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A Guide to Fishing Vessel Stability



The Society of Naval Architects and Marine Engineers

Developed by

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Preface

SNAME's "A Guide to Fishing Vessel Stability" was developed to educate the commercial fishing community on how a fishing vessel's stability works and the effect of common fishing operations on a fishing vessel's stability levels. The topics covered and the illustrations used are generic examples of situations that fishing vessel crews may encounter and should only be used as a reference guide. Stability is a very complex subject and there are many variations in fishing vessel designs and fishing methods. Contact your naval architect or one of the organizations listed at the end of this booklet to learn about your own boat's stability characteristics.

Table of Contents

<u>Section</u>	<u>Page</u>
Acknowledgements	2
Introduction	4
What is “Stability”?	5
When is a Vessel Stable or Unstable?	7
Key Terms Used in Fishing Vessel Stability	8
How Stability Works	9
How is a Fishing Vessel’s Stability Measured?	14
Initial vs. Overall Stability - The Hidden Danger	22
Free Surface - Shifting into Danger	27
Fishing Operations - Danger at the Helm	34
Wind and Waves - Danger in Heavy Seas	40
Prudent Seamanship - Keeping a Level Vessel	48
List of Stability Terms	51
How do Naval Architects Develop Stability Guidance?	53
List of Contacts for Additional Information	57

Introduction

This booklet introduces the basic concepts of a fishing vessel's stability to fishing vessel crews, vessel owners, and other interested parties in the commercial fishing community. The primary stability concepts explored are;

- What is stability?
- How does stability work?
- How do Naval Architects determine a fishing vessel's stability to develop safe operating guidance?
- What is the difference between initial and overall stability?
- What is the hidden danger in using a fishing vessel's "feel", which is its initial stability, to gauge if there is adequate overall stability?
- What are the effects of common fishing vessel operations on its stability?
- What can fishing vessel crews do to maintain adequate stability?

This booklet treats a wide range of subjects concerning fishing vessel stability. To assist the reader, critical important lessons are listed at the beginning of each section. Please consider each topic separately, remembering the following five important take-home messages.

1. A fishing vessel's stability is created by the interaction between the weight of the vessel pushing down and the buoyancy of the hull pushing up.
2. The "feel" of a vessel indicates how much initial stability it has - it **does not** indicate if the vessel has enough overall stability for a safe voyage.
3. A fishing vessel's stability is constantly changing throughout its voyage.
4. How a fishing vessel is loaded and operated affects the stability levels positively or negatively.
5. Work with your naval architect to determine suitable stability guidance your vessel's unique stability characteristics.

What is Stability?

Important Lessons

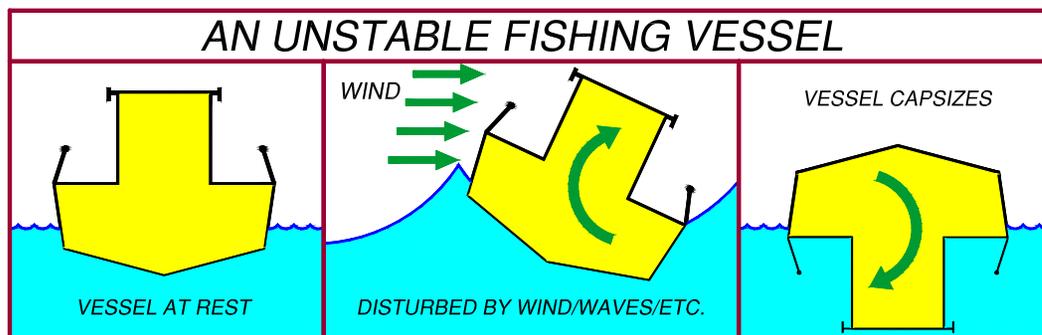
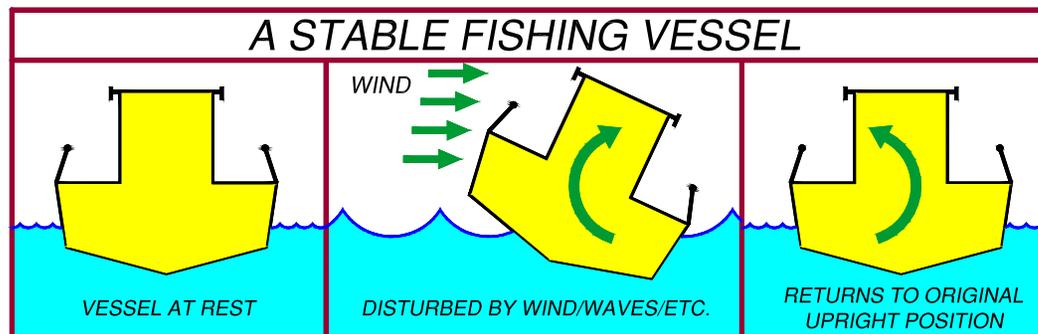
1. **Stability** is the ability of a fishing vessel to return to its upright position after being heeled over by any combination of wind, waves, or forces from fishing operations. (See page 6)
2. A **stable** fishing vessel has sufficient stability to counter the current external forces generated by weather and fishing conditions and return to its upright position. (See page 6)
3. An **unstable** fishing vessel does not have sufficient stability to counter the current external forces generated by weather and fishing conditions and capsizes. (See page 6)
4. A fishing vessel's stability is constantly changing during its voyage. An originally stable fishing vessel may become **unstable** from changes in the weather, the vessel's loading or fishing operations. (See page 6 & 7)
5. The key to having a **stable** vessel is making sure there is always be sufficient stability to counter the capsizing forces from the current weather, waves, and fishing conditions during the **entire** voyage. (See page 7)

What is Stability?

Stability is the ability of a floating object to return to its initial upright position of stable equilibrium after being disturbed by an outside force.

In fishing vessels, **stability** is the ability of the vessel to return to its upright position after being heeled over by any combination of wind, waves, or forces from fishing operations.

A fishing vessel is called **stable** when it has enough positive stability to counter the external forces generated by current weather and fishing conditions and will return to its upright position.

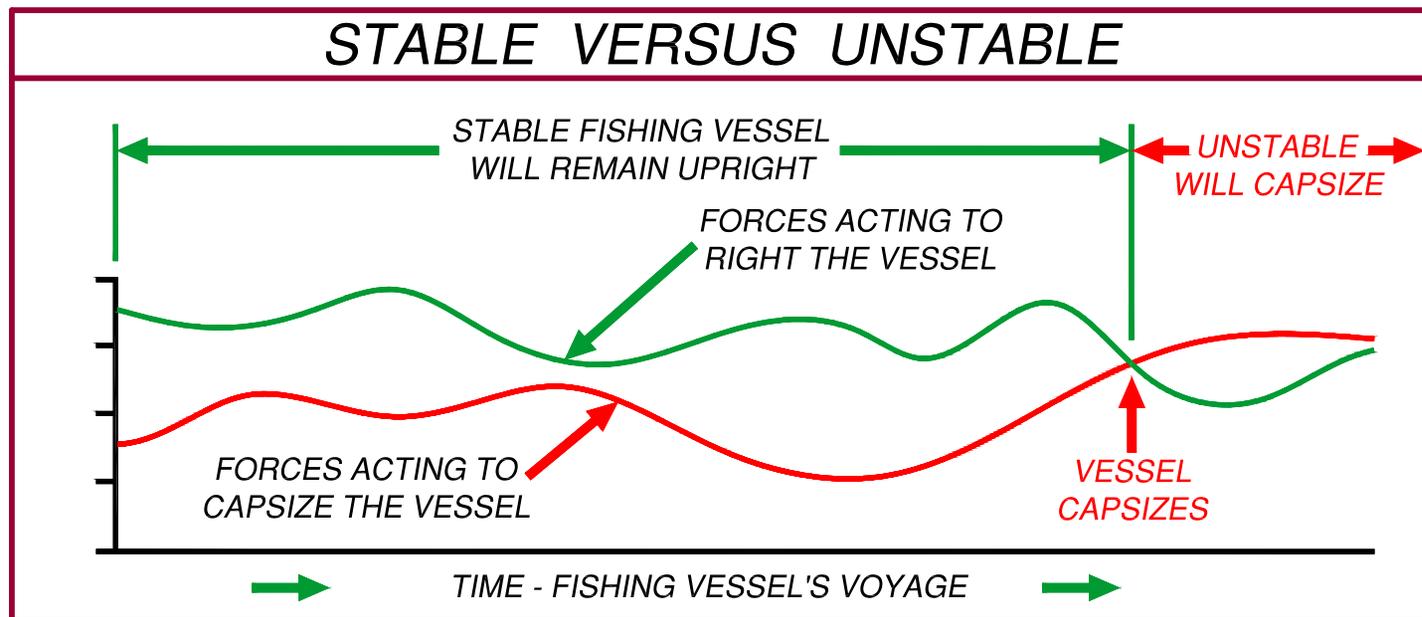


A fishing vessel is called **unstable** when it does not have enough positive stability to counter the external forces generated by current weather and fishing conditions and capsizes.

Important Lesson - Since a fishing vessel's stability is constantly changing during its voyage due to changes in the weather, the vessel's loading or fishing operations, an originally stable fishing vessel may become **unstable**.

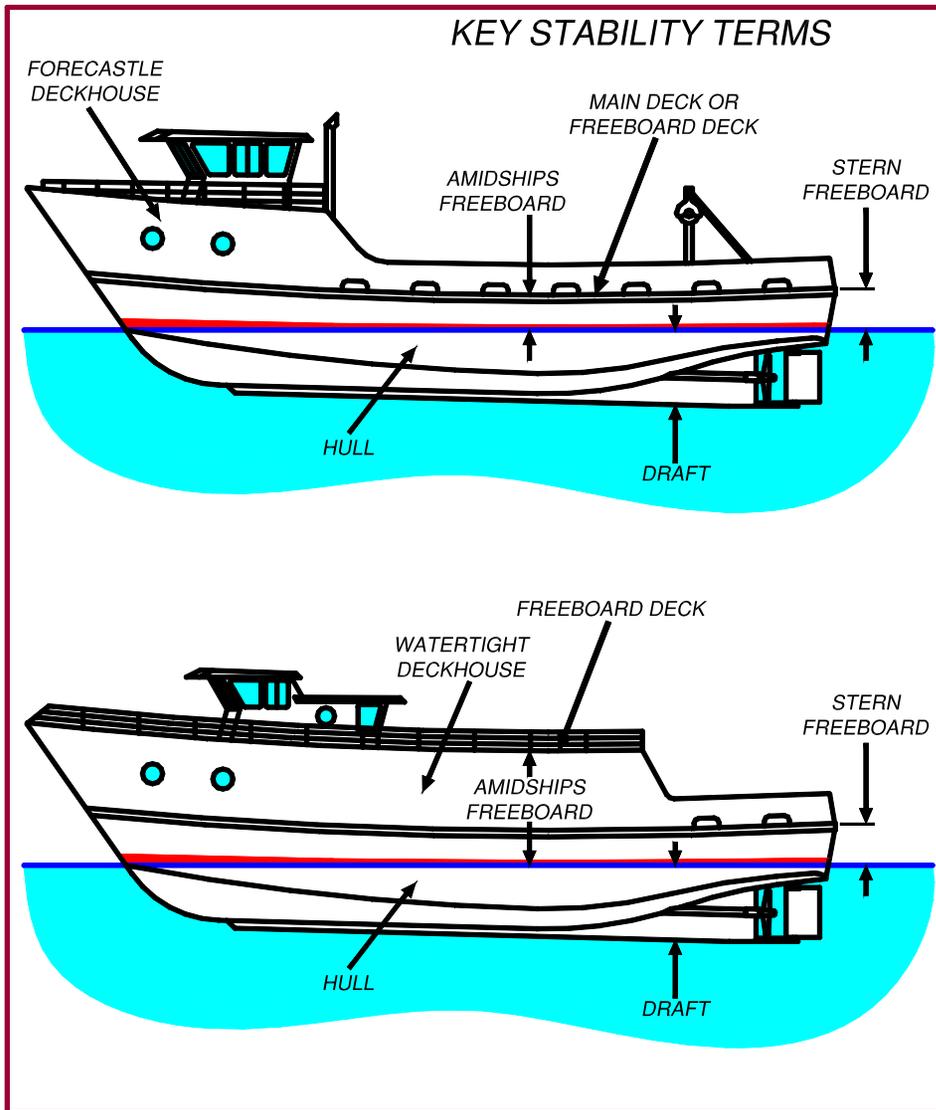
When is a Vessel Stable or Unstable?

Whether a fishing vessel is stable or unstable depends on two key factors; the forces acting to capsize the vessel and the forces acting to right the vessel. In the example below, the green line represents the total righting forces available and the red line is the total capsizing forces acting on the vessel from the weather, sea conditions, and fishing operations during its voyage. As long as the forces available to right the vessel (the green line) are greater than the forces acting to capsize the vessel (the red line), the vessel will remain upright and is considered stable. The instant the forces acting to capsize the vessel (the red line) are greater than the forces available to right the vessel (the green line), the vessel will be unstable and capsize.



Important Lesson - The key to having a **stable** vessel is making sure there is sufficient stability to counter the capsizing forces from the current weather, waves, and fishing conditions during the **entire** voyage.

Key Terms Used in Fishing Vessel Stability



Hull - The enclosed portions of the vessel below the highest watertight deck that runs continuously from the bow to the stern. In most fishing vessels, the main deck is the highest watertight deck.

Superstructure or Deckhouse - The enclosed portions of the vessel above highest watertight deck.

Waterline - The position of the water surface along the hull.

Freeboard - The vertical distance between the waterline and the highest watertight deck.

Draft - The vertical distance between the waterline and the bottom of the keel.

Watertight Envelope - The hull and watertight portions of the superstructure or deckhouses. The entire watertight envelope must remain watertight to ensure the vessel's stability.

How Stability Works

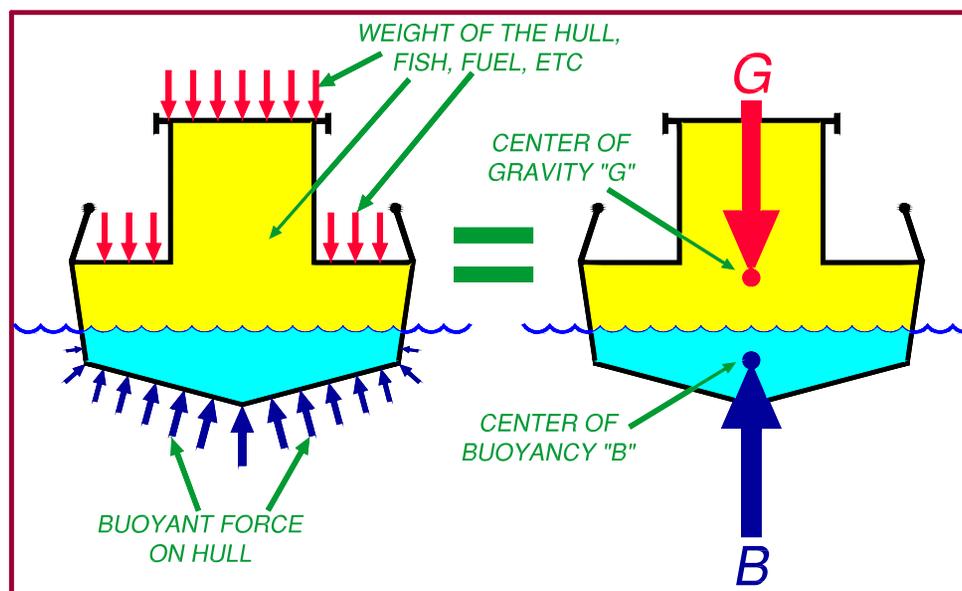
Important Lessons

1. There are two primary forces, **gravity** and **buoyancy**, that provide a vessel's stability. (See page 10)
 - A. The center of buoyancy "B" is a mathematical calculation of the geometric center of the submerged watertight volume of the vessel. (See page 11)
 - B. The outboard shift of the center of buoyancy "B" reduces when the freeboard deck edge becomes submerged and eventually reverses direction as the vessel heels further. (See page 11)
 - C. The center of gravity "G" is a mathematical calculation of the individual weight's center of gravities. (See page 12)
2. An **inclining experiment** (also called a stability test) is carried out to determine a fishing vessel's lightship characteristics that are used in all stability calculations. (See page 13)
3. A fishing vessel stays upright when the center of buoyancy "B" shifts faster outboard than the center of gravity "G" as the fishing vessel heels over. (See page 14)
4. The center of buoyancy "B" shifts when the shape of the submerged portion of the fishing vessel's hull changes as the vessel heels over. (See page 15)
 - A. Positive stability occurs when the center of buoyancy "B" has shifted farther outboard than the center of gravity "G". (See page 16)
 - B. Negative stability occurs when the center of gravity "G" has shifted farther outboard than the center of buoyancy "B". (See page 16)

The Forces That Create a Fishing Vessel's Stability

There are two primary forces, gravity and buoyancy, acting on fishing vessels that provide its stability.

Gravity is the force acting to pull the vessel down in the water; making the vessel sink. In stability analysis, the total weight of the vessel including its catch, fuel, and fishing gear, which are distributed throughout the hull, is mathematically combined into a single point called the Center of Gravity. This point is labeled "G" on stability diagrams.

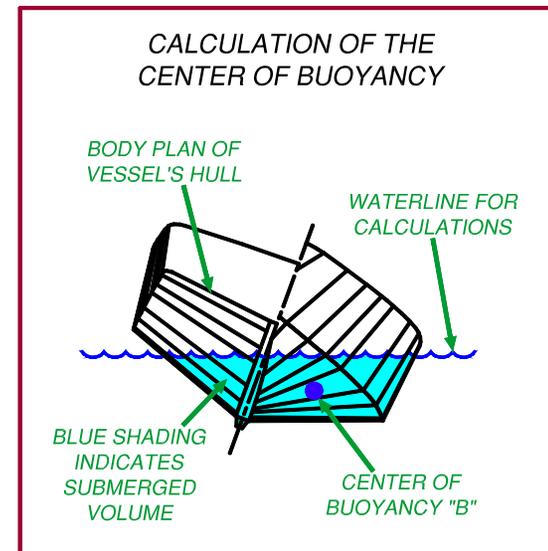


Buoyancy is the force acting to push the vessel up in the water; making the vessel float. In stability analysis, the total buoyancy forces, which are distributed over the part of the hull below the water, are mathematically combined into a single point called the Center of Buoyancy. This point is labeled "B" on stability model diagrams.

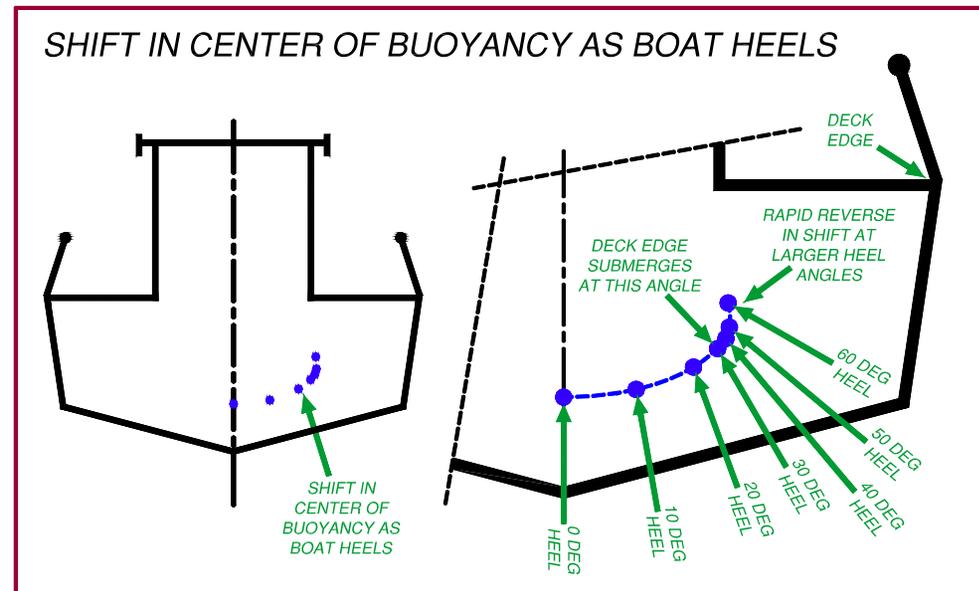
Interesting Fact - For typical commercial fishing vessels at rest with no outside forces such as wind or waves, the center of gravity "G" is directly above the center of buoyancy "B".

The Center of Buoyancy "B" - Where Does it Come From?

The center of buoyancy "B" is the centroid, i.e. geometric center, of the submerged watertight volume of the vessel calculated at the given heel angle. In addition to the hull, this volume may also include the watertight superstructure or deckhouses on the vessel.



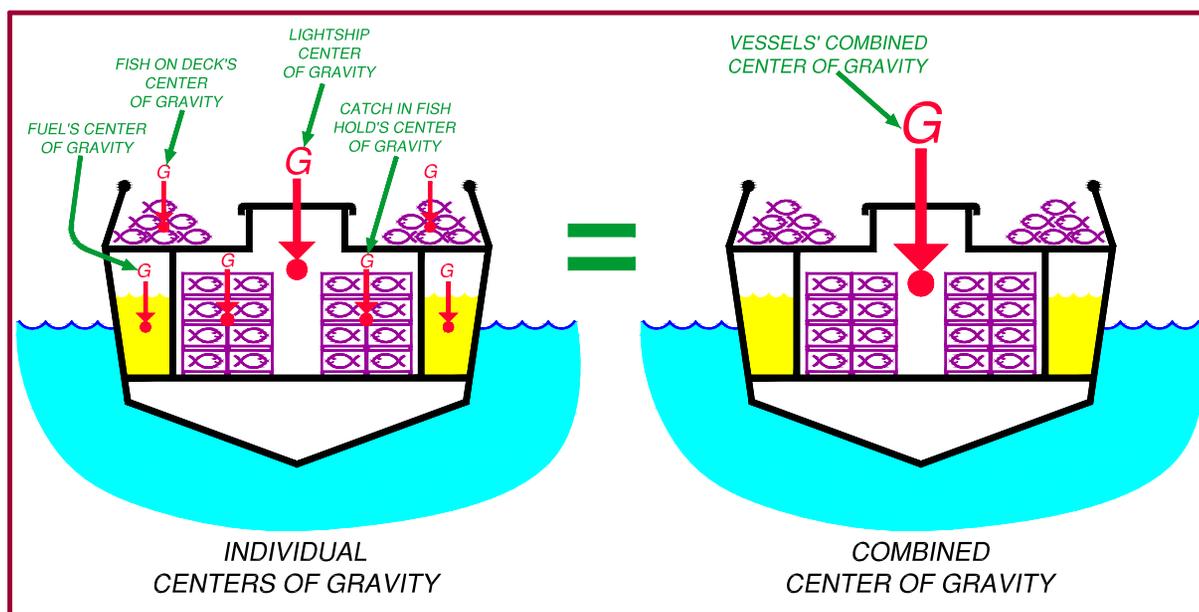
The diagram shows how the location of a typical fishing vessel's center of buoyancy shifts outboard as it heels over. Note how the outboard shift reduces when the freeboard deck edge becomes submerged and eventually reverses direction as the vessel heels further.



The Center of Gravity “G” - Where Does it Come From?

The vessel's center of gravity “G” is calculated by combining the individual center of gravities of the vessel's major weight groups. These groups include;

Vessel's Lightship is all of the “fixed” weights on the vessel. These are weights that do not change during the voyage such as the hull and deckhouse, the engines, and the fishing and processing gear.



Tankage is generally comprised of consumable fluids, cargo (fish) tanks and ballast. The consumable fluids are the fuel, lube oil, water, and sewage used during a voyage. The cargo tanks are all fish storage tanks that are flooded such as crab live tanks and refrigerated seawater (RSW) tanks. Also included in the tankage weights are any water ballast tanks used during a voyage. Hydraulic oil reservoirs are typically included in the lightship weight group, as they do not vary significantly during the trip.

Cargo is all of the fish caught as well as any ice, salt, or packaging carried to preserve the catch.

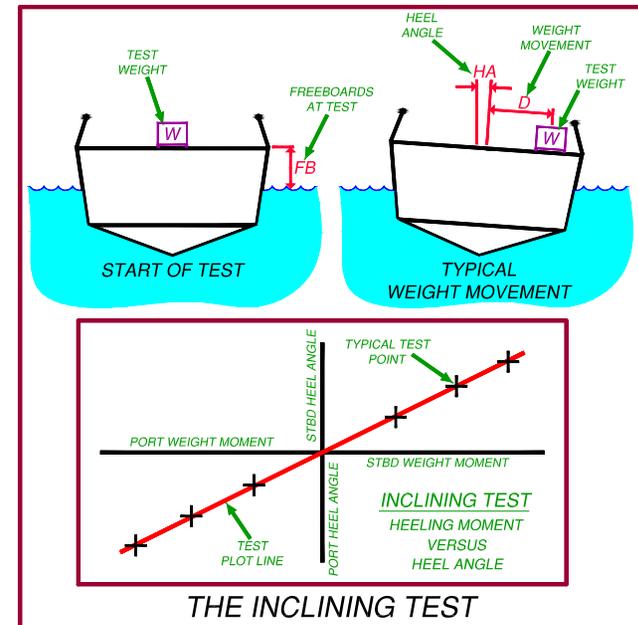
Ships Stores are all weights such as food or other similar items that are consumed during the fishing voyage.

The Inclining Experiment - The First Step in Determining Your Vessel's Lightship

An **Inclining Experiment** (also called a stability test) is performed to determine your vessel's lightship characteristics used in all stability calculations. The lightship characteristics calculated from the inclining test results are;

- Vessel's Weight (Displacement)
- Longitudinal Center of Gravity
- Vertical Center of Gravity

The inclining experiment is a precision test done using a procedure accepted by the USCG or other recognized organization to ensure its accuracy. The basic inclining experiment consists of the four steps below. Consult your naval architect or the USCG for the detailed requirements of an acceptable inclining.



Preparation of the Vessel: The vessel should be as complete as possible with all fishing gear onboard. If possible the vessel's tanks should be pressed full or pumped dry to minimize free surface effects. In addition all bilges and compartments should be pumped dry.

Setting on the Test Weights: The test weights must first be accurately weighed. The weights are then set precisely on marks placed on the vessel's deck.

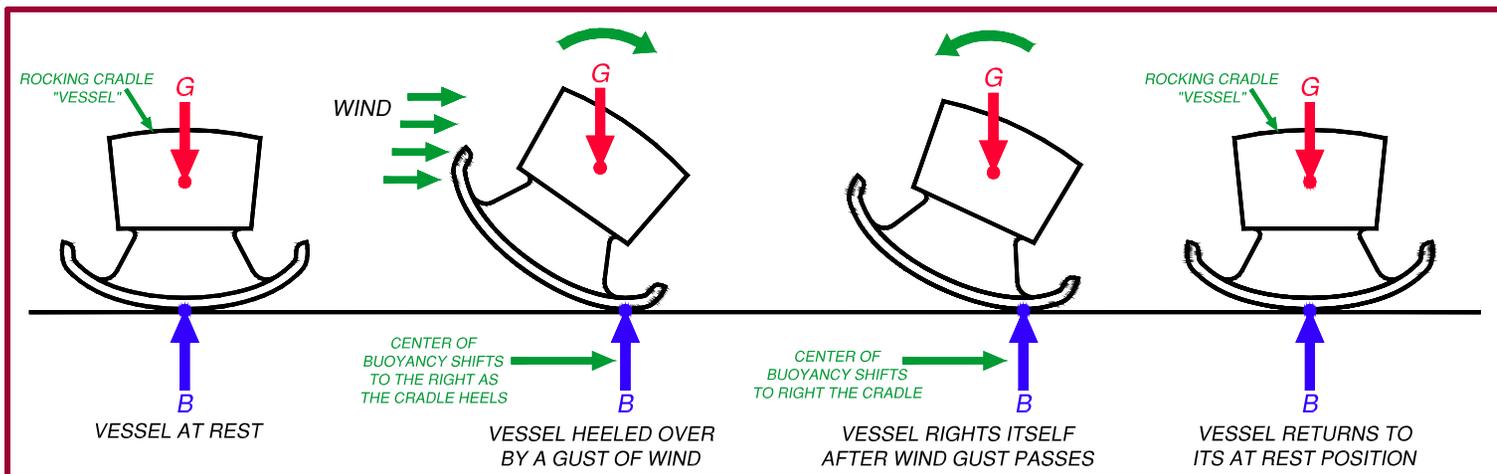
Moving the Test Weights: Next, the test weights are moved in three roughly equal groups to each side of the vessel. After each move the vessel's heel angle is measured by three pendulums or other accepted means. The heel angle and heeling moment are plotted as shown above. The resulting plot should be a reasonably straight line.

Measuring Freeboards: The freeboard is measured at five or more locations on both sides of the vessel.

Deadweight Survey: During the test, list all weights not onboard the vessel required to complete the vessel and all extraneous weights onboard.

Why a Fishing Vessel Remains Upright The Shifting of “B” Buoyancy

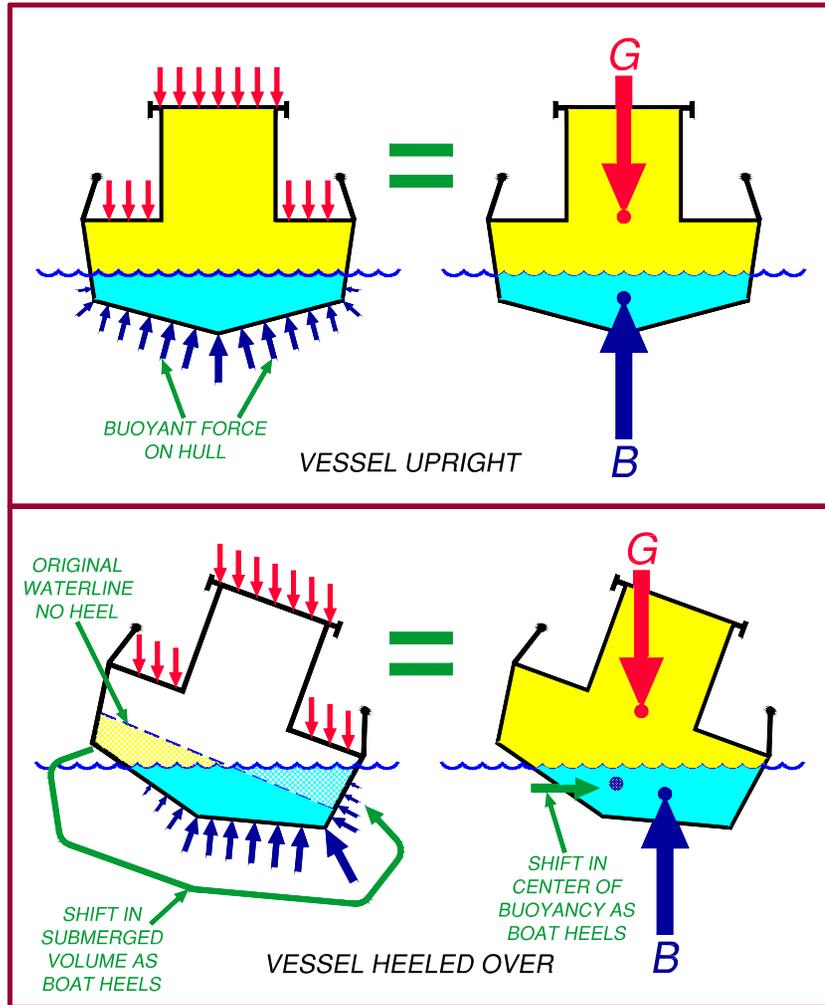
To understand how a fishing vessel stays upright, imagine the rocking of a baby cradle shown in the figure. The fishing vessel (weight) is the cradle. Its center of gravity “G” is the near the center of the cradle. The “buoyant force” supporting the cradle is the rocker resting on the floor. The center of buoyancy “B” is the point where rocker contacts the floor.



As with a fishing vessel, the cradle’s (vessel’s) center of gravity “G” is above its rocker, the center buoyancy “B”. The slightest disturbance (wind, waves, or the movement of weight on the deck) causes the cradle (vessel) to roll (heel) to one side.

To keep the cradle (vessel) upright, the point where the rocker touches the floor (the center buoyancy “B”) must shift faster outboard than the cradle’s (vessel’s) center of gravity “G”. It is this shifting of the center buoyancy “B” that allows a fishing vessel to stay upright after being heeled by the wind, waves, or the movement of weight on the deck.

What Causes a Fishing Vessel to Return Upright when Heeled Shifting Buoyancy to the Rescue

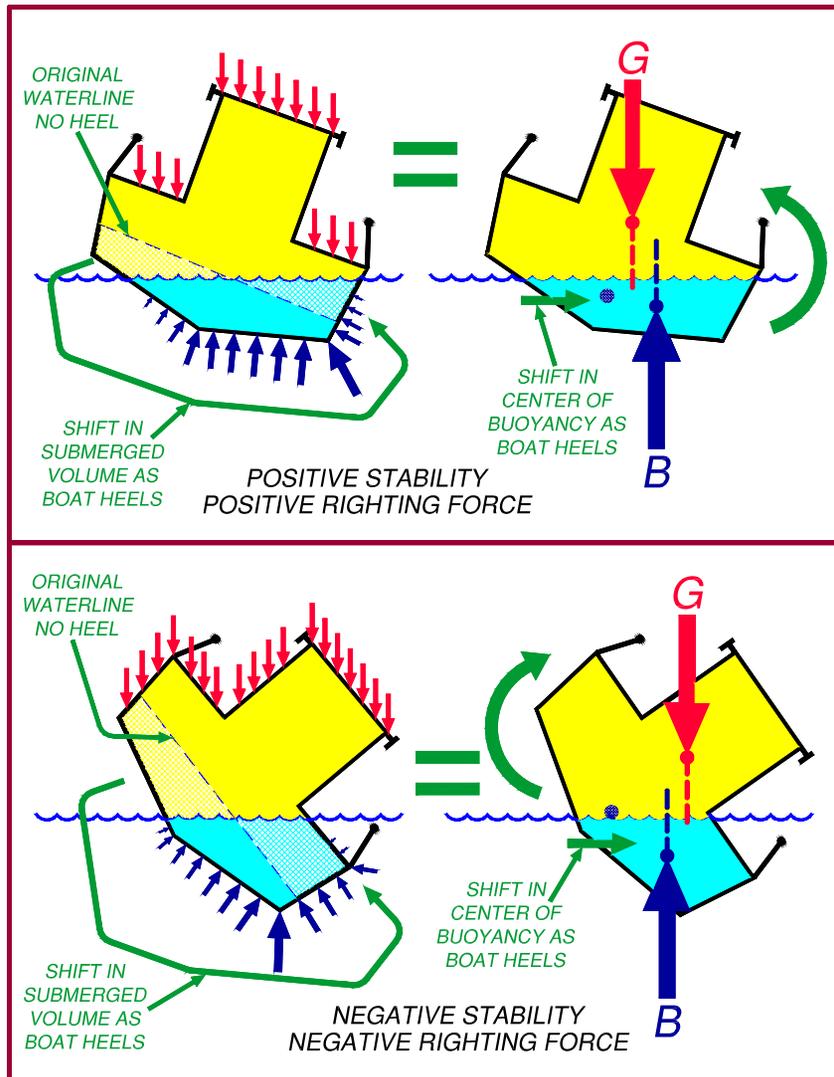


SHIFTING VOLUME AS THE VESSEL HEELS

When a vessel heels because of an external force, the portion of the hull below the waterline takes on a new shape. A portion of the original underwater volume rises above the heeled waterline. An equal volume of the hull that was previously above the heeled waterline is now submerged.

In this example, as the fishing vessel hull heels to starboard, a portion of the hull's port side is exposed and no longer provides any buoyant forces to support the hull. At the same time, an equal portion of the hull's starboard side is submerged and now provides additional buoyant forces on the starboard side of the hull.

By visual observation, since the example's port hull volume has been transferred to starboard side, the center of buoyancy "B" has also been shifted to starboard. This new location of the center of buoyancy "B" is determined from mathematical calculations based on the new submerged shape of the hull.



Positive Stability - The Good Life

Positive stability is when the combination of the center of gravity “G” pulling down coupled with the center of buoyancy “B” pushing up creates a righting action that forces the vessel back to its upright position.

Positive stability occurs when the center of buoyancy “B” has shifted farther outboard than the center of gravity “G” shown in the example.

Negative Stability - Turning Turtle

Negative stability is when the combination of the center of gravity “G” and the center of buoyancy “B” creates a capsizing action that forces the vessel to continue to roll over.

This condition occurs when the center of gravity “G” has shifted farther outboard than the center of buoyancy “B” shown in the example.

How is a Fishing Vessel's Stability Measured?

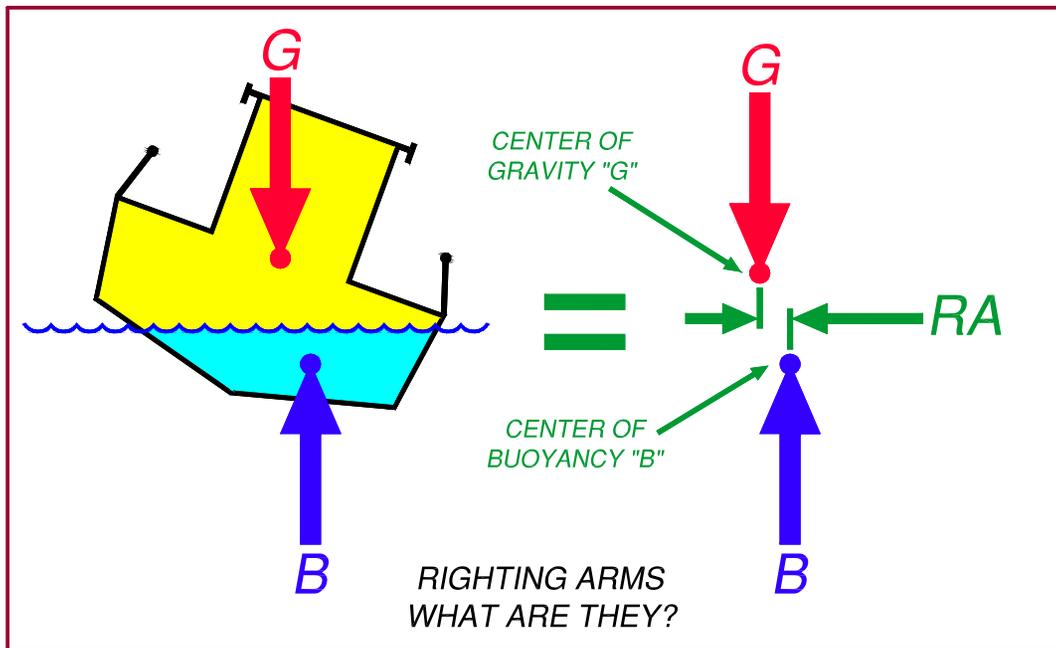
Important Lessons

1. The **righting arm** "RA" is the horizontal distance between the center of gravity "G" and the center of buoyancy "B". (See page 18)
2. The **righting arm curve** is the plot of the righting arm "RA" versus heel angle. (See page 19)
3. The righting arm curve is a graphical representation of a fishing vessel's stability. (See page 20 to 21)
4. The area under the curve is an indication of the righting forces available to counter the capsizing forces acting on the vessel. (See page 20)
5. The heel angle at which the righting arm crosses zero is an indication where the fishing vessel's stability changes from positive righting forces to negative, capsizing forces. (See page 20)
6. The heel angle that the maximum righting arm occurs at is approximately the heel angle at which the freeboard deck edge submerges. (See page 21)
7. The shape of the righting curve at low angles of heel indicates how the vessel responds when subjected to low to moderate wind and waves. (See page 21)

Righting Arms - What are They?

The **Righting Arm** is the primary measurement used to evaluate a fishing vessel's stability.

The righting arm is the horizontal distance between the center of gravity "G" and the center of buoyancy "B". The righting arm is labeled as "RA" on the figures.



When the center of buoyancy "B" has shifted farther outboard than the center of gravity "G" as shown in the figure, the righting arm "RA" is a positive number creating positive stability.

When the center of gravity "G" has shifted farther outboard than the center of buoyancy "B" the righting arm "RA" is a negative number creating negative stability (vessel will capsize).

When the center of gravity "G" is directly above the center of buoyancy "B" the righting arm "RA" is zero and the vessel has neither positive nor negative stability.

The Righting Arm Curve

To evaluate a fishing vessel's stability, a series of righting arm curves are calculated for full range of operating conditions encountered during the fishing trip. These calculations are based on the lightship parameters determined from the inclining experiment and the changes in the vessel's variable weights; fuel, water, catch, etc.

Typical loading conditions used for the righting arm curves are;

Full Load Departure - 100% Fuel & Water, No Catch Onboard

Mid-Fishing Trip - 50% Fuel & Water, 50% Catch Onboard

Return to Dock, Good Fishing Trip - 10% Fuel & Water, 100% Catch Onboard

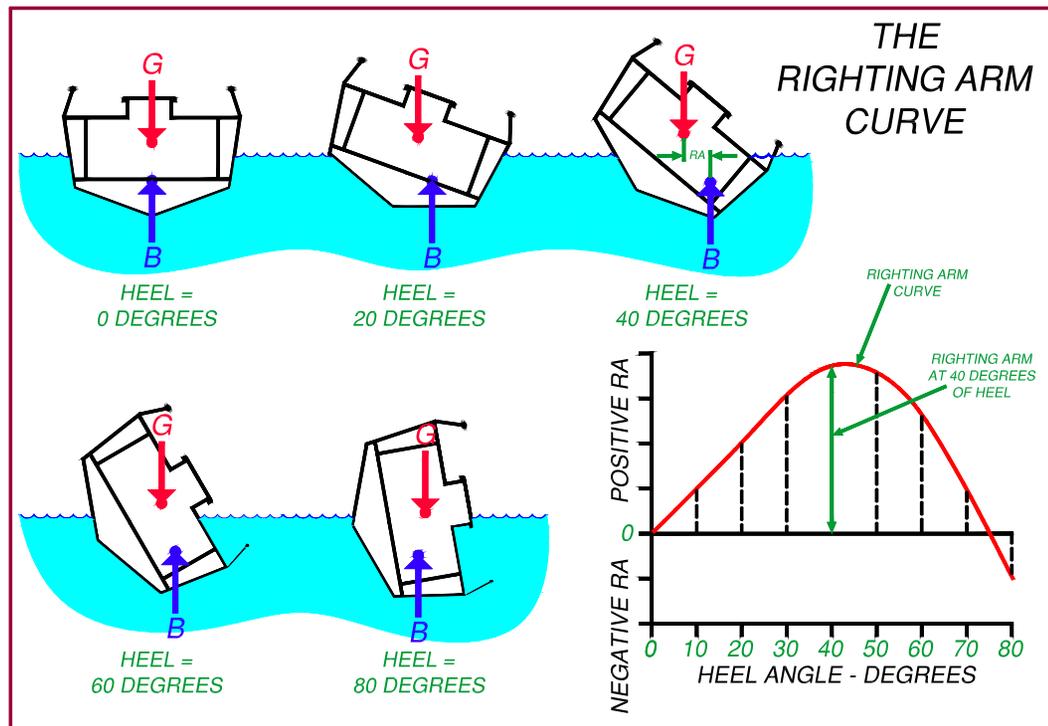
Return to Dock, Poor Fishing Trip - 10% Fuel & Water, 20% Catch Onboard

Other loading conditions may be used to reflect unique operating conditions for a particular fishing vessel.

The righting arm curve for a given loading condition is determined by calculating the center of gravity and center of buoyancy for the fishing vessel at a series of fixed heel angles.

In the example, the righting arms are calculated at 10 degree intervals, the graphical figures are shown at 20 degree intervals.

The righting arm curve has the heel angle in degrees plotted on the horizontal and the righting arms plotted on the vertical.

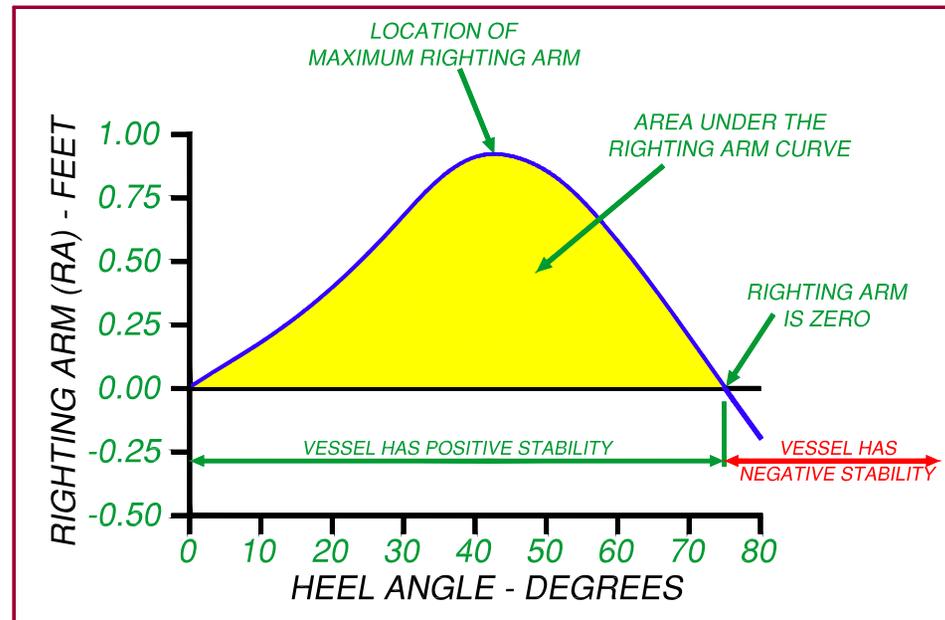


The Righting Arm Curve - What Does it Tell Us?

The righting arm curve is a graphical representation of the fishing vessel's stability at the loading condition it was calculated for. The following important information can be determined from each curve.

1) The area under the curve is an indication of the righting forces (the green line on page 7) available to counter the capsizing forces acting on the vessel. In general, the more area under the curve, the larger the righting forces that are present (the higher the green line) and the larger the storms or fishing disturbances the fishing vessel can handle.

2) The heel angle at which the righting arm crosses zero is an indication where the fishing vessel's stability changes from positive righting forces to negative, capsizing forces. In general, the higher the heel angle at which this transition occurs, the larger the righting forces available.



3) The heel angle and size of the maximum righting arm is an indication of the fishing vessel's ability to counter capsizing forces at high heel angles. In general, the larger the maximum righting arm and the higher the heel angle at which it occurs increases the righting forces that are present (the higher the green line) and the larger the storms or fishing disturbances the fishing vessel can handle.

For additional information on how Naval Architects use the righting arm curves in evaluating your fishing vessel's stability to develop suitable guidance, please see the appendix "How do Naval Architects Develop Stability Guidance?" on page 52.

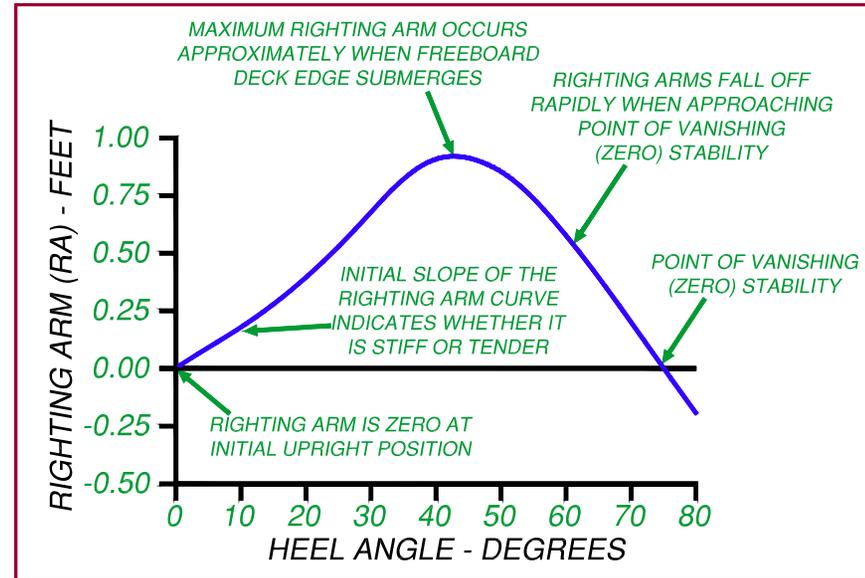
The Righting Arm Curve - Typical Characteristics

For typical fishing vessels, the righting arm curve has several general characteristics that define its shape;

The righting arm is zero at the initial upright position. (Remember the cradle analogy)

The righting arms decline rapidly as the heel angle approaches the point of vanishing stability.

The heel angle that the maximum righting arm occurs at is approximately the heel angle at which the freeboard deck edge submerges. For typical fishing vessels, the lower the freeboard, the sooner the maximum righting arm occurs. Higher freeboards move the maximum righting out to higher heel angles.



The shape of the righting curve at low angles of heel indicates how the vessel responds when subjected to low to moderate wind and waves.

With a lower slope, the vessel rolls more and recovers slowly, also known as being **tender**.

With a steeper slope, the vessel rolls less and recovers quickly, also known as being **stiff**.

Important Note: The stiffness or tenderness of a fishing vessel is not an indication of its ability to survive heavy weather conditions or handle large external capsizing forces from fishing operations.

Initial Versus Overall Stability The Hidden Danger

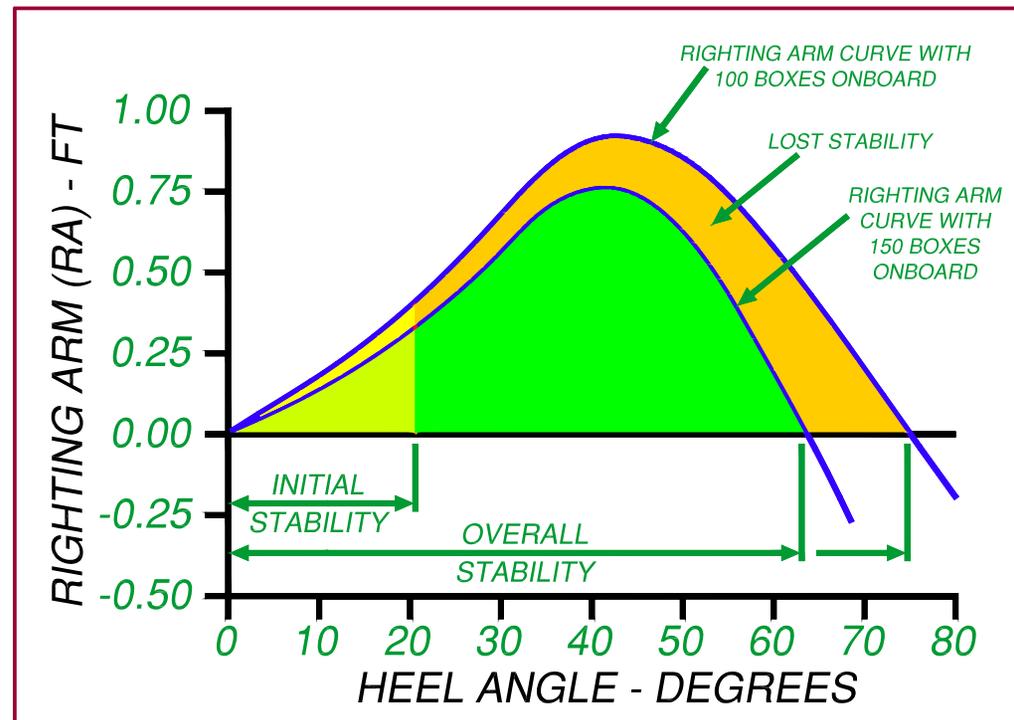
Important Lessons

1. **Initial Stability** is the stability felt by the crew during operations in relatively calm seas. (See page 23)
2. **Overall Stability** is the full range of stability from the initial upright position to the point of vanishing stability (range of positive stability). (See page 23)
3. Overall stability is critical to surviving severe storms. (See page 23)
4. Initial stability does not indicate if the vessel's overall stability is good, bad, or borderline. (See page 23)
5. Overloading and weight creep are a compound reduction in a fishing vessel's stability. (See page 24 & 26)
6. Adding ballast to improve a fishing vessel's ride without evaluating its effect on the vessel's overall stability can place the crew in increased danger of capsizing. (See page 25)
7. Loss of overall stability is a reduction in the righting forces (the green line) available to counter any capsizing forces acting on the fishing vessel. (See page 7)

Initial Vs. Overall Stability - The Hidden Danger

Initial Stability: The stability felt by the crew during operations in relatively calm seas. For typical fishing vessels this is limited to 10 degrees of heel from the initial upright position. Initial stability does not indicate if the vessel's overall stability is good, bad, or borderline.

Overall Stability: The full range of stability from the initial upright equilibrium position to the point of vanishing stability (range of positive stability). Overall stability is critical to surviving severe storms.

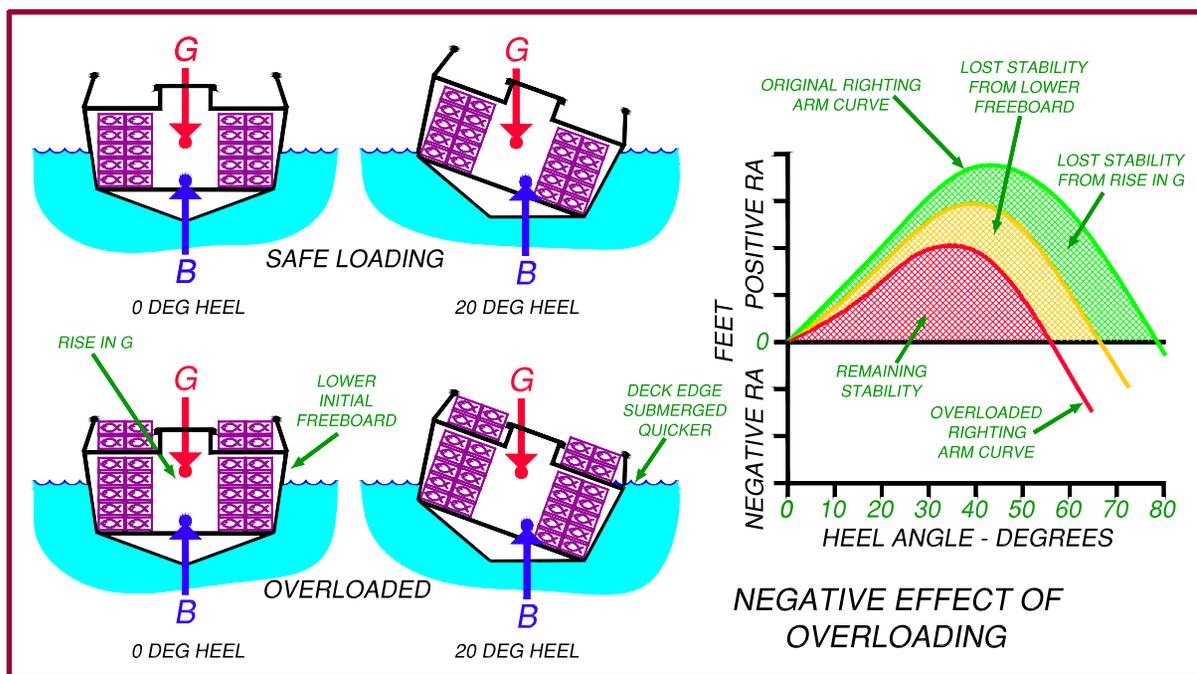


There is a potential hidden danger in using a fishing vessel's "feel" to determine if the vessel is safe from capsizing. The initial stability felt by the crew can be deceiving and give a false impression that the vessel has adequate stability levels. It may be too late to correct a problem by the time the vessel "feels" unsafe.

In the vessel example above, the crew places themselves in danger when they use the feel of the vessel to gauge their vessel's safety while operating with 150 boxes onboard. The initial stability is approximately the same for the two loading conditions shown because the righting arm curves are close to each other at low angles of heel. **The overall stability however, is significantly different between the two loading conditions because the area under the lower righting arm curve at large angles of heel is less than the upper righting arm curve.**

Initial vs. Overall Stability - Overloading

Overloading can significantly reduce a fishing vessel's overall stability without the crew being aware of the danger they are facing. The initial stability levels are only slightly reduced, which the crew may not notice.



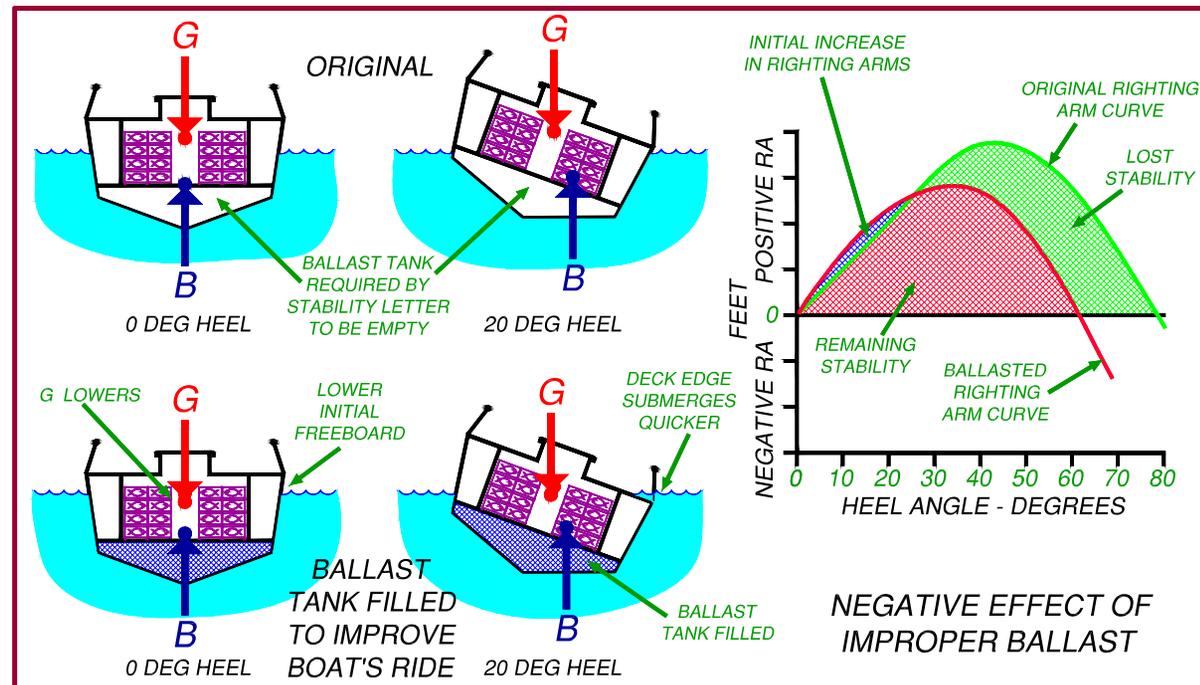
The vessel's overall stability has been reduced because:

- The center of gravity "G" is increased from the added weight high.
- The freeboard is reduced because of the added weight, which causes the deck edge to submerge at smaller heel angles.

Recommendations: Follow all stability guidance provided for the vessel. Do not exceed the loading recommendations in the vessel's stability letter at any time.

Initial vs. Overall Stability - Improper Ballasting

Improper use of ballast tanks or adding fixed ballast not allowed in the stability guidance to improve a vessel's ride can significantly reduce a fishing vessels overall stability, even though the crew may feel the vessel is safer. In this example, the initial stability levels may be increased slightly because the ballast was added low. This makes the vessel appear "stiffer", and therefore safer in the crews mind.



The vessel's overall stability though has been downgraded because the freeboard is reduced, causing the freeboard deck edge to submerge at smaller heel angles.

Recommendations: Follow all stability guidance provided for the vessel. Do not add any ballast not allowed in the stability guidance without consulting with a Naval Architect.

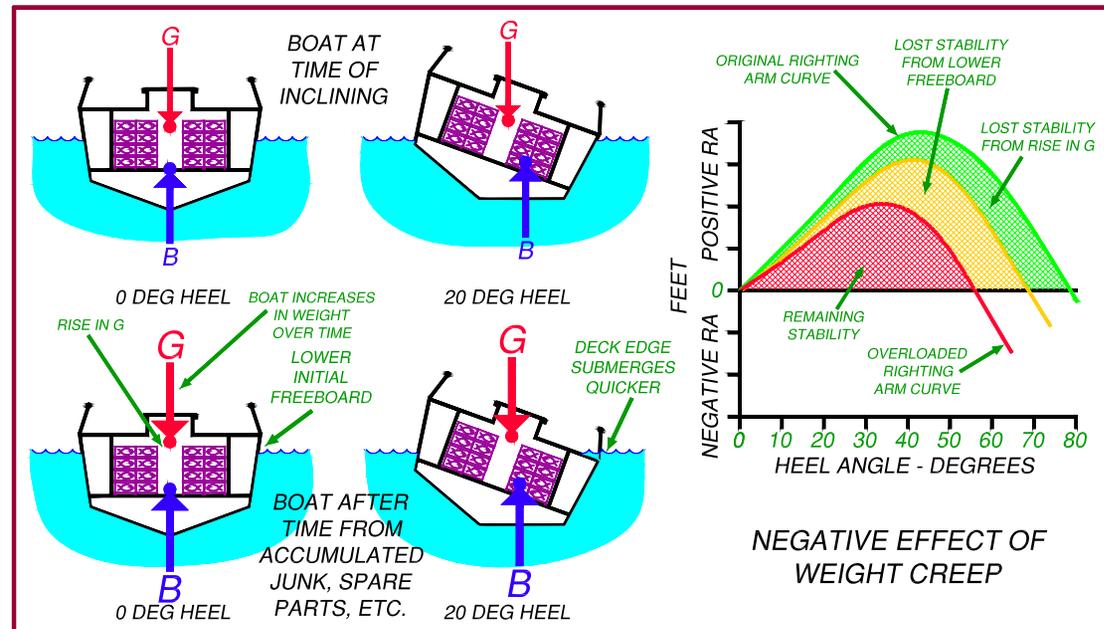
Initial vs. Overall Stability - Weight Creep

Weight creep from the accumulation of extra spare parts, fishing gear, and junk or a series of seemingly small modifications to the vessel or its fishing gear can significantly reduce a fishing vessel's overall stability. The weight creep often occurs over long periods of time in small amounts so the crew may not notice reduced initial stability levels.

The vessel's overall stability has been reduced from the accumulated total weight because:

The center of gravity "G" is raised from the added weight high; and

The freeboard is reduced because of the added weight that causes the deck edge to submerge at smaller heel angles.



Recommendations: Every 6 to 12 months, all areas of the vessel should be thoroughly inspected and cleaned of any extraneous spare parts, fishing gear, and equipment. If modifications to the vessel or its fishing gear not included in the vessel's current stability assessment must remain, consult a Naval Architect about developing new stability guidance.

Free Surface - Shifting into Danger

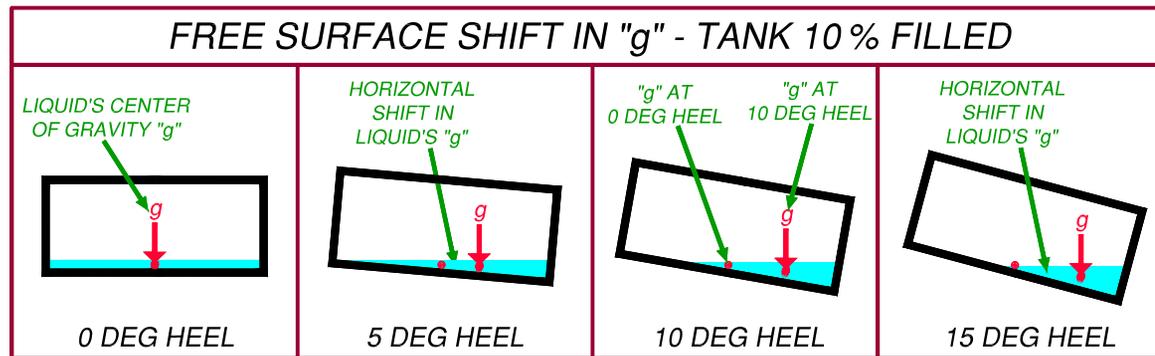
Important Lessons

1. **Free surface** is the term used to describe the effect on a fishing vessel's stability from slack tanks, water in fish holds, or flooded bilges. Free surface occurs when liquids can shift their location as the fishing vessel heels. (See page 28)
2. Open cross connected port and starboard tanks can cause a slow, but potentially significant, reduction in a fishing vessel's overall stability as the tanks content gradually flows to the low side. (See page 30)
3. Progressive downflooding causes a reduction in a fishing vessel's overall stability over time. If the downflooding is caused by a slow leak, its effect on the vessel's initial stability may not be noticeable until a dangerous reduction in the overall stability levels has occurred. (See page 31)
4. Water on deck from boarding seas creates a significant loss in overall stability from three negative impacts; weight added high, lower freeboards, and free surface. (See page 32)
5. The flooding of large deckhouses creates a significant, and often the most dangerous, loss in overall stability from free surface effects. (See page 33)
6. Free surface causes a reduction in the righting forces (the green line) available to counter any capsizing forces acting on the fishing vessel. (See page 7)

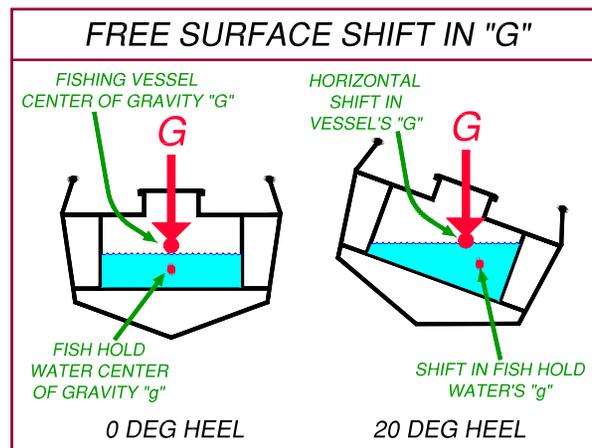
Free Surface - What is it?

Free Surface is the term used to describe the motion of liquids in slack tanks, water in the fish holds, flooded bilges and deck houses, or any location where liquids are free to move. Free surface occurs because the liquids can shift to the low side as the fishing vessel heels over.

The free surface of liquids generally causes a reduction in a fishing vessel's overall stability levels. This reduction occurs when the liquid, and thus its center of gravity "g", shifts to the vessel's low side when it heels over as shown in the figure below.

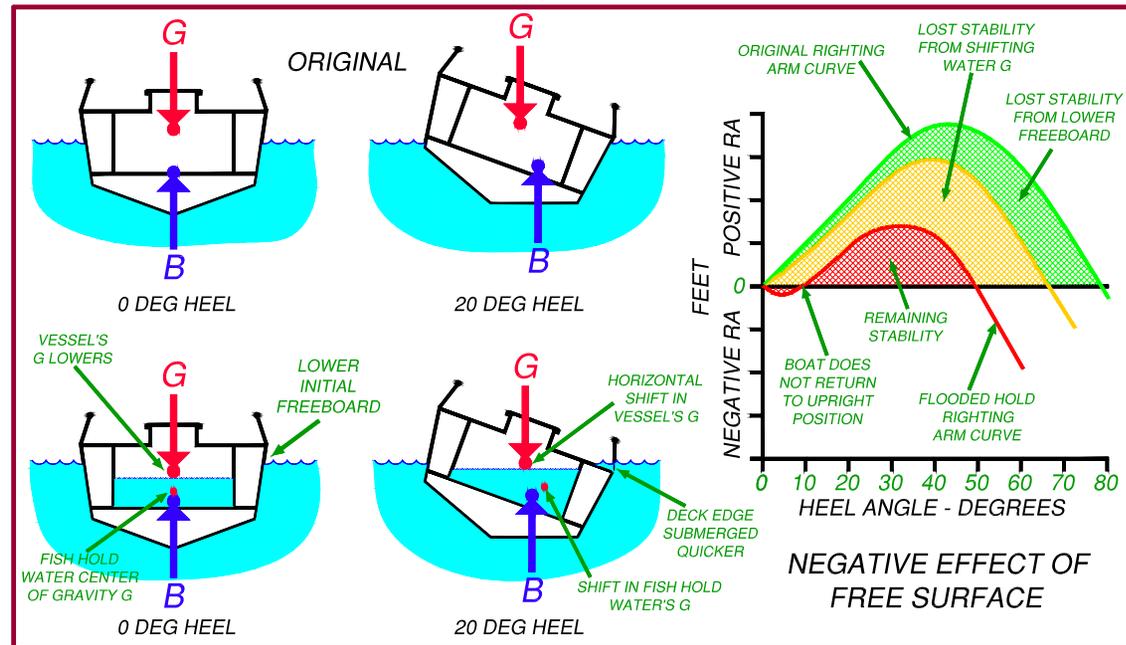


This shift in the liquid's center of gravity "g" causes the vessel's center of gravity "G" to shift outboard, reducing the righting arm "RA" as shown in the figure to the right.



Free Surface - Slack Tanks

Slack tanks, water in the fish holds, or flooded bilges create a free surface effect that can significantly reduce a fishing vessels overall stability.

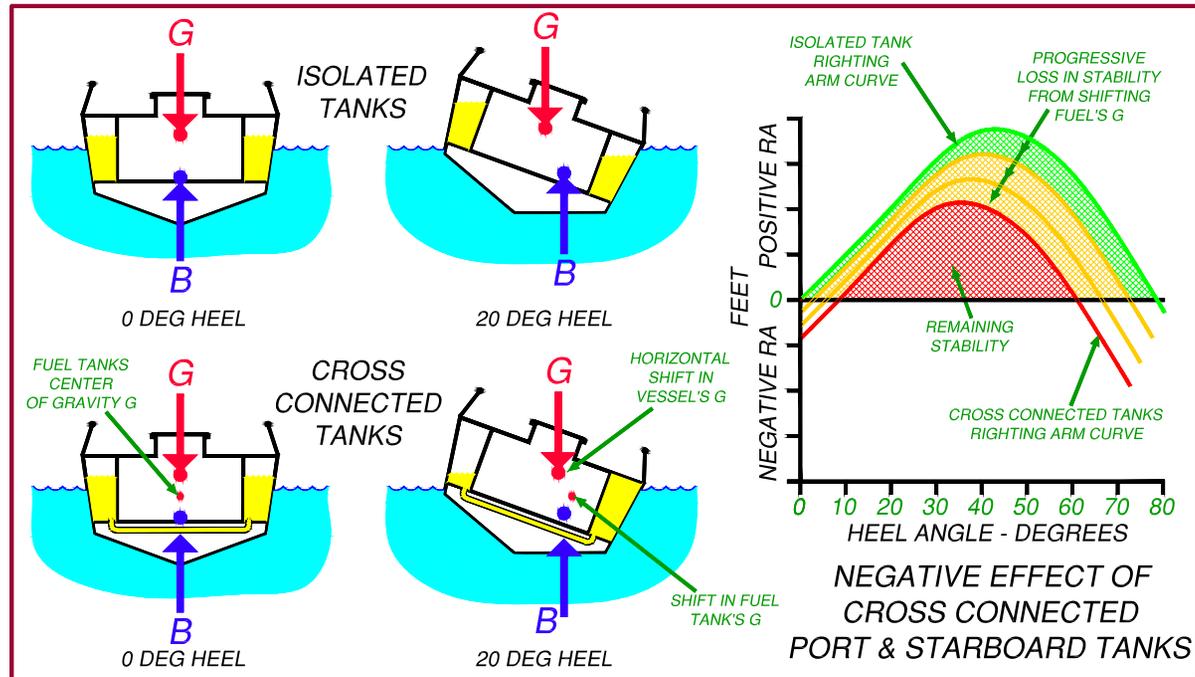


The diagram shows how the overall stability is reduced because the water in the hold has sloshed to the low (outboard) side. This shift causes the vessel's center of gravity "G" to shift farther outboard leading to a reduction in the vessel's righting arm curve. This reduction is significantly larger for very wide tanks or compartments that span the full beam of the vessel than for narrow wing tanks.

Recommendations: All bilges and compartments must be kept pumped dry. Seawater holds should be kept completely empty or pressed full and overflowing. Keep slack fuel, water or other consumables' tanks to the minimum number possible.

Free Surface - Cross Connected Port & Starboard Tanks

The open cross connection of port and starboard tanks can cause a gradual, but potentially substantial reduction, in a fishing vessel's overall stability that the crew may not be able to detect by their feel of the vessel's motions.

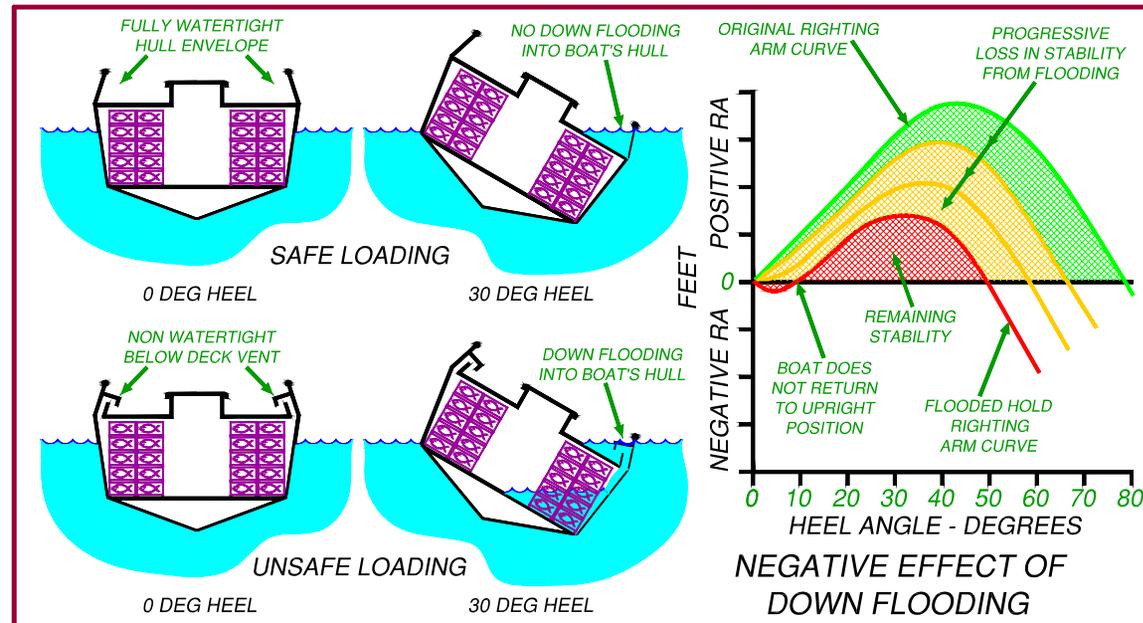


When a fishing vessel is held in a heeled over condition from fishing operations or weather conditions such as a sustained wind on the beam, open valves in tank cross connection piping allow the fluid in the higher tank to flow to the lower tank. This transfer of weight causes the center of gravity "G" to shift farther outboard, reducing the vessel's righting arm curve. Because this shift in fluids occurs slowly, the impact on the vessel's feel may be difficult to notice before significant reductions in the overall stability have occurred.

Recommendations: Keep all port and starboard tank pair cross connections closed while underway.

Free Surface - Progressive Downflooding

Failure to maintain the integrity of a fishing vessel's watertight envelope can significantly reduce a fishing vessel's overall stability due to unintentional flooding. If this minor flooding goes unnoticed, such as at the rudder post in a lazzerette, the gradual reduction in initial stability, or the feel of the vessel, may go unnoticed.



After downflooding occurs, the vessel's overall stability is reduced because:

- The center of gravity "G" is shifted farther outboard as the water sloshes to the low side.
- The freeboard is reduced because of the added weight, causing the deck edge to submerge faster.
- In cases of severe downflooding, the fishing vessel will not return to the upright condition, instead "lolling" at the angle of heel where the new righting arm curve goes through zero (about 10 degrees in the example).

Recommendations: Secure all watertight openings (doors, hatch covers, windows, etc.) in the hull and deck structures when not in use to prevent flooding. All watertight openings must be inspected regularly to ensure their tightness.

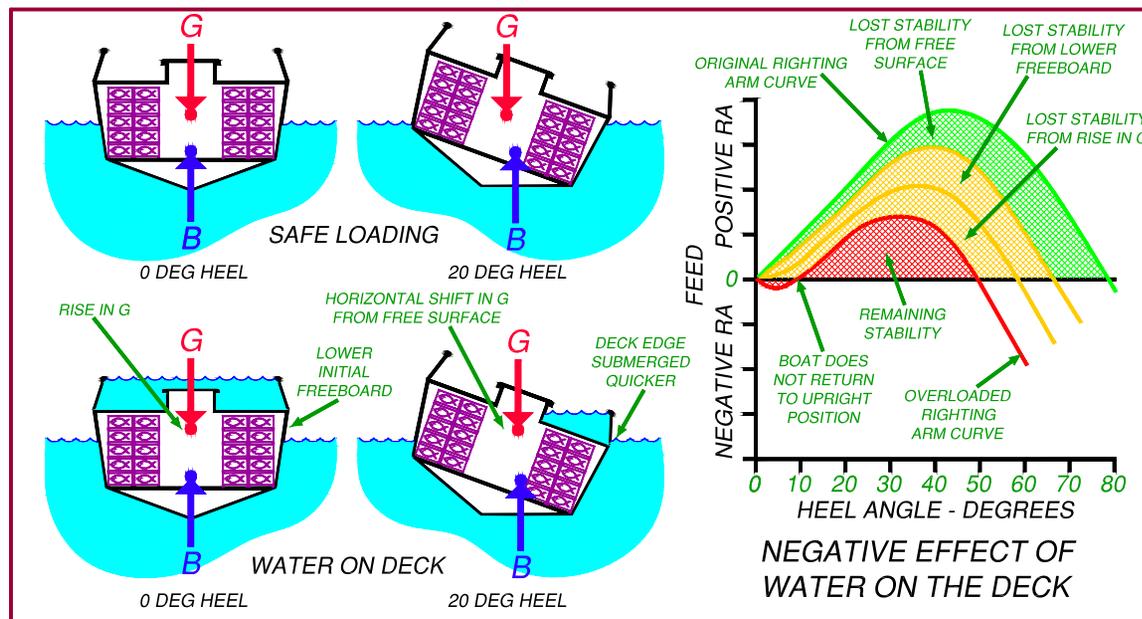
Free Surface - Water on Deck

Water from boarding seas that remains trapped on a fishing vessel's deck by her bulwarks can significantly reduce its overall stability because:

The center of gravity "G" is raised from the added weight of the trapped water high on the decks.

The freeboard is reduced due to the added weight, which causes the deck edge to submerge at smaller heel angles.

The effects of the trapped water on deck shifting reduce the righting arms.



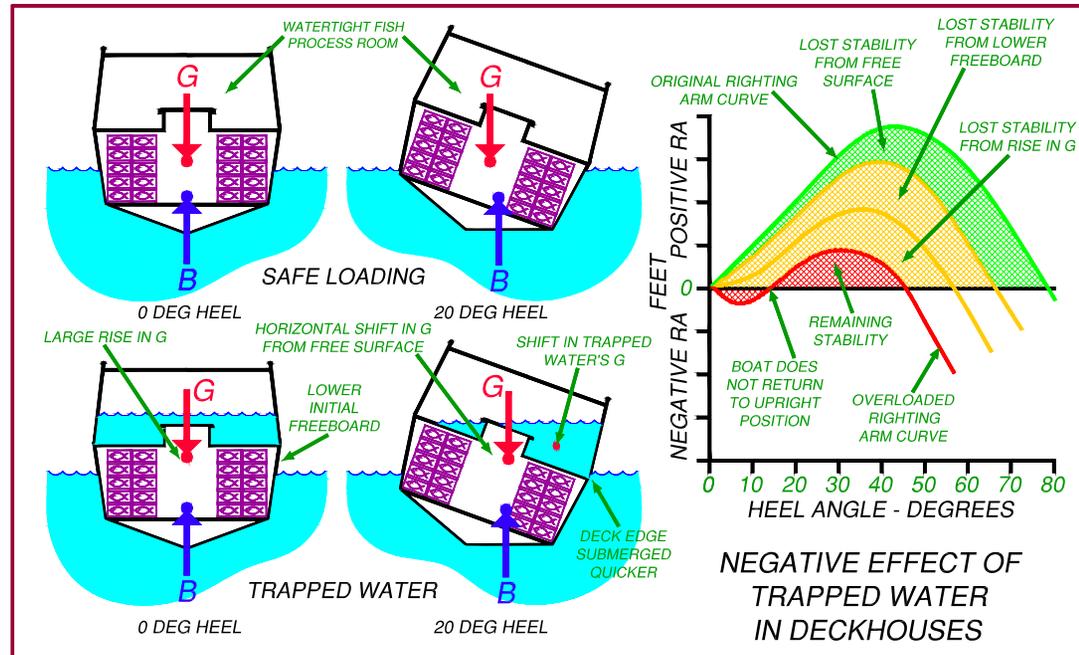
Because the trapped water on deck is located high on the vessel, the fishing vessel may not return to the upright equilibrium condition. Instead, it will lay over or "loll" at the angle of heel where the new righting arm curve goes through zero.

Recommendations: All freeing ports should be regularly inspected for blockage by fishing gear, fish, or other items to ensure the rapid removal of water on deck. If sea conditions are extremely rough, the helmsman should head the vessel into the seas to minimize water being shipped on deck.

Free Surface - Flooding of Deckhouses

Water trapped in a fishing vessel's deckhouse creates a significant, and often the most dangerous, reduction in its overall stability. The water can come from both openings in the fishing vessel's watertight envelope and from water used in processing the catch. The vessel's overall stability is reduced because:

- The center of gravity "G" is raised from the high location of the trapped water.
- The freeboard is reduced due to the additional weight that causes the deck edge to submerge quicker.
- In severe cases the vessel will lay over or "loll" at a significant heel angle because of the trapped water in the house shifting to the low side.



Recommendations: All watertight and weathertight openings should be closed and secured to prevent flooding. In addition all process space drains must be of adequate size and kept clear to prevent any standing water from the fish processing equipment.

Fishing Operations **Dangers at the Helm**

Important Lessons

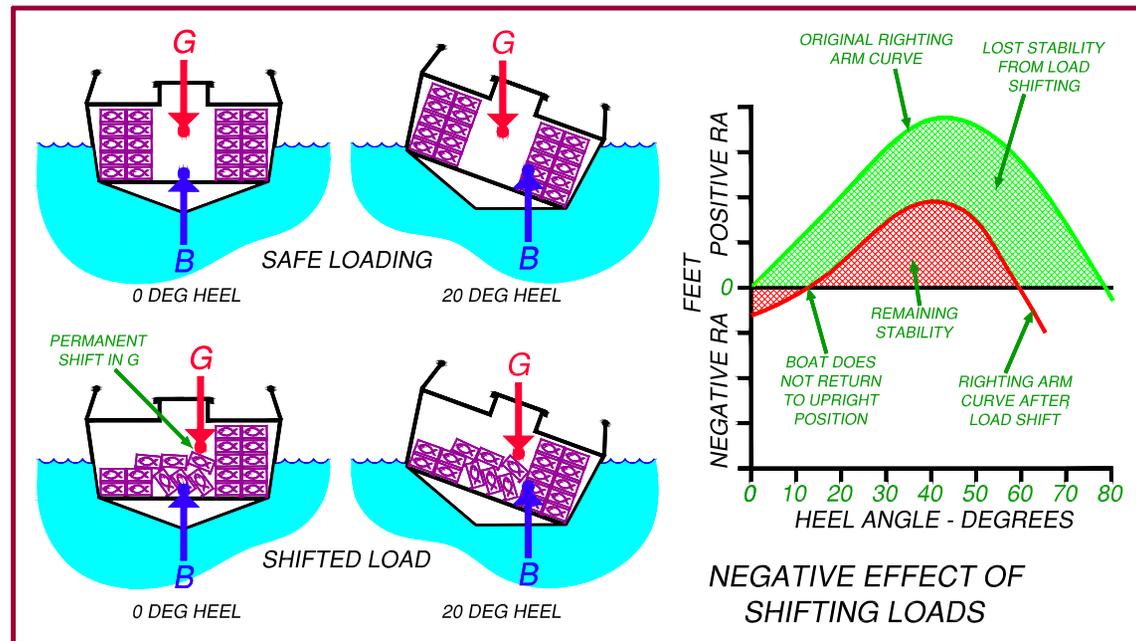
1. The shifting of the fishing vessel's catch or gear creates a "permanent" list, reducing its overall stability levels. (See page 35)
2. Lifting weights on board a fishing vessel results in a significant rise in the center of gravity "G" which reduces its overall stability. Additional reductions in the overall stability can result from the load being able to swing freely. (See page 36).
3. Lifting weights over the side of a fishing vessel adds a capsizing force to the stability reductions listed in lesson #2. (See page 37).
4. Towing fishing gear causes a reduction in a fishing vessel's overall stability levels by reducing the righting forces and increasing the capsizing forces. Turning while towing adds further capsizing forces which increase the chance of capsizing. (See page 38 & 39)
5. Fishing operations can cause both a reduction in the righting forces (the green line) and an increase in the capsizing forces (the red line) acting on the fishing vessel. (See page 7)

Fishing Operations - Shifting Loads

When the sudden shifting of a fishing vessel's catch or heavy fishing gear occurs during the voyage, its overall stability is reduced because:

The vessel's center of gravity "G" is shifted farther outboard because the catch has fallen to the low (outboard) side.

The vessel will not return to the upright condition due to the permanent shift in the catch's center of gravity. It lays over or "lolls" about the angle of heel where the righting arm curve is zero.



Recommendations: Secure all catch to prevent shifting. Also secure all fishing gear and other heavy items when not in use to prevent their unintended movement.

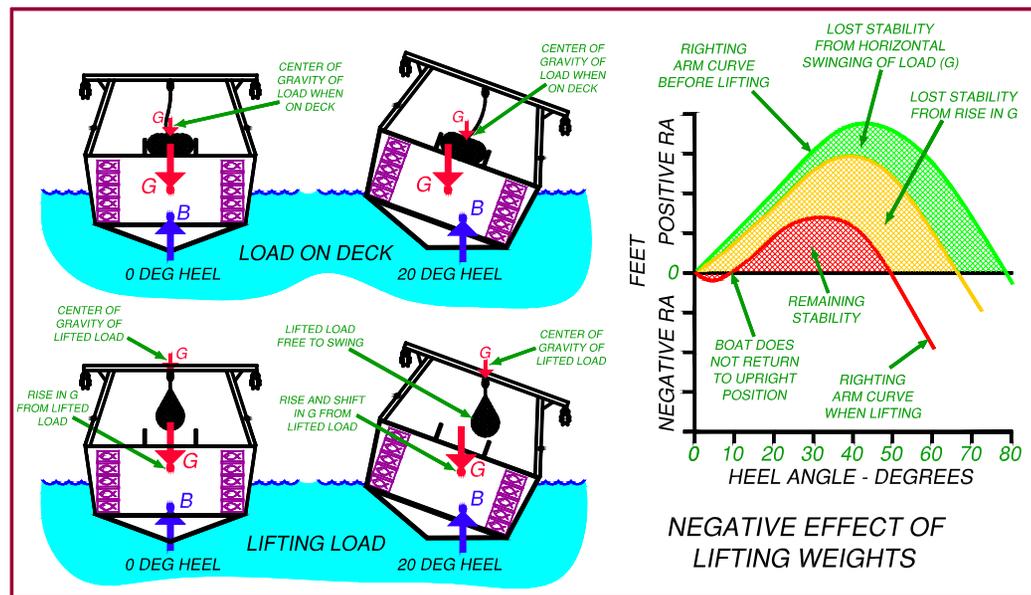
Fishing Operations - Lifting Weights

Lifting weights can significantly reduce a fishing vessel's overall stability without the crew being aware of the danger they are facing. Until the weight clears the deck the vessel's stability levels remain the same. However, the instant the weight clears the deck its effective center of gravity shifts to the tip of the boom, immediately raising the vessel's center of gravity. In addition, if the weight is free to swing, the dynamic swinging of the weight temporarily shifts the vessels center of gravity outboard, further reducing its stability. The vessel's overall stability has been reduced because:

The vessel's center of gravity "G" is raised due to the lifted weight's effective center of gravity being transferred to the boom's tip.

The vessel's center of gravity "G" is shifted outboard from the lifted weight's swinging.

When lifting very heavy weights the vessel may lay over or "loll" about the angle of heel where the righting arm curve is zero.



Recommendations: Never lift more weight than recommended in the vessel's stability guidance.

Minimize the time when lifting and secure the load with pen boards or ropes to prevent its swinging. If seas are moderate to large, suspend all lifting operations and secure all fishing gear and catch to prevent its shifting.

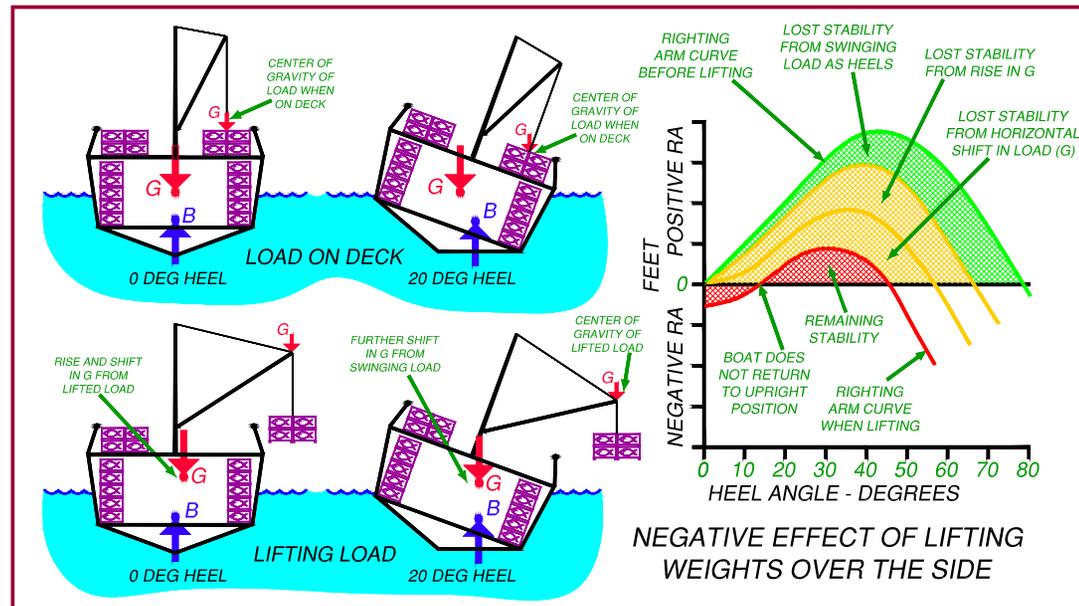
Fishing Operations - Lifting Weights Over the Side

Lifting heavy fishing gear over the side significantly reduces the overall stability of a fishing vessel. In addition to the rise in the vessel's center of gravity "G" from simply lifting the weight, the outboard location of the weight directly adds a heeling force, creating a temporary list which further reduces its stability. And if the lifted weight is free to swing, the dynamic swinging of the weight will temporarily shifts the vessels center of gravity outboard, further reducing its stability. The vessel's overall stability is reduced because:

The vessel's center of gravity "G" is raised due to the lifted weight's effective center of gravity being transferred to the boom's tip.

The vessel's center of gravity "G" is shifted outboard when the boom and lifted weight are moved over the vessel's side.

The outboard location of the fishing gear being lifted creates a direct capsizing force and generates a temporary list.



Recommendations: Never lift more weight than recommended in the vessel's stability guidance. Minimize the time when lifting fishing gear over the side of the vessel and if possible secure the load to prevent excessive swinging. If seas are moderate to large, suspend all lifting operations and secure the all fishing gear and catch to prevent its shifting.

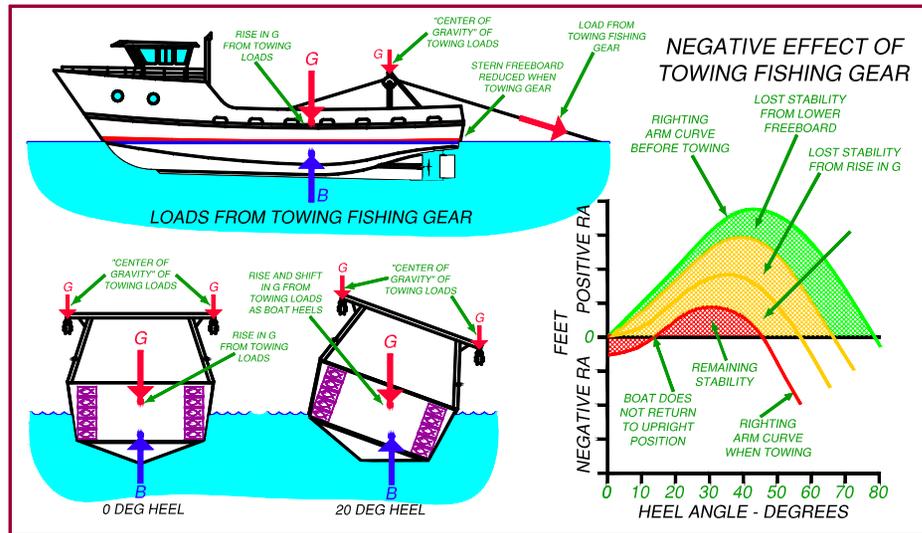
Fishing Operations - Towing Fishing Gear

Towing fishing gear can significantly reduce a fishing vessel's overall stability due to several factors. While each factor may be relatively small, the combined impact is sometimes large, especially in heavy seas and when the fishing gear hangs up.

First, the towing loads will act as added weight, which raises the vessel's effective center of gravity "G" because the towing point is generally located high on the vessel.

Second, the vessel's freeboard is reduced, especially in the aft corners, causing the deck edge to submerge at smaller heel angles.

Third, as the vessel responds to passing beam or quartering seas, the towing loads shift side to side on the vessel creating a temporary outboard shift in the vessel's effective center of gravity "G".



Recommendations: Tow directly off the vessel's stern using the lowest towing point possible.
 Minimize fishing time when using high towing points.
 If potentially dangerous wind or waves are present, suspend all fishing operations.

Fishing Operations - Towing Fishing Gear While Turning

Towing fishing gear while turning can significantly reduce a fishing vessel's overall stability due to several factors. As with the previous example, each factor may be small, but the combined impact can be quite large, especially in heavy seas and when the fishing gear hangs up. Towing fishing gear while turning reduces a fishing vessel's overall stability due to several factors:

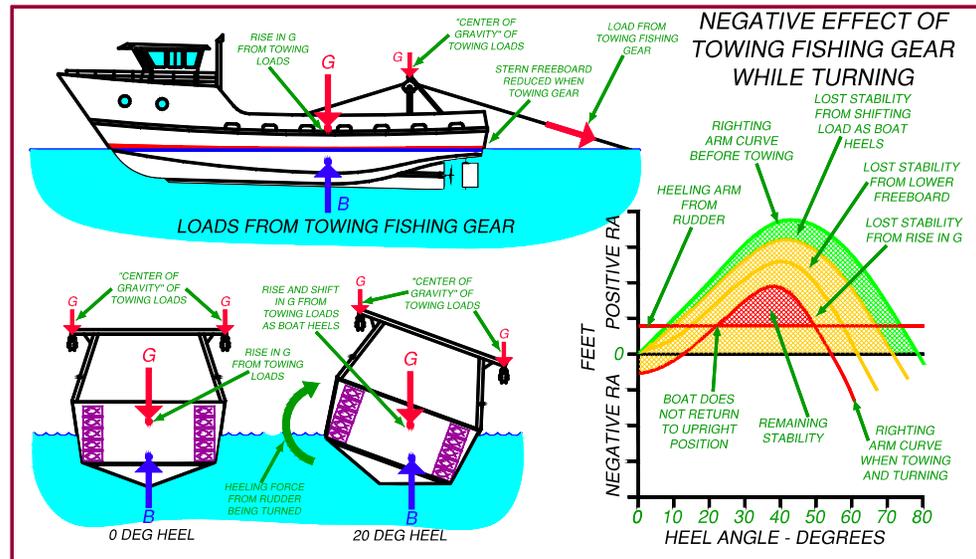
First, the towing loads acts as an added weight that raises the vessel's effective center of gravity "G" because the towing point is located high on the vessel.

Second, the vessel's freeboard is reduced, especially in the critical aft corners, causing the deck edge to submerge at smaller heel angles.

Third, as the vessel responds to passing beam or quartering seas, the towing loads shift side to side on the vessel creating a temporary outboard shift in the vessel's effective center of gravity "G".

Fourth, the rudder creates a heeling force (shown as the red line "Heeling Arm" in the figure), further acting to capsize the vessel.

Recommendations: Tow directly off the vessel's stern using the lowest towing point possible.
 Make wide turns when towing to minimize sideways pull from the gear.
 Minimize fishing time when using high towing points.
 If potentially dangerous wind or waves are present, suspend all fishing operations.



Wind and Waves **Dangers in Heavy Seas**

Important Lessons

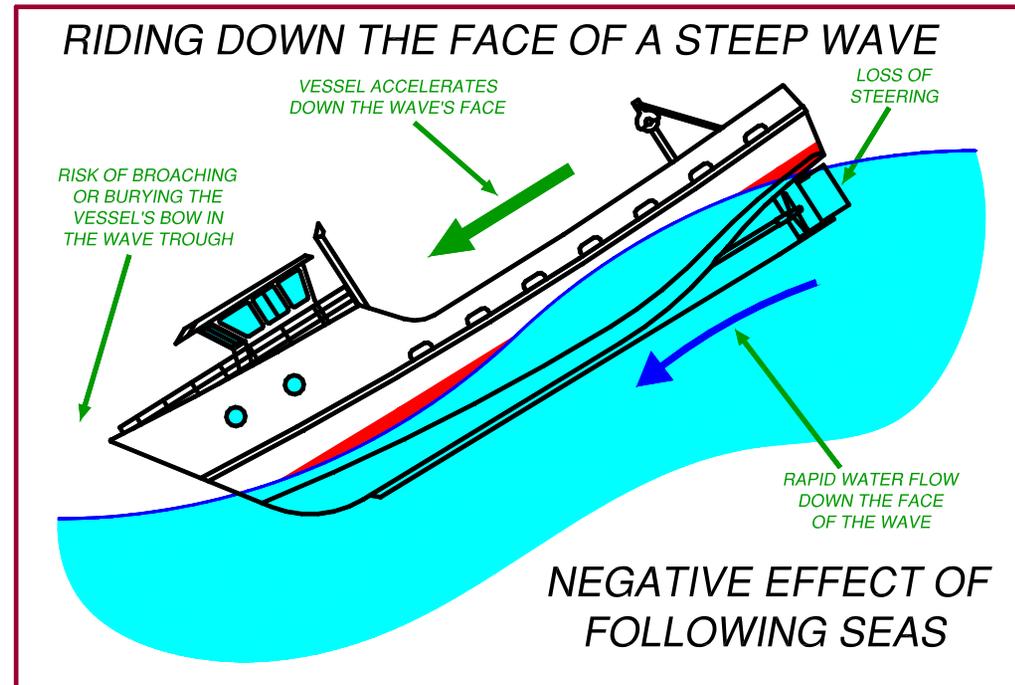
1. Operating in following seas (waves on the stern) increases the danger of capsizing. (See page 41 to 43)
2. If the vessel must run with the seas, riding on the backside of the preceding wave will minimize the dangers. (See page 41 to 43)
3. Operating in beam seas generally results in increased rolling of the fishing vessel. This can lead to shifting of the catch or heavy fishing gear and the increased chance of boarding seas. (See page 44)
4. Operating in stern quartering seas is the most dangerous heading for fishing vessels. All of the negative impacts from both following seas and beam seas are acting on the vessel at the same time. (See page 45)
5. Icing conditions significantly increase the danger of capsizing. The fishing vessel's overall stability is reduced from the weight of the accumulating ice. Complicating matters, the best means to minimize ice accumulation is to run with the seas, though this increases the capsizing risks noted above. (See page 47)
6. Wind and waves impacting a fishing vessel generally increase the capsizing forces (the red line) acting on the fishing vessel. (See page 7)

Following Seas - Riding Down the Face of a Steep Wave

Operating in following seas (waves on the stern) when riding down the face of a steep wave can lead to sudden capsizing of the vessel.

First, if the vessel surfs and accelerates down the wave, there is an increased chance of burying the bow in the backside of the preceding wave. This may cause the pilothouse windows to blow out or lead to the vessel broaching and capsize.

Second, because the natural flow of the water in the wave is in the same direction as the vessel, the rudder may lose effectiveness, leading to the loss of steering control. This can cause broaching and possible capsize.



Recommendations: 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.

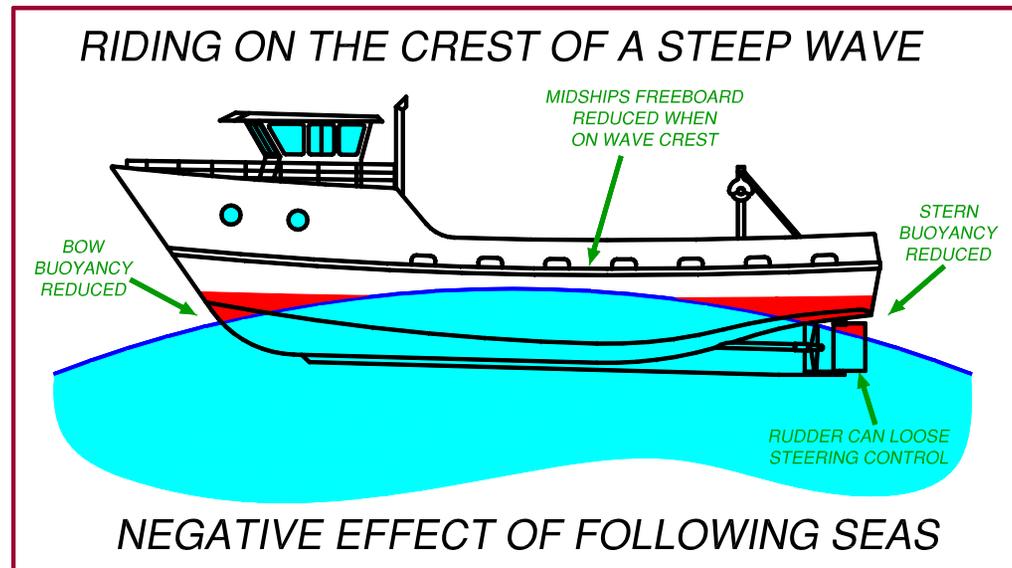
Following Seas - Riding on the Crest of a Steep Wave

Operating in following seas (waves on the stern) when riding on the crest of a steep wave can significantly reduce a fishing vessel's stability by several actions.

First, the critical stability supplied by the stern of the vessel is severely reduced when the stern is lifted clear of the water and no longer provides any righting forces.

Second, the reduction in the vessel's amidships freeboard further reduces the overall stability levels. This may lead to direct capsizing of the vessel.

Lastly, because the stern could be lifted clear of the water, the rudder may lose effectiveness, leading to the loss of steering control. This can lead to the danger of broaching and capsizing.



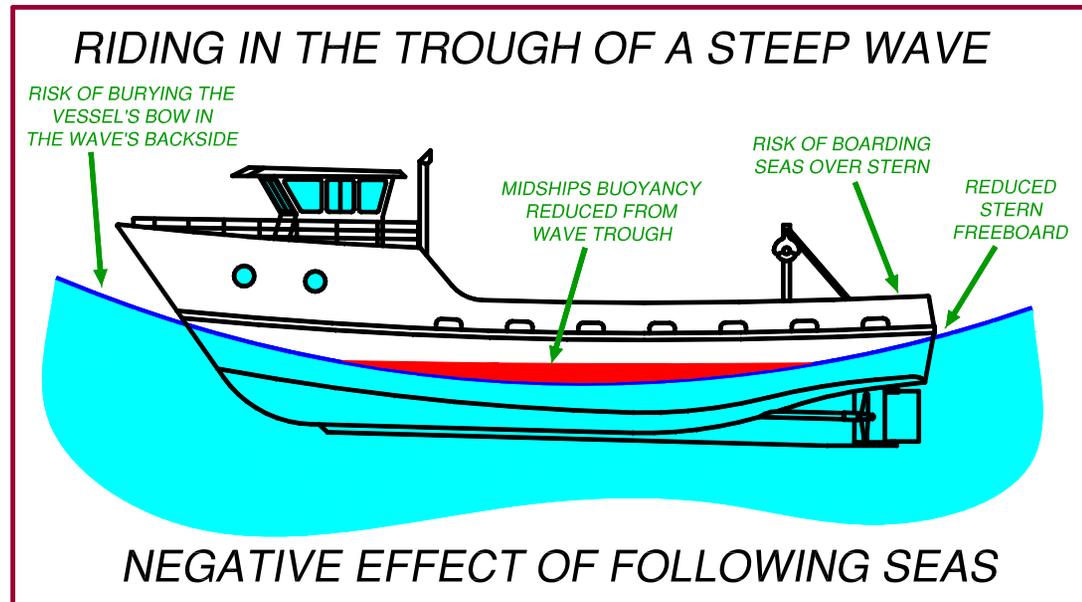
Recommendations: In severe sea conditions, change course to put the bow into the seas. If the vessel must run with the seas, riding on the backside of the preceding wave minimizes the dangers.

Following Seas - Riding in the Trough of a Steep Wave

Operating in following seas (waves on the stern) when riding in the trough of a steep wave can significantly reduce a fishing vessel's stability without making the crew aware of the danger they are facing. The overall stability is reduced by several actions:

First, there is an increased chance of burying the bow in the backside of the preceding wave's backside. This may cause the pilothouse windows to be blown out or lead to the vessel broaching and capsize.

Second, there is an increased chance of being swamped by a boarding wave. The added weight of the water on deck raises the vessel's center of gravity and creates a sizable free surface capsizing force. See page 35 Free Surface - Water on Deck for details.

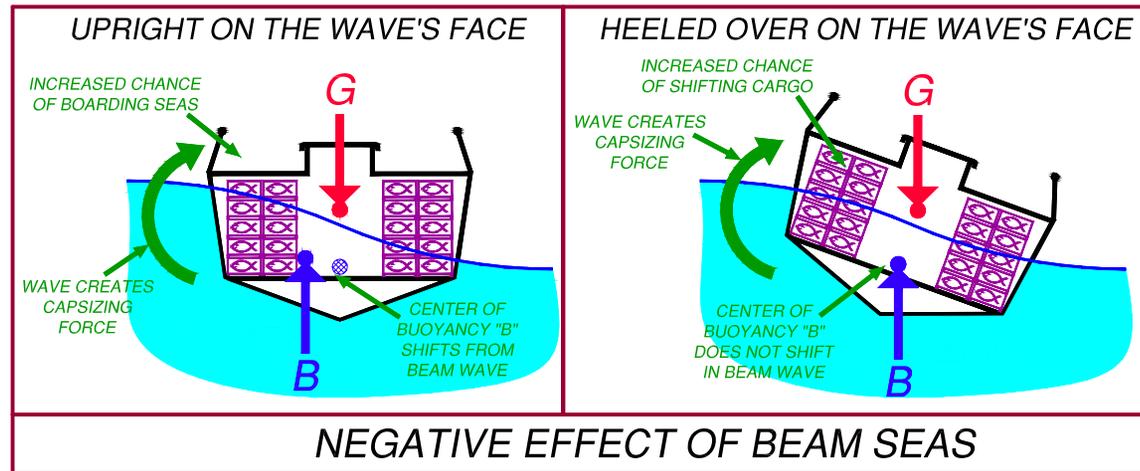


Recommendations: In severe sea conditions, change course to put the bow into the seas. If the vessel must run with the seas, riding on the backside of the preceding wave minimizes the dangers.

Wind and Waves - Beam Seas

Operating in beam seas (waves on the vessel's side) can significantly reduce a fishing vessel's stability.

First, there is an increased chance of being swamped by a boarding wave. The added weight of the water on deck raises the center of gravity and creates a sizable free surface capsizing force. See page 35 Free Surface - Water on Deck for details.



Second, the wave alters the crucial shifting of the center of buoyancy "B" to create a capsizing condition. As shown in the left figure above, when the vessel is upright the center of buoyancy "B" shifts outboard due to the beam wave's shape to create a capsizing force. And when the vessel heels over as shown in the right figure above, which in previous examples creates a positive righting force, it still has a capsizing force present because the beam wave's shape on the hull has prevented the center of buoyancy "B" from shifting outboard.

Third, there is an increased chance of the cargo or fishing gear shifting, leading to a sizable capsizing force. See page 38 Fishing Operations - Shifting Loads for details.

Fourth, in strong breaking waves the sheer physical force of the breaking wave may capsize the vessel.

Recommendations: In severe sea conditions, change course to put the bow into the seas.

Wind and Waves - Quartering Seas

Operating in quartering seas (waves on the vessel's stern quarters) is the most dangerous sea conditions for a fishing vessel. The effects of the previously discussed following stern (page 44 to 46) and beam (page 47) seas are combined to significantly reduce a fishing vessel's stability in the following ways:

First, there is an increased chance of being swamped by a boarding wave. The added weight of the water on deck raises the center of gravity and creates a sizable free surface capsizing force. See page 35 Free Surface - Water on Deck for details.

Second, the wave alters the crucial shifting of the center of buoyancy "B" to create a capsizing condition. As shown on page 44 Fishing Operations - Beam Seas, when the vessel is upright the center of buoyancy "B" shifts outboard due to the beam wave's shape to create a capsizing force. And when the vessel heels over which in previous examples creates a positive righting force, a capsizing force is still present because the beam wave's shape on the hull has prevented the center of buoyancy "B" from shifting outboard.

Third, there is an increased chance of the cargo or fishing gear shifting leading to a sizable capsizing force. See page 38 Fishing Operations - Shifting Loads for details.

Fourth, when riding down into a wave trough the rudder may lose effectiveness, leading to the danger of broaching. Also if the bow is buried in the backside of the leading wave crest, the vessel is in danger of broaching.

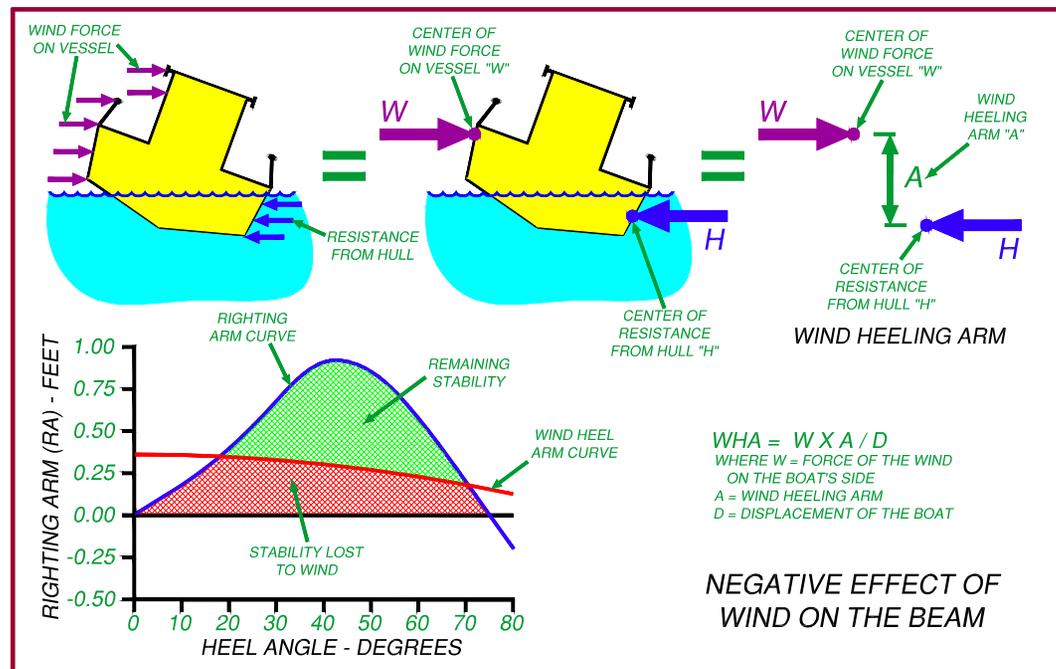
Fifth, the sheer physical force of large breaking waves can cause the vessel to broach when riding down the waves face and in the case of extreme conditions directly capsize the vessel.

Recommendations: In severe sea conditions, change course to put the bow into the seas.

Wind and Waves - Wind on the Beam

A strong wind on the fishing vessel's beam can significantly reduce its overall stability without the crew being aware of the danger they are facing.

The overall stability is reduced because the righting energy used to resist the beam wind (the red shaded area under the wind heeling arm curve) is no longer available for other forces acting on the fishing vessel such as the waves or the loads from fishing gear.



Recommendations: When in strong winds, head into the seas to remove the heeling forces from the wind.

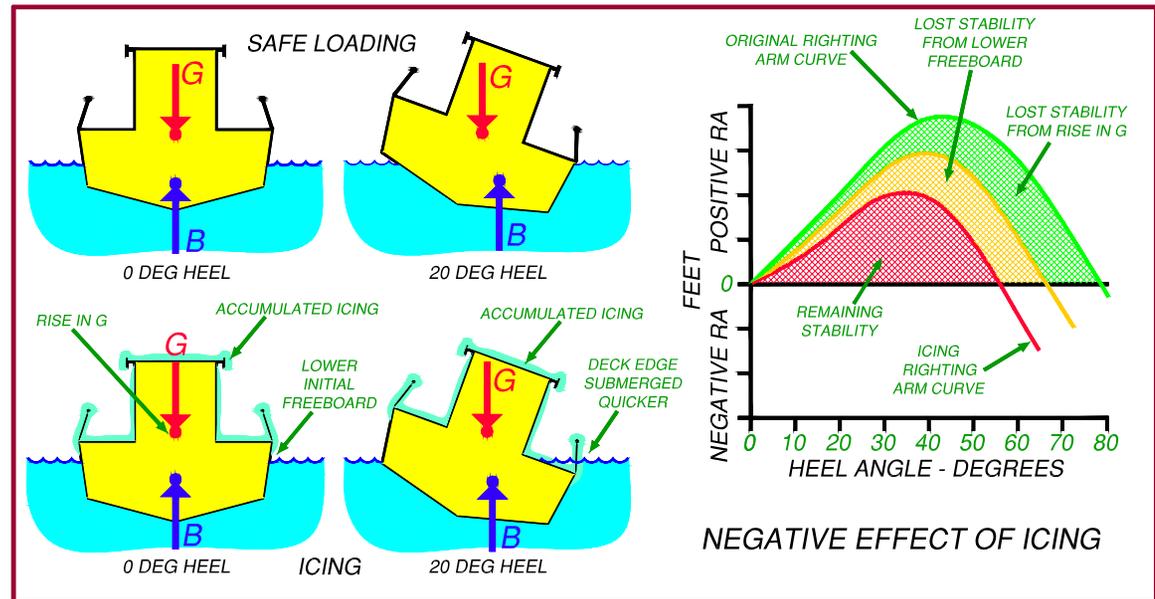
Wind and Waves - Icing

Operating in icing conditions significantly reduces a fishing vessel's stability from the weight of the accumulating ice because:

The center of gravity "G" rises rapidly from the added weight high on the vessel.

The freeboard is reduced because of the added weight, which causes the deck edge to submerge at smaller heel angles.

These are the same effects that occur when the vessel is overloaded. See page 28 Initial vs. Overall Stability - Overloading for details.



Recommendations: When icing conditions are encountered immediately take appropriate corrective action in any of the following procedures:

- If possible, alter course to return to warmer or protected waters.
- Steaming down wind reduces the speed of the ice formation, but use caution if the seas are very strong because stern seas increase the chance of broaching, boarding seas, or burying the bow.
- Secure all fishing gear below deck to minimize surfaces that ice can form on.
- Keep freeing ports clear of ice to allow rapid draining of water off the decks.
- Remove as much ice accumulation as is safe for the current weather conditions.
- Maintain radio communication with other vessels and shore side on a regular schedule.
- All lifesaving equipment should be broken out and ready for use.

Prudent Seamanship - Keeping a Level Vessel

The following measures are recommended for preserving your fishing vessel's stability. These measures are broken into three main categories; maintaining watertight integrity, stability guidance, and vessel operations and seamanship.

Maintaining Watertight Integrity

1. All openings in the hull and deckhouse should be fitted with watertight or weathertight closures.
2. All watertight doors, hatches, windows, and other closure devices must be maintained in good working condition. Institute a regular inspection program onboard the vessel to check their condition.
3. Train the crew the location and operation of all watertight and weathertight closures
4. Keep all watertight or weathertight closures secured close except when in use even in good weather.
Remember, an unexpected wave or wind gust can swamp the vessel as easily as a severe storm.
5. High water alarms should be fitted in all hull compartments potentially subject to flooding.
6. If the vessel is fitted with large fish processing spaces that can trap water, they should be fitted with high water alarms.

Prudent Seamanship - Keeping a Level Vessel Continued

Stability Guidance

1. Work with a qualified naval architect to create stability guidance appropriate for your vessel. Remember, this guidance is only as good as the information you provide the Naval Architect concerning your vessel's unique fishing methods, areas where you fish and the vessel's design.
2. Thoroughly understand the stability guidance provided for your vessel including its strengths and weaknesses. Discuss any questions with your Naval Architect.
 - Strengths include changes to the vessel's loading that significantly improve the stability levels.
 - Weaknesses include critical watertight doors that, if accidentally left open lead to rapid downflooding or large wet processing spaces that must be kept drained of standing water.
3. Train all crewmembers in how your fishing vessel's stability works.
4. Follow the stability guidance at all times. Key universal guidance advice includes:
 - Do not overload the vessel.
 - Keep cargo secured at all times.
 - Minimize the number of partially filled tanks to decrease free surface effects.
 - Keep all bilges, compartments and processing spaces dry and free of standing water.
 - Lastly, maintain your vessel's watertight envelope!
5. Always be aware of your vessel's current and future loading conditions and what impact this may have on your vessel's stability.
6. Always be aware of the current and future weather conditions and what impact this may have on your vessel's stability.
7. Keep track of physical changes made to your vessel such as installing new fishing gear. Consult with your Naval Architect to determine if new stability guidance is warranted.

Prudent Seamanship - Keeping a Level Vessel Continued

Vessel Operations and Seamanship

1. Ensure all freeing ports in the bulwarks are kept clear for rapid draining of water on deck.
2. Keep bilges pumped to minimum levels to prevent free surface effects and minimize excess weight.
3. When heavy seas are encountered,
 - Suspend all fishing operations.
 - Secure all fishing gear and cargo to prevent shifting.
 - Head the vessel into the seas to minimize water on deck and the vessel's motion.
4. Avoid operating in icing conditions. If icing cannot be controlled, leave the area immediately for shelter.
5. Avoid operating in following or quartering seas. They can cause heavy rolling or difficulty in steering especially when riding on the wave's face leading to broaching.
6. When towing fishing gear, always use extreme caution. Tow the gear directly off the stern to minimize capsizing forces on the vessel.
7. When lifting, always use extreme caution. Whenever possible, secure the load to prevent shifting during the lift.
8. Minimize the time lifting heavy fishing gear over the side, such as retrieving purse seines. Perform these lifts only in sheltered areas.
9. Maintain effective means for quickly releasing any towed or lifted fishing gear in the event the gear snags an obstruction or the fish dive to prevent capsizing the vessel.
10. Carry an effective sea anchor to keep the vessel's bow into the seas in the event of propulsion failure or loss of the ability to control the vessel's heading.

List of Definitions

- Buoyancy - Pg 10 - The forces acting to push the vessel up in the water.
- Cargo - Pg 16 - All of the fish caught as well as any ice, salt, or packaging carried to preserve the catch.
- Center of Buoyancy "B" - Pg 10 & 11 - The point on the vessel where its buoyancy forces act through.
- Center of Gravity "G" - Pg 10 & 12 - The point on the vessel where its weights act through.
- Draft - Pg 8 - The vertical distance between the waterline and the bottom of the keel.
- Freeboard - Pg 8 - The vertical distance between the waterline and the highest watertight deck.
- Free Surface - Pg 28 - The motion of liquids in slack tanks, fish holds, or bilges.
- Gravity - Pg 10 - The forces acting to pull the vessel down in the water.
- Hull - Pg 8 - The enclosed portions of the vessel below the highest watertight deck that runs continuously from the bow to the stern.
- Inclining Experiment (Stability Test) - Pg 13 - Procedure used to determine your vessel's lightship characteristics used in all stability calculations.
- Initial Stability - Pg 23 - The stability felt by the crew during operations in relatively calm seas.
- Lifting Fishing Gear Criteria - Appendix Pg 56 - A stability criteria is used to gauge a fishing vessel's performance when lifting or towing heavy fishing gear.
- Negative Stability - Pg 16 - The condition when the interaction between the Center of Buoyancy "B" and the Center of Gravity "G" creates a negative force working to capsize the vessel.
- Overall Stability - Pg 23 - The full range of stability from the initial upright equilibrium position to the point of vanishing stability (range of positive stability).
- Positive Stability - Pg 16 - The condition when the interaction between the Center of Buoyancy "B" and the Center of Gravity "G" creates a positive force working to right the vessel.
- Righting Arm "RA" - Pg 18 - The horizontal distance between the Center of Buoyancy "B" and the Center of Gravity "G"
- Righting Arm Curve - Pg 19 - The plot of the righting arms over a range of heel angles for a given loading.

List of Definitions Continued

Severe Wind & Roll Criteria - Appendix Pg 55 - A stability criteria is used to gauge a fishing vessel's performance in beam seas and strong winds.

Ships Stores - Pg 13 - All weights such as food or personal items that are consumed during the fishing voyage.

Stability - Pg 6 - The ability of a floating object to return to its initial upright position.

Stable Fishing Vessel - Pg 6 - A fishing vessel that has sufficient stability to remain upright in current weather and fishing conditions.

Superstructure or Deckhouse - Pg 8 - The enclosed portions of the vessel above highest watertight deck.

Tankage - Pg 13 - The consumable fluids, cargo (fish) tanks and ballast used during a voyage.

Unstable Fishing Vessel - Pg 6 - A fishing vessel that does not have sufficient stability to remain upright in current weather and fishing conditions and will capsize.

Vessel's Lightship - Pg 13 - All of the "fixed" weights on the vessel that do not change during the voyage.

Water on Deck Criteria - Appendix Pg 57 - A stability criteria is used to gauge a fishing vessel's performance in heavy seas when water may become trapped on deck by the bulwarks.

Waterline - Pg 8 - The position of the water surface along the hull.

Watertight Envelope - Pg 8 - The hull and watertight portions of the superstructure or deckhouses.

Appendix

How do Naval Architects Develop Stability Guidance?

Important Lessons

1. The **righting arm curve**, the plot of the righting arm “RA” versus heel angle, is the primary means used to evaluate a fishing vessel’s stability. (See page 54)
2. Additional curves reflecting the effects of severe winds, vessel rolling in heavy seas, lifting fishing gear over the side, or water on deck can be plotted on the basic righting arm curve as additional methods to evaluate a fishing vessel’s stability. (See page 55 to 57)
3. The characteristics of the righting arm curves are compared against various stability standards, “criteria”, to develop the appropriate stability guidance for the fishing vessel. (See page 55 to 57)
4. Compliance with any stability criteria does not insure protection against capsizing. The crew must exercise good seamanship, maintain the vessel’s watertight envelope, and use due diligence for the given sea conditions, weather forecasts, and the fishing vessel’s individual characteristics to prevent capsizing. (See page 57)

Stability Guidance by the Righting Arm Curve's Characteristics

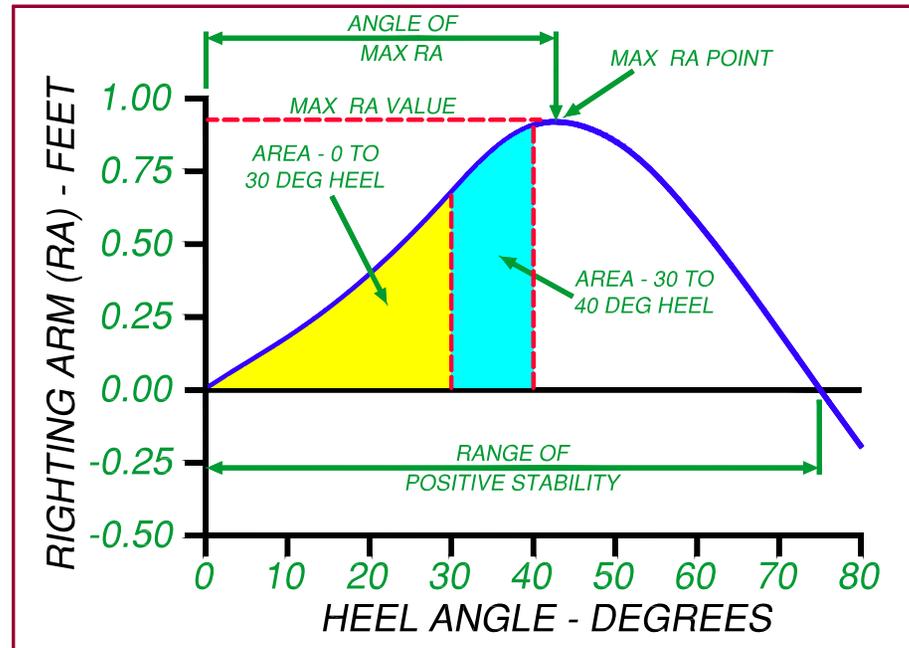
The primary method to determine if a fishing vessel has adequate overall stability is to measure the shape and size of the righting arm curve.

The typical standards are;

- A minimum area under the curve from 0 degrees to 30 degrees of heel.
- A minimum area under the curve from 30 degrees to 40 degrees of heel or the heel angle at which uncontrollable downflooding occurs.

(Uncontrollable downflooding is when an opening in the hull or superstructure such as fish hold hatch or engine room ventilation louver can not be made watertight and is submerged.)

- The heel angle of the maximum righting must be greater than a given angle.
- There is a minimum range of positive stability (positive righting arms).



Additional standards may be applied depending on the hull type, the organization reviewing the fishing vessels stability, or unique fisheries. Several examples of these standards, often called stability criteria, are shown on the following pages. For the purpose of this booklet, the reader should remember that these standards are available to develop stability guidance. The technical application of these stability criteria is the responsibility of the Naval Architect.

Stability Guidance by the Severe Wind & Roll Criteria

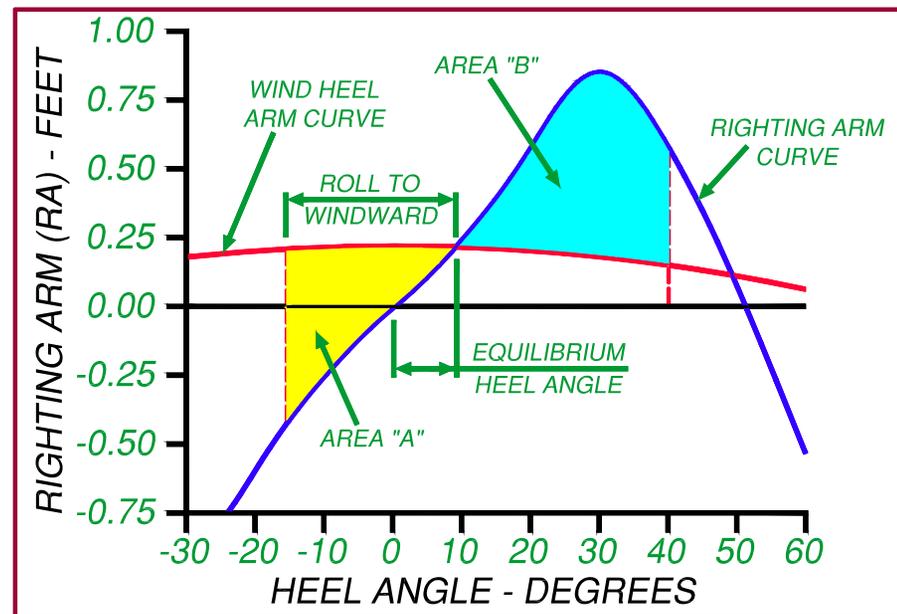
The “severe wind and roll” criteria are used to gauge a fishing vessel’s performance in beam seas and strong winds. These criteria assume that the fishing vessel has taken a large roll to windward from a passing beam wave. After the wave crest passes the vessel quickly rolls upright from both the wind on the beam and the backside of the passing wave.

In this example, Area “A” (in yellow) represents the forces that work to snap roll the fishing vessel back upright after the beam wave passes. Area “B” (in blue) is the remaining stability available to counter the fishing vessel’s rollback.

The criteria is applied by calculating:

- A wind-heeling arm (the red line) based on the fishing vessel’s profile and the expected wind speeds is plotted on the righting arm curve.
- A roll angle to windward based on the fishing vessel’s hull, the presence or absence of bilge keels and the expected sea conditions is calculated.
- The area between the righting arm curve and the wind heeling arm curve at the two locations shown.

To be considered satisfactory, area “B” must be larger than area “A”.



Stability Guidance by the Lifting Fishing Gear Criteria

The “lifting fishing gear” criteria are used to gauge a fishing vessel’s performance when lifting or towing heavy fishing gear. This includes vessels such as purse seiners, stern trawlers, or those using large dredges. The vessel does not need to lift the gear over the side to be in danger of capsizing from its fishing gear.

In this example, Area “A” (in yellow) represents the stability required to counter the effects of the fishing gear being lifted over the side. This stability is no longer available to counter the effects of wind, waves, or other capsizing disturbances.

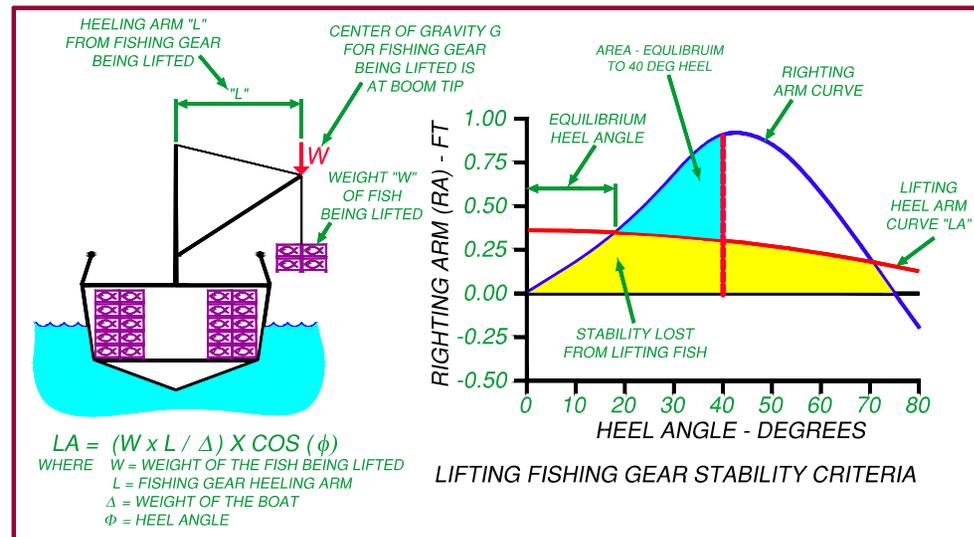
Area “B” (in blue) is the remaining stability available to counter any wind, waves, or other capsizing disturbances acting on the vessel while the fishing gear is lifted over the side.

The criteria is applied by calculating:

- The righting arm curve adjusted for the effect of lifting the weight.
- If the gear is being lifted over the side, a lifting heeling arm curve (the red line) is plotted on the corrected righting arm curve.

To be considered satisfactory;

- The shaded area must be greater than a minimum value up to 40 degrees of heel or the angle of downflooding.
- The heel angle of equilibrium must be less than a specified value.



Stability Guidance by the Water on Deck Criteria

The “water on deck” criteria is used to gauge a fishing vessel’s performance when encountering boarding seas that may become trapped by the vessel’s bulwarks.

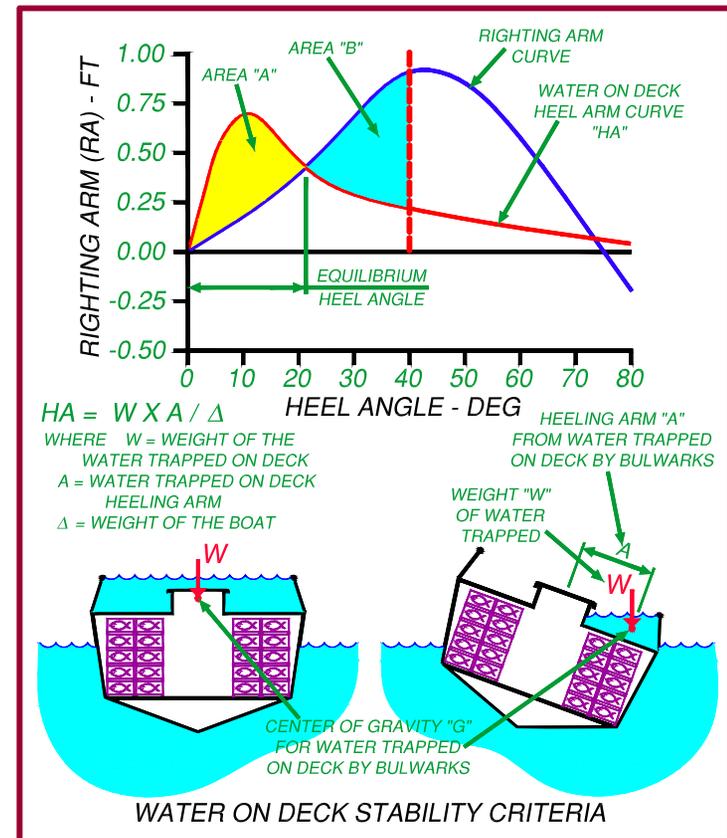
In this example, Area “A” (in yellow) represents the capsizing forces from the water trapped on deck.

Area “B” (in blue) is the remaining stability available to counter capsizing forces from the water trapped on deck.

The criteria is applied by calculating:

- A water on deck heeling arm curve (the red line) plotted atop the righting arm curve.
- The area between the righting arm curve and the water on deck heeling arm curve is calculated at the two locations shown.

To be considered satisfactory, area “B” must be larger than area “A”.



Other criteria or modifications may be used to evaluate a particular fishing vessel’s stability to reflect unique characteristics of the vessel or fishing methods such as gauging the effect of ice accumulations.

Important Lesson: Compliance with a stability criteria does not ensure protection against capsizing. The crew must exercise good seamanship, maintain the vessel’s watertight envelope, and be diligent for the given sea conditions, weather forecasts, and the fishing vessel’s individual characteristics to prevent capsizing.

List of Contacts for Additional Information

Please feel free to contact the following organizations for additional information on commercial fishing vessel stability or any other safety issues.

The Society of Naval Architects & Marine Engineers
601 Pavonia Avenue
Jersey City, NJ 07306
Phone: 1-201-798-4800
www.sname.org

Transport Canada
Marine Safety, Small Vessels
330 Sparks Street, 11th Floor
Ottawa, Ontario K1A 0N8
Phone: 1-613-991-3145
www.tc.gc.ca/marinesafety

North Pacific Fishing Vessel Owner's Association
Vessel Safety Program
Fisherman's Terminal
1900 West Emerson Place, Suite 101
Seattle, WA 98119
Phone: 1-206-285-3383
www.npfvoa.org

United States Coast Guard Contact Information On Following Page

09/20/03

United States Coast Guard (USCG) Headquarters
Commercial Fishing Vessel Safety (CFVS) Coordinator
2100 Second Street, SW, Room 1308
Washington, DC 20593 Phone: 1-202-267-2988 1-800-368-5647
www.uscg.mil/hq/g-m/cfvs/

USCG Atlantic Area CFVS Coordinator
Atlantic Area Marine Safety Division
Federal Building, 431 Crawford Street
Portsmouth, VA 23704 Phone: 1-757-398-6304

USCG District 8 CFVS Coordinator
Eighth Coast Guard District - TX, MI, AL, FL
Hale-Boggs Federal Building, 501 Magazine Street
New Orleans, LA 70130-3396 Phone: 1-504-589-4554

USCG Pacific Area CFVS Coordinator
PACAREA
Coast Guard Island, Building 50-6
Alameda, CA 94501-5100 Phone: (510) 437-2947

USCG District 9 CFVS Coordinator
Ninth Coast Guard District - NY, OH, MI, WI, MN, IN, IL
1240 East 9th Street
Cleveland, OH 44199-2060 Phone: 1-216-902-6052

USCG District 1 CFVS Coordinator
First Coast Guard District - NJ, NY, CT, MA, RI, NH, ME
408 Atlantic Avenue
Boston, MA 02210 Phone: 1-617-223-8440

USCG District 11 CFVS Coordinator
Eleventh Coast Guard District - CA
Coast Guard Island, Building 51-1
Alameda, CA 94501-5100 Phone: 1-510-437-5931

USCG District 5 CFVS Coordinator
Fifth Coast Guard District - PA, MD, DE, VA, NC
Federal Building, 431 Crawford Street
Portsmouth, VA 23704 Phone: 1-757-398-6554

USCG District 13 CFVS Coordinator
Thirteenth Coast Guard District - WA, OR
Jackson Federal Building, 915 Second Avenue
Seattle, WA 98174-1067 Phone: 1-206-220-7226

USCG District 7 CFVS Coordinator
Seventh Coast Guard District - SC, GA, FL
Brickell Plaza Federal Building, 909 S.E. First Avenue
Miami, FL 33131 Phone: 1-305-415-6868

USCG District 17 CFVS Coordinator
Seventeenth Coast Guard District - AK
P.O. Box 25517
Juneau, AK 99802 Phone: 1-907-463-2810