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United States Coast Guard

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Serial: H2-1801014
17 Jul 2018

MEMORANDUM

From: [redacted]

To: CG SECTOR Southeastern New England

Subj: POST-SINKING STABILITY ANALYSIS OF F/V MISTY BLUE, O.N. 1043789

Ref: (a) Your memo 16732, dated January 22, 2018
(b) Misty Blue Timeline, provided by [redacted] received March 30, 2018
(c) Conversation and emails between [redacted] and [redacted] dated January 31, 2018 through March 30, 2018

1. This is in response to reference (a), wherein you requested Marine Safety Center (MSC) assistance with a stability review of the F/V MISTY BLUE in support of a marine casualty investigation regarding the vessel's sinking on December 4, 2017. Specifically, you requested a review of the previous modifications documented in various marine surveyor reports and for the MSC to conduct a technical stability analysis of the vessel. We were unable to conduct a fully independent stability analysis of the vessel with the information provided. However, we reviewed the provided computer model of the vessel, reports detailing the modifications, estimated loading condition at the time of the casualty, and information supplied by [redacted] to evaluate the vessel's stability at the time of incident.

2. As requested in reference (a), we reviewed the marine survey reports to evaluate the stability impact of the various modifications made to the MISTY BLUE since the 2009 conversion. [redacted], of my staff, exchanged additional emails and phone calls with [redacted] to gather further details and supporting information which was used in our evaluation. Enclosure (1) is a list of our findings of the modifications documented in the survey reports with the corresponding estimated stability impacts.

3. Based on the computer model developed at the time of the 2009 inclining test and estimated changes to the vessel derived from the survey reports and witness testimony, we assessed the cumulative impact on vessel stability collectively since 2009. This work indicated that the positive impact of the ballast weight added after the 2009 conversion was reduced by subsequent weight modifications to the vessel.

4. While the MISTY BLUE was not required to meet any regulatory stability standards, the intact stability criteria found in 46 CFR 28.570 provides an objective reference standard to evaluate vessels of similar size, in similar service and is an appropriate measure for this vessel. Our analysis indicates that, at the time of the casualty, the vessel would likely have satisfied 46 CFR 28.570 criteria.

5. In our review of the vessel's loading and witness reports provided for the day of the sinking, the off-center flooding of the port clam tanks could have created the port list noted by survivors. We estimate that this list would have brought the bottom of the freeing ports to about the water line in a static condition. While our analysis provides insight into the vessel's stability in static conditions, we are not able to quantify the effects of the many external and dynamic forces that likely acted on MISTY BLUE at the time of the casualty. We did estimate the impact of water trapped on deck and found that even small amounts of water on deck would significantly reduce stability of the vessel. We found that the freeing port area on this vessel was relatively small compared to a vessel which must comply with the regulatory requirements of 46 CFR 28.555 which likely resulted in compounding water accumulation on the main deck.

6. Enclosure (2) is a detailed explanation of our analysis and provides further discussion of the stability characteristics of the vessel at the time of the sinking. If you have questions or need additional information, please contact [redacted] [redacted]n at [redacted]

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Enclosure: (1) Review Notes for MISTY BLUE Survey Reports
(2) Post-Sinking Analysis of MISTY BLUE

Enclosure (1) to USCG MARINE SAFETY CENTER (MSC) memo Serial: H2-1801014 dated July 17, 2018

Review of MISTY BLUE Marine Survey Findings

September 15, 2009 survey conducted by Marine Safety Consultants (MSC):

- Vessel in the water.
- This was first survey after conversion.
- Reference to a Farrel & Norton Naval Architect stability letter onboard. MSC was provided unsigned letters from Norton Marine Design, Inc. (NMD).
- Indicates that owners had not added ballast.
- Indicates 10” combings on the clam tanks, 31” bulwarks.

July 11, 2012 survey conducted by Marine Safety Consultants (MSC):

- Final report after a series of visits related to a grounding and repairs.
- Repairs made (weights not documented) appear to be in kind.
- Indicates 10” combings on the clam tanks, 31” bulwarks.
- Stability impact – unknown but likely minimal.

May 16, 2013 survey conducted by Marine Safety Consultants (MSC):

- Vessel afloat.
- Appears to be a survey conducted for insurance purposes.
- References the summer 2012 haul-out as last haul-out and no mention of subsequent repairs.
- Indicates 10” combings on the clam tanks, 31” bulwarks.
- Stability impact – none.

June 27, 2013 survey conducted by Marine Safety Consultants (MSC):

- Final visit following transmission repairs.
- Repairs made (weights not documented) appear to be in kind.
- Stability impact – unknown but likely minimal.

April 27, 2017 survey conducted by EIMC:

- Vessel on blocks at Promet Shipyard, Providence, RI.
- Recent work noted in the report includes: installing new pilot house windows, renewal of A-frame, hopper, and sheave, renewal of shaker/sorter and the tanktop conveyor; installation of armor plate “as necessary” across the stern; sandblasting and repainting the hull from rub rail to the keel.
- The installation of the crane is not mentioned, the report is written as if it were existing equipment.
- No significant findings. Recommended replacement of the wooden hatch covers for the clam tanks.
- Stability impact – negative. Witness testimony estimates a 2,000 to 3,000 pound weight addition at the stern. The crane was installed slightly to port of centerline. Marine Safety Center’s modeling indicates that any weight added to the stern would reduce freeboard, and any weight above the main deck would increase the vertical center of gravity.

Enclosure (2) to USCG MARINE SAFETY CENTER (MSC) memo Serial: H2-1801014 dated July 17, 2018

POST-SINKING STABILITY ANALYSIS OF F/V MISTY BLUE

1. General Comments Regarding Our Stability Analysis

All references in this analysis report are as listed on Marine Safety Center (MSC) Memo, Serial No. H2-1801014, dated July 9, 2018

Creative Systems' General HydroStatics (GHS) software version 15.50 was used for our analysis.

All weights are reported in long tons (LT) unless explicitly stated. One LT is equal to 2,240 pounds.

All vertical references and drafts were measured from the baseline drawn horizontally tangent to the lowest part of the modeled hull. Longitudinal references are measured forward or aft of mid-ship; forward represented as a negative number, and aft of mid-ships represented as a positive number.

This vessel employed paravanes, commonly known as "birds", to resist and dampen rolling. If the vessel is actively rolling to port, the starboard paravane will resist the roll and vice versa. While being raised or lowered their impact on the vessel is likely to be small. We did not evaluate their impact in this sinking scenario.

The impacts of wind, current, and waves were not quantitatively evaluated in this analysis. Based on witness reports, there were strong currents and 3-4 foot waves on the day of the casualty.

The clam cage weight used by MSC was 2700 pounds per cage. This number is consistent with witness testimony, and the estimated weight used by Norton Marine Design, Inc. (NMC) during the 2009 analysis.

Downflooding occurs when water enters the hull or superstructure of a vessel through an opening that is not watertight. Based on the information provided, three downflooding points were used in the vessel analysis. Two points are the engine room vents, assumed to be located at 3 feet 4 inches forward of amidships, 14 feet 3/8 inches above the baseline, and 4 feet outboard of centerline on the port and starboard sides, respectively. Witness reports indicated an additional vent on the aft port corner of the main deck leading to the lazarette. To prevent water on the main deck from entering the lazarette, a baffle plate was placed immediately in front of the vent, however detailed information regarding the arrangement, placement or watertight integrity of this vent was not known. Since this vent may not be truly watertight, a third downflooding point was assumed for this analysis to be located at 35.7 feet aft amidships, 9.16 feet to port, and 10.14 feet above the baseline. This vent was not considered by NMD in the 2009 analysis.

A number of measures are used to assess a vessel's stability. Perhaps the most fundamental measure is Metacentric Height (GM). GM is measured in feet and is an indicator of the vessel's initial stability in its equilibrium position. A vessel with positive GM will tend to right itself when external forces, such as wind and waves, are applied. As GM decreases, the vessel becomes more “tender” and responds slower to external forces. A vessel with a negative GM value will not return to the original equilibrium position when external forces are applied, and may capsize.

For a more detailed evaluation of stability, naval architects examine a vessel’s righting arm curve. The righting arm curve plots the vessel’s righting arm, a measure of a vessel’s ability to right itself, at various angles of heel. In general, the greater the righting arm (GZ), both in terms of magnitude and range, the greater the stability of the vessel. The area under the righting arm curve (measured in foot-degrees) or righting energy is often used as a measure of the vessel’s ability to absorb energy imparted by winds, waves, or other external forces. A vessel with very little area (righting energy) under its righting arm curve could roll past its range of positive stability and capsize by even a relatively small disturbance. Once this area approaches zero, the vessel is at immediate risk of capsizing.

2. Model Development

The GHS model used in this stability analysis was obtained from NMD. Mr. Garrett Norton of NMD performed a stability analysis on MISTY BLUE in early August, 2009 using GHS version 10.50. According to the lead Investigating officer (IO), [redacted] a survey of the subject vessel was performed by NMD in 2009. However, no vessel drawings or lines plans were available for MSC to validate the hull form as a part of this analysis. An AutoCAD file, with a profile view as shown in Figure 1, was provided by the IO.

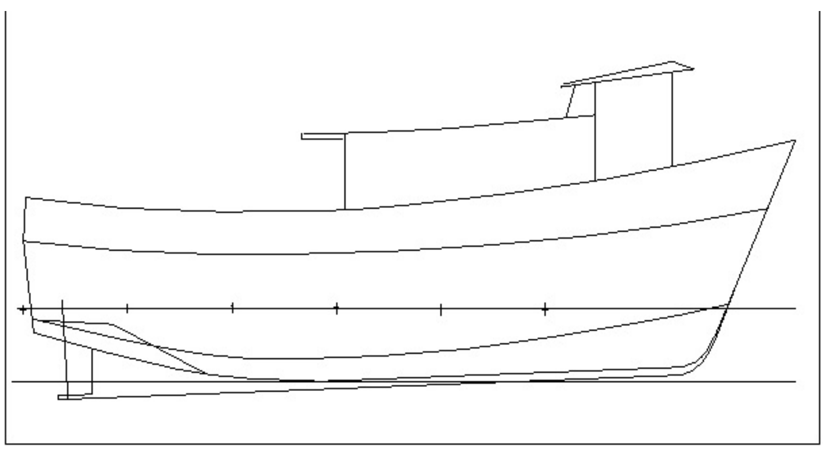

Figure 1: F/V MISTY BLUE from the AutoCAD file

The computer model used for this analysis depicted in isometric and body views are included as Figures 2 and 3.

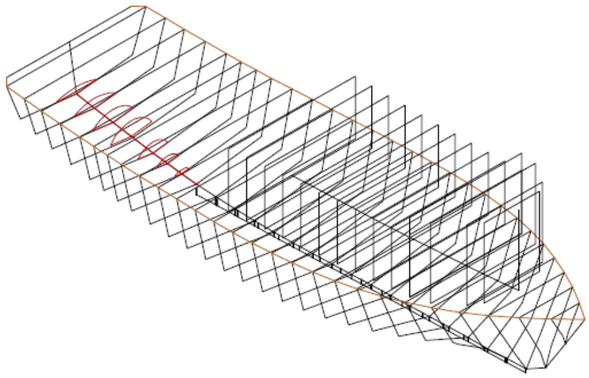

Figure 2: Isometric View of the MISTY BLUE GHS Model

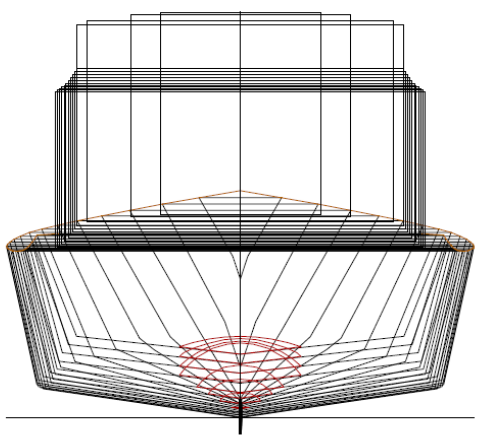

Figure 3: Body View of the MISTY BLUE GHS Model

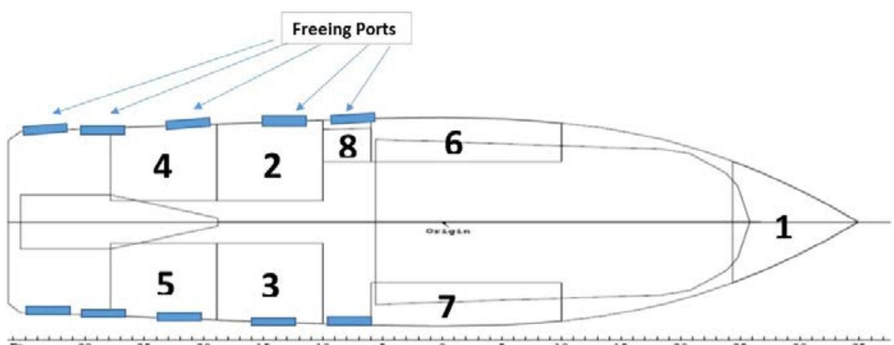

Figure 4: Plan View of the MISTY BLUE GHS Model

Figure 4 depicts the tank layout used in our analysis and includes freeing port arrangements. The tank layout was included with the NMD GHS model while the freeing port locations were estimated by MSC based on photos received from the IO.

Figure 4 also shows four clam tanks: tanks 2 and 4 are marked on the port and tanks 3 and 5 on starboard. A partition separates the forward and aft clam tanks vertically up to one foot below the main deck. Water can flow between forward and aft tanks above this partition. The watertight integrity of the partition is not known. In the GHS model and our analysis, all clam tanks were modeled individually.

According to marine survey reports, MISTY BLUE's "working deck" had four freeing ports, which measured 8" x 15" on each side of the vessel. However, in reviewing photos of the vessel, we observed five freeing ports configured along the open deck area aft of the house. We conservatively included this fifth freeing port area in our evaluation of the vessel. If five freeing ports were available with the same dimensions of 8"x15", the actual available freeing ports area on each side would be 4.13 ft^2. The freeing ports can be observed in Figure 5.

If required to meet a freeing port criteria, a suitable standard is in 46 CFR 28.555 and would require a freeing port area of 15.5 ft^2 on each side. The actual freeing ports area for MISTY BLUE was only estimated to be 4.13ft^2, which is 27% of the required freeing ports area on similarly sized vessels.

Figure 5: Freeing Ports

MSC did not have sufficient information to independently validate the accuracy of the GHS model provided by NMD to evaluate if the model used accurately represents the exact geometry and hydrostatic properties of the MISTY BLUE. However, based on prior experience with fishing vessels, the photos received of MISTY BLUE, and the use of the vessel's geometry files, MSC has no reason to doubt that the GHS model from NMD, as slightly modified by MSC by adding a new downflood point, is a valid numerical model and suitably represents this vessel for performing a stability analysis.

3. 2009 Stability Assessment

Although not required by regulation, the MISTY BLUE was evaluated by NMD against the intact stability criteria found in 46 CFR 28.570 after its conversion to a clamming vessel in 2009.

Based on notes and documents provided (reference (c)), it appears that an inclining experiment was conducted by Mr. Norton on July 31, 2009. He then conducted a stability analysis based on this information using the GHS hull model discussed above.

Mr. Norton's analysis indicated that, and our review confirmed that, the modeled vessel met the intact stability standards found in 46 CFR 28.570 when loaded with 16 cages below decks in the clam tanks, and eight cages on deck. This standard, although not applicable to this vessel, is used to evaluate vessels of similar size and service, and would serve as an appropriate criteria for this vessel.

Following the inclining experiment, NMD produced two letters to the vessel's owners. The first, dated August 6, 2009, explains that with the intended load of 16 cages below deck and 10 cages on deck, the vessel did not satisfy the intact stability criteria found in 46 CFR28.570. The letter details that while it had "good initial stability, with 10 clam cages on deck the vessel has quite a bit of stern trim and very little freeboard." A second letter, dated August 12, 2009, offers two options for satisfying the stability criteria with 10 clam cages on deck vice eight; first, a fuel load restriction or second, the addition of 8,300 pounds of ballast.

The ballast placement was directed to "be located as far forward and as low as possible." Based on the language of these letters, we assumed that the ballast weight had not yet been installed on the vessel at the time of the 2009 inclining experiment. We addressed this weight as an added weight after the inclining.

4. Lightship Weight Changes Since 2009 Inclining Experiment

Since the 2009 inclining experiment, three known stability related events occurred that MSC evaluated. The first was the addition of the ballast, second was the addition of the knuckle boom crane, and the third was the renewal of the A-Frame and related fishing gear on deck. Two other repair events (the 2012 and 2013 repairs) were not explicitly evaluated.

It is unclear when the ballast was added to the vessel. All of the survey reports produced by Marine Safety Consultants, Inc. indicate that the vessel owners opted for the fuel load restriction rather than the addition of ballast. However, witness testimony indicates the fixed ballast was added, and thus we include it as a weight addition after the inclining. A steel plate estimated to weigh 300 pounds, and an estimated 8,000 pounds of rocks were reportedly added to the vessel.

Documents provided to the MSC provide no detail of the ballast addition. Therefore, it is uncertain that full 8,300 pounds of ballast were installed, additionally, the location of the ballast was not specified. This lack of detail introduces uncertainty into the stability analysis. The addition of this specific amount of ballast was intended to shift the longitudinal center of gravity forward and reduced the vertical center of gravity to reduce stern trim, thereby increasing freeboard aft and improving overall stability of the vessel. MSC assumed the same weight amount and locations modeled by Mr. Norton.

Subsequent to the conversion, survey reports document two periods of repair to the vessel's rudder, propeller, shafting and transmission in 2012 and 2013. No details were provided as to the weight addition or removal. There was no estimate provided for a net change of weight resulting from the repairs. Given the location of the repairs, low in the vessel, and the relative size of the weight changes in comparison to the vessel's lightship, it is unlikely that any of the work negatively impacted the vessel's stability. We did not include these weight changes in our estimates; however, this work introduces further uncertainty to the evaluation.

In early 2017, a survey was completed of the MISTY BLUE after it underwent a repair and modification period. The survey report from April 27, 2017 indicates the A-frame and related on-deck equipment had been renewed during a recent yard period. It is unclear when the knuckle boom crane was added, but it was first mentioned in the April 27, 2017 survey report. Witness testimony indicates it was added sometime after the sale in 2016.

We received information related to the weight and geometry of the crane and related support structures. However, we were not provided detailed location or exact centers of gravity for the crane. We therefore estimated the centers of gravity of the crane, based on the noted location on the accommodation spaces, and to the port side of the vessel.

Insufficient details were provided to evaluate the impact of the equipment renewal, however witnesses estimate a 2,000 to 3,000 pound weight addition on the stern. It is unclear if that is a net weight addition, or if the weight of the replacement gear and A-Frame was 2,000 to 3,000 pounds in itself. We assumed the addition of a 2,500 pound of weight, with a conservatively placed center of gravity.

From witness statements, photos, and marine survey reports we know of other minor weight additions or changes that occurred since 2009 which we have not included in our weight estimate. For example, the addition of "armor plate" across the stern as discussed in the 2017 survey report.

Table 1 presents MSC's analysis of the estimated changes to lightship weight and the vessel's centers of gravity. We assumed a starting point that we have labeled Lightship 1 (LTSH 1) which represents the lightship weight and location of centers of gravity values calculated by NMD based on the July 31, 2009 inclining experiment.

Comparing LTSH 1 and LTSH 2 it can be seen that the ballast weight resulted in a shift of the center of gravity of the vessel forward and lower.

Comparing LTSH 2 and LTSH 3 the estimated impact of the crane addition can be seen.

The renewal project to the A-frame and deck equipment introduced a significant amount of uncertainty into our analysis. No details were available for these changes. LTSH 4 represents the estimated lightship weight and centers of gravity of the MISTY BLUE at the time of the incident.

We found that all of the known and assumed weight changes after the ballast addition would have an off-setting impact to the addition of ballast forward and low on the vessel. Therefore, although the magnitude and location of the weights are uncertain, cumulatively, the changes since the addition of the ballast likely shifted the longitudinal center aft, and raised the vertical center of gravity. Both of these movements would have reduced the righting energy for this vessel, and thus reduced intact stability. Additionally for this vessel, the weight changes after the ballast addition reduced the freeboard aft, submerging more of the hull, and bringing the freeing ports closer to the water's edge.

Table 1: Estimated Impact of Weights Added Since 2009 Lightship Calculation

Item No.	Description	Weight (lbs)	Weight (LT)	LCG (ft)	TCG (ft)	VCG (ft)
1	Rock forward of engine room	8,000	3.57	-18.00	0.00	1.50
2	Block on bow	3,00	0.13	-26.00	0.00	10.50
	Total Addition	8,300	3.71	-18.29	0.00	1.83
LTSH 1	**Lightship by NMD after incline**		**85.57**	**7.03**	**0.00**	**7.74**
LTSH 2	**LTSH 1 + ballast**		**89.28**	**5.98**	**0.00**	**7.49**
Item No.	Description	Weight (lbs)	Weight (LT)	LCG (ft)	TCG (ft)	VCG (ft)
1	Knuckle boom and based mount	2,370	1.06	3.07	-6.00	22.23
2	35" x 60" x 1" foundation plate (replacing 5/16" plate)	409 (net)	0.18	3.50	0.00	15.95
3	3" x 8' x 1/2' plate	490	0.22	3.50	0.00	8.00
	Total Addition	3,270	1.46	3.18	-4.35	19.31
LTSH 2	**LTSH 1 + ballast**		**89.28**	**5.98**	**0.00**	**7.49**
LTSH 3	**LTSH 2 + Crane**		**90.73**	**5.93**	**-0.07**	**7.68**
Item No.	Description	Weight (lbs)	Weight (LT)	LCG (ft)	TCG (ft)	VCG (ft)
	Renewal Estimate	2,500	1.12	3.07	0.00	22.23
LTSH 3	**LTSH 2 + Crane**		**90.73**	**5.93**	**-0.07**	**7.68**
LTSH 4	**LTSH3 + A-Frame Renew**		**91.85**	**5.90**	**-0.07**	**7.86**
Combined Estimated Changes			**6.28**	**-1.13**	**-0.07**	**0.12**

5. Loaded Condition and Stability Assessment

Despite the uncertainty in the estimated lightship of the vessel, we were able to evaluate the relative impact of various loading configurations of the vessel on the day of the casualty. MSC developed four Loading Cases using the assumed lightship values developed above (LTSH 4 from Table 1). We evaluated the righting energy of the vessel in its estimated loaded condition, and loaded the vessel with flooding water to consider the impact of the weight of the water in the port clam holds, the impact of water in both port and starboard holds, and the impact of water entrapment on deck. The results of the righting arm energy evaluations are presented in Figure 6.

In developing the estimated loading condition, MSC used the same weights and centers of gravity for crew and effects and provisions that Mr. Norton used in his 2009 analysis. We then assumed the fuel tanks to be 60% full, to be consistent with the common mid-voyage practice in stability analysis and both the fresh water and the hydraulic oil to be 60%. We estimated the weight of 14 crab cages evenly distributed between the tanks. In Cases 2-4 the impact of free surface effect of the water in the tanks was not considered. At the time of sinking, witness reports indicate the port tanks were full. In Case 4, the volume of water entrapped represents a uniform depth of approximately 7 inches on the after deck. In modeling this water, MSC did include free surface effect of the water on deck, which had a significant negative impact on the vessel's stability.

We did not estimate the weight of additional fishing gear, including the water hose used for dredging. Based on review of his work product from the 2009 stability analysis, fishing gear and equipment appears to have been included by Mr. Norton in the lightship calculations of the vessel. Mr. Norton did not include additional gear weight when estimating fishing and operating loads during his analysis in 2009. This indicates that the gear was on the vessel when it was inclined. As described by Mr. Arabian in his witness testimony, at the time of the incident, the dredge was hauled out of the water, but the hose was in the water behind the vessel; it was in the water, and full of water. Mr. Arabian testified that the hose in this condition did not typically create a list. The water weight in the hose was estimated to be approximately 1LT. MSC did not estimate the weight or drag of the water-filled hose for this evaluation.

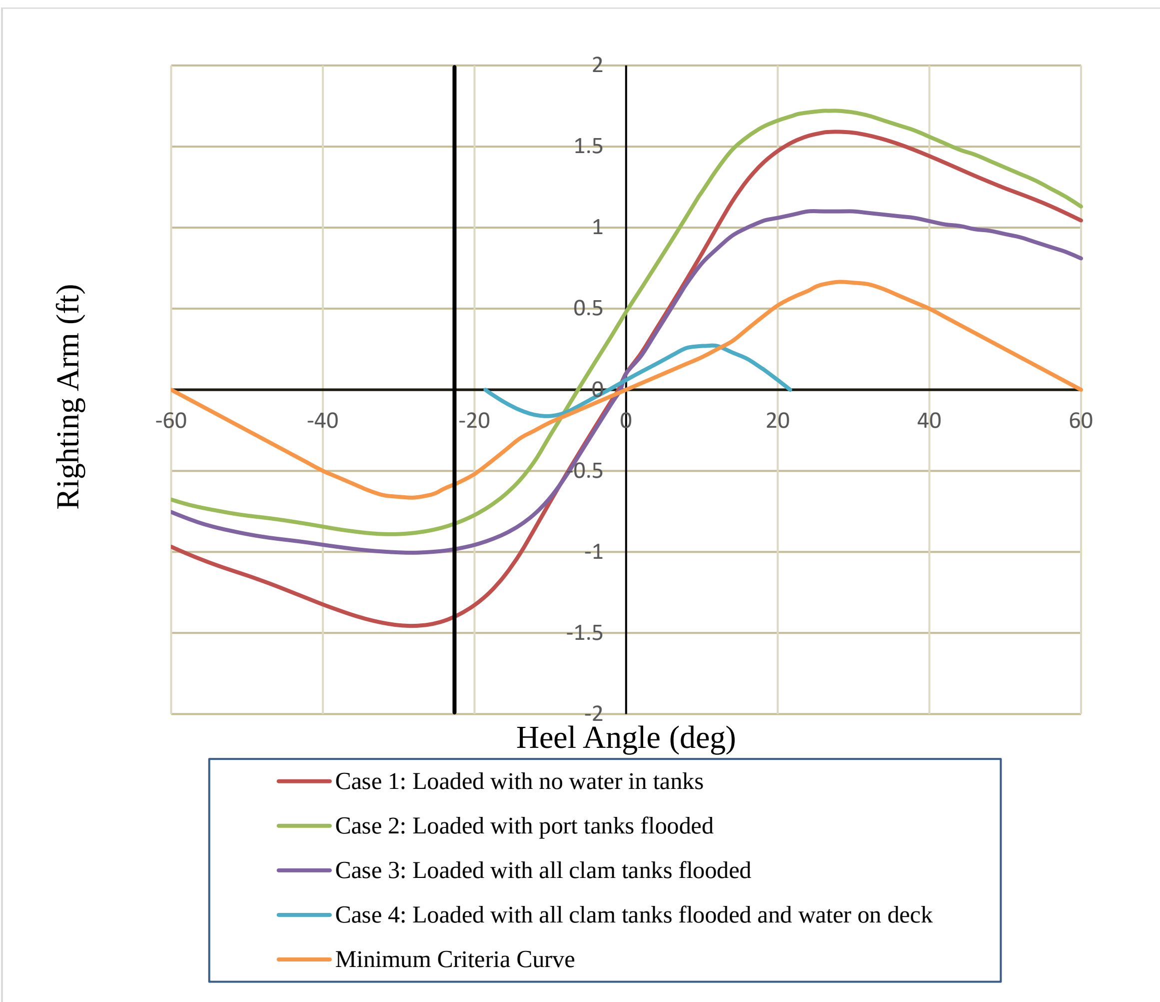

Figure 6: Righting Arm Curve Comparison for Incident Loading Cases

While there is significant uncertainty in the estimated initial lightship values as well as the assumed loading condition for the MISTY BLUE on the day of the incident, Figure 6 can nonetheless be used to demonstrate the relative impact on stability of the various evaluated Loading Cases. In Figure 6, heel angles to port and righting arm are assigned a negative value and can be seen on the left hand side of the figure. This is the convention used to distinguish between port and starboard. Our calculated angle of downflooding (22^{o} to port) is represented as a black vertical line.

To demonstrate the relative impact of the various loading conditions, MSC developed the Minimum Criteria Curve, shown as orange, as a visual representation of the minimum limits required to satisfy intact stability found in 46 CFR 28.570. Figure 6 demonstrates that Cases 1-3 exceed these intact stability limits.

Figure 6 demonstrates the negative impact of the off-center flooding at the time of sinking. The righting arm curve for Case 2 is shifted to the left and crosses the x-axis at -6.4 degrees; this crossing location represents the vessel at static equilibrium with a 6.4 degree list to port. MSC has calculated that at a heel angle of 22^{o} the vessel will downflood into the lazarette vent. This means that the off-center flooding of the port clam tanks decreases the range to down flooding by over 5 degrees. In addition the area under the righting arm curve from static equilibrium to the point of downflooding is significantly decreased due to the port list. The area for Case 2 is approximately 50% less than the area from equilibrium to downflooding for Case 1.

Case 4 places approximately 7 inches of water on deck above the assumed vertical center of gravity. The righting arm curve for this scenario demonstrates significant negative impact on righting energy, one that is particularly difficult to recover from. The weight of the water added was approximately 1LT, the approximate weight of one loaded clam cage.

6. Qualitative Discussion of Events Surrounding the Sinking

Reference (b) indicates that after noticing the port list, the captain throttled ahead full and turned to port. [redacted] asked what the impact of that maneuver might be, specifically if this would improve or worsen stability. We are unable to conduct an analysis that shows the quantitative effects associated with a maneuver such as this, that takes into account all of the dynamic factors with this event such as vessel motion and sea state. This action, however, would typically cause a vessel to roll to starboard.

As previously mentioned, we found that flooding of the port clam tanks alone could account for the unexpected port list identified by the master. At that time, witnesses indicate the freeing ports were at the waterline and water was not clearing the deck. Although not accounted for in the 2009 stability analysis by NMD, at the time of sinking, there was a vent leading to the lazarette which likely served as the primary downflooding point to the lazarette. The vent is not addressed in any of the survey reports. Photos from various surveys do not provide views of the vent. Based on guidance from the IO, we conservatively estimated a downflood point 24 inches above the deck. MSC found that in Case 3 the lazarette downflooding point would submerge when the vessel heeled to approximately 22^{o}.

Figure 7 presents the static condition of the vessel as loaded in Case 2, with an estimated port list of 6.4^{o}. When the vessel was loaded as estimated at the time of sinking, with the port tanks flooded, the freeing ports would be very near the water's edge. This aligns with witness testimony presented in reference (b), and indicates that the flooding in the port tanks alone would be sufficient to induce the reported list. Given the sea state at the time of the incident and the relatively small freeing port areas, it is likely that water accumulated quickly on deck and settled to the port side.

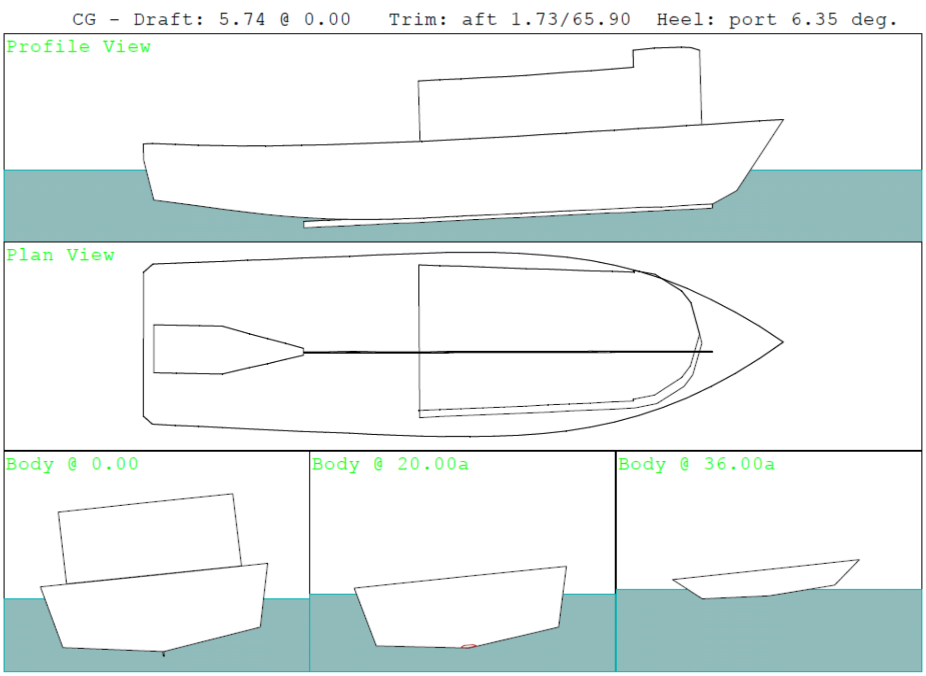

Figure 7: Floating Condition of the Vessel Loaded as Estimated At Time of Sinking

7. Conclusions

Based on the computer model developed at the time of the 2009 inclining test and the estimated changes to the vessel derived from the survey reports and witness testimony, we estimated the impact of assumed weight changes on the vessel since 2009. This work indicated that the positive impact of the ballast weight added after the 2009 conversion was reduced by subsequent weight modifications to the vessel.

In our review of the vessel's loading and witness reports provided for the day of the sinking, the off-center flooding of the port clam tanks could have created the port list noted by survivors. We estimate that this list would have brought the bottom of the freeing ports to about the water line in a static condition. While our analysis provides insight into the vessel's stability in static conditions, we are not able to quantify the effects of the many external and dynamic forces that likely acted on MISTY BLUE at the time of the casualty. We did estimate the impact of water trapped on deck and found that even small amounts of water on deck would significantly reduce stability of the vessel. Wind and wave action would have further negatively impacted stability. We found that the freeing port area on this vessel was relatively small compared to a vessel which must comply with the regulatory requirements of 46 CFR 28.555 which likely resulted in compounding water accumulation on the main deck.