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Impact of Bulk Carrier Disasters on the Amendments To the SOLAS Convention

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ABSTRACT: Maritime transportation facilitates global trade by transporting a wide range of commodities and products across the world's waterways. There are many types of vessels that carry merchandise across the water. Among them are bulk carriers, which transport unpacked or uncontenerized goods, like ore, sand, grain, etc. Like other water vessels, bulk carriers and their crews face many occupational hazards. To minimize these hazards and improve the safety of the work environment, organizations such as the International Maritime Organization developed and maintains regulations, such as the International Convention for the Safety of Life at Sea (SOLAS). Despite these regulations, accidents happen, and new occupational challenges arise, which result in revisions and amendments of the rules and requirements. This review focuses on the bulk carrier accidents that led to significant changes in the SOLAS convention to improve maritime transportation safety. An example of an accident and report are provided. Types of accidents and numerical trends of ships and lives lost across the last fifteen years are also summarized, demonstrating decreasing trends.

1 INTRODUCTION

Maritime transportation is vital in connecting nations, facilitating global trade, and transporting a wide range of commodities and products across the world's oceans, seas, rivers, and other navigable waterways. It is a crucial component of international trade and global transportation networks. It offers several advantages, including the ability to transport large quantities of goods over long distances, access to remote regions and landlocked countries through navigable waterways, lower energy consumption compared to other modes of transportation, and reduced carbon footprint per ton-kilometre. Merchandise is transported through the waters using various methods and vessels specifically designed for maritime transportation, such as container carriers, tankers, roll-on/-roll-off (ro-ro) and specialized vessels, and bulk carriers [30]. This last type of vessel is of particular importance due to its ability to efficiently transport commodities such as coal, iron ore, grain, cement, and other raw materials or commodities that are not containerized [4]. They play a pivotal role in maritime transportation by efficiently and cost-effectively transporting large quantities of bulk cargo, supporting global trade, and facilitating economic development and industrial growth worldwide [4].

The current SOLAS Convention has been expanded with a number of amendments that have a huge impact on navigation safety [39, 40]. The introduction of any amendment is supported by research.

Maritime transportation carries inherent risks. These risks include adverse weather conditions, accidents, piracy, environmental concerns, crew safety, technological challenges, and the remote nature of some routes [24]. Despite these risks, safety measures, regulations, and international organizations strive to mitigate dangers and improve standards, ensuring the safety and security of maritime operations [10, 31].

The aim of the publication is to show the impact of the disasters of several described bulk carriers on the amendments introduced to the SOLAS Convention [38].

Bulk carriers and their crews, in particular, are exposed to elevated dangers as the cargo they carry can be the source of accidents [7, 28]. Causes range from human error to inadequate equipment on the ship [7]. The safety problems of bulk carriers in terms of construction, equipment, and operation are a topical issue in the marine environment [5]. Each accident should result in a thorough investigation and analysis, and some have led to important amendments to the SOLAS to improve the safety of crews and cargo and help prevent reoccurrence.

The review focuses on maritime accidents involving bulk carriers that have led to changes in regulations to improve the safety of ship crews and cargo. Data on accidents at sea has been reviewed and summarised, and examples of accidents leading to amendments are provided. It is impossible to eliminate occupational risk in maritime transportation. However, by analysing the causes of maritime disasters, it is possible to mitigate them.

2 SOLAS

The SOLAS convention establishes minimum safety standards for the construction, equipment, and operation of ships, as well as procedures and guidelines for maritime safety. It covers various aspects, including ship design, fire protection, safety equipment, navigation, communications, and emergency response [3].

The first version of SOLAS was adopted in 1914, following the sinking of the RMS Titanic in 1912, and it came into force on July 1, 1915 [3]. Since then, SOLAS has undergone multiple amendments and updates to address emerging safety issues, technological advancements, and changing international regulations.

The most recent version of SOLAS is known as SOLAS 1974, as amended, which consolidated the amendments made to the original convention. SOLAS 1974, along with its subsequent amendments, is the current framework for maritime safety and is widely accepted and implemented by the majority of maritime nations worldwide [3].

Chapters II-1, VI, XII, and XI-2 address the safety requirements and considerations applicable to bulk carriers. Of importance is Chapter XII: Additional Safety Measures for Bulk Carriers. This chapter focuses explicitly on additional safety measures for bulk carriers. It includes regulations related to the design, construction, and operation of bulk carriers, such as structural requirements, stability considerations, cargo ventilation, and requirements for loading and unloading equipment [32].

Chapter XII and regulations within the SOLAS convention describe in detail the requirements for the construction and equipment of bulk carriers. The ship shall be provided with a watertight collision bulkhead up to the freeboard deck, and pipelines passing through the bulkhead shall be equipped with appropriate valves controlled from a position above the freeboard deck. The construction of the bulkhead should also meet the requirements. The vessel should have a double bottom constructed over the space from the forepeak bulkhead to the aft peak bulkhead. Bulk carriers should also be protected against fire. Evacuation routes should be identified, properly marked, and provided with the necessary rescue equipment to improve rescue operations.

All recommendations for the design of bulk carrier equipment introduced by the SOLAS Convention aim to maximise the safety of human life, the environment, and the protection of cargo. These are dictated by years of experience and lessons learned from maritime disasters. Technical experts examine every subsequent accident with severe consequences. They analyse its circumstances and causes and prepare amendments to the SOLAS Convention to prevent similar accidents in the future.

3 ACCIDENTS AT SEA

The increase in the number of victims of maritime disasters and the number of disappearances of bulk carriers drew international attention to this type of vessel. According to the International Association of Dry Cargo Shipowners (Intercargo), a voluntary non-profit association representing the interests of dry cargo vessel owners, the number one cause of bulk carrier failures is the vessel's grounding. Research on the causes and investigations into the sinking and disappearance of bulk carriers have already been carried out by many global institutions. The results of this activity indicate that the loss of watertight integrity of the sides in the cargo compartments caused 55% to 75% of known failures of bulk carriers. Mainly old vessels and ships carrying ore or other heavy loads sank [42]. The loss of integrity of the sides was caused by the corrosion of the structure occurring predominantly in the lower parts of the hold due to damage to the frames, beam knees, and sheets. As the vessel ages, the fatigue of the material from which it was built increases, corrosion progresses, and structural wear occurs, affecting the weakening of the hull.

Intercargo, using the data from the International Maritime Organization (IMO), also states that the number one cause of lost life at sea involving bulk carriers is the liquefaction or shifting of the cargo. Although the data indicates that the average number of lives lost during a rolling 10-year period has decreased (Table 2) [14] even a single life lost is a tragedy, which must be reported and investigated, lessons must be learned, and preventive measures instated.

The concept of a marine casualty can be interpreted as any damage to the vessel or its equipment or any other event that results in the loss of seaworthiness of the vessel or merely a reduction in its seaworthiness at any time.

The definition of marine casualties contained in the Maritime Chambers Act of 1 December 1961 [11] covers both accidents affecting a vessel and accidents involving only persons on board or in its immediate vicinity if they have experienced specific effects [11].

Based on reports from Intercargo and IMO, the average number of vessels lost has a downward trend between 1994 and 2017 [5]. Even more recent data, between 2005 and 2023, shows reduced ships lost (Tablet 1) [1, 15–21]. These improvements can be attributed to many factors, from younger ships through the better-trained crew to enhancements afforded by the amendments to SOLAS. The latter comes from thorough investigations and lessons learned after each accident.

Table 1. Summary of sea casualties between the years 2005 and 2023.

Year	2005-2015	2008-2017	2009-2018	2011-2020	2012-2021	2022	2023	Total (ships lost per year)
2005	6	-	-	-	-	-	-	6
2006	7	-	-	-	-	-	-	7
2007	9	-	-	-	-	-	-	9
2008	5	5	-	-	-	-	-	5
2009	9	10	10	-	-	-	-	10
2010	6	6	6	-	-	-	-	6
2011	11	11	11	11	-	-	-	11
2012	3	3	3	3	3	-	-	3
2013	7	7	7	6	6	6*	-	7
2014	2	2	2	2	2	2*	2*	2
2015	6	4	4	5	5	5*	5*	5
2016	-	3	3	3	3	3*	3*	3
2017	-	2	2	2	2	2*	2*	2
2018	-	-	0	0	1	1*	1*	1
2019	-	-	-	1	1	1*	1*	1
2020	-	-	-	1	2	2*	2*	2
2021	-	-	-	-	2	2*	2*	2
2022	-	-	-	-	-	2	2*	2
2023	-	-	-	-	-	-	0	0
Total (10-year period)	71	53	48	34	27	26	20	84

*- 10-year reports not available – numbers from the preceding report are carried over.

Marine casualties result from objective reasons, such as the growing number of ships and the intensifying competition in the shipping markets. The ruthless pursuit of profit becomes one of the most critical factors threatening the safety of human life and health. A characteristic feature of modern shipping is the intensification of the use of ships and the extension of their life, which significantly increases the risk of marine casualties [23].

Marine casualties in maritime transportation can occur due to various causes and circumstances. Human error is one of the most frequent causes. It can encompass various factors, such as navigational mistakes, miscommunication among crew members, inadequate training, or fatigue due to long working hours. Fatigue can impair judgment and decision-making abilities, leading to errors in navigation, collision incidents, or other accidents.

Ships and their crews transporting merchandise through open waters, like seas and oceans, often face adverse weather conditions, posing significant risks to vessels, crews, and cargo. Storms, hurricanes, heavy seas, and high winds can impact vessel stability, visibility, and manoeuvrability [35–37]. These conditions may cause vessels to lose control, collide with other vessels or objects, or be at a higher risk of capsizing or grounding [35]. In addition to the rapidly changing weather conditions, ships face many environmental factors, such as fog, poor visibility, ice, or strong currents, which can also increase the risks of maritime casualties.

Table 2. A summary of bulk vessel disasters that involved the loss of life.

Incident Year	Vessel's name	Built	Loss of life	Likely Root Cause	Reported Cause
2005	Aurelia	1980	6	Unknown	Structural
2005	Bright Sun	1985	1	Collision	Flooding
2005	Everise Glory	1979	1	Unknown	Collision
2006	Alexandros T	1989	26	Unknown	Flooding
2006	Giant Step	1985	10	Machinery failure	Grounding
2006	Ocean Seraya	2001	1	Weather	Grounding
2007	Mezzanine	1975	26	Weather	Unknown
2007	Orchid Sun	1985	13	Weather	Flooding
2008	Da Ji	1997	12	Weather	Flooding
2008	Jinshan	1976	2	Structural	Flooding
2009	Te Hsing	1977	16	Unknown	Fire / Explosion
2009	Chang Ying	1976	22	Unknown	Unknown
2009	Black Rose	1977	1	Cargo shift / liquefaction	Cargo shift / liquefaction
2010	Jian Fu Star	1983	13	Cargo shift / liquefaction	Cargo shift / liquefaction
2010	Nasco Diamond	2009	22	Cargo shift / liquefaction	Cargo shift / liquefaction
2010	Hong Wei	2001	10	Cargo shift / liquefaction	Cargo shift / liquefaction
2011	Jui Hsing	1974	10	Unknown	Grounding
2011	Bright Ruby	1987	7	Machinery failure	Unknown
2011	Vinalines Queen	2005	22	Cargo shift / liquefaction	Cargo shift / liquefaction
2013	Harita Bauxite	1983	15	Cargo shift / liquefaction	Cargo shift / liquefaction
2015	Bulk Jupiter*	2006	18	Cargo shift / liquefaction	Cargo shift / liquefaction
2015	Alan Manis	2007	1	Cargo shift / liquefaction	Cargo shift / liquefaction
2017	Stellar Daisy*	1993	22	Catastrophic structural failure	Flooding
2017	Emerald Star	2010	10	Unknown	Capsized
2019	Nur Allya*	2002	25	Unknown	Sank
2022	Curacao Pearl	1984	1	#	#

* - bulk carrier disasters that prompted changes to the SOLAS convention.
# - the incident involved a loss of life during the regular operation of the vessel.

Given the constant exposure to the harsh environment and external and internal conditions bulk carriers face, equipment failures occur frequently and can have severe consequences. Malfunctions in propulsion systems, steering mechanisms, communication equipment, or navigation instruments can compromise the vessel's ability to operate safely.

Structural failures, such as hull cracks, corrosion, or inadequate maintenance, can compromise a vessel's stability and seaworthiness, as can cargo shifting during rough weather or improper loading practices [7]. These factors can lead to loss of control, collisions, capsizing, or other types of incidents that put the crew, cargo, and vessel at risk.

Collisions can occur between vessels or with other objects such as rocks, reefs, or navigational hazards and are often the result of human error, misjudgement of distances, failure to adhere to navigation rules, or technical malfunctions. Contact incidents, on the other hand, such as striking submerged objects or grounding, can result from navigational errors or inaccurate charts [7, 34]. Although groundings could be a separate marine accident type, it is a form of contact incident. It happens when a vessel unintentionally runs aground on the seabed. Groundings can occur due to navigational errors, inaccurate charts, misjudgement of water depths, or underwater hazards [34]. Groundings can cause damage to the vessel's hull, potential breaches, or even capsizing if not appropriately handled.

These marine casualties can be divided into those threatening the safety of the vessel and its occupants and those not threatening the safety of the ship and its occupants. The first one is the result of an event that causes the loss or limitation of the vessel's ability to move within a specified time. As a result, the vessel's and its occupants' safety is endangered. The second case, on the other hand, is the result of an event that causes the loss or limitation of the vessel's ability to move within a specified time and does not cause a threat to the safety of the vessel and its occupants.

Maritime authorities and regulatory bodies conduct thorough investigations and analyses of marine casualties to determine the specific causes and circumstances surrounding each incident. The findings contribute to improving safety measures, implementing stricter regulations, enhancing crew training programs, and fostering a safer environment for maritime operations.

A vessel is an unusual place of work where the crew member every day faces new requirements. The introduction of modern technology on vessels is intended to increase the safety of the crew (passengers) and cargo. Both external and internal factors should be reduced to improve safety. External factors include the type of sailing water body (size of the water body, navigation markings, vessel traffic density, systems supporting traffic, i.e., delineation systems, VTS – Vessel Traffic Service – etc.), as well as the impact on the vessel and its crew of the marine element and the forces of nature, which in many cases constitute force majeure events [22]. In turn, the internal factors that directly impact the vessel's behaviour are the humans, their skills, and their psychophysical state. Geometrical parameters of the vessel and its manoeuvring properties. Technical equipment and degree of automation of the ship [12, 27]. All the factors mentioned affect navigation safety to a greater or lesser extent.

One of the most critical factors affecting safe navigation is, of course, the human. The European Marine Safety Agency, in their "Annual Overview of Marine Casualties and Incidents 2022" report, states that in the cargo ship category, human action accounted for 61.8% of all accidents in the period between 2014 and 2021 [6]. By far, this is the most significant contributing factor. Other categories listed in the report account for fewer percentages of accidents. System and equipment failure accounted for 20.5 % in the same period. Other agents and vessels caused 10.3% of all accidents, hazardous materials 6.3%, and unknown causes accounted for 1.3%. Danger can be avoided by the proper and efficient response of the crew in emergencies related to their psychophysical condition, knowledge of regulations, and the so-called good maritime practice. Thanks to the navigator's use of equipment located on the bridge and information provided by land centres, such as weather forecasts, navigation hazards, etc., they can avoid or mitigate the impact of dangerous external factors, increasing the risk to the ship.

The fallibility of the vessel can be significantly reduced in the design phase, but this is associated with an increase in the costs of its design and construction. They are the main reason for the lack of actions related to shaping the reliability of the ship and thus reducing its fallibility. These are due to the need to conduct research explaining the causes of damage during ship voyages and establish actions to increase safety.

Statistics on marine casualties of the merchant shipping fleet show that the number of accidents is increasing. Among navigational accidents, collisions and damage are still the most prevalent, while failures of the main engine dominate technical accidents. Most of the causes of navigational accidents lie outside the ship, and defects in the operation and construction of equipment cause most technical accidents.

In addition to amendments made to SOLAS, the International Maritime Solid Bulk Cargoes Code (IMSBC Code) was approved by the Maritime Safety Committee (MSC) during its 85th session in 2008 and took effect on January 1, 2011. The IMSBC Code replaced the Code of Safe Practice for Solid Bulk Cargoes (BC Code), initially introduced as a non-binding code in 1965, and has since been periodically updated [13].

Implementing the mandatory IMSBC Code aims to facilitate the safe handling and transportation of solid bulk cargo. It achieves this by providing essential information about the hazards associated with specific types of freight and offering guidelines on the appropriate procedures to follow during shipment.

Navigational hazards often lead to maritime disasters. The number and consequences of maritime disasters cause changes in international regulations, especially the SOLAS Convention. Accidents are taken so seriously because they pose a threat to life, pollute the environment and lead to financial losses for the ship owner and the insurance company. Much larger ships are now being and pose a significant risk, especially in heavily trafficked areas. The most common effects of disasters, the effects of witch can be noticed for many years, are environment pollution. Accidents can be prevented, in particular by taking into account the causes in the operation of the provisions of the SOLAS Convention [42].

Notable bulk carrier disasters are those of m/v Derbyshire (1980), m/v Bulk Jupiter (2015), m/v Stellar Daisy (2017), and m/v Nur Allya (2019). Incidents involving these vessels led to significant changes in the SOLAS.

3.1 *Bulk carrier disaster – m/v Derbyshire (1980)*

The sinking of the bulk carrier m/v Derbyshire in 1980 remains one of the most tragic maritime disasters in British history. The vessel, owned by the British-India Steam Navigation Company and operated by the Bibby Line, was an ore carrier built in 1976. It had a length of 269 meters and a gross tonnage of 91,655. On its fateful voyage, the m/v Derbyshire departed from Sept-Îles, Canada, carrying a cargo of iron ore bound for Kawasaki, Japan. However, it encountered Typhoon Orchid, a powerful tropical cyclone, in the South China Sea. The typhoon, with winds reaching up to 190 kilometers per hour (120 miles per hour) and massive waves, proved overwhelming for the bulk carrier. Despite being a large and modern vessel, the m/v Derbyshire could not withstand extreme weather conditions. On September 9, 1980, the ship abruptly disappeared from radar and was lost with all 44 crew members onboard, with no distress signals or communication received [13, 25]. All attempts to establish contact with the vessel failed. In the aftermath of the disaster, extensive investigations were conducted to determine the cause of the sinking. Various theories were proposed, including structural failure, cargo shifting, and problems with hatch covers. However, the exact circumstances that led to the sinking of the m/v Derbyshire remain uncertain. The sinking of the m/v Derbyshire, one of the largest ships ever lost at sea, profoundly impacted the maritime industry and international shipping regulations. It highlighted the vulnerability of bulk carriers to severe weather conditions and raised concerns about their structural integrity and safety measures [8].

The official report on the incident was released in 1998. It prompted Maritime Safety Committee (MSC) to launch a new review of bulk carrier safety using Formal Safety Assessment (FSA) studies to determine what additional regulatory changes might be required. Significant amendments to the SOLAS convention were made, including introducing new regulations specific to bulk carriers, such as improved structural standards, stability requirements, and enhanced inspection procedures. At its 76th session in December 2002, the MSC enacted revisions to SOLAS Chapter XII and the 1988 Load Lines Protocol, as well as a number of suggestions to improve bulk carrier safety. The MSC published a new language for SOLAS chapter XII in December 2004, integrating updates to several standards and new criteria for double-sided skin bulk carriers. These modifications went into effect on July 1, 2006 [14].

3.2 *Bulk carrier disaster – m/v Bulk Jupiter (2015)*

The bulk carrier m/v Bulk Jupiter met a tragic fate in 2015. On January 2, 2015, the Bahamas-flagged vessel encountered a disastrous incident in the waters off Vietnam while transporting bauxite, a type of cargo prone to liquefaction, from Malaysia to China. The ship encountered severe weather conditions causing significant difficulties during its voyage. It is believed that the load on board shifted, leading to instability and dynamic separation of the cargo, ultimately causing the vessel to capsize.

The incident resulted in the loss of 18 crew members, with only one individual found alive. The remaining crew members were declared missing and presumed lost at sea. The rapid capsizing of m/v Bulk Jupiter raised concerns about the safety risks of transporting certain bulk cargoes, particularly those prone to liquefaction.

Following the sinking of m/v Bulk Jupiter, investigations were carried out to understand the causes and circumstances surrounding the incident. This tragic event highlighted the need for improved regulations, cargo handling practices, and safety measures to prevent similar accidents involving bulk carriers. Efforts within the maritime industry were deployed to raise awareness about the risks associated with transporting bulk cargoes prone to liquefaction and the importance of proper cargo testing, certification, and stowage procedures to ensure the safety of seafarers and vessels.

The incident and the lesson learned also led to amendments to the International Maritime Solid Bulk Cargoes Code (IMSBC 05-19), which entered into force on 1 January 2021. The Code changes the focus and is directed at vessels carrying cargo similar in physico-chemical attributes to that of bauxite fines, m/v Bulk Jupiter's load. "According to the Code, 'This cargo may suffer instability due to moisture content resulting in dynamic separation and formation of a liquid slurry (water and fine solids) above the solid material, leading to a free surface effect which may significantly affect the ship's stability. This cargo is not liable to undergo dynamic separation when the cargo is shipped below its TML [transportable moisture limit]' (Res MSC.462(101), adopted on 13 June 2019) [9, 14, 15, 26, 29, 41].

3.3 *Bulk carrier disaster - m/v Stellar Daisy (2017)*

The sinking of the bulk carrier m/v Stellar Daisy in 2017 remains a significant and tragic event in maritime history. The South Korean vessel, owned by Polaris Shipping, was transporting iron ore from Brazil to China when it encountered a catastrophic incident.

On March 31, 2017, while in the South Atlantic Ocean, m/v Stellar Daisy suddenly sank, plunging into the depths of the sea. The ship's distress signal was received, and a search and rescue operation were launched. However, only two crew members were found alive among the debris, while the remaining 22 crew members were declared missing and presumed lost at sea [2].

The sinking of m/v Stellar Daisy sparked immediate investigations and raised questions about the circumstances that led to the vessel's demise. One prevailing theory suggested that the ship may have suffered a catastrophic structural failure due to a structural breakdown in the No. 2 portside water ballast tank. This triggered progressive structural failure along the cargo length and produced a total loss of buoyancy. The exact cause, however, remained uncertain, as no eyewitnesses could provide a detailed account of the events leading to the sinking [2].

The incident garnered significant attention within the maritime industry and revived discussions about the safety of bulk carriers. Concerns were raised about the structural integrity of aging vessels and the need for more stringent inspections and maintenance standards.

The International Maritime Organisation (IMO) is anticipated to evaluate additional bulk carrier safety measures under SOLAS Chapter XII and the 2011 International Code on the Enhanced Programme of Inspections during Surveys of Bulk Carriers and Oil Tankers (2011 ESP Code). These steps are intended to identify potential shortcomings in safety regulations and reduce the possibility of comparable maritime tragedies involving bulk and ore vessels.

3.4 *Bulk carrier disaster - m/v Nur Allya (2019)*

The bulk carrier m/v Nur Allya was transporting nickel ore and had 25 crew members on board from Weda Island (North Maluku) to Morosi (Southeast Sulawesi), Indonesia. The 189-meter (620-foot) bulk carrier's crew last communicated with the owner, PT Gurita Lintas Samudra,

on August 20, 2019, while near Bulu Island in Maluku. Soon after, the vessel went missing. Local authorities located the vessel 843 meters below the surface in the eastern 'spice island' of Maluku in October of 2019.

The official report is yet to be released. The investigation results will most likely stimulate discussions related to bulk carriers, potentially prompting the introduction of new amendments to the SOLAS [33].

Table 3. Lives lost in 10-year periods between 2005 and 2023. * - 10-year reports not available – numbers from the preceding report are carried over.

Year	2005-2015	2008-2017	2009-2018	2010-2019	2011-2020	2012-2021	2022	2023	Total (ships lost per year)
2005	8								8
2006	37								37
2007	39								39
2008	14	14							14
2009	39	39	39						39
2010	45	45	45	45					45
2011	39	39	39	39	39				39
2012	0	0	0	0	0	0			0
2013	15	15	15	15	15	15	15*		15
2014	0	0	0	0	0	0	0*	0*	0
2015	19	18	18	18	18	18	18*	18*	19
2016		0	0	0	0	0	0*	0*	0
2017		32	32	32	32	32	32*	32*	32
2018			0	0	0	0	0*	0*	0
2019				25	25	27	27*	27*	27
2020					0	0	0*	0*	0
2021						0	0*	0*	0
2022							1	1*	1
2023								0	0

Total (10-year period) 255 202 188 174 129 92 93 78
315

Other bulk carrier disasters that should be mentioned are those with significant loss of life. As mentioned earlier, 84 bulk carrier incidents were reported between 2005 and 2023 Table 2 provides a summary of bulk vessel disasters that involved the loss of life [1, 15–21]. Other trends that can be noted are that incidents often involve older vessels, and cargo shift and/or liquefaction are the most frequent cause of bulk carrier accidents.

4 SUMMARY

When concluding the disaster of the bulk carrier m/v Debryshire, it was concluded that the accident was caused by design errors that led to a sudden loss of buoyancy. The roofs of the venting system turned out to be faulty, they broke off under the pressure of water, revealing holes in the flooded deck. Due to the rapid loss of buoyancy, the ship suddenly sank to the bottom.

Following the m/v Bulk Jupiter disaster, operators were advised to always check the shipper's cargo declaration and moisture content certificate, paying attention to the cargo description, handling in accordance with the IMSBC Code and the stated moisture content.

After the loss of the bulk carrier m/v Stellar Daisy structural damage was found on exactly eleven ships. An investigation conducted in the Marshall Islands concluded that the contributing factors included large port and starboard wing tanks which increased the risk of structural failure and loss of buoyancy.

The problem of the bulk carrier m/v Nur Allya may have been caused by the movement of cargo caused by the phenomenon of liquefaction, witch may even cause the ship to lose its stability.

The amendments to the SOLAS Convention consider several conditions that result from analyses of maritime disasters. Bulk carriers should be equipped with high-quality alarms and systems to monitor water levels in the hold, ballast, and dry spaces. This is very important because good equipment usually proves reliable in emergencies. Without proper access, the structural condition of a vessel can deteriorate imperceptibly, resulting in major failures. Therefore, each internal space of the cargo area should be provided with adequate means of access, thus allowing comprehensive inspections throughout the vessel's life.

It may be essential to strengthen the supervision of class inspections of repairs, which would minimise or eliminate the practice of in-house repairs and significantly improve the safety of shipping.

Since the adoption of the SOLAS Convention, various amendments have been made. The new SOLAS regulations aim to improve maritime safety. Recommendations are given for individual vessel types. This makes it possible to provide the most detailed, well-defined solutions to operate particular vessel types, such as bulk carriers, safely.

Unfortunately, the path to improved vessel design has been strewn with many tragic experiences. Based on accident analysis, conclusions are drawn to improve specific design elements. The large bulk carrier fleet is particularly vulnerable to the risks of failure and sinking. Lack of shipowner control of corrosion progress and maintenance performed can contribute to the deterioration of the hull.

Initially, many dynamic loads on the hull during sea voyages of ships are known. However, large and uneven loads may occur on bulk carriers when, for example, only every second hold is filled with heavy cargo, when the ship undergoes prolonged ballast admissions, and when there is a short rocking period at a high metacentric height. The most significant stresses on the hull structure occur in severe weather conditions, like storms on large vessels, even though their wave work may appear lighter than that of small vessels.

When analysing marine casualties and their causes, it is clear that the most common cause is human errors. Unfortunately, they cannot be eliminated because they relate to and depend on humans. Nevertheless, we should strive to amend the necessary regulations to minimize these errors and the often-tragic consequences.

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