U.S. Coast Guard
Marine Safety Center

Technical Report

SCANDIES ROSE
Stability Analysis

February 8, 2021

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1. EXECUTIVE SUMMARY

This report documents a forensic technical stability analysis of Fishing Vessel SCANDIES ROSE, completed by the U.S. Coast Guard Marine Safety Center (MSC) in support of the formal Marine Board of Investigation into the capsize and sinking that occurred on December 31, 2019.

MSC used available information to independently generate a detailed computer hydrostatics model. This model was compared to the hydrostatics model prepared by Mr. Bruce Culver, the naval architect hired by the owner of SCANDIES ROSE, who conducted and documented stability analyses and instructions for the ship in 1988 and 2019. Significant modeling differences were observed when comparing the owner's naval architect's hydrostatics model to MSC's.

Using available stability test data from 1988 and 2019 tests, MSC evaluated the suitability of the tests and resulting light ship characteristics. Light ship characteristics used by the owner's naval architect in stability analysis are not supported by the stability test notes. Available stability test procedures and documentation in 2019 give MSC low confidence in calculated light ship weight and centers of gravity.

Hydrostatics models and light ship characteristics were used to evaluate each of SCANDIES ROSE's sample loading conditions as well as potential casualty voyage conditions for compliance with relevant stability criteria. When modeled by MSC, the majority of SCANDIES ROSE's 2019 sample loading conditions fail required stability criteria. Hydrostatics modeling demonstrates that the estimated casualty voyage loading condition may have met the restrictions of the owner's naval architect's 2019 Stability Instruction but failed regulatory stability criteria, including water on deck, intact stability, and severe wind and roll criteria.

2. REFERENCES

(a) Bruce Culver, GHS Hydrostatics Computer Model: “JOB1945.GF”

(b) Bruce Culver’s Calculations and Notes, dates ranging from 1988 to 2019, 138 pages

(c) Bruce Culver, Stability Booklet for F/V SCANDIES ROSE, dated April 2019

(d) Bender Welding & Machine Co., Inc., "Lines," 132B-915-1, Rev. 1, Dated May-1977

(e) Bender Welding & Machine Co., Inc., "Scantling Plan and Profile," 130KC-001-101-03, Rev. 0, Dated June-1977

(f) Bender Welding & Machine Co., Inc., "Poop and Focsle Deck," 132B-108-1, Rev. 1, Dated Sept-1977

(g) Bender Welding & Machine Co., Inc., "Midship & Typ Sections," 132B-101-2, Rev. 0, Dated June-1977

(h) Bender Welding & Machine Co., Inc., "Transv. Bulkheads & Long'l," 303-114-1, Rev. 1, Dated June-1977

(i) Bender Welding & Machine Co., Inc., "Bulkheads, Sheet 2," 303-114-2, Rev. 2, Dated Aug-1977

(j) Bender Welding & Machine Co., Inc., "Vents Fills and Sounding Tubes," 303-511-1, Rev. 0, Dated Aug-1977

(k) Bender Welding & Machine Co., Inc., "Midship & Typ. Sections," 130KC-001-101-02, Rev. 0, Dated June-1977

(l) Bender Welding & Machine Co., Inc., "Maindeck," 130KC-001-107-01, Rev. 0, Dated June-1977

(m) Bender Welding & Machine Co., Inc., "Pilot House," 130KC-001-111-05, Rev. A, Dated Sept-1977

(n) "Capacity Plan," Not Numbered or Titled, Dated Feb-1978

(o) Fishermen’s Maritime Services, Inc., “Condition and Valuation Survey, F/V SCANDIES ROSE,” dated June 20, 2019.

(p) American Bureau of Shipping, International Load Line Certificate Issued to PATRICIA LEE (O.N. 597612), dated 23 January 1996

3. INTRODUCTION

A Formal Marine Board of Investigation into the sinking of Commercial Fishing Vessel SCANDIES ROSE (O.N. 602351) was convened as required by USCG Deputy Commandant of Operations (CG-DCO) Memorandum on January 16, 2020. As requested by the members of the investigation team, MSC utilized relevant naval architecture principles to evaluate the stability of SCANDIES ROSE to assist in determining the cause of sinking on December 21, 2019. This report has been generated to provide a summary of MSC's findings.

Documentation made available to MSC included an existing computer hydrostatics model (ref (a)), miscellaneous notes and documentation on stability from 1988 and 2019 (ref (b)), the 2019 Stability Booklet for SCANDIES ROSE (ref (c)), vessel drawings (refs (d) through (n)), a recent condition and valuation survey (ref (o)), sample loading conditions (within refs (b) and (c)), and sister vessel PATRICIA LEE's Load Line Certificate (ref (p)). Based on this documentation, MSC completed a series of independent technical analyses culminating in an evaluation of regulatory stability criteria for 17 sample loading conditions and two potential casualty voyage loading conditions. MSC's analysis follows the procedure typical of modern stability analysis: hydrostatics modeling, stability test, and loading condition evaluation.

Section 4 provides a detailed description of the development of MSC's computer model and assumptions made to hydrostatically model SCANDIES ROSE. MSC's computer model is compared against the computer model provided as reference (a).

Section 5 reviews the owner's naval architect's documented stability test data from 1988 and 2019. Using this data, independent light ship weights and centers of gravity are calculated by MSC and differences are highlighted between MSC's values and those in references (b) and (c).

Section 6 evaluates loading conditions provided in references (b) and (c) using regulatory stability criteria. Loading conditions are analyzed using a combination of light ship characteristics and hydrostatics models. Estimated loading conditions during the casualty voyage are also analyzed for compliance with regulatory stability criteria.

Section 7 details initial conclusions based on the analyses contained in Sections 4 through 6.

4. SCANDIES ROSE COMPUTER HYDROSTATIC MODELING

The stability requirements of 46 CFR Part 28, Subpart E involve comparing a vessel's static stability characteristics against statutory criteria. These criteria provide safety margins to account for actual operation of the vessel in a dynamic environment. Hydrostatic properties involved in regulatory analysis include draft, displacement, heel, trim, free surface effects from tanks, and calculation of righting arm plots against angles of heel. Although it is possible to accomplish these tasks through calculation by hand, the calculation complexity typically requires the use of a computerized hull model. The computerized hull model is a 3-D representation of the hull of the vessel and can include tanks and windages (like superstructure and masts).

Hydrostatics computer models are typically constructed using the vessel's lines plan or table of offsets. If available, additional vessel drawings are used to add detail and verify dimensions; these drawings can include the tank capacity plan, general arrangements plan, and structural drawings.

4.1. SCANDIES ROSE – Reference Drawings

Sufficient drawings are available to create a hydrostatic model of the SCANDIES ROSE. Many of the plans noted as references (d) through (n) bear hand-written markings that identify the plans as pertaining to PATRICIA LEE (Bender Welding and Machine Co. Hull #303), a sister vessel to SCANDIES ROSE (ex. ENTERPRISE, Bender Welding and Machine Co. Hull #747).

4.2. MSC Modeling Software

MSC modeled SCANDIES ROSE using Robert McNeel & Associates' "Rhinoceros" Software. This software was used to create a 3-D surface model of the hull, bulwarks, and superstructure of SCANDIES ROSE. Once the outer shell was constructed in Rhinoceros, MSC created body-section cuts of the hull surface to generate offsets that were imported into Creative System's "GHS" Software Version 17. MSC created tanks, added crab pot windage, and added weights within the GHS software in preparation for hydrostatic analysis.

4.3. MSC Model Building Assumptions

The primary reference drawing for hydrostatically modeling SCANDIES ROSE is the Lines Plan (132B-915-1), reference (d), as shown in Figure 1. However, modern photographs of SCANDIES ROSE show significant differences in the poop and forecastle profiles when comparing the lines plan to a profile picture from 2019 (Figure 2).

When the Lines Plan for SCANDIES ROSE is overlaid on a 2019 profile photograph from the vessel survey in Figure 2, it can be clearly seen that the actual watertight envelope, especially in the area of the enclosed poop and forecastle, differs from the lines plan: the poop deck is significantly shorter, and the forecastle has less height and is longer. When the Scantling Plan and Profile drawing (ref (e)) is overlaid over the same 2019 profile picture (Figure 3), it shows that the as-built transom angle is inaccurately reflected in the Structural Profile, but the length of the Forecastle and Poop is still much different. These discrepancies may be the result of vessel modification.

It is not clear from drawing numbers if each document listed as reference (d) through (n) is specific to SCANDIES ROSE or a sister vessel. Hand written markings on many of the drawings indicate possible applicability to several hull numbers. In order to complete the model, MSC made several assumptions documented below.

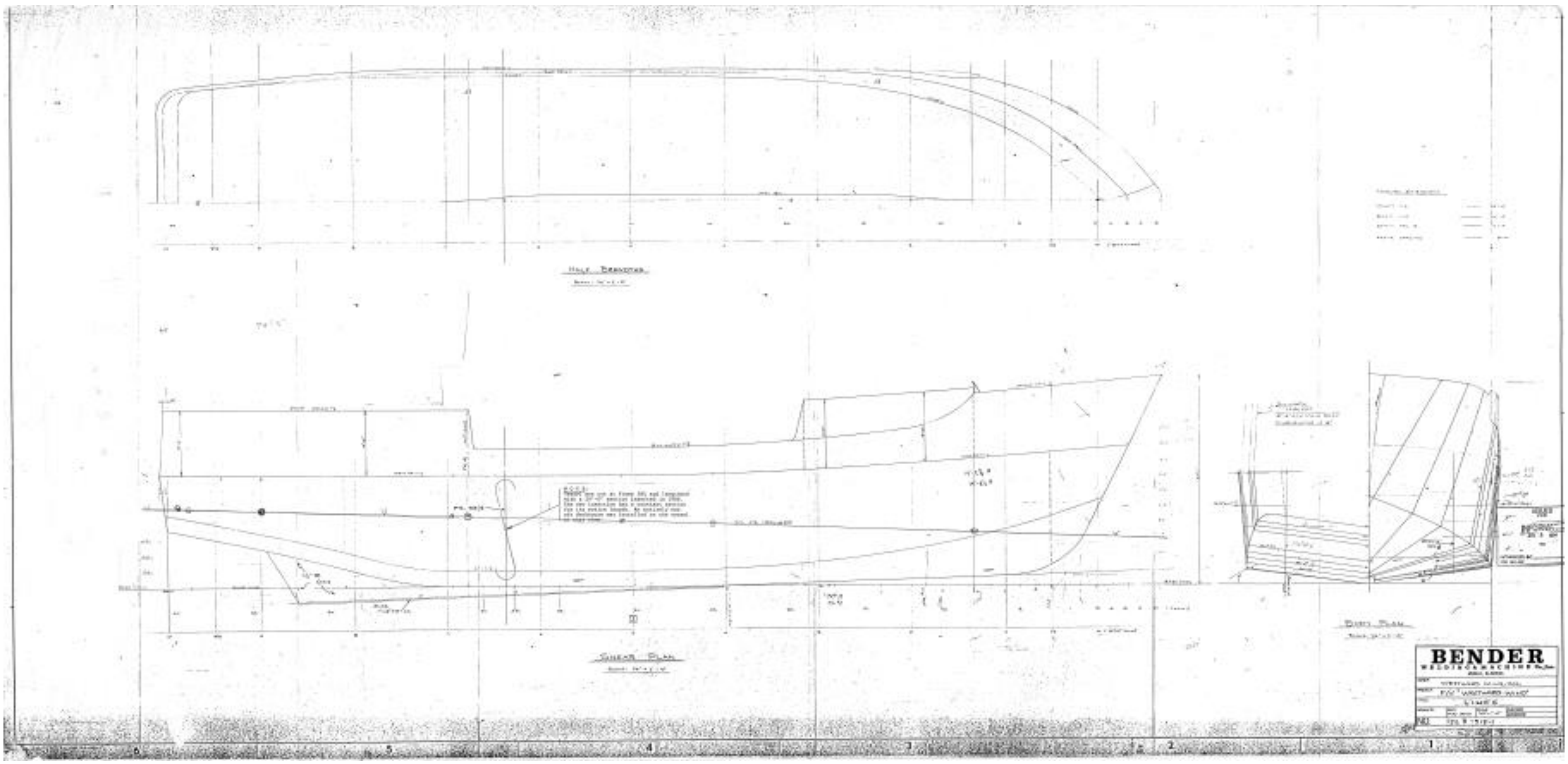

Figure 1: SCANDIES ROSE Lines Plan, dated May 1977 (ref D)

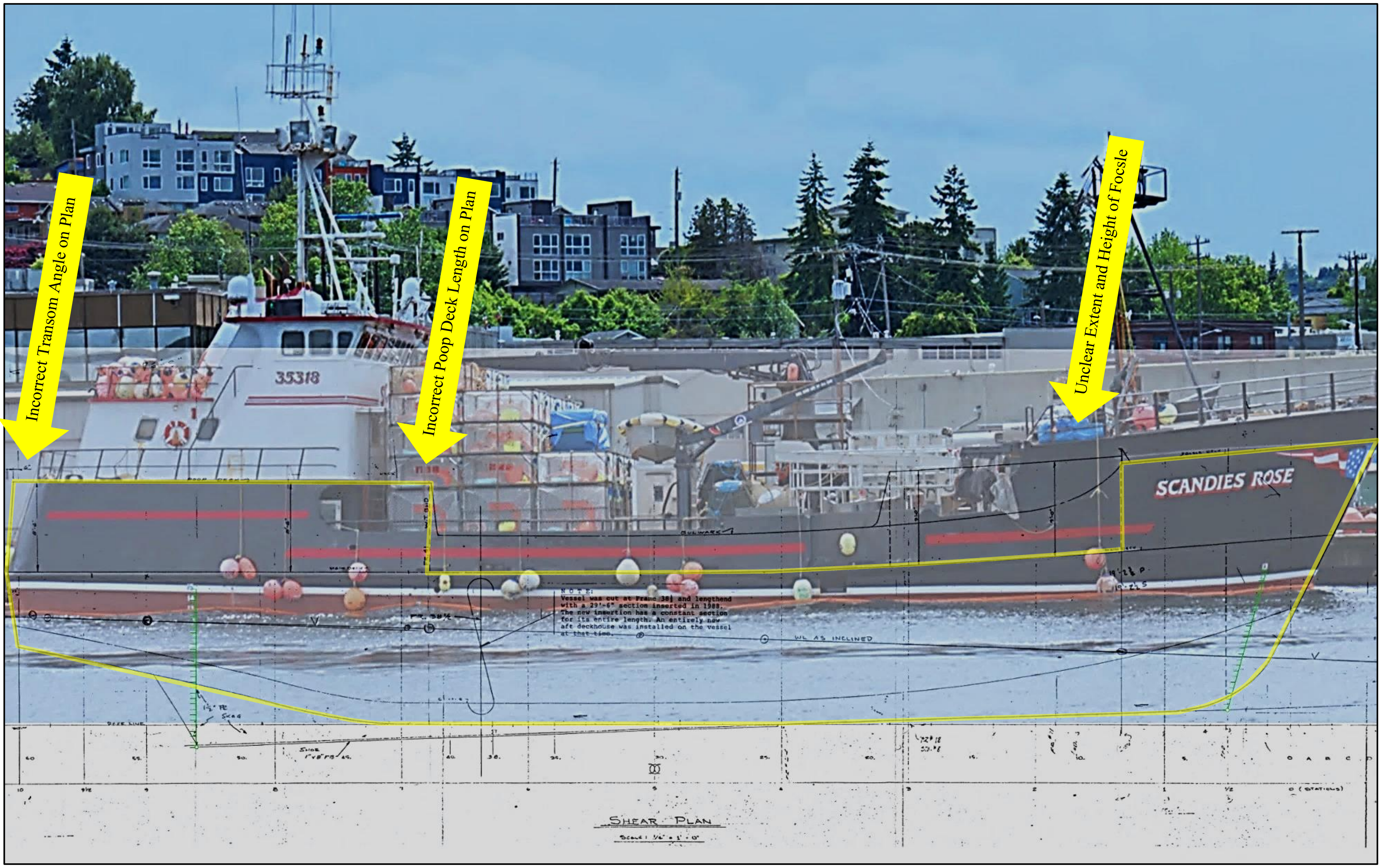

Figure 2: 2019 Profile photograph of SCANDIES ROSE (ref (o)) with Lines Plan profile (ref (d)) overlaid with watertight envelope highlighted in yellow and large profile differences in the poop and forecastle called out

Figure 3: 2019 Profile photograph of SCANDIES ROSE from (ref (o)) with Scantling Plan and Profile (ref (e)) overlaid. Note that the plan matches the vessel's transom, but indicates additional buoyant volume at the forward end of the poop (white highlighted area)

4.3.1. Forecastle and Poop Buoyancy Modeling

The "Poop and Focsle Deck" Drawing (ref (f)) provides dimensions for the extent of the Poop. This drawing also indicates that the engine room vents are located on the Poop Deck behind the pilothouse stairs between frames 45 and 47. These dimensions for the Poop Deck extents appear to match the 2019 profile photograph (ref (o)). MSC assumed that these dimensions and downflooding points are accurate.

No drawings are available that accurately show the extents of the forecastle. Overlaid recent photographs of SCANDIES ROSE (Figure 2 and Figure 3) indicate that the forecastle extended higher and further aft than indicated on vessel drawings. Assumptions were made by MSC to account for the extents of this buoyant volume. Figure 4 shows SCANDIES ROSE (ex. ENTERPRISE) at delivery in 1978; in this photograph, the forecastle apparently matches vessel drawings (with less height and less aft extent). In 2019, the shelter area aft of the enclosed forecastle was open at the after end but enclosed by bulwarks and the forecastle deck as shown in Figure 5; this area was not fully enclosed and therefore not buoyant. The aft extent of the enclosed forecastle was assumed to remain in the same location as shown on the drawings (frame 8). This assumption is supported by the visible crane pedestal in Figure 5, which shows the pedestal aft of the forecastle bulkhead. Additional support is provided in Figure 3, which shows the foremast at the aft extent of the enclosed forecastle, which matches the aft extent of the forecastle in Figure 4.

Figure 4: SCANDIES ROSE (ex. ENTERPRISE) at delivery in 1978. Photograph provided by USCG Marine Board of Investigation

It appears that, at some point, the forecastle was modified to increase its height. The original forecastle deck appears to be indicated on the side shell just above the vessel name with what appears to be half round. Interior views (from ref (o)) of the forecastle storage spaces indicate a lower ceiling as well. To model the height of the forecastle deck, the 2019 profile picture from reference (o) was measured and scaled to determine the forward and aftmost heights. The side shell was extended tangent to the existing side shell to meet these new forecastle heights.

4.3.2. Superstructure Modeling

Similar to forecastle decks heights, MSC measured and scaled the 2019 profile photograph within reference (o) to develop profiles for the bulwarks, house, masts, anchor, and cranes. Transverse extents of these superstructure elements were determined using measurements from reference (o) and estimated from photographs using these measurements as a reference.

For stability modeling, bulwarks are assumed to match the condition shown in Figure 2 and Figure 3. Figure 7 shows much greater bulwark heights with fitted wave walls but these were not modelled.

Overlapping windage areas are present in MSC's model due to the cranes, crab pots, and bulwarks. To account for this, the MSC model windage calculations include the effect of

Figure 5: Photo from page 21 of ref (o) showing starboard crane pedestal aft of forecastle bulkhead

shielding from other components. For example: a crane could be shielded by crab pots if they are in front of the crane, and crab pots on the lowest tier are partially shielded by the bulwarks. These areas are not double counted for windage.

4.3.3. Surface Ice Modeling

To evaluate icing, as required by 46 CFR 28.550, ice is assumed to be a thin layer on the exposed surfaces of areas above the water. 46 CFR 28.550 prescribes a thickness of ice for exposed vertical and horizontal surfaces; however, diagonal surfaces (ex. tumblehome at the transom) are not addressed by the regulations. MSC accounted for these diagonal surfaces by vectoring exposed surfaces on the poop, forecastle, bulwarks, and superstructure vertically 1.3 inches and outward 0.65 inches.[1] The diagonally downward facing pilothouse windows and flood lights on the masts were assumed to remain free of ice. The layer formed by the vectored surface to the existing structural component was given a density of 56.7 lbs. per cubic foot to be equivalent to the weight specified by 46 CFR 28.550: 6.14 lbs. per square foot of 1.3-inch thick ice (or 3.07 lbs. per square foot of 0.65-inch thick ice). By modeling ice in this manner, MSC accounted for both the weight and centers of gravity of ice as shown in Table 1.

No icing layer was added below the main deck level, assuming that any surfaces above the waterline but below the main deck frequently contact sea water and do not experience icing. Within MSC's model, the ice layer was assumed to have no buoyancy or windage and could be turned off for conditions where icing was not required.

[1] Outward means:

- outboard for longitudinal surfaces
- aftward for transverse surfaces aft of amidships
- forward for transverse surfaces forward of amidships and the front of the house

Ice Weight and Center of Gravity	*Ice Weight (LT)*	*Ice LCG (from MS)*	*Ice VCG (abv. BL)*
Ice on House	4.0	36.9a	31.8
Ice on Forecastle	2.0	55.2f	26.8
Ice on Poop	2.6	45.0a	21.5
Ice on Port Crane Boom	0.3	3.8a	35.1
Ice on Port Crane Pedestal	0.1	13.6f	26.0
Ice on Starboard Crane Boom	0.1	12.7f	27.4
Ice on Starboard Crane Pedestal	0.1	2.9f	21.2
Ice on Aft Mast	0.02	33.3a	48.8
Ice on Aft Mast Stays	0.03	31.3a	43.8
Ice on Forward Mast	0.05	44.2f	39.3
Ice on Forward Mast Stays	0.15	50.3f	35.9
Ice on Bulwarks	2.0	15.2f	18.1
Total Icing Load	**11.3**	**10.0a**	**26.2**

Table 1: Icing Loads on Hull and Superstructure Parts Calculated by MSC Model

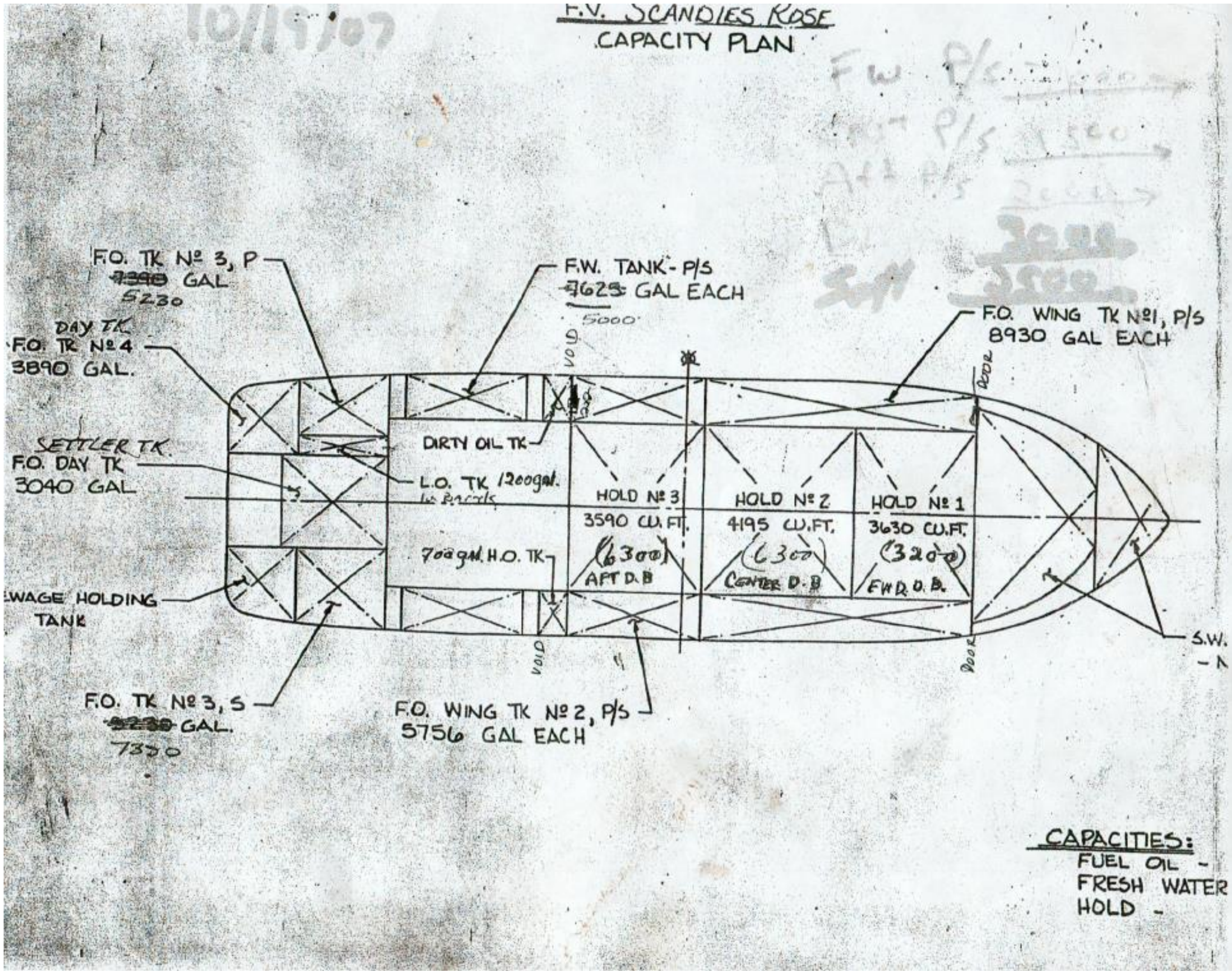

Figure 6: SCANDIES ROSE Capacity Plan, dated October 2007 (ref (n))

4.3.4. Tank Modeling

Tanks were modeled using dimensions provided in the structural drawings (refs (e), (g), (h), (i), and (j)). The permeability of these tanks was then set so that the tank capacities matched the provided Tank Capacity Plan (Figure 6, ref (n)). The Tank Capacity Plan is of unknown origin which leads to lower confidence in tank volumes. To mitigate the potential error caused by differences in tank volumes, stability criteria evaluation of loading conditions within this report are performed by loading tanks by weight and not volume fractions. This method allows tanks to be loaded with the correct weight magnitude and results in negligible errors in the center of

Tanks (Side Indicated by Last Character)	*Capacity Plan Volume (cu.ft)*	*Capacity Plan Volume (gallons)*	*MSC Model Volume (cu.ft)*	*MSC Model Volume (gallons)*	*Difference with Capacity Plan %*	*MSC Permeability (set to match capacity plan)*	*MSC Final Model Volume (cu.ft)*	*MSC Final Model Volume (gallons)*	*Permeable Volume Error to Capacity Plan %*
HOLD1.C	3630.0	27154.3	4225.3	31607.4	-16%	0.859	3630.0	27154.3	0%
HOLD2.C	4195.0	31380.8	5006.3	37449.7	-19%	0.838	4195.0	31380.8	0%
HOLD3.C	3590.0	26855.1	4342.0	32480.4	-21%	0.827	3590.0	26855.1	0%
DBLBTM_F.C	427.8	3200.0	581.0	4346.2	-36%	0.736	427.8	3200.0	0%
DBLBTM_M.C	842.2	6300.0	1024.5	7663.8	-22%	0.822	842.2	6300.0	0%
DBLBTM_A.C	842.2	6300.0	1004.7	7515.7	-19%	0.838	842.2	6300.0	0%
FWDWING.S	1193.8	8930.0	420.8	3147.8	-5%	0.949	399.2	2986.1	0%
FWDWING.P	1193.8	8930.0	420.8	3147.8	-5%	0.949	399.2	2986.1	0%
MIDWING.S	**tank added from fwd*		837.6	6265.7	-5%	0.949	794.6	5943.9	0%
MIDWING.P	**tank added from fwd*		837.6	6265.7	-5%	0.949	794.6	5943.9	0%
AFTWING.S	769.5	5756.0	773.5	5786.2	-1%	0.995	769.5	5756.0	0%
AFTWING.P	769.5	5756.0	773.5	5786.2	-1%	0.995	769.5	5756.0	0%
AFTFUEL.S	987.9	7390.0	1016.2	7601.7	-3%	0.972	987.9	7390.0	0%
AFTFUEL.P	699.1	5230.0	765.1	5723.3	-9%	0.914	699.1	5230.0	0%
DAYTANK.P	520.0	3890.0	529.6	3961.7	-2%	0.982	520.0	3890.0	0%
HYD_OIL.S	93.6	700.0	175.1	1309.8	-87%	0.534	93.6	700.0	0%
HYD_OIL.P	93.6	700.0	175.1	1309.8	-87%	0.534	93.6	700.0	0%
WATER.S	1019.3	7625.0	1028.7	7695.2	-1%	0.991	1019.3	7625.0	0%
WATER.P	1019.3	7625.0	1028.7	7695.2	-1%	0.991	1019.3	7625.0	0%
LUBE_OIL.P	160.4	1200.0	251.2	1879.1	-57%	0.639	160.4	1200.0	0%
SETTLING.C	406.4	3040.0	408.6	3056.5	-1%	0.995	406.4	3040.0	0%
SEWAGE.S	520.0	3890.0	529.6	3961.7	-2%	0.982	520.0	3890.0	0%
BULWARK.C			12530.3	93733.2		0.950	11903.8	89046.5	
FOREPEAK.C			635.6	4754.6		0.950	603.8	4516.9	
BALFWD.C			750.3	5612.6		0.950	712.8	5332.0	
BOWSTORE.C			3861.1	28883.0		0.950	3668.0	27438.9	
WORKSHOP.C			5278.7	39487.4		0.950	5014.8	37513.0	
PWAY.S			1401.6	10484.7		0.950	1331.5	9960.5	
PWAY.P			1401.6	10484.7		0.950	1331.5	9960.5	
ER.C			9396.0	70287.0		0.500	4698.0	35143.5	
BERTHING.C			8489.6	63506.6		0.950	8065.1	60331.3	

Table 2: Tank Table for MSC Model Tank Capacities

gravity and moment of inertia of the contents within the tanks. The notable limitation to this method is when prescribed loading of a tank is greater than the capacity of the tank, in which case the tank can only be loaded to 100% capacity. The magnitude of these errors is addressed in Section 6.2.10.

As shown in Table 2, some model tank capacities significantly differed from the values in the capacity plan and required significant correction by adjusting the assumed permeability. MSC assumed that cargo hold capacities, which required permeability corrections of 16-21%, differ because of installed insulation.

Double bottom fuel tank permeability corrections of 19-36% indicate inaccuracy in either the modeling of these tanks or the tank capacity table. While some reduced permeability may be due to internal structure and piping, the magnitude of the corrections is indicative of some geometric modeling errors in either MSC's model or the capacity plan. This potential error is mitigated in the stability criteria analysis section of this report (Section 6) because no double bottom tanks are loaded in any of the 2019 loading conditions, and only the forward double bottom tank is partially loaded in the 1988 loading conditions.

Hydraulic and lube oil tanks are small and the large permeability adjustments made to match the capacity plan were assumed to have negligible impact on the stability analysis.

Interior compartments are not included in the capacity plan but are listed in Table 2 for completeness.

4.3.5. Crab Pot Modeling

Crab pots were modeled using available deck area with a clear overhead. For MSC's model, the deck area was chosen from two feet forward of the Poop and House to the foremast (the overhanging shelter deck at the aft end of the forecastle can take pots both on the main deck and on top of the forecastle deck; MSC assumed the shelter deck does not substantially restrict loading). Available crab pot deck area extends from 44 feet forward to 25 feet aft of amidships. This area is 33 feet wide at the aft end and 31.5 feet wide at the extreme forward end (for the forward-most row only). Because the crane booms on the port and starboard pedestal cranes can be moved and pots can be shifted slightly, cranes were not deducted from available deck area and do not restrict the volume in which pots can be loaded for MSC's model. SCANDIES ROSE had a raised wear deck on which pots were stacked. This wear deck is noted as 18" above the steel deck at the rails by the 2019 Condition and Valuation Survey (ref (o)); crab pots were loaded starting at this vertical height by MSC.

Two pot dimensions were provided:

- Small Pots: 7 x 6.5 x 3 feet at 835 lbs. each (dimensions from ref (o); weight taken from ref (b))
- Large Pots: 8.5 x 7.5 x 3.5 at 867 lbs. each (as measured by Coast Guard Marine Safety Detachment Dutch Harbor and averaged for pots with gear)

Crab Pot Capacities	*Number of Small Pots*	*Number of Large Pots*
1st Tier	98	72
2nd Tier	44	32
3rd Tier	44	32
4th Tier	44	32
5th Tier	44	32
Total:	274	200
Pot Weight, Each (lbs.)	835	867
Total Pot Weight (lbs.)	228,790	173,400
Wind Profile Area (sq. ft)	167	172

Table 3: Crab Pot Dimensions and MSC Model Capacities

With limited deck space available and a maximum height prescribed by ref (c) ("Do not obscure vision from the pilothouse"), crab pot capacity varies dependent on the size of pots as shown in Table 3. Crab pot sizes specified in SCANDIES ROSE stability instructions from 1988 and 2019 call out pot capacities of 220, 208, and 168 to the pilothouse windows. If large pots were used and limited to a height below the top of the pilothouse windows, a maximum of only 200 pots could be carried within the available deck space.

Figure 7: SCANDIES ROSE profile picture with 5-tiers of pots, date unknown

4.3.6. Crab Pot Icing

46 CFR 28.550 provides little guidance for the manner in which crab pots should be treated for icing. The text of the regulation requires ice to be applied to horizontal and vertical surfaces. This could mean just the outer round tube structure of the pot and not the mesh in between, however pictures of iced crab pots suggest that this is not a conservative assumption (Figure 8). Additionally, 46 CFR 28.550 (d) states:

> *The height of the center of gravity of the accumulated ice should be calculated according to the position of each corresponding horizontal surface (deck and gangway) and each other continuous surface on which ice can reasonably be expected to accumulate. The projected horizontal and vertical area of each small discontinuous surface such as a rail, a spar, and rigging with no sail can be accounted for by increasing the calculated area by 15 percent.*

The mesh between tubular crab pot frames is not a continuous surface to which 15% can be added so an assumption must be made to account for the icing on the stack. For the purpose of crab pot icing calculations required by 46 CFR 28.550, MSC assumed that the top of the exposed tier, outboard sides, and fore and aft areas of the stack are surfaces prone to icing, and treated them as continuous horizontal and vertical surfaces. Areas were not increased by 15%.

Small Crab Pot Icing Cumulative Weights and Center of Gravity	*Cumulative Number of 7x6.5x3 ft Pots on Deck*	*Cumulative Ice Weight (LT)*	*Cumulative Ice VCG (abv. BL)*
1st Tier	1 - 98	7.2	22.3
2nd Tier	99 - 142	7.8	24.5
3rd Tier	143 - 186	8.6	26.7
4th Tier	187 - 230	9.3	28.7
5th Tier	231 - 274	10.1	30.7

Table 4: Crab pot ice weights and centers of gravity for small pots

Large Crab Pot Icing Cumulative Weights and Center of Gravity	*Cumulative Number of 7x6.5x3 ft Pots on Deck*	*Cumulative Ice Weight (LT)*	*Cumulative Ice VCG (abv. BL)*
1st Tier	1 - 72	7.8	23.1
2nd Tier	73 - 104	8.5	25.6
3rd Tier	105 - 136	9.4	28.0
4th Tier	137 - 168	10.3	30.3
5th Tier	169 - 200	11.3	32.5

Table 5: Crab pot ice weights and centers of gravity for large pots

Because this analysis evaluates loading conditions having differing crab pot tier heights, Table 4 and Table 5 provide the assumed icing weights and centers of gravity for each tier of crab pots. To simplify analysis, a step function was used: horizontal icing was assumed to act on the highest tier on which *any* pots are loaded; this effectively creates a five-sided rectangular box of ice around loaded crab pots (no ice is assumed on the bottom of the stack).

Figure 8: Iced crab pots on SANDRA FIVE (photo credit: NTSB)

4.3.7. Downflooding Points

In SCANDIES ROSE's "Vents Fills and Sounding Tubes" drawing (ref (j)) all tank fittings are noted to have caps or vent check valves to prevent downflooding. Watertight doors are noted on the main deck. With these features being effectively water tight, the lowest downflooding points are the engine room vents, which are noted to be behind the stairs to the pilothouse on the poop deck. The location of these vents is indicated on the "Poop and Focsle Deck" drawing (ref (f)) which shows them as 4' long, on the poop deck between frames 45 and 47, and 12 feet 10 inches off centerline on both the port and starboard sides. The location appears to be confirmed by Figure 9, which appears in reference (o).

4.3.8. Reference Drafts

No design or full load draft is provided for SCANDIES ROSE in the drawings. To assume a reasonable draft, MSC used sister ship PATRICIA LEE's winter load line as provided in reference (p). The winter load line freeboard is 1 foot 4-¾ inches below the main deck at amidships, which provided an assumed design molded draft of 13.0 feet. The stability instructions provided in 2019 (within ref (c)) indicate that the vessel can safely operate with a 6-inch freeboard. The amidships molded draft associated with this freeboard is 13.8 feet. A light operating draft is assumed at 8.5 feet to correspond with the lowest drafts in provided hydrostatics tables from reference (b) (Table 6).

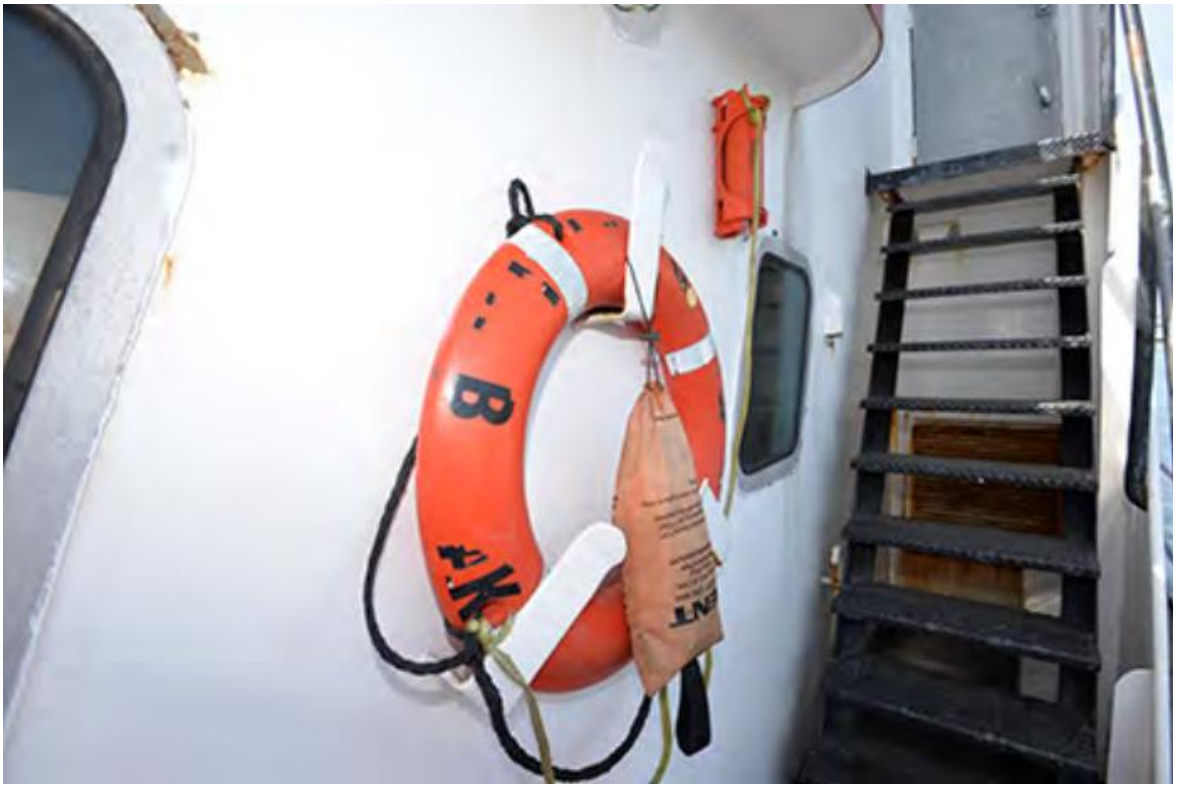

Figure 9: Engine room vent shown behind pilot house stairs from ref (p)

4.4. Model Comparison and Results

A hull model of SCANDIES ROSE was provided to MSC by the Coast Guard Marine Board of Investigation (ref (a)). This model is in the format of a "geometry file" for use with Creative System's GHS software. The model does not bear any notes regarding dates or authorship. To verify that reference (a) is the computer model used in the stability notes provided in reference (b), MSC checked the hydrostatics using Table 6 which appears in ref (c)) and compared that to hydrostatics of Mr. Culver's reference (a) model generated by MSC's GHS software, shown in Table 7. This comparison showed only negligibly small differences, assumed to be caused by the different software versions.[2] Based on this comparison, reference (a) is assumed to be the same model used to carry out stability calculations within references (b) and (c).

To validate the accuracy of the stability models, comparisons were made between reference (a) and MSC's model with the small crab pot sizes in Table 9 through Table 13.

Hull modeling results compare well for hull shape below the main deck. Hydrostatics of both models match within 1% tolerance of displacement between drafts of 8.5 feet to 12.25 feet when comparing Table 7 and Table 8.

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GHS 6.44

Page 1

SCANDIES ROSE

HYDROSTATIC PROPERTIES
No Trim, No Heel, VCG = 0.00

LCF Draft	Displacement Weight (LT)	Buoyancy-Ctr. LCB	VCB	Weight/ Inch	LCF	Moment/ Deg trim	KML	KMT
8.500	578.11	1.37a	5.20	8.28	4.82a	1738.24	172.3	19.08
8.750	603.08	1.51a	5.34	8.33	4.89a	1769.76	168.1	18.76
9.000	628.19	1.64a	5.48	8.38	4.96a	1802.13	164.4	18.49
9.250	653.46	1.77a	5.62	8.43	5.03a	1835.38	160.9	18.26
9.500	678.87	1.88a	5.76	8.48	5.06a	1866.42	157.5	18.05
10.000	729.99	2.09a	6.04	8.53	4.92a	1899.51	149.1	17.57
10.250	755.66	2.18a	6.18	8.55	4.86a	1915.72	145.2	17.37
10.500	781.28	2.27a	6.32	8.55	4.97a	1911.86	140.2	17.19
10.750	806.96	2.35a	6.46	8.58	4.92a	1927.17	136.8	17.04
11.000	832.70	2.43a	6.60	8.60	4.86a	1942.68	133.7	16.89
11.250	858.52	2.50a	6.73	8.62	4.81a	1958.42	130.7	16.77
11.500	884.40	2.57a	6.87	8.64	4.75a	1974.38	127.9	16.66
11.750	910.34	2.63a	7.01	8.67	4.69a	1990.55	125.3	16.56
12.000	936.36	2.68a	7.14	8.69	4.64a	2006.95	122.8	16.47
12.250	962.45	2.73a	7.28	8.71	4.58a	2023.57	120.5	16.40

Distances in FEET.-------Specific Gravity = 1.025.-----------Moment in Ft-LT.
Draft is from Baseline.

Table 6: Hydrostatics Properties of for SCANDIES ROSE from ref (c)

[2] Ref (b) uses GHS Version 6.44. The creation date of this version of GHS was estimated by Creative Systems to be approximately 1995. GHS Version 17 was released by Creative Systems in 2020.

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GHS 17.30C **SCANDIES ROSE**

GHS Model: JOB1945.GF

HYDROSTATIC PROPERTIES
No Trim, No Heel, Fixed VCG = 0.00

LCF Draft	Displacement Weight(LT)	Buoyancy-Ctr. LCB	VCB	Weight/ Inch	LCF	Moment/ Deg trim	KML	KMT
8.500	578.12	1.37a	5.19	8.28	4.82a	1738.20	172.2	19.07
8.750	603.09	1.51a	5.33	8.33	4.89a	1769.72	168.1	18.75
9.000	628.20	1.64a	5.47	8.38	4.96a	1802.09	164.3	18.48
9.250	653.47	1.77a	5.61	8.43	5.03a	1835.32	160.9	18.25
9.500	678.89	1.88a	5.75	8.48	5.06a	1866.36	157.5	18.04
9.750	704.41	1.99a	5.89	8.51	4.99a	1883.49	153.2	17.79
10.000	730.01	2.09a	6.03	8.53	4.92a	1899.43	149.1	17.57
10.250	755.68	2.18a	6.17	8.55	4.86a	1915.63	145.2	17.37
10.500	781.30	2.27a	6.31	8.55	4.97a	1911.77	140.2	17.18
10.750	806.97	2.35a	6.45	8.58	4.92a	1927.06	136.8	17.03
11.000	832.72	2.43a	6.59	8.60	4.86a	1942.58	133.6	16.88
11.250	858.53	2.50a	6.72	8.62	4.81a	1958.31	130.7	16.76
11.500	884.42	2.57a	6.86	8.64	4.75a	1974.26	127.9	16.65
11.750	910.36	2.63a	7.00	8.67	4.69a	1990.43	125.3	16.55
12.000	936.38	2.68a	7.13	8.69	4.64a	2006.82	122.8	16.46
12.250	962.47	2.73a	7.27	8.71	4.58a	2023.43	120.4	16.39

Distances in FEET. Specific Gravity = 1.025. Moment in Ft-LT.
Draft is from Baseline.

Table 7: Hydrostatics Properties of Mr. Culver's ref (a) Model Using GHS Version 17

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GHS 17.30C **MSC - SCANDIES ROSE**

GHS Model: SR-MSC.GF

HYDROSTATIC PROPERTIES
No Trim, No Heel, Fixed VCG = 0.00

LCF Draft	Displacement Weight(LT)	Buoyancy-Ctr. LCB	VCB	Weight/ Inch	LCF	Moment/ Deg trim	KML	KMT
8.500	583.42	0.33a	5.16	8.28	4.34a	1763.56	173.2	18.75
8.750	608.33	0.50a	5.30	8.33	4.48a	1795.58	169.1	18.48
9.000	633.40	0.66a	5.45	8.38	4.54a	1820.90	164.7	18.22
9.250	658.57	0.81a	5.59	8.41	4.55a	1840.99	160.1	17.96
9.500	683.84	0.94a	5.73	8.43	4.51a	1855.82	155.5	17.72
9.750	709.17	1.07a	5.87	8.46	4.46a	1869.89	151.1	17.49
10.000	734.57	1.19a	6.00	8.48	4.41a	1884.10	146.9	17.29
10.250	760.04	1.29a	6.14	8.50	4.35a	1898.50	143.1	17.11
10.500	785.58	1.39a	6.28	8.53	4.30a	1913.10	139.5	16.95
10.750	811.19	1.48a	6.42	8.55	4.25a	1927.93	136.2	16.80
11.000	836.88	1.57a	6.55	8.57	4.20a	1943.00	133.0	16.68
11.250	862.63	1.64a	6.69	8.59	4.13a	1957.00	130.0	16.56
11.500	888.45	1.72a	6.83	8.62	4.09a	1973.31	127.2	16.47
11.750	914.34	1.78a	6.96	8.64	4.04a	1989.26	124.6	16.38
12.000	940.31	1.84a	7.10	8.67	3.98a	2005.33	122.2	16.31
12.250	966.35	1.90a	7.23	8.69	3.93a	2021.61	119.9	16.24

Distances in FEET. Specific Gravity = 1.025. Moment in Ft-LT.
Draft is from Baseline.

Table 8: Hydrostatics Properties of MSC's SCANDIES ROSE Model

Although models match well for below deck volume, significant differences exist between reference (a) and MSC's volumes for the forepeak and poop. These volumes provide reserve buoyancy for SCANDIES ROSE and are important when evaluating stability scenarios as they become submerged. The accuracy of these volumes become especially important when freeboard is low: at an assumed design draft of 13.0 feet, where SCANDIES ROSE has low freeboard and parts of the forecastle and poop become submerged at heel angles of 5 degrees. With a draft of 13.8 feet, parts of the forecastle and poop submerge at heel angles of only 2 degrees.

Table 12 compares tank volumes between reference (a), MSC's model, and the noted volumes on the tank capacity plan (Figure 6, ref (n)). MSC's modeled tank capacities are set to equal the noted capacity plan tank volumes. Reference (a) tank capacities are generally larger than noted on SCANDIES ROSE's capacity plan with modeled hold volumes 4% to 8% larger and wing fuel tanks 1% to 9% larger. The portside aft fuel tank in reference (a) has 16% less volume than the capacity plan; this is a result of the lube oil tank being modeled differently than shown on the capacity plan. Reference (a) also has deductions within the water tanks that are not present on

MSC Icing Cumulative Weights and Center of Gravity (Small Crab Pots)	*Cumulative Number of 7x6.5x3 ft Pots on deck*	*Cumulative Ice Weight (LT)*	*Cumulative Ice LCG (aft of MS)*	*Cumulative Ice VCG (abv. BL)*
Icing on Superstructure and Hull	0	11.3	10.0	26.2
1st Tier	1 - 98	18.5	3.7	24.7
2nd Tier	99 - 142	19.1	3.5	25.5
3rd Tier	143 - 186	19.9	3.2	26.4
4th Tier	187 - 230	20.6	2.9	27.3
5th Tier	231 - 274	21.4	2.6	28.3

Table 9: Cumulative ice weights and centers of gravity combining superstructure and hull icing with small crab pot icing

MSC Icing Cumulative Weights and Center of Gravity (Large Crab Pots)	*Cumulative Number of 8.5x7.5x3.5 ft Pots on deck*	*Cumulative Ice Weight (LT)*	*Cumulative Ice LCG (aft of MS)*	*Cumulative Ice VCG (abv. BL)*
Icing on Superstructure and Hull	0	11.3	10.0	26.2
1st Tier	1 - 72	19.1	2.2	24.9
2nd Tier	73 - 104	19.8	1.8	25.9
3rd Tier	105 - 136	20.7	1.3	27.0
4th Tier	137 - 168	21.7	0.9	28.1
5th Tier	169 - 200	22.5	0.5	29.3

Table 10: Cumulative ice weights and centers of gravity combining superstructure and hull icing with large crab pot icing

the capacity plan or structural drawings. These deductions result in reference (a)'s water tanks having 12% less volume than the capacity plan. Reference (a) does not include the settling tank in the engine room or the mid and aft double bottom fuel tanks.

Significant differences also exist between reference (a) and MSC's modeled wind profiles as shown in Table 13. Compared to recent profile pictures (Table 13), reference (a) underrepresents the windage area of the crab pots and the average height of the windage area of the superstructure. Reference (a) lacks any apparent way to model higher tiers of crab pots even though the model is limited to approximately 3 tiers as shown in the picture overlay in Table 13. This results in erroneously low heeling moments when a wind pressure is applied to the vessel: Table 13 shows an example 53 knot wind at a draft of 13.0 feet. For this condition, reference (a) has a heeling moment 45% less than MSC's with 5 tiers of pots and 30% lower than MSC's with 3 tiers of pots. Table 14 compares reference (a) to MSC's model with large crab pots. Because the large crab pots have more wind area, greater differences between reference (a) and MSC's model are shown.

Differences in windage and crab pots between models leads to drastically different weight calculations for icing as well. To accurately model the weight and centers of gravity of accumulated ice, MSC's model explicitly adds this layer to top and vertical sides of windage volumes. Reference (a) does not include icing—reference (b) indicates that it is later added as a fixed weight and no calculations showing the derivation of this weight and center of gravity are provided. For comparison, reference (b) accounts for icing that is fixed with 16.08 long tons of ice at a longitudinal center of gravity of 3.89 feet forward of amidships and vertical center of gravity of 21.39 feet. Table 9 shows the icing weights from MSC's model. Reference (b)'s weight for icing is 24 to 27% lower than MSC's for icing on 5-tiers of pots. Because this ice weight is located at a high vertical center of gravity, it has a significant impact on SCANDIES ROSE's stability.

No downflooding points are present within reference (a) or indicated in the notes provided in reference (b) for comparison. However, an erroneous statement within reference (b) was noted regarding 2019 Stability Test notes shown in Figure 10.

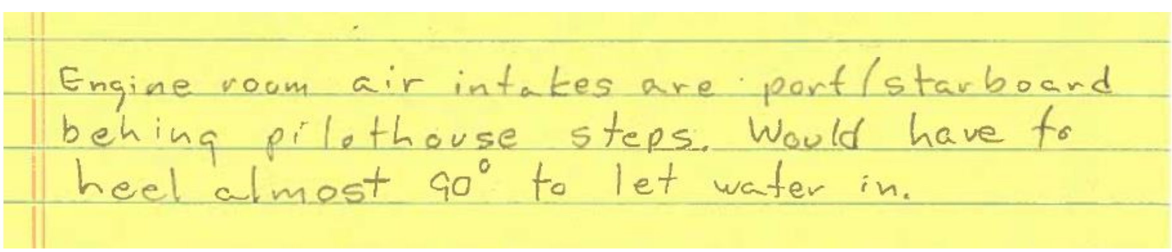

Engine room air intakes are port/starboard behind pilothouse steps. Would have to heel almost 90° to let water in.

Figure 10: Downflooding statement from 2019 stability test notes within ref (b)

Using MSC's Model (Figure 11) at a draft of 13.0 feet, downflooding occurs at a heel angle of 35°. Even at an assumed light ship draft of 8.5 feet, the downflooding heel angle to the engine room vents is 56° which is far below the statement shown in Figure 10 that the vessel "would have to heel almost 90° to let water in."

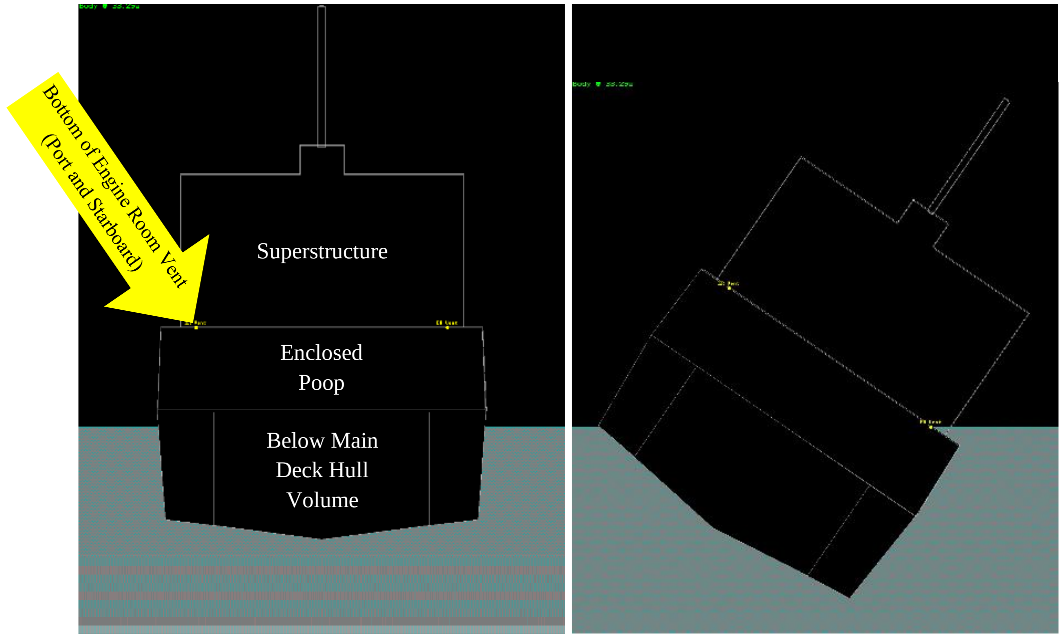


Figure 11: Downflooding points at reference draft (13.0 feet) and associated angle of downflood (35°)

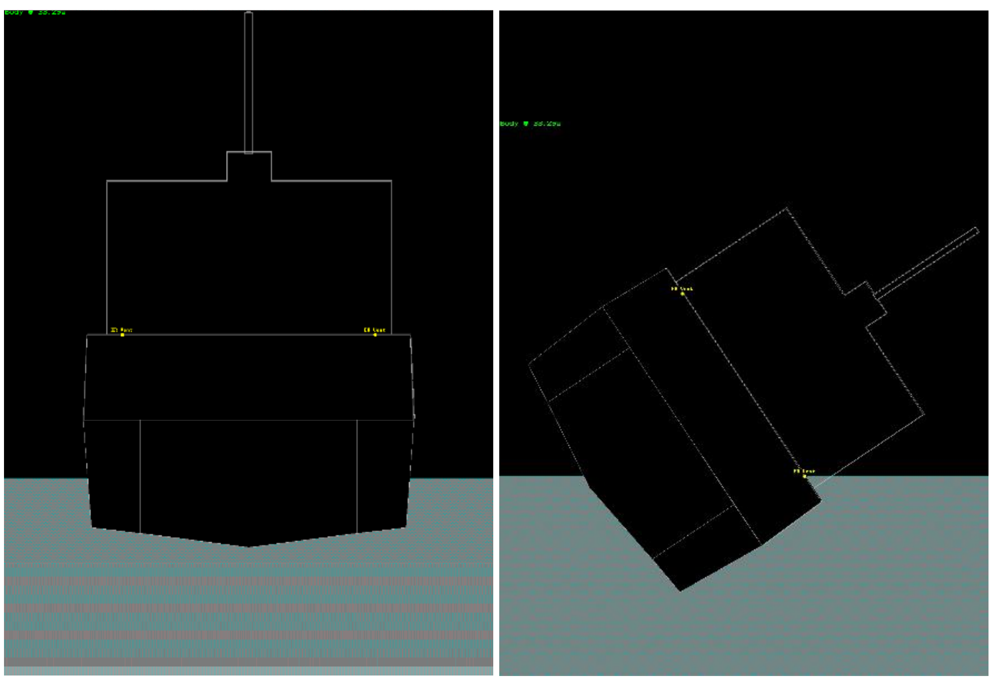
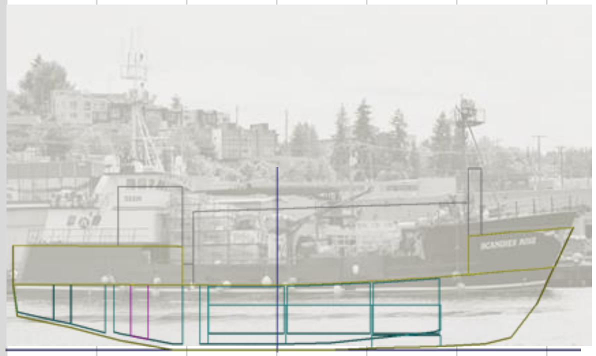
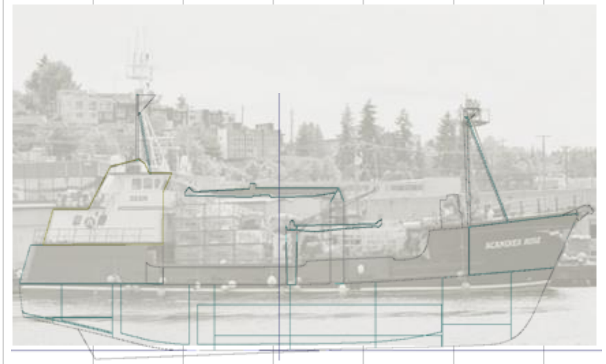


Figure 12: Downflooding points at light draft (8.5 feet) and associated angle of downflood (56°)

F/V SCANDIES ROSE Computer Model Comparison	**Reference A - Provided GHS Computer Hull Model**	**CG MSC GHS Computer Hull Model**
All Dispacement, Tank, and Profile: (Survey Photo - 6 June 2019)		
Displacement (Buoyant) Parts Only:		

Displacement (Buoyant) Parts:	*Ref. A Volume (cu.ft)*	*MSC Model Volume (cu.ft)*	*Difference with Ref. A %*
HULL.C	43743.2	43,643.30	-0.2%
FORECASTLE.C	3837.7	4,925.50	28.3%
POOP.C	10628.5	8,489.60	-20.1%
SKEG.C	0	79.9	100.0%
Total Displacement Volume	*58,209.4*	*57,138.3*	*-1.8%*

Table 11: Comparison of ref (a) and MSC's Hull Model Buoyancy with 2019 Profile Photo from ref (o)

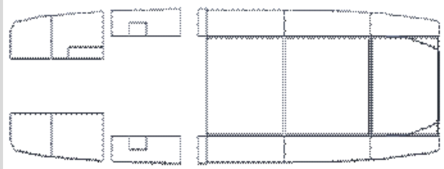
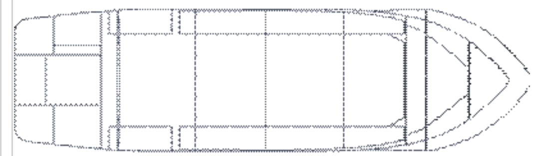
F/V SCANDIES ROSE Computer Model Comparison			**Reference A - Provided GHS Computer Hull Model**							**CG MSC GHS Computer Hull Model**						
Tanks Only (Compared with Capacity Plan Dated 10/19/2007)																
Tanks	*Capacity Plan Volume (cu.ft)*	*Capacity Plan Volume (gallons)*	*Ref. A Volume (cu.ft)*	*Ref. A Volume (gallons)*	*Difference with Capacity Plan %*	*Ref. A Per-meability*	*Ref. A Final Model Volume (cu.ft)*	*Ref. A Final Model Volume (gallons)*	*Permeable Volume Error to Capacity Plan %*	*MSC Model Volume (cu.ft)*	*MSC Model Volume (gallons)*	*Difference with Capacity Plan %*	*MSC Per-meability (set to match capacity plan)*	*MSC Final Model Volume (cu.ft)*	*MSC Final Model Volume (gallons)*	*Permeable Volume Error to Capacity Plan %*
HOLD1.C	3630.0	27154.3	3830.6	28654.9	-6%	0.985	3773.1	28225.1	-4%	4225.3	31607.4	-16%	0.859	3630.0	27154.3	0%
HOLD2.C	4195.0	31380.8	4464.8	33399.0	-6%	0.985	4397.8	32898.0	-5%	5006.3	37449.7	-19%	0.838	4195.0	31380.8	0%
HOLD3.C	3590.0	26855.1	3924.0	29353.6	-9%	0.985	3865.1	28913.3	-8%	4342.0	32480.4	-21%	0.827	3590.0	26855.1	0%
DBLBTM_F.C	427.8	3200.0	488.1	3651.2	-14%	0.985	480.8	3596.5	-12%	581.0	4346.2	-36%	0.736	427.8	3200.0	0%
DBLBTM_M.C	842.2	6300.0	*Tank not modeled*		100%		0.0	0.0	100%	1024.5	7663.8	-22%	0.822	842.2	6300.0	0%
DBLBTM_A.C	842.2	6300.0	*Tank not modeled*		100%		0.0	0.0	100%	1004.7	7515.7	-19%	0.838	842.2	6300.0	0%
FWDWING.S	1193.8	8930.0	384.8	2878.5	-2%	0.985	379.0	2835.3	-1%	420.8	3147.8	-5%	0.949	399.2	2986.1	0%
FWDWING.P	1193.8	8930.0	384.8	2878.5	-2%	0.985	379.0	2835.3	-1%	420.8	3147.8	-5%	0.949	399.2	2986.1	0%
MIDWING.S	**tank added from fwd*		835.4	6249.2	-2%	0.985	822.9	6155.5	-1%	837.6	6265.7	-5%	0.949	794.6	5943.9	0%
MIDWING.P	**tank added from fwd*		835.4	6249.2	-2%	0.985	822.9	6155.5	-1%	837.6	6265.7	-5%	0.949	794.6	5943.9	0%
AFTWING.S	769.5	5756.0	849.1	6351.7	-10%	0.985	836.4	6256.4	-9%	773.5	5786.2	-1%	0.995	769.5	5756.0	0%
AFTWING.P	769.5	5756.0	849.1	6351.7	-10%	0.985	836.4	6256.4	-9%	773.5	5786.2	-1%	0.995	769.5	5756.0	0%
AFTFUEL.S	987.9	7390.0	1013.0	7577.8	-3%	0.985	997.8	7464.1	-1%	1016.2	7601.7	-3%	0.972	987.9	7390.0	0%
AFTFUEL.P	699.1	5230.0	821.7	6146.7	-18%	0.985	809.4	6054.5	-16%	765.1	5723.3	-9%	0.914	699.1	5230.0	0%
DAYTANK.P	520.0	3890.0	500.0	3740.3	4%	0.985	492.5	3684.2	5%	529.6	3961.7	-2%	0.982	520.0	3890.0	0%
HYD_OIL.S	93.6	700.0	145.7	1089.9	-56%	0.985	143.5	1073.6	-53%	175.1	1309.8	-87%	0.534	93.6	700.0	0%
HYD_OIL.P	93.6	700.0	145.7	1089.9	-56%	0.985	143.5	1073.6	-53%	175.1	1309.8	-87%	0.534	93.6	700.0	0%
WATER.S	1019.3	7625.0	906.1	6778.1	11%	0.985	892.5	6676.4	12%	1028.7	7695.2	-1%	0.991	1019.3	7625.0	0%
WATER.P	1019.3	7625.0	906.1	6778.1	11%	0.985	892.5	6676.4	12%	1028.7	7695.2	-1%	0.991	1019.3	7625.0	0%
LUBE_OIL.P	160.4	1200.0	191.3	1431.0	-19%	0.985	188.4	1409.6	-17%	251.2	1879.1	-57%	0.639	160.4	1200.0	0%
SETTLING.C	406.4	3040.0	*Tank not modeled*		100%	0.985	0.0	0.0	100%	408.6	3056.5	-1%	0.995	406.4	3040.0	0%
SEWAGE.S	520.0	3890.0	500.0	3740.3	4%	0.985	492.5	3684.2	5%	529.6	3961.7	-2%	0.982	520.0	3890.0	0%
BULWARK.C										12530.3	93733.2		0.950	11903.8	89046.5	
FOREPEAK.C										635.6	4754.6		0.950	603.8	4516.9	
BALFWD.C										750.3	5612.6		0.950	712.8	5332.0	
BOWSTORE.C										3861.1	28883.0		0.950	3668.0	27438.9	
WORKSHOP.C										5278.7	39487.4		0.950	5014.8	37513.0	
PWAY.S										1401.6	10484.7		0.950	1331.5	9960.5	
PWAY.P										1401.6	10484.7		0.950	1331.5	9960.5	
ER.C										9396.0	70287.0		0.500	4698.0	35143.5	
BERTHING.C										8489.6	63506.6		0.950	8065.1	60331.3	

Table 12: Tank Capacity Comparison between ref (a) and MSC's Model

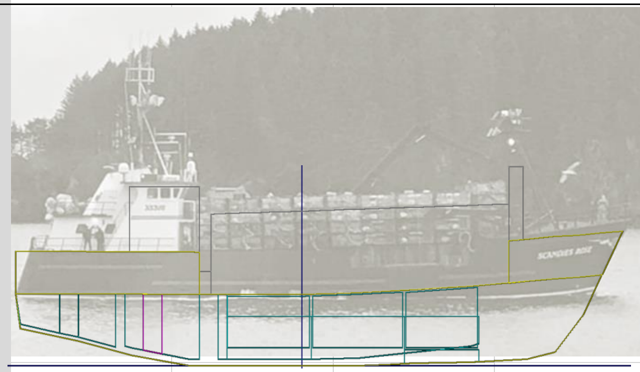
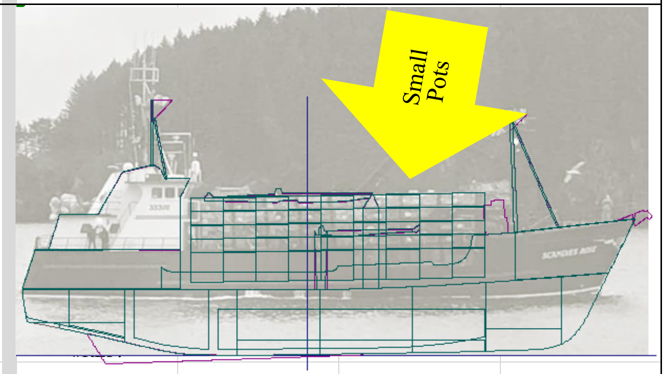
F/V SCANDIES ROSE Computer Model Comparison	**Reference A - Provided GHS Computer Hull Model**				**CG MSC GHS Computer Hull Model**			
Windage Surface Areas and Heeling Moments								
Windage Part	*Tiers of Pots*	*Average Height Above Waterline (feet)*	*Exposed Area (sq.feet)*	*Heeling Moment with 53 knot wind (foot-Long Tons)*	*Tiers of Pots*	*Average Height Above Waterline (feet)*	*Exposed Area (sq.feet)*	*Heeling Moment with 53 knot wind (foot-Long Tons)*
Hull Windage at 13.0' Draft	not noted	6.1	796.0	27.5	5	7.0	681.5	31.8
Superstructure Windage	not noted	11.0	1056.0	66.3	5	14.8	933.0	84.9
Crab Pot Windage	not noted	17.0	252.4	24.9	5	13.4	1211.2	100.2
Totals	not noted		2104.4	118.7	5		2825.6	216.9
Hull Windage at 13.0' Draft					4	7.0	681.5	31.8
Superstructure Windage					4	14.8	933.0	84.9
Crab Pot Windage					4	11.9	1005.1	74.5
Totals					4		2619.6	191.2
Hull Windage at 13.0' Draft					3	7.0	681.5	31.8
Superstructure Windage					3	14.8	933.0	84.9
Crab Pot Windage					3	10.2	816.7	52.6
Totals					3		2431.2	169.2

Table 13: Windage area comparison between ref (a) and MSC's Model with small pots overlaid on profile picture of SCANDIES ROSE (date unknown)

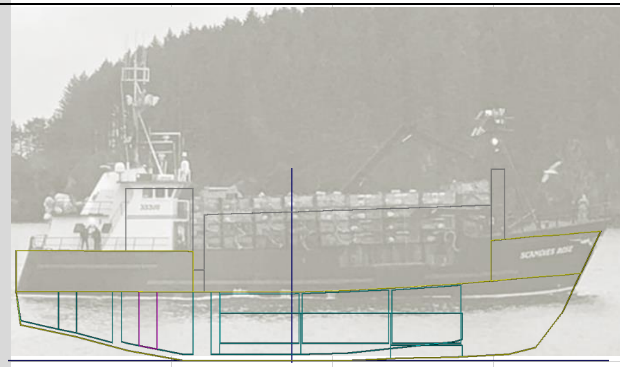
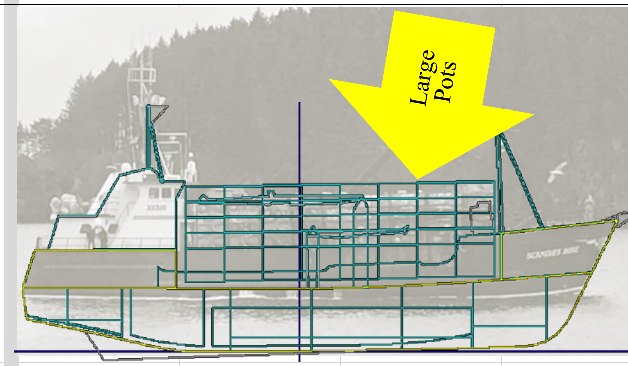
F/V SCANDIES ROSE Computer Model Comparison	**Reference A - Provided GHS Computer Hull Model**				**CG MSC GHS Computer Hull Model**			
Windage Surface Areas and Heeling Moments								
Windage Part	*Tiers of Pots*	*Average Height Above Waterline (feet)*	*Exposed Area (sq.feet)*	*Heeling Moment with 53 knot wind (foot-Long Tons)*	*Tiers of Pots*	*Average Height Above Waterline (feet)*	*Exposed Area (sq.feet)*	*Heeling Moment with 53 knot wind (foot-Long Tons)*
Hull Windage at 13.0' Draft	not noted	6.1	796.0	27.5	5	7.0	681.5	31.8
Superstructure Windage	not noted	11.0	1056.0	66.3	5	14.8	933.0	84.9
Crab Pot Windage	not noted	17.0	252.4	24.9	5	15.3	1477.2	138.9
Totals	not noted		2104.4	118.7	5		3091.6	255.5
Hull Windage at 13.0' Draft					4	7.0	681.5	31.8
Superstructure Windage					4	14.8	933.0	84.9
Crab Pot Windage					4	13.3	1244.3	102.4
Totals					4		2858.8	219.0
Hull Windage at 13.0' Draft					3	6.9	681.5	31.8
Superstructure Windage					3	14.8	933.0	84.9
Crab Pot Windage					3	13.3	994.4	71.5
Totals					3		2608.8	188.1

Table 14: Windage area comparison between ref (a) and MSC's Model with large pots overlaid on profile picture of SCANDIES ROSE (date unknown)

4.5. Hydrostatic Hull Modeling Conclusions

Sufficient drawings and recent photographs of SCANDIES ROSE were provided to allow detailed hull modeling and a high confidence in MSC's hydrostatic model. Buoyant volumes (Hull, Forecastle, Poop) are modeled with the highest confidence given the quality of the lines plan and verification using structural drawings. Superstructure and windage profiles are modeled with high confidence as well, with multiple photographs matching MSC's modeled profile. Icing surfaces are accurate to regulatory requirements of 46 CFR 28.550 with the assumption that only the outer surfaces of the crab pot stack are subject to surface icing.

Good correlation of buoyant volumes below the main deck was obtained between the owner's naval architect's model in reference (a) and MSC's model. Almost all other model areas have significant differences. Reference (a) differs from recent photographs. Many of the differences in reference (a) occur in the non-conservative direction, making the model portray a safer condition than reality: the poop buoyant volume is too large, windage areas are too small, icing loads are lower in magnitude and height, and tank capacities do not match SCANDIES ROSE documented tank capacities. Reference (a) neglects downflooding altogether, which drastically inflates the maximum heel angles at which the model predicts SCANDIES ROSE can survive without flooding.

5. SCANDIES ROSE STABILITY TESTS

An inclining test was required for SCANDIES ROSE by 46 CFR 28.535 due to substantial alterations of the vessel after 1991. As revealed by the 2019 inclining test, SCANDIES ROSE experienced the following changes, all defined as "substantial alterations" by 46 CFR 28.501 (c):

- An increase in the vertical center of gravity at lightweight by more than 2 inches (51 millimeters) compared to the original lightweight value.
- An increase or decrease of lightweight displacement by more than 3 percent of the original lightweight displacement.
- A shift of the longitudinal center of gravity of more than 1 percent of the vessel's length.

Federal regulations for the procedure and performance of inclining tests on uninspected fishing vessels are not strictly defined; 46 CFR 28.535 (d) states:

> *ASTM F 1321 (incorporated by reference, see §28.40), with the exception of Annexes A and B, may be used as guidance for any inclining test or deadweight survey conducted under this section.*

For the purpose of evaluating the accuracy of inclining tests performed on SCANDIES ROSE, this document will compare documented procedures with reference (b) to those prescribed in ASTM F 1321-92.

The purpose of an inclining test is to determine a vessel's light ship characteristics, specifically the empty vessel weight (light ship weight) and center of gravity. Inclining test results are dependent on the 3-D form of the vessel, and modern tests typically use computerized hull models to perform required calculations. Section 4 of this report describes discrepancies found with the computerized hull model of SCANDIES ROSE.

A complete inclining test consists of two distinct parts: a lightweight (or deadweight) survey and an inclining test. The terms "stability test" and "inclining test" are often used interchangeably; however, the lightweight survey is an integral and required part of an inclining test as outlined by ASTM F 1321-92.

The purpose of the lightweight survey is to identify the vessel's light ship weight and longitudinal center of gravity (LCG). This is achieved through the following generalized steps with quoted text from ASTM F 1321-92:

(1) "Survey the entire vessel to identify all items that need to be added to the vessel, removed from the vessel, or relocated on the vessel to bring the vessel to the light ship condition." This includes liquids in tanks while recommending "all tanks should be empty and clean or completely full." Specific accuracy requirements include tank soundings to the nearest 1/8 inch.

(2) "Take freeboard/draft readings to establish the position of the waterline to determine the displacement of the vessel at the time of the stability test. It is recommended that at least five freeboard readings, approximately equally spaced, be taken on each side of the vessel or that all draft marks (forward, midship, and aft) be read on each side of the vessel. Take draft mark readings to assist in determining the waterline defined by freeboard readings or to verify the vertical location of draft marks on vessels where their location has not been confirmed. The locations for each freeboard reading should be clearly marked. The longitudinal location along the vessel must be accurately determined and recorded since the (molded) depth at each point will be obtained from the vessel's lines. All freeboard measurements should include a reference note clarifying the inclusion of the coaming in the measurement and the coaming height." Specific accuracy requirements include freeboard measurements to the nearest 1/8 inch.

The purpose of the inclining test is to identify the vertical center of gravity (VCG). Transverse center of gravity (TCG) is also found during the inclining test, although this point is normally near the centerline of a vessel that is symmetric about its centerline. Determination of the VCG is achieved by moving weights a known transverse distance on the vessel and measuring the inclination of the vessel. "The standard test uses eight weight movements" according to ASTM F1321-92.

During the stability test, two conditions for the vessel are found:

- Condition 0 is the vessel weight, LCG, and VCG as found during the test (this includes weights that must be deducted or added such as inclining test weights)
- Condition 1 is the vessel weight, LCG, and VCG for the empty, but operationally complete vessel (the light ship condition)

Two documented stability tests were performed on SCANDIES ROSE as indicated by the documents within reference (b):

Date	Location	Naval Architect
1988 Aug 28	Duwamish Shipyard, Seattle, WA	Bruce Culver and R. Merrill
2019 April 12	Lake Union, Seattle, WA	Bruce Culver

Available documentation for both tests indicates that the tests do not conform to the ASTM F1321-91 standard and fail to provide a basis for the resulting lightweights and centers of gravity used in subsequent stability analysis in reference (b).

5.1. 1988 Stability Test

5.1.1. 1988 Lightweight Survey

Documentation provided within reference (b) for the 1988 lightweight survey (Figure 13) indicates that SCANDIES ROSE displacement at the time of the stability test was 690.49 long tons with an LCG of 11.24 feet aft of amidships. These values are normally based on the freeboard and draft measurements provided on page 2 of the stability test documentation, which are provided in Figure 14.

Items	Displacement and Weight (Tons)	C. G. Above Base		C. G. From M. P.			
		Lever	Vertical Moments (Ft.-tons)	Feet Aft	After Moments (Ft.-tons)	Feet For'd	Forward Moments (Ft.-tons)
Ship in Condition O	690.49	11.93	8237.55	11.24	7761.11		
Weight to complete	3.00	15.50	46.50			2.00	6.00
	693.49		8284.05		7755.11		
Foreign weight—to be deducted	208.14		1444.22		2542.02		
Ship in Condition I	485.35	14.09	6839.83	10.74	5213.09		

Figure 13: Notes within ref (b) Calculating the Light ship Weight Condition of SCANDIES ROSE from 1988

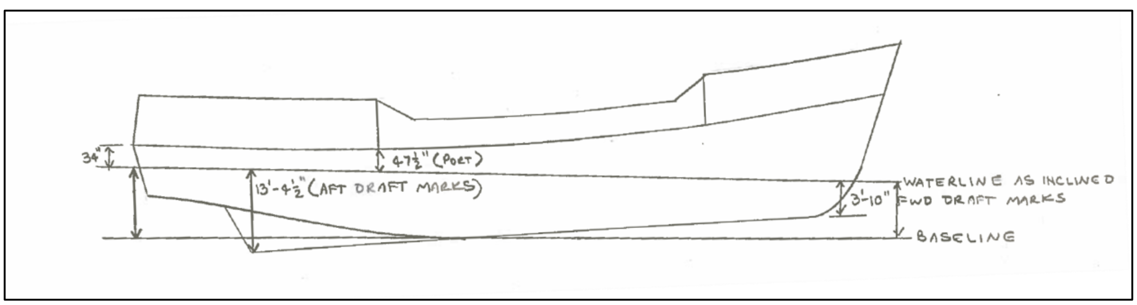


Figure 14: Notes within ref (b) Plotting the Location and Position of Lightweight Survey Freeboard and Draft Readings

Using the sketch in Figure 14, the following potential errors are noted when referencing ASTM F1321-92:

- Only two freeboards and two draft readings are noted. Five freeboard are recommended. (ASTM F1321-92 Section 7.1.2.1)
- The longitudinal location of readings is not noted, although some major reference features of the vessel can be inferred (i.e. Extreme aft, aft-most part of main deck, draft mark locations) (ASTM F1321-92 Section 7.1.2.1)
- Freeboards do not note the inclusion of coaming heights or deck thickness (ASTM F1321-92 Sections 7.1.2.1 and 7.1.2.8)
- It is not apparent whether freeboards were recorded on both sides of the vessel (ASTM F1321-92 Section 7.1.2.1)
- Although draft marks may be substituted for freeboards, the exact location of the mark should be verified in drydock (ASTM F1321-92 Section 7.1.2.6)
- Freeboard and draft readings do not appear to meet the recommended precision of 1/8 inch (ASTM F1321-92 Section 9.1)

No drawings are available showing draft mark locations on the hull. To reference these locations, a picture of the vessel was used (Figure 15, from ref (o)). Visible draft marks in the picture were referenced to the shear plan by matching this plan to the main deck line. Good correlation was found between the size of the marks (typically 6 inches tall, 6 inches between marks) as well as with the bottom of the skeg and bottom tangent line of the bow; however, the draft markings may have changed between the 1988 stability test and the time of the photograph.

Drafts are calculated by deducting the freeboard from the hull depth at the reading location using the hull model provided (ref (a)). Draft marks are converted to baseline drafts as shown in Table 15.

	Freeboard/ Draft Measurement 1	*Freeboard/ Draft Measurement 2*	*Freeboard/ Draft Measurement 3*	*Freeboard/ Draft Measurement 4*
Longitudinal Location (feet from amidships)	-61.500	-44.400	-36.000	56.000
Hull Depth at Location (ref (a), feet to baseline)	14.450	22.960	14.430	26.070
Deck Thickness (if noted)	0.000	0.000	0.000	0.000
Freeboard (From ref (b), feet from top of deck)	2.833		3.958	
Draft at Marks (feet)		13.375		3.833
Draft at Location (ref (a), feet to baseline)	11.617	11.167	10.472	5.173
Least Squared Fit Trendline	11.873	10.905	10.430	5.221
Error	0.257	-0.262	-0.042	0.047

Table 15: Drafts Calculated from Freeboards Using Depths from ref (a)

Figure 15: 2019 profile photograph from ref (o) with Lines Plan profile (ref (d)) and green draft marks overlaid to indicate MSC's assumed draft mark locations

ASTM F1321-92 recommends that the naval architect use an outboard profile drawing of the ship to plot the location and position of each freeboard and draft reading. The resultant line from the plot can then be used to identify the quality of the readings: the points should fall on a straight line for a ship that is not hogging or sagging. Good correlation with a straight line is found using these measurements with an R-squared value of 0.9948. Using the model provided as reference (a), the displacement for Condition 0 is calculated as 595.44 long tons with an LCG of 10.94 feet aft of amidships.

The computer hull model independently developed by MSC has slightly different main deck depths than reference (a). When using these depths to reduce freeboards to drafts, the R-squared value is 0.9951 (closeness of fit with a straight line). The displacement is calculated as 597.71 long tons with an LCG of 9.97 feet aft of amidships representing good correlation with reference (a).

No correction for deck thickness is noted in the freeboard measurements. Structural drawings note that deck plating is 5/16" thick, which represents an error in weight calculation of 1 long ton when applied to the freeboard readings to convert them to baseline drafts. This plate thickness error is considered negligible and is not addressed further.

The hydrostatics model provided as reference (a) does not match the waterplane shown in Figure 14 when the weights listed in Figure 13 are entered: the model provided by Mr. Culver cannot replicate the results of Mr. Culver's 1988 Lightship Calculations. A comparison of Table 6 (provided hydrostatics table using GHS version 6.44) and Table 7 (hydrostatics of the provided model using MSC's GHS version 17.30C) demonstrate through similarity that the software version is not a source of the discrepancy. It is therefore likely that a different hydrostatics model was used in 1988 and not the hydrostatics model provided as reference (a).

	Weight Magnitude (LT)	*Longitudinal Center of Gravity (Feet, Positive Aft)*	*Longitudinal (Trimming) Moment (Feet*LT)*
Calculations from 1988 Test Notes in ref (b), As Tested, Condition 0:	690.49	11.24	7761.11
ref (a) Calculation, As Tested, Condition 0:	595.44	10.94	6514.11
MSC Model Calculation, As Tested, Condition 0:	597.71	9.97	5959.17
Weight to Deduct from 1988 Test Notes in ref (b):	208.14	12.61	2624.52
Weight to Add from 1988 Test Notes in ref (b):	3.00	-2.00	-6.00
Calculations from 1988 Test Notes in ref (b), Light Ship, Condition 1:	485.35	14.09	5213.09
ref (a) Calculation, Light Ship, Condition 1:	390.30	9.95	3883.60
MSC Model Calculation, Light Ship, Condition 1:	392.57	8.47	3325.07

Table 16: Calculation of light ship weight (Condition 1) from 1988 stability test notes provided with ref (b)

The weights to remove and add to the tested condition (Condition 0) to calculate the light ship condition (Condition 1), cannot be verified from the information provided to MSC in reference (b). Using the weight magnitudes and locations as given, the results are calculated as shown in Table 17. Using reference (a), the as-tested (Condition 0) displacement is 95 Long Tons less than documented. This 95 LT weight discrepancy is carried forward from Condition 0 through the light ship weight calculation (Condition 1) contained in reference (b).

For the reasons noted previously, MSC considers its model and calculations of light ship characteristics to be more accurate than those determined in reference (a) and B, and thus used them in subsequent analysis. MSC's calculations match those completed with reference (a) within a 2% tolerance. MSC's calculated lightweight of 392.57 long tons and LCG of 8.47 feet aft of amidships was used in the stability analysis in this report.

5.1.2. 1988 Inclining Test

Calculation of the vertical center of gravity is dependent upon the calculation of vessel lightweight; noted errors in the weight calculation propagate into the vertical center of gravity calculation.

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WEIGHTS TO DEDUCT

Data for Tanks				ITEMS (Include list of tanks completely empty)	Weight	C. G. Above Base		C. G. From M. P.			
Liquid	Sound'g	Net Inertia of Free Surface	Inertia Feet³/Ton		Tons	Lever	Vertical Moments Ft.-tons	Feet Aft	After Moments Ft.-tons	Feet For'd	Forward Moments Ft.-tons
				FUEL - FWD DOUBLE BOTTOM	7.02	2.01	14.11			25.15	176.55
				FUEL - FWD WINGS P/S	24.98	5.98	149.38			25.19	629.25
				FUEL - MIDSHIPS WINGS P/S	42.46	5.69	241.60			7.86	333.74
				FUEL - AFT WINGS P/S	39.07	5.63	219.96	11.00	429.77		
				FUEL - AFT STORAGE TANK(S)	18.64	10.40	193.86	49.60	924.54		
		399.30	11.12	WATER (12750 GAL.)	47.47	8.50	403.49	33.00	1566.51		
				LUBE OIL	4.02	12.90	51.86	47.75	191.96		
				MISC. TOOLS & EQUIPMENT	.22	12.50	2.75	20.00	4.40		
				INCLINING WEIGHTS	2.07	16.70	34.57			1.00	2.07
				PERSONNEL	1.07	12.50	13.37	10.00	10.70		
		4436.46	105.63	FUEL - MIDSHIPS DOUBLE BOTTOM	5.20	.50	13.52			7.86	40.87
		3992.81	95.07	FUEL - AFT DOUBLE BOTTOM	4.68	.50	2.34	11.00	51.48		
		857.22	20.41	FUEL - AFT STORAGE TANK (P)	11.24	9.20	103.41	48.50	545.14		
			232.23		208.14	6.94	1444.22		3724.50		1182.48
									(1182.48)		
								12.21	2542.02		

Figure 16: Stability test notes (from ref (b)) calculating weights to add and remove with calculation error highlighted. The correct calculation is: $5.20\ LT\ x\ 0.50\ ft = 2.60\ LT * ft$

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SHIP AT TIME OF STABILITY TEST—CONDITION ●

Pendulums No.	Location	Length to Batten (Inches)
1st	INSIDE FOCSLE	84.5 A
2d	FWD OF DECKHOUSE	88.38 ~~87.75~~ AA
3d		

Inclining Weights

Location MIDSHIPS

Description STEEL DRUMS FILLED WITH CONCRETE

Weight No.	Tons	V.C.G.	Initial Position Port (Feet)	Initial Position Starboard (Feet)
1	.55			
2	.50			
3	.53			
4	.48			

Trial	Weight No.	Weight (Tons)	Distance From Initial Position Port (Feet)	Distance From Initial Position Starboard (Feet)	Moment (Ft.-tons)	Total Inclining Moment Port (Ft.-tons)	Total Inclining Moment Starboard (Ft.-tons)	Pendulum Deflections No.	Pendulum Deflections Port (Inches)	Pendulum Deflections Starboard (Inches)	Tangent Port	Tangent Starboard
1st trial	1	1240		16.85	7.72		14.62	1st		.250		.0030
	2	11.20	~~14.85~~	16.55	6.90			2d		.312		.0035
								3d				
2d trial	1	.55		14.04	7.72		28.92	1st		.593		.0070
	2	.50		13.79	6.90			2d		.610		.0069
	3	.53		14.46	7.66			3d				
	4	.48		13.83	6.64							
3d trial		—					0	1st				—
		—						2d				—
		—						3d				
4th trial	1	—	—		—			1st		.3125	.0037	
	2	—	—		—			2d		.295	.0033	
	3	.53	9.31		4.93	10.67		3d				
	4	.48	11.96		5.74							
5th trial	1	.55	8.96		4.93			1st		.469	.0055	
	2	.50	11.48		5.74			2d		.5625	.0063	
	3	.53	9.31		4.93	21.34		3d				
	4	.48	11.96		5.74							
6th trial								1st				
								2d				
								3d				
7th trial								1st				
								2d				
								3d				
8th trial								1st				
								2d				
								3d				

Figure 17: Stability test notes recording weight shifts and inclination angles from 1988 (ref (b))

Figure 17 documents the inclining test performed on SCANDIES ROSE in 1988. This inclining test does not conform to the following items recommended by ASTM F1321-92:

- Inclining used only 4 weight movements (6 off-centerline movements are recommended by ASTM F1321-92 Section 7.1.3.3)
- Maximum pendulum deflection is unacceptably low at a maximum of 0.5625 inches (6 inches is recommended by ASTM F1321-92 5.6.2)
- The inclining plot does not cross the origin as shown in Figure 18, and the pendulum deflection with zero weight shift should have been recorded twice (ASTM F1321-92 7.1.3.8). Figure 18 would have a point on the origin if the "3rd Trial" entry in Figure 17 was accurate. Lack of zero crossing indicates a potential error or steady heeling moment which could be verified if zero weight shift readings were obtained and plotted.

The slope of the plot provided in Figure 18 represents the ship's transverse metacentric height, GM, multiplied by the total weight of the vessel (this product is referred to as "GMTM") and this is how the vertical center of gravity is calculated. A slope of 3866.55 foot·tons is noted in Figure 18.

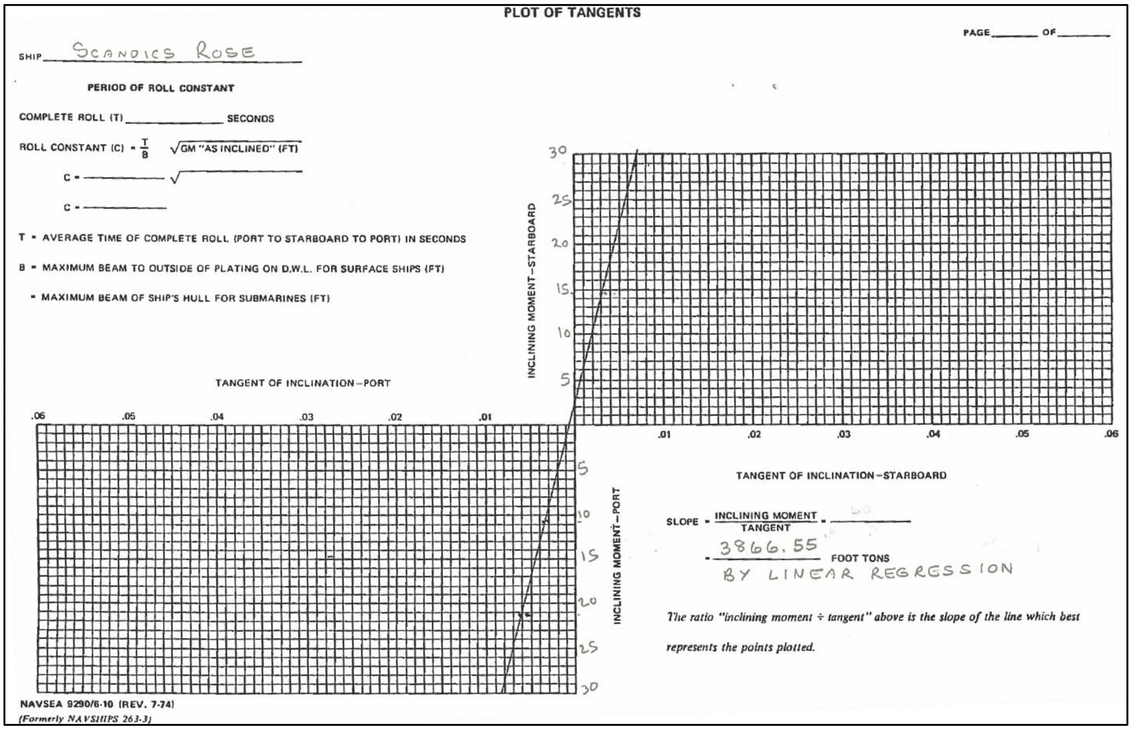

Figure 18: Stability test notes plotting heeling moments and tangents of inclining from 1988 notes in ref (b)

Using the data from Figure 17, MSC independently plotted and calculated the slope by least-squared linear regression. If the measurement for "Trial 3" is correct, the slope is 3856.49 foot·tons. If the measurement provided for "Trial 3" is erroneous (as indicated by omission of it in Figure 18), the slope is calculated as 3844.66 foot·tons by MSC.

Table 17 indicates that the vertical center of gravity ranges from a minimum, or most favorable value, of 14.09 feet (as used by the stability analysis provided in ref (b)) to a maximum of 15.08 feet. MSC considers the most accurate value to be MSC's calculated value without using the "Trial 3" point; future stability analysis in this report is based on this assumed vertical center of gravity of 14.63 feet.

Weight Source	*Condition 0 Weight (LT)*	*GMTM Source*	*GMTM (ft*LT)*	*GM (feet)*	*Formal Free Surface Corr. (feet)*	*Condition 0 KM (from model, feet)*	*Condition 0 VCG (feet)*	*Condition 0 Vert. Moment (ft*LT)*	*Sum of Weight to Add/ Remove*	*Moment of Wt. to Add/ Remove (ft*LT)*	*Light Weight (LT)*	*Light Weight VCG (feet)*
ref (b) Calculation	690.49	MSC[a]	3856.49	5.59	0.34	17.94	12.01	8296.13	-205.14	1386.80	485.35	14.24
ref (b) Calculation	690.49	MSC[b]	3844.66	5.57	0.34	17.94	12.03	8307.96	-205.14	1386.80	485.35	14.26
ref (b) Calculation	690.49	ref (b)	3866.55	5.60	0.34	17.94	12.00	8286.07	-205.14	1386.80	485.35	14.22
ref (b) Calculation (as recorded)	690.49	ref (b)	3866.55	5.60	0.34	17.87[c]	11.93	8237.55	-205.14	1397.72[d]	485.35	14.09
ref (a) Model	595.44	MSC[a]	3856.49	6.48	0.34	19.01	12.19	7260.37	-205.14	-1386.80	390.3	15.05
ref (a) Model	595.44	MSC[b]	3844.66	6.46	0.34	19.01	12.21	7272.20	-205.14	-1386.80	390.3	15.08
ref (a) Model	595.44	ref (b)	3866.55	6.49	0.34	19.01	12.18	7250.31	-205.14	-1386.80	390.3	15.02
MSC Model	597.71	MSC[a]	3856.49	6.45	0.34	18.70	11.91	7117.47	-205.14	-1386.80	392.57	14.60
MSC Model	597.71	MSC[b]	3844.66	6.43	0.34	18.70	11.93	7129.30	-205.14	-1386.80	392.57	14.63
MSC Model	597.71	ref (b)	3866.55	6.47	0.34	18.70	11.89	7107.41	-205.14	-1386.80	392.57	14.57

Note (a) MSC calculated GMTM including "trial 3" zero weight movement point
Note (b) MSC calculated GMTM not including "trial 3" zero weight movement point
Note (c) KM is given in ref (b) notes, not from Model
Note (d) Moment includes mathematical error in calculation shown in Figure 16

Table 17: Variability in Vertical Center of Gravity (VCG) Calculations with Lightweights and Incline Plot

5.1.3. 1988 Stability Test Results

USCG review of stability test procedures and results for SCANDIES ROSE was not required in 1988. The stability test procedure performed and results obtained do not conform to ASTM F1321-92 as recommended by 46 CFR Subpart 28.535. Calculation errors resulted in a large lightweight discrepancy (95LT) and a significant vertical center of gravity discrepancy (0.54 feet) between SCANDIES ROSE's naval architect's values and MSC's results.

Although the calculations contain discrepancies, the test was sufficiently documented and formed the basis for MSC's independent analysis, which used the data from the notes to obtain the following light ship characteristics:

Lightweight	392.57	Long Tons
Vertical Center of Gravity	14.63	Feet above Baseline
Longitudinal Center of Gravity	7.41	Feet Aft of Amidships

Table 18: MSC Calculated Light ship Characteristics from 1988 Stability Test Notes

MSC's level of confidence in its calculated values of light ship parameters is limited by the following:

- Insufficient of heel angle obtained during the inclining test (and insufficient of pendulum deflection)
- Too few weight movements during inclining test
- Limited number of freeboard and draft readings and lack of verification on both sides
- Confidence in accuracy of liquid load and weights to add and deduct

5.2. 2019 Stability Test

5.2.1. 2019 Lightweight Survey

The results of the 2019 lightweight survey are not explicitly provided as stability test notes or results despite these items being recommended by ASTM F1321-92 Section 8. However, the light ship weight and centers of gravity are documented in stability analysis files provided in reference (b) as shown in Figure 19.

To validate the light ship weight from freeboard and draft readings, limited additional information is provided on several sheets within reference (b) as shown in Figure 20 and Figure 21.

```
19-05-13 03:20:08                                                        Page 8
GHS 6.44                           SCANDIES ROSE
CONDITION 1 DEPARTURE, MAXIMUM CONSUMABLES, 208 POTS

                         WEIGHT and DISPLACEMENT STATUS
 Baseline draft: 13.114 @ Origin,  Trim: Fwd 0.34 deg.,  Heel: Port 1.31 deg.

 Part------------------------------Weight(LT)----LCG-----TCG-----VCG
 LIGHT SHIP                            548.32     3.30a   0.00    14.69
 Crew & Effects                          1.00     5.00a   0.00    18.00
 Stores                                  1.50    15.00a   0.00    16.00
 1st tier 88 pots                       32.80     8.50f   0.00    18.75
 2nd tier 40 pots                       14.91     8.50f   0.00    23.67
 3rd tier 40 pots                       14.91     8.50f   0.00    26.50
 4th tier 40 pots                       14.91     8.50f   0.00    29.33
 Ice on Hull                            16.08     3.89f   0.00    21.37
   Total Fixed--------->               644.43     1.73a   0.00    15.89
```

Figure 19: 2019 stability analysis (provided within ref (b)) noting the light ship weight and centers of gravity, dated 13-May-2019

3000 Settling Tank
3000 Day Tank
2000 StB Fresh Watter
2000 Port Freshwatter
~~4195 CF~~

Figure 20: Ref (b) notes with apparent weights to deduct. Undated but assumed to be relevant to the 2019 stability test.

Using the notes in Figure 19 and Figure 20, the "weight to deduct" is calculated so that the weight and longitudinal center of gravity can be calculated in the as-tested condition (Condition 0).

The total weight to deduct from Table 19 and the light ship weight used in Figure 19 were used by MSC to calculate the weight and LCG of SCANDIES ROSE during the 2019 stability test because this was not provided in reference (b). The as-tested (Condition 0) weight was assumed to be 587.73 Long Tons with an LCG of 2.96 feet aft of amidships.

Several disparate freeboard and draft measurements are provided in reference (b) as shown in Table 20. Using reference (a), these measurement sets provide a range of weights for the vessel as tested (Condition 0) from 606.52 LT to 611.47 LT. It is not known which freeboards were actually measured during the lightweight survey performed at the time of the stability test in 2019. MSC assumed that the freeboards within the larger list of depths, freeboards, and drafts at the top of Figure 21 represent data as measured during the lightweight survey because these measurements do not result in a perfectly straight waterline plot—indicative of rough data as measured in the field. However, observed erasures and lack of context for the values in Figure 21 decrease confidence in these values.

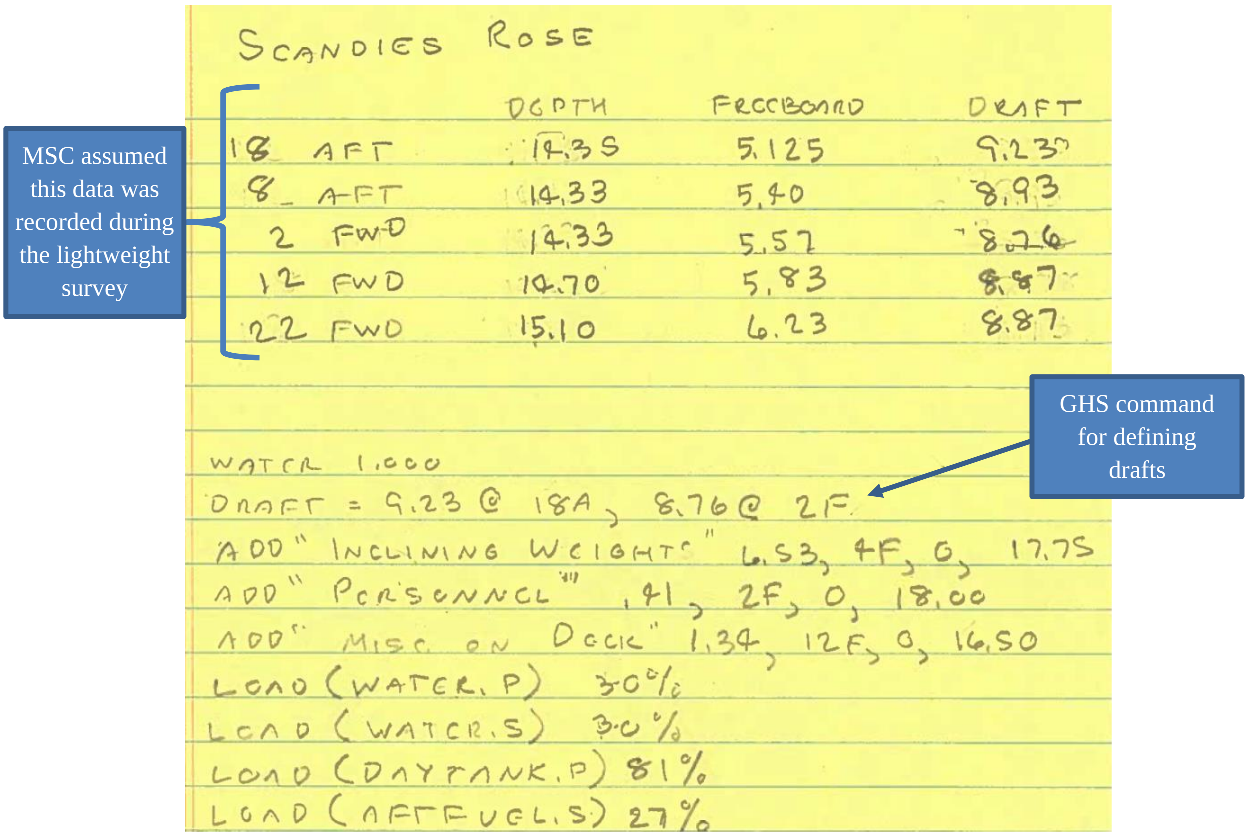

Figure 21: ref (b) notes with apparent draft and freeboard readings and weights to deduct. Weights to deduct mostly correspond to those in Figure 20 (see Table 19). Undated but assumed to be relevant to the 2019 stability test.

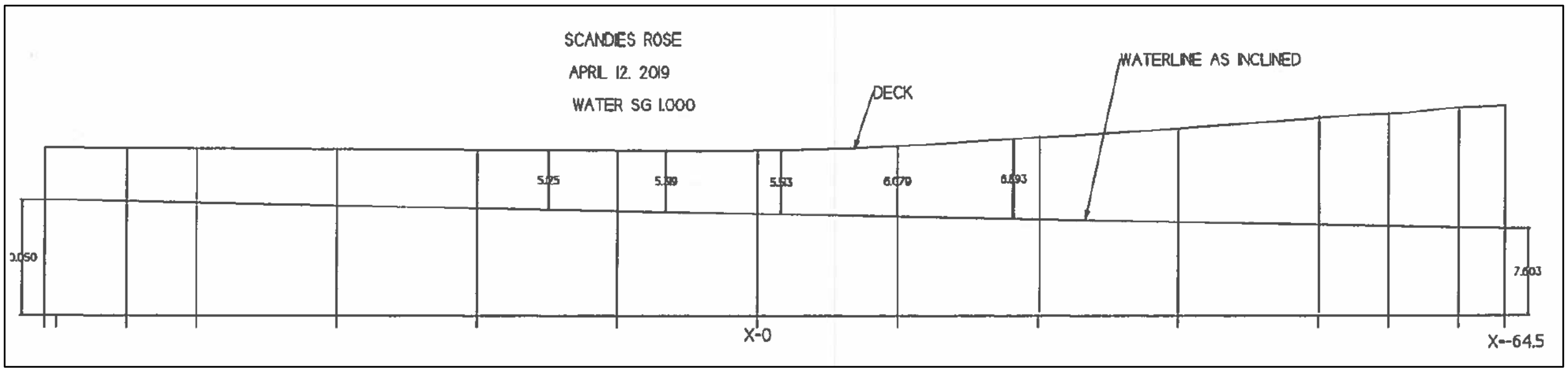

Figure 22: ref (b) notes plotting the location and position of lightweight survey freeboard and draft readings on SCANDIES ROSE dated 12-Apr-2019

Item			*Weight (LT)*	*LCG (feet)*
Inclining Weights			6.53	4.00f
Personnel			0.41	2.00f
Misc. on Deck Weights			1.34	12.00f
WATER.P Tank	30% Capacity	2000 gal	7.46	28.45a
WATER.S Tank	30% Capacity	2000 gal	7.46	28.45a
DAYTANK.P Tank	81% Capacity	3000 gal	9.67	56.08a
AFTFUEL.S Tank	27% Capacity*	2000 gal*	6.53	44.78a
Total Weight to Deduct			**39.40**	**30.87a**
** Note: 27% capacity in the Starboard Aft Fuel Tank is equivalent to 2,000 gallons/6.53 LT of diesel as noted by ref (n), which indicates the aft fuel tank capacity is 7,390 gallons. ref (b) indicates 27% and 3,000 gallons are loaded in this tank. 3,000 gallons would be equivalent to 41% of capacity with 9.80 LT of diesel according to the Capacity Plan, Ref N.*				

Table 19: Weights to Deduct from ref (b) 2019 Stability Test Notes

Light ship is determined by applying the weight to deduct to the as-tested (Condition 0) weight of the vessel as shown in Table 22. Using the freeboard measurement sets in reference (b), light ship weight ranges from 567.12 LT to 572.07. However, reference (b) indicates 548.32 LT was used in stability calculations shown in Figure 19. This light ship weight is between 18.80 LT to 23.75 LT less than calculated during the stability test and approximately 150 LT heavier than the light ship weight in 1988.

In addition to using a light ship weight that is not supported by the stability test measurements, documentation within reference (b) indicate the following items that do not conform to recommended stability test procedures:

- SCANDIES ROSE had excessive trim (>2 feet) during the lightweight survey and was not “as close as possible to even list and design trim” as recommended (ASTM F1321-92 section 5.4)
- Five freeboards were apparently recorded (Figure 21) but not on each side as recommended (ASTM F1321-92 section 7.1.2.1)
- Draft marks were apparently not taken, although extreme baseline drafts are shown in Figure 22 (ASTM F1321-92 section 7.1.2.1)
- A survey of the vessel to “identify all items that need to be added to the vessel, removed from the vessel, or relocated on the vessel” was apparently not complete as indicated by Figure 23 (ASTM F1321-92 section 7.1.1.4)
- Freeboards do not note the inclusion of coaming heights or deck thickness (ASTM F1321-92 sections 7.1.2.1 and 7.1.2.8)
- No report, data sheets, or calculations are provided (ASTM F1321-92 sections 8.1 through 8.3)

A lightweight of 578.33 long tons with an LCG of 0.52 feet aft of amidships is calculated as item (d) of Table 22. These values are calculated using MSC’s model from the freeboards listed in Figure 21; this list of depths, freeboards, and calculated drafts is the typical way that raw data is recorded during a lightweight survey and these values are the most supported within the stability test notes. However, this light ship weight is 183 long tons (46%) heavier than that found in 1988. Possible sources of this discrepancy include errors in freeboard readings or weights to deduct.

A letter to Mr. Mattesen within reference (b) acknowledges the heavier than expected lightweight after the stability test (Figure 23). This letter cites several possible discrepancies including missing weights, weight growth, and tankage.

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May 17, 2019
Dan Mattesen
1517 Perry Avenue
Bremerton, Washington 98310

Enclosed are two copies of the stability book for the Scandies Rose. It can carry pots up to the pilothouse windows as discussed without much difficulty. The light ship weight was a bit heavier than I expected – there may have been something in the holds that we missed, or it may have gained some weight over the years. The tankage is a little different between this boat and the Patricia Lee, and some things may be done differently than when I first did this. If you see anything that should be changed let me know and I'll revise it at no charge.

Sincerely,

Bruce A. Culver, P.E.

Figure 23: Letter from Mr. Culver to Dan Mattesen dated 17 May 2019 (found within ref (b)), indicating that unknown weight may have been onboard during the stability test

Longitudinal Location (feet from amidships) →		61.5a	18a	8a	2f	12f	22f	64.5f	Calculated Displacement and LCG using ref (a) GHS Model		
Source ↓	Reading										
(a) ref (b) List of Depths, Freeboard, Drafts (Top of Figure 21)	Freeboard		5.125	5.400	5.570	5.830	6.230		Displacement:	611.47	LT
	Draft		9.225	8.930	8.760	8.870	8.870		LCG:	2.78	ft aft MS
	Error		-0.140	0.078	0.171	-0.016	-0.093		Least-squared fit, R^2:	0.4816	
(b) ref (b) GHS Command for Defining Drafts (Line 10 of Figure 21)	Freeboard								Displacement:	606.52	LT
	Draft		9.230		8.760				LCG:	5.51	ft aft MS
	Error		0.000		0.000				Least-squared fit, R^2:	N/A	
(c) ref (b) Plotted Data (Figure 22)	Freeboard		5.125	5.319	5.513	6.079	6.693		Displacement:	608.99	LT
	Draft	10.050	9.225	9.011	8.817	8.621	8.407	7.603	Longitudinal Center of Gravity:	4.52	ft aft MS
	Error	0.006	-0.018	0.001	-0.001	0.000	0.019	-0.006	Least-squared fit, R^2:	0.9998	

Cell Shading Represents Data Provided in ref (b), all others calculated by MSC

Table 20: Disparate freeboard and draft measurements from 2019 stability test using ref (a) GHS model to calculate values

Longitudinal Location (feet from amidships) →		61.5a	18a	8a	2f	12f	22f	64.5f	Calculated Displacement and LCG using MSC's GHS Model		
Source ↓	Reading										
(d) ref (b) List of Depths, Freeboard, Drafts (Top of Figure 21). Drafts Calculated from MSC Model	Freeboard		5.125	5.400	5.570	5.830	6.230		Displacement:	617.73	LT
	Draft		9.275	8.970	8.800	8.760	8.780		LCG:	2.43	ft aft MS
	Error		-0.118	0.067	0.117	0.037	-0.103		Least-squared fit, R^2:	0.7656	
(e) ref (b) Plotted Data (Figure 22). Drafts Calculated from MSC Model	Freeboard		5.125	5.319	5.513	6.079	6.693		Displacement:	612.38	LT
	Draft	10.050	9.275	9.051	8.857	8.511	8.317	7.603	LCG:	3.59	ft aft MS
	Error	0.026	-0.069	-0.045	-0.051	0.095	0.089	-0.047	Least-squared fit, R^2:	0.9919	

Cell Shading Represents Data Provided in ref (b), All Others Calculated by MSC

Table 21: Disparate freeboard and draft measurements from 2019 stability test using MSC's model to calculate values

	Calculation Source	*Weight Magnitude (LT)*	*Longitudinal Center of Gravity (Feet, Positive Aft)*	*Longitudinal (Trimming) Moment (Feet*LT)*
Condition 0 (Weight as Tested)	(a) ref (b) List of Depths, Freeboard, Drafts (Top of Figure 21), Using ref (a)	611.47	2.78	1699.89
	(b) ref (b) GHS Command for Defining Drafts (Line 10 of Figure 21), Using ref (a)	606.52	5.51	3341.93
	(c) ref (b) Plotted Data (Figure 22), Using ref (a)	608.99	4.52	2752.63
	(d) ref (b) of Depths, Freeboard, Drafts (Top of Figure 21). Drafts Calculated from MSC Model	617.73	2.43	1501.08
	(e) ref (b) Plotted Data (Figure 22). Drafts Calculated from MSC Model	612.38	3.59	2198.44
	Weight to Deduct from 2019 Test Notes (Table 19):	39.40	30.87	1216.161
	Weight to Add from 2019 Test Notes:	0	0	0
Condition 1 (Light Ship Weight)	(a) ref (b) List of Depths, Freeboard, Drafts (Top of Figure 21), Using ref (a)	572.07	0.85	483.73
	(b) ref (b) GHS Command for Defining Drafts (Line 10 of Figure 21), Using ref (a)	567.12	3.75	2125.76
	(c) ref (b) Plotted Data (Figure 22), Using ref (a)	569.59	2.70	1536.47
	(d) ref (b) List of Depths, Freeboard, Drafts (Top of Figure 21). Drafts Calculated from MSC Model	578.33	0.52	300.73
	(e) ref (b) Plotted Data (Figure 22). Drafts Calculated from MSC Model	572.98	1.74	996.99
	Weight Actually Used in ref (b) Calculations (Figure 19), Not Supported by Test Notes	548.32	3.30	1809.46

Table 22: Calculation of light ship weight (Condition 1) from 2019 Stability Test Notes

5.2.2. 2019 Inclining Test

Calculation of the vertical center of gravity from an inclining test is dependent upon the calculation of vessel lightweight; errors in the weight calculation propagate into the vertical center of gravity calculation.

Figure 24 documents the inclining test performed on SCANDIES ROSE in 2019. This inclining test does not conform to the following items recommended by ASTM F1321-92:

- Maximum pendulum deflection is low at a maximum of 5.43 inches (6 inches is recommended by ASTM F1321-92 section 5.6.2)
- The plot of points contained in Figure 24 would not cross the origin as shown in Figure 25 and does not appear to be a "best fit" through the points. The pendulum deflection with zero weight shift should have been recorded twice (ASTM F1321-92 section 7.1.3.8). Figure 25 would have a point on the origin if the "4th Trial" entry in Figure 24 was accurate. Lack of zero crossing indicates a potential error or steady heeling moment which could be verified if zero weight shift readings were obtained and plotted.

STABILITY TEST DATA

VESSEL Scandies Rose DATE Apr. 12, 2019 LOCATION Seattle - Lake Union

		WEIGHT	DISTANCE MOVED		MOMENT	TOTAL MOMENT	PENDULUM DEFLECTION		TANGENT	
			PORT	STBD			PORT	STBD	PORT	STBD
1ST TRIAL	1	6.53		5.98	39.04	39.04 S		2.01		.0193
	2							1.93		.0185
	3							1.38		.0175
2ND TRIAL	1	6.53		10.46	68.29	68.29 S		3.30		.0318
	2							3.30		.0316
	3							2.36		.0300
3RD TRIAL	1	6.53		13.96	91.15	91.15 S		4.53		.0435
	2							4.41		.0422
	3							3.15		.0401
4TH TRIAL	1	6.53		–	–	0		–		–
	2							–		–
	3							–		–
5TH TRIAL	1	6.53	7.83		51.15	51.15 P	2.56		.0246	
	2						2.72		.0260	
	3						1.77		.0225	
6TH TRIAL	1	6.53	12.37		80.81	80.81 P	4.45		.0428	
	2						4.65		.0445	
	3						3.43		.0437	
7TH TRIAL	1	6.53	14.92		97.42	97.42 P	5.35		.0515	
	2						5.43		.0520	
	3						3.42		.0436	

PENDULUM #1 104"
PENDULUM #2 104 1/2"
PENDULUM #3 78 1/2"

WEIGHT #1 14620# (6.53 TONS)
WEIGHT #2
WEIGHT #3
WEIGHT #4
WEIGHT #5

Figure 24: 2019 test notes recording weight shifts and inclination angles (from ref (b))

The slope of the plot provided in Figure 25 represents the ship's transverse GM multiplied by the total weight of the vessel (this product is referred to as "GMTM") and this is how the vertical center of gravity is calculated. A slope of 2067 foot·tons is indicated in Figure 25.

Using the data from Figure 24, MSC independently plotted and calculated the slope by least-squared linear regression. If the measurement for "Trial 4" is correct, the slope is 2042.4 foot·tons. If the measurement provided for "Trial 4" is erroneous (as indicated by the lack of recorded pendulum readings in Figure 24), the slope is calculated as 2043.4 foot·tons by MSC. These GMTM results are close in value and the latter calculated value of 2043.4 foot·tons is considered most accurate.

Table 23 shows the method for calculating lightweight VCG. There is no documentation within available test notes in reference (b) to support the values used in stability analysis to generate reference (c). Table 23 indicates that the vertical center of gravity ranges from a minimum or most favorable of 14.69 feet (as used in the ref (b) stability analysis) to a maximum of 15.62 feet (the most accurate value supported by test notes and the MSC computer model).

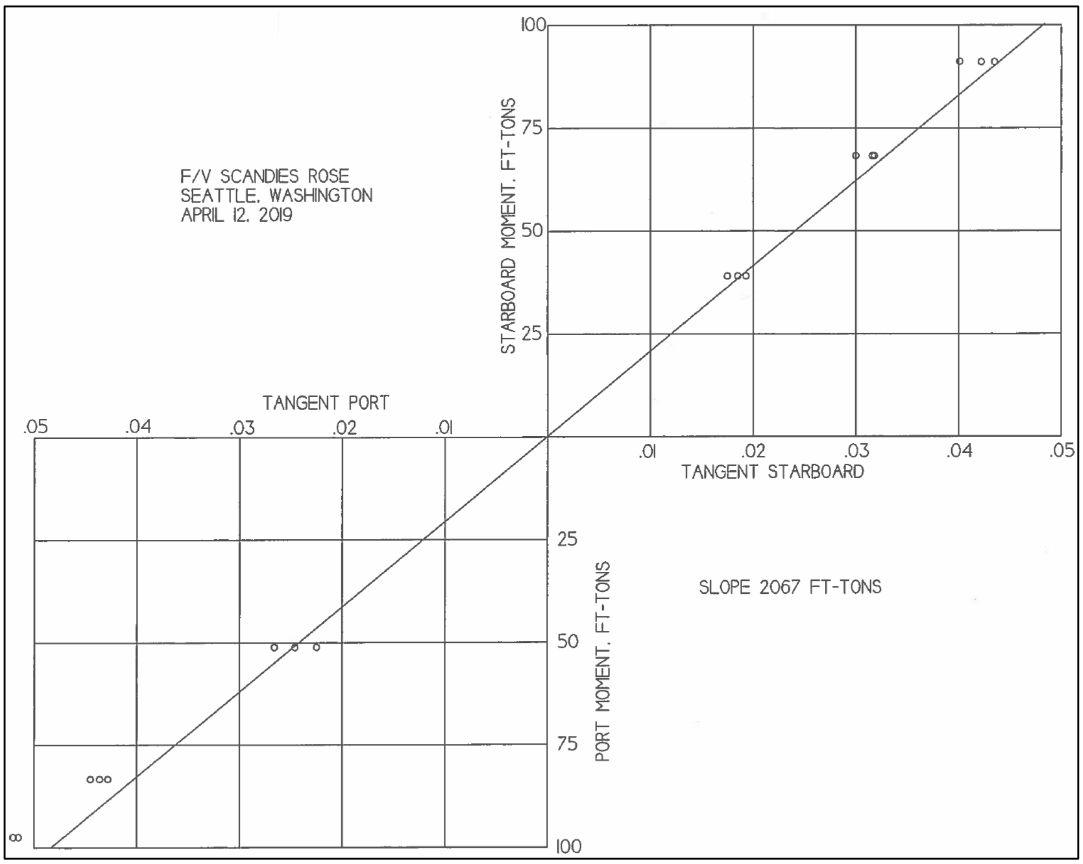

Figure 25: Stability test notes plotting heeling moments and tangents of inclining from 2019 (ref (b))

Weight Source	*Condition 0 Weight (LT)*	*GMTM Source*	*GMTM (ft*LT)*	*GM (feet)*	*Formal Free Surface Corr. (feet)*	*Condition 0 KM (from model, feet)*	*Condition 0 VCG (feet)*	*Condition 0 Vert. Moment (ft*LT)*	*Sum of Weight to Add/ Remove (LT)*	*Moment of Wt. to Add/ Remove (ft*LT)*	*Light Weight (LT)*	*Light Weight VCG (feet)*
Item (a) from Table 20	611.47	ref (b)	2067	3.38	0.068	18.61	15.16	9270.86	-39.40	-359.53	572.07	15.58
Item (d) from Table 21	617.73	ref (b)	2067	3.35	0.067	18.24	14.83	9158.80	-39.40	-359.53	578.33	15.21
Item (a) from Table 20	611.47	MSC	2043.4	3.34	0.068	18.61	15.20	9294.46	-39.40	-359.53	572.07	15.62
Item (d) from Table 21	617.73	MSC	2043.4	3.31	0.067	18.24	14.86	9182.40	-39.40	-359.53	578.33	15.26
ref (b) 2019 Loading Conditions	?	?	?	?	?	?	?	?	?	?	548.32	14.69

Table 23: Variability in vertical center of gravity (VCG) calculations with lightweights and incline plots

5.2.3. 2019 Stability Test Results

Although an inclining test was required after substantial alterations between 1988 and 2019, USCG review of stability test procedures and results for SCANDIES ROSE was not required. Documentation within reference (b) indicates that the stability test procedure performed did not conform with ASTM F1321-92, as recommended by 46 CFR Subpart 28.535. Available documentation within reference (b) appears to use a lightweight and center of gravity that are not supported by the stability test performed in 2019.

The stability test in 2019 was not well documented, and MSC's independent analysis attempted to use the best available information to calculate the following approximate light ship characteristics:

Lightweight	578.33	Long Tons
Vertical Center of Gravity	15.26	Feet above Baseline
Longitudinal Center of Gravity	0.52	Feet Aft of Amidships

Table 24: MSC calculated light ship characteristics from 2019 stability test notes

MSC has a low level of confidence in the light ship weight characteristics in Table 24. MSC's level of confidence in these values is limited by the following:

- Lack of confidence in weights to deduct during the stability test (this concern is shared in the letter provided as Figure 23)
- Spacing of freeboard measurements along the hull and apparent lack of verification on both sides
- Potential errors in measurement or recording of freeboard values
- Excessive additional light ship weight of vessel as compared to 1988 stability test results (45% higher).

Of the above items, the excessive weight growth from 1988 is the most concerning. Figure 23 notes that there may have been additional weight in the holds that was unaccounted for during the deadweight survey. Using the light ship weight and centers of gravity from 2019 and 1988, MSC calculated the hypothetical amount of weight and average location of this additional weight in Table 25.

Change in Lightweight	180.09	Long Tons
VCG of Changed Weight	16.65	Feet above Baseline
LCG of Changed Weight	14.72	Feet Fwd. of Amidships

Table 25: MSC calculated weight change and centers of gravity from 1988 to 2019

The average center of gravity of the additional weight corresponds to a longitudinal location near the port side crane pedestal and vertical location near the deck level. This weight and center of gravity could be achieved in many different ways including (but not limited to) structural changes to the hull (possibly the additional height added to the forecastle or crane modifications) and loaded tanks or holds not discovered during the deadweight survey as noted in Figure 23. The apparent change in weight and center of gravity may also indicate erroneous measurements in either the lightweight survey or inclining.

5.3. Stability Test Conclusions

Significant errors exist in both the 1988 and 2019 lightweight surveys as part of their respective stability tests. These surveys provide the light ship weight and longitudinal center of gravity of the vessel. Reference (b) does not contain information from either the 1988 or 2019 test data that supports the light ship weights used in the stability calculations conducted by the owner's naval architect. MSC's low confidence in the 2019 lightweight survey carries forward though the inclining test and results in overall low confidence in the stability test results.

	Lightweight (Long Tons)	*LCG (Ft. Aft of Amidships)*	*VCG (Ft. Abv Baseline)*	*Notes*
1988 Values Used in ref (b) Calculations	485.35	10.74	14.09	Not Supported by Test Notes
1988 Values from MSC Review of Test Notes	392.57	7.41	14.63	Moderate Confidence
2019 Values Used in ref (b) Calculations	548.32	3.30	14.69	Not Supported by Test Notes
2019 Values from MSC Review of Test Notes	578.33	0.52	15.26	Low Confidence

Table 26: Results of 1988 and 2019 Stability Tests

6. SCANDIES ROSE STABILITY CRITERIA

SCANDIES ROSE was required to meet 46 CFR Part 28 Subpart E, Stability Requirements for Commercial Fishing Industry Vessels which include the following operational stability criteria:

- 46 CFR 28.530: Stability Instructions
- 46 CFR 28.565: Water on Deck
- 46 CFR 28.570: Intact Righting Energy
- 46 CFR 170.173(c): Alternate Intact Criteria (per 46 CFR 28.570(c))
- 46 CFR 28.575: Severe Wind and Roll

Loading conditions for SCANDIES ROSE are documented within the 1988 and 2019 Stability Instructions and Stability Books (ref (b) and (c)). Two additional loading conditions were provided to MSC by the Marine Board of Investigation—these conditions are estimates of the loading condition during the casualty voyage.

Items from Sections 4 and 5 of this report (hydrostatic modeling and stability tests) provide the required information and means by which to evaluate stability criteria for each loading condition. Errors in the hydrostatic model and stability test results propagate into the evaluation of stability criteria.

6.1. Stability Instructions Provided by Mr. Culver

46 CFR 28.530 requires that SCANDIES ROSE maintain stability instructions developed by a qualified individual. This regulation requires:

> *Each vessel must be provided with stability instructions which provide the master or individual in charge of the vessel with loading constraints and operating restrictions which maintain the vessel in a condition which meets the applicable stability requirements of this subpart.*

To provide flexibility, 46 CFR 28.530(d) provides a list of specific information that MAY be included in the stability instructions.

Two distinct documents with "Instructions to Master" of SCANDIES ROSE were made available: stability instructions from 1988 are shown in Figure 26 found within reference (b), and stability instructions provided in 2019 in Figure 27 found within reference (c).

In the 1988 stability instructions, the prescriptive limits of SCANDIES ROSE can be summarized as:

- A maximum of 220 crab pots in up to 5 tiers OR deck load not to exceed 160,000 lbs.[3]
- A maximum of four tiers of pots in icing conditions

Other limits are provided, but it is not clear if they are requirements. These include:

- Fuel volume when leaving port (50,000 gallons)
- Water tanks full when leaving port
- The best stability condition for cargo holds is filling center only or center and aft
- Use of fuel from one wing tank pair at a time sequencing burn off to minimize trim (maximum trim not given).

2019 stability instructions (ref (c)) provide the following prescriptive stability limits:

- 208 pots (of 835 lbs. each) can be carried on deck with one or two holds flooded
- 168 pots can be carried on deck with all three holds flooded and the forward wing fuel tanks empty
- Flooded holds must be full or empty
- Freeboard must not be less than 6 inches at any point

[3] It is not clear if 220 crab pots would equal a deck load of 160,000 lbs., which would equate to 727 lbs. per pot

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NAVAL ARCHITECT & MARINE ENGINEER

RT. 3, BOX 134-B
VASHON, WA 98070

(206) 463-5274

INSTRUCTIONS TO MASTER

F/V SCANDIES ROSE

1. This vessel meets I.M.O. and voluntary U.S. Coast Guard standards for intact stability in all conditions investigated.

2. A maximum of 220 crab pots may be carried in up to five tiers, or a total weight of deckload not to exceed 160000 pounds, when leaving port with approximately 50000 gallons of fuel and water tanks full.

3. The best condition for departure is with center or center and aft crab tanks filled.

4. In icing conditions not over four tiers of pots should be carried.

5. Crab tanks should be either blocked off so water can't enter them or filled to the overflows. Never operate with a crab tank slack except while actually filling.

6. If it is necessary to fill a crab tank at sea it should be done in good weather with the vessel headed slowly into the sea. Never allow more than one tank to be partially filled at a time.

7. Use fuel from one pair (port/starboard) of tanks at a time. Sequence burnoff of tanks to minimize trim by bow or stern.

Bruce A. Culver

BRUCE CULVER — STATE OF WASHINGTON — 12912 — REGISTERED — PROFESSIONAL ENGINEER

Figure 26: 1988 Stability Instructions for SCANDIES ROSE from ref (b)

INSTRUCTIONS TO MASTER

F/V SCANDIES ROSE

1. Stability characteristics of this vessel are evaluated for compliance with 46CFR Subchapter C, paragraph 28

2. A total of (208) 835 pound crab pots can be carried on deck, The first tier on edge and the rest flat, Do not obscure vision from the pilothouse. This applies in icing or non-icing conditions. If all three Holds are flooded (168) pots can be carried, and forward wing tanks are to be empty.

3. Flooded holds must be filled or emptied. In a sheltered location or in port. ~~Do not operate with a slack~~ . Do not operate with a slack (partially filled) hold.

4. Freeboard is not to be less than six inches at any point.

5. Always determine the cause of any list before taking corrective action.

6. All gear carried on deck or in a hold must be firmly secured against shifting.

7. All doors, hatches, manholes, scuttles, etc., must be kept securely closed while at sea except when Actually in use.

8 Bilges must be kept pumped to minimum content at all times subject to pollution regulations.

9. Freeing ports must be kept clear and operable at all times.

10. Avoid accumulation of unnecessary weights such as spare parts, tools, gear and stores.

11. No modifications to the vessel, such as adding or removing ballast or other weights is to be performed without first determining their effect on stability.

12. The master of the vessel is responsible for maintaining watertight integrity at all times and to exercise prudent seamanship, giving consideration to the season of the year, weather, sea and ice conditions.

May 28, 2019

Figure 27: 2019 Stability Instructions for SCANDIES ROSE from ref (c)

6.2. Stability Criteria Assumptions

6.2.1. Load Line Assumption

46 CFR Chapter I, Subchapter E did not require SCANDIES ROSE to have a load line. However, SCANDIES ROSE sister ship PATRICA LEE was issued a load line by the American Bureau of Shipping in 1996 as shown in Figure 28 and provided to MSC by the American Bureau of Shipping (ref (p)). This load line requires a winter freeboard of 1 foot, 4.75 inches from the main deck at amidships. As a reference point on SCANDIES ROSE, this load line is incorporated into stability evaluations at a height of 13.0 feet above the baseline to correspond with 1 foot 4.75 inches from the molded deck line at amidships. Although a load line was not compulsory for SCANDIES ROSE, the sister ship load line provides a regulatory measure of reserve buoyancy that is an alternative to the criteria in 46 CFR Chapter I Subchapter E. Because the load line was an alternate criterion and not required for SCANDIES ROSE, submerged load line results are highlighted in yellow instead of red in Table 29 to Table 46.

6.2.2. Initial Heel Angles After Loading

Off center or asymmetric consumable tanks such as the fuel day tank, aft fuel tanks, lube oil tank, and sewage tank result in initial heel angles for many of SCANDIES ROSE's loading conditions. MSC assumed the SCANDIES ROSE was upright with zero initial heel in all loading conditions by shifting cargo transversely to correct heel. When crab pots are loaded, this transverse shift is calculated and applied for the top tier pot weights first and progress to lower tiers if needed to attain enough magnitude in righting moment. When tendering equipment is specified in sample loading conditions, the transverse weight shift is achieved by loading deck equipment off centerline to correct the vessel's heel angle.

The assumption that SCANDIES ROSE was always upright in a static equilibrium condition for all conditions of loadings is not conservative; it is likely that off-center tanks, especially the constant use of the fuel oil day tank on the port side, frequently caused a heel angle for SCANDIES ROSE. Righting arms for a vessel with an off-centerline weight condition are subject to a cosine correction which can significantly reduce righting area and range (angles) of stability.

INTERNATIONAL LOAD LINE CERTIFICATE (1966)

Issued under the provisions of the International Convention on Load Lines, 1966, under the authority of the Government of the

UNITED STATES OF AMERICA,

Commandant, U. S. Coast Guard,

by the American Bureau of Shipping

duly authorized for assigning purposes under the provisions of the Convention

7809843-~~1~~ 2
Certificate No.

Name of Ship	Official number or Distinctive Letters	Port of Registry	Length (L) as defined in Article 2 (8); i. e., 46 CFR 42.13-15
PATRICIA LEE	597612	SEATTLE, WASHINGTON	118.203'

Freeboard assigned as: * A new ship / ~~An existing ship~~

* Delete whatever is inapplicable.

Type of Ship * ~~Type "A"~~ / Type "B" / ~~Type "B" with reduced freeboard~~ / ~~Type "B" with increased freeboard~~

	Freeboard from deck line				Load Line	
Tropical	0	feet	10-1/4	inches (T)	3-1/4	inches above (S)
Summer	1	feet	1-1/2	inches (S)	-	Upper edge of line through center of ring
Winter	1	feet	4-3/4	inches (W)	3-1/4	inches below (S)
Winter North Atlantic	1	feet	6-3/4	inches (WNA)	5-1/4	inches below (S)

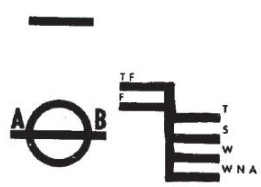
Note: Freeboards and load lines which are not applicable need not be entered on the certificate.

Allowance for fresh water for all freeboards 3 inches.

Note: All measurements are to upper edge of the respective horizontal lines.

The upper edge of the deck line from which these freeboards are measured is OPPOSITE TOP OF STEEL UPPER deck at side.

THIS CERTIFICATE IS VALID ONLY SO LONG AS THE OPERATING RESTRICTIONS IN THE VESSEL'S STABILITY LETTER, ISSUED BY THE USCG MARINE SAFETY CENTER AND DATED 30 DECEMBER 1993, ARE OBSERVED.



Date of initial or periodical survey 31 AUGUST 1995

THIS IS TO CERTIFY that this ship has been surveyed and that the freeboards have been assigned and load lines shown above have been marked in accordance with the International Convention on Load Lines, 1966.

This Certificate is valid until 31 AUGUST 2000 **, subject to annual surveys in accordance with Article 14 (1) (c) of the Convention, and endorsement thereof on the reverse side of the Certificate.

**At the expiration of this certificate, applicable reissuance should be obtained in accordance with the Load Line Regulations.

Issued at HOUSTON, TEXAS 23 JANUARY 1996

The undersigned declares that he is duly authorized by the said Government to issue this Certificate.

M. J. Davison, Supervisor
American Bureau of Shipping
By Direction of J. C. Smith, Manager
Classification & Documentation Center

LL 9-A Rev. 2/82

Figure 28: International Load Line Certificate Issued to PATRICIA LEE in 1996 (ref (p))

6.2.3. 46 CFR 28.540 Free Surface Assumption for All Criteria

46 CFR 28.540 requires the use of either formal free surface effect or calculation of free surface using the moment of transference method to evaluate the transverse weight shift in tanks as the vessel heels. The moment of transference method results in lesser weight shifts for large angles of heel and less negative impact to righting area in general. MSC approximated the moment of transference method by calculating the true weight shifts in each tank and assigning free surface as the product of tank waterplane moment of inertia, tank permeability, and density of tank contents; this process is the “true free surface” calculation method within GHS software.

It is not known if wing fuel tanks had cross connection piping. Wing tank pairs were treated as individual tanks by MSC for the purpose of free surface moments. This assumption is less conservative and results in lower free surface moments than assuming the tanks are cross connected.

6.2.4. 46 CFR 28.550 Icing Assumptions

Icing is discussed in Sections 4.3.3 and 4.3.6. MSC’s model applied vertical surface ice weight to the sides and ends of each crab pot tier that is loaded. MSC’s model applied horizontal surface ice weight to the highest tier of pots that are loaded as indicated in Section 4.3.6. The owner’s naval architect’s model, reference (a), requires the use of a fixed weight and center of gravity for ice which was applied using the weights documented in reference (b).

6.2.5. 46 CFR 28.555 Freeing Ports

The size of freeing ports was evaluated below in Section 6.4. For these measurements, the deck edge (sheer line) of the MSC hydrostatics model was used to evaluate main deck bulwark lengths. A procedure for determining required sheer (longitudinal main deck curvature) is not noted in 46 CFR 28.555 (g). SCANDIES ROSE was assumed to have sufficient sheer for the purpose of 46 CFR 28.555 (g). The bycatch chute was assumed to provide no contribution to freeing port area.

6.2.6. 46 CFR Watertight and Weathertight Integrity Assumptions

Both reference (a) and MSC’s model assumed that the hull below the main deck, enclosed forecastle, and enclosed poop are watertight. All doors leading to these enclosed buoyant volumes were assumed to be watertight and closed. No buoyancy is assumed for the house and superstructure. The skeg, included in MSC's model, is assumed to be non-buoyant.

All compartment and tank vents are assumed to have effective check valves that prevent water ingress.

The only known downflooding points were assumed to be the engine room vents behind the pilothouse stairs (see section 4.3.7). Although references (a) through (c) did not include these points for stability analysis, MSC added them to the reference (a) model for the purpose of evaluating all stability criteria; this model with added downflooding points is named "CulverDF" in results tables (Table 29 to Table 46).

6.2.7. 46 CFR 28.570 Intact Righting Energy Assumptions

46 CFR 28.570(a)(7) requires a range of positive righting arms to 60° of heel unless hatches are normally kept closed or open holds are flooded. Because Stability Instructions for SCANDIES ROSE require the holds to be full or closed and empty, the lesser criteria of 46 CFR 28.570(b)(3) which specifies a range of positive righting arms to 50° of heel is required.

46 CFR 28.570(c) allows the Rahola Criteria listed in 46 CFR 170.173(c) to be used as a suitable alternative to the Torremolinos Criteria given in 46 CFR 28.570(a). Because this is an alternate standard and not required, failing conditions for these alternate criteria are shown in yellow rather than red in results tables (Table 29 to Table 46).

6.2.8. 46 CFR 28.575 Severe Wind and Roll Assumptions

MSC evaluated SCANDIES ROSE for the Severe Wind and Roll Criteria using the International Maritime Organization (IMO) Severe Wind and Roll function within GHS. Both IMO Severe Wind and Roll Criteria (from Resolution A.562(14)) and 46 CFR 28.575 criteria follow the same procedure, applying a "gust" wind speed to the lateral area (windage) of the hull that logarithmically increases as a function of the height above waterline. For a vessel that operates on "other than protected waters," 46 CFR 28.575 (b) requires the gust wind speed to be:

$$V(h) = 85.3[0.124 \times \ln(0.3048 \times h) + 0.772] \text{ (in feet per second)}$$

At a nominal height of 33 feet above the waterline, this gust wind speed is 53.4 knots (90.2 feet per second). The area that the wind speed acts upon was calculated by breaking up the lateral plane area or windage into horizontal bands that are 0.25 feet high. Every 0.25 feet of height above the waterline, the wind velocity was calculated using the above formula with the windage area calculated with consideration for shielded components (e.g. crab pots on deck could prevent wind pressure from acting on a crane's windage).

Wind speed must be used with a coefficient of drag in order to define a pressure acting on the lateral plane area. Although the drag coefficient is not explicitly defined within 46 CFR 28.575, MSC calculated it as 1.2 using the wind heeling lever formula specified by the regulation.

MSC evaluated the k-coefficient required in 46 CFR 28.575(c) by calculating the lateral plane area of the skeg (98.8 square feet) and treating it as a bar keel for the purpose of the regulation. The k-coefficient is evaluated using either prescribed values for round hulls or hard-chine hulls or using the third table of Tables 28.575 in 46 CFR. Entering values for this table include the area of keel and loading condition waterplane length and breadths. Using SCANDIES ROSE's loading condition waterline lengths and breadths, a k-coefficient value of approximately 0.79 is found. Because SCANDIES ROSE has sharp bilges (chines), a k-coefficient of 0.7 is allowed. The k-coefficient is less conservative with smaller values of "k." MSC's analysis assumed the lower 0.7 value for the k-coefficient.

For each load condition evaluated in this report, all 46 CFR 28.575 coefficients are presented in the Appendices under the heading "IMO parameters."

6.2.9. 46 CFR 28.580 Unintentional Flooding Assumptions

Unintentional flooding (damage) criteria does not apply to SCANDIES ROSE because these criteria are limited to vessels that were "built on or after September 15, 1991." Although SCANDIES ROSE underwent some modifications after 1991, modification or alteration is not a factor considered in the regulatory applicability of 46 CFR 28.580.

Loading Condition	Hydro-Statics Model	Tank fwdwing (s) Weight Diff. (LT)	Tank fwdwing (p) Weight Diff. (LT)	Tank midwing (s) Weight Diff. (LT)	Tank midwing (p) Weight Diff. (LT)	Tank aftwing (s) Weight Diff. (LT)	Tank aftwing (p) Weight Diff. (LT)	Tank water (s) Weight Diff. (LT)	Tank water (p) Weight Diff. (LT)	Tank aftfuel (s) Weight Diff. (LT)	Tank aftfuel (p) Weight Diff. (LT)	Tank Lubeoil (p) Weight Diff. (LT)	Tank daytank (p) Weight Diff. (LT)	Tank sewage (s) Weight Diff. (LT)	Tank dblbtmc Weight Diff. (LT)	Total Difference (LT)	% Difference (of Displacement, LT)
1988 Stability Book Condition 1: Departure, Full Fuel, 212 Pots	MSC	-2.8	-2.8	-1.9	-1.9	-1.7	-1.7	0.0	0.0	0.0	-1.0	0.0	0.0	0.0	0.0	**13.8**	1.54%
1988 Stability Book Condition 2: Arrival on Fishing Grounds, 75% Fuel and Water	MSC	-2.8	-2.8	-1.9	-1.9	-1.7	-1.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**12.8**	1.32%
1988 Stability Book Condition 3: Fishing, Moving Pots, 50% Fuel, 212 Pots, 3 Holds Full	MSC	0.0	0.0	0.0	0.0	-1.7	-1.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**3.4**	0.33%
1988 Stability Book Condition 4: Fishing, 25% Fuel	MSC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	0.00%
1988 Stability Book Condition 5: Burned Out, 10% Fuel, 50 Pots, 3 Holds Full	MSC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	0.00%
1988 Stability Book Condition 6: Departure, Full Fuel, 3 Holds Full, 168 Pots	MSC	-2.8	-2.8	-1.9	-1.9	-1.7	-1.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**12.8**	1.16%
2019 Stability Book Condition 1: Max Consumables, 208 Pots, Holds 2 and 3 full	MSC	0.0	0.0	-0.3	-0.3	-2.1	-2.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**4.8**	0.45%
2019 Stability Book Condition 2: 75% Consumables, 208 Pots, Holds 2 and 3 Full	MSC	0.0	0.0	0.0	0.0	-2.1	-2.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**4.2**	0.41%
2019 Stability Book Condition 3: 50% Consumables, 208 Pots, Holds 2 and 3 Full	MSC	0.0	0.0	0.0	0.0	-2.1	-2.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**4.2**	0.41%
2019 Stability Book Condition 4: 25% Consumables, 208 Pots, Holds 2 and 3 Full	MSC	0.0	0.0	0.0	0.0	-2.1	-2.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**4.2**	0.43%
2019 Stability Book Condition 5: 10% Consumables, 208 Pots, Holds 2 and 3 Full	MSC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	0.00%
2019 Stability Book Condition 6: Max Consumables, Tendering, All Holds Full	MSC	0.0	0.0	-0.3	-0.3	-2.1	-2.1	0.0	0.0	-0.3	-1.6	0.0	0.0	0.0	0.0	**6.7**	0.58%
2019 Stability Book Condition 7: 75% Consumables, Tendering, All Holds Full	MSC	0.0	0.0	0.0	0.0	-2.1	-2.1	0.0	0.0	-0.3	-1.6	0.0	0.0	0.0	0.0	**6.1**	0.55%
2019 Stability Book Condition 8: 50% Consumables, Tendering, All Holds Full	MSC	0.0	0.0	0.0	0.0	-2.1	-2.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**4.2**	0.40%
2019 Stability Book Condition 9: 25% Consumables, Tendering, All Holds Full	MSC	0.0	0.0	0.0	0.0	-2.1	-2.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**4.2**	0.41%
2019 Stability Book Condition 10: 10% Consumables, Tendering, All Holds Full	MSC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	0.00%
2019 Stability Book Condition 11: Crabbing, 3 Holds Full, 168 Pots	MSC	0.0	0.0	-0.3	-0.3	-2.1	-2.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**4.8**	0.41%
Investigating Officer's Condition 1: 198 Pots, Holds 2 and 3 Full. Fuel and Water Full, 20,000lb bait	MSC	0.0	0.0	-0.3	-0.3	-2.1	-2.1	0.0	0.0	-0.3	-1.6	0.0	0.0	0.0	0.0	**6.7**	0.61%
Investigating Officer's Condition 2: 198 Pots, Holds 2 and 3 Full. Fuel and Water Full except #1 WTs, 20,000lb bait	MSC	0.0	0.0	-0.3	-0.3	-2.1	-2.1	0.0	0.0	-0.3	-1.6	0.0	0.0	0.0	0.0	**6.7**	0.62%

Table 27: MSC model tank load differences from ref (b) load condition specification

Loading Condition	Hydro-Statics Model	Tank fwdwing (s) Weight Diff. (LT)	Tank fwdwing (p) Weight Diff. (LT)	Tank midwing (s) Weight Diff. (LT)	Tank midwing (p) Weight Diff. (LT)	Tank aftwing (s) Weight Diff. (LT)	Tank aftwing (p) Weight Diff. (LT)	Tank water (s) Weight Diff. (LT)	Tank water (p) Weight Diff. (LT)	Tank aftfuel (s) Weight Diff. (LT)	Tank aftfuel (p) Weight Diff. (LT)	Tank Lubeoil (p) Weight Diff. (LT)	Tank daytank (p) Weight Diff. (LT)	Tank sewage (s) Weight Diff. (LT)	Tank dblbtmc Weight Diff. (LT)	Total Difference (LT)	% Difference (of Displacement, LT)
1988 Stability Book Condition 1: Departure, Full Fuel, 212 Pots	CulverDF	-3.3	-3.3	-1.3	-1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**9.2**	1.05%
1988 Stability Book Condition 2: Arrival on Fishing Grounds, 75% Fuel and Water	CulverDF	-3.3	-3.3	-1.3	-1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**9.2**	0.98%
1988 Stability Book Condition 3: Fishing, Moving Pots, 50% Fuel, 212 Pots, 3 Holds Full	CulverDF	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	0.00%
1988 Stability Book Condition 4: Fishing, 25% Fuel	CulverDF	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	0.00%
1988 Stability Book Condition 5: Burned Out, 10% Fuel, 50 Pots, 3 Holds Full	CulverDF	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	0.00%
1988 Stability Book Condition 6: Departure, Full Fuel, 3 Holds Full, 168 Pots	CulverDF	-3.3	-3.3	-1.3	-1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**9.2**	0.87%

Table 28: Ref (a) model tank load differences from ref (b) load condition specifications from 1988

6.2.10. Tank Loading Assumptions

Section 4 discusses assumptions made to generate MSC's tank model. Because of differences between reference (a) and MSC's model tank sizes, tank loadings are performed by adding the specified weight of fluid and not using volume fractions. The benefit of this method is that it allowed tanks to be loaded with the correct weight magnitude of fluid resulting in negligible errors in center of gravity and moment of inertia within the tank. However, this method does result in errors when modeled tanks have less capacity than specified by the loading condition. Because several of MSC's modeled tanks are smaller than reference (a)'s as shown in Table 12, tanks loads must be limited to 100% of their capacity resulting in lesser loads than specified in the loading condition. The total magnitude of these errors is less than 2% of the displacement weight of the vessel in all loading conditions as shown in Table 27.

The reference (a) model also truncated some loading conditions from 1988, presumably because the model provided to MSC is different than the one used in 1988. Table 28 shows the loading conditions in which reference (a)'s forward and aft wing tanks have insufficient capacity to take the load specified in the 1988 loading conditions.

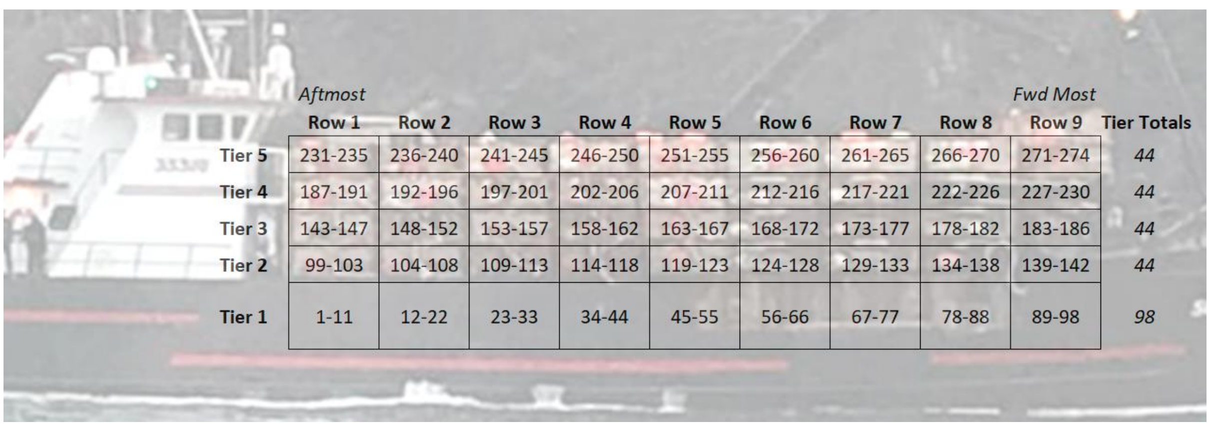
6.3. Hydrostatics Model Modifications for Loading Condition Evaluation

The MSC model modifies the wind profile of crab pots based on the number of pots loaded assuming that pots are loaded in the sequence indicated in Figure 29. This sequence was chosen so that modeling could account for loading conditions with various numbers of crab pots. With this sequence, pots are loaded in the most densely packed manner possible. Wind profile and icing for crab pots are added using a stepwise function that adds the lateral wind profile area and surface ice weights of an entire tier once a single pot is loaded on that tier.[4] This function uses Table 3 for crab pot capacities on each tier. For the MSC model, no crab pot or deck equipment profile is assumed when only tendering equipment or non-crab pot cargos are loaded.

Reference (a) has a fixed wind profile that remains unmodified throughout all calculations. To allow measurement of the model's response, MSC added several points to reference (a):

- Downflooding points were added as specified in Section 4.3.7 to enable evaluation of all required stability criteria
- A reference point was added that corresponds to PATRICIA LEE's load line
- A deck edge reference line was added to enable freeboard measurements along the length

No further modifications to the reference (a) model were made by MSC. The resulting hydrostatics model is named "CulverDF" in the following results tables (Table 29 to Table 46).



	Aftmost Row 1	Row 2	Row 3	Row 4	Row 5	Row 6	Row 7	Row 8	*Fwd Most* Row 9	Tier Totals
Tier 5	231-235	236-240	241-245	246-250	251-255	256-260	261-265	266-270	271-274	*44*
Tier 4	187-191	192-196	197-201	202-206	207-211	212-216	217-221	222-226	227-230	*44*
Tier 3	143-147	148-152	153-157	158-162	163-167	168-172	173-177	178-182	183-186	*44*
Tier 2	99-103	104-108	109-113	114-118	119-123	124-128	129-133	134-138	139-142	*44*
Tier 1	1-11	12-22	23-33	34-44	45-55	56-66	67-77	78-88	89-98	*98*

Figure 29: MSC Model Assumed Crab Pot Loading Sequence

[4] Using a stepwise function to generate an assumed wind profile and icing surfaces can overestimate the height of the center of the windage pressure and the vertical center of gravity of ice on the pots. However, the assumed "maximum density" loading pot sequence underestimates the vertical center of gravity of pot weights by loading pots as low to the deck as possible. Both the loading sequence and stepwise functions are used to simplify modeling by limiting the number of loading permutations necessary while allowing the model to adjust the wind profile and icing surfaces. While these assumptions do not cancel each other out, the potential error they introduce is negligibly small. Both approaches can theoretically result in possible loading conditions that conform to the stability instruction provided in ref (c).

6.4. 46 CFR 28.555 Freeing Port Criteria Evaluation

Freeing port criteria was evaluated using the profile picture from reference (o). Using the length of SCANDIES ROSE to scale measurements from the picture, freeing port area and bulwark length was measured as indicated in Figure 30. The resolution of the photograph and relatively small freeing port dimensions limit measurement accuracy to the nearest 0.1 foot representing an estimated 15% error in freeing port area.[5]

The length of bulwark, including the sheltered area forward was measured along the sheer line to be 76.2 feet.

The minimum freeing port area on each side is required by 46 CFR 28.555 (d) to be 0.23 times the length of the bulwark. For a deck length of 76.2 feet, the minimum freeing port area was 17.5 feet on each side. Total freeing port area on the starboard side was measured to be 8.0 square feet (with a potential range of 6.9 to 9.2 square feet due to measurement error). This freeing port area is 50% to 60% less than required by 46 CFR 28.555 (d).

46 CFR 28.555 (e) requires increased freeing port area for bulwarks higher than 4 feet. Using the profile picture shown in Figure 30, a combined bulwark length of 38.2 feet was measured to be higher than 4 feet above the deck edge. This additional bulwark height would have increased the required freeing port area by approximately 3 square feet (some heights of the bulwark could not be accurately measured due to obstructions in the photograph).

Figure 30: Profile Picture of SCANDIES ROSE from Ref (o) with Scaled Freeing Port Areas and Deck Lengths, the photograph and measurements are scaled with Rhinoceros drawing software

[5] Typical freeing ports were measured on the photograph at 2.8 feet long by 0.5 feet high with an area of 1.2 square feet. With a measurement accuracy within 0.1 feet, freeing port area measurements have approximately 15% error. Ref. (o) lists the freeing port size as 28 inches to 30 inches (2.3 to 2.5 feet) long. These indicated lengths are 10% to 16% smaller than measured using the photograph. This variability between documented freeing port dimensions and measurements from the photograph apparently support the estimated error percentage.

SCANDIES ROSE

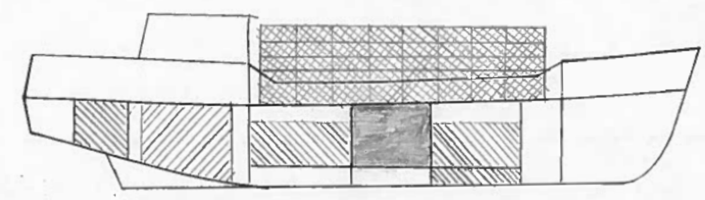
CONDITION #1 DEPARTURE, FULL FUEL, 212 POTS

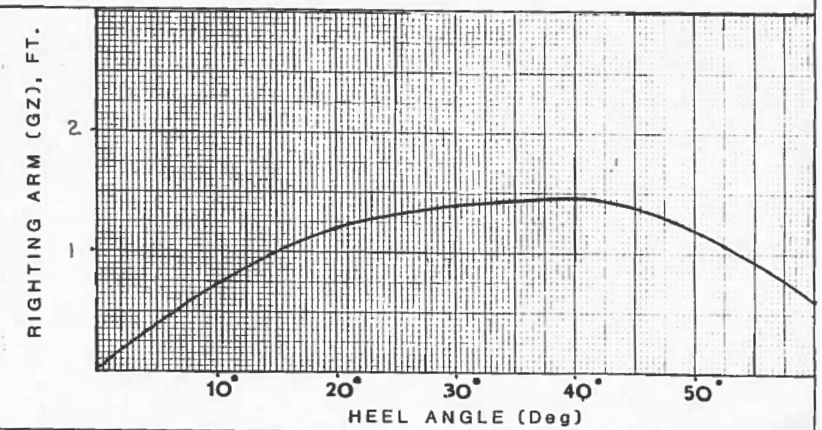
ITEM	F.S.	WEIGHT	VCG	V. MOM.	LCG	L. MOM.
LIGHT SHIP		485.35	14.09	6839.83	-10.74	- 5213.09
CREW & STORES		3.00	16.00	48.00	-33.00	- 99.00
FRESH WATER	11.12	47.47	8.50	403.49	-33.00	- 1566.51
LUBE OIL		4.02	12.90	51.86	-47.75	- 191.96
FUEL-FWD DBL BTM		7.02	2.01	14.11	+25.15	+ 176.55
FUEL-FWD WINGTKS		24.98	5.98	149.38	+25.19	+ 629.25
FUEL-MIDSHIP WING		42.46	5.69	241.60	+7.86	+ 333.74
FUEL-AFT WINGS		39.07	5.63	219.96	-11.00	- 429.77
FUEL-AFT STORAGE	49.32	18.64	10.40	193.86	-49.60	- 924.54
CENTER HOLD		138.28	8.00	1106.24	+8.00	+ 1106.24
1ST TIER (80 POTS)		28.57	19.00	542.83	+3.00	+ 85.71
2ND TIER (44 POTS)		14.11	23.83	336.24	+3.00	+ 42.33
3RD TIER (44 POTS)		12.77	26.50	338.40	+3.00	+ 38.31
4TH TIER (44 POTS)		12.77	29.17	372.50	+3.00	+ 38.31
TOTAL	60.44	878.51	12.36	10857.06	-6.80	- 5974.00

11.244
2.947

KM Trans.	16.61
VCG	12.36
GM-Uncorr.	4.25
F.S. Corr.	.07
GM - Corr.	4.18
TRIM	35" BY STERN

IMO; NVIC 5-86		YES	NO
AREA TO 30° > 10.34 Ft-Deg.	27.08	✓	
AREA TO 40° > 16.92 Ft-Deg.	41.43	✓	
AREA 30 to 40 > 5.64 Ft-Deg.	14.35	✓	
Max. GZ > 25°	40°	✓	
Max GZ>.66 Ft.	1.48	✓	
GM>1.18 Ft.	4.18	✓	





HEEL	10°	20°	30°	40°	60°
GZ'	.754	1.228	1.429	1.519	0.714
Free Surface	.012	.024	.034	.044	.060
GZ	.742	1.204	1.395	1.475	.654

Figure 31: Sample loading conditions from 1988 from within ref (b)

6.5. Loading Condition Stability Criteria Evaluation

All loading conditions were analyzed by MSC using Creative Systems' GHS Software version 17. Detailed results for each loading condition are included in Appendix A for loading conditions evaluated with the reference (a) hydrostatics model and Appendix B for loading conditions evaluated with the MSC hydrostatics model with small pots (as defined in Section 4.3.5), and Appendix C for loading conditions evaluated with the MSC hydrostatics model with large pots.

In the tables below, required stability criteria were highlighted in red if the SCANDIES ROSE loading condition failed to comply with them. Optional, alternate, and stability criteria prescribed by the reference (b) and reference (c) stability instructions were highlighted in yellow when a failing condition was encountered or the calculation could not be completed.

6.6. 1988 Loading Condition Evaluation

Loading conditions were evaluated by using the weights provided in reference (b) (Figure 31 provides an example of a loading condition from 1988 as specified in reference (b)). Section 5 of this report demonstrates the variability in light ship weights and centers of gravity and separate evaluations were made with the values specified in reference (b) and calculated by MSC.

Crab pot total weights were used with reference (a) because they were provided in this manner within the loading conditions found in reference (b). The effective weight of one crab pot in these 1988 load conditions is 721 lbs. each.

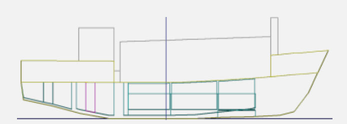
As noted in Section 4.3.5, "small" and "large" crab pots were assumed in the MSC model. Respectively, these pots weigh 835 and 867 lbs. each and were loaded to the total quantity of pots prescribed by the loading conditions in reference (b). This assumption significantly increased the total weight of pots for MSC model load conditions.

1988 Loading Condition 5 is the only loading condition analyzed in this report that passed stability criteria with both hydrostatics models and crab pot sizes. Appendices contain righting arm plots for this loading condition on pages A5-1, A11-1, B5-1, B11-1, C5-1, and C11-1.

6.6.1. 1988 Loading Condition Evaluation: Provided Model/Provided Light ship

The provided model, reference (a), does not have enough detail to evaluate the 46 CFR 28.565 Water on Deck Criterion. Otherwise, all 1988 loading conditions passed stability criteria when using the reference (a) model and provided light ship in reference (b) and shown in Figure 31.

Hydrostatics Model: ref (a)	Light ship Characteristics Source: ref (b) (from Figure 31)



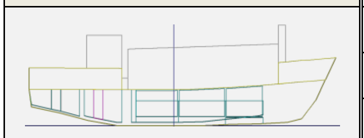
ITEM	F.S.	WEIGHT	VCG	V. MOM.	LCG	L. MOM.
LIGHT SHIP		485.35	14.09	6839.83	-10.74	- 5213.09

Loading Condition	Light-ship Source	Hydro-Statics Model	Displace-ment (LT)	Trim (ft aft)	Minimum Freeboard (feet above waterline)	PATRICIA LEE Winter Loadline Height (feet abv waterline)	§28.565 Water on Deck	§28.570 Intact Righting Energy	§170.173(c) Alternate Intact Criteria	§28.575 Severe Wind and Roll
1988 Stability Book Condition 1: Departure, Full Fuel, 212 Pots	Culver 1988	CulverDF	875.34	4.47	2.46	1.73	Not Evaluated	PASS	PASS	PASS
1988 Stability Book Condition 2: Arrival on Fishing Grounds, 75% Fuel and Water	Culver 1988	CulverDF	936.60	2.56	2.07	1.06	Not Evaluated	PASS	PASS	PASS
1988 Stability Book Condition 3: Fishing, Moving Pots, 50% Fuel, 212 Pots, 3 Holds Full	Culver 1988	CulverDF	999.73	-1.32	1.68	0.30	Not Evaluated	PASS	PASS	PASS
1988 Stability Book Condition 4: Fishing, 25% Fuel	Culver 1988	CulverDF	931.90	-1.31	2.32	0.95	Not Evaluated	PASS	PASS	PASS
1988 Stability Book Condition 5: Burned Out, 10% Fuel, 50 Pots, 3 Holds Full	Culver 1988	CulverDF	869.91	-1.11	2.93	1.55	Not Evaluated	PASS	PASS	PASS
1988 Stability Book Condition 6: Departure, Full Fuel, 3 Holds Full, 168 Pots	Culver 1988	CulverDF	1062.13	-0.47	1.11	-0.26	Not Evaluated	PASS	PASS	PASS

Table 29: 1988 loading condition evaluation using the ref (a) hydrostatics model and ref (b) specified light ship weight and centers of gravity from 1988 (see Appendix A, pages A1 to A6 for loading condition detail)

6.6.2. 1988 Loading Condition Evaluation: Provided Model/MSC Light ship

All 1988 loading conditions were determined to pass stability criteria (with the exception of Water on Deck Criterion) when using the reference (a) model. The evaluation results below used the light ship calculated by MSC (shown in Table 18) using the stability test notes within reference (b).

Hydrostatics Model: ref (a)	**Light ship Characteristics Source: MSC (Table 18)**		
	Lightweight:	392.57	Long Tons
	Vertical Center of Gravity:	14.63	Feet above Baseline
	Longitudinal Center of Gravity:	7.41	Feet Aft of Amidships

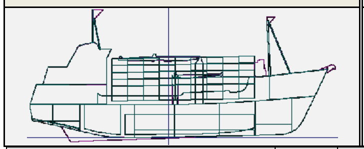
Loading Condition	Light-ship Source	Hydro-Statics Model	Displace-ment (LT)	Trim (ft aft)	Minimum Freeboard (feet above waterline)	PATRICIA LEE Winter Loadline Height (feet abv waterline)	§28.565 Water on Deck	§28.570 Intact Righting Energy	§170.173(c) Alternate Intact Criteria	§28.575 Severe Wind and Roll
1988 Stability Book Condition 1: Departure, Full Fuel, 212 Pots	MSC 1988	CulverDF	782.53	2.25	3.60	2.54	Not Evaluated	PASS	PASS	PASS
1988 Stability Book Condition 2: Arrival on Fishing Grounds, 75% Fuel and Water	MSC 1988	CulverDF	843.80	0.34	3.20	1.86	Not Evaluated	PASS	PASS	PASS
1988 Stability Book Condition 3: Fishing, Moving Pots, 50% Fuel, 212 Pots, 3 Holds Full	MSC 1988	CulverDF	906.92	-3.55	2.49	1.11	Not Evaluated	PASS	PASS	PASS
1988 Stability Book Condition 4: Fishing, 25% Fuel	MSC 1988	CulverDF	839.09	-3.56	3.14	1.76	Not Evaluated	PASS	PASS	PASS
1988 Stability Book Condition 5: Burned Out, 10% Fuel, 50 Pots, 3 Holds Full	MSC 1988	CulverDF	777.11	-3.38	3.74	2.37	Not Evaluated	PASS	PASS	PASS
1988 Stability Book Condition 6: Departure, Full Fuel, 3 Holds Full, 168 Pots	MSC 1988	CulverDF	969.32	-2.67	1.92	0.55	Not Evaluated	PASS	PASS	PASS

Table 30: 1988 loading condition evaluation using the ref (a) hydrostatics model and MSC calculated light ship weight and centers of gravity from 1988 (see Appendix A, pages A7 to A12 for loading condition detail)

6.6.3. 1988 Loading Condition Evaluation: MSC Model/Provided Light Ship/Small Pots

Using MSC's model and reference (b)'s light ship weight and centers of gravity, two loading conditions failed required intact stability criteria. These conditions passed the criteria when using the reference (a) model and failed when using MSC's model because the MSC model has less above deck buoyancy from the enclosed poop, and a greater total weight of crab pots (each pot weighs more). These features each cause downflooding points to submerge faster: less buoyancy and more weight leads to lesser righting moments at higher angles of heel.

Model: MSC/Small Pots	Light ship Characteristics Source: ref (b) (from Figure 31)



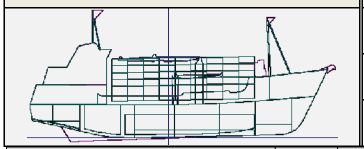
ITEM	F.S.	WEIGHT	VCG	V. MOM.	LCG	L. MOM.
LIGHT SHIP		485.35	14.09	6839.83	-10.74	- 5213.09

Loading Condition	Light-ship Source	Hydro-Statics Model	Displace-ment (LT)	Trim (ft aft)	Minimum Freeboard (feet above waterline)	PATRICIA LEE Winter Loadline Height (feet abv waterline)	§28.565 Water on Deck	§28.570 Intact Righting Energy	§170.173(c) Alternate Intact Criteria	§28.575 Severe Wind and Roll
1988 Stability Book Condition 1: Departure, Full Fuel, 212 Small Pots	Culver 1988	MSC Small Pots Small Pots	896.63	4.36	2.04	1.54	PASS	PASS	PASS	PASS
1988 Stability Book Condition 2: Arrival on Fishing Grounds, 75% Fuel and Water	Culver 1988	MSC Small Pots	970.65	2.50	1.67	0.75	PASS	PASS	PASS	PASS
1988 Stability Book Condition 3: Fishing, Moving Small Pots, 50% Fuel, 212 Small Pots, 3 Holds Full	Culver 1988	MSC Small Pots	1045.21	-1.74	1.27	-0.10	PASS	FAIL	FAIL	PASS
1988 Stability Book Condition 4: Fishing, 25% Fuel	Culver 1988	MSC Small Pots	980.82	-1.72	1.89	0.52	PASS	PASS	PASS	PASS
1988 Stability Book Condition 5: Burned Out, 10% Fuel, 50 Small Pots, 3 Holds Full	Culver 1988	MSC Small Pots	908.79	-1.28	2.60	1.22	PASS	PASS	PASS	PASS
1988 Stability Book Condition 6: Departure, Full Fuel, 3 Holds Full, 168 Small Pots	Culver 1988	MSC Small Pots	1103.67	-0.84	0.77	-0.62	PASS	FAIL	FAIL	PASS

Table 31: 1988 loading condition evaluation using MSC's hydrostatics model and ref (b) specified light ship weight and centers of gravity from 1988 with small pots modeled (see Appendix B, pages B1 to B6 for loading condition detail)

6.6.4. 1988 Loading Condition Evaluation: MSC Model/MSC Light ship/Small Pots

MSC's calculated light ship weight is 93 long tons less than the reference (b) specified weight. Using MSC's model with MSC's lower light ship weight, SCANDIES ROSE was shown to have more reserve buoyancy and is shown to pass all stability criteria when using MSC's lower calculated light ship weight.

Model: MSC/SmallPots	**Light ship Characteristics Source: MSC (Table 24)**		
	Lightweight:	392.57	Long Tons
	Vertical Center of Gravity:	14.63	Feet above Baseline
	Longitudinal Center of Gravity:	7.41	Feet Aft of Amidships

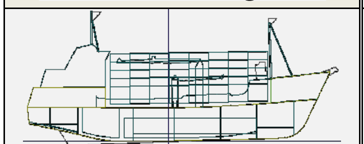
Loading Condition	Light-ship Source	Hydro-Statics Model	Displace-ment (LT)	Trim (ft aft)	Minimum Freeboard (feet above waterline)	PATRICIA LEE Winter Loadline Height (feet abv waterline)	§28.565 Water on Deck	§28.570 Intact Righting Energy	§170.173(c) Alternate Intact Criteria	§28.575 Severe Wind and Roll
1988 Stability Book Condition 1: Departure, Full Fuel, 212 Small Pots	MSC 1988	MSC Small Pots	803.82	2.08	3.37	2.36	PASS	PASS	PASS	PASS
1988 Stability Book Condition 2: Arrival on Fishing Grounds, 75% Fuel and Water	MSC 1988	MSC Small Pots	877.87	0.24	2.96	1.57	PASS	PASS	PASS	PASS
1988 Stability Book Condition 3: Fishing, Moving Small Pots, 50% Fuel, 212 Small Pots, 3 Holds Full	MSC 1988	MSC Small Pots	952.40	-4.02	1.94	0.72	PASS	PASS	PASS	PASS
1988 Stability Book Condition 4: Fishing, 25% Fuel	MSC 1988	MSC Small Pots	888.01	-4.03	2.55	1.34	PASS	PASS	PASS	PASS
1988 Stability Book Condition 5: Burned Out, 10% Fuel, 50 Small Pots, 3 Holds Full	MSC 1988	MSC Small Pots	815.99	-3.59	3.30	2.04	PASS	PASS	PASS	PASS
1988 Stability Book Condition 6: Departure, Full Fuel, 3 Holds Full, 168 Small Pots	MSC 1988	MSC Small Pots	1010.87	-3.08	1.50	0.19	PASS	PASS	PASS	PASS

Table 32: 1988 loading condition evaluation using MSC's hydrostatics model and MSC's calculated light ship weight and centers of gravity from 1988 with small pots modeled (see Appendix B, pages B7 to B12 for loading condition detail)

6.6.5. 1988 Loading Condition Evaluation: MSC Model/Provided Light ship/Large Pots

Using MSC's model with large crab pots, the total capacity with 5-tiers is limited to 200 pots. This prevents the MSC model from attaining the specified capacity of 212 pots for 1988 loading conditions 1 through 3. When compared to MSC's model evaluation using small pots, the additional weight of large crab pots causes many 1988 loading conditions to fail intact stability criteria as a result of downflooding and failure to produce enough righting area over a range of angles from 0 to 30 degrees.

Model: MSC/Large Pots | **Light ship Characteristics Source: ref (b) (from Figure 31)**



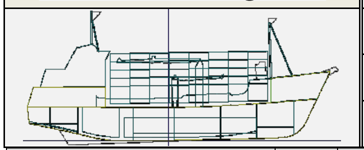
ITEM	F.S.	WEIGHT	VCG	V. MOM.	LCG	L. MOM.
LIGHT SHIP		485.35	14.09	6839.83	-10.74	- 5213.09

Loading Condition	Light-ship Source	Hydro-Statics Model	Displace-ment (LT)	Trim (ft aft)	Minimum Freeboard (feet above waterline)	PATRICIA LEE Winter Loadline Height (feet abv waterline)	§28.565 Water on Deck	§28.570 Intact Righting Energy	§170.173(c) Alternate Intact Criteria	§28.575 Severe Wind and Roll
1988 Stability Book Condition 1: Departure, Full Fuel, 212 Large Pots	Culver 1988	MSC Large Pots	895.01	4.12	2.10	1.54	PASS	PASS	PASS	PASS
1988 Stability Book Condition 2: Arrival on Fishing Grounds, 75% Fuel and Water	Culver 1988	MSC Large Pots	969.05	2.26	1.73	0.76	PASS	FAIL	FAIL	PASS
1988 Stability Book Condition 3: Fishing, Moving Large Pots, 50% Fuel, 212 Large Pots, 3 Holds Full	Culver 1988	MSC Large Pots	1043.59	-1.99	1.27	-0.09	PASS	FAIL	FAIL	PASS
1988 Stability Book Condition 4: Fishing, 25% Fuel	Culver 1988	MSC Large Pots	979.20	-1.97	1.89	0.52	PASS	FAIL	PASS	PASS
1988 Stability Book Condition 5: Burned Out, 10% Fuel, 50 Large Pots, 3 Holds Full	Culver 1988	MSC Large Pots	909.51	-1.35	2.59	1.21	PASS	PASS	PASS	PASS
1988 Stability Book Condition 6: Departure, Full Fuel, 3 Holds Full, 168 Large Pots	Culver 1988	MSC Large Pots	1106.07	-1.08	0.73	-0.65	PASS	FAIL	FAIL	PASS

Table 33: 1988 loading condition evaluation using MSC's hydrostatics model and ref (b) specified light ship weight and centers of gravity from 1988 with large pots modeled (see Appendix C, pages C1 to C6 for loading condition detail)

6.6.6. 1988 Loading Condition Evaluation: MSC Model/MSC Light ship/Large Pots

Using MSC's model with large crab pots, the total capacity with 5-tiers is limited to 200 pots. This again prevents the MSC model from attaining the specified capacity of 212 pots for 1988 loading conditions 1 through 3. All 1988 loading conditions with large pots passed all stability criteria using MSC's 1988 calculated light ship weight which is 93 long tons less than the reference (b) specified weight.

Model: MSC/Large Pots	**Light ship Characteristics Source: MSC (Table 24)**		
	Lightweight:	392.57	Long Tons
	Vertical Center of Gravity:	14.63	Feet above Baseline
	Longitudinal Center of Gravity:	7.41	Feet Aft of Amidships

Loading Condition	Light-ship Source	Hydro-Statics Model	Displace-ment (LT)	Trim (ft aft)	Minimum Freeboard (feet above waterline)	PATRICIA LEE Winter Loadline Height (feet abv waterline)	§28.565 Water on Deck	§28.570 Intact Righting Energy	§170.173(c) Alternate Intact Criteria	§28.575 Severe Wind and Roll
1988 Stability Book Condition 1: Departure, Full Fuel, 212 Large Pots	MSC 1988	MSC Large Pots	802.20	1.83	3.43	2.36	PASS	PASS	PASS	PASS
1988 Stability Book Condition 2: Arrival on Fishing Grounds, 75% Fuel and Water	MSC 1988	MSC Large Pots	876.24	-0.02	2.97	1.57	PASS	PASS	PASS	PASS
1988 Stability Book Condition 3: Fishing, Moving Large Pots, 50% Fuel, 212 Large Pots, 3 Holds Full	MSC 1988	MSC Large Pots	950.78	-4.28	1.92	0.73	PASS	PASS	PASS	PASS
1988 Stability Book Condition 4: Fishing, 25% Fuel	MSC 1988	MSC Large Pots	886.34	-4.29	2.53	1.35	PASS	PASS	PASS	PASS
1988 Stability Book Condition 5: Burned Out, 10% Fuel, 50 Large Pots, 3 Holds Full	MSC 1988	MSC Large Pots	816.70	-3.66	3.29	2.03	PASS	PASS	PASS	PASS
1988 Stability Book Condition 6: Departure, Full Fuel, 3 Holds Full, 168 Large Pots	MSC 1988	MSC Large Pots	1013.26	-3.33	1.45	0.16	PASS	PASS	PASS	PASS

Table 34: 1988 loading condition evaluation using MSC's hydrostatics model and ref (b) specified light ship weight and centers of gravity from 1988 with large pots modeled (see Appendix C, pages C7 to C12 for loading condition detail)

6.7. 2019 Loading Condition Evaluation

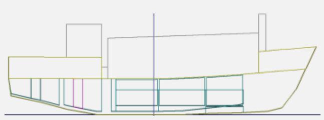
Loading conditions were evaluated by using the weights and tank loadings provided in reference (b). Section 5 demonstrates the variability in light ship weights and centers of gravity and separate evaluations were made with the values specified by reference (b) and those calculated by MSC.

MSC noted that many of the prescribed loading conditions in reference (b) have significant forward trim. Although trim is not explicitly limited by any stability guidance or regulation, forward trim is usually avoided on most operating ships.

2019 Loading Condition 1 was the closest example stability book condition to the estimated casualty condition provided to MSC. Appendices contain righting arm plots for the evaluation of 2019 Loading Condition 1 stability criteria on pages A13-1, A24-1, B13-1, B24-1, C13-1, and C24-1.

6.7.1. 2019 Loading Condition Evaluation: Provided Model/Provided Light ship

Four of the 2019 loading conditions failed stability criteria when using the reference (a) hydrostatics model and light ship characteristics calculated by the owner's naval architect (ref (b)). Downflooding angle is the cause of failure for each of the failing cases noted in Table 35. As provided to MSC, reference (a) did not include downflooding points and MSC added them to conduct this evaluation; without downflooding points, these failing cases would not have been apparent. Sample loading condition #11, found in reference (c) failed to maintain 6 inches of freeboard as required by the 2019 stability instructions to the master also appearing in reference (c).

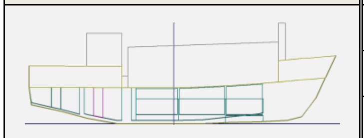
Hydrostatics Model: ref (a)	**Light ship Characteristics Source: ref (b) (from Figure 19)**
	Part-------Weight(LT)----LCG-----TCG-----VCG LIGHT SHIP 548.32 3.30a 0.00 14.69

Loading Condition	Light-ship Source	Hydro-Statics Model	Displace-ment (LT)	Trim (ft aft)	Minimum Freeboard (feet above waterline)	PATRICIA LEE Winter Loadline Height (feet abv waterline)	§28.565 Water on Deck	§28.570 Intact Righting Energy	§170.173(c) Alternate Intact Criteria	§28.575 Severe Wind and Roll
2019 Stability Book Condition 1: Max Consumables, 208 Pots, Holds 2 and 3 full	Culver 2019	CulverDF	1050.57	-0.72	1.22	-0.16	Not Evaluated	FAIL	FAIL	PASS
2019 Stability Book Condition 2: 75% Consumables, 208 Pots, Holds 2 and 3 Full	Culver 2019	CulverDF	1003.74	-0.08	1.68	0.31	Not Evaluated	PASS	PASS	PASS
2019 Stability Book Condition 3: 50% Consumables, 208 Pots, Holds 2 and 3 Full	Culver 2019	CulverDF	990.50	1.03	1.72	0.48	Not Evaluated	FAIL	FAIL	PASS
2019 Stability Book Condition 4: 25% Consumables, 208 Pots, Holds 2 and 3 Full	Culver 2019	CulverDF	956.14	-0.40	2.13	0.75	Not Evaluated	PASS	PASS	PASS
2019 Stability Book Condition 5: 10% Consumables, 208 Pots, Holds 2 and 3 Full	Culver 2019	CulverDF	925.59	-0.69	2.41	1.03	Not Evaluated	PASS	PASS	PASS
2019 Stability Book Condition 6: Max Consumables, Tendering, All Holds Full	Culver 2019	CulverDF	1122.68	-1.83	0.50	-0.87	Not Evaluated	FAIL	FAIL	PASS
2019 Stability Book Condition 7: 75% Consumables, Tendering, All Holds Full	Culver 2019	CulverDF	1075.85	-1.24	0.96	-0.42	Not Evaluated	PASS	PASS	PASS
2019 Stability Book Condition 8: 50% Consumables, Tendering, All Holds Full	Culver 2019	CulverDF	1019.70	-2.22	1.46	0.08	Not Evaluated	PASS	PASS	PASS
2019 Stability Book Condition 9: 25% Consumables, Tendering, All Holds Full	Culver 2019	CulverDF	985.34	-3.62	1.74	0.36	Not Evaluated	PASS	PASS	PASS
2019 Stability Book Condition 10: 10% Consumables, Tendering, All Holds Full	Culver 2019	CulverDF	954.77	-3.93	2.00	0.65	Not Evaluated	PASS	PASS	PASS
2019 Stability Book Condition 11: Crabbing, 3 Holds Full, 168 Pots	Culver 2019	CulverDF	1125.43	-3.94	0.39	-0.96	Not Evaluated	FAIL	FAIL	PASS

Table 35: 2019 loading condition evaluation using the ref (a) hydrostatics model and ref (b) specified light ship weight and centers of gravity from 2019 (see Appendix A, pages A13 to A23 for loading condition detail)

6.7.2. 2019 Loading Condition Evaluation: Provided Model/MSC Light ship

Using the model provided in reference (a), eight of eleven loading conditions failed intact stability criteria when MSC's calculated light ship characteristics are applied. Two loading conditions (6 and 11) have a minimum freeboard less than 6 inches.

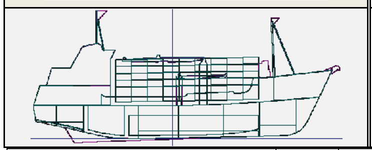
Hydrostatics Model: ref (a)	Light ship Characteristics Source: MSC (Table 24)		
	Lightweight:	578.33	Long Tons
	Vertical Center of Gravity:	15.26	Feet above Baseline
	Longitudinal Center of Gravity:	0.52	Feet Aft of Amidships

Loading Condition	Light-ship Source	Hydro-Statics Model	Displace-ment (LT)	Trim (ft aft)	Minimum Freeboard (feet above waterline)	PATRICIA LEE Winter Loadline Height (feet abv waterline)	§28.565 Water on Deck	§28.570 Intact Righting Energy	§170.173(c) Alternate Intact Criteria	§28.575 Severe Wind and Roll
2019 Stability Book Condition 1: Max Consumables, 208 Pots, Holds 2 and 3 full	MSC 2019	CulverDF	1080.55	-2.59	0.87	-0.50	Not Evaluated	FAIL	FAIL	PASS
2019 Stability Book Condition 2: 75% Consumables, 208 Pots, Holds 2 and 3 Full	MSC 2019	CulverDF	1033.75	-1.99	1.33	-0.04	Not Evaluated	FAIL	FAIL	PASS
2019 Stability Book Condition 3: 50% Consumables, 208 Pots, Holds 2 and 3 Full	MSC 2019	CulverDF	1020.51	-0.90	1.49	0.12	Not Evaluated	FAIL	FAIL	PASS
2019 Stability Book Condition 4: 25% Consumables, 208 Pots, Holds 2 and 3 Full	MSC 2019	CulverDF	986.15	-2.33	1.77	0.40	Not Evaluated	FAIL	FAIL	PASS
2019 Stability Book Condition 5: 10% Consumables, 208 Pots, Holds 2 and 3 Full	MSC 2019	CulverDF	955.60	-2.63	2.05	0.68	Not Evaluated	FAIL	FAIL	PASS
2019 Stability Book Condition 6: Max Consumables, Tendering, All Holds Full	MSC 2019	CulverDF	1152.65	-3.62	0.17	-1.21	Not Evaluated	FAIL	FAIL	PASS
2019 Stability Book Condition 7: 75% Consumables, Tendering, All Holds Full	MSC 2019	CulverDF	1105.87	-3.07	0.62	-0.75	Not Evaluated	FAIL	FAIL	PASS
2019 Stability Book Condition 8: 50% Consumables, Tendering, All Holds Full	MSC 2019	CulverDF	1049.71	-4.06	1.08	-0.26	Not Evaluated	PASS	PASS	PASS
2019 Stability Book Condition 9: 25% Consumables, Tendering, All Holds Full	MSC 2019	CulverDF	1015.34	-5.45	1.21	0.03	Not Evaluated	PASS	PASS	PASS
2019 Stability Book Condition 10: 10% Consumables, Tendering, All Holds Full	MSC 2019	CulverDF	984.77	-5.78	1.43	0.31	Not Evaluated	PASS	PASS	PASS
2019 Stability Book Condition 11: Crabbing, 3 Holds Full, 168 Pots	MSC 2019	CulverDF	1155.42	-5.79	-0.21	-1.32	Not Evaluated	FAIL	FAIL	PASS

Table 36: 2019 loading condition evaluation using the ref (a) hydrostatics model and MSC's calculated light ship weight and centers of gravity from 2019 (see Appendix A, pages A24 to A34 for loading condition detail)

6.7.3. 2019 Loading Condition Evaluation: MSC Model/Provided Light ship/Small Pots

MSC's analysis indicated that nine of eleven of SCANDIES ROSE 2019 loading conditions failed stability criteria using MSC's model with reference (b) light ship characteristics. These were likely the result of differences in MSC's model compared to reference (a), including enclosed poop buoyancy, windage area, icing load and center of gravity, and water on deck.

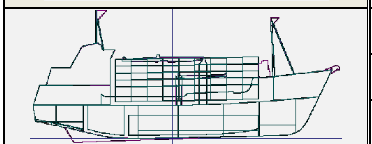
Model: MSC/Small Pots	Light ship Characteristics Source: ref (b) (from Figure 19)
	Part------Weight(LT)----LCG-----TCG-----VCG LIGHT SHIP 548.32 3.30a 0.00 14.69

Loading Condition	Light-ship Source	Hydro-Statics Model	Displace-ment (LT)	Trim (ft aft)	Minimum Freeboard (feet above waterline)	PATRICIA LEE Winter Loadline Height (feet abv waterline)	§28.565 Water on Deck	§28.570 Intact Righting Energy	§170.173(c) Alternate Intact Criteria	§28.575 Severe Wind and Roll
2019 Stability Book Condition 1: Max Consumables, 208 Small Pots, Holds 2 and 3 full	Culver 2019	MSC Small Pots	1077.45	0.04	1.02	-0.38	PASS	FAIL	FAIL	FAIL
2019 Stability Book Condition 2: 75% Consumables, 208 Small Pots, Holds 2 and 3 Full	Culver 2019	MSC Small Pots	1031.14	0.66	1.41	0.08	PASS	FAIL	FAIL	FAIL
2019 Stability Book Condition 3: 50% Consumables, 208 Small Pots, Holds 2 and 3 Full	Culver 2019	MSC Small Pots	1017.91	1.78	1.32	0.24	PASS	FAIL	FAIL	FAIL
2019 Stability Book Condition 4: 25% Consumables, 208 Small Pots, Holds 2 and 3 Full	Culver 2019	MSC Small Pots	983.55	0.37	1.91	0.52	PASS	FAIL	FAIL	FAIL
2019 Stability Book Condition 5: 10% Consumables, 208 Small Pots, Holds 2 and 3 Full	Culver 2019	MSC Small Pots	957.09	0.10	2.16	0.77	PASS	FAIL	FAIL	FAIL
2019 Stability Book Condition 6: Max Consumables, Tendering, All Holds Full	Culver 2019	MSC Small Pots	1154.28	-1.97	0.23	-1.13	PASS	FAIL	FAIL	PASS
2019 Stability Book Condition 7: 75% Consumables, Tendering, All Holds Full	Culver 2019	MSC Small Pots	1107.95	-1.41	0.70	-0.68	PASS	FAIL	FAIL	PASS
2019 Stability Book Condition 8: 50% Consumables, Tendering, All Holds Full	Culver 2019	MSC Small Pots	1053.68	-2.27	1.16	-0.19	PASS	FAIL	FAIL	PASS
2019 Stability Book Condition 9: 25% Consumables, Tendering, All Holds Full	Culver 2019	MSC Small Pots	1019.32	-3.65	1.35	0.10	PASS	PASS	PASS	PASS
2019 Stability Book Condition 10: 10% Consumables, Tendering, All Holds Full	Culver 2019	MSC Small Pots	992.86	-3.94	1.57	0.34	PASS	PASS	PASS	PASS
2019 Stability Book Condition 11: Crabbing, 3 Holds Full, 168 Small Pots	Culver 2019	MSC Small Pots	1162.71	-3.64	-0.01	-1.27	FAIL	FAIL	FAIL	FAIL

Table 37: 2019 loading condition evaluation using MSC's hydrostatics model and ref (b) specified light ship weight and centers of gravity from 2019 with small pots modeled (see Appendix B, pages B13 to B23 for loading condition detail)

6.7.4. 2019 Loading Condition Evaluation: MSC Model/MSC Light ship/Small Pots

When MSC's light ship weight was used with the MSC model, all 2019 loading conditions failed stability criteria. During evaluation, Loading Condition 11 was initially unstable with excessive forward trim (7.35 feet) and list (27° to port).

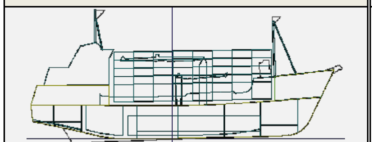
Model: MSC/Small Pots	**Light ship Characteristics Source: MSC (Table 24)**		
	Lightweight:	578.33	Long Tons
	Vertical Center of Gravity:	15.26	Feet above Baseline
	Longitudinal Center of Gravity:	0.52	Feet Aft of Amidships

Loading Condition	Light-ship Source	Hydro-Statics Model	Displace-ment (LT)	Trim (ft aft)	Minimum Freeboard (feet above waterline)	PATRICIA LEE Winter Loadline Height (feet abv waterline)	§28.565 Water on Deck	§28.570 Intact Righting Energy	§170.173(c) Alternate Intact Criteria	§28.575 Severe Wind and Roll
2019 Stability Book Condition 1: Max Consumables, 208 Small Pots, Holds 2 and 3 full	MSC 2019	MSC Small Pots	1107.46	-1.80	0.65	-0.71	FAIL	FAIL	FAIL	FAIL
2019 Stability Book Condition 2: 75% Consumables, 208 Small Pots, Holds 2 and 3 Full	MSC 2019	MSC Small Pots	1061.15	-1.21	1.12	-0.26	FAIL	FAIL	FAIL	FAIL
2019 Stability Book Condition 3: 50% Consumables, 208 Small Pots, Holds 2 and 3 Full	MSC 2019	MSC Small Pots	1047.95	-0.12	1.29	-0.11	FAIL	FAIL	FAIL	FAIL
2019 Stability Book Condition 4: 25% Consumables, 208 Small Pots, Holds 2 and 3 Full	MSC 2019	MSC Small Pots	1013.56	-1.53	1.55	0.17	FAIL	FAIL	FAIL	FAIL
2019 Stability Book Condition 5: 10% Consumables, 208 Small Pots, Holds 2 and 3 Full	MSC 2019	MSC Small Pots	987.09	-1.82	1.78	0.41	FAIL	FAIL	FAIL	FAIL
2019 Stability Book Condition 6: Max Consumables, Tendering, All Holds Full	MSC 2019	MSC Small Pots	1184.26	-3.82	-0.27	-1.51	PASS	FAIL	FAIL	PASS
2019 Stability Book Condition 7: 75% Consumables, Tendering, All Holds Full	MSC 2019	MSC Small Pots	1137.95	-3.20	0.29	-1.01	PASS	FAIL	FAIL	PASS
2019 Stability Book Condition 8: 50% Consumables, Tendering, All Holds Full	MSC 2019	MSC Small Pots	1083.69	-4.06	0.69	-0.52	PASS	FAIL	FAIL	PASS
2019 Stability Book Condition 9: 25% Consumables, Tendering, All Holds Full	MSC 2019	MSC Small Pots	1049.33	-5.45	0.80	-0.23	PASS	FAIL	FAIL	PASS
2019 Stability Book Condition 10: 10% Consumables, Tendering, All Holds Full	MSC 2019	MSC Small Pots	1022.87	-5.75	0.99	0.01	PASS	FAIL	PASS	PASS
2019 Stability Book Condition 11: Crabbing, 3 Holds Full, 168 Small Pots	MSC 2019	MSC Small Pots	1192.72	-7.35	-10.59	-11.14	FAIL	FAIL	FAIL	FAIL

Table 38: 2019 loading condition evaluation using MSC's hydrostatics model and MSC's calculated light ship weight and centers of gravity from 2019 with small pots modeled (see Appendix B, pages B24 to B34 for loading condition detail)

6.7.5. 2019 Loading Condition Evaluation: MSC Model/Provided Light ship/Large Pots

MSC's analysis indicated that nine of eleven of the 2019 loading conditions failed stability criteria using MSC's model large pots and reference (b)'s light ship characteristics. Pot capacity was limited to 200 pots for 2019 Loading Conditions 1 through 5 (208 specified).

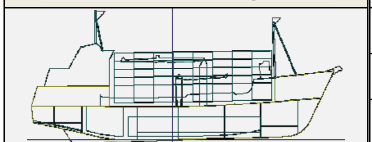
Model: MSC/Large Pots	**Light ship Characteristics Source: ref (b) (from Figure 19)**
	Part-------Weight(LT)----LCG-----TCG-----VCG LIGHT SHIP 548.32 3.30a 0.00 14.69

Loading Condition	Light-ship Source	Hydro-Statics Model	Displace-ment (LT)	Trim (ft aft)	Minimum Freeboard (feet above waterline)	PATRICIA LEE Winter Loadline Height (feet abv waterline)	§28.565 Water on Deck	§28.570 Intact Righting Energy	§170.173(c) Alternate Intact Criteria	§28.575 Severe Wind and Roll
2019 Stability Book Condition 1: Max Consumables, 208 Large Pots, Holds 2 and 3 full	Culver 2019	MSC Large Pots	1079.25	-0.29	0.99	-0.40	FAIL	FAIL	FAIL	FAIL
2019 Stability Book Condition 2: 75% Consumables, 208 Large Pots, Holds 2 and 3 Full	Culver 2019	MSC Large Pots	1032.98	0.33	1.44	0.05	FAIL	FAIL	FAIL	FAIL
2019 Stability Book Condition 3: 50% Consumables, 208 Large Pots, Holds 2 and 3 Full	Culver 2019	MSC Large Pots	1019.71	1.45	1.36	0.21	FAIL	FAIL	FAIL	FAIL
2019 Stability Book Condition 4: 25% Consumables, 208 Large Pots, Holds 2 and 3 Full	Culver 2019	MSC Large Pots	985.34	0.03	1.88	0.49	FAIL	FAIL	FAIL	FAIL
2019 Stability Book Condition 5: 10% Consumables, 208 Large Pots, Holds 2 and 3 Full	Culver 2019	MSC Large Pots	958.88	-0.24	2.13	0.73	FAIL	FAIL	FAIL	FAIL
2019 Stability Book Condition 6: Max Consumables, Tendering, All Holds Full	Culver 2019	MSC Large Pots	1154.28	-1.97	0.23	-1.13	PASS	FAIL	FAIL	PASS
2019 Stability Book Condition 7: 75% Consumables, Tendering, All Holds Full	Culver 2019	MSC Large Pots	1107.95	-1.41	0.70	-0.68	PASS	FAIL	FAIL	PASS
2019 Stability Book Condition 8: 50% Consumables, Tendering, All Holds Full	Culver 2019	MSC Large Pots	1053.68	-2.27	1.16	-0.19	PASS	FAIL	FAIL	PASS
2019 Stability Book Condition 9: 25% Consumables, Tendering, All Holds Full	Culver 2019	MSC Large Pots	1019.32	-3.65	1.35	0.10	PASS	PASS	PASS	PASS
2019 Stability Book Condition 10: 10% Consumables, Tendering, All Holds Full	Culver 2019	MSC Large Pots	992.86	-3.94	1.57	0.34	PASS	PASS	PASS	PASS
2019 Stability Book Condition 11: Crabbing, 3 Holds Full, 168 Large Pots	Culver 2019	MSC Large Pots	1166.85	-3.95	-0.11	-1.34	FAIL	FAIL	FAIL	FAIL

Table 39: 2019 loading condition evaluation using MSC's hydrostatics model and ref (b) specified light ship weight and centers of gravity from 2019 with large pots modeled (see Appendix C, pages C13 to C23 for loading condition detail)

6.7.6. 2019 Loading Condition Evaluation: MSC Model/MSC Light ship/Large Pots

MSC's analysis indicated that all 2019 loading conditions failed stability criteria using MSC's model with large pots and MSC's light ship characteristics. Pot capacity was limited to 200 pots for 2019 Loading Conditions 1 through 5 (208 specified). Condition 11 was initially unstable.

Model: MSC/Large Pots	Light ship Characteristics Source: MSC (Table 24)		
	Lightweight:	578.33	Long Tons
	Vertical Center of Gravity:	15.26	Feet above Baseline
	Longitudinal Center of Gravity:	0.52	Feet Aft of Amidships

Loading Condition	Light-ship Source	Hydro-Statics Model	Displace-ment (LT)	Trim (ft aft)	Minimum Freeboard (feet above waterline)	PATRICIA LEE Winter Loadline Height (feet abv waterline)	§28.565 Water on Deck	§28.570 Intact Righting Energy	§170.173(c) Alternate Intact Criteria	§28.575 Severe Wind and Roll
2019 Stability Book Condition 1: Max Consumables, 208 Large Pots, Holds 2 and 3 full	MSC 2019	MSC Large Pots	1109.26	-2.13	0.62	-0.74	FAIL	FAIL	FAIL	FAIL
2019 Stability Book Condition 2: 75% Consumables, 208 Large Pots, Holds 2 and 3 Full	MSC 2019	MSC Large Pots	1062.94	-1.54	1.08	-0.29	FAIL	FAIL	FAIL	FAIL
2019 Stability Book Condition 3: 50% Consumables, 208 Large Pots, Holds 2 and 3 Full	MSC 2019	MSC Large Pots	1049.71	-0.45	1.26	-0.14	FAIL	FAIL	FAIL	FAIL
2019 Stability Book Condition 4: 25% Consumables, 208 Large Pots, Holds 2 and 3 Full	MSC 2019	MSC Large Pots	1015.35	-1.87	1.51	0.14	FAIL	FAIL	FAIL	FAIL
2019 Stability Book Condition 5: 10% Consumables, 208 Large Pots, Holds 2 and 3 Full	MSC 2019	MSC Large Pots	988.89	-2.16	1.74	0.38	FAIL	FAIL	FAIL	FAIL
2019 Stability Book Condition 6: Max Consumables, Tendering, All Holds Full	MSC 2019	MSC Large Pots	1184.26	-3.82	-0.27	-1.51	PASS	FAIL	FAIL	PASS
2019 Stability Book Condition 7: 75% Consumables, Tendering, All Holds Full	MSC 2019	MSC Large Pots	1137.95	-3.20	0.29	-1.01	PASS	FAIL	FAIL	PASS
2019 Stability Book Condition 8: 50% Consumables, Tendering, All Holds Full	MSC 2019	MSC Large Pots	1083.69	-4.06	0.69	-0.52	PASS	FAIL	FAIL	PASS
2019 Stability Book Condition 9: 25% Consumables, Tendering, All Holds Full	MSC 2019	MSC Large Pots	1049.33	-5.45	0.80	-0.23	PASS	FAIL	FAIL	PASS
2019 Stability Book Condition 10: 10% Consumables, Tendering, All Holds Full	MSC 2019	MSC Large Pots	1022.87	-5.75	0.99	0.01	PASS	FAIL	PASS	PASS
2019 Stability Book Condition 11: Crabbing, 3 Holds Full, 168 Large Pots	MSC 2019	MSC Large Pots	1196.86	-9.05	-28.49	-6.47	FAIL	FAIL	FAIL	FAIL

Table 40: 2019 loading condition evaluation using MSC's hydrostatics model and MSC's calculated light ship weight and centers of gravity from 2019 with large pots modeled (see Appendix C, pages C24 to C34 for loading condition detail)

6.8. Investigating Officer's Conditions for Loading during the Casualty Voyage

Two conditions approximating the casualty voyage were evaluated using both the reference (a) and MSC hydrostatic models. Each loading condition assumed 195 pots were loaded. Both large and small crab pot dimensions and weights were analyzed. Each loading condition assumed that #2 and #3 holds were full. 20,000 lbs. (8.9 long tons) of bait was assumed to be loaded in the freezer in the port forecastle.[6] All wing and aft fuel tanks are assumed full in condition 1. Wing and aft fuel tanks are assumed full in condition 2 with the exception of the forward wing tanks. Because references (b) and (c) did not consider the double bottom fuel tanks in any of the 2019 loading conditions, these tanks are assumed empty in both conditions.

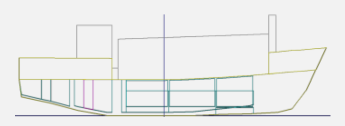
In each evaluation of the casualty loading conditions, the stability instructions in reference (c) were satisfied or very nearly satisfied regardless of model or light ship characteristics (Loading Condition 1 has a freeboard of 5 inches when using the ref (a) model with MSC's lightship characteristics). Pot loads, cargo holds, and fuel tanks were also loaded in accordance with reference (c) with the exception of the tank capacity limitations described in Table 27.

Righting arm plots are provided for Estimated Casualty Condition 1 in the appendices on pages A35-1, A37-1, B35-1, B37-1, C35-1, and C37-1. These righting arm plots indicate low righting areas for all combinations of hydrostatics model, lightship weights, and crab pot sizes.

[6] Bait weight is considered in one document within ref (b) for Loading Condition 1; this document is dated 2004-May-12. For the 2019 loading conditions, MSC did not add the weight of bait because Loading Condition 1 is described by a newer document within ref (b) dated 2019-May-13, with no bait.

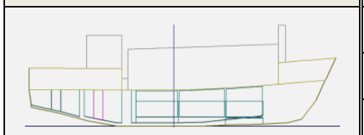
6.8.1. Casualty Voyage Estimated Loading Condition Evaluation Using Ref (a) Model

Table 41 and Table 42 show the stability criteria evaluation results when using the reference (a) hydrostatics model. Both casualty voyage loading conditions failed intact stability criteria as a result of downflooding angle regardless of light ship weight used in the analysis.

Hydrostatics Model: ref (a)	Light ship Characteristics Source: ref (b) (from Figure 19)
	Part-------Weight(LT)----LCG-----TCG-----VCG LIGHT SHIP 548.32 3.30a 0.00 14.69

Loading Condition	Light-ship Source	Hydro-Statics Model	Displace-ment (LT)	Trim (ft aft)	Minimum Freeboard (feet above waterline)	PATRICIA LEE Winter Loadline Height (feet abv waterline)	§28.565 Water on Deck	§28.570 Intact Righting Energy	§170.173(c) Alternate Intact Criteria	§28.575 Severe Wind and Roll
Investigating Officer's Condition 1: 195 Pots, Holds 2 and 3 Full. Fuel and Water Full, 20,000lb bait	Culver 2019	CulverDF	1098.72	0.83	0.72	-0.56	Not Evaluated	FAIL	FAIL	PASS
Investigating Officer's Condition 2: 195 Pots, Holds 2 and 3 Full. Fuel and Water Full except #1 WTs, 20,000lb bait	Culver 2019	CulverDF	1084.43	1.46	0.78	-0.40	Not Evaluated	FAIL	FAIL	PASS

Table 41: Estimated casualty voyage loading condition evaluation using the ref (a) hydrostatics model and ref (b) light ship characteristic (see Appendix A, pages A35 to A36 for loading condition detail)

Hydrostatics Model: ref (a)	Light ship Characteristics Source: MSC (Table 24)		
	Lightweight:	578.33	Long Tons
	Vertical Center of Gravity:	15.26	Feet above Baseline
	Longitudinal Center of Gravity:	0.52	Feet Aft of Amidships

Loading Condition	Light-ship Source	Hydro-Statics Model	Displace-ment (LT)	Trim (ft aft)	Minimum Freeboard (feet above waterline)	PATRICIA LEE Winter Loadline Height (feet abv waterline)	§28.565 Water on Deck	§28.570 Intact Righting Energy	§170.173(c) Alternate Intact Criteria	§28.575 Severe Wind and Roll
Investigating Officer's Condition 1: 195 Pots, Holds 2 and 3 Full. Fuel and Water Full, 20,000lb bait	MSC 2019	CulverDF	1132.46	-1.09	0.43	-0.95	Not Evaluated	FAIL	FAIL	FAIL
Investigating Officer's Condition 2: 195 Pots, Holds 2 and 3 Full. Fuel and Water Full except #1 WTs, 20,000lb bait	MSC 2019	CulverDF	1114.44	-0.42	0.62	-0.75	Not Evaluated	FAIL	FAIL	FAIL

Table 42: Estimated casualty voyage loading condition evaluation using the ref (a) hydrostatics model and MSC calculated light ship characteristic (see Appendix A, pages A37 to A38 for loading condition detail)

6.8.2. Casualty Voyage Estimated Loading Condition Evaluation Using MSC's Model

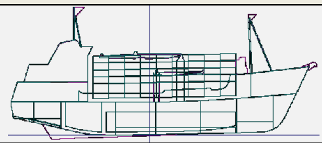
Table 43 and Table 44 show the stability criteria evaluation results when using MSC's hydrostatics model and small crab pots. Table 45 and Table 46 show stability criteria evaluation with large crab pots.

For the casualty voyage loading conditions using MSC's model, icing was applied as required by 46 CFR 28.550: 1.3 inches of surface ice was applied to exposed horizontal surfaces and 0.65 inches was applied to exposed vertical surfaces on the port and starboard sides and ends of the vessel. Sloped surfaces received a combination of horizontal and vertical icing thickness as described in Section 4.3.3.

All casualty voyage loading conditions were shown to fail intact stability and severe wind and roll criteria for both light ship weight assumptions (ref (b)'s and MSC's). When MSC's calculated light ship characteristics or large pots are used in the evaluation, both estimated casualty loading conditions failed all stability criteria while remaining in apparent compliance with the Stability Instructions to the Master (ref (c)) with the exception of the minimum freeboard of 6 inches.[7]

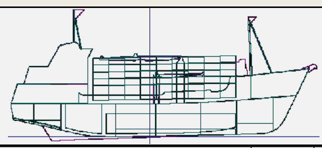
Righting arm plots and the detailed stability criteria information provided in the appendices indicate that the estimated casualty loading conditions have sufficient metacentric height (GM) to pass that specific criterion of the 46 CFR 28.570 and alternate 46 CFR 170.170 intact stability criteria. Because GM is a measure of initial stability and closely related to roll period, SCANDIES ROSE may have physically felt stable to crew members in these conditions despite having dangerously low righting energy.

[7] Calculated freeboards are nearly compliant attaining values ranging from 3 to 6 inches.

Model: MSC/Small Pots	**Light ship Characteristics Source: ref (b) (from Figure 19)**
	Part-------Weight(LT)----LCG-----TCG-----VCG LIGHT SHIP 548.32 3.30a 0.00 14.69

Loading Condition	Light-ship Source	Hydro-Statics Model	Displace-ment (LT)	Trim (ft aft)	Minimum Freeboard (feet above waterline)	PATRICIA LEE Winter Loadline Height (feet abv waterline)	§28.565 Water on Deck	§28.570 Intact Righting Energy	§170.173(c) Alternate Intact Criteria	§28.575 Severe Wind and Roll
Investigating Officer's Condition 1: 195 Small Pots, Holds 2 and 3 Full. Fuel and Water Full, 20,000lb bait	Culver 2019	MSC Small Pots	1122.60	1.46	0.39	-0.76	PASS	FAIL	FAIL	FAIL
Investigating Officer's Condition 2: 195 Small Pots, Holds 2 and 3 Full. Fuel and Water Full except #1 WTs, 20,000lb bait	Culver 2019	MSC Small Pots	1104.55	2.15	0.43	-0.57	PASS	FAIL	FAIL	FAIL

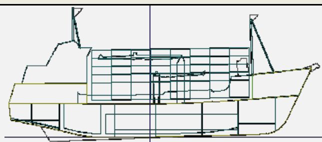
Table 43: Estimated casualty voyage loading condition evaluation using MSC's hydrostatics model and ref (b) light ship characteristics with small pots modeled (see Appendix B, pages B35 to B36 for loading condition detail)

Model: MSC/Small Pots	**Light ship Characteristics Source: MSC (Table 24)**		
	Lightweight:	578.33	Long Tons
	Vertical Center of Gravity:	15.26	Feet above Baseline
	Longitudinal Center of Gravity:	0.52	Feet Aft of Amidships

Loading Condition	Light-ship Source	Hydro-Statics Model	Displace-ment (LT)	Trim (ft aft)	Minimum Freeboard (feet above waterline)	PATRICIA LEE Winter Loadline Height (feet abv waterline)	§28.565 Water on Deck	§28.570 Intact Righting Energy	§170.173(c) Alternate Intact Criteria	§28.575 Severe Wind and Roll
Investigating Officer's Condition 1: 195 Small Pots, Holds 2 and 3 Full. Fuel and Water Full, 20,000lb bait	MSC 2019	MSC Small Pots	1152.58	-0.37	0.30	-1.10	FAIL	FAIL	FAIL	FAIL
Investigating Officer's Condition 2: 195 Small Pots, Holds 2 and 3 Full. Fuel and Water Full except #1 WTs, 20,000lb bait	MSC 2019	MSC Small Pots	1134.55	0.29	0.48	-0.91	FAIL	FAIL	FAIL	FAIL

Table 44: Estimated casualty voyage loading condition evaluation using MSC's hydrostatics model and MSC calculated light ship characteristics with small pots modeled (see Appendix B, pages B37 to B38 for loading condition detail)

Model: MSC/Large Pots	**Light ship Characteristics Source: ref (b) (from Figure 19)**

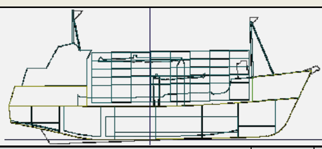


```
Part------Weight(LT)---LCG-----TCG-----VCG
LIGHT SHIP    548.32    3.30a   0.00   14.69
```

Loading Condition	Light-ship Source	Hydro-Statics Model	Displace-ment (LT)	Trim (ft aft)	Minimum Freeboard (feet above waterline)	PATRICIA LEE Winter Loadline Height (feet abv waterline)	§28.565 Water on Deck	§28.570 Intact Righting Energy	§170.173(c) Alternate Intact Criteria	§28.575 Severe Wind and Roll
Investigating Officer's Condition 1: 195 Large Pots, Holds 2 and 3 Full. Fuel and Water Full, 20,000lb bait	Culver 2019	MSC Large Pots	1127.30	1.12	0.41	-0.81	FAIL	FAIL	FAIL	FAIL
Investigating Officer's Condition 2: 195 Large Pots, Holds 2 and 3 Full. Fuel and Water Full except #1 WTs, 20,000lb bait	Culver 2019	MSC Large Pots	1109.25	1.81	0.45	-0.63	FAIL	FAIL	FAIL	FAIL

Table 45: Estimated casualty voyage loading condition evaluation using MSC's hydrostatics model and ref (b) light ship characteristics with large pots modeled (see Appendix C, pages C35 to C36 for loading condition detail)

Model: MSC/Large Pots	**Light ship Characteristics Source: MSC (Table 24)**		
	Lightweight:	578.33	Long Tons
	Vertical Center of Gravity:	15.26	Feet above Baseline
	Longitudinal Center of Gravity:	0.52	Feet Aft of Amidships



Loading Condition	Light-ship Source	Hydro-Statics Model	Displace-ment (LT)	Trim (ft aft)	Minimum Freeboard (feet above waterline)	PATRICIA LEE Winter Loadline Height (feet abv waterline)	§28.565 Water on Deck	§28.570 Intact Righting Energy	§170.173(c) Alternate Intact Criteria	§28.575 Severe Wind and Roll
Investigating Officer's Condition 1: 195 Large Pots, Holds 2 and 3 Full. Fuel and Water Full, 20,000lb bait	MSC 2019	MSC Large Pots	1157.28	-0.72	0.24	-1.16	FAIL	FAIL	FAIL	FAIL
Investigating Officer's Condition 2: 195 Large Pots, Holds 2 and 3 Full. Fuel and Water Full except #1 WTs, 20,000lb bait	MSC 2019	MSC Large Pots	1139.26	-0.05	0.43	-0.97	FAIL	FAIL	FAIL	FAIL

Table 46: Estimated casualty voyage loading condition evaluation using MSC's hydrostatics model and MSC calculated light ship characteristics with large pots modeled (see Appendix C, pages C37 to C38 for loading condition detail)

6.9. Stability Criteria Evaluation Conclusions

Most loading conditions from 1988 for SCANDIES ROSE were shown to pass stability criteria. Compared to reference (a), MSC's model uses higher crab pot weights and has less buoyant volume aft than the loading conditions provided in reference (b). This likely caused some of the 1988 loading conditions to fail intact righting energy criteria as a result of downflooding angle and righting area.

Using reference (a) (without downflooding points) and light ship weight characteristics specified in reference (b) resulted in loading conditions that apparently passed all applicable stability criteria. However, when downflooding angles were added to the reference (a) hydrostatics model (as required by the stability criteria), four 2019 loading conditions failed to meet stability criteria in any combination of light ship characteristics or crab pot dimensions. Additionally, the estimated casualty voyage condition, while nearly meeting all stability instructions from reference (c), failed intact stability requirements for righting area.

Dramatically worse results are obtained when using MSC's hydrostatics model. While closely matching reference (a)'s hydrostatics properties from the main deck down, MSC's model differs in wind profile, reserve buoyancy, bulwarks to evaluate water on deck, and icing weight and center of gravity. The majority of the reference (b) sample loading conditions failed stability criteria when using MSC's model. MSC's model showed that when crab pots are loaded on deck, no 2019 loading conditions met the Severe Wind and Roll criteria. Using MSC's model, this evaluation indicated that for MSC's calculated lightship weight based on the 2019 stability test notes, all 2019 sample loading conditions failed, and Condition 11 was initially unstable. Larger and heavier crab pots were shown to fail stability criteria by larger margins.

Potential casualty voyage conditions evaluated with MSC's model each failed intact and severe wind and roll criteria. When using MSC's calculated light ship characteristics or large crab pots, both casualty voyage conditions failed all stability criteria.

Although SCANDIES ROSE did not require a load line, sister vessel PATRICIA LEE's winter load line was included in evaluations. Many cases were found where stability criteria failed in loading conditions that did not submerge the load line, and some loading conditions submerged the load line and passed stability criteria. For SCANDIES ROSE and the sample loading conditions, load line submergence is correlated with failing stability conditions (load line height correctly predicted passing stability criteria for 80% of loading conditions evaluated).

7. CONCLUSIONS

The following observations and conclusions are provided based on MSC's modeling, assumptions and analysis:

1. Compared to recent pictures, the hydrostatics model provided for SCANDIES ROSE (ref (a)) did not accurately represent the SCANDIES ROSE and has the following deficiencies:
    a. Reference (a) did not accurately model poop or forecastle enclosed volume, thus overstating the reserve buoyancy of the poop and understating the reserve buoyancy of the forecastle.
    b. Reference (a) did not model bulwarks, precluding evaluation of the water on deck criterion required by 46 CFR 28.565.
    c. Reference (a) had significantly less superstructure windage than shown in photographs. This error in windage modeling significantly underpredicted wind heeling moments for the severe wind and roll criteria of 46 CFR 28.575.
    d. References (a) and (b) apparently neglected downflooding, which inflated the maximum heel angles at which the reference (a) model predicted SCANDIES ROSE could survive without flooding.
    e. Compared to MSC's hydrostatics model and calculations, reference (b)'s indicated icing weight, icing center of gravity, and reference (a)'s crab pot windage area were significantly lower.
    f. Significant differences were observed when comparing reference (a)'s tank capacities to the provided capacity plan (ref (n)) or MSC's modeled tank capacities.
2. Reference (b) documentation of stability tests conducted on SCANDIES ROSE in 1988 and 2019 did not support the light ship characteristics used in the owner's naval architect's stability evaluations:
    a. Significant errors exist in both the 1988 and 2019 lightweight surveys. These surveys provided the light ship weight and longitudinal center of gravity of the vessel. Neither the 1988 nor 2019 test data supported the light ship weights used by reference (b) in stability calculations.
    b. Reference (b)'s inclining test calculations contained mathematical errors and carried through errors in light ship weight, precluding the accurate calculation of the vessel's vertical center of gravity.
    c. Stability test data from 2019 represented weight growth from 1988 in such excess (45% increase) that MSC has low confidence the data can be used to accurately calculate light ship weight and center of gravity.

3. A combination of errors in hydrostatic modeling and stability test determination of light ship characteristics indicates that references (b) and (c) could not have accurately evaluated SCANDIES ROSE loading conditions for compliance with regulatory stability criteria:
    a. Reference (a) contains significant errors and omissions in hydrostatic modeling such that the provided model (ref a) could not accurately evaluate loading conditions for compliance with all regulatory criteria.
    b. MSC's analysis indicated that when appropriate downflooding points are added to reference (a), four sample 2019 loading conditions failed to meet stability criteria.
    c. MSC's analysis indicated that the majority of 2019 sample loading conditions from references (b) and (c) failed to meet stability criteria when using the MSC model.
4. MSC's analysis indicated that the estimated casualty voyage conditions, while nearly meeting all of reference (c)'s stability instructions, failed to meet regulatory stability requirements; this is the case for all combinations of hydrostatics modeling and light ship weight characteristics.
5. The magnitude and asymmetry of icing during the casualty voyage was likely different than the symmetric 1.3/0.65-inch-thick icing required for stability criteria evaluation by 46 CFR 28.550; this could have made stability worse than calculated during the casualty voyage.

8. APPENDICES

A. Stability Book Loading Conditions Using Reference (a) Model with Downflooding Points

B. Stability Book Loading Conditions Using MSC Model with Small Pots

C. Stability Book Loading Conditions Using MSC Model with Large Pots