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ENVIRONMENTAL RISK MANAGEMENT IN SHIPPING. CASE STUDY: THE HUMAN FACTOR INFLUENCE IN OIL SPILLS

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Abstract: *Human factors - either individual errors or organizational failures - have been reported to cause as much as 80% of oil spills and marine accidents. Improvements to oil spill prevention technologies, tanker design, and systems engineering are often cited, along with improved regulatory oversight, as contributors to a general decline in the number of marine oil spills over the last decade. Yet, oil spills and industrial accidents continue to occur. This is due, in part, to the fact that human and organizational errors continue to occur despite, or sometimes because of, improved technologies. The study of human factors is based on the acknowledgement that human characteristics and behaviors are intrinsically linked with the functioning of the technology people design, build, maintain, and operate. The human-technology relationship works in both directions, though. Not only do humans impact the functioning of our technology, but technology can also influence human decisions and actions.*
Key words*: human factor, shipping, oil spills*

1. INTRODUCTION

Maritime safety is an integral part of operating commercial vessels. Theorized in terms conceptually, environmental risk management is currently one of the major objectives of the international shipping. Starting from these issues the study is based on the analysis of incidents and accidents involving shipping and marine pollution present in the database of the British Agency MAIB *(Marine Accident Investigation Branch).* Reported on issues related to **the human factor influence on oil discharges from ships** observations and conclusions that the authors have come within the framework of the study can be particularly useful for all “stakeholders” in the field of shipping (regulatory authorities, operators, shipping companies, training institutions, profile universities).

2. THE ANALYSIS OBJECT ADDRESSED WITHIN THE PAPER

The paper was founded on the basis of the documentation of a large number of bibliographic sources, which highlights for the period 2000-2009 more than 652 naval accidents and incidents involving spills in the marine environment (note that all the cases analyzed are documented on the MAIB website and regulations under the Merchant Marine Rules of the UK).

The purpose of this study is to highlight human factor as a main cause of the large number of accidents aboard merchant ships, accidents involving among others the oil pollution of the marine environment due to the failures that occur on the navigating bridge.

3. MANAGEMENT ISSUES IN ORGANIZING THE WATCH TEAM

Safe navigation implies the effective application of the principles of command, control, communication and management, and consideration/ analysis of each navigation situation, endowment of human/ technical data on the navigation control, operational status of navigation equipment and propulsion system (main engine, auxiliary generators) or the system of government. Since people/ crew are those who control and manage the ship, quality, management and teamwork are key factors in achieving satisfactory performance. Watch team structure will be determined by the need to maintain a proper lookout appropriate to the circumstances and specific situation conditions, table 1 (table obtained in consultation with responsibilities crew management – 38 officers or operational – 52 engine and deck officers from 8 companies: Fair Play Maritime, CMA/CGM, Maersk Sealand, Capital Shipping, AB Crewing, MCL International, Bright Balkan, Tinecomar).

Table 1 Factors governing the watch keeping with or without unpatended personnel

Watch team without unpatended personnel	Watch team with unpatended personel
-visibility, sea state and weather conditions	-navigation order should not remain without a person ever an the lookout
-traffic density or other activities performed in navigation	-weather conditions, visibility and whether day or night
-attention needed to the execution of navigation in traffic separation zones	-potential danger in navigations requires the officer on watch a volume of additional measures
-additional loads imposed by the functional status of the ship	-use and functional status of the means of navigation
-health and physical ability of team members watch	-if the vessel is equipped with autopilot
-level of professional knowledge and competence of team members watch	-if the watch officer must perform radio traffic
-the experience of the watch team and familiarity with ships equipment	-if propulsion plant is automated or not
-activities on board	-equipping level alarm and indication
-operational status of bridge instruments	-any unusual requirement that might arise from the specific situation of navigation

An accident is by nature something unexpected, but most accidents happen because there doesn’t exist a system for early detection and countering the errors made by a person.

A good organization of the service and watch team combined with good management practices in addressing duties assigned to create the necessary system for the prevention of accidents. In this context, the concept of “Management watch team” can be defined as the implementation of methods/ procedures work by recognizing that maintaining the performance standards can be achieved only by applying best international practices and an efficient organization of the watch keeping activity.

4. THE HUMAN FACTOR – ERROR CHAIN MANAGEMENT – ACCIDENT – OIL POLLUTION

In most cases, maritime accidents were the result of a successive series of errors which culminated in the **accident** itself and **marine oil pollution**. Clear knowledge of the operational environment and the results/ key information they produce in a normal course of business – in other words, to know what happens on the ship and around them – will substantially contribute to early detection of errors and allow for necessary measures. There are three main components of the ship that involves movement and thus can generate dangerous situations. These are: governance system, propulsion system and navigation system. A technical fault or human error occurred in these systems can generate a potentially dangerous situation.

The most common forms of manifestation of errors are:

- failure to complete a task in time
- ignorance and / or ignoring the size and quality of the ship maneuver
- non-observance of the Travel Plan or established work procedures
- lack of effective monitoring of the road vessel, to rule, indications MP, registered road, probe, log, GPS, etc.
- lack of effective visual vigilance and lack of proper identification markers to dry;
- non- execution of calculations to avoid collision;
- non-displaying lights and signs required;
- lack of monitoring VHF / radio and non-performance rounds on the ship.

Human factors that can release a chain of errors

Ambiguity

Can be relatively easily identified and defined. For example, if two independent position determination give different positions of the ship, it is clear that something is wrong with one of them. Such a situation calls for immediate verification of both systems / positions to determine which one is correct. Another example of ambiguity is that two team members have different opinions about how course is to be performed a certain action. Ambiguity can result from lack of experience or training. Sometimes, new employees have a reluctance to express doubts. Such a phenomenon should be avoided on board, and each crew member should be encouraged to express freely and without fear any doubt or misunderstanding blur without fear that this could have adverse consequences / penalty against him.

Distraction

Distraction from the purpose of an action or focus on one aspect at the expense of others is the first indication that vigilance begins to wane. Such a phenomenon may occur due to an excessive workload as a result of fatigue deleted or, in emergencies, or, most commonly the case, as a result of refusing the due attention to the details of it. Sometimes this phenomenon can occur as a result of sudden event that even without such danger can divert attention to be paid to the primary activity. For example, a call / VHF conversation can lead to neglect regular supervision navigation.

Confusion

May occur due to lack of experience. It's hard to detect because the person may have the feeling that what is doing is good, confusing the personal opinions with the principles of good practice principles of interpretation. Experienced officers will develop a sense of the situation for navigation and ship control / position, but to such a level, the system needs to compensate for any confusion that may occur.

Inadequate communications

Poor communications, both internally and externally, are another indication that the watch keeping can be placed in a situation of risk. Internal communications can be affected by physical causes, such as noise or language difficulties and / or working methods. External communications can be affected in general language and non-understanding or different interpretation of specific terms of this language. In all these situations, every effort must be accurate clarification of the message to be transmitted and that the recipient understands the message clearly what to do.

Inadequate watch keeping/ management

Improper management of the ship or improper maintenance of wakefulness may be the result of a lack of situational awareness or alertness disruption of performance required a watch. This is perhaps the most important in ensuring the safety of the ship and stop alertness during watch.

Failure to plan / procedures

Deviation from previously executed Travel Plan and approved by the commander or the standard procedures used to control navigation, is another indication of decreased vigilance and because of this misconduct should be investigated immediately.

5. QUANTIFICATION OF HUMAN FACTOR IN THE CHAIN OF A SHIP ACCIDENT

Analysis in the study was structured according to the following algorithm:

a) handling information on shipping accidents in accordance with information provided by the literature (Marine Accident Investigation Branch).

b) limiting research only to those accidents about which there is sufficient information (type of vessels involved, the causes of the accident, the amount of discharge of oil, etc.).

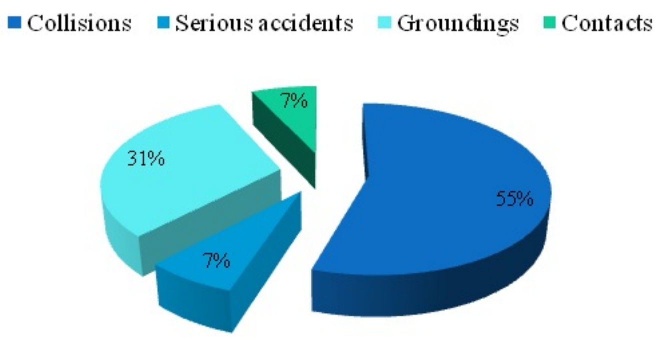

Fig. 1 Type of shipping accident

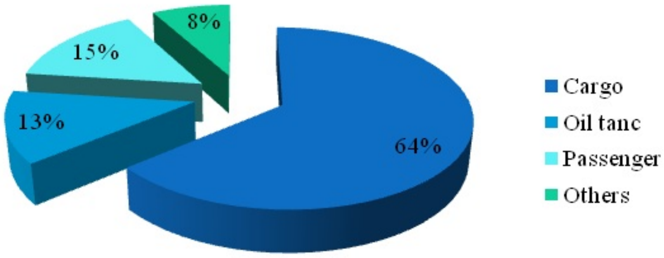

Fig. 2 Type of vessel involved in shipping accident

c) fishing vessels and vessels less than 500 GRT, were excluded from this analysis due to differences in rules applicable in the field of navigation.

All graphics in this study are obtained from processing the information documented on the site www.maib.gov.uk and is the author's personal contribution to the work on quantifying the human factor in naval accident chain.

The presentation of these issues will follow a logical route, which in the opinion of the author, brings together all the "assets" associated with "event" of shipping: crew, ship navigation hydro-meteorological conditions, commodity and its impact on the environment as a result of naval accident.

Thus, Figures 3-6 show the distribution of accidents by: size, type of ship, time of day when the accident occurred, visibility conditions.

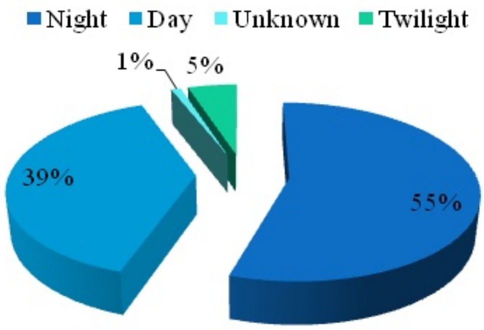

Fig. 3 Naval accident – day period

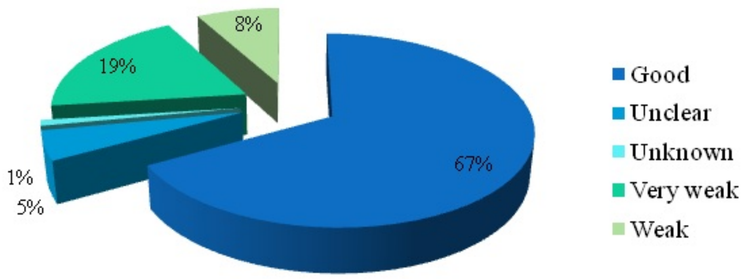

Fig. 4 Visibility conditions

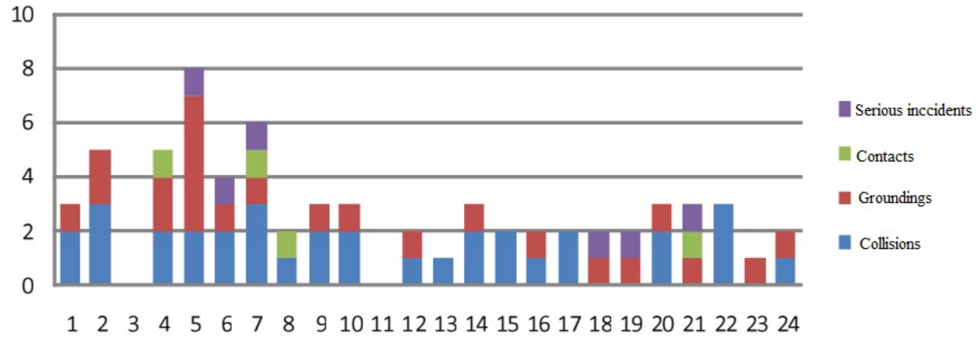

Fig. 5 Period of the day when shipping accidents occurred followed by oil pollution

6. THE INFLUENCE OF HUMAN FACTOR ACCIDENTS BY TYPE OF SHIP

Groundings

The time interval examined 23 vessels have failed, representing approximately 30% of vessels analyzed. From Figure 6 it can be seen that 11 of the groundings occur between 00.00 and 06.00, corresponding diurnal distribution. Fatigue was considered significant factor in 9 or 82% of failures occurring between 00.00 and 06.00.

It is worrying that 8 of 9 cases of accidents have fatigue as a major factor, with only two ships involved officers on watch keeping. In each case, was not found to ensure proper bridge, autopilot was on and the alarm was not used watch and watch officer fell asleep. These 8 vessels represent 35% of all failures studied.

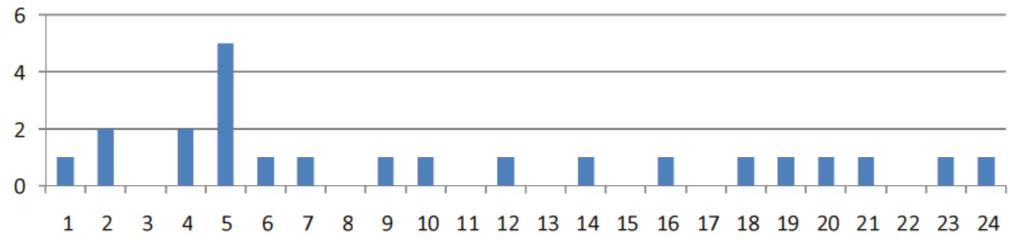

Fig. 6 Number of grounded vessels in the schedule of one day

Minimum safe manning and fatigue

For vessels with a single officer on watch on the bridge found a total of 20 groundings. All ships were type cargo / container, 84% are less than 3000 GRT, 92% with only two deck officers and sailors to three (Figure 7). Groundings occurred in good visibility of 75% at night.

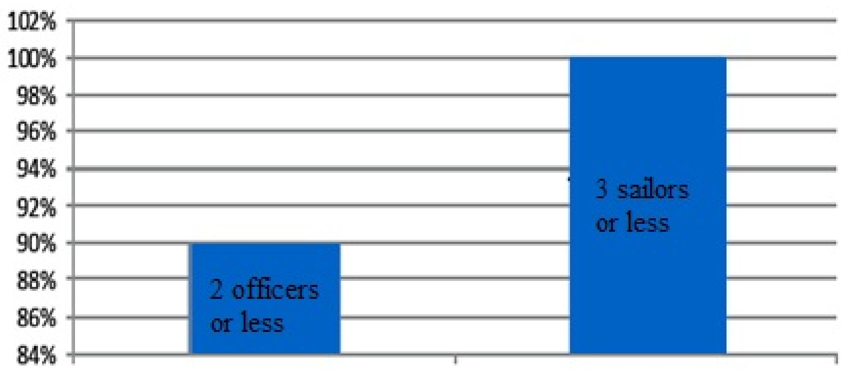

Fig. 7 The performance level of safe manning crew

The data correspond to type cargo vessels operating in small limited areas of navigation on board who is sailing with only two deck officers. Due to these factors the watch crew fatigue is high, being one of the marine groundings reasons. A lot of factors that probably contributed to this type of incident are: time of the voyage, the hours they work, problems associated with sleep, stress, relationships between the crew, the type / size of vessel and type of goods transported.

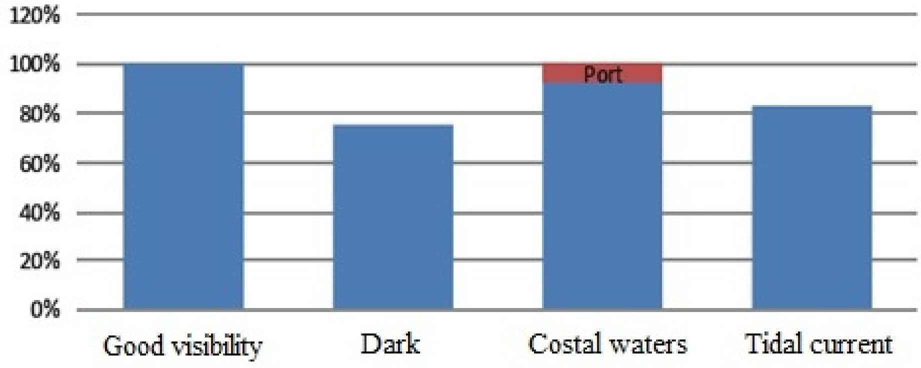

Fig. 8 Environmental conditions when groundings occurred

In Figure 9 are two of the work programs of officers on watch, 4 with 4, and 6 with 6 hours, showing that a large majority of groundings occurred between 00.00 and 06.00 program of 6 hours continuous work.

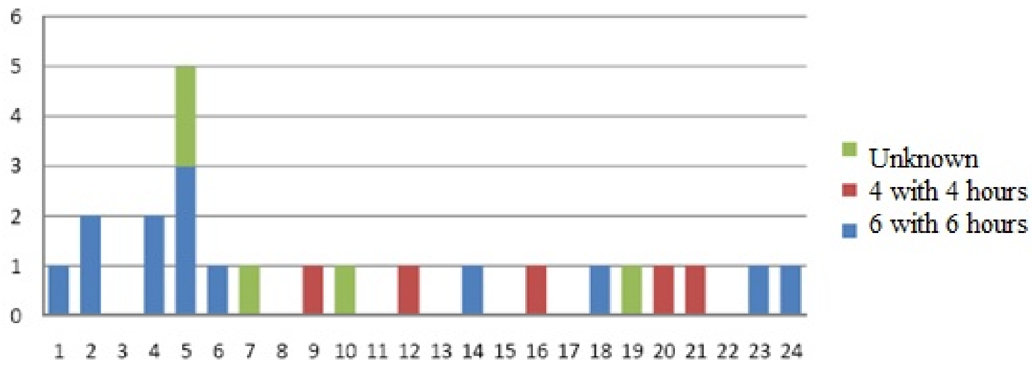

Fig. 9 Work programme – a cause of groundings

Given that this cycle of work remains uninterrupted human body will adapt this program, resulting in a higher level of performance and alert throughout the night watch. Uninterrupted work cycle is possible during the voyage, but the waters of Northern Europe, where the voyage length varies between several hours and several days, this cycle is interrupted by the frequency of ports visited. During this voyage, pilotage, cargo operation and the large number of inspections, makes work cycle of the bridge crew, inevitably, be discontinued. Also, a night in port, may seem to be the closest solution to stop fatigue, but may be a break factor of the cycle of work of watch officers.

Even if there are opportunities to rest, it is not guaranteed that an officer on watch or want to sleep. Personal problems such as the ability to communicate with family should be considered, but existing shipboard noise, temperature, light, will affect individual opportunities to sleep. In fact most of these factors are influenced by weather, explaining that most failures occur during the winter months when the outside temperature is low, bad weather phenomena are more and nights are longer.

The interval shown STCW requirements for crew rest. According to they rest period should not be less than 10 hours in 24 hours and 77 hours in a period of 7 days. It also added that the hours of rest would be divided into two periods, one being at least 6 hours, and the interval between them should not exceed 14 hours. Even if a watch is 6 for 6 hours, these requirements may be imposed for a period of seven days because an officer of the watch will work 84 hours a watch. If you add a minimum of 77 hours of rest, there is still 7 hours, which can be used one hour a day watch the pulse for the benefit of the master or captain to carry out responsibilities of books. For captain, these responsibilities include supervising cargo operation, maps and publications corrections, supervision and coordination of maintenance and equipment, and the role of security officer.

Collisions

Collisions should theoretically be avoided if every vessel would respect international regulations for preventing collisions at sea, which were implemented in 1977. Common factors in all collisions are usually associated mostly with superficial supervision (standby) and improper use of radar. The analysis conducted in this paper highlights the fact that 67% of collisions involved fishing vessels were 33% and in other cases other commercial vessels. This should lead officers on watch to maintain additional vigilance on small vessels. Even if small vessels are observed in time to avoid actions often are taken for the officer on watch. A common explanation for such tardiness in taking measures to avoid is that vessels move irregularly. Collision statistics indicate that a correction should be made to COLREG, to avoid such accidents.

Watch

For a number of 26 ships involved in collisions (65%) had joint rule 5 of Regulation COLREG failure, which claims: "Every vessel must maintain by any means, including audio and visual surveillance continuous supervision to avoid a collision".

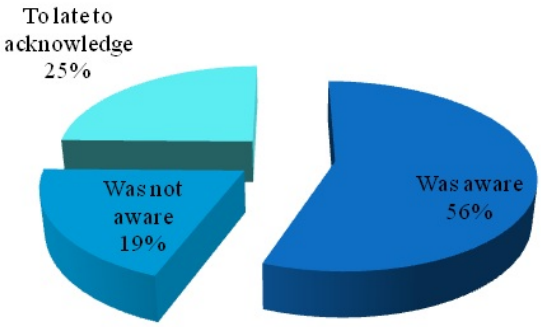

Fig. 10 The level of immediate perception of a collision

In Figure 10 we see that in 19% of cases, vessels involved in collision, watch keeping officer didn't knew of the presence of other vessels in close proximity to the collision, and in some cases even after the collision. And a rate of 24% of vessels involved in collisions went on alert when it was too late for any avoidance maneuver.

The role of the commander

To reduce fatigue to the officers on watch on ships for short voyages economic reasons only two watch keeping officers are available, which is totally contraindicated. For journeys lasting medium or large problematic organization has its specific navigation charts, the human factor is decisive in achieving security for the ship, cargo and crew.

The study in this paper highlighted the importance of managerial skills and competencies of the commander are to prevent accidents naval and involved in preventing oil pollution from ships.

From this perspective I think it must identify, assess and manage correctly all risk factors associated with making the trip:

- visibility, weather and sea state;
- traffic density and other activities taking place in the area of navigation;
- attention required when sailing near a traffic separation scheme;
- employment supplement caused the type of vessel operation and anticipate immediate maneuvers;
- good preparation of each crew member of a watch;
- knowledge and confidence in the professional competence of officers and crew;
- high level of training for each officer of navigation.

7. THE HUMAN FACTOR - RECOMMENDATIONS TO REDUCE OIL POLLUTION FROM SHIPS

Regardless of the level of automation of management and merchant ships with cargo operations default, the human factor cannot be "removed" from shipping. The study analysis shows that the study of marine accidents resulting in spills of oil leads not only to the specific re-engineering of working crew and the engineering approach to problems associated with changing systems and naval equipment in order to substantiate the technical solutions reduce accidents in the field and default prevention of marine pollution.

The actions identified are summarized below:

- Substantiating information structures organized in databases by standardizing the way of collecting information to quantify the influence of human factor in the causal chain of an incident / accident involving discharge of oil;
- Identification and quantification of individual and group typologies causal relationship naval accident resulting in oil pollution;
- Create procedural obligations reporting system with cargo and ballast operations performed (Oil Record Book, regional centers reporting procedures, eg Network Baltic Sea, Black Sea Network, etc.).
- Promotion and implementation of best practices (for navigation, cargo operation, etc..) generally recognized to reduce the risks of accidents and spills caused by human factors;
- Incorporating the human factor studies and risk analysis to assess the risk of pollution;
- Identifying causal relationships in the interaction human-technical system (the human factor, technical factor) and integration of all observations to obtain optimal solutions in terms of engineering, useful in the practice of operating ships;
- Formulation of new regulations on maritime safety implications on the human factor.

8. CONCLUSIONS

The central objective of the work is associated with identify courses of action to prevent oil pollution from ships in connection with the human factor. From this point of view outlined four fundamental questions:

What is the human factor contributing to the discharge of oil from ships?

Existing statistics worldwide shows that over 80% of shipping accidents have human factor as the main cause. By consequence the identification and assessment processes associated with the risk factor, followed by grounding control measures may result in reducing the risk of pollution during operation.

What are the most appropriate methods for quantifying human factor influence on oil discharges from ships?

In this paper several models are suggested for analysis. The results are mainly obtained by statistical processing of information in a centralized database (www.maib.gov.uk) (results presented in this chapter are contributing authors). As I remembered above solution is based on the selection of types (type individual, group or organizational).

What are the most effective options for preventing / reducing oil spills caused by human factor?

Global initiatives to study these issues are mostly corporate type (guides to good practice in the major shipping companies) or are specific to a certain level of regulation in the international authorities (IMO).

What is the relationship between technical solutions used to prevent the discharge of hydrocarbons (such as ships with double plating) and the human factor?

In the opinion of the authors this relationship takes into account interaction between the complex and dynamic human operator and the ship looked like a very complex system engineering. It should be noted that an effective technical solution (such as ships with double plating, redundant systems, high degree of automation, etc..) cancellation does not necessarily mean pollution risk associated with human error (for oil discharge from ships).

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