EXPERT REPORT

THE SINKING OF THE *EL FARO* - ENGINEERING FACTORS

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Expert Report of John Daly

1. Opinions

I have been retained as an expert to examine engineering factors related to the sinking of the ***EL FARO.*** In forming my opinions, I have reviewed drawings, documents, manuals, transcripts of testimony of numerous witnesses, and other documents listed in Appendix 1. I have also interviewed TOTE shore side management personnel and vessel engineers and conducted independent research. Based upon the above and upon my knowledge, skill, experience, training and education, it is my opinion that:

a. The ***EL FARO*** was a fully and properly certificated vessel. To remain certificated, the vessel was frequently attended and inspected by the Flag State and Class surveyors (of the United States Coast Guard and the American Bureau of Shipping, respectively) and was found to be in compliance with all applicable international shipping conventions, U.S. regulations and Classification Society rules.

b. The engineering plant on the ***EL FARO*** was well and properly maintained and in good operating condition, at the time of the incident.

c. The engineering department personnel on board the ***EL FARO*** were fully credentialed, as required by law, highly experienced and competent.

d. Tote exhibited a high level of cooperation and openness with the USCG and ABS regarding deficiencies on board the ***EL FARO,*** in the years leading up to the incident.

e. The ***EL FARO*** did not lose electrical power until just moments before the vessel sank.

f. The loss of propulsion was caused by the loss of lubricating oil pressure to the main engine. This loss of lubricating oil pressure, and the inability of the crew to restore propulsion, were likely due to the extreme list, trim and motion of the vessel.
    i. Main Engine Lube Oil System- Description & Operation
    ii. Main Engine Lube Oil levels
    iii. Main Engine and Turbo Generator Sump Configuration and Construction
    iv. Effects of List & Trim on Main Engine & Turbo Generator Lube Oil System Operations

v. Likely Efforts of Engineering Personnel to Restore Lube Oil Pressure/ Propulsion
vi. Possible Reasons for the Continued Loss of Propulsion

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2. Methodology and Basis for Each Opinion

a. The *EL FARO* was a Fully and Properly Certificated Vessel. In order to remain certificated, the vessel was frequently attended and inspected by the Flag State and Class surveyors (of the United States Coast Guard and the American Bureau of Shipping, respectively) and was found to be in compliance with all applicable international shipping conventions, U.S. regulations and Classification Society rules.

I reviewed the following: USCG Inspection records and ABS Class records for the vessel, 2006 through August of 2015. I also reviewed NTSB interviews of USCG Inspectors and ABS Surveyors, who had conducted inspections and surveys on board the ***EL FARO.*** My review confirmed that all Flag State and Class documentation and certification were in current and in good order.

An annual Alternate Compliance Program (ACP) oversight examination to verify the continued validity of the vessel's USCG Certificate of Inspection was conducted on March 6, 2015. The USCG Lead Inspector had over 22 years of experience inspecting ships. He is one of the USCG's Marine Inspection Training Officers. Marine Training Officers are responsible for training new Coast Guard marine inspectors. He led a team of four USCG inspectors who examined the vessel. The team was highly experienced. In his testimony, the lead inspector referred to this highly experienced group of ship inspectors as their "A team". The machinery inspector had 27 years in the Coast Guard. The inspection report indicates that all systems, including all engineering systems (which include the main propulsion and related systems) were inspected and found to be "satisfactory". At the conclusion of this examination, the vessel was confirmed to be "**fit for route and service**" by the U.S. Coast Guard.

- Review of vessel's ABS class records indicate that there were no outstanding deficiencies relating to any equipment critical to the propulsion of the vessel. The vessel had completed Annual Hull and Annual Machinery Surveys in February of 2015. Boiler Survey- Water Tube Boiler had been completed for both the port and starboard boilers in December of 2013.

- All vessel USCG and Class certifications and documentation were current, with no outstanding deficiencies. There are no "Conditions of Class" or outstanding USCG 835's involving any critical equipment related to vessel propulsion.

Note: *The USCG Activity Summary Report for the* ***EL FARO*** *can be found in Appendix 5 of this report***.**

Note: *The ABS* ***EL FARO*** *Attendance History Report can be found in Appendix 4 of this report.*

b. The engineering plant of the *EL FARO* was well and properly maintained and was in good operating condition, at the time of the incident.

I reviewed the following: ABS Class records for the vessel from 2006 through August 2015, the vessel's planned maintenance system (AMOS), dating from December 2013 through August 2015, and the Engine Room Log Books from December 2013 through August 2015. Service reports for the starboard boiler and the turbines and reduction gears were reviewed. I also reviewed various email correspondences related to planned and unplanned maintenance between the vessel's Chief Engineers and TOTE's shoreside engineering support staff. This includes the inspection report made by Walachek Industrial Marine, Inc. (Walachek), pertaining to the inspection of the ***EL FARO*** 's starboard boiler conducted in September 2015.

My review revealed the following:

- This review of the vessel's maintenance system (AMOS) over a period spanning from 2013 through September 2015 indicates that the vessel's propulsion equipment is well and properly maintained. Maintenance items on all critical engineering equipment were up to date and in my review of these records, I did not find any scheduled or unplanned maintenance items to have been neglected, deferred or overlooked.
- Deficiencies affecting the operation of vital equipment, such as the boilers were identified. Those deficiencies that could be safely corrected by ship's force, while the vessel remained in operation, were corrected. Outside support was utilized when repairs or maintenance were outside the of the normal capabilities of the ship's force.
- The observations and recommendations in the Walachek boiler inspection report documented the condition of various components of the starboard boiler. These conditions affected boiler efficiency. These conditions, as documented in the inspection report, did not, and would not, adversely affect boiler safety or reliability. The Walachek report confirmed the findings of the vessel's engineers from their previous observations of the boiler operation and their numerous documented fire side inspections. The boiler efficiency was degraded, due to a reduction in the quality of combustion in both boilers. This lower quality of combustion resulted in

heavy soot deposits on the boiler tubes and in the gas paths. It also resulted in some slag build up on the furnace floor. A major cause of this degraded combustion was the condition of the burner throats. The geometry and condition of the burner throats significantly affect the quality of combustion. The function of the burner throat is to provide proper shape to the flame and allow for the proper mix of fuel and air to achieve optimal combustion. Over time, burner throats tend to break down and lose the geometry required to achieve optimal combustion. If there is a degradation of the burner throats, the quality of combustion suffers which results in more soot deposits and unburned fuel that falls to the boiler floor unburned, creating slag deposits. The conditions observed and the repairs recommended by Walachek are, in my experience, typical routine maintenance items for marine boilers.
Based upon documentation, the burner throat repairs were being scheduled for the November 2015 ship yard period along with the removal of slag from the boiler floors and the clearing of the boiler gas paths. Other issues noted in the Walachek report were to be further evaluated and addressed after the vessel transited to the West Coast. In my opinion, none of the conditions documented in this survey report affected the reliability and safe operation of these boilers.

- The vessel operated under an approved Safety Management System (SMS), which includes an ABS approved Preventative Maintenance System (PMS). TOTE utilizes AMOS for implementing its PMS system. ABS completed a "Confirmation of Compliance- Management Systems- SQE and an ISM Initial Audit- SQE on July 29, 2014 indicating that the vessel's PMS system, AMOS, is an approved system and that the vessel is properly utilizing the system. PMS programs are routinely reviewed by attending ABS surveyors.

- My review of the vessel log books, with dates ranging from December 2013 through August 2015, indicated that the boilers and the main engines operated reliably and without failures during this period. The vessel experienced no blackouts. They did experience one loss of propulsion. This event was caused by a valve on the main engine lube oil system being closed, inadvertently, by an unlicensed crewmember. This caused the main engine throttle to trip due to low lube oil pressure. The cause of the loss of propulsion was operator error on the part of a new unlicensed crewmember and was not caused by any equipment or system failure. This loss of propulsion incident was properly reported to the USCG. It was also reported to the appropriate TOTE shoreside personnel and properly addressed in accordance with TOTE's Safety Management System.

- Off duty Chief Engineer, Mr. James Robinson, who had departed from the vessel on September 22, 2015, was asked in an NTSB interview whether he had noticed, any problems with the boilers, turbo generators, emergency generator or main engines, before he disembarked from the vessel. He replied, "*Nothing that wasn't normal routine, I mean, steam ships there's always little things come up that, you know, nothing, it was nothing show stopping. It was just regular wear and tear, you know, and changing out a pump motor on one of the contaminated. But, I mean,* ***nothing that would affect the propulsion or anything***."

- In his 8/18/15 Turnover Notes, Chief Engineer Robinson reported that the lube oil analysis report on the strut had been coming back with high tin readings. To manage the situation, he had been flushing the system every couple weeks by draining 10-15 gallons, and continued monitoring the condition more frequently. If necessary, the condition would be addressed in the upcoming shipyard visit. (MBI Ex. 130, p.16). I consider this approach to have been reasonable and following normal and good marine practice. It should be noted that the lubricating oil system for the strut bearing is completely separate from and independent of the main engine lube oil system. In my opinion, the presence of tin in the strut bearing lube oil samples played no role in the loss of the propulsion.

- He was also asked whether he was subjected to any pressure from the company in terms of deferring maintenance, or if he was given support. His reply to this was,

  > "***the support was great*** *on that. I mean, whatever the shortest time period, you get whatever you needed. If you didn't have it on board, you put in an emergency req (requisition) and as soon as the vendor can have it or whatever, it's there.*"

- The vessel's Port Engineer, Mr. Tim Neeson, who sailed as an oceangoing engineer for 28 years and held an unlimited Chief Engineer's License for both steam and motor vessels, was asked about the company's responsiveness to his requests to get maintenance completed. His response to this question was,

  > "***Very good. They never hamstrung me in any way to save money or save time or, you know, maintain the schedule. If we need to fix it, we fix it. So, they are very good about that."***

c. The engineering department personnel on board the *EL FARO* were fully credentialed, as required by law, highly experienced and competent.

The engineering complement on board the EL FARO consisted of eleven men. There were six engineering officers and five unlicensed members of the engineering staff. Each of these men held current US Coast Guard issued licenses and/ or credentials necessary to hold their respective positions. Each of these licenses and credentials were in good standing at the time of the incident. There is no record, that I have reviewed, and no records that have been presented during the course of the USCG/ NTSB ***EL FARO*** investigation that indicate that there are any current or past disciplinary actions against the US Coast Guard licenses or credentials of any of these men. In addition to these eleven men, an off- duty chief engineer was on board acting as the supervisor of the Polish riding gang.

I reviewed the personnel files of each of the five engineering officers. The records indicate that the ***EL FARO*** was staffed by a competent engineering group who had a significant amount of experience operating vessels with steam propulsion, a significant amount of time on Ponce Class[1] vessels and a significant amount of time on board the ***EL FARO.*** Each of the engineers on board had evaluations on file from previous engagements on board the ***EL FARO*** and other Ponce Class vessels. These evaluations ranged from good to excellent with a significant amount of evaluations being “Very Good” to “Excellent”.

At the time of the incident, the ***EL FARO*** had a Chief Engineer and an off- duty Chief Engineer on board. The off-duty Chief Engineer was on board supervising a riding gang. He is identified on the VDR transcript as “Sup 1”. Each of these men had a vast amount of experience on Ponce class steam ships dating back to 2008 and both had extensive experience on the ***EL FARO.*** Commentary contained in the Chief Engineer’s past evaluations indicated that he had a great knowledge of steam plants and that he possessed “troubleshooting” skills.

I also reviewed the evaluations on file for the off- duty chief engineer. These evaluations indicated that he was a highly competent engineer. Some of the commentary, included:

- *“He had several **plant emergencies** and handled each of them professionally”*
- *“Jeff is the best first engineer I have worked with since I became C/E.”*
- *“He understands the engine room and its machinery and **can diagnose pretty much any mechanical problem that arises.**”*

TOTE crewed this vessel with an experienced and highly capable engineering staff that was very familiar with their vessel. There was also an additional Chief Engineer on board supervising a riding gang who was highly experienced and extremely capable. I do not believe that it is likely that the decision making and actions of this group negatively affected the outcome of this incident. To the contrary, I believe that it is likely that this group did everything the could to avert the final outcome from occurring.

d. TOTE exhibited a high level of cooperation and openness with the USCG and ABS regarding any deficiencies on board the EL FARO, in the years leading up to the incident.

I reviewed the transcripts of NTSB interviews of USCG and ABS inspectors who had attended the ***EL FARO*** for inspections and surveys in recent years. It is my opinion

[1] The ***SS EL FARO*** (originally named the ***SS PUERTO RICO*** and later the ***SS NORTHER LIGHTS***) was one of a series of ten Ponce Class trailerships built by Sun Shipbuilding & Drydock Company in Philadelphia, Pennsylvania. The ***SS EL FARO***, built in 1974, was the seventh Ponce Class Vessel to be delivered. Same class vessels have the basic same design, however, the design tends to evolve with each new vessel, so each vessel in a class of vessels will be different. The ***SS EL YUNQUE*** was also a Ponce Class vessel.

that TOTE showed a high level of cooperation and openness with both the USCG and ABS regarding vessel operations, repairs and deficiencies.

The USCG Lead Inspector from San Juan had conducted inspections on board the ***EL FARO*** in 2011, 2013 as well as in 2015. He was asked the following question in his interview by the NTSB;

> “*So in the history that you have and the experience that you have working with TOTE and working with all the crews in all the vessels in the entirety of the system, do you think that the safety culture is superior or average? What’s your overall take on the operations, the support that you've received, the safety management system and the entirety of the company's support and management support efforts?*

> He Replied;

> *“Everything I've seen over the years* ***they have a very good safety culture. It seems like they really take pride in it****. If there would have been a problem, if they have any issues, they call us and let us know. Or they have scheduling of exams. They're always good about scheduling exams. We've never really had any issues with them in that regard. And if there's a problem with them, they let us know.”*

- The USCG Inspector also recounted that TOTE contacted USCG, San Juan, when they were conducting boiler maintenance and request permission to transit on one boiler. They would take an extra tug, in these cases, for safety.
- The vessel experienced a loss of propulsion, on March 14, 2015. The vessel self-reported this incident to the USCG by submitting the required USCG2692 form. (The cause was investigated and determined to be operator error.)

This speaks highly about TOTE’s management of their vessels. It also speaks very highly of their company and vessel safety cultures.

e. The *EL FARO* did not lose electrical power until just moments before the vessel sank.

I reviewed the VDR transcript, the VDR data and vessel drawings and plans. My review of this information leads me to conclude that the vessel did not lose power (i.e. lose the plant) until approximately 0734 on October 1, 2015.

- One of the VDR data inputs is labeled “VDR Power AC”. There is one readout per second in this column throughout the entirety of the recording. There is an indication of “OK” when AC power is present or an indication of “NOT_PRESENT”, in the case that AC power is lost.

- In the case of a blackout during the voyage, in which power is lost, the "VDR Power AC" would have indicated, for some period of time, "NOT_PRESENT". The Emergency Diesel Generator (EDG) would then have started, come on line automatically and restored electrical power to the emergency switchboard. This process of starting, coming up to speed and automatically restoring power takes approximately fifteen seconds. Thus, had such a loss of power occurred during the voyage, there would have been approximately fifteen data points indicating "NOT PRESENT" in the "VDR Power AC" column of the VDR data extract indicating that there was no AC power available during that period. However, there is no such indication of loss of AC power at any point in the recording until 07:34:09 on October 1, 2015.

There are conflicting statements recorded on the VDR transcript regarding whether the vessel lost propulsion or experienced a blackout. The VDR transcript records the Captain as stating, "I think we just lost the plant." This was at 0613 on the morning of October 1st. The expression, "lost the plant", is commonly used on board ships to describe a condition in which a vessel has lost electrical power. It is interchangeable with the term, "blackout". Based upon the totality of the evidence, I believe that the Captain misspoke here and incorrectly equated the phrase "lost the plant" with "lost propulsion".
In addition to the concrete evidence in the VDR data discussed above, which demonstrates that the vessel did not lose electrical power in the hours preceding the loss of the vessel, there is other evidence that the Captain misspoke when he stated that they lost the plant:

- Had the vessel experienced a black out/ loss of electrical power, there would be no need to say, "I think we lost the plant.". The Captain, and everyone present, would have immediately experienced the loss of all lighting on the bridge. Had the vessel lost the plant, it is my opinion that the Captain would have had no reason to speculate, "**I think** we lost the plant", but instead would have said, "We lost the plant" or "We had a blackout".

- There was also a lack of audible alarms evident on the VDR transcript immediately following the Captain's statement. The radars, steering gear, gyrocompass, GMDSS and other bridge equipment would have lost power and gone into an alarm state. These audible alarms would also have been evident on the VDR recording. Multiple alarms are recorded when the VDR data indicates a loss of AC power at 0734, These same alarms would have sounded and been recorded at 0613, had there been a blackout/ loss of electrical power.

- In addition, after a blackout, there would undoubtedly be a greatly heightened level of activity on the bridge involving the Captain, Second Mate and the AB. This would include activities such as silencing the numerous alarms that would have been sounding, restarting radar units, gyrocompasses and other equipment. This situation is one that rarely has to be dealt with and it would be expected that significant discussions regarding the situation and how to proceed would have occurred between the Captain, the Second Mate and the AB. However, no discussions relating to a blackout were evident on the bridge during this period.

- Furthermore, there is no conversation recorded on the bridge during this period regarding flashlights. Flashlights would have been a concern for, at least, the 15 seconds until the EDG came on line and emergency lighting was restored.

- The level of concern of the Captain, Second Mate and the AB, as indicated in the recording at this point, is not consistent with the level of concern that would have been expected had the vessel lost power, particularly in a hurricane. Again, there is no conversation recorded that indicates that a blackout occurred. Instead, the subsequent conversations on the VDR transcript were focused on exposing and securing the scuttle, addressing the vessel's list and restoring lube oil pressure and main propulsion. There is no recorded discussion of the loss of or restoration of electrical power.

- There was also no indication from recorded conversation or recorded background noise that the EDG came on line. The EDG is located on the Cabin Deck, three decks below the bridge. The EDG emits a loud, high pitched whine when its starting motor is engaged during start up and it is loud when it is running. In my experience, on this class of vessel and other vessels, the noise from the EDG, when brought on line, is audible throughout the house, including on the bridge. The vibration of the EDG can be also felt throughout the house and on the bridge. Thus, in my opinion, the sound of the EDG starting and running would have been evident on the VDR recording. I also believe that conversation on the bridge would have recorded of bridge personnel anticipating the EDG starting and then reacting to the EDG starting and emergency lighting and power being restored. However, no such conversations or sounds were evident on the VDR transcript.

- Additionally, at 0624, the Third Assistant Engineer reported to the Captain that he was pumping ballast and pumping the cargo hold bilges. This is eleven minutes after the Captain said that he thought that they had lost the plant. I estimate that it would take 10 minutes, at a minimum, to crossover the emergency diesel generator to the main switchboard. This would leave approximately one minute for starting two bilge and ballast pumps, establishing flow between the port ramp tank and the starboard ramp tank and establishing suction on the cargo hold bilges. Had there been a blackout at 0613, there would not have been enough time to get both of these pumps running. Additionally, after a blackout, there are numerous critical things that have to be done to stabilize and restore the plant and there is a limited number of engineering crew available to do them. Restarting the plant is normally an "all hands" operation. It is debatable whether, or not, the Chief Engineer would have directed the Third Assistant Engineer to restart the bilge and ballast pumps at this time. It is also debatable whether the Chief Engineer would run two bilge and ballast pumps along with all of the pumps and fans required for restarting the plant. The EDG did have the capacity to power all of these pumps and fans. However, EDG's are not often run under heavy loads during testing. I would question the Chief's comfort level with putting additional load on the EDG during a crisis situation. The critical task at that time would have been to get a fire in a boiler and restore electrical power and then propulsion.

- Also, at 0634, the Chief Mate asks if the radar had been secured. The Second Mate replied that she thought that it had gone out on its own or due to a wet array. Had there been a blackout, there would have been no doubt about why the radar had gone out and no reason to ask if the radar had been secured. Instead, it would have been obvious that the radar had gone out during the power outage, had a power outage occurred. And, had a power outage occurred, the radar would have had to have been restarted by someone on the bridge. In addition, the radar images recorded on the VDR do not show any discernable outage until approximately 0734.

- Had the vessel "lost the plant" in the final hours of the voyage, it is my opinion that the Master would have displayed more distress in his phone messages and conversations, due to the severity of the situation. Restarting a steam plant, after losing electrical power, is a difficult and time-consuming process in the best of circumstances. They were not having any success pumping the cargo hold and correcting the list with the plant on line. Had the vessel experienced a blackout, the Captain would have immediately recognized that the situation was dire and relayed that to Captain Lawrence during the phone call he had with him.

- There is further evidence that when Captain Davidson used the phrase, "lost the plant", he was actually referring to a loss of propulsion. Specifically, in his phone conversation with Captain Lawrence at 0707, on October 1, 2015, the Captain states, "the engineers cannot get lube oil pressure on the ***plant*** therefore we have no **main engine**." The use of the word "plant" in this sentence indicates that the Captain is referring to the main engines as the "plant".

The timeframe in question is between 0613 when the Captain states that he thought they lost the plant, and 0644, when the Captain announced that they had "RPM's", which indicates that a boiler (or both boilers), a turbo generator (or both turbo generators) and the main engine were on line at this time. Had there been a blackout, identifying and correcting the cause of the blackout (most likely lube oil level in the turbo generator sumps) and restarting the plant (as described in the paragraphs above) would likely have taken longer than 31 minutes, even with all engineering hands available and every step going as well as possible. One Third Assistant Engineer was engaged in bilge and ballast pumping operations, according to the VDR transcript. This would have removed one vital engineering team member away from the plant re-starting operations. My opinion, that the timeframe (0613 to 0644) was an insufficient amount of time to accomplish all of these tasks, was shared by Mr. James Robinson, the ***EL FARO 's*** off- duty Chief Engineer who was interviewed by the NTSB, on October 8, 2015. When asked about the possibility of running a bilge pump, in the given time frame, had the vessel suffered a black out, Mr. Robinson replied that, "…**they still had their power because it wouldn't have had time to back feed, swing the plant, back feed and establish power to the main…**"

The lack of supporting evidence of recorded conversation; back ground noise and alarms that should have been present (had there been a blackout), the short time between losing the plant and restoring propulsion, the fact that at least one key engineering team member was engaged in tasks other than restarting the plant, bilge and ballast being pumped at 0624 and the Captain's use of the word, "plant" when referring to the main engine, all lead me to the opinion that the vessel did not lose power- it lost propulsion. The VDR data indicating that AC power was available and uninterrupted from the beginning of the recording until 0734, on October 1st, validates this opinion.

The captain also made two references to the engineers "'getting that boiler back on line." These statements were made at 0633 and 0634. It is possible, though not likely in my opinion, that, at the same time the vessel lost propulsion, one of the two boilers tripped off line. Losing one boiler would not have resulted in a blackout, as the remaining boiler would still have been supplying steam to the ship service turbo generator. Additionally, the loss of one boiler would not result in a loss of propulsion. While this scenario is possible, it is my opinion that the Captain is again misspeaking, using the word "boiler" in place of "main engine."

- Considering the number of serious problems that the engineers were facing during this period, including the loss of propulsion resulting from the inability to maintain lube oil pressure (due to vessel list), the severe list itself and continued flooding of the vessel, it is likely that a tripped boiler would only be secured and dealt with after the other, more critical, aspects of the situation had been stabilized. It is doubtful that precious time and resources would have been diverted from the several critical problems they were facing. At this point in the voyage, correcting the list and restoring lube oil pressure and propulsion would have, in my opinion, taken precedence over getting a single boiler back on line.

- The vessel can operate normally with one boiler in service. One boiler can supply steam to the turbo generators to maintain electrical power at the same time providing steam to the main engine for vessel propulsion. It is not highly unusual for a vessel to complete a transit on one boiler in order to complete repairs or for other operational considerations. This was the case, earlier in 2015, when the voyage from Jacksonville to San Juan was completed with one boiler out of service to accommodate the survey of the port boiler by Walachek.

- According to the USCG Lead Inspector, the ***EL FARO*** had requested and been granted permission to sail on one boiler on three separate occasions in 2015.

- In the case that one boiler had tripped off line and the engineers were attempting to restart it, the engineers would have opened the super heater vent line on that boiler. When these vents are opened at full boiler pressure a loud, high pitched noise is audible throughout the house, including on the bridge. When the superheater vent valve is then closed.

The sudden stoppage of this high-pitched noise is also very noticeable from within the house. However, noise from a boiler superheater steam vent was not evident on the VDR transcript. Nor were comments regarding the superheater vent recorded on the VDR, as would be expected had the vents been opened.

f. Loss of Propulsion was caused by the loss of lubricating oil to the main engine. This loss of lubricating oil pressure, and the inability of the crew to restore propulsion, were likely due to the vessel's extreme list, trim and motion of the vessel.

I reviewed the VDR Transcript, VDR Data, MBI testimonies, vessel lube oil system drawings and manuals, MBI Exhibits 323 and 412, the NTSB Engineering Factual Report, Engineering Group, the NTSB Engineering Factual Report and the Joint Response to the USCG MSC Technical Reports submitted by the Parties in Interest. I also surveyed the lube oil system on the ***SS EL YUNQUE***.

The vessel was built in accordance with the 1973 ABS Steel Vessel Rules (SVR's). The vessel's lubricating oil systems were designed and constructed to comply with ***Rule 36.65 Lubricating- oil Systems***, which states the following:

"*The lubricating systems are to be so arranged that they will function satisfactorily when the vessel is permanently inclined to an angle of 15 degrees athwartship and 5 degrees fore and aft. The lubricating-oil piping is to be entirely separated from other piping systems".*

Based upon my review of available information, it is my opinion that the main engine lubricating oil system was in compliance with the 1973 Steel Vessel Rules, as stated in paragraph E-5 and E-6 of the Joint Response to the USCG MSC's Technical Reports Concerning the ***EL FARO*** Stability and Structures. Modeling presented in this Joint Response and in MBI Exhibit 323. Lube Oil System Visualization confirms this opinion.

I agree with the statement, made in paragraph E-6 of the Joint Response, that the "worst case scenario" for the main engine lube oil system would be a combination of port list and forward trim. This "worst case scenario" is confirmed by the main engine sump modeling in MBI Exhibit 323.

Rule 36.5 of the 1973 SVR's considers only static operating conditions. The available evidence indicates that the vessel was operating in conditions that were in excess of the conditions described in Rule 36.5. The vessel was experiencing a sustained port list that was reported to be fifteen degrees. Due to the weather conditions and sea state, at that time, the vessel's motion, pitching and rolling, would have been significant. The combination of the sustained list and the vessel motion would create conditions that were well outside of the operating conditions listed in Rule 36.5.

My review of the VDR transcripts and data reveals that the vessel lost propulsion at approximately 0656, on October 1, 2015, after the vessel completed a turn to the port, with the purpose of putting the wind on the vessel's starboard side to heel the vessel over to port to allow access to and the securing of an open scuttle on Second Deck. The information reviewed also indicates that this loss of propulsion was caused by a loss of lube oil pressure to the main engine and that this loss of lube oil pressure was caused by the inability of the main lube oil pumps to maintain lube oil pressure, due to a, sustained, severe port list in conjunction with vessel pitching and rolling that was, likely to have been, severe given the weather conditions at that time and place.

i. Main Engine Lube Oil System- Description & Operation

Two 450 gallons per minute positive displacement pumps supply lubricating oil pressure to the main engine. These pumps take suction through an 8-inch suction line that runs from suction side of the pumps through a duplex suction strainer into the main engine sump.

During normal operation, one pump is in operation and one pump is in the standby mode. Lube oil pump discharge pressure is generally around 60 PSI. After the lube oil travels through the discharge strainer and main lube oil cooler, the main lube oil discharge piping splits. One line supplies lube oil to the lube oil gravity tank. The other line supplies lube oil pressure to the main propulsion unit (reduction gear and turbines) through an orifice. The orifice is sized to reduce the lube oil pressure to the main turbine and reduction gears to 12 psi. The standby pump will start upon either a loss of power to the primary pump or if lube oil pump discharge pressure drops below the standby pump pressure switch set point (typically 45 PSI).

The lube oil gravity tank provides emergency lubricating oil to the main propulsion unit, in the case that lube oil pump pressure is lost. Lube oil flows down from the gravity tank to the main propulsion unit lubricating system, providing lube oil pressure to the main propulsion unit which allows time for the main propulsion unit to be stopped. This prevents catastrophic damage of the gears and bearings which would result from the rotation of the turbine and reduction gear without lubrication. The lube oil gravity tank holds approximately 3200 gallons when the system is in operation. Upon loss of lube oil pump discharge pressure, the oil from the gravity tank drains down and supplies lube oil to the main propulsion unit. The main engine throttle trips when the oil pressure to the main unit drops below 4 psi. In my experience, the lube oil in the gravity tank will provide lube oil pressure to the turbine and reduction gear for approximately 8 to 12 minutes before the main engine throttle trips.

ii. Main Engine Lube Oil levels

Engine room log book entries for the year preceding the incident indicate that the main engine lube oil sump level was generally maintained at 25 to 26 inches. Oil was added when the sump level reached approximately 23 inches. The last available engine room log entry for main engine sump level indicates that the sump level was 26 inches at 1200 on September 1, 2015.

Information was presented during the MBI investigations using CargoMax to determine main engine sump levels. In my experience, CargoMax provides an unreliable record of the levels of various tanks in the engine room and should not be relied upon to perform any type of analysis of engine room tank levels. The volumes of liquids in most engine room tanks change very little over time and these changes are, in relative terms, insignificant in calculating vessel stability. As a result, the record (of engine room tank levels) maintained by the Chief Mate in CargoMax is not maintained with the same level of precision and regularity that the engine room logs are maintained. Chief Mates often use the same numbers repeatedly, or estimate tank levels without confirming them with the engineers or verifying them using engine room records, because they generally change very little over time and because the changes that do occur in the various tank levels have an inconsequential impact on vessel stability.

Additionally, lube oil sump the volume reported, in the CargoMax Departure Trim & Stability Summary- JAX Final (MBI Exhibit 059), was 163.8 ft^3, which equates to 1225 gallons and a sounding of approximately 24.6 inches. This was the sounding used in the USCG Lube Oil System Visualization (MBI Exhibit 323). This volume appears to be based on a liquid with a specific gravity of 0.927. The ***EL FARO*** used Chevron GST Oil ISO 100 in its main engine and turbo generator sumps. The API gravity for this lubricating oil is listed as 31.4 (which equals a specific gravity of 0.8686). The specific gravity of this lubricating oil is listed as between 0.86 and 0.87 on its Material Safety Data Sheet (MSDS). If the correct specific gravity is used, the 4.2 long tons, recorded as the weight of the lube oil in the main sump (final departure from Jacksonville), would equate to 1300 gallons and a sounding of 25.5 inches. In my opinion, because CargoMax does not provide an accurate record of main sump levels and main engine lube oil sump levels change very little over time, the sounding of 26 inches, recorded at 1200 on September 1, 2015[2], is likely the most reliable.

A former ***EL FARO*** chief engineer testified, on February 8, 2015, that his recollection, from his time on board the ***EL FARO***, was that he kept the oil level between 28 and 32 inches and that he would raise the sump level to 32 inches depending on the weather conditions. I worked for, approximately, fifteen years on board numerous steams ships with propulsion systems similar to the ***EL FARO*** (including time on board the ***EL FARO*** (then called the ***NORTHERN LIGHTS***) and the ***WESTWARD VENTURE***, which was also a Ponce Class vessel. Raising the sump oil levels above the recommended operating level for weather related reasons was not a policy on any of these vessels. The same can be said for the motor vessels that I worked on. Running with the oil level above the operating level

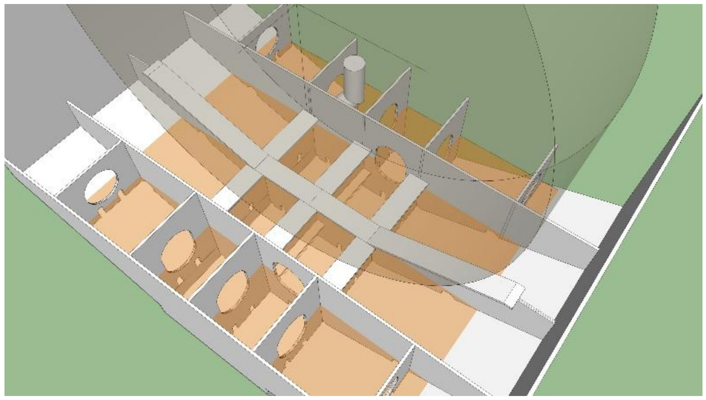
[2] The 26-inch sump level recorded on the engine on September 1, 2015 at 1200 is the last engine log book entry, relating to the main engine sump level, that was available to the investigation.

recommended by the manufacturer, in rough weather, could result in churning and frothing of the lube oil from contact with the bull gear. In the case of the ***EL FARO***, the sump high level alarm was set to alarm at 33 inches. Raising the sump level to 32 inches would cause the high level to be activated constantly and repeatedly in rough weather.

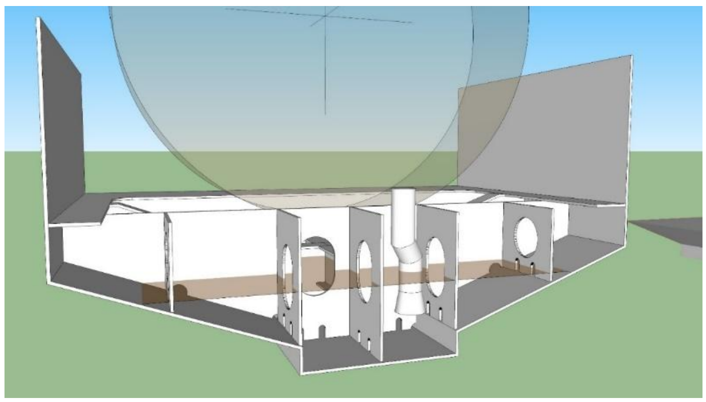
iii. Main Engine and Turbo Generator Sump Configuration and Construction

Main Engine
The sump tank runs approximately 132 inches fore and aft and is approximately 202 inches wide. The sump has a channel running fore and aft on its centerline. The channel is approximately 56 inches wide by 8 inches deep. This channel is flanked on both sides by bottom plating extending from the top edges of the channel to the port and starboard side plating of the sump. The bottom plating slopes down from the side plating to the centerline channel at a 20-degree angle.

The lower section of the sump is heavily constructed with both longitudinal and transverse framing. These frames serve two purposes. The sump structure acts as the foundation for the main reduction gear. The framing gives that foundation the strength it needs to support the reduction gear unit. The framing and bulkheads are also designed to impede the flow and movement of oil, as the vessel pitches and rolls in a seaway, thereby resulting in a more consistent level of oil throughout the tank in heavy seas, particularly around the lube oil suction pipe. The flow of oil is channeled through limber holes in the frames and bulkheads, which slows down the speed and volume of that flow away from the suction bell.



Main Sump Framing looking down and aft from forward port



Main Sump framing looking forward [3]

View of framing and limber holes from port side tank top level inside SS EL YUNQUE main lube oil sump

Lube oil pipe suction bell inside SS EL YUNQUE main lube oil sump

During normal operation, the vessel is trimmed to the stern and the list is neutral. Rolling tends to be, generally, even; i.e. rolling the same amount to the port as to the starboard. The same is true for pitching. The low point in the sump (where the oil level would be the highest) would be in the after end of the center channel of the sump. Flow away from this area is impeded by the internal structure.

However, this structure would have the opposite effect, in the case that the vessel is listing to the port or trimmed down by the head (bow) and/ or "hanging" (not recovering normally from pitches and rolls). The longer the vessel hangs (pauses) at a low point of a pitch and/ or roll, the more oil can flow to that low point and away from the normal low point, in the sump's after end of the center channel, which is where the lube oil suction pipe is located. For example, if the vessel had a port list and was trimmed down by the head (i.e. due to cargo hold flooding), more oil would tend to accumulate, and level out, in the forward, port side of the sump and the oil level near the lube oil suction pipe would be lessened. As the vessel temporarily rolls back towards the starboard and pitches aft, the internal structure would then act to impede the flow of oil back to the lube oil suction pipe. In my opinion, it is likely that this contributed to the loss of lube oil suction.

Turbo Generators
The turbo generator sumps are configured in the shape of an "L". The main section of the sump is 16 inches wide and run fore and aft 122 inches. It is located to the port side of the gear box and turbine (on both the No. 1 and 2 turbo generators) and spans from the forward end of the gear box to the after end of the steam turbine for each generator. The floor of the main sump section is pitched so that the depth of the sump is 12 inches at the port side of the sump and 11 inches at the starboard side.

The after end of the sump (the lower leg of the "L") extends outboard, 36 inches, from the after end of the main sump section. The top of this section aligns with the top of the main sump section. The floor of this section is pitched (downward towards the main sump section) and the depth of this sump section is 6 inches where it connects with the main section and 4 inches at the outboard side. This section is 16 inches wide.

The main sump sections have baffles. These baffles are designed to impede the flow of oil when the vessel is moving in a seaway and to keep oil around the pump suctions.

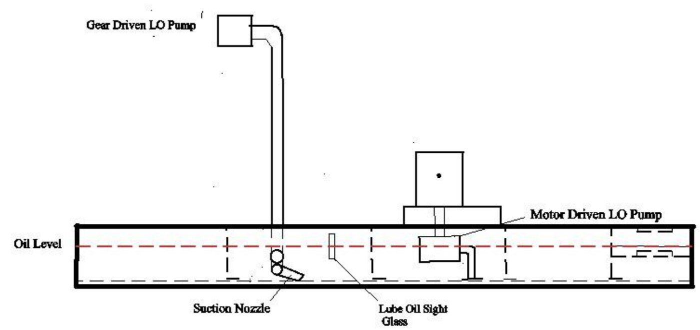
"The main oil sump is an integral part of the sub- base. It contains baffles to allow for pitch and roll in shipboard service."[4]

Each turbo generator is fitted with two lube oil pumps. The main pumps are positive displacement pumps mounted directly to, and driven by, the bull gear of the turbo generator gear box. The pump is located approximately 4 feet 3 inches above the suction nozzle in the sump. The suction nozzle is located at the bottom end of the suction piping inside the main section of the lube oil sumps. The nozzles are conical in shape, ranging in diameter from approximately 1 to 2 inches from end to end over its length of 3 inches. The nozzles are perforated to also act as strainers. The uppermost portion of the nozzle is located 34 inches from the forward end of the sump and approximately at the center of the 16-inch-wide

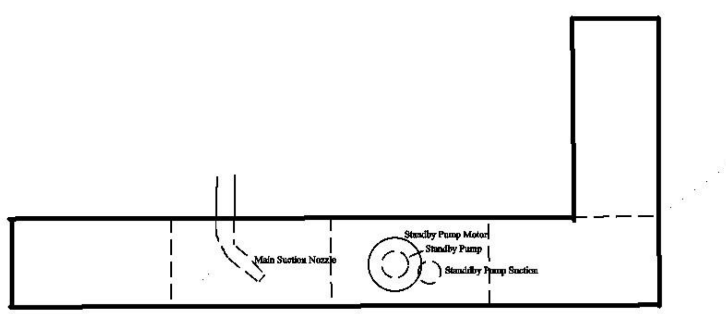
[3] Drawings based upon builder's drawings plus measurements and observations from ***SS EL YUNQUE*** sump inspection. Not all items pictured were measured (as all parts of the sump were not safely accessible), so some dimensions are approximations. The position of framing and bulkheads is according to builder's drawings.
[4] Terry Steam Turbine Technical Manual. Section 5-4

sump section. The top of the nozzle is approximately 3-¾ inches above the bottom of the sump in relation to the inboard side of the sump. The nozzles angle outboard, aft and downward in the sumps. The upper surface of the lower end of the nozzle is approximately 1-½ inches above the sump bottom in relation to the inboard side of the sump. This end of the nozzle is approximately 3 inches inboard (to the port side) of the centerline of the main sump section.

The stand-by pump is an electric motor driven pump rated at 40 gallons per minute which is mounted 74 inches aft of the sump's forward bulkheads. The suction line is submersed and offset by to 2-$^{3/8}$ inches to the port side of the sump's centerlines. The stand-by pump is designed to start when the oil pressure (which is normally between 55 and 60 psi) drops to 34 psi. Turbo generator throttle trips are generally set to trip at 4 to 8 psi.



Turbo Generator Sump View from port side



Turbo Generator Sump Plan (Top) View showing positions of main suction pipe and standby pump motor, pump and suction

iv. Effects of List & Trim on Main Engine & Turbo Generator Lube Oil System Operations

Marine equipment, which is oil lubricated, is required to function in a highly dynamic environment. The 1973 ABS Steel Vessel Rules (SVR's), ***Rule 36.65 Lubricating- oil Systems***, to which the ***EL FARO*** was built, states the following about lube oil systems:

"*The lubricating systems are to be so arranged that they will function satisfactorily when the vessel is permanently inclined to an angle of 15 degrees athwartship and 5 degrees fore and aft. The lubricating-oil piping is to be entirely separated from other piping systems."*[5]

Starboard List
The VDR transcripts indicate that the vessel was, in fact, originally experiencing a significant starboard list, until approximately 0600. The Captain changed course at this time, causing the list to change to port list. The vessel experienced a severe port list from this point until the end of the VRD transcript.

At 0440-0445, the issue of lube oil levels is first discussed on the bridge. First, at 04:40:03, the Chief Mate reports to the Captain that the Chief Engineer "just called…something about list and oil levels." At 04:44:49, the Captain states "…just the list. the sumps are actin' up", to which the Chief Mate responds, "yeah the oil sumps. I understand". I found it unusual that they used the plural, "levels" and "sumps". There is only one main engine lube oil sump or level, and thus the reference to "levels" (*O4:40:33.7 on the VDR Transcript*) and "sumps" (*04:44:49.4 on the VDR Transcript*) caused me to analyse whether the difficulty maintaining lube oil pressure, as reported on the VDR transcript, was related to other equipment – specifically, the turbo generators.[6]

At 0518 the Chief Mate can be heard (possibly) saying that the list was 18 degrees[7] (to the starboard). Conversation recorded on the VDR indicates that the engineers were "having problems with the sumps". In my opinion, if the vessel was in fact experiencing an 18 degree starboard list, or any starboard list, this statement was most likely referring to problems with the turbo generator sumps. The main engine sump level (at the lube oil suction pipe) would have increased due to a starboard list. Main Lube Oil Pump performance would not have been adversely affected by a starboard list. The supernumerary Chief Engineer is recorded on the VDR as saying, "I've never seen it list like this" and, "I've never even seen it hang like this." These comments were made at 0511 and indicate that the vessel was not recovering normally from the rolling or pitching by returning to an even keel

[5] ABS Rule 36.65. Lubricating- Oil Systems (1973)

[6] The Chief Mate is recorded on the VDR transcript (04:41:28.3) as saying, "*can't even see the **(level/bubble)***." This statement was made immediately after the engine room had called the bridge and discussed the difficulties with the list and oil levels. The main engine sump does not have a sight glass like the turbo generators have. The sump is sounded through a sounding tube, using a sounding rod.
Note: The use of parentheses surrounding the words "level/ bubble", indicates that this wording was considered questionable and was not agreed upon by VDR Transcription Group or the group was uncertain.

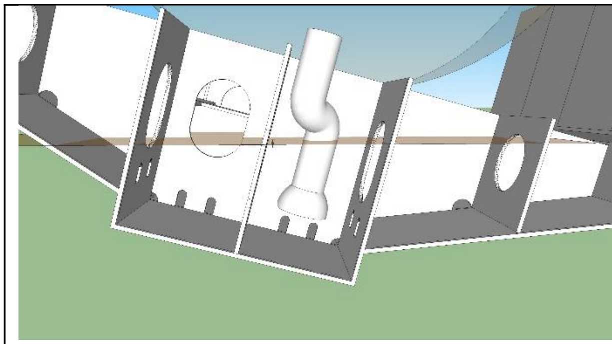
[7] The "eighteen" figure was also transcribed with parentheses around it, indicating the group could not agree to what was said or was uncertain.

position. Instead, the vessel was pitching or rolling to a low spot and "hanging" at that angle longer than was normal for the vessel. Furthermore, turbo generator sump modeling indicates that the oil would not have been visible in the lube oil sight glass, if in fact there was an 18 degree starboard list (with an oil level at the midpoint of the sight glass with a 0 degree list). As previously noted, the vessel did not experience an electrical failure, and therefore the turbo generators (at least one) remained on line during the period that the vessel was experiencing a starboard list. It is my opinion that, if the heel was significant to the starboard, the turbo generator lube oil pressure may, possibly, have dropped below the low-pressure alarm point, but not below the throttle trip pressure, which is normally 8 to 10 psi.

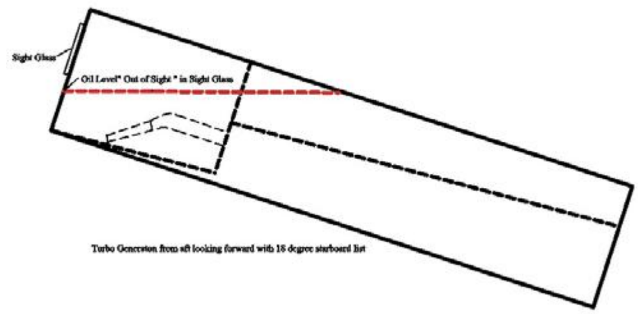
It should be noted that the problems with oil levels mentioned in the VDR transcript, (while the vessel was experiencing a starboard list), were not defined. At 0440, the Chief Mate informs Captain that the Chief Engineer had called and called back again and said, "something about the list and oil levels". Later (at 0444), after speaking with the engine room, the Captain says, "just the list. The sumps are actin' up." These statements may have been referring to any, or all, of the machinery on board that is oil lubricated such as the steering gear pumps, air compressors and refrigeration and air conditioning compressors. Each of these machines have sumps and lube oil sight glasses in which oil may not have been visible, in the case of an extreme heel of the vessel.

My modeling of the turbo generator sumps indicated that the oil level would not have been visible in the sump's lube oil sight glass, if the vessel had an 18-degree starboard list. This may have been the extent of the "problems with lube oil levels" mentioned in the transcripts while the vessel had a starboard list. Operating a generator (or any rotating machinery) with no indication that there is lube oil in the sump is never done (in normal situations). Not being able to verify a lube oil level would have been extremely troubling to the vessel's engineers. It is possible, or even likely, that no problems relating to turbo generator lube oil pressure occurred, such as low lube oil pressure alarms activating and stand- by pumps starting and that the problem was the visual verification of the oil level in these machines.

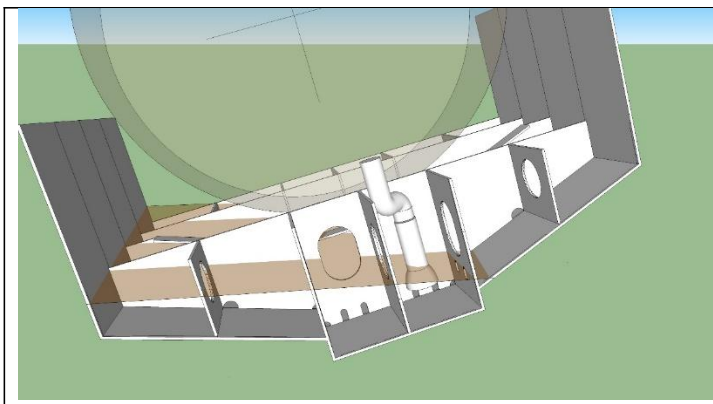
The drawings below illustrate the effect of a starboard list on the lube oil levels in the main engine and turbo generator sumps and the effect of a port list on both the main engine and turbo generator sumps. It also illustrates that the oil levels in the turbo generator would have been out of sight in the sight glass (located on the port, outboard side of the sump) with an 18 degree starboard list[8]



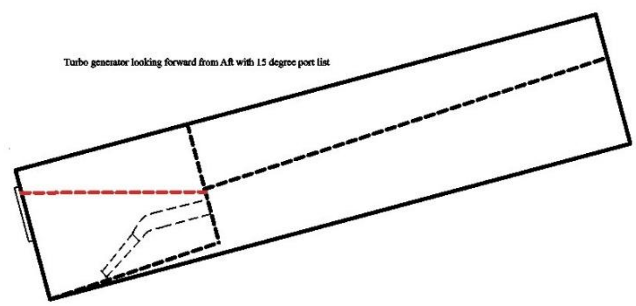
Main Sump viewed from aft with starboard list. Oil level at suction bell increased relative to oil level with zero degree list.



Turbo Generator Sump viewed from aft with starboard list. Oil level decreased over LO pump suction nozzle and oil level not visible in sight glass.



Main Sump viewed from aft with port list. Oil level at suction bell decreased relative to oil level with zero degree list.



Turbo Generator Sump viewed from aft with port list. Oil level increased over LO pump suction nozzle and oil level visible in sight glass.

Note: Modeling of the effect of list and trim on turbo generator sump levels can be viewed in Appendix 2 of this report.

[8] Drawings based upon builder's drawings and observations and measurements taken on board the ***SS EL YUNQUE.***

Port List
The Captain changed course at approximately 0554 and transferred ballast, in an attempt to change from a starboard to a port list. The list changed at this time, from a starboard list to a port list, either due to the turning of the vessel, so that the wind was acting on the starboard side, by transferring ballast from the starboard ramp tank to the port ramp tank or by a combination of the two. The first mention of a port list was at 0557 when the Captain is recorded as saying, “alright we got a nice port list…” The scuttle was subsequently secured and the Captain instructed the Chief Mate to pump from the port ramp tank to the starboard ramp tank at 0611.

The Captain is then recorded as saying, “I’m not liking this list.”, at 0612. This may indicate that the list was worsening and becoming more extreme to port, or the vessel was “hanging” at the low end of the pitching or rolling to port. At 0613, the Captain is recorded as saying, “I think we just lost the plant.”

Due to the positioning of the lube oil suction pipe inside the sump tank, to the starboard of centerline and in the aft part of the tank, any listing to port, trim down by the bow or a combination of the two would tend to reduce the oil level above the lube oil suction bell, while raising the level in other areas of the tank.

The ***EL FARO*** is reported to have been operating with a sustained starboard list, which was reported to be, possibly, as much as 18 degrees (prior to approximately 0557 on October 1, 2015, according to the VDR transcript). During the period that the vessel was operating with this extreme starboard list, operating difficulties were reported, but no equipment failures were noted. After the list changed to the port, the main engine lost lube oil pump pressure and was secured or tripped off line.

The ***EL FARO*** was built in accordance with The 1973 ABS standard, **Rule 36.65 Lubricating- Oil Systems**. The rule dictates design criteria for maintaining the satisfactory operation of lubricating systems in a static condition. Dynamic motions are not considered when applying this criterion. The ***EL FARO*** is reported to have been operating with a significant, and sustained, port list, of approximately 15 degrees (after approximately 0557 on October 1, 2015, according to the VDR transcript). Based upon my review of relevant documents and drawings and upon my inspections and modeling of the ***EL YUNQUE*** main engine and turbo generator sumps, the ***EL FARO*** ’s lube oil systems were in compliance with the above design criteria. In my opinion, this type of extreme and “permanent” list, in combination with the significant vessel motion that would have been experienced in a hurricane, would have resulted in conditions that exceeded the design criteria of the ABS rule.

v. Likely Efforts of Engineering Personnel to Restore Lube Oil Pressure/ Propulsion

After the vessel’s list was changed to the port, the oil in the main engine sump would have begun to migrate towards the new low point of the sump. Though it was not indicated in the VDR, it is my opinion that the trim of the vessel was likely changing down to the bow, due to the flooding in the cargo holds. The migration of oil would have been to the port, forward section of the sump and away from the lube oil pipe suction bell. When the oil level, in the area of the suction pipe, reached a level that exposed the suction bell to air, or low enough that that a sufficient amount of air was being drawn into the pump suction through the surface of the oil, the pump would become air bound, pump discharge pressure would drop below the set point for the stand-by pump and the second main lube oil pump would have started. The second pump would not have gained suction, due to the lube oil level in the sump. The main lube oil pump discharge pressure alarm on the engine room console would have sounded, alerting the engineers. The flow of oil through the "bulls- eye"[9] would also have stopped, confirming that there was no lube oil pump pressure and the lube oil gravity tank was now supplying lube oil to the main reduction gear and turbines.

It would have been critical, at this point, to stop the main engine and shaft from turning. The rotation of the reduction gear and turbines, without lubrication, would destroy their bearings and permanently disable the propulsion unit, leaving the vessel adrift. To stop the main engine, steam to the ahead throttle would have to be secured. Then, after opening the Astern Guardian valve, steam would be introduced to the to the astern element, via the astern throttle valve to stop the shaft. The shaft has to be stopped before the lube oil supply in the gravity is exhausted, lubrication is lost and the throttle is tripped by the main bearing low lube oil pressure trip, which closes the throttle valve by dumping the hydraulic control oil to that valve.

The jacking gear might be engaged at this point lock the shaft to prevent the resumption of rotation. The turning gear motor would not be started, due to no lubrication.

Certain adjustments to the steam plant would be called for due to the decrease in steam demand, or it would be possible to lose vacuum on the main condenser or lift the boiler safety valves.[10]

Concurrent (ideally[11]) to the securing of the main engine and the adjustments to the steam plant, the lube oil pumps would be secured while the cause of the loss of lube oil pressure was investigated. At this point the sump would be sounded. It is likely that oil would be added to the main engine from the lube oil storage tank. The lube oil purifier is the normal way to add this oil, but it is likely that the direct fill line from the storage tank would be utilized. This fill line is 1 inch at the storage tank level. In my experience, adding oil to an engine through this size of line can be a lengthy process.

The results of the main engine lube oil sump soundings and the determination of the quantity of oil to add to the engine would have been difficult to evaluate, due

[9] A "bulls-eye" is a segment in the overflow piping from the lube oil gravity tank back to the main engine sump. This segment of piping is fitted with glass lenses to allow the verification of lube oil flow in that pipe indicating that the gravity tank is full. The "bulls eye" can be viewed from the engineer's operating platform. The presence of oil flowing through the overflow piping indicates that the lube oil system is functioning and the lube oil gravity tank able to provide emergency lube oil flow to the main reduction gears and turbines, in the case of the loss of lube oil pressure.

[10] When the operating condition of a steam plant is altered, all of its sub-parts must be altered, accordingly, for the plant to stay in balance. Some of these sub-parts are automatically controlled and some are controlled manually. Rapid changes in steam demand; i.e. stopping the steam flow to the main engine, tend to throw a steam plant out of balance. For example, if the fuel supply to the burners is not reduced, accordingly, pressure will rise in the boiler causing pressure relief valves (Boiler safety valves) to open.

[11] The actions of the engineering team are not recorded on the VDR transcript. But, ideally, the lube oil pumps would be shut down to prevent damage from running dry.

to the presence, in the sump, of the additional 3200 gallons of lube oil from the now depleted gravity tank and the motion of the vessel.

Once it was thought that there was a sufficient amount of lube oil in the system to compensate for the vessel's list and trim, a lube oil pump would have to be primed and started, thereby supplying lube oil pressure to the main engine and oil flow to replenish the lube oil gravity tank. Once the gravity tank was confirmed to be full, as indicated by flow through the overflow "bulls-eye", the main engine would be ready for operation.

Prior to readmitting steam to the main turbines, the accumulated condensate in the superheated steam supply and turbines would have to be drained. Admitting wet steam to the turbines could cause catastrophic damage and incapacitate the propulsion system.

After the above items were completed, and the jacking gear was disengaged, steam could then be admitted to the turbines and propulsion regained. The time span from when the Captain said that they had "lost the plant" to when he stated, "you got turns now" was approximately 31 minutes. In my opinion, this was a reasonable amount of time to get the main engine back on line, given the information at hand.

vi. Possible Reasons for the Continued Loss of Propulsion

The vessel appears to have regained propulsion, to some extent, at approximately 0644. Speaking to the AB at the helm, the Captain says, "alright @AB1 you got some turns right now" and proceeds to issue steering commands. However, propulsion was lost again sometime before 0649.[12] In a subsequent phone call ashore, to the vessel's DPA,[13] the Captain stated that, "we have a very healthy port list. T*he engineers cannot get lube oil pressure on the plant, therefore we got no main engine*". Based upon the information available, the cause of the original loss of propulsion was almost undoubtedly, caused by air entering the lube oil pipe suction bell, due to vessel list, trim and motion. There are other failures or deficiencies that could cause a lack of lubricating oil pressure, but the evidence does not support any of these alternative possibilities.

There are questions to which we do not have clear answers: Why did the vessel lose propulsion the second time? And, why were the engineers not able to restore the lube oil to a level sufficient to maintain pump suction? There are a number of possible answers, including:

- The engineers continued to add oil after regaining propulsion, but lost lube oil pressure due to the lube oil pipe suction bell becoming exposed due to extreme vessel motion. In my opinion, this appears to be the most likely scenario, given the weather conditions on scene.

[12] NTSB El Faro Transcript. 06:44:34.1, 06:48:48.1

[13] The DPA (Designated Person Ashore) is a member of the company's management who, in accordance with the Safety Management System, provides a link between the managing company and those on board the vessel and has direct access to the highest levels of management.

- The engineers may not have added enough lube oil to the sump before restarting the engine. They could have added an amount of oil that appeared to be sufficient for continued operation and stopped adding. The time required to repeat the required actions, as described above, would likely have taken until 0720 or later.

  Note: The General Alarm was sounded at 0727 and the Captain gave the order to abandon ship at 0731.[14]

- One or both main lube oil pumps could have been damaged, as a result of running dry (without liquid) for an (unknown) amount of time on two separate occasions. These pumps are positive displacement gear pumps. The oil that they pump acts as their lubrication. Without proper lubrication, the pump's gears or mechanical seals would be damaged. Upon the loss of lube oil pressure, on both occasions, the standby pump would have started. It is unknown how long they were left running. The engineers' first priority, in each of these cases, would have been to take the steps necessary to stop the main engine. They also would have been spread thin dealing with other emergencies. It is possible that one or both of these pumps were damaged beyond operability. It is also possible that the pump used to restart the main engine failed during operation, due to damage it sustained from running dry earlier.

The trim of the vessel was likely worsening (listing more to the port and going more down by the bow) with the ingress of sea water into the cargo holds. This worsening of the vessel's trim could have negated the effect of the lube oil added to the sump and not resulted in an oil level above the lube oil pipe suction bell sufficient for sustained and effective lube oil pump operation.

In his 8/18/15 Turnover Notes, Chief Engineer Robinson included comments regarding the lube oil pumps. (MBI Ex. 130) He noted that the aft lube oil pump discharge pressure, after warm-up, was a few pounds (approximately 3 psi) lower than the forward oil pump. The resulting difference in pressure to the main bearings was approximately 0.2 psi. I find this pressure difference to be insignificant to engine operation and it is not likely that this condition contributed to the loss of propulsion. In the case that either of these pumps had failed, either mechanically or electrically, the other pump would have started automatically (in standby mode) and continued the supply of lube oil to the main engine. Mr. Robinson also noted that he had included as a shipyard item that included the aft pump being rebuilt or replaced with a reconditioned pump from the warehouse and the mechanical seal being replaced on the forward pump. I find this to be consistent with good marine engineering practice.

g. The *EL FARO* 's Cargo Hold Bilge System Was Approved by ABS/USCG and Satisfied (or Exceeded) Applicable Requirements

I reviewed the VDR transcript, reviewed vessel drawings and technical manuals and surveyed the ***EL YUNQE*** and found the following:

[14] NTSB El Faro Transcript. 07:27:16.2, 07:31:18.2

i. Pumping Capabilities

The vessel is equipped with two vertically mounted, centrifugal Bilge and Ballast Pumps, each rated at 850 GPM[15] (195 Long Tons per hour) and one vertically mounted, Bilge Fire and General Service Pump, rated at 575 GPM.

There are several operational factors that will adversely affect the actual discharge capacity (as opposed to the rated capacity) of centrifugal pumps. It is unclear from the evidence whether these operational factors played a role in reducing the actual overall bilge dewatering capacity. For example, these pumps require priming to establish pump suction. Priming is achieved by opening the pump's sea suction valve. This provides sea water at positive head pressure to the suction piping and pump casing, because the pump is located below the water line. This priming water displaces the air in the pump casing and suction piping. Once flow through the pump is established, the amount of priming water is reduced, by closing in on the sea water suction valve. Generally, some amount of priming water is supplied to the pump throughout the course of the pumping operation to try to prevent a loss of suction. The use of priming water reduces the overall bilge dewatering capacity.

Other factors that may degrade the overall bilge dewatering capacity include leaking valve packing glands, wear of the pump's casing, impeller and wearing rings, clogging of cargo hold suction piping by floating debris and the fouling of bilge suction strainers. According to my experience, the bilge suction strainer(s) may also have become clogged (possibly multiple times) given the volume of water being pumped. Cleaning the suction strainer requires that the pump be secured along with the sea water piping. After the strainer is cleaned and reinstalled, the whole process of gaining suction on the cargo bilges needs to be repeated. This can take several minutes.

There does not appear to be any evidence found in the case suggesting that these factors played any role in impeding the bilge pumping process. As a result, I cannot precisely estimate the actual discharge capacity of the ballast system. However, in my experience if one or more of these factors exists, to varying degrees, the actual discharge capacity would be reduced. I would estimate, assuming that there were no major problems with suction pipe being clogged by floating debris or other pumping problems, that the engineers would have been able to dewater the holds at a rate of between 220 and 550 GPM (50 and 125 Long Tons per hour).

ii. Operation of Bilge Pumps - Pumping Cargo Hold 3

The two Bilge and Ballast Pumps are located forward in the lower level of the engine room, one on the port side and one on the starboard. The pumps are connected to suction and discharge manifolds that allow each pump to draw suction from the bilge wells in the cargo hold and to discharge water from those

[15] According to the NTSB Group Chairman's Factual Report- Engineering Group, the Bilge & Ballast Pumps were rated at 950 GPM @ 28.5 PSI. However, Drawing 666-901-1, Arrangement of Machinery Material List, lists the pump capacity for the Bilge & Ballast Pumps as 850 GPM at 30 PSI for Hull Nos. 666 and 670.
NOTE: The ***EL FARO*** was Hull No. 670

cargo holds overboard. These manifolds are also piped so that each pump can transfer ballast between the Port Ramp Tank and the Starboard Ramp Tank. The manifold and piping configuration also allows for normal ballasting and de-ballasting operations.

The Bilge, Fire and General Service Pump can be also crossed over to the starboard suction manifold, to draw suction from the cargo holds. This system can then be used to remove water from the cargo holds and discharge it overboard.

The cargo holds are fitted with bilge wells in the after part of each hold, on both the port and starboard sides. These bilge wells are recessed pockets in the floors of the cargo holds, which serve as suction points to accommodate the removal water from the cargo holds utilizing the vessel's pumps described above. Suction can be drawn simultaneously from multiple bilge wells during dewatering operations.

Pumping the cargo hold would first involve ensuring that the overboard discharge valve at the skin of the ship is open. Based on testimony of various witnesses, this overboard skin valve was capable of remote operation on the second deck, but was normally in the open position.

Next, one of the engineers would open the main bilge suction valve on the pump suction manifold, open the sea suction valve and then start the pump to establish flow. The bilge suction valve, on the pump suction manifold, would then be opened. The sea suction would be throttled down (closed partially) to create a vacuum in the cargo hold bilge manifold. After vacuum was established on the manifold, the suction valve for the desired cargo hold bilge well would be opened slightly to purge the air out of that bilge suction line. Due to the location of the pumps in relation to the cargo hold bilge manifolds, this was most likely a two-man operation, with one man monitoring the pump suction and discharge pressures and adjusting the sea suction and the other adjusting the bilge well suction valve. Due to the short length of suction piping, pumping one bilge well in No. 3 hold would be a relatively simple process. With the amount of water reported in No. 3 hold, it would be expected that the engineers would have been able to pump with the bilge well suction wide open and the sea suction nearly closed. The pumping efficiency would be adversely affected if any debris from the hold blocked the suction pipe or became lodged in the pipe. Suction would have been lost when the list changed from starboard to port, unless the water level in that hold was covering both bilge wells at that time. Had they lost suction upon the change in list, the process would have been repeated on the No. 3 port bilge well.

As noted above, suction can be drawn from one, or both, of the bilge wells in cargo Hold No. 3 (port and/or starboard). Because the vessel initially had a starboard list, it is quite possible the engineering crew were only drawing suction from the starboard bilge well. In such circumstances, one potentially complicating factor is that suction could have been lost when the list changed from starboard to port, unless the water level in that hold was covering both bilge wells at that time. Had they lost suction upon the change in list, the process would have been repeated on the No. 3 port bilge well.

In addition, a bilge alarm sounded in Cargo Hold 2A at 0716, according to conversations recorded on the VDR transcript. Presumably, there was some attempt or effort to pump this cargo hold. The bilge well is approximately 125 feet forward of the cargo hold bilge suction manifold. That is, approximately, 125 feet of 4” pipe full of air. To achieve suction on that hold, all of the air in that length of pipe would have to be sucked out of the suction line. It is likely that suction on No. 3 Port would be lost in the process of getting suction on No. 2A. The captain asks the Chief Engineer about pumping all cargo holds, but the Chief Engineer said, “*if you pump and you catch air, then the whole thing is—“.*

3. Conclusions

My conclusion, based upon all available information, is that the ***EL FARO*** sank due to flooding in the Nos. 2 and 3 cargo holds (and possibly other holds) that exceeded the capacities of the installed cargo hold bilge pumping system. This system was approved by the U.S. Coast Guard and the American Bureau of Shipping. No available evidence gives any indication that this system was not well maintained and operating as designed.

Evidence confirms that the vessel maintained normal and uninterrupted electrical power until moments before the vessel sank. This indicates that the boilers and turbo generators functioned as designed in the severe conditions in the VDR transcript.

The vessel was experiencing a severe starboard list, prior to approximately 0557 on October 1, 2017. References, in the VDR transcript prior to 0557, indicating problems with lube oil sumps and levels were, likely, related to the turbo generators or other oil lubricated machinery. It is not likely that the references made were related to the main engine sump lube oil level.

Main propulsion was lost due to the extreme list and trim of the vessel. This list and trim, along with the severe motion of the vessel exceeded the design capabilities of the main engine lube oil system, which was designed and installed in accordance with ABS Rule 36.65. Lubricating- Oil Systems (1973).

There was no available evidence indicating that improper design or a lack of maintenance of any vessel machinery, (particularly the boilers, turbo generators, main engine lube oil system and the cargo hold bilge system), contributed to the loss of the vessel.

The efforts of the vessel’s engineering team were not documented on the VDR transcript. However, in my opinion, the engineering team on the ***EL FARO*** was highly competent and very familiar with the vessel’s systems and the capabilities of those systems. I believe that every possible corrective action would have been properly taken to restore propulsion and remove the water from the cargo holds, but, ultimately, the extreme conditions exceeded the design capabilities of the vessel’s equipment.

4. Data Considered in Forming Each Opinion:

Opinion a:

EL FARO Certificate of Inspection- Expiration Date February 22, 2016
EL FARO Certificate Documentation- Expiration Date October 31, 2015
USCG ***EL FARO*** Activity Summary Report- 2005 to Present
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Witness Interview – Robinson, dated 2-23-16
Witness Interview - Timothy James Neeson, dated February 26, 2016
Witness Interview - Transcript of Interview of El Faro off duty Ch Engr, dated October 8, 2015
Witness Interview- USCG Lead Inspector, dated October 10, 2015
Witness Interview- USCG Machinery Inspector, dated April 12, 2016
Witness Interview- USCG Rider, dated October 15, 2015

Opinion b:

NTSB El Faro VDR Transcript
Witness Interview – Lee Peterson.MBI.Phase III, February 13, 2017
Witness Interview – Robinson, dated 2-23-16
Witness Interview - Timothy James Neeson, dated February 26, 2016
Witness Interview – 51916 Daddico ROUGH, dated May 19, 2016
Witness Interview – 51916 Larose ROUGH, dated May 19, 2016
Witness Interview – 52416 Hohenshelt ROUGH, dated May 24, 2016
Witness Interview – 52516 [redacted] ROUGH, dated May 25, 2016
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AMOS Overdue Jobs Spreadsheet

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Email string between Matthew Barker, Jim Fisker Anderson, dated September 23, 2015 Subject: FW: El Faro Boiler survey
Email string from EL FARO CE to Tim Neeson to Jim Fisker-Anderson, dated July 29-30/15. Subject: RE: Walashek Boiler Inspection
Repair Quote from Walashek Industrial and Marine, Inc. for work to be completed in November 2015 in Portland, Oregon or Seattle Washington Area
NTSB Group Chairman's Factual Report- Engineering Group. EL FARO DCAMM001

Opinion c:

Personnel File- Mr. Anthony Thomas, Oiler Maintenance Utility
Personnel File- Mr. Dylan Mecklin, Third Assistant Engineer
Personnel File- Mr. German Solar cortes, Oiler Maintenance Utility
Personnel File- Mr. Howard Schoenly, Second Assistant Engineer
Personnel File- Mr. Jeffrey Mathias, Supernumerary Chief Engineer
Personnel File- Mr. Joe Edward Hargrove, Oiler Maintenance Utility
Personnel File- Mr. Louis Champa, Refrigeration Engineer
Personnel File- Mr. Michael Holland, Third assistant Engineer
Personnel File- Mr. Mitchell Kuflik, Third Assistant Engineer
Personnel File- Mr. Richard Pustare, Chief Engineer
Personnel File- Mr. Sylvester Crawford Jr., QMED ElectricianOpinion d:
NTSB Group Chairman's Factual Report of Investigation- Voyage Data Recorder-
Witness Interview- Lee Peterson MBI Phase III, February 13, 2016
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Witness Interview - Transcript of Interview of El Faro off duty Ch Engr, dated October 8, 2015
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Witness Interview - Fisker-Andersen, Jim, dated February 19, 2016

Opinion e:

NTSB Group Chairman's Factual Report of Investigation- VDR Data
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Opinion f:

NTSB Group Chairman's Factual Report of Investigation- Voyage Data Recorder- Audio Transcript
Witness Interview- Gay, dated February 8, 2016
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Technical Manual, Main Engine Turbines and Gears. General Electric
Drawing No. 663-734-117, Lube Oil Gravity Tank & Forced Draft Fan
Drawing No. 663-904-01, Sheets 1-5 Lube Oil Service System
Drawing No. 663-904-04, Connections on Lube Oil Sump Tank
Drawing No. 663-904-06, Connections on Lube Oil Gravity Storage Tank
NTSB Group Chairman's Factual Report- Engineering Group. EL FARO DCAMM001
NTSB Addendum 1 to the Engineering Group Chairman's Factual Report. EL FARO DCAMM001
MBI Exhibit 059. CargoMax Trim and Stability Summary EF 185 REVISED 1 Oct 15
MBI Exhibit 412. MSL Lube Oil Modeling and Analysis of the EL Faro (48532)
MBI Exhibit 323. Lube Oil System Visualization rev. 2-1
Material Safety Data Sheet- Chevron GST Oil
Chevron Texaco GST ISO 100 Specification Sheet (http://www.matweb.com)
PII's' Joint Response to MSC Technical Reports- 2017 05 03 (49656)
Observations from Site Inspections on board ***SS EL YUNQUE***

Opinion g:

NTSB Group Chairman's Factual Report of Investigation- Voyage Data Recorder- Audio Transcript
Witness Interview- Lee Peterson MBI Phase III, February 13, 2016
Witness Interview – Robinson, dated 2-23-16

NTSB Group Chairman's Factual Report- Engineering Group. EL FARO
DCAMM001
Drawing 663-918-103, Diagrammatic Arrangement of Pump Priming for Bilge & Ballast System
Drawing No. 666-901-1, Arrangement of Machinery Material List
Drawing No. 674-918-03, Bilge & Ballast System in Machinery Space
Drawing No. C5-666-918-100, Diagrammatic Arrangement Bilge & Clean Ballast System in Machinery Space
Technical Manual, Bilge & Ballast Pump/ Fire & Bilge Pump/ Fire Pump/ Potable Water Pump. Worthington
Observations from Site Inspections on board ***SS EL YUNQUE***

5. Qualifications

I am the owner and principal surveyor of Daly Marine Services, LLC. I conduct surveys and investigations on behalf of vessel owners, underwriters and other interested parties. I have been involved in cases involving, among other things, losses of propulsion and main and auxiliary engine failures.

I worked as a licensed marine engineer employed on board ocean going merchant vessels from 1982 through 2010. My experience includes time as Chief Engineer with overall responsibility for the safe operation and maintenance all shipboard equipment. My time as Chief Engineer, included four years on a vessel powered by a MAN B&W 12L90 main engine and over nine years as the Chief Engineer of a steam propulsion RO/RO vessel outfitted with Babcock & Wilcox boilers and General Electric propulsion turbines and gears. As Chief Engineer, I was involved in creating and implementing operating procedures for my vessel's Safety Management System. My sailing career included time on board the ***EL FARO*** (then known as the ***NORTHERN LIGHTS***) and the ***WESTWARD VENTURE*** which was another Ponce Class vessel.

My formal education includes a Bachelor of Science Degree in Marine Engineering, which I received from the U.S. Merchant Marine Academy in 1982 and a Diploma in Marine Surveying from Lloyds Maritime Academy and North Kent College in 2017.

Note*: My current CV can be viewed in Appendix 6 of this report.*

6. Other Cases Testified in During the Past Four Years
I was deposed in the following cases:

Case No. 3:14-cv-04854-JD 6/2015-1/2016

LIFEONE SHIPPING CORP. AND ALLASSIA NEWSHIPS MGT., in personam

vs. TRANSBAY CABLE LLC

Case Number CGC-11-516911
RAYMOND SARNO, Plaintiff v. SEARIVER MARITIME, INC., Defendant

DATED: August 31, 2017

Respectfully,

[redacted]

John P. Daly

Daly Marine Services LLC

7. Appendix

Appendix 1

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AMOS 2013 Job List
AMOS 2014 Job List
AMOS 2015 Job List
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BAE Systems service report with strut wear down measurements, dated 1-9-11
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Drawing EF Electrical Alaska Wire Locations
Drawing EF Tank Layout
Drawing El Faro Fire Plan
Drawing No. 01 666-700-101 General Arrangement
Drawing No. 01 674-700-201 Midship Section
Drawing No. 20069-938-1 Electrical Power & Distribution Diagram- One Line Alt 11
Drawing No. 662-318-01 Torque Tube Details ALT 15
Drawing No. 662-318-02 Shaft Details Torque Tube ALT 7
Drawing No. 662-842-04 Arrangement & Details of Stern Tube, Strut Bearings and Seals
Drawing No. 662-842-05 Torque Tube Protection Alt 12
Drawing No. 663-734-117 Lube Oil Gravity Tank & Forced Draft Blower
Drawing No. 663-900-00 Diagrammatic Arrangement of Auxiliary & Contaminated Steam Systems
Drawing No. 663-900-01 Superheated Steam System
Drawing No. 663-900-100 Diagrammatic Arrangement of Heat Balance at Maximum Shaft Horsepower
Drawing No. 663-900-104 Diagrammatic Arrangement of Auxiliary Steam Systems
Drawing No. 663-900-107 Diagrammatic Arrangement of Auxiliary Exhaust & Extraction Steam System
Drawing No. 663-904-01Lube Oil Service System, Sheets 1-5, 6, 8

Drawing No. 663-904-100 Diagrammatic Arrangement of Lubrication Oil System Alt. 5
Drawing 663-918-103, Diagrammatic Arrangement of Pump Priming for Bilge & Ballast System
Drawing No. 666-879-16 Fuel Oil Burning System
Drawing No. 666-900-105 Diagrammatic Arrangement of Superheated Steam System ALT 7
Drawing No. 666-901-1 Arrangement of Machinery- Material List
Drawing No. 666-901-02 Arrangement of Machinery - Elevations ALT 13 Drawing No. 666-901-03 Arrangement of Machinery Sections Aft of Frame 180 Sheet 1/2
Drawing No. 666-906-101 Diagrammatic Arrangement of Feed System ALT 3
Drawing No. 666-915-00 Engine Room Ventillation Arrangement
Drawing No. 674-918-03, Bilge & Ballast System in Machinery Space
Drawing No. 666-938-2 General Load Analysis Electrical Distribution Sys Drawing No. 666-938-2,General Load Analysis Electrical Distribution System ALT 3
Drawing No. 674-713-03 Struts & Bosses (Propeller) Alt 3
Drawing No. 674-713-05 Stern Tube Casting & Sleeve Alt1
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Drawing No. 674-938-04 Interconnection Wiring Diagram Electrical Power Plant
Drawing No. C5-666-918-100 Diagrammatic Arrangement of Bilge & Clean Ballast System in Machinery Space
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MBI Exhibit 002

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MBI Exhibit 384 Lube Oil Sump Level excerpt_ENG_v1Machinery Operating Manual El Yunque

MBI Exhibit 412 MSL Lube Oil Modeling and Analysis of the El Faro(48532)

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Personnel File- Mr. Dylan Mecklin, Third Assistant Engineer
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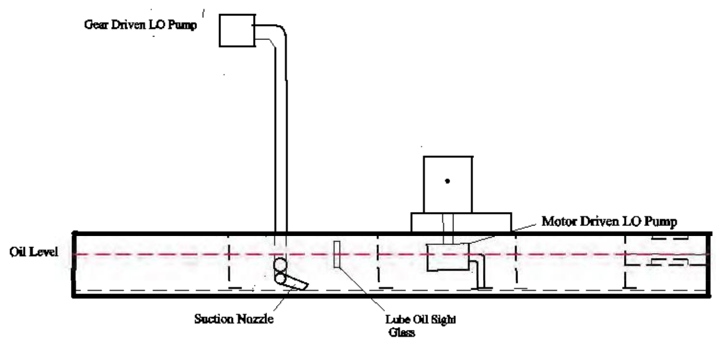
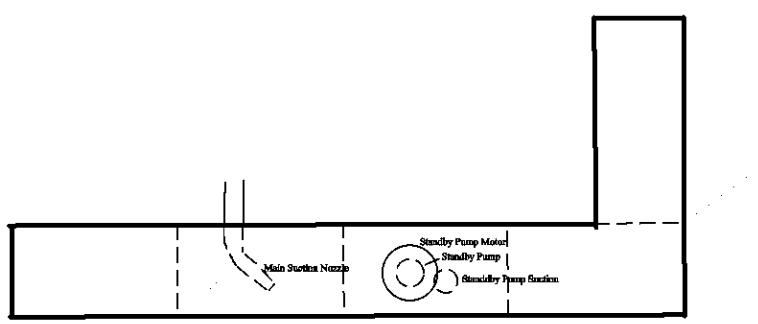
Witness Interview – 52516 [redacted] dated May 25, 2016
Witness Interview – Capt Lawrence.MBI.Testimony ,dated February 20, 2017
Witness Interview - Fisker-Andersen, Jim, dated February 19, 2016
Witness Interview – Lee Peterson.MBI.Phase III, February 13, 2017
Witness Interview - Luke Laakso.NTSB Transcript, dated October 13, 2015
Witness Interview - Luke Laakso.USCG.MBI.Transcript, dated February 25, 2016
Witness Interview- Mark Gay, dated February 8, 2016
Witness Interview – Robinson, dated 2-23-16
Witness Interview - Timothy James Neeson, dated February 26, 2016
Witness Interview - Transcript of Interview of El Faro off duty 1AE, dated October 8, 2015
Witness Interview - Transcript of Interview of El Faro off duty Ch Engr, dated October 8, 2015
Witness Interview- USCG Lead Inspector, dated October 10, 2015
Witness Interview- USCG Machinery Inspector, dated April 12, 2016
Witness Interview- USCG Rider, dated October 15, 2015

Appendix 2

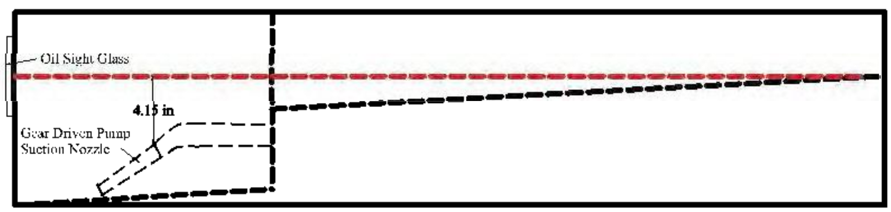
Turbo Generator Sump Drawings



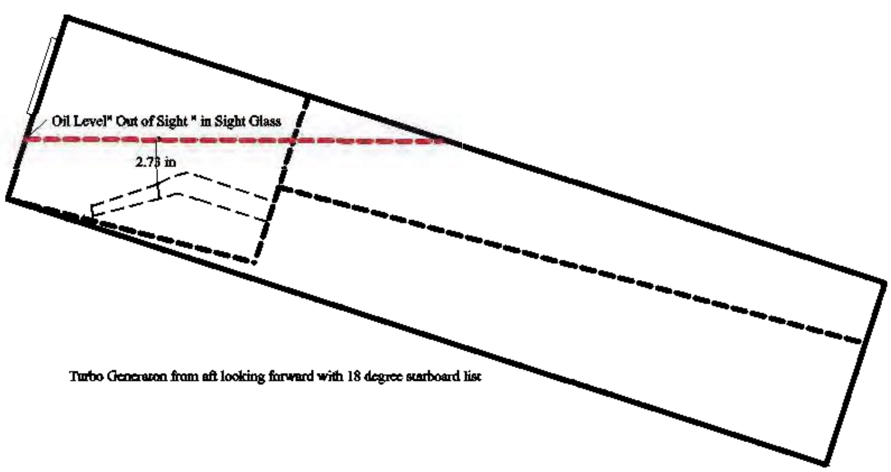
Turbo Generator Right Side View



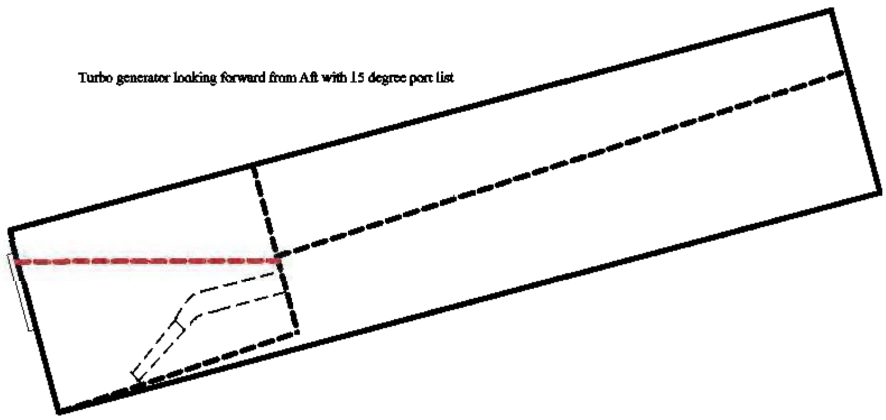
Turbo Generator Plan View



Turbo Generator Looking Forward with 0 degree List



Turbo Generator Looking Forward with 15 degree Starboard List. Oil Level is "Out of Sight" in Sight Glass



Turbo Generator Looking Forward with 15 degree Port List

Appendix 3

SS EL YUNQUE Pictures

Main Lube Pumps

Main Lube Oil Suction Pipe at Inner Bottom

Lube Oil Storage Tank

Lube Oil Storage Tank Drop Valve

Lube Oil Storage Tank Drop Line

Main Engine Lube Oil Sump from Inner Bottom Level Port Side

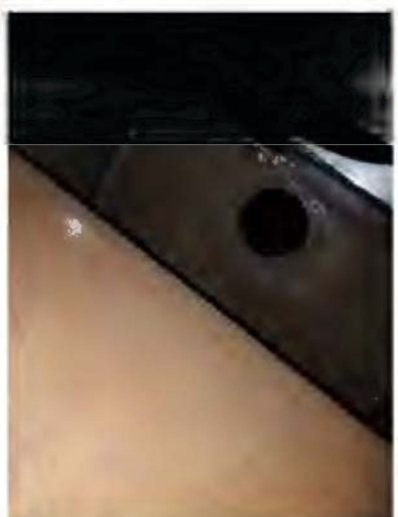

Main Engine Bull Gear and Sump Framing from Inner Bottom Level Port Side


Sump Framing and Limber Holes from Port Side looking down to Center Channel


Limber Holes Port Side/ Center Channel/ After Bay Looking Forward

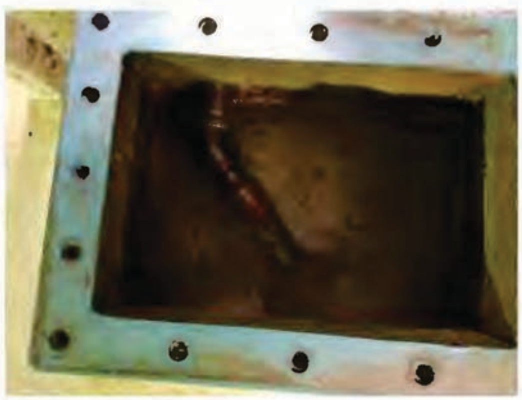
Center Channel/ Starboard Side/ After Bay to Starboard with Suction Bell

Limber Holesand Center Frame Port Side/ Center Channel/ 2nd Bay from Aft Looking Forward



Framing Center Channel/ Port Looking Forward

Turbo Generator Main Lube Oil Pump (Gear Mounted)



Turbo Generator Main Lube Oil Pump Suction Nozzle Viewed from Access Plate

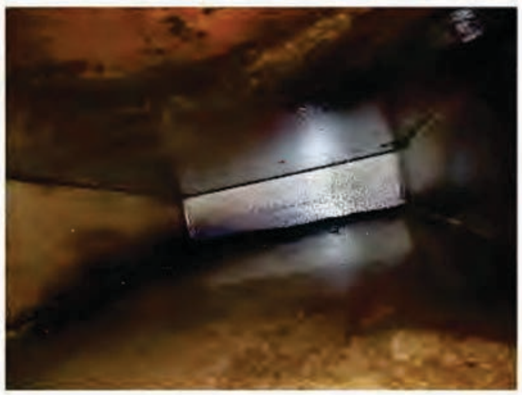
Turbo Generator Main Lube Oil Pump Suction Nozzle Viewed from Sump Looking Forward. Internal Baffle can be seen Forward of Suction Nozzle

Turbo Generator Standby Lube Oil Pump Motor

Turbo Generator Standby Lube Oil Pump and Motor

Turbo Generator Standby Lube Oil Pump and Suction

Turbo Generator Looking Forward. Measuring Tape Indicates Length of After Sump Section



Turbo Generator After Sump Section Extending to Starboard from Main Sump Section

Turbo Generator After Sump Section Looking Forward. Limber Holes to the Upper and Lower Left of the Picture Drain to the Main Sump Section

Turbo Generator Sump Lube Oil Sight Glass Mounted Vertically on the Port Side of the Sump

Turbo Generator Sump Lube Oil Sight Glass

No. 2 Bilge & Ballast Pump and Suction Manifold

No. 2 Bilge & Ballast Pump Suction Manifold

Port Cargo Hold Ballast Manifold

Starboard Cargo Hold Ballast Manifold

Cargo Hold Bilge Well

Emergency Fire Pump No. 3 Cargo Hold Port Side Aft

Clinometer Mounted in Engine Room Operating Platform

Scuttle From 2nd Deck to No. 3 Tween Deck Cargo

Appendix 6

John Daly CV

Curriculum Vitae

John Patrick Daly Chief Engineer
Cell: [redacted]
Email: [redacted]

August 2017

GENERAL BACKGROUND: Mr. Daly is an accomplished marine engineer with over 30 years of experience in the maritime industry. Mr. Daly is a marine surveyor and the owner of, and principal surveyor for, Daly Marine Services LLC. Daly Marine Services LLC specializes in Hull & Machinery surveys. He has conducted investigations and reported on issues including loss of propulsion, engine failures, equipment failures, various fuel related casualties, machinery space fires, structural damage, vessel sinkings, emission cases, personal injuries and other incidents on behalf of ship owners and underwriters. He has also conducted MARPOL Annex I audits for vessel owners. His background includes experience as an operating engineer responsible for a variety of steam and motor propulsion plants and electrical and auxiliary systems on board various types of merchant vessels including: Ro- Ro's, Oil and Chemical Tankers, Bulk Carriers and Passenger and Container Vessels. He gained extensive managerial experience sailing as Chief Engineer from 1991 through 2010 on vessels of both steam and motor propulsion. During this period, he headed the operation, maintenance and repair, logistics and purchasing, safety, environmental, payroll and budgeting programs and assisted in formulating business plans of various merchant vessels. He has extensive training and hands on experience in marine safety and environmental systems and programs. Mr. Daly has also worked as a marine engineering consultant and as a marine superintendent. Mr. Daly has been contracted as an expert witness on behalf of vessel owners and other interested parties and as a consulting expert on behalf underwriters and on behalf of the U.S. Department of Justice.

PROFESSIONAL HISTORY:

MARINE SURVEYOR

Daly Marine Services LLC 1/2015- present

Senior Surveys, LLC 4/2013- 1/2015

Duncan Shoemaker and Associates, LLC 4/2012- 4/2013

EXPERT WITNESS

The sinking of the ***SS EL FARO*** 10/2015- Present
Retained as Engineering Expert by TOTE Maritime

Case No. 16-cv-05379 9/2016- Present
USA vs. Puglia
Retained as Engineering Expert by the Department of Justice
On Behalf of the USA

Case No. RG-14734205 8/2016-10/2016
David Kabasinskas vs. Maersk Lines Limited
And DOES 1-10, inclusive
Retained as Engineering Expert by Gibson, Robb & Lindh LLP
On behalf of Maersk Lines Limited

Case No. 3:14-cv-02321-HSC 5/2016- 11/2016
Singapore Technologies Marine Technologies Ltd. v. Pacific Princess Partnership Ltd.
Retained as Engineering Expert by Hinshaw & Culbertson LLP
On Behalf of Singapore Technologies Marine Technologies

Case No. 3:15-cv-00098-H-HSG 5/2016- Present
USA vs. Alecio Shipping N.D. California.
Retained as Engineering Expert by the Department of Justice
On Behalf of the USA

Case No. 3:14-cv-04854-JD 6/2015- 01/2016
LIFEONE SHIPPING CORP. and ALASSIA NEWSHIPS MGT., in personam vs. TRANSBAY CABLE LLC
Retained as Engineering Expert by Hinshaw & Culbertson LLP, Foran Glennon and Locke Lord LLP

On behalf of Trans Bay Cable LLC

Case No. CGC-11-516911 7/2013- 10/2013
RAYMOND SARNO v. SEARIVER MARITIME, INC.
Retained as Engineering Expert by Mr. David Russo of Sterling & Clack
On behalf of SeaRiver Maritime, Inc.

CHIEF ENGINEER

SS Cape Inscription	4/2001 - 7/2010
M/V USNS Shughart	10/1996 - 4/2000
M/V USNS Sealift Mediterranean	3/1991- 6/1991

SLOW SPEED DIESEL PROPULSION PLANTS

M/V USNS Shughart- Chief Engineer	10/1996 - 4/2000
First Asst. Engineer	4/1996 -10/1996
M/V Sam Cobb- Third Asst. Engineer	11/1985-3/1986

MEDIUM SPEED DIESEL PROPULSION PLANTS

M /V Sealift Mediterranean- Chief Engineer	3/1991- 6/1991
M/V Julius Hammer- First Asst. Engineer	11/1993-4/1995
Second Asst. Engineer	11/1992-4/1993
M/V Sealift Artic- First Assist. Engineer	2/1992-7/1992
M/V Pride of Texas- First Assist. Engineer	3/1989-6/1991
Second Assist Engineer	5/1988-12/1988

M/V Moku Pahu- Second Assist Engineer 8/1987-12/1987
Third Asst. Engineer 7/1987- 8/1987
M/V Falcon Princess- Second Assist. Engineer 7/1986-12/1986

STEAM PROPULSION PLANTS

SS Cape Inscription- Chief Engineer 4/2001-7/2010

SS Cape Jacob- First Asst. Engineer 7/2000-11/2000

SS Westward Venture- Third Asst. Engineer 4/1995-9/1995

SS Northern Lights- Third Asst. Engineer 10/1995

SS Cove Leader- Third Asst. Engineer 3/1984-7/1984

SS Independence- Third Asst. Engineer 11/1982-3/1983

SS Constitution- Third Asst. Engineer 7/1983-10/1983

SS Ogden Traveler- Third Asst. Engineer 6/1982- 8/1982

COMBINATION CONTAINER/ RO-RO VESSELS

SS Cape Inscription- Chief Engineer 4/2001-7/2010

M/V USNS Shughart- Chief Engineer 10/1996-4/2000
-First Asst. Engineer 4/1996-10/1996

SS Westward Venture- Third Asst. Engineer 4/1995-9/1995

SS Northern Lights- Third Asst. Engineer 10/1995

OIL/CHEMICAL TANK VESSELS

M /V Sealift Mediterranean- Chief Engineer 3/1991- 6/1991

M/V Julius Hammer- First Asst. Engineer 11/1993-4/1995
-Second Asst. Engineer 11/1992-4/1993

M/V Sealift Artic- First Assist. Engineer 2/1992-7/1992

M/V Falcon Princess- Second Assist. Engineer 7/1986-12/1986

M/V Sam Cobb- Third Asst. Engineer	11/1985-3/1986
SS Cove Leader- Third Asst. Engineer	3/1984-7/1984

BULK CARRIERS/GENERAL CARGO VESSELS

SS Cape Jacob- First Asst. Engineer	7/2000-11/2000
M/V Pride of Texas- First Assist. Engineer	3/1989- 6/1991
- Second Assist Engineer	5/1988-12/1988
SS Ogden Traveler- Third Asst. Engineer	6/1982- 8/1982

PASSENGER VESSELS

SS Independence	11/1982-3/1983
SS Constitution	7/1983-10/1983

MARINE ENGINEERING CONSULTANT

Advanced Marine Enterprises, Inc.	1/1997-4/1997
Bay Ship Mgt. (on behalf of NAVSEA)	4/1997-5/1997
Nichols Marine Enterprises	6/1999-7/1999

MARINE SUPERINTENDANT

Aalborg Ciserv, Wilmington, Ca.	5/1993- 10/1993

QUALIFICATIONS:

Chief Engineer, Unlimited Horsepower,
Steam, Motor and Gas Turbine Vessels
(1991-2011)

STCW

TWIC

ISPS Security Officer

CSO/VSO

EDUCATION:

Bachelor of Science in Marine Engineering,
United States Merchant Marine Academy, Kings Point, NY.
1982.

Diploma in Marine Surveying
Lloyds Maritime Academy and North Kent College
2017

Advanced Fire Fighting, 4/1982, 6/2008

Marine Oil Spill Training for Hazardous Waste Operations & Emergency Response (HAZWOPER)
24 Hr. Course, 11/2007
8 Hr. Refresher, 10/2008, 1/2010

AFFILIATIONS:

Society of Naval Architects & Marine Engineers

Institute of Marine Engineers, Science and Technology

Society of Port Engineers, LA/LB

US Merchant Marine Academy Alumni Association, President LA/ Long Beach Chapter 2007 – 2012

American Merchant Marine Veterans Memorial, San Pedro - Committee Member

PERTINENT EXPERIENCE:

MARINE SURVEYOR

Mr. Daly has been contracted by vessel owners, underwriters and legal counsel to conduct various investigations and surveys including, but not limited to, losses of propulsion, fuel related casualties and failures, engine casualties, equipment failures, machinery space fires, hull damage, engine room floodings, vessel sinkings, accidents and personal injuries and has conducted vessel condition surveys and MARPOL Annex I Audits for vessel owners.

EXPERT WITNESS

Mr. Daly has acted as an expert witness in cases involving personal injury, loss of propulsion, vessel sinkings and in oil pollution related cases. He has also acted as a consulting expert in pollution and emissions related cases.

USCG LICENSED CHIEF ENGINEER

In his 28 plus years as a licensed Marine Engineer, Mr. Daly has gained a wide variety of experience. He has successfully worked to assure the continuous successful operation of numerous different types of merchant vessels, with different propulsion systems. As Chief Engineer, Mr. Daly had a wide variety of responsibilities. He was responsible for the operation, maintenance and repair of all machinery on board vessels on which he was employed. This included assigning, supervising and tracking all repairs completed by shipboard personnel and writing repair specifications for outside contractors, creating requisitions for repair parts and overseeing the entire repair process. He was responsible for creating and implementing annual and long term business plans in which he formulated maintenance, repair and operating budgets for the operation of the vessel. Mr. Daly designed numerous shipboard systems to replace obsolete systems. This included the research, design, procurement and installation of these systems. He also assisted in creating shipyard specifications and oversaw all repairs during various dry dock and repair periods.

MARINE ENGINEERING CONSULTANT

Mr. Daly assisted an international cement company in the pre-purchase vetting process of a 44,000-gross metric ton cement processing vessel. In 1997 he was contracted to provide a failure analysis and a remediation plan for the hydraulically operated valve system on the M/V USNS Shughart. After providing these items, Mr. Daly was contracted by Bay Ship Management, on behalf of NAVSEA, to act as a liaison between NAVSEA and NASSCO Shipyard in the warranty repair of this system that utilized his remediation plan. The plan was successfully implemented and the system was returned to a high degree of operating reliability. Mr. Daly was contracted by Nichols Marine Enterprises, on behalf of the Military Sealift Command, to provide forensic analysis of the stern tube and strut bearing failures on the M/V USNS Bob Hope Class vessels. His analysis was utilized in the remediation of this class-wide system failure. Mr. Daly is currently advising the City of Long Beach on the ***HMS QUEEN MARY*** repair project and providing peer review of the proposed testing and repair plans for that vessel.

MARINE SUPERINTENDENT

Mr. Daly was employed by Aalborg Ciserv of Wilmington, Ca. as a Marine Superintendent. During this period, he supervised numerous shipboard repair projects.

REFERENCES

Joe Walsh II- Clyde & Co.
David Russo- Sterling, Clack & Russo,
Forrest Booth- Hinshaw & Culbertson
Mike Underhill- U.S. Department of Justice
Captain Paul Foran- Consolidated Maritime Resources
Kjartan Hague- Wilhelmsen North America