Scientific Journals
of the Maritime University of Szczecin

Zeszyty Naukowe
Akademii Morskiej w Szczecinie

2015, 44 (116), 68–73
ISSN 1733-8670 (Printed)
ISSN 2392-0378 (Online)
DOI: 10.17402/059

Received: 16.07.2015
Accepted: 01.12.2015
Published: 07.12.2015

Analysis of the cause and effect of passenger ship accidents in the Baltic Sea

Dorota Łozowicka[1]✉, Magdalena Kaup[2]

[1] Maritime University of Szczecin
1–2 Wały Chrobrego St., 70-500 Szczecin, Poland, e-mail: d.lozowicka.nazwisko@am.szczecin.pl
[2] West Pomeranian University of Technology, Faculty of Maritime Technology and Transport
41 Piastów Avenue, 71-065 Szczecin, Poland, e-mail: mkaup@zut.edu.pl
✉ corresponding author

Key words: passenger ships, safety, human factor, threats, accidents

Abstract
This article analyzes some maritime accidents involving passenger ships that occurred in the Baltic Sea. Existing forms of passenger transport by sea have been identified, and passenger-ship accident statistics in the years 2003 to 2013 are presented. We discuss threats that may exist in passenger transport such as, technical, operational and navigational risks, as well as threats caused by human error and bad weather. In the last part of the paper, we analyze the cause and effect of selected incidents of passenger ships in the Baltic Sea, which include the grounding of the ship MS *Amorella*, the *Stena Spirit* ferry collision with infrastructure, and the collision of two ships, the MS *Gotland* with HSC *Gotlandia II*. The impact of the human factor on the safety of passenger ships is also analyzed.

Introduction

Modern passenger ships operate regular and irregular shipping lines. They have different dimensions and parameters and different designs. The global trend in the construction of passenger ships means that they are becoming bigger and more exclusive, with every kind of attraction being offered on their decks. In comparison with other modes of transport, the occurrence of accidents in maritime passenger transport per year is not frequent. However, the effects of accidents at sea are often much larger proportionately and are more spectacular.

Although the overall safety level of passenger ships in European Union waters is now higher than in the past, risks associated with the carriage of passengers by sea have not been eliminated. Every year, there are hundreds of accidents and incidents. Therefore, learning from past events is required to improve the level of safety. The important thing is to identify and systematize threats in passenger transport, which will enable the selection of effective methods to counteract them.

Literature on this subject determines different classifications of threats. Considerable attention is focused on the human factor. The Human Factors Analysis and Classification System (HFACS), is a separate method of identifying human causes of an accident, and is used for different kinds of incidents; for example, grounding (Mazaheri et al., 2015) and collision (Chauvin et al., 2013). The other method for quantitative estimation of the "human factor", based on analysis of the physical and mental conditions of the operator and the working environment, is presented in a paper by Goncharov (Goncharov, 2015).

It is essential to make such changes that will contribute to increasing the safety levels of passenger ships. To prevent future tragedies, we should also draw lessons from recent events. For this purpose, it is important to analyze the cause and effect of all accidents and disasters in order to make the necessary changes to the regulations and safety

standards, to apply proper practices, and to take appropriate action to avert the threats. This article presents the proceedings in the analysis of cause and effect of passenger ship disasters. It examines three accidents that occurred in the Baltic Sea in recent years. The methodology used is not new, but allows for the selection of the essential aspects.

In the first part of the paper, we present a statistical analysis of passenger-ship accidents in the Baltic region between the years of 2003 and 2013 and we identify the threats in passenger transport.

The passenger-ship accidents in the Baltic sea region, that is, the grounding of MS *Amorella*, the collision of MS *Gotland* and *HSC Gotlandia II*, and the wharf incident caused by the ferry, *Stena Spirit* are analyzed in the second part of the article.

For each of them, we have created a scheme showing the development of events, which places the initiating factors, threats, emergency situations, and types of events and effects. This analysis confirms the importance of the human element as a factor in initiating events, but also examines the relationship between the type of event and the scale of its effects.

Statistical analysis of passenger ship accidents in the Baltic Sea region

The need to organize problems associated with seafaring and with the increasing number of users of the seas, gave rise to the International Maritime Organization (IMO).

According to the IMO, passenger ships are ships that carry more than 12 passengers on international routes and which must comply with the applicable provisions of the IMO (PRS, 2006).

The Central Statistical Office in Poland formulated the definition of a passenger ship, which specifies that a passenger ship is "...a ship designed to carry more than 12 passengers (with or without cabin facilities) who have purchased tickets ..." (GUS, 2015).

The statistical analysis of passenger ship accidents is based on the Baltic Marine Environment Protection Commission (HELCOM) from the years 2003–2013. During this time, there were 320 accidents involving passenger ships in the Baltic Sea. Figure 1 shows the number of passenger ship accidents for each year.

The highest number of accidents, 45 in all, occurred in 2013. The smallest number of accidents, 19, occurred in 2003 and 2005. Figure 2 shows the percentage of passenger ship accidents against the total number of marine accidents, which over ten years, ranges from 12 to 26% of all accidents.

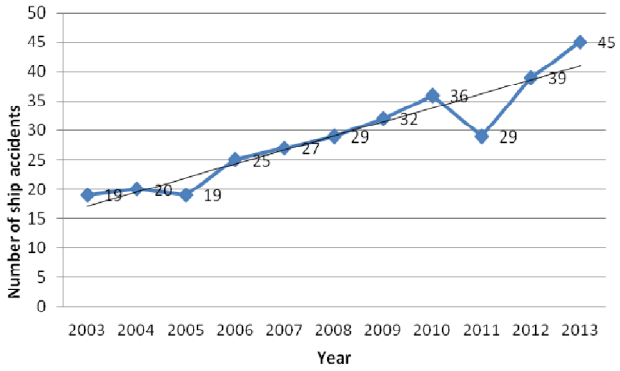

Figure 1. Number of passenger ship accidents in the years 2003 to 2013 (HELCOM, 2014)

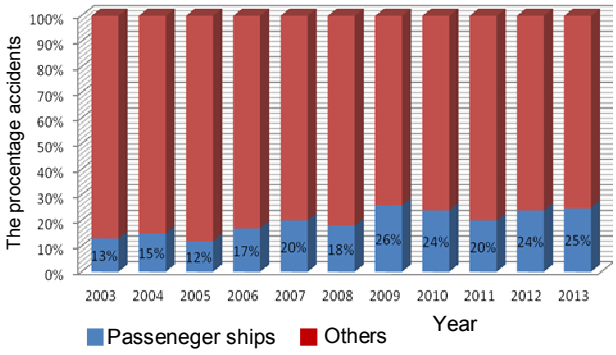

Figure 2. Percentage of passenger ship accidents in the total number of accidents in the years 2003 to 2013 (HELCOM, 2014)

The most common accidents were grounding, collisions, and collisions with infrastructure. However, other types of incidents are fire or explosion, damage to the ship and its equipment, or pollution. Figure 3 shows the types of accidents incurred by passenger ships in the Baltic Sea in 2013; while Figure 4 shows their causes. As Figure 3 shows, 29% of all accidents are passenger ships that have grounded and 18% are collisions. Human error and technical reasons are the most frequent causes of these accidents.

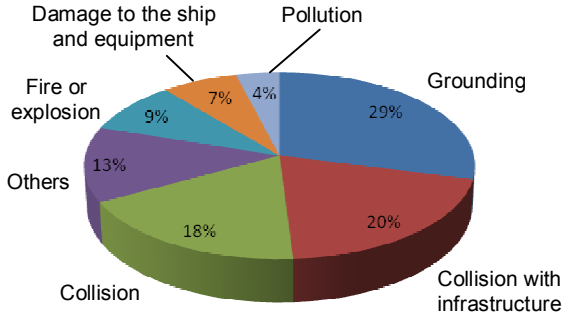

Figure 3. Types of passenger ship accidents in 2013 (HELCOM, 2014)

Despite raising safety standards for passenger ships with increasingly restrictive legislation, the number of accidents is rising. They are not perhaps,

spectacular events, but there are human casualties and destruction of vessels.

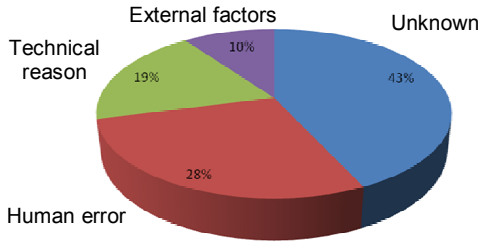

Figure 4. Reasons for passenger ship accidents in 2013 (HELCOM, 2014)

Cruise ships are found to have more mortalities than non-cruise ships. The biggest number of mortalities is associated with shipping accidents that occur far away from the coastal area, harbor, or port (Weng & Yang, 2015). However, hazardous events that occur in ports may be due to the fact that passenger terminals are located in close proximity to other cargo terminals and are subject to additional risk factors. Possible accidents on cargo terminals, oil spills or fires could influence the safety of passenger ships (Vidmar & Perkovič, 2015).

Identification of threats in passenger transport

The definition of threat is "... the possibility of specific losses, adjusted for the situation arising after the occurrence of a single adverse event in the present system of man – technology – environment ..." (Szopa, 2009).

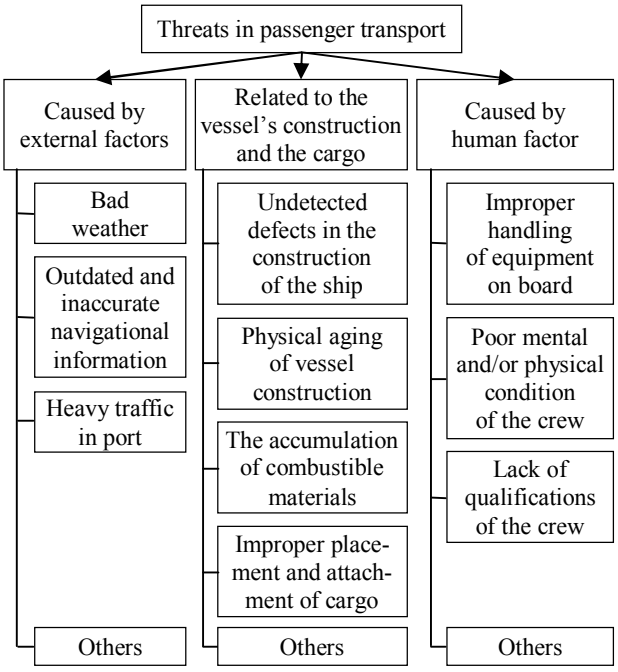

Figure 5. Examples of threats in passenger transport

Table 1. The types of threats because of their origin (Girtler, Kuszmider & Plewiński, 2003; Semenov, 2003; Jagniszczak & Łusznikow, 2010)

No.	The threat type	Comment
1.	Technical	These refer to the reliability of marine equipment, energy, technology and the significance of undesirable events occurring in each element of mechanisms, equipment and construction. These are design, production and operating dangers. They can also be predictable or unpredictable
2.	Operating	Threats determined by external, internal and navigation factors. Associated with work such as loading and unloading of vehicles and cargo, passenger embarkation and disembarkation, and the ship's supplies
3.	Navigation	These are associated with sailing a predetermined route. The possibility of their occurrence depends on the parameters of waterways, in hazardous areas, hydro- meteorological conditions, methods used in navigation and the technical means, timeliness and reliability of navigational information, steering the ship, etc.
4.	Climatic	Strong wind and waves affect the ship causing a reduction in speed, and maneuverability; they , increase the size of drift, adding stress to the hull structure; transverse and longitudinal sways cause waves to destroy the ship's equipment and cargo. Dense fog, rain or snow reduces visibility, causing difficult sailing conditions. Thus increasing the probability of collision with other ships or icebergs
5.	Human errors	About 80% of accidents and crashes are caused by human error. Crew behavior, and their qualifications and experience have an impact on the quality of service throughout the ship. Proper execution of all operations can eliminate a danger to the ship, crew and passengers

There are many types of threats. The first division indicates the internal and external threats. Another classification takes into account the causative factors such as, the human factor, the ship's structure, or the specifics of transported cargo (RO-RO), which is illustrated in Figure 5. Detailed classification distinguishes threats because of their origin (Table 1).

External factors that could endanger listed on the possibility of collisions and groundings. For vessels operating on short lines and on high-traffic routes, ship collision risk seems to be high. Generally, although grounding in comparison with collision is not too dangerous, it can end in tragedy as in the case of *Costa Concordia,* which shows the dramatic consequences resulting from running aground.

Among other external factors are hydro-meteorological processes, which often contribute to the disaster of even the largest vessels.

Passenger ships carrying a very large number of persons on board can be a potentially attractive target for a terrorist attack. Taking into consideration the current political situation, this type of threat should be carefully considered.

It should be noted that the risk of fire increases on passenger ships. This threat can be high, medium or low depending on the density of combustible materials. Passenger ships are equipped with upholstered furniture and all kinds of decorative materials. It is impossible to completely eliminate the risk as the passengers themselves can carry inflammable material in their personal luggage. This is why passenger ships are equipped with more fireproof doors than cargo ships. Threats in passenger transport can be due to many unforeseen events. These include groundings, collisions, or technical failures. The most common type of incident on passenger ships is technical failure, followed by collisions with floating or stationary objects, and then groundings. The least likely threats are adverse events such as flooding or sinking, although these are the most dangerous in their consequences.

Analysis of selected passenger ship accidents in the Baltic Sea region

Ship traffic flow in the Baltic Sea Region is steadily growing; there are new, increasingly larger ships. Note the large number of regular ferry connections. Shipping routes and traffic separation schemes in conjunction with the possibility of monitoring the movement make it ever more necessary to move ships along specified routes. A situation, in which the ship is between partially determined waterways with the possibility of free route choice, raises questions about the current level navigation safety. This applies particularly to waterways that border on orderly and free traffic. The impact of weather conditions on the safety of passenger transport is undeniable. The rate of accidents is proof of that. The Baltic Sea is of cold and shallow, and unpredictable in strong winds. Taking into account the above considerations, namely heavy traffic and adverse weather conditions, a specific analysis should be made of not only accidents that have occurred so far, but also to estimate the risk of accidents across the Baltic Sea region. Such analyses are necessary to continuously invest in technologies to improve safety at sea, and to prevent damage to both humans and the marine environment.

Table 2 presents selected passenger ship accidents that have occurred in the Baltic Sea in recent years. Among the events shown in the table, most of the initiating factors were human error. The other incidents were a result of technical failure and adverse weather conditions. Fortunately, in these cases there were no fatalities, although there were injuries. Figures 6, 7 and 8 show the diagrams of three different events: the grounding of MS *Amorella*, the *Stena Spirit* ferry collision with infrastructure, and the collision of two ships MS *Gotland* with HSC *Gotlandia II*. The analysis shows that these events in the Baltic Sea, would not have occurred had the ships' crews acted with greater prudence and caution.

The human factor is invariably the weak link in safety systems, and its impact will be further discussed in the next section.

Table 2. Examples of passenger ship accidents in the Baltic Sea in recent years (Portal Pomorza, 2008; Szwecja, 2009; E-transport, 2010; Dziennik Baltycki, 2012; Gospodarka Morska, 2013)

No.	Type of event	Time and place	Description of the situation
1.	Grounding of the ship MS *Amorella*	February 2013, Coast of the Åland Islands	As a result of a power failure, passenger and car ferry lost steering and ran aground off the shipping lane. No decision was taken to evacuate. After the incident, the ship, powered by its own engines, came off the rocks, and escorted by tug, headed for the port of Mariehamn
2.	The collision of and ferry *Stena Spirit* with infrastructure	May 2012, Port of Gdynia	Passenger ferry was dangerously close to the waterfront and clipped the crane gantry on the Baltic Container Terminal. The crane collapsed onto the quay and containers, injuring three Terminal employees
3.	Fire on MV *Lisco Gloria*	October 2010, Route: Klaipeda-Kiel	As a result of technical failure of one of the transported vehicles, fire broke out on the car deck. 28 people were injured, and the ferry was scrapped due to the extensive damage caused by the fire
4.	The collision of two ships MS *Gotland* and HSC *Gotlandia II*	July 2009, Port of Nynashamn	A collision of two passenger ferries in port. As a result, all the passengers were evacuated to shore. The accident disrupted ferry services between the island of Gotland and the mainland. Four people were seriously injured, and more than 20 were slightly injured
5.	Grounding of the ship *Mona Lisa*	May 2008, Irbe Isthmus	The cruise ship ran aground off the coast of Latvia, after being taken off course by a tipsy crew. An attempt to refloat it with the passengers aboard failed and the vessel had to be evacuated
6.	The collision with the quay of ship MS *Nortlandia*	October 2008, Port of Tallinn	The ship was unable to overcome the force of the wind itself due to limitations in maneuvering in the port and hit the quay. The result of hitting the wharf was damaged the ship's side, the port waterfront and the destruction of the ladder on the waterfront

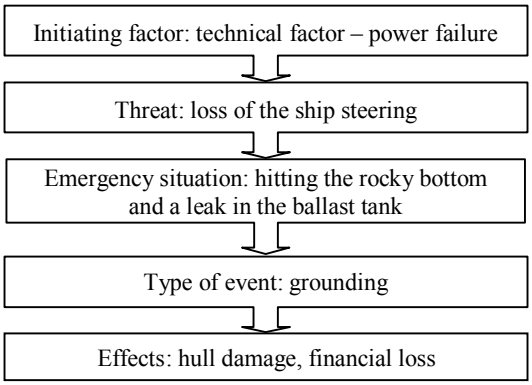

Figure 6. Scheme of the development of events for the ship MS *Amorella*

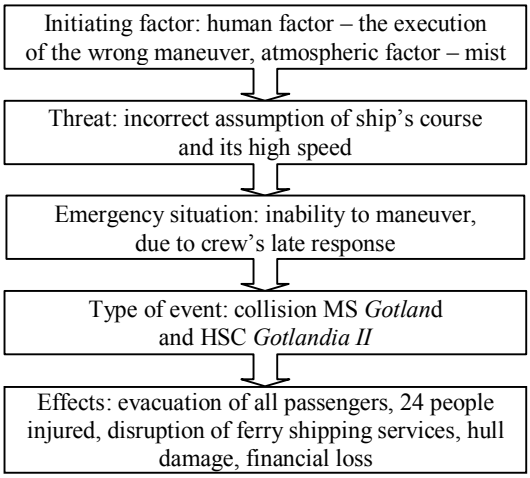

Figure 7. Scheme of the development of events for the collision of ships MS *Gotland* and HSC *Gotlandia II*

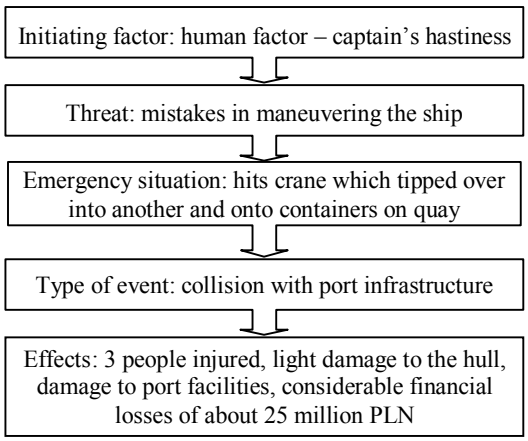

Figure 8. Scheme of development of events in port after ship *Stena Spirit* hits crane gantry

Impact of human factors on the safety of passenger ships

Risks in passenger transport initiated the broader human factor that can result from many different reasons. They often occur due to failure to perform the required procedures, or functions improperly executed, or to perform actions that do not comply with the procedure. The work of the crew members on a ship is heavily influenced by the external environment, which depends on the technical and operational parameters of the vessel and has a huge impact on the safety of navigation. A common problem is crew fatigue caused by a specific work system. The daily arrival of a ship to the same ports often results in routine behavior among crew members, which is highly detrimental to the safety of navigation.

A large number of people on board the vessel (both passengers and crew) cause an increase in the risk of fire. The reason for this may be inattention, drunkenness, neglect of duties etc. Especially if we take into account the random behavior in a large passenger population. The problem also arises in the case of the need for a possible evacuation. This subject has been described in publications (Łozowicka & Łozowicki, 2010; Łozowicka, 2011; Łozowicka & Kaup, 2014).

The human factor can be a direct threat to passenger ships; it may be the first element in initiating adverse events in situations such as navigational error or terrorist attack. The human factor is not a direct source of danger, but incorrect actions exacerbate dangerous development of events, which in turn can have disastrous consequences. Figures 9 and 10 are general diagrams of the development of events indicating the place of the direct and indirect impact of the human factor.

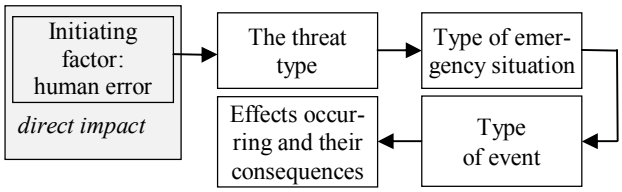

Figure 9. Scheme of development of events in which human error was initiating factor (direct impact)

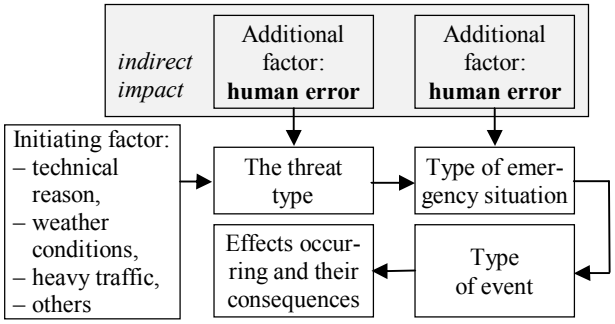

Figure 10. Scheme of development of events in which human error further influences the development of the events and consequences of an accident (indirect effects)

It is essential that, in everyday situations, all crew members perform their duties correctly, so

that in an emergency they can eliminate a threat by responding appropriately. Unfortunately, in many cases, the human factor exacerbates the threat and becomes an additional hazard factor in the event of an emergency situation. Such a situation occurred, for example, with a fire on the ship *Lisco Gloria*, where the initiating factor was a technical failure, but where the crew's mismanagement led to the spread of fire, which resulted in dozens of people being injured, and the ship had to be scrapped. Passenger safety largely depends on a sufficient number of skilled, experienced and suitably qualified crew and staff.

Conclusions

The safety of sea-faring passenger ships depends on several factors that include technical, operational, navigational, hydro-meteorological, and human factors. The analysis made in this article confirms that many kinds of events on passenger ships are triggered by the human factor. Human error directly causes up to 80% of accidents. In other incidents, it is often human behavior and responses that indirectly affect the development of a hazardous situation, leading to the evolution of various types of disasters or accidents. External factors, such as climatic and sailing conditions play an important role in maritime accidents involving passenger ships. Bad weather conditions may affect and limit visibility, and loss of stability could cause the vessel to heel, which in turn could contribute to a ship sinking. While we cannot eliminate the impact of the meteorological factor for the safety of passenger ships, as the forces of nature are unpredictable, we can ensure the ship is safely managed, so as to diminish the risk of dangerous situations. Examples of passenger ship accidents presented in this article show that the human factor is the most unreliable link, and that undisciplined behavior can further exacerbate events and their consequences. For example:

- Hastiness of the captain of the *Stena Spirit* led to the execution of erroneous maneuvers in the port of Gdynia, with the result that the ship hit the quay and damaged port facilities and storage containers;
- Incorrect maneuvers performed in adverse weather conditions, by the crews of MS *Gotland* and HSC *Gotlandia II* in the port of Nynashamn, led to the collision.

References

1. CHAUVIN, CH., LARDJANE, S., MOREL, G., CLOSTERMANN, J. & LANGARD, B. (2013) *Human and organizational factors in maritime accidents:* Analysis of collisions at sea using the HFACS. *Accident Analysis & Prevention***.** 59. pp. 26–37.
2. Dziennik Bałtycki (2012) [Online] Available from: http://www.dziennikbaltycki.pl/artykul/3410647,gdynia-kapitan-promu-stena-spirit-oskarzony-ws-wypadku-w-bct-z-maja-2012-r,id,t.html?cookie=1. [Accessed: 10th February 2015]
3. E-transport (2010) *Pożar promu Lisco Gloria na Bałtyku*. [Online] October 2010. Available from: http://etransport.pl/wiadomosc,12565,pozar_promu_lisco_gloria_na_baltyku.html. [Accessed: 10th February 2015]
4. GIRTLER, J., KUSZMIDER, S. & PLEWIŃSKI, L. (2003) *Wybrane zagadnienia eksploatacji statków morskich w aspekcie bezpieczeństwa żeglugi*. Szczecin: Wyższa Szkoła Morska.
5. GONCHAROV, V. (2015) A possible approach for "human factor" estimation. *Scientific Journals of the Maritime University of Szczecin*. 43 (115). pp. 65–67.
6. Gospodarka Morska (2013) *Wypadek promu Amorella na Bałtyku*. [Online] December 2013. Available from: http://www.gospodarkamorska.pl/wydarzenia/wypadek-promu-amorella-na-baltyku.html. [Accessed: 10th February 2015]
7. GUS (2015) http://www.stat.gov.pl. [Accessed: 10th February 2015]
8. HELCOM (2014) *Report on the ship accidents in the Baltic Sea area for the year 2012*. Helsinki Comission, Baltic Marine Environment Protection Commission, Helsinki 2004–2014.
9. JAGNISZCZAK, I. & ŁUSZNIKOW, E. (2010) *Bezpieczeństwo nawigacji*. Gdańsk: Wydawnictwo Fundacji Promocji Przemysłu Okrętowego i Gospodarki Morskiej.
10. ŁOZOWICKA, D. & KAUP, M. (2014) Analysis of risk passangers and evaluation of the possibility of evacuation of high speed crafts. *Scientific Journals of the Maritime University of Szczecin*. 39 (111). pp. 100–106.
11. ŁOZOWICKA, D. & ŁOZOWICKI, A. (2010) Identification of factors having an impact at the moment of commencing the evacuation of people from a vessel. *Transport Problems*. 5. 2. pp. 59–64.
12. ŁOZOWICKA, D. (2011) Investigation of the influence of people's "herding behavior" for evacuation time from a passenger ship. *Logistyka –nauka*. 6. pp. 2341–2047.
13. MAZAHERI, A., MONTEWKA, J., NISULA, J. & KUJALA P. (2015) Usability of accident and incident reports for evidence-based risk modeling – A case study on ship grounding reports. *Safety Science***.** 76. pp. 202–214.
14. Portal Pomorza (2008) *Wczoraj w Gdyni, dzisiaj uwięziony na mieliźnie na Bałtyku!* [Online] May 2008. Available from: http://portalpomorza.pl/artykul/14994/wczoraj-w-gdyni-dzisiaj-uwieziony-na-mieliznie-na-baltyku. [Accessed: 10th February 2015]
15. PRS (2006) Międzynarodowa Konwencja o Bezpieczeństwie Życia na Morzu, SOLAS 1974. Polski Rejestr Statków.
16. SEMENOV, I.N. (2003) *Zarządzanie ryzykiem w gospodarce morskiej. Tom 1. Zarządzanie bezpieczeństwem statków transportowych i obiektów oceanotechnicznych*. Szczecin: Wydawnictwo Uczelniane Politechniki Szczecińskiej.
17. SZOPA, T. (2009) *Niezawodność i bezpieczeństwo*. Warszawa: Wydawnictwo OWPW.
18. Szwecja (2009) *Kolizja promów w Nynäshamn*. [Online] July 2009. Available from: http://szwecja.net/NOW/fs-now/2009/kolizjaPromow.html. [Accessed: 10th February 2015]
19. VIDMAR, P. & PERKOVIČ, M. (2015) Methodological approach for safety assessment of cruise ship in port. *Safety Science*. 80. pp. 189–200.

20. WENG, J. & YANG, D. (2015) Investigation of shipping accident injury severity and mortality. *Accident Analysis & Prevention*. 76. pp. 92–101.