On Developing a Rational and User-friendly Approach to Fishing Vessel Stability and Operational Guidance

Bruce Johnson, NAOE Department, U. S. Naval Academy, Annapolis, MD 21402
e mail: aronj@bellatlantic.net
John Womack, Mid-Atlantic Shipwrights LLC, Cambridge, MD 21613

e-mail: Shipsjw@aol.com

Summary There is common recognition that a major shift in the commercial fishing culture is necessary. It is understood that this can only be accomplished by increased awareness of the risk and the problems faced, whether in design or operations. The key element for the SNAME Ad Hoc Panel #12 on Fishing Vessel Operations and Safety will be development and pursuit of awareness efforts while working with other like-minded organizations to affect a major shift to a safety culture. The scope of this effort is to address fishing vessel safety from a broad perspective including: basic issues affecting fishing vessel safety, vessel design, vessel construction, vessel operation, vessel maintenance, survey, safety training and awareness, voyage planning, costing, marine weather prediction, fishing regulation, risk analysis and assessment and to investigate and recommend ways to improve awareness on the part of commercial fishing vessel community to aid in getting that community embrace a safety culture.

1. INTRODUCTION

The Society of Naval Architects and Marine Engineers (SNAME) has recently organized a new Ad-Hoc Panel on Fishing Vessel Operations and Safety. As stated in our charter,
http://www.sname.org/committees/tech_ops/fishing/home.html
the initial objectives of the FV Panel, each supported by a working group, are to:

A.Investigate the feasibility of establishing risk-based fishing vessel stability criteria appropriate to the type of vessel and its operating area.
B.Evaluate the effectiveness of existing stability letters and develop better ways to communicate to the fishing community the importance of following reasonable stability and survivability guidelines.
C.Develop proposed design, production, operation and maintenance guidelines for various classes of fishing vessels that address basic safety, vessel design, vessel construction, vessel operation, vessel surveys and vessel maintenance.
D.Coordinate with SNAME Panel SC-3 in developing a long-range plan to deal with marine engineering and environmental issues of all types within the commercial fishing industry.

Working Group A (which has its organizational meeting during the Trieste workshop) is tasked to:
1. Identify hazards associated with small vessel capsizes and sinkings and develop guidelines to reduce wave impact damage and personal injuries.
2. Work with NOAA and the international meteorological community to improve predictions of dangerous local wave conditions.
3. Suggest ways to improve survivability for smaller vessels and their crews when they encounter extreme waves.
4. Review the Torremolinos Protocol, which has been criticized by the international naval architecture community a) for lacking "rational criteria" and b) for promoting capsize resistance for the vessel at the expense of operational safety conditions on board. Satisfying the IMO Torremolinos criteria for fishing vessels does not insure surviving a direct hit by rogue waves, or by other extreme (breaking) wave conditions and does not adequately address or insure crew survivability, which frequently involves escaping from a vessel that is stable while inverted.
5. Formulate a proposed fishing vessel research program to develop a new set of scalable, non-dimensional parameters for designing and building safer vessels. It is expected that the effects of variations in length, beam, draft, freeboard, sheer line, bulwark and deckhouse arrangements and loading conditions can be correlated with a new set of design parameters for increasing small vessel safety and survivability in a variety of situations.

Working Group B is charged with the following tasks related to the stability letter and operator guidance:
1. Since most fishing boat captains regard the determination of a vessel's stability letter as a lot of black magic by the naval architect/ surveyor, develop a user-friendly format that most fishermen and owners can more easily comprehend.
2. Work with fishermen, owners, surveyors, marine insurers, fishing boat designers and builders to insure that all parties understand the purpose and implication of stability letters.
3. Involve fishermen, vessel owners, insurance representatives, fishing safety trainers, Coast Guard representatives and naval architects in developing understandable, but not oversimplified, fishing vessel safety materials and training devices.

2. The Torremolinos Protocol

The IMO voluntary fishing boat safety regulations for vessels > 79 feet (24 m) in length are based on one-size-fits-all criteria derived from computer generated static stability righting-arm curves. The current version is known as the 1993 Torremolinos Protocol and can be found on the IMO web site. (For technical and historical details on its development see Bird 1986, Cleary 1993, Dyer 2000 and Kobylinski 1994 and 2000.) The Torremolinos Protocol has been criticized 1) for lacking "rational criteria" (Kobylinski 1994 and 2000, Umeda 1994, Dahle 1995) and 2) for promoting capsize resistance at the expense of operational safety conditions on board (Boccadamo 1994 and 2000, Umeda 1999 and 2000).

The frequently used interpretation in applying the Torremolinos Protocol stability criteria is that the area under the righting arm curve represents righting energy. This is incorrect, and in the US, The Code of Federal Regulations (CFR) and NVIC 5-86 criteria are frankly wrong in making such statements!!!! (Work and energy are in lb-ft or N-m. Reference PNA 1988, Volume 1, pp 87-93 on Dynamic Stability.)

Briefly, scalability in vessel stability characteristics depends on the square-cubed rule, i.e. the heeling forces, which depend on water and wind impact areas, go up with the square of the dimensions but the righting moment depends on the displacement which goes up with the cube of the dimensions. Thus, bigger is almost always better Correctly using the Torremolinos criteria should mean that vessels double in dimensions should survive without capsizing in twice the wave height conditions but that is not the interpretation given by the existing guidelines. The wind heel criteria do scale with size, as PNA points out, since the both the heeling arm and the righting arm are divided by the vessel displacement.

In addition, existing voluntary guidelines for fishing vessel stability are intended to provide significant capsize resistance for the vessel during storms that contain few rogue waves. Satisfying the voluntary IMO Torremolinos criteria for fishing vessels longer than 24 meters, for example, does not provide the capability to survive a direct hit by rogue waves or by other extreme (breaking) waves. Capsize resistance criteria for fishing vessels generally do not address or insure crew survivability, which frequently involves escaping from a vessel that is stable while inverted. In addition crew members who abandon a vessel in a major storm can be in danger of life threatening capsizes in many types of life rafts. Of the six men who died in the 1998 Sydney-Hobart sailboat race, three were attempting to survive in a life raft that capsized repeatedly in extreme waves (Mundle 1999).

3. Capsize and Extreme Wave Research on Smaller Vessels

Most capsize research concerning vessels of all sizes has concentrated on loss of waterplane area (hull form) stability on a wave crest in steep waves and/or spilling breakers. (Grochowalski 1989, 1993 and 1997, Blume 1993, Dahle 1995, Umeda 1999 and 2000. See also an excellent review of the 2000 Stability Conference in Belenky 2001.)

On the other hand, much yacht capsizing research has concentrated on wave impact capsizes caused by extreme breaking waves, thought to be a primary cause during the 1979 Fastnet Race disaster. (Kirkman, 1983, Salsich 1983, Claughton 1984, Zseleckzy 1988) These studies showed that in beam seas, the location of the vessel relative to the breaking position of the wave is critical. If the vessel is caught in the curl of a plunging breaker, or in the secondary wave created by the jet impact of the plunger, capsize is possible in waves as small as 1.2 times the beam of the vessel, even for a yacht with a low center of gravity. The roll moment of inertia is also an important parameter because a vessel with a large value of this parameter will roll to a smaller angle on impact but expose the deckhouse and work area to the full impact of the plunging wave jet. More recently, experiments on multihull capsizing (Deakin 2001) and the re-righting of sailing yachts in waves (Renilson 2001) have been investigated.

Part of the capsize research effort suggests that the experimenter attempt to characterize the asymmetry of the breaking wave by analyzing the wave parameters suggested by Kjeldsen (Myrhaug 1983, Bonmarin 1984 and 2000, Duncan 1987, Zseleczky 1989).

As discussed at the Rogue Wave 2000 Conference (Olagnon 2000), open ocean rogue waves appear to be short-lived and the probability of measuring one from a single platform record is small. During the 1998 Sydney-Hobart race as reported in deKat 1999, from which his Figure 10 (below) is taken, the Esso Kingfish-B platform located in the Bass Strait measured no waves more than twice the significant wave height, even though the participants reported many very large breaking waves during the race (Mundle 1999). (Note that the date is incorrect and should be 27-12-98.)

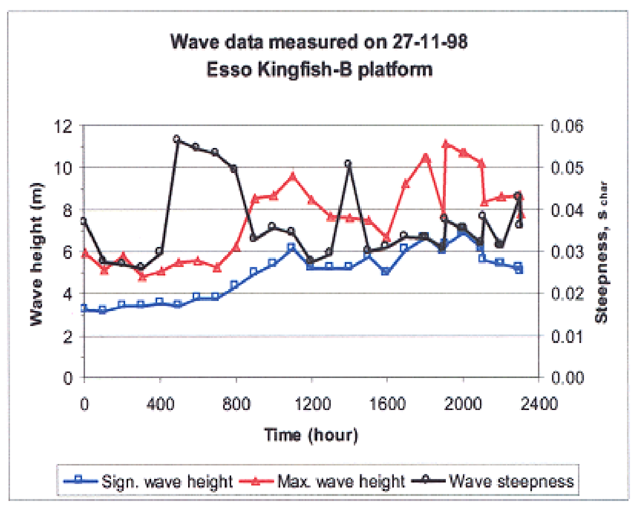

Figure 10. Wave height (significant and maximum) and direction in eastern Bass Strait.

Figure 1 from deKat 1999

The workshop presentation will also discuss and illustrate with video clips two capsize modes:
1) Loss of waterplane area (hull form) stability on a wave crest in steep waves and/or spilling breakers, *a high risk for improperly designed and or loaded vessels in storms.* and
2) Wave impact capsize caused by a plunging extreme wave, *a lower risk for stable vessels in storms, i.e. being in the wrong place at the wrong time during a low probability event.*

4. Operator Guidance

The primary means for providing stability operating guidance to small fishing boat crews is the "Stability Letter". These stability letters are generally a simplified version of the traditional "Stability Book" that is generated for large commercial boats. These simplified stability letters have been the preferred means of conveying the critical stability information and boat operating guidance to crews given the simpler configuration of small fishing boats and the lower or non-existent training levels of the crews.

For a stability letter to be effective, it must first be understandable to the crews, and second, the crews must believe that the guidance information provided is correct. While the first requirement is fairly obvious, the second requirement is equally important. The best stability letter on the most seaworthy boat in the world is of no value if the crew believes the loading requirements are wrong and ignores the stability guidance.

There are two basic stability letter types in use today, the text only version and the pictorial version. In both versions, the intent is to provide the crews with all of information to allow safe navigation of their boat under typical weather conditions and fishing operations. Unfortunately, most forms of the stability letters currently in use are neither readily comprehensible and/or are trusted by the crews. The current versions of these stability letters may suffer from one or more of the following basic flaws:

First, they may be written using terms more familiar to Naval Architects then to crews. The concept of terms such as Transverse Metacenter (KM), Metacentric Height (GM), Center of Buoyancy (KB), and Righting Arm (GZ) are unknown to most small fishing boat crews. These terms, while useful in determining if a boat has adequate stability, are simply foreign concepts to most crews and only serve to confuse them. Imagine trying to explain what Transverse Metacenter and Metacentric Height are to crews who have little or no knowledge of boat design let alone can barely read and write.

Secondly, these stability letters may use loading restrictions that are either very difficult to measure when underway or are impractical to use during typical fishing operations. One example is the specifying of minimum freeboards. While a good method in theory to specify maximum loadings, it is impracticable, and dangerous for a crew to measure freeboards while underway by hanging over the boat's side in any type of sea. The same criticism holds true for specifying maximum drafts. Draft marks on a boat's side are basically impossible to see from the deck due to flare, rubrails, or other obstructions. And the typical draft marks used are generally not sufficiently accurate to determine a good draft reading for stability purposes.

The other type of loading restrictions that may be impractical to use underway are those limiting the weight of a net catch, the loose catch on deck awaiting processing, or other similar temporary conditions during fishing. An example is the restrictions on deck loading when hauling in the net on the F/V Artic Rose (which sank on April 02, 2001). From an article in the Seattle Times on June 17, 2001, the naval architects that created the boat's stability letter stated that the maximum deck loading was 5,000 pounds in most cases, up to a maximum of 21,000 pounds under the most optimum conditions. The boat was capable of catch capacities of 40,000 pounds for each net haul back. This type of restriction requires the crew to accurately estimate the weight of the fish in the net while it is still under tow as well as accurately estimate the weight of the fish on deck. In addition, because this loading restriction is such a small percentage of what the boat can typically catch, the crew is faced with a difficult decision if they have a very successful tow that exceeds the loading restriction. In theory the crew must dump a portion of the net before bringing the net onboard to ensure the boat has adequate stability. In practice though, the extra fish are brought on board which makes this type of restriction basically useless.

Another problem is with stability letters that use a series of simple pictures of the boat under different loading conditions with a safe or unsafe notation. To adequately show the crew all possible loading conditions, both safe and unsafe, a large number of loading pictures must often be created. This creates several problems. First, to determine if the boat is safe, the crew must search through a large selection of loading pictures. And second, given the many possible loading variations of tanks, catch, and other variable loads, the crew more than likely will have to "select", (more actually guess), which loading picture best approximates the actual boat's condition. With the crews not likely to have any technical training, the potential exists that crew could guess wrong and create a dangerous stability situation.

Pictorial types of stability letters can also suffer from a lack of clarity when attempting to depict fishing boats with multiple tanks, fish holds, and other variable loading areas. For example, use a fishing boat with (3) centerline fish holds, (2) port and (2) starboard belly tanks under the holds, and (2) port and (2) starboard wing tanks alongside the holds, a typical arrangement. To adequately depict one loading condition, at least (2) inboard profiles, see Figure 2, must be used if it is assumed that port and starboard tank pairs are at equal levels. This is not always a valid assumption for many boats that use the port and starboard tanks to compensate for built-in or temporary lists. In this case at least (4) inboard profiles, see Figure 3, must be used to show all tanks and holds. This though, can be very confusing as to which are the port tanks and which are the starboard tanks, especially to untrained crews. In addition, in two of the profiles, the fish holds must be duplicated, which can add to the confusion. Deck plan views can be added as shown, but the problem then exists in clearly indicating the level of the tank or fish hold.

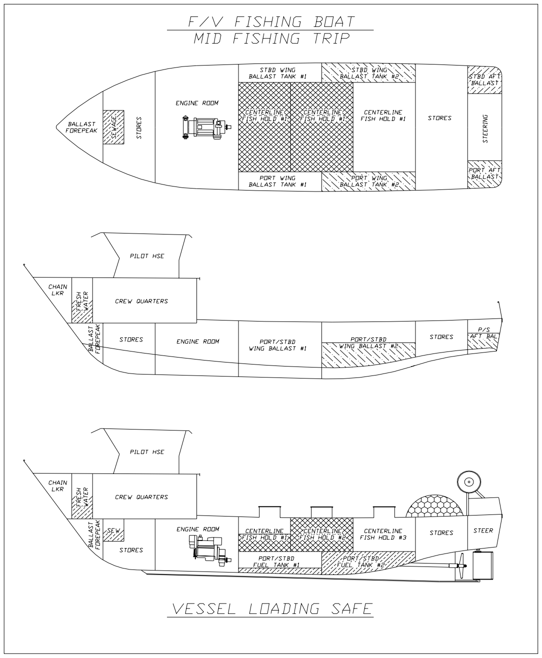

Figure 2 - Sample Pictorial Loading Page

The last problem with pictorial types of stability letters is they assume the fishing boat crews can "read" drawings to be able to transfer the real boat to the picture and vice versa. To naval architects with formal training, this ability is often blindly assumed. In practice though, this is often a poor assumption. Being able to visualize a 3-D boat with hidden tanks and then transfer that information to 2-D pictures takes formal training. From practical experience, the crews may know where all of the tanks are on the boat, but often have problems in looking at a drawing and being able to locate them.

Assuming the stability letter adequately provides the necessary stability operating guidance, the crews must also believe that the guidance provided is correct so they will follow it. Unfortunately, from many casualties reports in the US, the crews often ignore stability letters because they believe they know how to load the boat correctly. (USCG 1999)

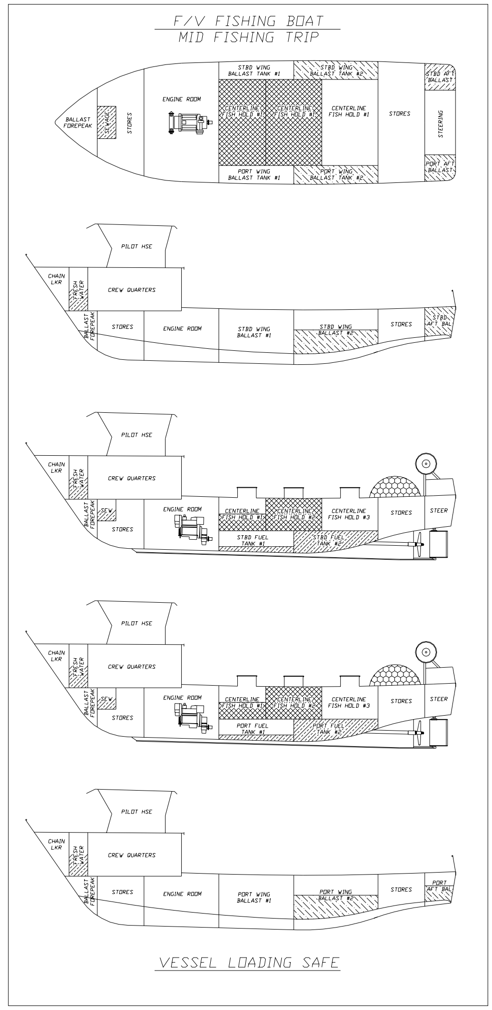

Figure 3 - Sample Pictorial Loading Page

This situation exists for several reasons. First, many of the crews have little or no formal training in seamanship and stability. Their experience comes from many years of hands-on learning under captains who themselves had little or no formal training. As an example is this excerpt from the forthcoming book "Wages of the Sea" by Douglas Campbell and published by Carroll & Graff.

> There were few in the clam industry who would have ridiculed Novack or his mate for their disregard of the stability letter carried in their boat. Many clam boat captains were either ignorant of the contents of these documents or held them in disdain. They had been on the ocean for years, and the ocean had taught them lessons. There was little that a so-called expert could tell these men that they had not already learned through their daily lives on the water. One such man was William Parlett, captain of the clam boat Richard M. Parlett, a twenty-five-year veteran of commercial fishing,

twenty of them as a skipper. At one time, he had filled in as captain of the Beth Dee Bob. He knew that boat had a stability letter. Several years later he could recall precisely where it was kept on the boat. When asked if he had ever read it, he replied stiffly: ``No, sir. " Asked why, he explained, as if it were obvious: ``Didn't need to. " But why? ``If I felt she was unsafe, I'd get off it. "

An example of Parlett's attitude toward the stability of a boat is found in his approach to the presence of water in the clam holds. How much water in the hold was okay? That amount, Parlett said, that would ``keep (the boat) on a level keel. "

``You could flood the holds completely if you wanted to," the captain said. ``All it did was make it more stable. "

Another reason for why crews may chose to ignore the stability letter occurs because of the way a typical fishing boat's stability works. A fishing boat's stability can be divided into two ranges, initial stability and overall stability. Initial stability is typically from zero degrees (no heel) to about 10 degrees of heel. Overall stability encompasses the boat's stability from zero degrees to the point of vanishing stability. For fishing boat crews, the boat's initial stability is what they encounter, "feel", during typical fishing trips. The boat's overall stability characteristics are more rarely encountered during severe storms.

The problem occurs because a boat's initial stability is not a reliable indicator of a boat's overall stability. A "tender" boat with a high freeboard or one that is too stiff may feel uncomfortable during typical operations, but may have excellent overall stability. Conversely, a boat that feels very safe during typical operations, may have poor overall stability. Because of this, crews that load their boat so that it "feels" safe during everyday operations may have little or no warning that they have significantly reduced their boat's overall stability to dangerous levels.

Figure 4, which shows the effect on a boat's stability of adding ballast low, will illustrate this point. Crews will fill ballast tanks under the fish hold to stiffen a boat's motion to make it more comfortable during everyday operations. Many crews believe they have improved the boat's stability when in fact it has been significantly reduced. The solid line indicates the righting arm curve without ballast and dashed line is righting arm curve with ballast. Note that initially the righting arms, and thus initial stability is increased by adding the ballast, which the crew feels during everyday operations. Note also that the overall stability has been significantly reduced in several critical areas; the range of positive righting arms is reduced, the area under the righting arm is reduced, and the heel angle of the maximum righting is reduced.

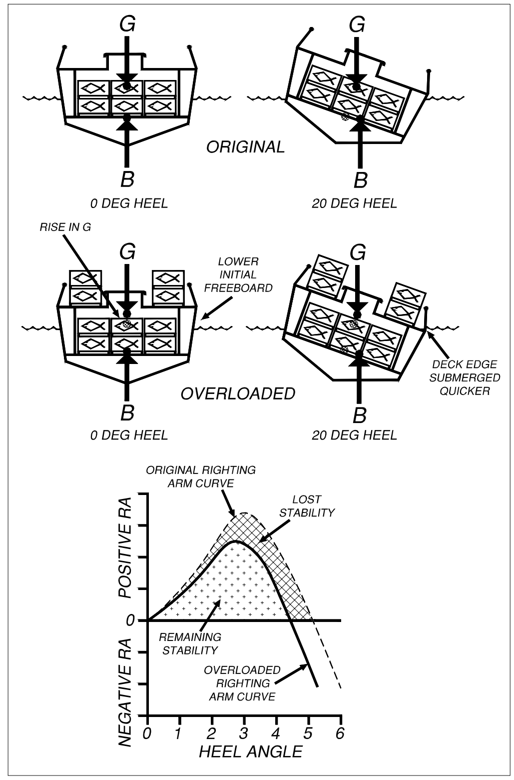

Figure 4 - Effect of Overloading on Stability

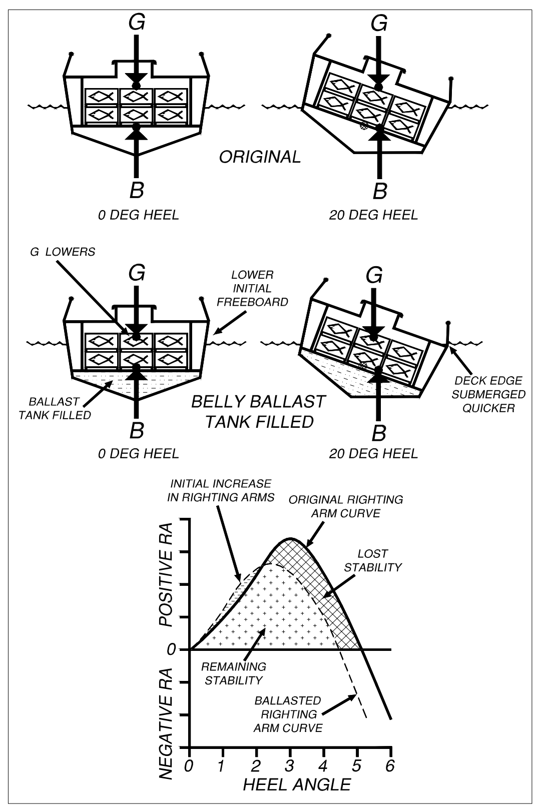

Figure 5 - Effect of Ballasting on Stability

This initial/overall stability conflict also explains why crews often disregard maximum catch limits in their stability letters. Figure 5, which shows the effect on a boat's stability from overloading, will illustrate this point. In this figure, the solid line indicates the righting arm curve before overloading and dashed line is righting arm curve after overloading. In this case, note that righting arms up to 10 to 15 degrees of heel have not been significantly reduced. The overall stability though, has been significantly reduced. Because the crews usually evaluate the "feel" of the rolling motions under initial stability conditions, the boat dose not "feel" unsafe when they bring in extra fish from a good trip. This happens several times and they understandably start to disregard their stability letter. As long as the weather remains good, they can get away with the overloading. In bad weather though, they do not realized how much their boat's stability has been degraded and the significant danger they are in. (The Workshop Presentation will include statistics from USCG on overloading losses.)

The impractical loading conditions mentioned previously can also cause crews to ignore their stability letter. Restricting a crew to catch amount of 5,000 pounds when they can catch 40,000 pounds is just asking for the crew to ignore the stability letter. Faced with having a net full of fish and bills due, human nature says most will keep the fish. And as mentioned above, because they can successfully do this in good weather with no apparent effect on their boat's stability level, they will likely continue to ignore the stability letter limits.

Finding solutions to these problems is the task of SNAME's Working Group B on Stability Letters, Stability Education, and Training. The solutions are simple: improving stability letters and the training of basic stability concepts to fishing boat crews so they understand and trust their letters. Since the principal blame for problems with stability letters lies with the naval architects and marine surveyors who create them, the solutions must then come from naval architects who understand what the fishermen need and want to fix the system.

To improve stability letters, the members of Working Group B will be working with naval architects, regulators, and fishing boat crews to develop an improved format. The basic criteria for developing the improved stability letter format will be;

1. Written to provide stability guidance, not dictate the boat's operation.
2. Present the safe loading conditions clearly, both visually and written..
3. Provide some means for conveying the stability levels, i.e. risk of capsizing, associated with each of the loading conditions.
3. Be comprehensible by crews with little or no formal training.
4. Use practical operating restrictions on variable catch limits, etc.
5. Use practical means to allow the crew to check if the boat is loaded correctly.
6. Develop a series of operating guidelines on proper seamanship and boat maintenance suitable for preserving a boat's stability.

In summary, the goal is to provide the captain with practical stability guidance and a way to gauge the risks of capsizing based on loading, weather, and other factors, and let them run their boats.

Using a safe/unsafe loading matrix is one of the formats being investigated for a new type of stability letter. These matrixes (see Figure 6 for an example) have been proposed in the past and have several advantages. First, a large number of loading conditions can be shown on a single page. And second, the matrix is relatively easy to use. With catch levels on the left column and various tank loadings across the top, it is easy for the crew to check if the boat's stability is acceptable.

F/V FISHING BOAT - STABILITY LOADING MATRIX								
		MAXIMUM CAGES IN HOLD - DREDGE FULL & ON RAMP						
PORT & STBD FUEL TANKS	POTABLE WATER	0 CAGES	10 CAGES	20 CAGES	30 CAGES	40 CAGES	50 CAGES	60 CAGES
100%	100%	SAFE	SAFE	UNSAFE	UNSAFE	UNSAFE	UNSAFE	UNSAFE
75%	100%	SAFE	SAFE	UNSAFE	UNSAFE	UNSAFE	UNSAFE	UNSAFE
75%	75%	SAFE	SAFE	SAFE	UNSAFE	UNSAFE	UNSAFE	UNSAFE
50%	75%	SAFE	SAFE	SAFE	UNSAFE	UNSAFE	UNSAFE	UNSAFE
50%	50%	SAFE	SAFE	SAFE	SAFE	UNSAFE	UNSAFE	UNSAFE
50%	25%	UNSAFE	SAFE	SAFE	SAFE	UNSAFE	UNSAFE	UNSAFE
25%	50%	UNSAFE	SAFE	SAFE	SAFE	SAFE	UNSAFE	UNSAFE
25%	25%	UNSAFE	UNSAFE	SAFE	SAFE	SAFE	SAFE	UNSAFE
10%	10%	UNSAFE	UNSAFE	UNSAFE	SAFE	SAFE	SAFE	UNSAFE

Figure 6 - Sample Safe/Unsafe Loading Matrix

Working Group B is also investigating expanding the safe/unsafe loading matrix into a risk based loading matrix (see Figure 7). In this matrix scheme, instead of a safe/unsafe (go-no go) indication for each possible loading condition, a risk level would be assigned. How to clearly indicate the risk level still needs to be investigated. Suggestions include using red, yellow, and green shading for a visual representation or using a "risk of capsizing" number.

F/V FISHING BOAT - STABILITY LOADING MATRIX								
		MAXIMUM CAGES IN HOLD - DREDGE FULL & ON RAMP						
PORT & STBD FUEL TANKS	POTABLE WATER	0 CAGES	10 CAGES	20 CAGES	30 CAGES	40 CAGES	50 CAGES	60 CAGES
100%	100%	STORMS	HEAVY SEAS	FAIR SEAS	CALM SEAS	UNSAFE	UNSAFE	UNSAFE
75%	100%	STORMS	STORMS	HEAVY SEAS	FAIR SEAS	CALM SEAS	UNSAFE	UNSAFE
75%	75%	STORMS	STORMS	STORMS	HEAVY SEAS	CALM SEAS	UNSAFE	UNSAFE
50%	75%	STORMS	STORMS	STORMS	HEAVY SEAS	FAIR SEAS	UNSAFE	UNSAFE
50%	50%	STORMS	STORMS	STORMS	STORMS	FAIR SEAS	CALM SEAS	UNSAFE
50%	25%	HEAVY SEAS	STORMS	STORMS	STORMS	HEAVY SEAS	FAIR SEAS	UNSAFE
25%	50%	HEAVY SEAS	STORMS	STORMS	STORMS	STORMS	HEAVY SEAS	CALM SEAS
25%	25%	FAIR SEAS	HEAVY SEAS	STORMS	STORMS	STORMS	STORMS	FAIR SEAS
10%	10%	CALM SEAS	FAIR SEAS	HEAVY SEAS	STORMS	STORMS	STORMS	HEAVY SEAS

Figure 7 - Sample Risk Based Loading Matrix

This risk based loading matrix scheme ties into Working Group A's review of the stability criteria currently in use. The current one size, one weather stability criteria such as the Torremolinos Convention have many flaws. This approach leads to overly conservative stability levels for good weather trips. As discussed above, crews soon learn they can overload the boat "safely" in good weather. But when bad weather occurs, the crews have no means to gauge the risk caused by the overloading. The crews have intuitively figured out that weather is an important criteria in determining a boat's potential loading levels. What can not be figured out intuitively by the crews is the overall stability levels and potential capsizing risks. This can only be done by a trained naval architect.

This type of loading matrix also has the advantage of putting the operational decisions for the boat back to the captain instead of with the naval architect as current stability letters do. This approach does require that the captain, vessel owner, and other decision makers must clearly understand the basic concepts of stability in order to select the appropriate risk level, given predicted weather conditions and other trip factors.

For teaching basic stability concepts to fishing boat crews, the working group has started the development of a new type of training course. From discussions with fishing boat crews, they are interested in understanding their stability letters. The problem is the creation of the stability letter appears to be a lot of black magic by the naval architect. From moving some weights back and forth on their boat, the architect comes back with a piece of paper on how to load their boat. And often, the stability instructions run counter to how they believe their boat should be loaded or restrict the maximum allowable catch to levels below what they are carrying now.

To teach stability to fishing boat crews will require explaining fishing boat stability and its complex interactions to crews who generally lack an education. As noted previously, the common naval architecture terms used in stability are simply unknown, and often incomprehensible, to the crews. For example, even the basic concept of center of buoyancy is unknown to many crews. The challenge will be in convincing the crew that the center of buoyancy is a real location that all of the buoyant forces are acting through, not an imaginary point on their boat that the crews may have a hard time conceiving.

The course is only intended to teach the basic concepts of stability and the effect of typical fishing operations on a boat's stability. The course is not intended to teach how stability is calculated. That is the responsibility of the naval architect. The primary goals for the proposed stability training course are:

1. Explain what center of gravity (G) and center of buoyancy (B) are.
2. Show the relationship between G and B as the boat heels and how that works to keep the boat upright.
3. Explain the basic methods of determining if a boat has adequate stability.
A. Show what a righting arm curve is.
B. Show how the righting arm curve is calculated.
C. Show the basic parts of the righting arm curve used to determine the boat's stability level.
4. Show the effect on a boat's stability level from typical boat operations.
A. Explain the difference between initial and overall stability.
i. Initial stability is what the crews typically feel and see.
ii. Overall stability is what keeps the boat upright in a storm.
iii. Initial stability is not an accurate indicator of overall stability.
B. Show the effect of free surface, overloading, lifting over the side, and other similar loading conditions.

The initial layout of the stability training course consists of two parts; a written manual and a verbal presentation. The two individual components of the training course will be developed to be mutually supporting. Figures in the written manual would be similar to the models used in the presentation, and concepts demonstrated in the presentation would be in the manual. This will allow crews that have taken the training course to use the written manual as a refresher.

The written manual will be developed to be self-explanatory to persons who have some formal education or seamanship training. The figures intended to show the basic stability concepts will be kept simple and structured to appear similar to existing fishing boats designs. It is important to make the figures believable to the crews. If they look similar to their boat, the chances are better the crew will believe the message even when it runs counter to past beliefs. Figure 8 is an example of the proposed figures (more will be shown during the Workshop) which will show the relationship between center of gravity and center of buoyancy and how the righting arm curve is developed. The preferred use of the written manual will be as follow-up take-home notes to the verbal presentation.

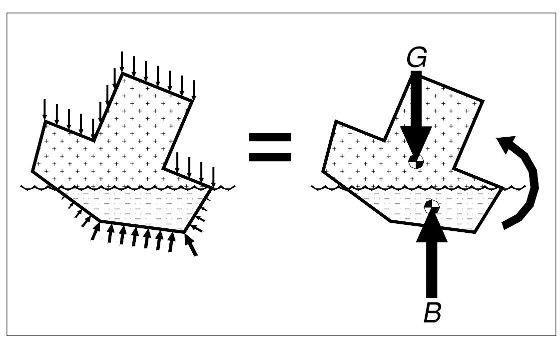

Figure 8 - Positive righting Arm

The second component of the training course, the verbal presentation, will be developed for both small and large groups. The small group is intended to be an individual fishing boat's crew and owner, with the larger groups being at meetings such as trade shows or NMFS regional council meetings. The presentation for individual boats will be made easily transportable to allow the presentation to be made onboard, at dockside, or even in the local watering hole. This will allow a naval architect to give the presentation when delivering a stability letter to a boat.

For both presentations, a series of static and dynamic demonstration models with companion posters is proposed. Figure 9 is an example of a proposed static demonstration model. By having removable sections as shown in figure 10, several different stability issues can be demonstrated. The models are an important part of the presentation as they allow the crews to see "hands-on" what is happening during typical fishing operations. As an example, the crews can see directly the loss of stability when they boat is overloaded or the negative effects of slack tanks. Actually "capsizing" the model, especially when they believe they have loaded the model to make it safer, is a very convincing training method.

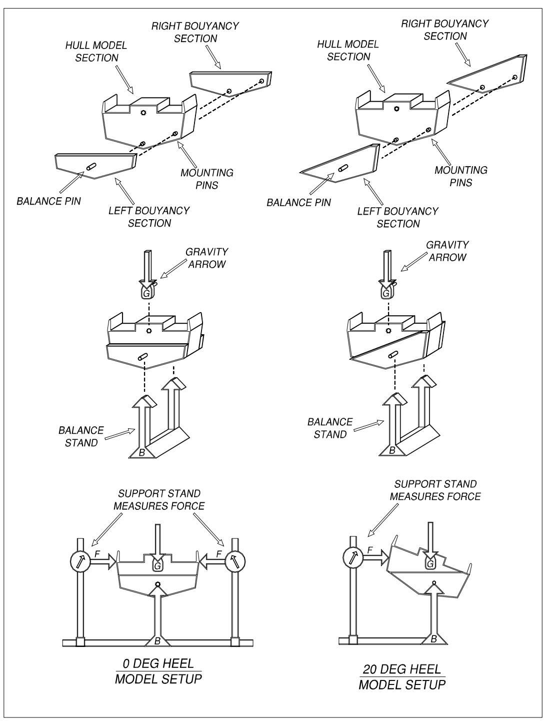

Figure 9 - Static Stability Demonstration Model

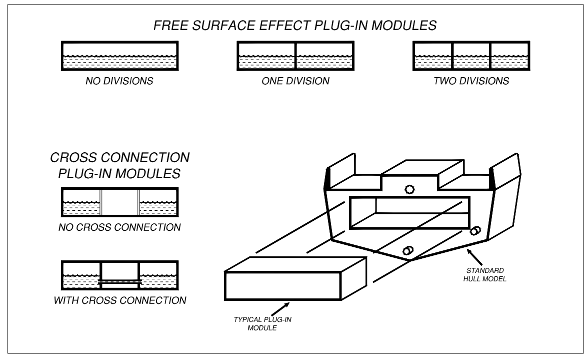

Figure 10 - Static Stability Demonstration Model

In summary, problems exist with current types of stability letters used to provide stability to small fishing boat crews. These problems are the principal reason crews are disregarding these letters, either intentionally or because the letters are incomprehensible, and putting themselves in danger. Fishing boat crews don't have a death wish, they just truly don't understand the potential adverse impacts on their boat's overall stability when they load the boat to make it "feel" better under normal fishing operations. The initial stability the crew feels is no indication of the boats overall stability levels. This "hidden flaw" is not seen by the crews because they have never been taught the basic concepts of their boat's stability.

On the positive side, experience has shown that the crews are willing to learn and do a better job following their stability letters if we, as naval architects, can give them practical, intelligent, flexible stability guidance and the tools to understand that guidance. Responsibility for the proper operation of the boat should be put back to the captain instead of being dictated by the naval architect as current stability letters are.

5. Future Work

Working Group B is considering formats for risk-based Sea State vs Loading Consequence Diagrams appropriate to the type of vessel and its operating area. It is expected that the initial versions will be based on avoiding loss of waterplane area and shipping water capsizes, for which significant prediction tools already exist (Grochowalski 1997). The breaking wave capsize probabilities are unknown at present because the statistics of the occurrence of steep waves, especially plunging breakers, in a particular geographic region are not presently included in marine forecasting models. This must eventually be addressed, even though being in the wrong place at the wrong time is a low probability event.

A longer range goal of Working Group A of the ad-hoc F/V Panel is to create a fishing vessel research program to develop a new set of scalable non-dimensional parameters for designing and building safer fishing vessels (Blume 1993, Boccadamo 1994, Buckley 1994). In order to experimentally determine fishing vessel design parameters, which improve survivability in a severe seaway, a new "free-to-broach" towing rig will be developed. This rig will allow models of a series of existing and proposed new fishing boat designs to be investigated for capsizing resistance while being towed under computer control to a region of the tank where computer-generated irregular waves are combined with deterministic steep waves produced by wave energy concentration (Salsich 1983a, Duncan 1987, Takaishi 1994, Buckley 1994, Kriebel 2000 and several methods presented at the Rogue Wave 2000 conference). This technique avoids using radio-controlled models which are difficult to position precisely in capsizing wave conditions. It should also be useful for validating attempts to mathematically model the surf-riding phenomenon (Vassalos 1994). Towing models in quartering seas should shed light on the dynamic stability characteristics of several classes of fishing vessels, improving on the zero-speed beam-sea capsize testing previously done at the Naval Academy on sailing yachts (Salsich 1983b, Zseleczky 1988) and the USCG 44 ft and 47 ft Motor Life Boats (Zseleczky 1989).

It is expected that the effects of variations in length, beam, draft, freeboard, sheer line, bulwark and deckhouse arrangements and loading conditions can be correlated with a new set of design parameters for increasing fishing boat safety in a variety of situations (Boccadamo 1994).

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