VESSEL STABILITY

By Dr. Bruce H. Adee

LTJG Jennifer M. Lincoln: Our next speaker is Dr. Bruce H. Adee, whose presentation is entitled *Vessel Stability*. Dr. Adee is an associate professor of mechanical engineering at the University of Washington. He received his Bachelor of Science degree in engineering from Princeton and his Master of Science and Ph.D. degree from the University of California, Berkeley. Dr. Adee has held several posts at the University of Washington including Director of the Ocean Engineering Program and Adjunct Associate Professor for the Institute for Marine Studies. He is a member of several naval and marine engineering and naval architectural societies. Dr. Adee has authored numerous publications regarding fishing vessel stability. Dr. Bruce Adee:

INTRODUCTION

The gentleman from the Department of Commerce pointed out that nobody had fallen asleep yesterday. Of course, that was before we started to discuss the subject of fishing vessel stability. I promise to do my best to keep the record intact and make the subject exciting for you.

While those who operate fishing vessels may regard vessel stability as a technical subject beyond their understanding, I believe this is a fundamental mistake. A basic knowledge of the principles of stability is essential to the safe operation of a fishing vessel.

We should begin by examining the vessel accident or casualty statistics. To this point, these statistics have been gathered primarily by the U.S. Coast Guard and examined in a number of studies. They have also been presented by previous speakers at this meeting. In particular, we should consider deaths associated with a vessel casualty.

Even a cursory review of the statistics reveals that the most frequent cause of death is a vessel losing stability. In addition to those casualties which are classified as stability casualties, there are a large number of fishing vessels which disappear and the cause of the casualty cannot be determined. One possible explanation of this is that they were unable to make a distress call, because they capsized very quickly.

We may also wish to group the vessel casualties attributed to foundering and flooding with the stability casualties. While the way in which the vessel is lost may differ, the method of reducing foundering and flooding casualties is similar to the method which should be used to reduce stability casualties.

What is clear from the statistics is that more than half the fishermen who die as a result of a vessel casualty die as the result of a stability-related casualty. It is also clear that the Alaska crab fishery has the worst casualty record.

It is ironic that the Alaska crab fishery should have the worst stability casualty/loss-of-life record. For at least 15 years, insurance companies have required stability reports and booklets for the Alaska crab vessels before they would issue insurance policies. These reports prepared by naval architects are based on the vessel's exceeding the International

Maritime Organization (IMO) stability standards for fishing vessels.

In September 1991 the U.S. Coast Guard issued final fishing vessel regulations which include stability regulations for vessels over 79 feet in length (most Alaska crab vessels are over 79 feet long).

The heart of the stability regulations which have been issued are identical to the IMO stability standards. So, what should we expect the effect of the new regulations to be? Nothing, unless there is a vigorous campaign to change peoples' attitudes and methods of operation.

Stability is not just a vessel-related problem. It is a people problem as well. Every fishing vessel has stability characteristics which result from the vessel's design and construction.

These are carefully documented in the stability report prepared by the naval architect. Each time the vessel is loaded and puts to sea the operator is determining the level of stability of the vessel by choosing how to load it.

This is where behavior enters because when that vessel leaves the dock its stability is determined. Every time a change is made during the voyage, such as where to load the catch or which fuel tank to burn from, the stability of the vessel is altered. Whether these decisions are made by someone who is cognizant of their implications for vessel stability does not matter; they completely determine the vessel's stability.

The first step in solving the "stability problem" is to have someone on the vessel who will consider stability and be able to make loading decisions consistent with maintaining proper stability of the vessel. Under these circumstances we must ask ourselves: What are the incentives to reduce the loading or leave the vessel tied to the dock if it is less stable than it is required to be?

The next step in averting tragedy will be up to the U.S. Coast Guard enforcement officers under the fishing vessel regulations which have been in effect for over a year. During a boarding at sea, these people need to quickly assess the vessel's stability and exercise the authority to send the vessel back to port if it has insufficient stability.

Another area of the safety activity where problems arise is in gathering statistics about vessel accidents and crew member injuries and deaths. Everybody would like to have complete and accurate statistics. However, we must recognize a serious problem. Determining the causes leading to a vessel casualty is often very difficult. This is far different than the normal attempt to determine the cause of death. To determine the cause of death, you perform an autopsy on the body. In most cases the required information is quickly obtained and conclusions can be reached.

For the most important fishing vessel casualty cases, you may start with nothing. All of the most relevant information is at the bottom of the sea. Even if you could locate the sunken vessel, the cost of recovery or underwater examination would be staggering.

As an example of the problem, consider two of the most celebrated casualty investigations we have had in the Pacific Northwest. These are the investigations into the loss of the F/V *Americus* and the F/V *Altair*, and the investigation into the loss of the F/V *Aleutian Enterprise*. While these investigations and reports were very enlightening and worthwhile, the conclusion of the investigation took place years after the casualties. We will never have perfect statistics for marine casualties, but we must not let this deter us from pursuing a course of action which will improve safety based on the best available information.

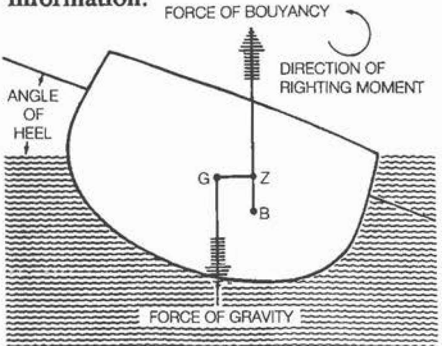

Figure 1. Buoyant Force and Weight Force for a Stable Vessel.
—Source: *Principles of Naval Engineering*

There is one other topic we have heard about at this meeting that deserves more comment, and that topic is Total Quality Management (TQM). TQM has become a "buzz" word that we are hearing more and more in the marine industry. My only warning is that we make sure that the word "TOTAL" really means total.

Consider the example of salmon fishing vessels. Over the past 10 years or so there has been a very strong incentive to improve the quality of the fish produced.

One method of improving the fish is to convert the fish hold in the fishing vessels from using ice to chill the catch to using refrigerated seawater cooling systems. What we have done is to make little crab boats out of the salmon fishing vessels. We have applied TQM to the product without considering the overall effect on vessel safety as part of the total system.

Now, with this introduction to the topic, let's progress to some of the technical aspects of vessel stability.

FISHING VESSEL STABILITY

The first thing to recognize is that the basic principles of vessel stability are very straightforward. The intact statical stability of a vessel is determined by examining two forces which act on the vessel. The first force is the buoyant force which results from the water pressure on the hull.

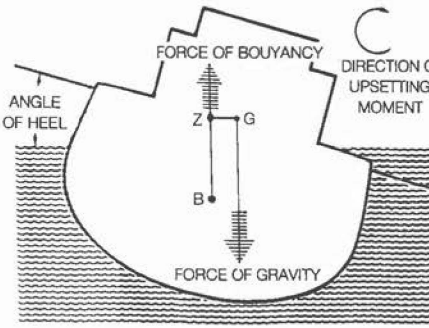

Figure 2. Buoyant Force and Weight Force for an Unstable Fishing Vessel.
— Source: *Principles of Naval Engineering*

The second force is the weight force which arises from the gravitational attraction. The buoyant force acts at a point we call the center of buoyancy and the weight force acts at the center of gravity.

An example of a stable vessel is shown in Figure 1. In this figure the points labelled G and B represent the center of gravity and the center of buoyancy, respectively. The large dark arrows represent the forces of buoyancy and weight.

The vessel is stable because when it is released from the angle of heel shown it would return to its original upright position. If you examine the combination of the buoyant force pushing upward and the weight force pulling downward, you will recognize that together these forces impose a torque on the vessel in the opposite direction to the way the vessel is heeling.

An unstable vessel is illustrated in Figure 2. Notice that in this case the center of gravity is higher and the relationship between the weight and buoyant forces has the opposite effect as for a stable vessel.

Here these forces act in concert to cause the vessel to heel to a larger angle. In fact a vessel in this situation is likely to capsize.

Although the difference between a stable vessel and an unstable vessel may be precisely determined, it is of little consequence in practice. At sea the effects of wind, waves, partial flooding, shifting cargo, and many other changes must be anticipated. So, a vessel must have a sufficient level of stability to ensure its survival.

To establish a baseline for the stability calculations, a loading condition called lightship condition is used. The lightship condition is a loading condition in which only the "permanent" equipment is aboard the vessel. The vessel does not have fuel, water, consumables, crew, or gear such as crab pots aboard.

When a naval architect is hired to prepare a stability report for a fishing vessel, the first step is to determine the weight of the vessel and the location of the center of gravity by performing a stability test. Since every vessel is different, an individual stability test is required for every vessel unless it is identical to another vessel.

The stability test consists of several parts. In preparation for the test the vessel should be in a loading condition as close to the lightship condition as possible. The deadweight survey is a survey to determine the loading of the vessel at the time the test is conducted. This information will be used later to adjust the results from the actual loading condition at the time of the test to results appropriate for the lightship condition.

During another part of the stability test the freeboard at various points on the vessel is measured. From this the position of the waterline on the hull is calculated. By referring to the hull shape shown on the plans, the displacement or weight of the vessel and the fore and aft location of the center of gravity can be calculated.

The remaining part of the stability test is the inclining experiment. In this experiment long pendulums are hung to accurately measure the heel angle as weights are moved around on the deck to cause the vessel to heel to a number of different angles. The result of this experiment is a determination of the vertical position of the center of gravity.

After the stability test the naval architect will use the measurements taken to calculate the lightship weight of the vessel and the vertical and longitudinal position of the center of gravity. To complete a stability booklet, the naval architect takes this basic information about the vessel and calculates the vessel's stability for a variety of different loading conditions which reflect the operation of the vessel.

One of the ways a naval architect will evaluate the level of stability is by examining the righting arm curve. An example of a righting arm curve is shown in Figure 3. The vertical scale on the left is the righting arm in feet. Looking back at Figures 1 and 2, the righting arm is the horizontal distance between the weight force and the buoyant force. If this is large, the vessel is very stable. As it gets smaller, the stability decreases and when it is negative the vessel is unstable and the relationship shown in Figure 2 exists.

The horizontal axis for the righting arm curve is the angle of heel in degrees. The curve is essentially a graphical representation of the tendency of the vessel to return to the upright from any angle of heel. The larger the righting arm, the more stable the vessel.

At the far right of the curve, the value of the righting arm goes to zero at a large angle of heel. This means that if this vessel, in this loading condition, were heeled to an angle greater than the point where the righting arm goes to zero, it would capsize. From zero angle of heel to the point where the righting arm goes to zero is called the range of stability.

In evaluating the vessel's stability by examining the righting arm curve, the important characteristics to look for are the shape of the curve (particularly how large the righting arm becomes), the area under the curve, and the range of stability. Figure 3 also illustrates a number of the IMO stability requirements which are based on the righting arm curve.

FISHING VESSEL STABILITY REQUIREMENTS

Traditionally, in the United States, fishing vessels have been exempt from most of the regulations applied to other commercial vessels. As fish tenders and fish processing vessels developed in the Pacific Northwest in the 1960s, the exemption was extended to them as well.

A dramatic change occurred with the passage of Public Law 99-509.

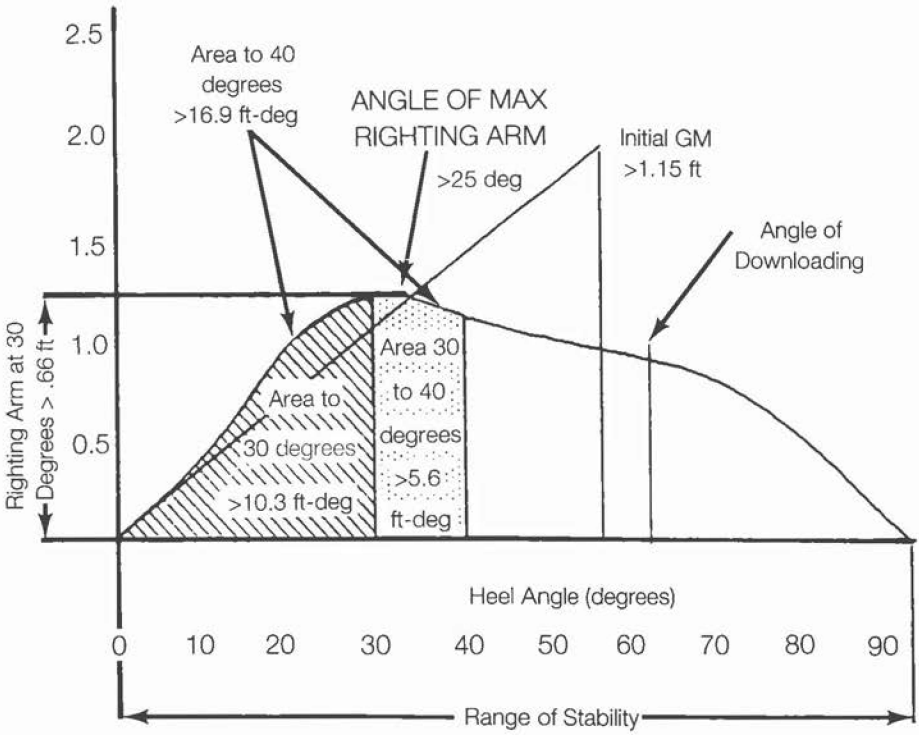

Figure 3. A Righting Arm Curve Illustrating IMO Stability Requirements.
— Source: U.S. Coast Guard, NVIC 5-86)

Section 5102 deals with the application of the load line regulations and states that exemptions are granted to the following:

- Fishing vessels.
- A fish processing vessel of not more than 5000 gross tons constructed as a fish processing vessel before August 16, 1974, or converted for use as a fish processing vessel before January 1, 1983.
- A fish tender vessel of not more than 500 tons constructed, under construction, or under contract before January 1, 1983.

Operators were slow to come into compliance with load line regulations until the loss of the F/V *Aleutian Enterprise* on March 22, 1990. The loss of this fish processing vessel accelerated the application of the load line regulations to vessels engaged in processing and tendering.

In a separate development the Congress passed Public Law 100-424, "The Commercial Fishing Vessel Safety Act of 1988." This law called for the creation of an advisory committee to assist the Coast Guard in developing regulations for commercial fishing vessel safety including stability regulations for newly constructed vessels. The rule-making procedure was followed, which eventually led to 46 CFR, Part 28, effective in September 1991.

The stability portion of these regulations applies to vessels over 79 feet long which are newly constructed or substantially altered. They contain many requirements, but a major portion of the requirements are the IMO stability guidelines which have been in use for many years on larger vessels.

Implementation of stability regulations for vessels less than 79 feet in length was deferred for further study and implementation at a later date. A proposed rule pertaining to these vessels was published on October 27, 1992, and the comment period was extended to February 28, 1993. The proposed rule splits vessels under 79 feet in length into two groups, those less than 50 feet and those between 50 and 79 feet. Differing stability requirements are applied to each group.

STABILITY DISCUSSION

We have discussed the basic principles of vessel stability, how stability is evaluated, and the applicable regulations. Now let us turn our attention to using this knowledge to examine typical decisions which face fishing vessel operators. Throughout this discussion it is important to remember that every vessel is different, and each situation we examine in this section is appropriate for a specific loading condition.

The first decision usually faced at the time of departure by the person operating a vessel equipped with circulating seawater or refrigerated seawater tanks is, "Which holds should I fill with seawater at the time of departure?"

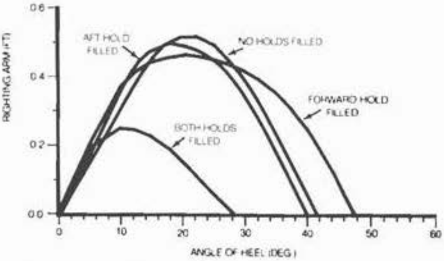

Figure 4. Righting Arm Curves for 107-foot Alaskan Crab Vessel with Different Holds Filled with Seawater.

Figure 4 shows the righting arm curves for an Alaskan crab vessel of 107 feet overall length. The condition shown is a departure condition with full fuel and water tanks and a heavy deck load of crab pots. The vessel has two circulating seawater crab holds and the four curves represent possible alternatives for filling these holds.

The first thing to notice about Figure 4 is that none of these curves meets the IMO stability standards. There is not much difference in the vessel's stability with no holds filled or with either forward or aft hold filled. However there is very marked decrease in stability with both holds filled. This vessel departed with its forward hold filled and capsized shortly after filling the aft hold while underway. The decision to fill the aft hold was made in order to "increase" the stability.

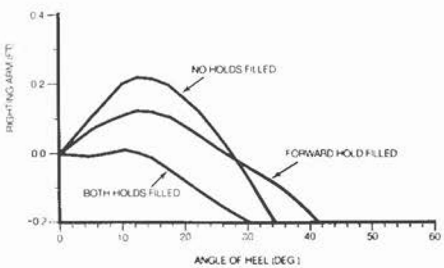

Figure 5. Righting Arm Curves for 84-foot Alaskan Crab Vessel with Different Holds Filled with Seawater. (Note righting arm scale includes negative values.)

Figure 5 shows a similar situation for an 84-foot Alaskan crab vessel. In this loading condition this vessel is in extreme danger (note the different scale for righting arm curve which includes negative and unstable values). This vessel also capsized when operated with the forward hold filled.

Figures 6 and 7 should be viewed together. They show an Alaska limit seiner which is used for salmon seining. In Figure 6 the vessel is lightly loaded meaning it has very little fuel, fresh water, and stores aboard.

In this case, filling the forward hold with seawater has a positive

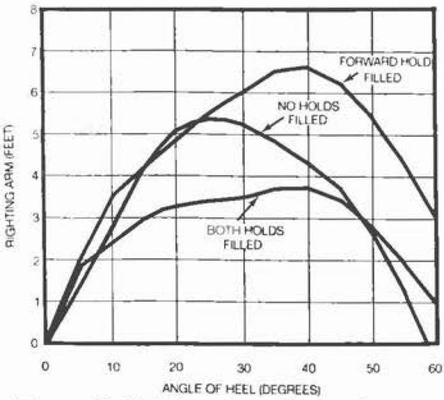

Figure 6. Righting Arm Curves for an Alaskan Limit Seiner Lightly Loaded with Different Holds Filled.

effect on stability. In fact, with no holds filled, the vessel does not meet the IMO stability standards, but with the forward hold filled, it does. Filling both holds reduces stability significantly.

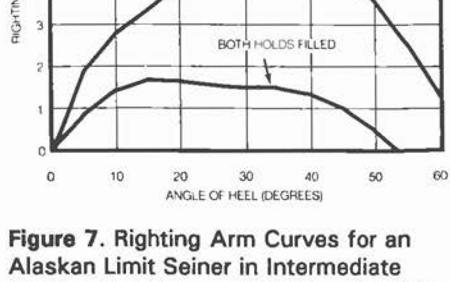

Figure 7. Righting Arm Curves for an Alaskan Limit Seiner in Intermediate Loading Condition with Different Holds Filled.

Figure 7 illustrates an intermediate loading condition for the same vessel with the fuel, fresh water, and stores about half full. In this case the vessel does not meet IMO standards in either situation shown and would be in an extremely dangerous condition with both holds filled.

If this same vessel were operated with fuel and fresh water tanks filled, there would be a further decrease in stability for each possible combination of holds filled.

Figure 8 shows an 86-foot long Alaskan crab vessel which is equipped with three holds. The curve shown is with a maximum load of crab pots on deck. Again there is improvement when one hold is filled but the stability deteriorates when more than one hold is filled.

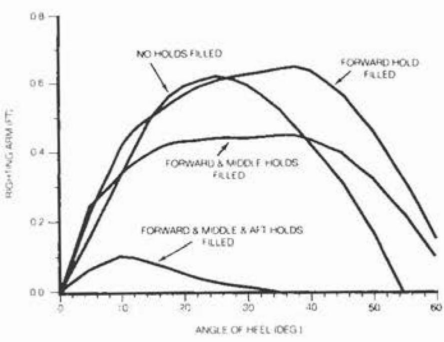

Figure 8. Righting Arm Curves for an 86-foot Alaskan Crab Boat with a Large Number of Pots on Deck and Different Holds Filled.

One of the many problems that fishing vessels encounter at sea is the problem of partial flooding of the vessel. This may occur because of the failure of the seal for a hull penetration such as a rudder or propeller shaft, a leak resulting from a crack, failure of a through-hull fitting or failure of a closure such as a hatch cover, permitting water to enter the hull.

The end result will be influenced by factors including the ability to dewater a space, loading conditions at the time, placement of watertight bulkheads and the ability to recognize and correct the problem quickly.

Many vessels have been lost as water usually enters through the seal around the rudder or through the hatch to the main deck. A vessel for which the consequences of lazarette flooding are very severe is shown in Figure 9.

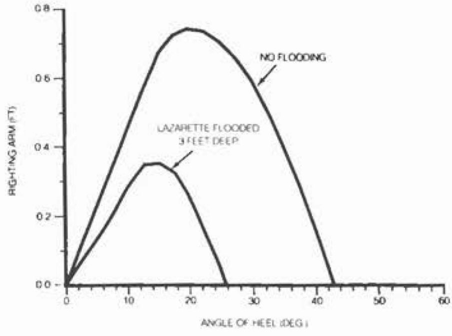

Figure 9. Righting Arm Curves for a 123.5-foot Alaskan Crab Vessel without Flooding of the Lazarette and with the Lazarette Flooded to a Depth of Three Feet.

The length of the Alaskan crab fishing vessel is 123.5 feet overall and it has a large lazarette which extends across the vessel from side to side. The initial condition shown without flooding does not meet the IMO requirements. The second righting arm curve indicates the vessel's stability under the same loading condition with three feet of water in the lazarette. The reduction of stability is dramatic and puts this vessel in an extremely dangerous situation.

The unintentional flooding of any compartment within a fishing vessel is a severe problem which should be avoided or dealt with very rapidly. If the initial flooding is not dealt with quickly, the problem may cascade into a vessel-threatening situation in short order. Compartments should be monitored with alarms where feasible. In addition, an inspection should be made as part of the regular watchkeeping procedure. Finally, there should be the capacity to use a pump to dewater all compartments.

A poop deck is a raised deck at the aft end of fishing vessels. It may extend from 10 to 20 percent of the length of the vessel forward from the stern. It is a break in the line of the main deck aft and is raised on the order of 9 to 12 inches at the break. On most vessels it would not be noticed because the false wooden deck extends forward from the poop deck to the house at the raised level of the poop deck.

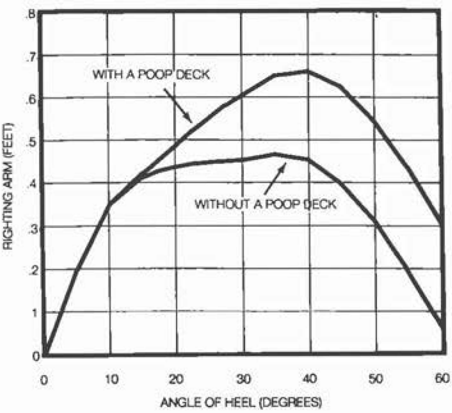

Figure 10. Righting Arm Curves for an Alaskan Limit Seiner with and without a Poop Deck.

Figure 10 shows the effect of the poop deck on the stability of an Alaskan limit seiner. The effect is quite clearly demonstrated. The vessel meets the IMO stability standards with a poop deck and is well below without.

Icing is a major problem in many fisheries in the waters off Alaska, which operate during the winter months. In order to anticipate the detrimental effect of icing on stability, IMO has developed a standard loading allowance for icing. They recommend that the ice loading of horizontal surfaces be 6.15 lb./ft^2 and vertical surfaces be 3.08 lb./ft^2 be added to the vessel.

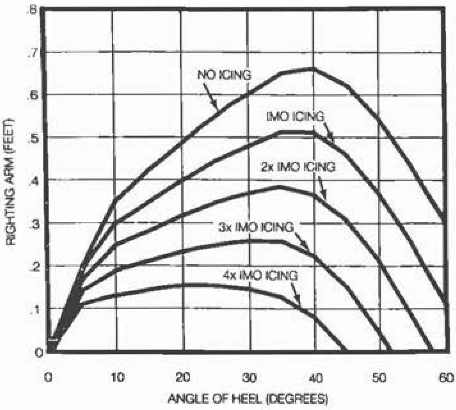

Figure 11. Righting Arm Curves for an Alaskan Limit Seiner with Various Levels of Icing.

If seawater froze perfectly into ice this would be an ice thickness of 1.15 inches on horizontal surfaces. In order to evaluate the effect of icing, the surface area of exposed surface is determined and then the additional loading due to icing is added to the vessel.

As an example of the effect various icing loads have on stability, consider the Alaskan limit seiner shown in Figure 11. Without ice the vessel meets the IMO stability criteria. With various levels of icing, the stability of the vessel decreases.

Figure 12 shows the effect of icing on a 98-foot trawling vessel which survived a major icing storm. The vessel does not initially meet the IMO stability criteria (no icing condition). When ice is added, the decrease in stability is again evident.

There are many vessels for which the stability falls well below the IMO standards, making them unsuitable for their intended purpose. One method of increasing the stability of these vessels is to increase their beam by adding sponsons to each side.

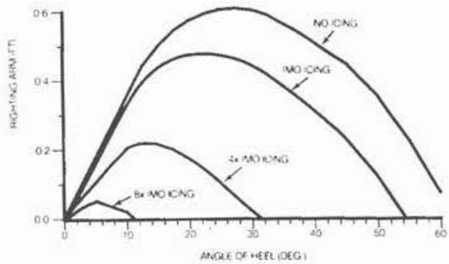

Figure 12. Righting Arm Curves for a 98-foot Trawler with Various Levels of Icing.

The bow is left unchanged and the additional beam starts about one-

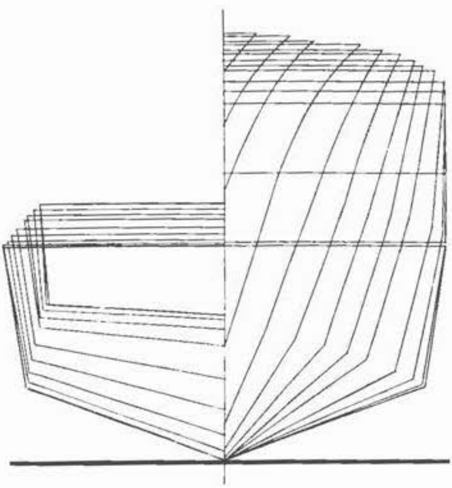

Figure 13. Cross Sections of a 98-foot Alaskan Crabber/Trawler as Designed and Built. (Forward sections on the right, aft sections on the left.)

fourth of the length aft of the bow and increases to a constant value a small distance aft. The constant increase of the beam is carried aft all the way to the stern.

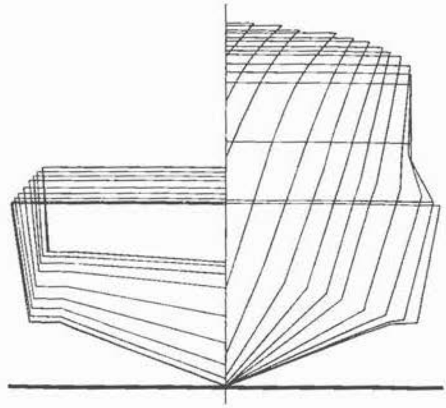

Figure 14. Cross Sections of a 98-foot Alaskan Crabber/Trawler with Sponsons Added.

Figures 13 and 14 show a sectional view of a vessel as it was designed and built and with the addition of sponsons. For this vessel, the sponsons increase the beam by about 1.5 feet on each side.

Figure 15 shows the dramatic positive effect that the additions of sponsons have on this vessel. The peak in the righting arm curve is more than doubled as is the area under the curve.

For many vessels the addition of sponsons would provide an opportunity to increase the fuel-carrying capacity of the vessel. Turning the sponsons into additional fuel tanks might enhance the operation of the vessel and would be beneficial so long as this did not seriously reduce the positive effect on stability.

Figure 16 shows the stability for the same 98-foot crabber/trawler shown in Figure 15. In this case the internal volume added by the sponson is filled with fuel. The calculation illustrates the effect of using 25 percent, 50 percent, 75 percent, and 100 percent of the added volume as fuel tanks. This figure shows that the stability is reduced only a small amount when the sponsons are used as fuel tanks.

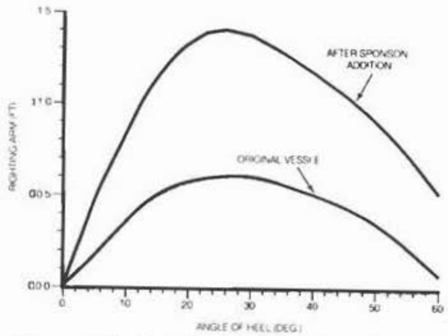

Figure 15. Righting Arm Curves for a 98-foot Alaskan Crabber/Trawler Before and After the Addition of Sponsons.

At first glance one might not have expected the results shown in Figure 16. When the sponson is 100 percent filled with fuel, there is essentially no gain in freeboard because the added weight and buoyancy are almost equal. However, when the vessel is heeled over, the buoyancy, which the sponsons add, is far from the center of the vessel, providing a large restoring moment to increase the stability.

WHAT YOU SHOULD DO

As an owner/operator you bear a great responsibility for the safety of your crew and vessel. Based upon experience examining a number of stability related casualties, I have prepared the list shown in Table I to suggest several important safety considerations related to vessel stability. With a little thought you should be able to add other items to this list.

The first item on the list is to obtain current stability information. In his presentation Jim Herbert discussed the stability report for a fishing vessel. Did you notice the date on that report? It was 1979. One should assume about a five-year life on a stability report. The reason is that in most cases the operation of the vessel changes dramatically and the vessel most likely gets heavier because of added equipment. You need the current information applicable to the vessel in its present condition.

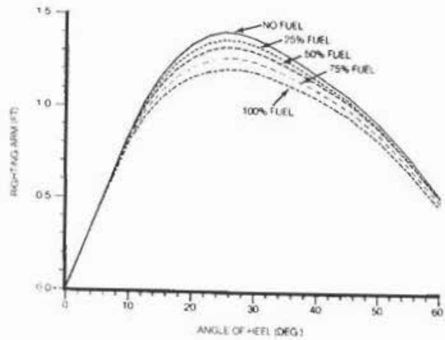

Figure 16. Righting Arm Curves for a 98-foot Crabber/Trawler with Sponsons Added and Various Portions of the Sponsons Volume Used to Carry Fuel.

One way to keep the stability data up-to-date is to maintain a log of the weight changes. Keep a list of everything that is added or removed from the vessel. Enter the weight of the item and the location it is installed. This will help you recognize when a new stability test is needed and how to modify the stability calculations to account for changes. The cumulative effect of continually adding weights over a long period of time has contributed to the loss of many vessels.

A method of keeping track of weight changes is to regularly monitor the waterline. For the same loading condition you should see if the vessel's draft is the same. Maybe you should take a picture of the vessel in profile at the time of departure. If you measure a change in the waterline position, then it is time to reexamine the stability.

Table I. Items to be Considered to Maintain the Stability and Safety of Your Fishing Vessel.

1. Obtain current stability information.
2. Keep a log of weight growth.
3. Regularly check the waterline and record.
4. Maintain watertight integrity.
   — Bulkheads
   — Openings
5. Be able to monitor all spaces.
6. Be able to pump all spaces.
7. Close openings to holds not in use.
8. Learn everything you can about stability.
9. Use your stability information wisely.
10. Plan what you would do under various "disaster" scenarios.
11. Load your vessel to maintain adequate stability.

Maintaining watertight integrity is crucial. You would not think of drilling a hole through the hull. Why would you consider putting the same hole through a watertight bulkhead?

The difference is that you would notice a hole through the hull immediately but the hole in the bulkhead would not become critical until your vessel was sinking and your life depended on the bulkhead's holding water. In addition, all through-hull fittings must be checked on a regular basis and the hatches and openings must be maintained and renewed.

You also need to monitor all spaces within your vessel to prevent them from flooding. This means a visual inspection as part of the normal watchkeeping and alarms in areas that cannot be observed or where rapid flooding would result in the loss of the vessel.

The dewatering system on the vessel should include the capability to pump any space which has the potential to flood. Gravity drains have proven to be insufficient in many cases. In fact you must remember that water may flow either way through an open drain depending on the trim or heel of the vessel.

Openings to holds not in use should be closed. This is particularly true for the overflow openings on crab holds. In many cases these openings are left open which allows water to flow from the deck down into the hold. To compensate for this, the crab pumps are run continuously and a suction is maintained which pumps any water flowing into the hold overboard. In theory this procedure sounds fine, but the problem often arises when there is flooding somewhere else in the vessel which causes more rapid flooding of the hold through the openings.

Because of the way the valves are set to maintain a prime on the pump, only a small fraction of its capacity is being used to pump the hold. When water flows rapidly into the hold, it is more than the pump can keep up with and rapid flooding of the hold takes place.

Another problem arises when you have an electrical failure or pump failure and water flows from the sea chest through the pump and into the hold. Exactly the opposite of what is desired.

Learn as much as you can about stability. The more everyone aboard the vessel knows about stability the better. The stability book which has been prepared contains an extraordinary amount of information about the vessel. It should be used as an integral part of the operation of the vessel.

Disaster always seems to strike at the most inopportune time at sea. If you are not prepared, there is nothing you can do. Plan for your response in any emergency situation. Ask yourself: What will I do if hold number one floods? What could I do? Should I abandon ship or try and save it? These questions should be answered before you leave the dock.

The ultimate act that would save most vessel and human losses related to stability is very simple. Load your vessel to maintain adequate stability.

CONCLUSION

I would like to close by discussing a severe frustration that one experiences when looking back at the record of fishing vessel losses related to stability. In many of these cases the required facts and information were available to the people on board the vessel to make an informed judgement about the prudent operation of the vessel.

If they had considered their situation in light of the stability of their vessel, they would have made different choices. In many cases people did not even consider the information available. We must make every effort to encourage operators to continually assess the stability of their vessel.

The U.S. Coast Guard investigation into the loss of the F/V *Americus* and F/V *Altair* was long and very thorough. They concluded that there were many factors which contributed to the loss of these vessels with all hands. One estimate of how the F/V *Americus* went to sea is shown in Figure 17. In this condition it had reasonable initial stability up to a few degrees of heel. No one would notice any difference in the "feel" of the vessel at the dock. However, the stability of the vessel was well below the level required by the IMO and the range of stability (less than 30 degrees of positive stability) was very low.

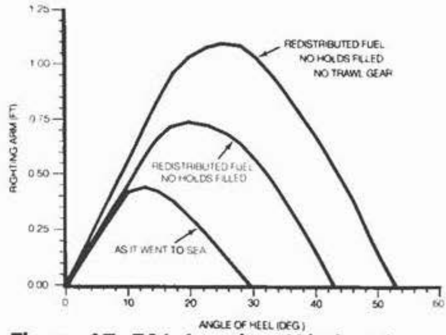

Figure 17. F/V *Americus/Altair* as It Went to Sea and with Variations on That Loading.

Now, if we examine the stability of the vessel after redistributing the fuel on board to other available tanks and after the seawater in the fish hold is removed, we arrive at the stability curve for the vessel marked "redistributed fuel, no holds filled" in Figure 17. There is a large increase in the stability of the vessel. In this condition the vessel would not quite meet the IMO stability criteria, but it is very likely that the vessel would not have been lost.

If we take one more additional step and remove the weight of all the trawling gear that was added to the vessel, then the stability of the vessel is shown in the final stability curve. In this loading condition this vessel is extremely stable and exceeds the IMO stability criteria.

What we all need to realize is that the stability characteristics for every vessel are different. The concept of stability may seem like a complicated subject, but it can be considerably simplified by focusing on the vessel's stability curve. This is usually available in the stability information provided by the naval architect.

A vessel's stability will not take care of itself. It is just as important on every trip as the fuel for the engine. If you run out of fuel, you can at least call for help. If you capsize, you will be in the water or dead. □

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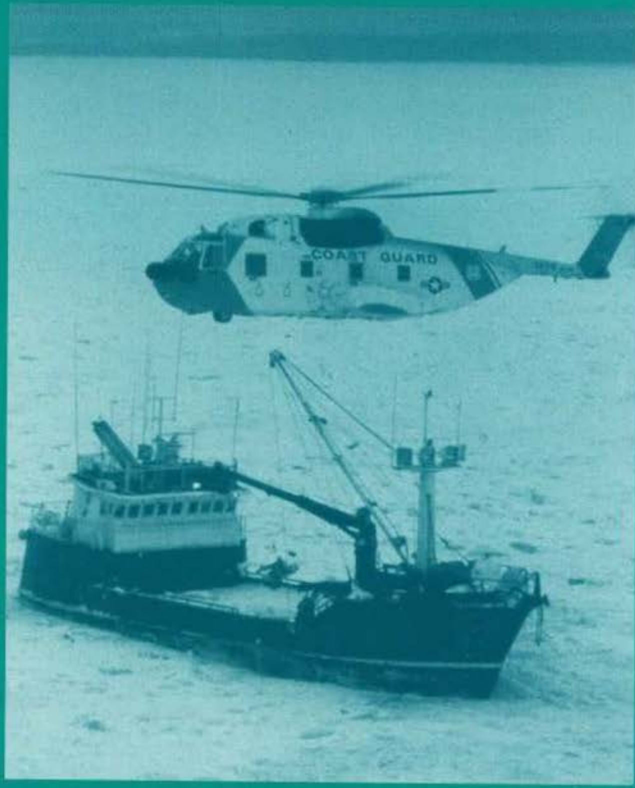

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