

## CONCLUSIONS

1. **GOLDEN RAY Material Condition.** At the time of the incident, GOLDEN RAY was three years old and by all accounts maintained in excellent material condition by her owners and operators. The vessel was compliant with all relevant requirements of the Marshal Islands flag state, Korean Register of Shipping classification society, International Maritime Organization (IMO), and Safety of Life at Sea Convention (SOLAS). The U.S. Coast Guard's ten Port State Control inspections of the vessel between 2017 and 2019 revealed no significant deficiencies. Lt. [REDACTED] of the USCG's Marine Safety Center testified that GOLDEN RAY's design was not a factor in the capsizing. Hearing Transcript, p. 408. As a result, the joint government investigation into the incident revealed that GOLDEN RAY's material condition did not cause or contribute to the incident.
2. **GOLDEN RAY Safety Management System.** GOLDEN RAY's Safety Management System (SMS) was approved by its classification society and underwent regular internal and external audits. Prior to the incident, none of these audits identified a deficiency that caused or contributed to the incident.
3. **GOLDEN RAY Personnel.** At the time of the incident, the vessel was in compliance with its SOLAS Minimum Safe Manning Certificate. Each of the members of GOLDEN RAY's crew held the required licenses and endorsements for their positions. Each of the vessel's officers were experienced at their position and none of the senior officers were serving in a position for the first time. For instance, GOLDEN RAY's Master had served as master for over 20 years at the time of the incident, including onboard car and truck carriers. Hearing Transcript, pp. 197-198. The Chief Officer had been serving as a chief officer for 10 years, 6 of which were spent on car carriers prior to the incident. Hearing Transcript, p. 444. The incident was not caused or contributed to by a lack of manning, appropriate licensing, or the crew's inexperience at their respective positions.
4. **GOLDEN RAY Vessel Stability Program.** Prior to GOLDEN RAY being placed into operation, the vessel obtained a trim and stability booklet in accordance with the IMO 2008 Intact Stability Code. This trim and stability booklet was onboard the vessel as required at the time of the incident. GOLDEN RAY was also equipped with a class approved Totem Plus Ltd. LOADCOM stability computer that received direct inputs from the vessel's Integrated Monitoring, Alarm, and Control System (IMACS). The IMACS system receives input from sensors throughout the vessel and allows the crew to visualize the power management system, most tank-level indicators, anti-heeling and loading programs, and engine performance. Using this information, the LOADCOM can determine the vessel's center of gravity and perform a metacentric height (GM) calculation and inclining experiment. The resulting data can be printed as a stability report. Equipping a vessel with LOADCOM and IMACS is not required by the vessel's flag state, classification society, or any other international or U.S. code or regulation. At the time of incident, the vessel's crew had more than the required tools to calculate the vessel's stability and safely operate

the vessel. Therefore, the incident was not caused or contributed to by the lack of sufficient vessel stability program or other information necessary to calculate the vessel's stability.

5. **GOLDEN RAY Stability Policies.** Consistent with international industry custom, GOLDEN RAY's class-approved SMS placed responsibility for issues relating to stability with the chief officer. As set forth in the SMS excerpts contained in Hearing Exhibit 9, the Chief Officer is responsible for the "task of loading/discharging and cargo related work," specifically including "to make/adjust load/discharge work plans and confirm its results," "cargo management," and "confirm the vessel's stability." The Chief Officer is also responsible "to manage ballast water, bilges and fresh water," "to manage the control documents, drawings, and manuals of Deck Department," and "to keep/maintain the records of performance for areas of responsibility," all of which are also related to stability. The SMS also incorporates the IMO's stability requirements and requires use of the LOADCOM computer which has been provided to make the stability calculation easier and more reliable: "The stability as calculated by using loadcom must be OK condition and above the IMO required Min. GoM for that condition." Finally, "the Master is to be satisfied that the ship has sufficient stability at all times." These SMS policies are consistent with international industry standards and they were not a cause or contributing factor to the incident.
  
6. **GOLDEN RAY's Crew Performance: Stability.** GOLDEN RAY's Master testified that the Chief Officer informed him that vessel's GM was "2.45" and "okay." Hearing Transcript, pp. 203; 232. In accordance with industry custom and the SMS policy, the Master was entitled to rely on the Chief Officer to satisfy himself that GOLDEN RAY had sufficient stability to depart. The Master's testimony is confirmed by pre-hearing interviews of the Chief Officer where he said that the GM was "2.45." Hearing Exhibit 18B, p. 16. The government investigation, through the research of private consultants, found that the GOLDEN RAY's actual GM at the time of the incident was less than 2.45 meters and that the vessel did not meet the minimum stability criteria required by IMO guidelines and GOLDEN RAY's SMS. Owners' own investigation and calculations (as referred to in the NTSB report) also determined that the actual GM at the time of the incident was less than 2.45m and the vessel did not meet the minimum stability criteria required by IMO guidelines and GOLDEN RAY's SMS. At the investigation hearing, Dr. Falzarano testified that if the ship had met its stability criteria, this incident would not have happened. Hearing Transcript, p. 438.
  
7. **GOLDEN RAY's Crew Performance: Watertight Integrity.** Prior to the incident, the Master ordered the crew to open the watertight pilot door in preparation for the pilot's departure. The open pilot door allowed water into the vessel after it began capsizing and developing a severe list. While water ingress through the pilot door resulted in progressive flooding, the Coast Guard's Marine Safety Center analysis concluded that the open pilot door was not the cause of GOLDEN RAY's capsizing. Hearing Transcript, p. 409. Moreover, Dr. Falzarano, the Coast Guard's hydrodynamics expert, testified that he did

not analyze the role of down-flooding in the casualty and it would be difficult to do so due to the complexity of other factors, such as shifting cargo caused solely by the vessel's insufficient stability. Hearing Transcript, pp. 430-432. Therefore, the evidence is inconclusive as to whether flooding through the pilot door actually contributed to the worsening of the incident.

- 8. GOLDEN RAY's Shoreside Personnel.** As is customary in the industry, GOLDEN RAY's land-based support personnel do not conduct stability calculations for the vessel. Under current legislation, there is no requirement for shore-based personnel to calculate the stability of the vessel. As such, their role does not require this and, consistent with industry standards for the operation of PCTC vessels, shore-based personnel do not have access to the necessary information and/or training to do so. While the personnel perform preliminary cargo loading and discharge planning, the actual distribution of the cargo is subject to change and that final distribution is one input of many that are necessary to perform a proper calculation. All of this input data is available to the vessel's crew first-hand, but it is not available to shoreside personnel. Therefore, throughout the industry, stability calculations are performed by the crew onboard the vessel rather than ashore. Hearing Transcript, pp. 107-108; 118-119; 164. Accordingly, the lack of stability calculations being performed ashore was not a cause or contributing cause of the incident.

### **Probable Cause**

The investigation revealed that the probable cause of the incident was insufficient stability upon departure from Brunswick.

### **Recommendations**

GOLDEN RAY's owners and operators have taken several steps since this incident as part of their efforts at continual improvement. These initiatives, designed to improve safety and reduce the likelihood of a recurrence of the Golden Ray casualty, include the following:

- Increased training for Chief Officers on topics including:
  - Stability and stress
  - Effect of trim and other factors on stability
  - Calculation of draft
  - Cargo management during loading/voyage/discharge
  - Use of LOADCOM stability computer
  - Properly inputting cargo information into LOADCOM based on stowage plan
  - Properly inputting ballast/bunker/fresh water into LOADCOM
- Case review of Golden Ray Casualty with senior officers throughout the fleet
- Revised procedures throughout the fleet requiring the calculated GM from the stability computer to be compared with the minimum required GM from the trim and stability manual (for the given draft of the vessel). Both figures are now required to be included on the vessel's departure report.
- Enhanced procedures for all Masters and Officers to receive refresher training for the loading computer, prior to boarding.

- Although not related to the cause of this incident, during the investigation, it was apparent that there were occasions when the final stowage plan was only provided to the vessel after departure from the loading port. This practice has now been revised such that vessels are only permitted to depart after the final stowage plan has been received and the stability of the vessel has been verified based upon the final loading data.
- Enhanced focus by Vessel Superintendents on stability during on-board audits, including use of hard copy records and LOADCOM data
- Posting of vessel-specific minimum GM tables from Trim & Stability Manual in the cargo office and on the bridge as an additional aid for checking stability
- Ongoing initiative to standardize the make and type of stability computer in use throughout the fleet. The Totem LOADCOM will be replaced with a more user-friendly stability computer system, which will be standardized throughout the fleet later this year.

In light of these proactive corrective measures, the owners and operators of GOLDEN RAY do not believe any additional measures at the company level are necessary.

Due to the international nature of this industry issue, the U.S. government should make a formal request to the IMO that it take up the issue of whether additional stability measures should be adopted and enforced by member states. Doing so will ensure uniformity of requirements, greater clarity for vessel owners, operators, and mariners, and ultimately provide the best chance for global compliance with any increased safety standards.