G**) of a vessel is above the metacentre (**M**) the vessel is said to have a negative **GM** or a negative initial stability. A vessel in this state has a loll, i.e. it floats at an angle from the upright to one side or the other and there is a danger that it may capsize.

(See also the section on loll on page 5.)

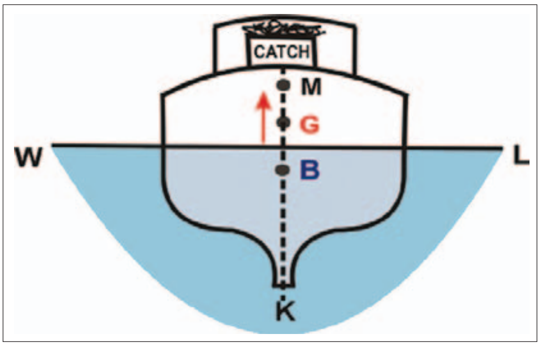
NEUTRAL EQUILIBRIUM

When the position of a vessel's centre of gravity (**G**) and the metacentre (**M**) coincide the vessel is said to be in neutral equilibrium (**Zero GM**) and if inclined to a small angle of heel it will tend to remain at that angle.



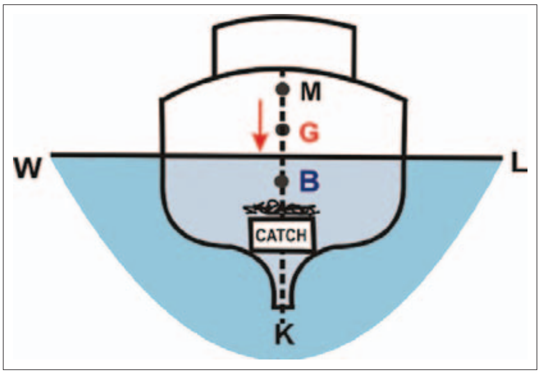
STIFF AND TENDER VESSELS

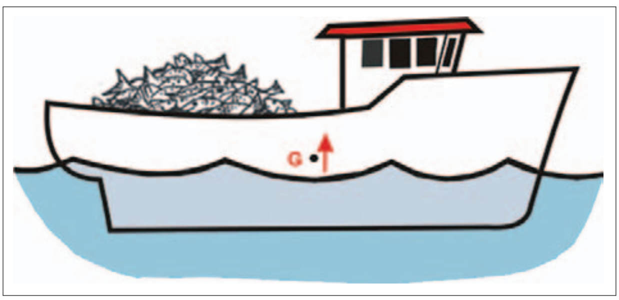
When weight is added to a vessel, the centre of gravity (**G**) of the vessel always moves in the direction of the added weight.



Weight added at deck level results in the vessel's centre of gravity (**G**) rising, causing a decrease in the vessel's metacentric height (**GM**) and thereby its stability. A vessel with little or no metacentric height is said to be **tender**.

Weight added low down in the vessel lowers the vessel's centre of gravity (**G**) and consequently causes an increase in the vessel's metacentric height (**GM**). A vessel with a large metacentric height is said to be a **stiff** vessel.





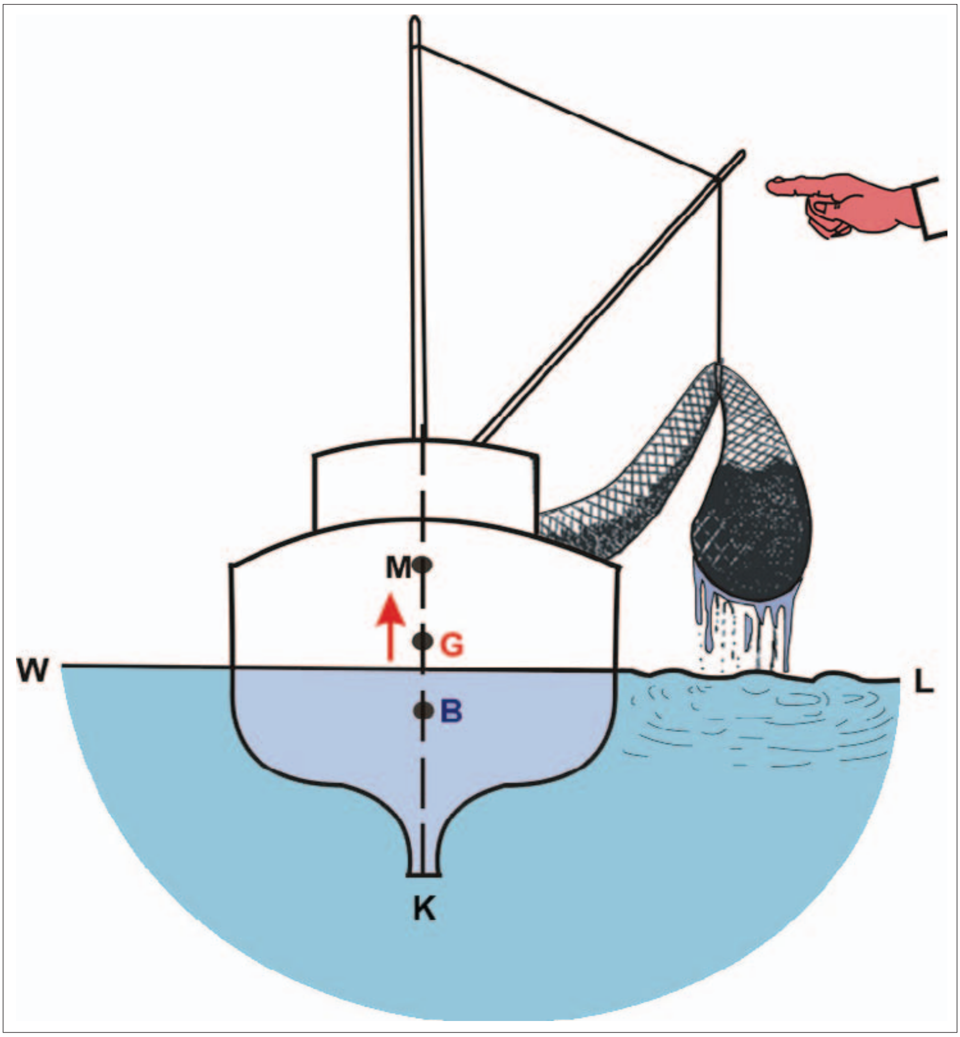
Heavy weights should always be positioned as low as possible and catch should generally not be carried on deck as the vessel's centre of gravity (**G**) will rise and the metacentric height (**GM**) will decrease which will increase the likelihood of a capsize of the vessel.

A stiff vessel tends to be comparatively difficult to heel and will roll from side to side very quickly and perhaps violently.

A tender vessel will be much easier to incline and will not tend to return quickly to the upright. The time period taken to roll from side to side will be comparatively long. This condition is not desirable and can be corrected by lowering the vessel's centre of gravity (**G**).

(See also the section on rolling period tests on page 31.)

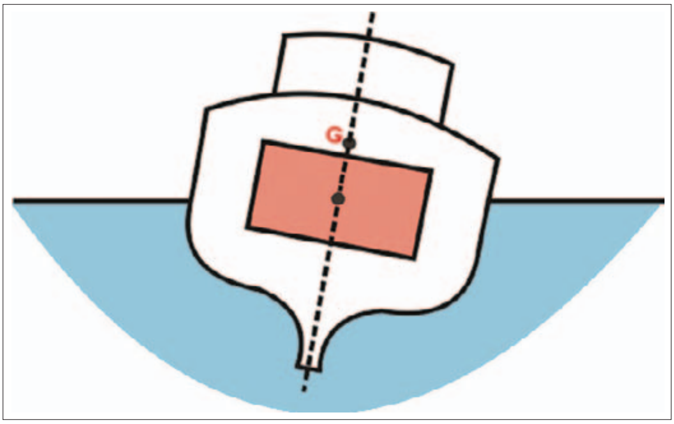
SUSPENDED WEIGHT



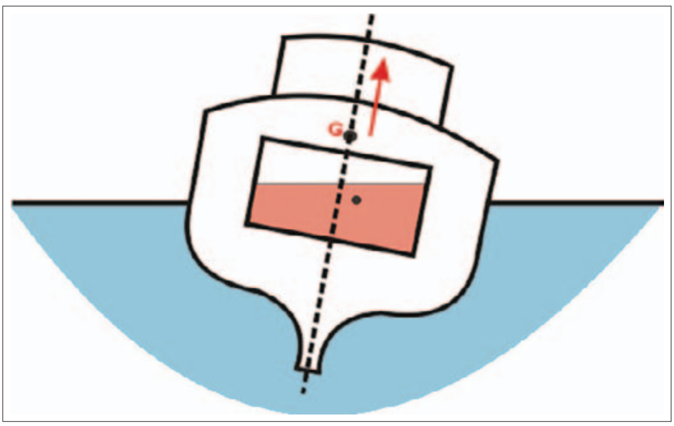
The centre of gravity of a suspended weight can be considered to be acting at the point of suspension. Therefore, a net lifted clear of the water has the same effect on the vessel's centre of gravity **(G)** as if the net were actually at the head of the boom.

If not at the centreline, this weight will also exert a heeling force upon the vessel and may, under unfavourable circumstances, capsize the vessel.

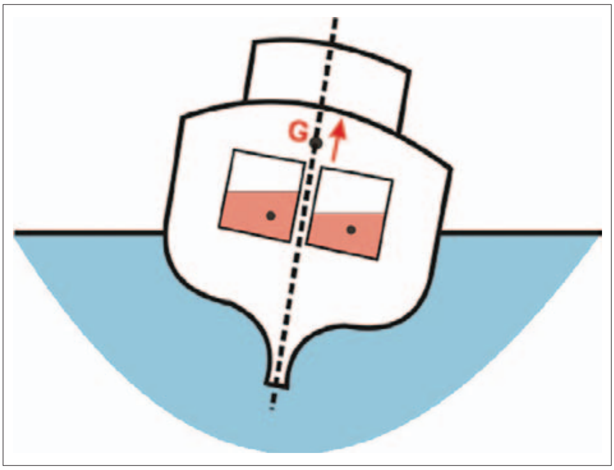
FREE SURFACE EFFECT



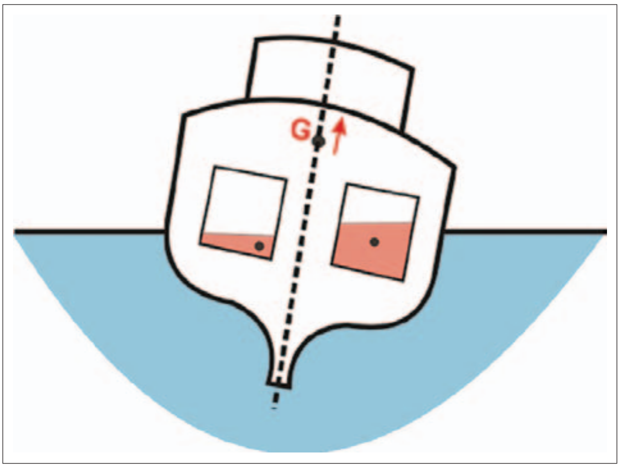
When a vessel with a full tank is heeled, the liquid within the tank acts like a solid mass. Its centre of gravity, being the centre of its volume, remains constant and therefore does not cause any change in the vessel's centre of gravity (**G**) or its metacentric height (**GM**) as the vessel is heeled.



When a vessel with a partially-filled tank is heeled, the liquid will seek to remain parallel with the waterline. The centre of gravity of the liquid, being the centre of its volume, will move with the liquid and can have a considerable effect upon the vessel's stability. This effect is similar to that caused by adding weight on deck, i.e. rise of the vessel's centre of gravity (**G**) which causes a decrease in the vessel's metacentric height (**GM**) and thereby its stability.



Partially-filled tanks have the greatest adverse effect upon a heeled vessel's metacentric height (**GM**). The division of the tank into two equal parts by the use of a watertight bulkhead will reduce the adverse effect on the vessel's metacentric height (**GM**) by up to 75 percent of that of an undivided tank.



Care should be taken when endeavouring to correct a list by filling tanks. Having two partially-filled tanks will create additional free surface effect. If there is a possibility that the vessel's list is caused by loll, it is recommended that the tank on the low side be filled before commencing to fill the tank on the high side.

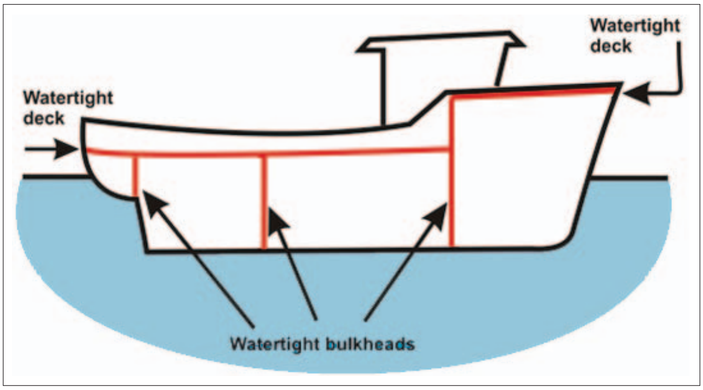
(See also the section on loll on page 5.)

Free surface effects are not only caused by partially-filled tanks. They can, for example, also be caused by accumulated water on deck. To enable the water to run off quickly, a vessel should have adequate freeing ports. Poundboards should be arranged so that water can flow easily to the freeing ports which should always be clear.

Anti-rolling tanks have a free surface effect which decreases the vessel's metacentric height (**GM**). They should, therefore, always be emptied when the metacentric height is small and, in particular, when there is a risk of ice accretion.

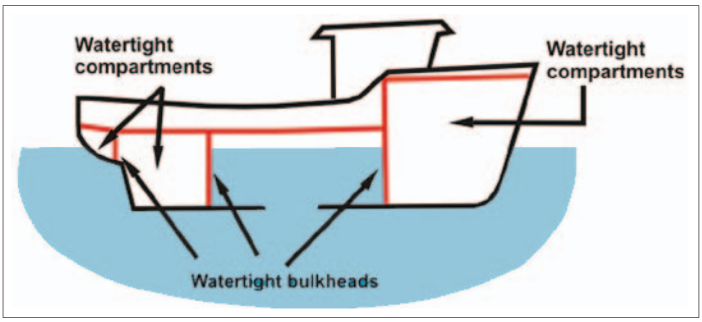
At any one time the number of partially filled tanks should be kept to a minimum. Tanks that are either completely full or completely empty do not have a free surface effect and therefore do not reduce the vessel's metacentric height (GM).

WATERTIGHT AND WEATHERTIGHT INTEGRITY



The vessel's hull must be tight to prevent water from entering the vessel. Closing devices to openings, through which water can enter the hull and deckhouses, should be kept closed in adverse weather. This applies to doors, hatches and other deck openings, ventilators, air pipes, sounding devices, sidescuttles and windows and inlets and discharges. Any such device should be maintained in good and efficient condition.

Vessels are often subdivided into compartments by bulkheads in order to minimize the effects of water flowing from one part of the vessel to another.



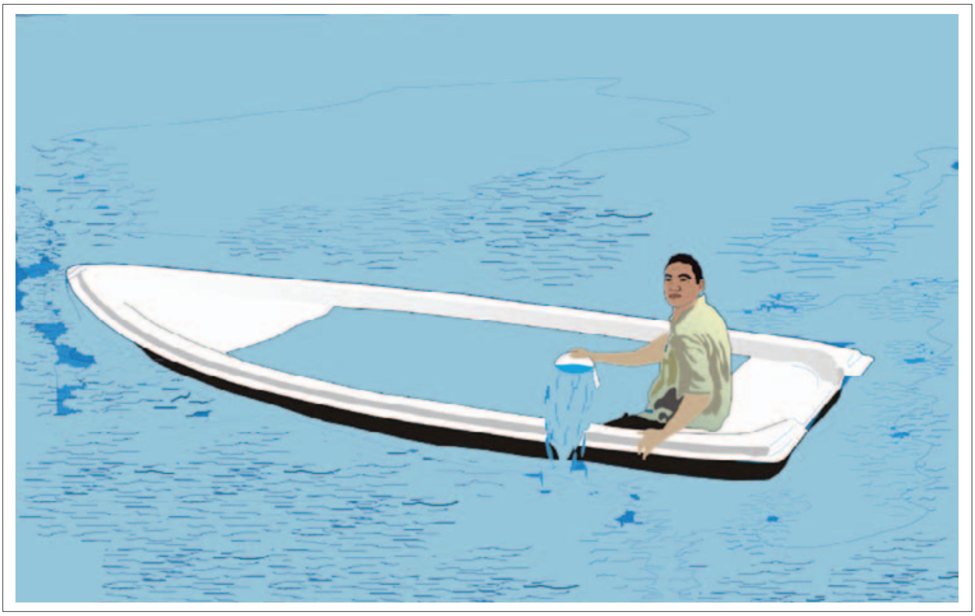
"Watertight" means that a structure is designed and constructed to withstand a static head of water without leakage. Water (or any other liquid) is not able to pass through the structure into or out of any of the watertight compartments, i.e. prevention from the passage of water in any direction. The vessel's hull, working deck (weather deck) and bulkheads between compartments must be watertight. Watertight bulkheads must be watertight up to the working deck. Any openings on such bulkheads must be equipped with watertight closing devices.

"Weathertight" means that in any sea condition water will not penetrate into the vessel, i.e. prevention from the passage of water in one direction only. Hatches, sidescuttles and windows must be equipped with weathertight closing devices. The same applies for doors and other openings on enclosed superstructures.

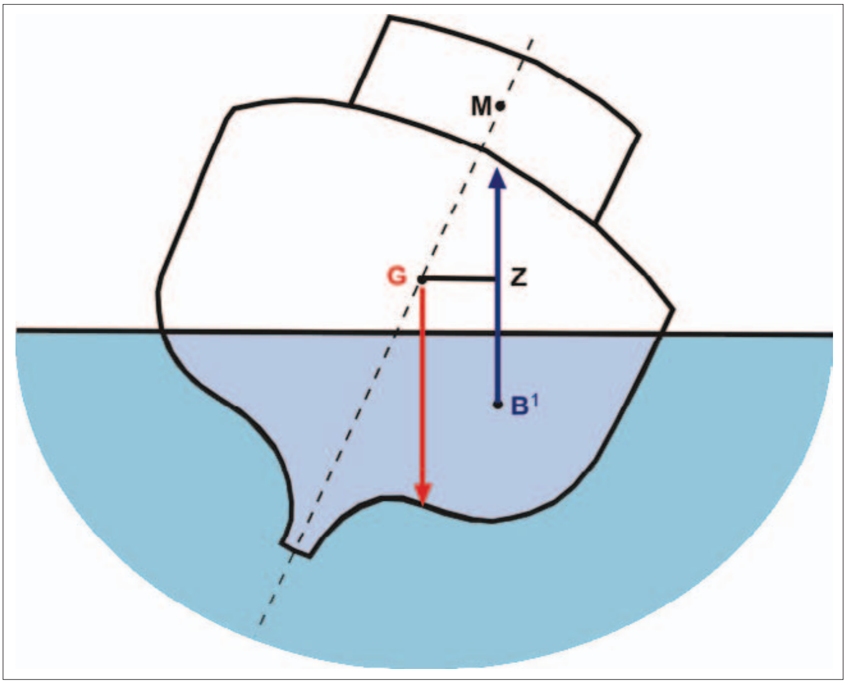
BUILT-IN BUOYANCY FOR UNDECKED VESSELS

Undecked vessels do not have a fixed watertight deck and will therefore not have the watertight and weathertight integrity of decked vessels. The safety of undecked vessels can be considerably improved if they are fitted with sealed buoyancy compartments, which are filled with solid buoyancy material.

Such compartments should be distributed so that the vessel stays afloat and on an even keel and without listing, in order to make bailing possible even if the vessel is fully swamped.



RIGHTING LEVER

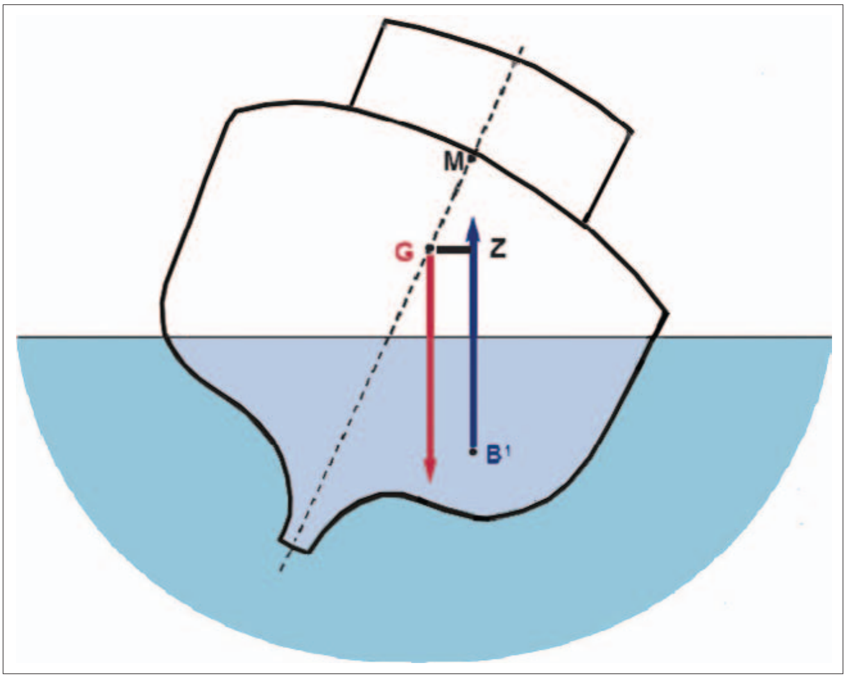


When heeled by an external force, the vessel's centre of gravity (**G**), which is unaffected by the heel and the weight (of the vessel), is considered to act vertically downward through **G**. The centre of buoyancy (**B**) (being the geometric centre of the underwater section) has moved to a new position **B**^{1} and the force of buoyancy (equal to the weight of water being displaced) is considered to act vertically up through the new centre of buoyancy **B**^{1}.

The horizontal distance from the centre of gravity (**G**) to the vertical line from **B**^{1} is called the **righting lever**. This distance can be measured and is usually referred to as **GZ**.

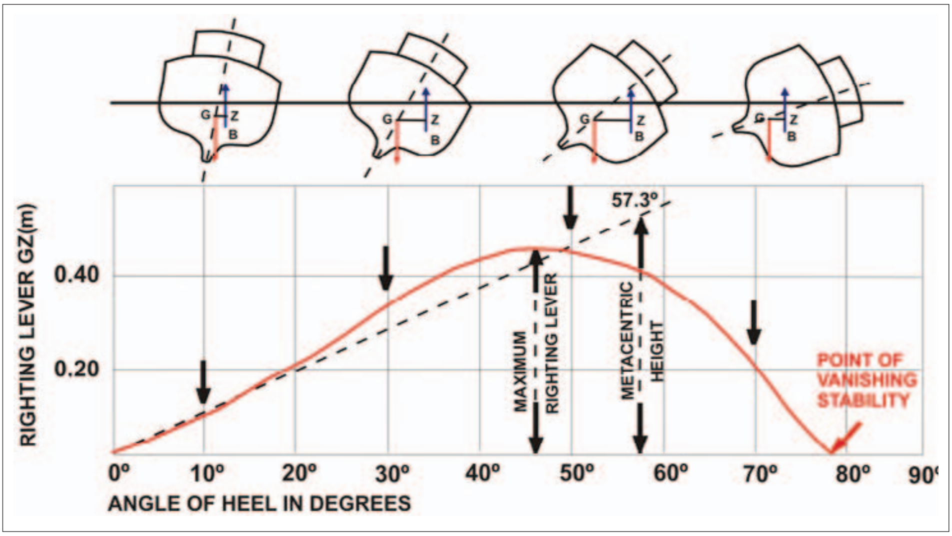
Therefore, the force involved in returning the vessel to the upright position is the weight of the vessel acting down through the centre of gravity (**G**) multiplied by the righting lever (**GZ**). This is referred to as the **moment of statical stability**.

The vessel's centre of gravity (**G**) has a distinct effect on the righting lever (**GZ**) and consequently the ability of a vessel to return to the upright position. The lower the centre of gravity (**G**), the bigger is the righting lever (**GZ**).



Should the vessel's centre of gravity (**G**) be near the metacentre (**M**) the vessel will have only a small metacentric height (**GM**) and the righting lever (**GZ**) will also be a small value. Therefore, the moment of statical stability to return the vessel to the upright position will be considerably less than that of the previous illustration.

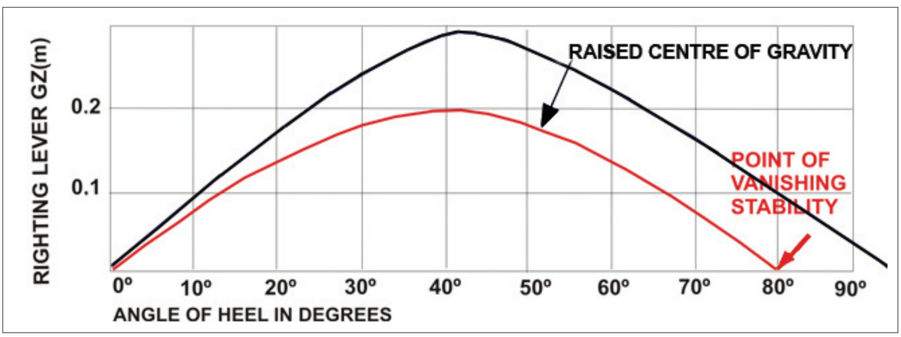
STABILITY CURVES (GZ CURVES)



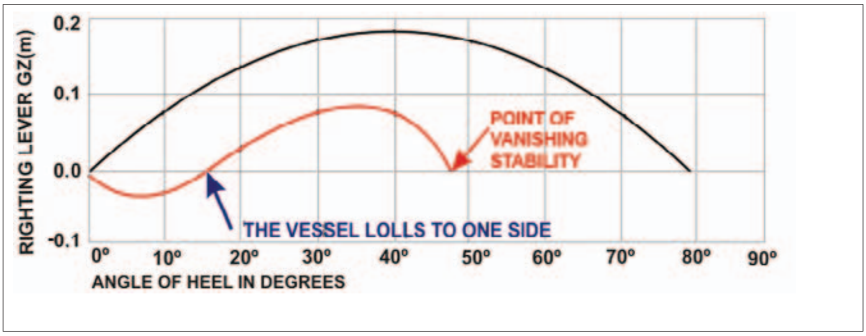
Stability curves (**GZ** curves) are used to show graphically the stability levers (**GZ**) exerted by a vessel to return itself to a position of equilibrium from the various conditions of heel. The curves have several general characteristics and the following factors should be observed:

(a) the metacentric height (**GM**);
(b) the maximum value of the righting lever (**GZ**); and
(c) the point of vanishing stability.

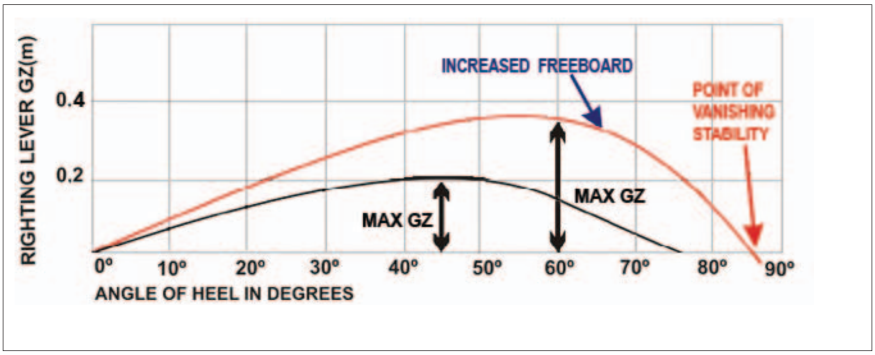
The shape of the righting lever curves is dependent on the form of the vessel's hull and its loading. The shape of the curve at small angles of heel generally follows the slope of the line plotted to the initial metacentric height (GM). In this regard, the freeboard and the ratio between the vessel's breadth and depth are also very important.



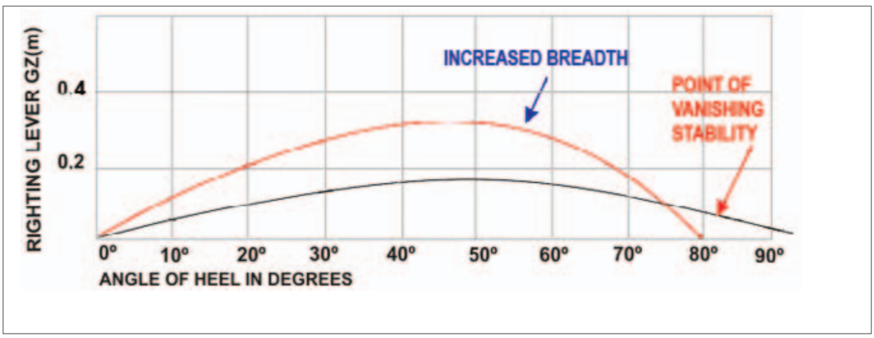
Raising the vessel's centre of gravity (**G**) causes a decrease in the metacentric height (**GM**) and thereby smaller values of the righting levers (**GZ**).



If the vessel's centre of gravity (**G**) is above the metacentre (**M**), the vessel is in an unstable equilibrium. The vessel has a negative **GM** and is not able to float upright. Either the vessel will capsize of or float at an angle from the upright to one side. (See also the section on loll on page 5).



By loading less the vessel will have more freeboard and the values of the righting lever (**GZ**) will, in general, be higher. The point of vanishing stability will also be higher, i.e. the vessel's ability to return to upright after having been heeled to large angles of heel is better.



The hull form of a vessel is an important factor in determining the characteristics of its stability. Increased breadth (beam) will result in higher values for metacentric heights (**GM**) and righting levers (**GZ**). However, the point of vanishing stability will be less, i.e. the vessel will capsize at a **smaller** angle of heel.

DYNAMIC STABILITY

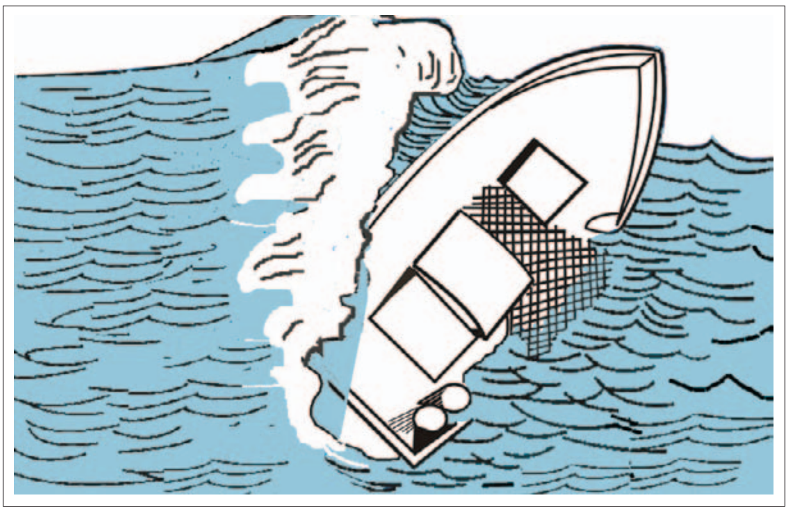
This is the stability characteristic of the vessel when moving (particularly rolling) and is the energy necessary to incline a vessel to a certain angle of heel and thereby counteract the **moment of statical stability**.

The dynamic stability may be determined by measuring the area under the righting lever curve (**GZ** curve) up to a certain angle of heel. The larger the area, the better is the dynamic stability.

Waves are the most common external force that causes a vessel to heel. Steep waves with short wavelengths, particularly breaking waves, are the most dangerous to small vessels.

The relationship between a vessel's dynamic stability and wave energy is complex and is, for example, dependent on the speed and course of the vessel in relation to the speed and direction of the wave. However, in general, the smaller the vessels, the smaller the waves they are able to cope with.

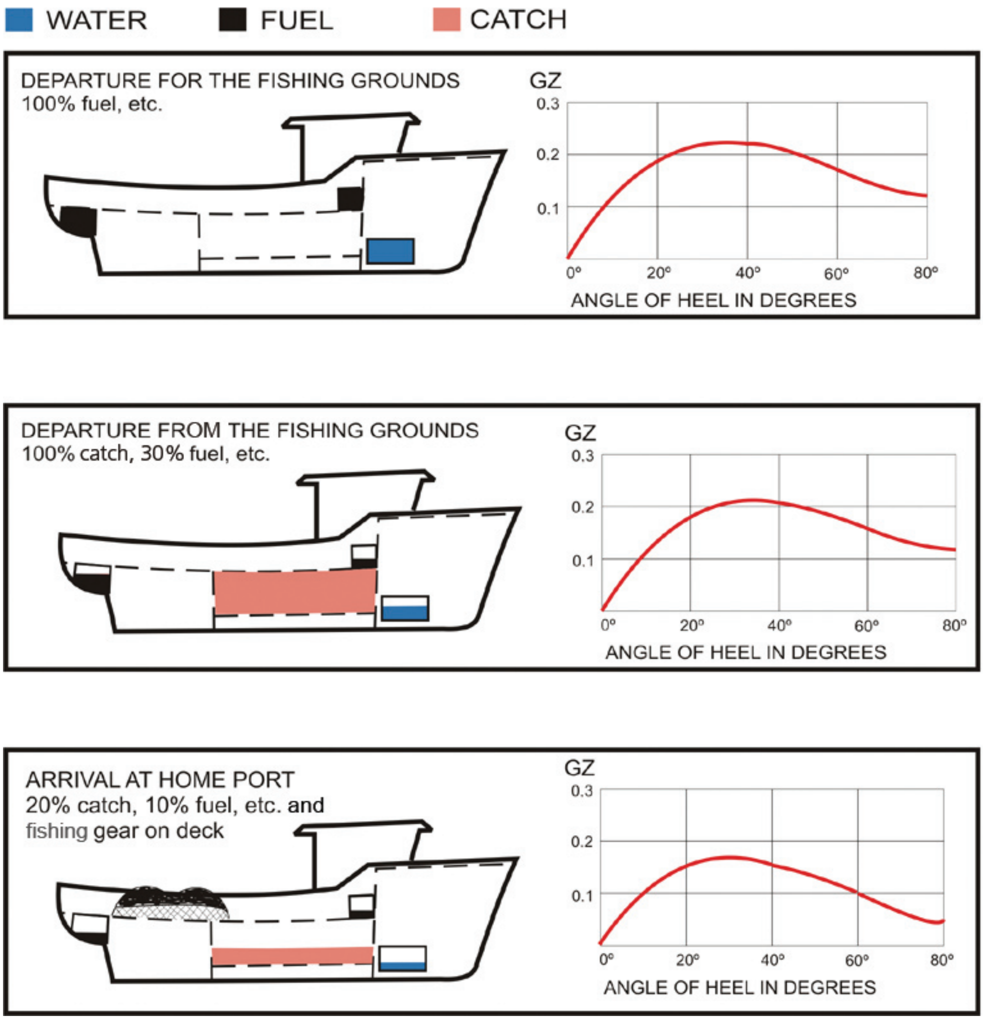
> The skipper should keep himself informed on weather forecasts in order to have sufficient time to avoid any weather conditions that could threaten the safety of his vessel.



CHANGES IN THE STABILITY CURVE DURING A VOYAGE

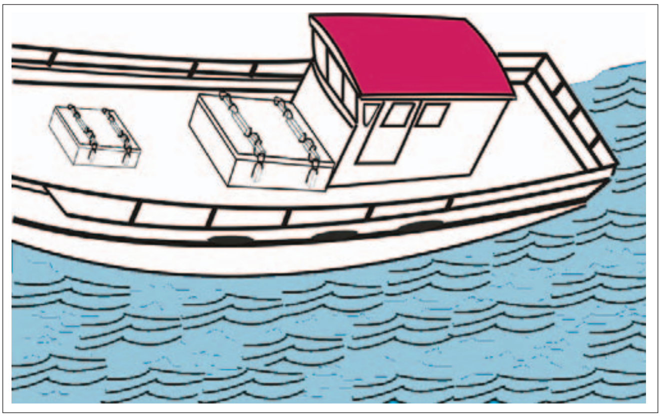
A fishing vessel's stability constantly changes during its voyage, depending on how the vessel is loaded and operated.

The following figures show typical stability curves for different operating conditions.



3. Precautions

The following sections illustrate some precautions which can be taken to ensure the stability of fishing vessels.

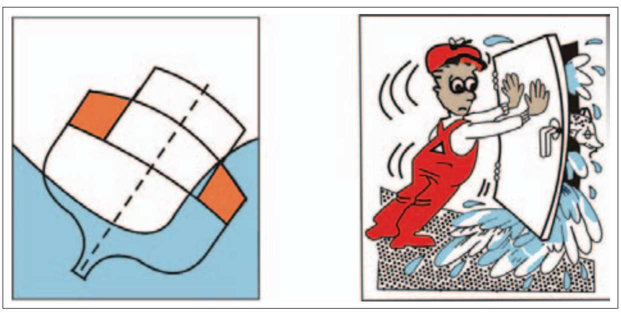


ENCLOSED SUPERSTRUCTURES AND MEANS OF CLOSING

All hatches, doorways, side scuttles and port deadlights, ventilators and other openings through which water can enter into the hull or deckhouses, forecastle, etc., should be kept closed in adverse weather conditions.

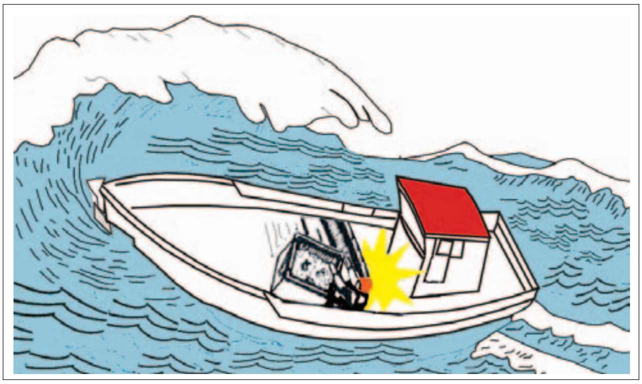
Accordingly, all fittings for closing and securing such openings should be maintained in good condition and periodically inspected.

All air pipes to fuel or water tanks should be properly protected and sounding pipes should be maintained in good condition and securely closed when not in use.



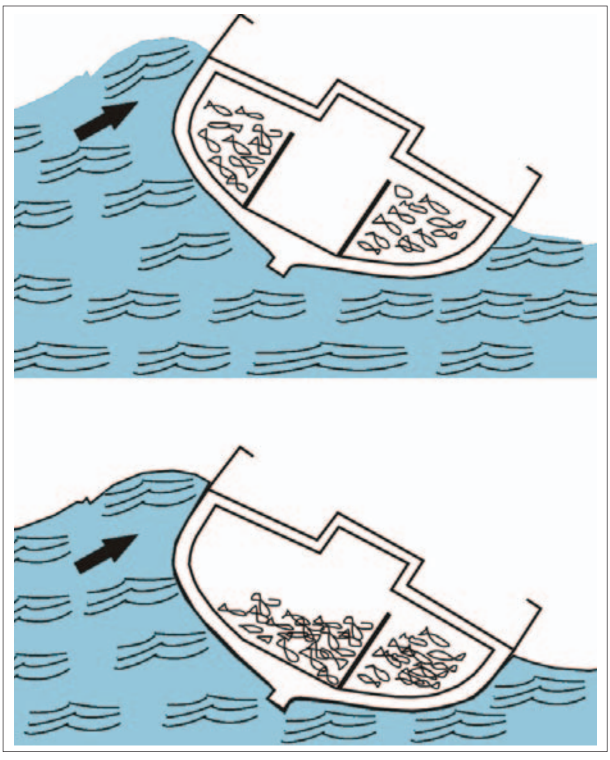
When the vessel is heeled by an external force to a large angle, a substantial part of its buoyancy, and thereby the vessel's ability to return to the upright position, comes from enclosed superstructures as shown in the picture above. In order to provide buoyancy, the enclosed superstructures must be fitted with appropriate closing appliances that are kept in good condition and securely closed.

SECURING OF HEAVY MATERIAL



All fishing gear and other heavy items should be properly stowed, placed low in the vessel and prevented from moving. **Fishing gear or other heavy items placed high in the vessel (for example on the top of the wheelhouse) will reduce the stability of the vessel.**

When ballast is provided to ensure sufficient stability of small vessels it must be permanent, solid and fixed securely in the vessel. Permanent ballast must not be removed from the vessel or relocated without the approval of a competent authority.

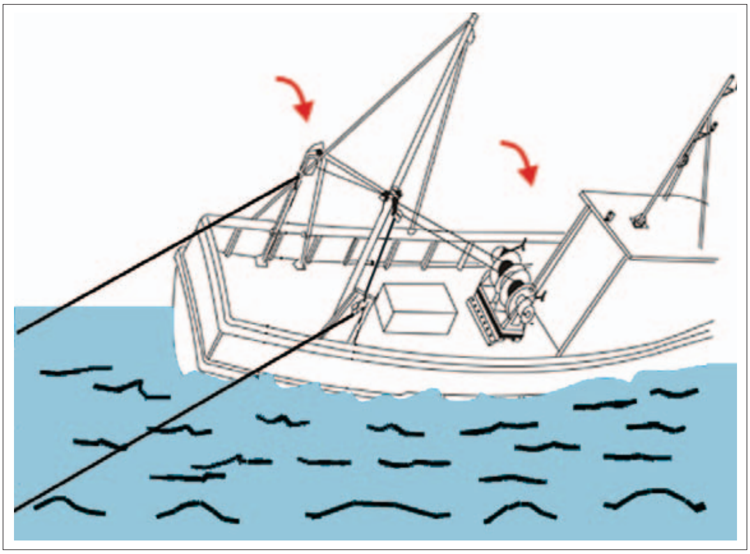


STOWAGE OF THE CATCH

Fishholds should be filled in a manner and order to prevent any extremes of heel or trim; and should not result in inadequate freeboard of the vessel.

To prevent a movement of the fish load carried in bulk, portable divisions in the holds should be properly installed.

EFFECTS OF FISHING GEAR ON STABILITY



Particular care should be taken when the pull from fishing gear might have a negative effect on stability (e.g. when nets are hauled by a power block or the trawl catches obstructions on the seabed). The pull of the fishing gear should be from as low a point on the vessel as possible.

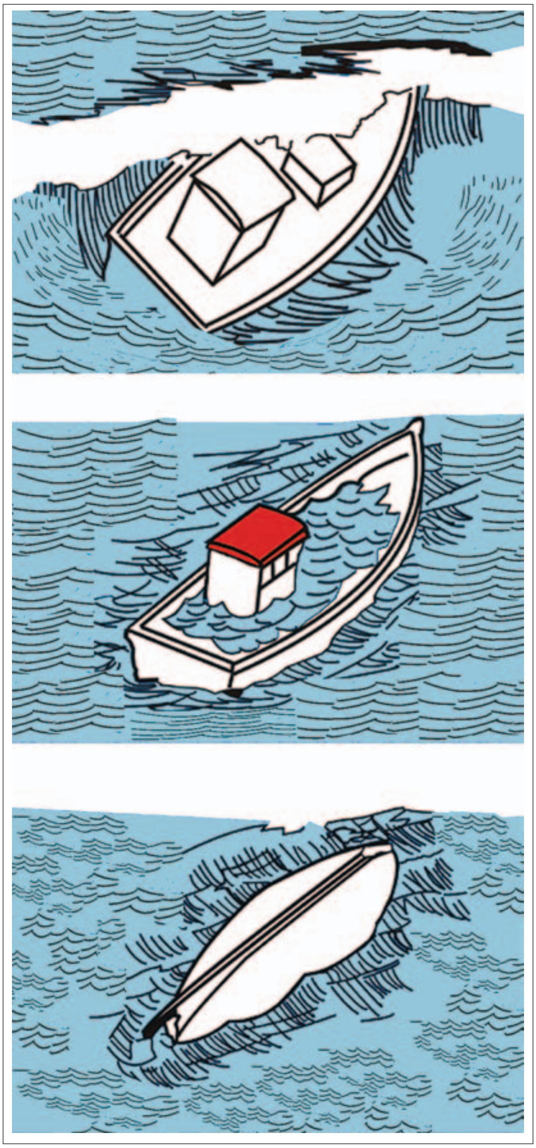
Extra care should also be taken when the vessel hangs fast by its fishing gear.

The heeling moment caused by the pull from the fishing gear will cause the vessel to capsize if it is larger than the righting moment (**moment of statical stability**).

Factors that increase the heeling moment and thereby the risk of capsizing of a vessel, include the following:

- heavy fishing gear, powerful winches and other deck equipment
- high point of pull of the fishing gear
- increased propulsion power (trawlers)
- adverse weather conditions
- vessel hanging fast by its fishing gear

FREE SURFACE EFFECTS



Care should always be taken to ensure the quick release of water trapped on deck. Locking freeing port covers is dangerous. If locking devices are fitted, the opening mechanism should always be easily accessible. Before vessels depart into areas subject to icing, freeing port covers, if fitted, should be kept in the open position or removed.

When the main deck is arranged for carrying deck loads with dividing pound boards, there should be slots of suitable size between the boards to allow an easy flow of water to the freeing ports, thus preventing the trapping of water.

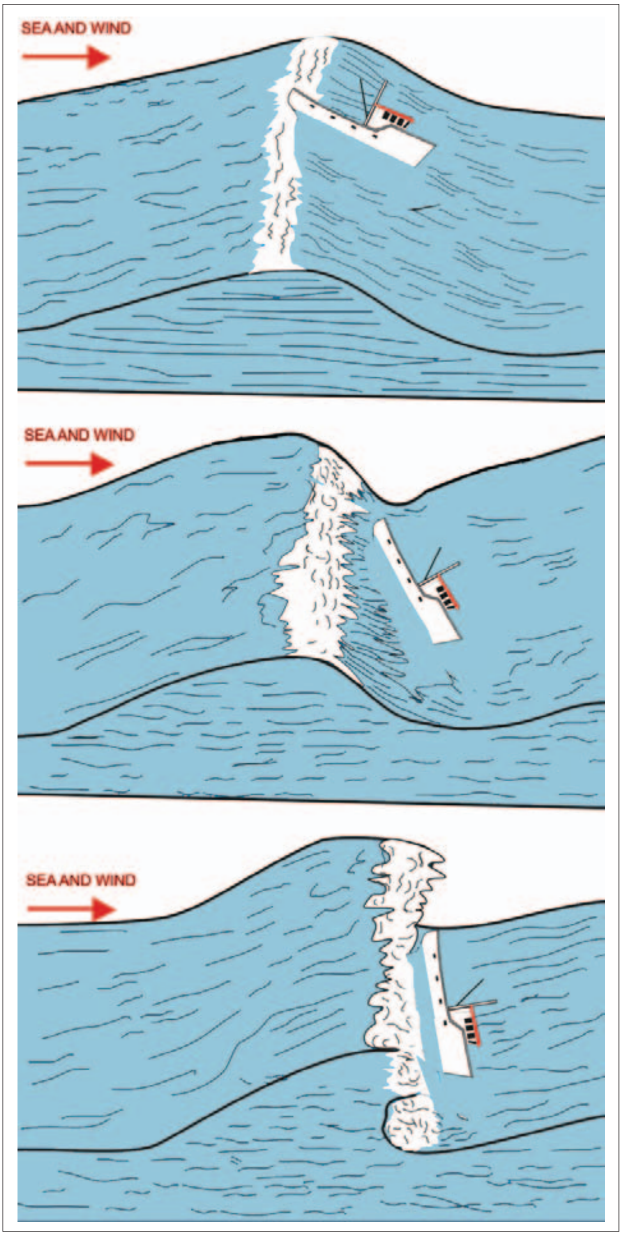
Partially-filled (slack) tanks can be dangerous; the number of slack tanks should be kept to a minimum.

Care should be taken when empty fish boxes are carried on the weather deck as water may become trapped in them and this will reduce the vessel's stability and increase the risk of capsizing.

FREEBOARD

Care should be taken to maintain adequate freeboard in all loading conditions and, when applicable, load line regulations should be strictly adhered to at all times. By reducing the freeboard, the values of the righting lever (**GZ**) will be smaller. The point of vanishing stability will also be at a smaller angle of heel, i.e. the vessel's ability to return to upright from large angles of heel will be less.

FOLLOWING AND QUARTERING SEAS



The crew should be alerted to all the dangers of following or quartering seas. Stability can be considerably reduced when the vessel is traveling at a similar speed and direction as the waves. If excessive heeling or yawing (change of heading) occurs, the speed should be reduced and/or the course changed.

CROSSING SAND BARS AND BEACH LANDINGS[1]

Operation of vessels from unprotected beaches requires special skills and special care should be taken in surf zones.

General

- Prior to crossing a bar, always contact the local authority for an update on conditions at the bar.
- Do not attempt to cross any bar without experience or local knowledge. Obtain advice from a local skipper or from the coastguard. Cross the bar with other experienced skippers before trying it yourself.
- Know the times of the tides and obtain an up-to-date weather forecast.
- Check the steering and throttle and gear controls and ensure that all watertight hatches are closed and scuppers are cleared before attempting to cross the bar.
- Secure all loose items of gear and equipment on board.
- Ensure that all crew are briefed and wearing lifejackets and that a sea-anchor is ready to be deployed in an emergency, if required.
- Once committed, keep going because trying to turn around in the middle of a bar can be dangerous.
- It is always preferable to cross on a slack or incoming tide and in daylight.
- Ensure that any other vessel is well clear of the bar before attempting to cross.

[1] Based on Part A of the FAO/ILO/IMO Code of Safety for Fishermen and Fishing Vessels, 2005

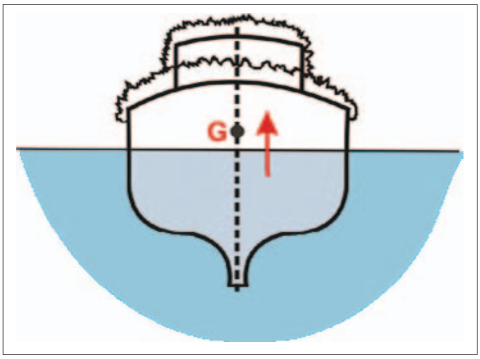
Proceeding to sea

- Request permission prior to leaving the port and inform the local authority of the time of the expected return of the vessel and the number of crewmembers aboard. The port authority should inform the vessel of any information relevant to the weather conditions and of any recent changes to the bar or expected weather conditions.
- Should the conditions for the exiting port deteriorate, identify an alternative port and ensure that there is enough fuel and supplies on board to undertake such an alternative plan.
- Ensure that all safety equipment required by the competent authority is on board and is fit for use.
- In crossing the bar, idle towards the breaking waves watching carefully for any lull. If a flat period occurs, apply the throttle and run through.
- If the waves keep rolling in, move to the surf zone and accelerate over the first wave and apply more power to run to the next wave.
- The outgoing vessel should meet the incoming wave energy at a moderate speed, because at high speed a vessel can become airborne, which can cause damage and loss of control. At a low speed the waves can break on board the vessel or the vessel can broach. Aim the vessel for the lowest part of the wave which will be the last to break and cross the wave at an angle of no more than 10°.
- Back off the power just before contact with the swell and as you come through or over the breaking wave accelerate again and repeat the process until clear.

Heading back to port

- Vessels should request permission to enter the port and the local port authority should advise of any changes to the bar.
- Approaching from the sea, increase the power of the vessel to catch up with the bigger set of waves.
- Position the vessel on the back of a wave and on no account attempt to surf down the face of a wave.
- Adjust the vessel's speed to match the speed of the waves and do not attempt to overtake the waves, nor allow the breaker behind to overtake you.
- If your vessel is not capable of keeping up with the incoming waves, then you will need to let the waves run under your vessel. It may be necessary to slow your vessel or use a sea-anchor to maintain steerage and avoid broaching in a following sea.

ICING



Icing significantly reduces the stability of the vessel.

Icing will increase the displacement of a vessel and reduce the freeboard. The centre of gravity **(G)** will rise and the metacentric height **(GM)** will decrease, causing a reduction in the stability of the vessel. Icing also leads to an increase of windage area due to ice formation on the upper parts of the vessel and, hence, an increase in the heeling moment due to the action of the wind.

Some causes of ice formation:

- deposit of water droplets on the vessel's structure: these droplets come from spray driven from wave crests and from vessel-generated spray;
- snowfall, sea fog including arctic sea smoke, a drastic fall in ambient temperature, as well as from the freezing of rain drops upon impact with the vessel's structure;
- water shipped on board and retained on deck.

Listen for weather forecasts and warnings of the possibility of ice accretion; such areas should be avoided if possible.

If in spite of all measures taken the vessel is unable to leave the dangerous area, all means available for removal of ice from the vessel should be used while it is subjected to ice formation.

The ice from large surfaces of the vessel should be removed, beginning with the upper structures – even a small amount of ice in these areas will cause a drastic worsening of the vessel's stability. Ice should be removed from the freeing ports and scuppers as soon as it appears in order to ensure free drainage of water from the deck.

When the distribution of ice is not symmetrical and a list develops, the ice should be removed from the lower side first. Bear in mind that any correction of the list of the vessel by pumping fuel or water from one tank to another may reduce stability during the process when tanks are slack.

DETERMINING STABILITY OF SMALL VESSELS WITH ROLLING PERIOD TESTS

As a supplement to the approved stability information, the initial stability can be determined approximately by means of a rolling period test.

Vessels with a high initial stability are "stiff" and have a short rolling period; while vessels with a low initial stability are "tender" and have a long rolling period.

The following describes a rolling period test which can be performed at any time by the crew of a small vessel.

Test procedure

- The test should be conducted in smooth water with the mooring lines slack and the vessel "breasted off" to avoid making any contact with any vessel or harbour/port structure during the rolling test. Care should be taken to ensure that there is a reasonable clearance of water under the keel and the sides of the vessel.

- The vessel is made to roll. This can, for example, be done by crew running together from one side of the vessel to the other. As soon as this forced rolling has commenced, the crew should stop and place themselves amidships and the vessel allowed to roll freely and naturally.

- Timing and counting the oscillations should begin only when it is judged that the vessel is rolling freely and naturally and only as much as it is necessary to accurately time and count these oscillations (approximately 2°-6° to each side).

- With the vessel at the extreme end of the roll to one side (say port) and the vessel about to move toward the upright, one complete oscillation will have been made when the vessel has moved right across to the other extreme side (i.e. starboard) and returned to the original starting point and is about to commence the next roll.

- Using a chronometer, times should be taken for at least four complete oscillations. Counting should begin when the vessel is at the extreme end of a roll.
- After the roll completely fades, this operation should be repeated at least twice more. Knowing the total time for the total number of oscillations made, the time for one complete oscillation, say T seconds, can be calculated.

Determining whether the initial stability is sufficient

- If the calculated value of T, in seconds, is less than the breadth of the vessel, in metres, it is likely that the initial stability is sufficient, provided that the vessel carries full fuel, stores, ice, fishing gear, etc.

- The rolling period T usually increases and the vessel becomes "tenderer" as the weight of fuel, stores, ice, fishing gear, etc. decreases. As a consequence, the initial stability will also decrease. If the rolling period test is conducted under such circumstances it is recommended that, for the estimate of the initial stability to be considered satisfactory, the calculated value of T, in seconds, should not be more than 1.2 times the breadth of the vessel, in metres.

Limitations to the use of this method

This method may not be applicable to vessels with a hull shape that dampens the rolling, for example vessels with large bilge keels or vessels of an unconventional design, such as high-speed fishing vessels.

4. Alterations to vessels

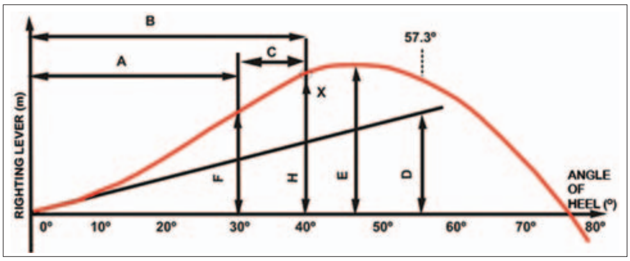
When alterations to a vessel can affect its stability, the competent authority should approve the alterations before they are undertaken.

Such alterations may include the following:
- conversion to new fishing methods;
- changes in the main dimensions, such as lengthening of the hull;
- changes in the size of the superstructures;
- changes in the location of bulkheads;
- change in the closing appliances of openings through which water can enter into the hull or deckhouses, forecastle, etc.;
- removal or shifting, either partially or fully, of the permanent ballast; and
- change of the main engine.

Consider how changes can affect the stability of the vessel.

5. Stability criteria for small fishing vessels

Fishing vessels should be so designed, constructed and operated that the minimum stability criteria established by the competent authority will be met in all operating conditions. The following minimum stability criteria are recommended for decked fishing vessel.[2]



- A The area under the righting lever curve (**GZ** curve) should not be less than **0.055** m-rad up to 30° angle of heel.
- B The area under the righting lever curve (**GZ** curve) should and not less than **0.090** m-rad up to X° angle of heel.
- C The area under the righting lever curve (**GZ** curve) between the angles of heel of 30° and X° should not be less than **0.030** m-rad.
- X 40° or the angle of flooding θ_f if this angle is less than 40°. θ_f is the angle of heel at which openings in the hull, superstructures or deckhouses which cannot rapidly be closed watertight commence to immerse.
- D The initial metacentric height $\mathbf{GM_0}$ should not be less than **350 mm** for single deck vessels. In vessels with complete superstructure the metacentric height may be reduced to the satisfaction of the competent authority but in no case should be less than 150 mm.
- E The maximum righting lever **GZmax** should occur at an angle of heel preferably exceeding **30°** but not less than **25°**.
- F The righting lever **GZ** should be at least **200 mm** at an angle of heel equal to or greater than 30°. The righting lever **GZ** may be reduced to the satisfaction of the competent authority but in no case by more than 2(24-L)%, where L is the length of the vessel as defined in the FAO/ILO/IMO Voluntary Guidelines for the Design, Construction and Equipment of Small Fishing Vessels (2005).

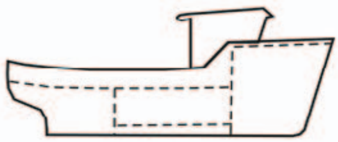
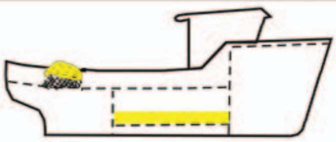
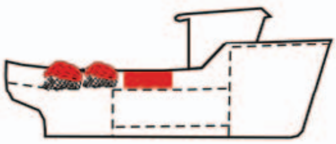
2 Based on the FAO/ILO/IMO Voluntary Guidelines for the Design, Construction and Equipment of Small Fishing Vessels, 2005

6. Stability documentation

Suitable stability information, prepared to the satisfaction of the competent authority, should be provided for each vessel to enable the skipper to easily assess the stability of the vessel under various operating conditions.

Stability notice such as the one below may be suitable for small vessels.

STABILITY NOTICE

	PLACEMENT OF GEAR AND CATCH	STABILITY		
		Acceptable	At the limit	Danger of capsize
	• Empty fish hold			
	• Catch in fish hold			
	• Part load in hold • Gear on deck			
	• Considerable catch on deck • Gear on deck • Empty fish hold			

Simple effects for maintaining stablility:

- Close doors and hatches
- Ensure that scuppers and freeing ports are open and clear of obstructions to allow water to drain quickly from the deck
- Secure catch and gear against shifting
- Move gear and catch from the deck into the fish hold
- Avoid following seas
- Large helling moments when hauling gear are to be avoided

Stability information provided for larger vessels will often include the following:

a) operating conditions;
b) hydrostatic curves; and
c) cross curves.

The curves can also be presented in the form of tables, as illustrated below:

TABLE 1
HYDROSTATIC CURVES

Draught T_{kc} m	Displacement mass DISM t	KM m	MTC tm/cm	XB m	XF m	Max. KG m
...	...	...	...	...	...	...
1.35	14.68	1.909	0.129	3.940	3.842	1.347
1.36	14.91	1.906	0.130	3.939	3.841	1.344
1.37	15.14	1.904	0.131	3.937	3.840	1.341
1.38	15.36	1.901	0.133	3.935	3.839	1.337
1.39	15.59	1.898	0.134	3.934	3.838	1.333
1.40	15.82	1.895	0.135	3.932	3.837	1.329
1.41	16.06	1.892	0.136	3.930	3.836	1.326
1.42	16.30	1.890	0.137	3.928	3.835	1.324
1.43	16.54	1.887	0.138	3.926	3.834	1.323
1.44	16.77	1.884	0.139	3.925	3.833	1.322
1.45	17.01	1.882	0.140	3.923	3.832	1.321

TABLE 2
CROSS CURVES (LK CURVES)

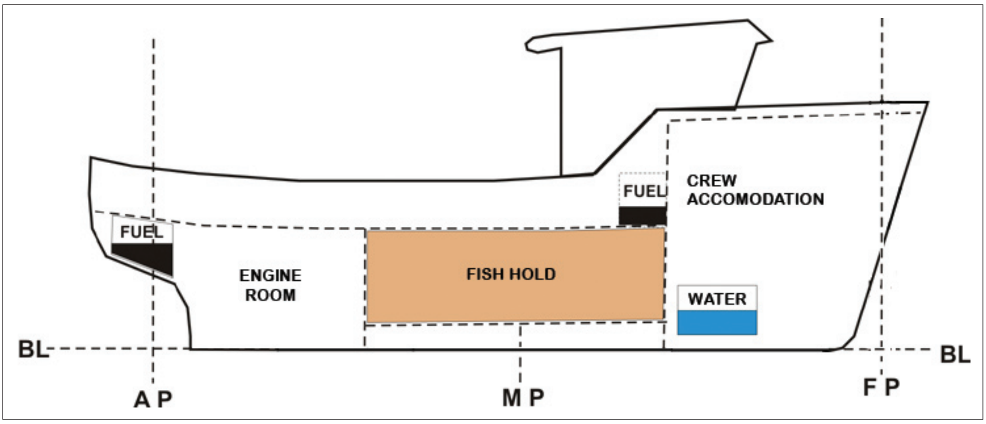
Draught T_{kc} m	LK 10° m	LK 20° m	LK 30° m	LK 40° m	LK 50° m	LK 60° m	LK 70° m
...	...	...	...	...	...	...	...
1.36	0.328	0.634	0.872	1.058	1.217	1.339	1.428
1.37	0.327	0.633	0.871	1.057	1.216	1.339	1.428
1.38	0.326	0.632	0.869	1.056	1.216	1.338	1.428
1.39	0.325	0.629	0.866	1.054	1.215	1.338	1.428
1.40	0.324	0.627	0.864	1.053	1.215	1.338	1.428
1.41	0.323	0.626	0.863	1.052	1.214	1.338	1.428

OPERATING CONDITIONS

In order to assess the vessel's stability, planning for different operating conditions should be prepared. For example, this can be done by creating a form similar to the one below and thereafter calculating the stability particulars as required by the competent authority.

EXAMPLE:

Operating condition: Departure from the fishing grounds with full catch.



Item	Mass t	XG m (from AP)	LMOM t m	ZG m (above BL)	VMOM t m	i_B ρ t m
Water	0.03	6.50	0.195	0.40	0.012	0
Fuel	0.22	0.00	0.000	1.30	0.286	0
Fuel	0.03	5.80	0.174	1.90	0.057	0
2 crew	0.16	4.00	0.640	2.60	0.416	0
Catch	5.00	4.50	22.500	1.15	5.750	0
Deadweight	5.44	-	23.509		6.521	0
Lightship weight	10.15	4.17	42.326	1.38	14.007	0
Displacement mass	15.59		65.835		20.528	0

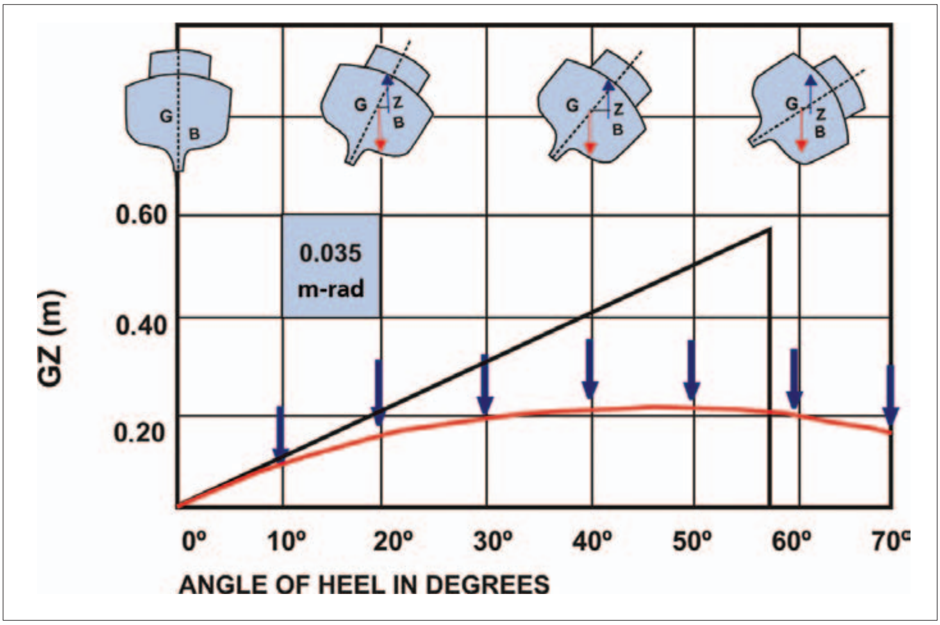
Calculate **KG**:
KG = VMOM/Mass = 20.528/15.59 = **1.317 m** above the base line, **BL**.
From the vessel's mass displacement of **15.59 tonnes** the values for the reference draught $\mathbf{T_{KC}}$ and the **KM** can be found from the table of hydrostatic curves on page 38.
T_{KC} = 1.39 m and KM = **1.898 m** above **BL**.

Calculate **GM**: **GM** = KM – KG = 1.898 – 1.317 = **0.581 m**.

From the reference draught 1.39 m the values for LK for all angles of heel (ф) can be found from the table of cross curves on page 38. Thereafter calculate the GZ: GZ = LK – KG x sin ф

ф (°)	10	20	30	40	50	60	70
sin ф	0.174	0.342	0.500	0.643	0.766	0.866	0.940
LK (m)	0.325	0.629	0.866	1.054	1.215	1.338	1.428
KG x sin ф (m)	0.229	0.450	0.659	0.847	1.009	1.141	1.238
GZ (m)	0.096	0.179	0.208	0.207	0.206	0.197	0.190

STABILITY CURVE



Various methods can be used to calculate the area under the stability curve (**GZ**). The simplest is to divide the area under the curve into a suitable number of trapezes and calculate their total area (the trapezoidal rule). The area may also be calculated by the so-called "Simson's rules" which is demonstrated below:

ϕ (°)	10	20	30	40	
GZ (m)	0.096	0.179	0.208	0.207	
SM I	3	3	1		
GZ-SM I	0.288	0.537	0.208		SUM I : 1.033
SM II	4	2	4	1	
GZ-SM II	0.384	0.358	0.832	0.207	SUM II : 1.781

Area 0°-30°: 0.0654 x SUM I = 0.0654 x 1.033 = 0.068 m-rad
Area 0°-40°: 0.0582 x SUM II= 0.0582 x 1.781 = 0.104 m-rad
Area 30°-40°: = 0.104 – 0.068 = 0.036 m-rad

Compare the calculated stability values with the stability criteria in Chapter 5.

Stability value	Calculated	Criteria
Area under the curve 0°-30°	**0.068 m-rad**	0.055 m-rad
Area under the curve 0°-40°	**0.104 m-rad**	0.090 m-rad
Area under the curve 30°-40°	**0.036 m-rad**	0.030 m-rad
GZ max	**0.21 m**	
Angle where GZ max occurs	**37°**	25°
Angle where GZ > 0.20 m occurs	**37°**	30°
Metacentric height (GM)	**0.581 m**	0.350 m
The point of vanishing stability	**>70°**	

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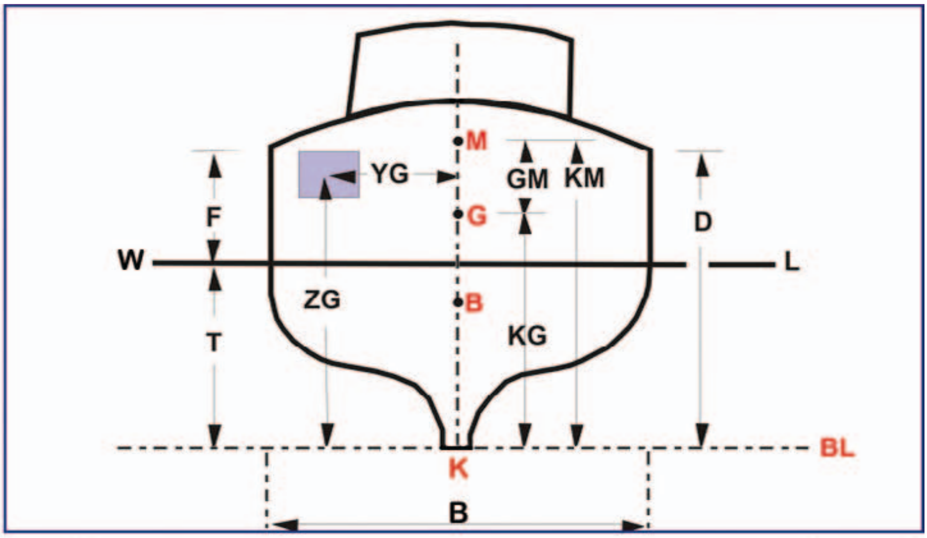
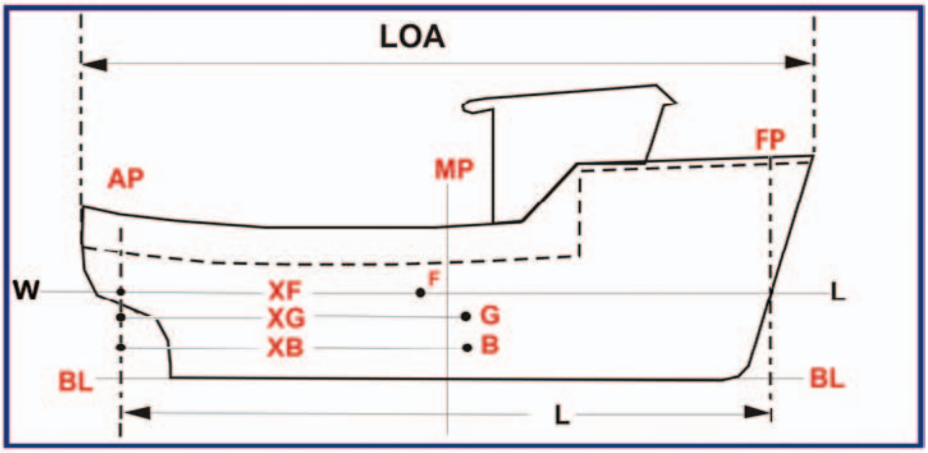
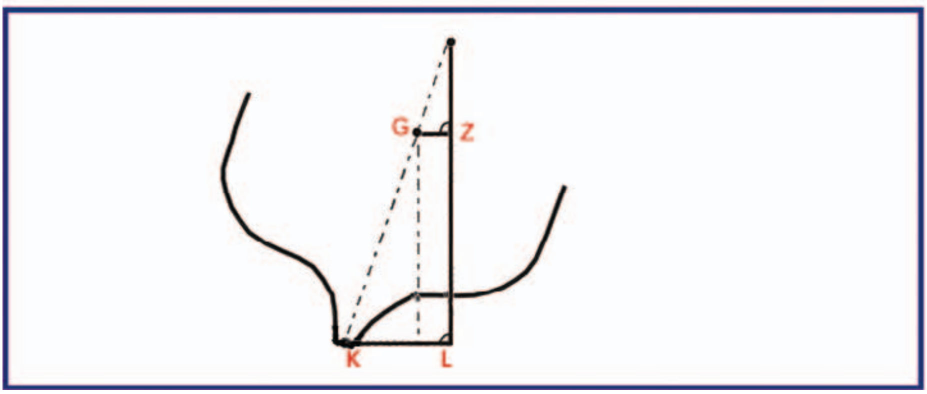
Annex 1. Examples of symbols used in stability documentation







Annex 2. Terms and symbols

Term	Symbol	Page
After perpendicular	AP	7,39,45
Baseline	BL	7,39,45
Breadth	B	45
Buoyancy		7
Centre of buoyancy	B	7
Centre of floatation	F	45
Centre of gravity	G	6
Centreline	CL	
Cross curves		38
Deadweight	DW	4
Density	ρ	
Depth	D	45
Displacement (or displacement volume)	DISV	3
Displacement mass	DISM	4
Dynamic stability		21
Equilibrium		10
Forward perpendicular	FP	7,39,45
Free surface effect		13,26
Freeboard	F	3,26,45
Freeing ports		14,26
Gravity		6
GZ-curves		19
Heel		5
Heel angle		19,20,22,35,40
Hydrostatic curves		38
Keel	K	6,45
Length (usually Lpp)	L	45
Length over all	LOA	45
Light ship weight		4
List		5
Loll		5
Metacentre	M	8
Metacentric height	GM	10,45
Mid between perpendiculars (amidships)	MP	7,39,45
Moment to change trim one centimetre	MTC	38

Annex 3. Test on fishing vessel stability

1	Heel	Is the heel the inclination of a vessel: a) by an external force? OR b) by movement of weight within the vessel?
2	Deadweight	Is the deadweight: a) the weight of water a vessel displaces? OR b) the actual weight that a vessel carries when loaded?
3	Draught	Is the draught: a) the vertical distance from the waterline to the working deck? OR b) the vertical distance from the waterline to the keel?
4	Centre of gravity	Is the centre of gravity the point at which the whole weight of a body is said to act: a) vertically downwards? OR b) vertically upwards?
5	Centre of buoyancy	Is the centre of buoyancy: a) the point through which the force of buoyancy is said to act vertically downwards? OR b) the geometric centre of the underwater section of the vessel?

6	A stable vessel	Is a vessel in stable equilibrium when the metacentre is: a) above the centre of gravity? OR b) in the same position as the centre of gravity?
7	Free surface effect	Is the free surface effect eliminated: a) when all tanks are full? OR b) when all tanks are empty?
8	Righting lever	Is the righting lever: a) the horizontal distance between the centre of gravity and a vertical line through the centre of buoyancy when a vessel is heeled? OR b) the GZ?
9	Free surface effect	Is the free surface reduced: a) by subdividing tanks? OR b) by keeping tanks half full?
10	Stiff vessel	Is a stiff vessel a vessel with: a) a large metacentric height? OR b) a small GM?
11	Tender vessel	Is a tender vessel a vessel with: a) a large GM? OR b) a small metacentric height?
12	Fish on deck	Do fish on deck: a) increase the stability of the vessel? OR b) decrease the stability of the vessel?

13	Freeing ports	Should freeing ports: a) be blocked and only cleared when needed? OR b) always be clear?
14	Heavy weights at high points	Do heavy weights at high points: a) decrease the GM? OR b) increase the stability of the vessel?
15	Icing	Is icing an accumulation of ice which: a) reduces the freeboard of a vessel and its stability? OR b) increases the deadweight and stability of the vessel?
16	Alterations to vessels	Should a fishing vessel owner report to the competent authority alterations to his vessel: a) before the alterations are undertaken? OR b) after the alterations are undertaken?

ANSWERS TO TEST

1 a); 2 b); 3 b); 4 a); 5 b); 6 a); 7 a) and b); 8 a) and b); 9 a); 10 a); 11 b); 12 b); 13 b); 14 a); 15 a); 16 a).

Annex 4. Documentation consulted

FAO/ILO/IMO Code of Safety for Fishermen and Fishing Vessels, Part A – Safety and Health Practice, 2005

The revised version of part A of the Code is directed primarily towards competent authorities, training institutions, fishing vessel owners, representative organizations of the crew, and non-governmental organizations having a recognized role in crewmembers' safety and health and training.

FAO/ILO/IMO Code of Safety for Fishermen and Fishing Vessels, Part B- Safety and Health Requirements for the Construction and Equipment of Fishing Vessels, 2005

The revised version of part B of the Code is directed primarily towards shipbuilders and owners, containing requirements for the construction and equipment for fishing vessels of 24 metres in length and over

FAO/ILO/IMO Voluntary Guidelines for the Design, Construction and Equipment of Small Fishing Vessels, 2005

The purpose of the Voluntary Guidelines is to provide an updated, general guidance on safe practices for the design, construction and equipment of smaller fishing vessels i.e. fishing vessels of 12 metres in length and over but less than 24 metres in length

The 1993 Torremolinos Protocol and Torremolinos International Convention for the Safety of Fishing Vessels (Consolidated edition, 1995)

This publication contains the regulations for the construction and equipment of fishing vessels of 24 metres in length and over

Code on Intact Stability for All Types of Ships covered by IMO Instruments (resolution A.749(18), as amended)

This publication provides in a single document recommended provisions relating to intact stability, based on existing IMO instruments

Recommended Practice on Portable Fish-Hold Divisions (resolution A.168(ES.IV), as amended by resolution A.268(VIII), appendix V)

This resolution contains formulae for scantlings of portable fish-hold divisions

Model Loading and Stability Manual (MSC/Circ. 920)

This document provides guidance on the preparation of stability documentation, using a uniform layout as well as agreed terms, abbreviations and symbols, which are important for the correct use of such documentation.

BOBP/MAG/16 - A safety guide for small offshore fishing boats

This publication provides information to boatyards, boat owners and crew on the design and operational aspects related to the safety of decked fishing boats of less than 12 m in length.

This document introduces some basic principles on the stability of small fishing vessels and provides simple guidance on what fishing vessel crews can do to maintain adequate stability for their vessels. It is not intended to be a complete course on fishing vessel stability. The publication is aimed at fishers and their families, fishing vessel owners, boatbuilders, competent authorities and others who are interested in the safety of fishing vessels and fishers. It may also serve as a guide for those concerned with training in matters of safety of fishing vessels.

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