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Contribution of Human Factors to Fishing Vessel Accidents and Near Misses in the UK

Iraklis Lazakis, Rafet Emek Kurt and Osman Turan

Department of Naval Architecture, Ocean and Marine Engineering, University of Strathclyde, Glasgow G4 0LZ, UK

Abstract: The research paper in hand presents a thorough exploration of the fishing vessel accidents and near misses in the UK fishing industry as well as the underlying human element factors and sub-factors contributing to them. In this respect, the regulatory regime in the fishing industry both at a national and international level is initially examined while also complemented by the investigation of past research efforts to address these issues. Furthermore, the analysis of the fishing vessels accidents and near misses as recorded in the UK MAIB (Marine Accident Investigation Branch) database for a period of 19 years is performed in order to derive the very causal factors leading to the fishing vessel accidents. It is initially shown that the fatalities and injuries taking place due to fishing vessels' accidents have alarmingly remained unchanged over the last 15-20 years. Another key finding is that the number of accidents and near misses per day and night shifts is quite similar while most accidents take place in coastal waters. Furthermore, human factors are related to the vast majority of fishing vessels accidents with the principal ones referring to "non-compliance", "equipment misuse or poorly designed", "training" and "competence". Finally, remedial measures are also suggested in order to address the main accident causes identified.

Key words: Fishing vessels, accidents, near misses, human factors, accident factors, accident sub-factors.

1. Introduction

The fishing vessel industry is a sector in which accidents, injuries and fatalities still occur with alarming proportions as shown in many studies by ILO (International Labour Organization) [1], FAO (Food and Agriculture Organization) [2] and the UK MCA (Maritime Coastguard Agency) [3]. The international labour and maritime community has repeatedly tried to address this issue during the past decades by introducing regulations and guidelines as well as pursuing the training and safety regime of crew and workers onboard fishing vessels. However, accidents and near misses still occur, compromising the life and occupational well-being of crew and workers onboard these vessels. Moreover, the rate of vessel losses as well as that of injuries and fatalities occurring onboard fishing vessels has almost remained unchanged throughout the years. Therefore, the foremost aim of the present paper is to examine and analyse the fishing vessels accidents as these have been recorded in the UK MAIB (Marine Accident Investigation Branch) database for a period of 19 years in order to find the principal as well as the underlying factors which contribute to these accidents. Furthermore, the study herein attempts to drill into the details of the recorded accidents and near misses so as to identify the contributing factors specifically attributed to the human element, thus highlighting the significance of this aspect. Additionally, the present study is expanded in order to examine the relevance and influence of the aforementioned factors to the accidents and near misses occurring on different types of fishing vessels (trawlers, potters, netters, liners) as well as in different locations (coastal waters, high seas, port/harbour area, river/canal).

In this respect, the paper in hand consists of the following sections. An in-depth review of the national and international regulations and guidelines with regards to commercial fishing is shown in the Section

Corresponding author: Iraklis Lazakis, Ph.D., research fields: ocean and marine engineering. E-mail: iraklis.lazakis@strath.ac.uk.

2, while Section 3 presents the investigation on the fishing vessel accidents derived from the analysis of the MAIB database for a period of 19 years. Furthermore, the results of the aforementioned study are discussed in Section 4 while the conclusions derived from the analysis performed are presented in Section 5. Moreover, further suggestions on how to tackle the issues identified from the analysis performed before are also suggested.

2. Review of Fishing Vessel Incidents

The efforts of the international community to address the accidents and near misses stemming from commercial fishing activities were initially tackled with the cooperation of international bodies such as the IMO (International Maritime Organization), ILO and FAO. In this respect, a good number of publications exist both at national and international level. In this respect, the requirements pertaining to safety, health practices, construction and equipment for fishing vessels over 24 m in length were introduced in 1968 and updated at a later stage by FAO/ILO/IMO [4, 5], but also for fishing vessels of less than 12 m long [6]. Related to the maritime context, IMO introduced and adopted the Torremolinos Protocol in 1993, addressing the safety of fishing vessels [7] as well as the STCW-F (International Convention on Training, Certification and Watchkeeping for Fishing Vessel Personnel) in 1995, supporting the overall operation and watchkeeping of fishing vessels [8]. More recently, ILO also suggested a series of guidelines for the work onboard fishing vessels [9, 10]. All the above show the continuous support and efforts of the international community to assist and regulate the commercial fishing sector in order to reduce the fishing vessel incidents, injuries and fatalities occurring worldwide.

Moreover, further research has been performed regarding the accidents and near misses in the fishing industry. In a paper by Jin et al. [11], the vessel losses as well as the injuries and fatalities in the US commercial fishing industry are examined, while Wiseman and Burge [12] discuss the accidents occurring in the fishing vessels of less than 20 m in the Newfoundland region of Canada. The ABS (American Bureau of Shipping) prepared a study which compares the US, UK, Canada, and Australia accident databases [13] in which they show that 80%-85% of accidents are attributed to human error and almost 50% are directly initiated by them. On the other hand, Chauvin and Le Bouar [14] focus on the occupational hazards of fishing in the French fishing industry and more particularly, during the actual process of fishing, while Antao et al. [15] discuss the occupational hazardstaking place in the Portuguese fishing sector. Additionally, Roberts [16] investigates the fatality rates of crew onboard fishing vessels in the UK sector and compares them with similar fatality rates in other UK industries. He furthermore suggests that the use of personal safety devices, reducing lone fishing as well as properly maintained fishing vessels may reduce the number of fatalities and injuries occurring.

The investigation regarding fishing vessel accidents is also examined by Wang et al. [17], who discuss the loss of vessels and the related contributing factors. Among other factors, they identify the vessel machinery damage, vessel groundings as well as collisions and contacts as the principal factors for the fishing vessels' accidents. Machinery failure is also the dominant accident factor for vessels less than 12 m as shown in a report by MCA [18]. In this direction, FAO/ILO/IMO [19] has issued guidelines regarding the standards on design, construction and equipment so as to address the issue of smaller fishing vessels. Moreover, in a report by MAIB [20], other factors contributing to the fishing vessel accidents are related to human factors like fatigue and lack of sleep, as well as technical factors including pipework failures, malfunction of the automatic bilge alarm and deck openings exposed to weather and seawater.

In addition to the above, Turan et al. [21] carry out a more thorough investigation of the loss of life onboard fishing vessels. In their paper, they combine the FTA (fault tree analysis) with the FST (fuzzy set theory) in order to identify the most critical factors and events which lead to the potential loss of life on fishing vessels. In this respect, they present a list of the most important contributing factors regarding the design of the vessels and the actual operational issues involving the workers and crew onboard. Moreover, the specific design issues which influence the human related errors are also examined in a study by McSweeney et al. [22] in which various factors are mentioned such as fatigue and stress, human-machine interface design, workplace design as well as procedures onboard the vessel.

Having observed the above research and regulatory efforts, it is worthwhile investigating not only the principal reasons of the fishing vessel accidents but also the major factors and sub-factors leading to them. In this respect, the present paper investigates the recorded accidents and near misses as mentioned in the MAIB database with particular reference to the human underlying factors and sub-factors of the registered fishing vessel accidents. In this way, the fishing vessel accidents and near misses are studied in depth bearing in mind that the fatalities and injuries in this industry still remain high over the last few years. In order to perform the above, the number of accidents and near misses, the fishing vessel GT (gross tonnes) and number of fishing vessels are initially examined. Moreover, the fishing vessel injuries and fatalities through the years are also investigated together with the relationship the aforementioned examination. Moreover, it is important to supplement the generic overview of fishing vessels accidents and near misses by specifically considering their distribution per vessel type (trawler, netter, potter and liner), GRT (gross registered tonnes) capacity (smaller or bigger vessels) and location (coastal waters, high seas, and port/harbour and river/canal areas). Besides the above, the fishing vessel accident distribution per crew shift is examined in order to observe whether the working schedule influences the number of accidents. Furthermore, the various AF (accident factors) category per location and vessel type is shown. Detailed analysis is also performed regarding the AF "people" and "system" per year while the ASF (accident sub-factors) are examined per vessel type and location as well. All the above are described in detail in the following section.

3. Analysis of the MAIB Database

3.1 Initial Analysis of the MAIB Database

As mentioned before, the accidents and near misses presented in this study are part of the UK MAIB database which has been recorded for a period of 19 years (1991 to 2009). These refer to accidents and incidents that have occurred onboard UK fishing vessels or have taken place in UK waters.

While accidents are a commonly used term, near misses refer to any hazardous incident. Moreover, "fishing vessels" denote the "fishing catching and processing" vessels. Having the above definitions in mind, the total number of incidents per vessel type as they recorded in the UK MAIB database for the last 19 years is investigated as shown in Table 1. As can be seen, out of a total number of 8,676 vessels which were involved in near misses or accidents, almost one third of the total number included fishing vessels (2,688 incidents or 30.98%).

Table 1 Total number of incidents per vessel type (1991 to 2009).

Vessel category	Count	%
Fish catching/processing	2,688	30.98
Dry cargo	1,985	22.88
Other commercial	1,464	16.87
Pleasure craft (non-commercial)	876	10.10
Passenger/passenger cargo	800	9.22
Tanker/combination carrier	651	7.50
Other (non-commercial)	198	2.28
Blanks	14	0.16
Total	8,676	100.00

This is a surprisingly high number, especially when compared to other vessel types in the database, denoting that almost one fishing vessel is involved in an accident or near miss every day over the period of 19 years. Furthermore, fishing vessels are closely followed by dry cargo vessels (22.88%), other commercial vessels (16.87%), pleasure craft (non-commercial) accidents and near misses (10.10%). "Other commercial" vessels refer to commercial angling vessels as well as workboats and other small commercial vessels.

Having observed Table 1, it is clearly depicted that fishing vessel accidents require more in-depth analysis in order to identify their underlying causes and comprehend their occurrence mechanism so as to enable the suggestion of measures for safer fishing vessel operations. In addition to the above and in continuation of the investigation of the key contributors of the fishing vessel incidents, the MAIB database is analysed and examined in depth. In this respect, the number of fishing vessels registered in the UK as well as their number over the years is shown in Fig. 1.

As is shown in Fig. 1, the number of registered fishing vessels has declined over the past few years (from around 8,500 vessels in 1996 down to 6,500 in 2009), influencing the GT number for the same fleet (270,000 down to around 200,000). The latter is expected as it is directly proportional to the number of UK fishing vessels. This also can be partially attributed to the decrease in the number of bigger fishing vessels employed in distant areas far away from shore, compared to the smaller one, which mainly operate in waters around the UK as is mentioned by Roberts [16]. Related to the above, a decrease in the number of vessels lost per year as well as the number of fishing vessel accidents is presented during the same time interval in Fig. 2. As is shown in Fig. 2, the total loss of fishing vessels has declined through the years apart from fluctuations shown at specific time points, which can be attributed to high accident rate at that time.

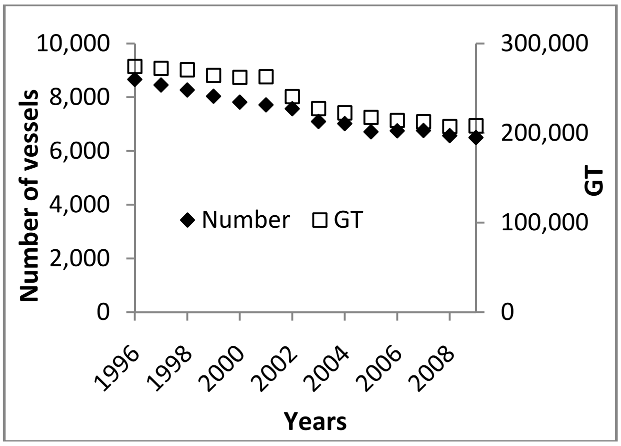

Fig. 1 Number and GT of UK fishing vessels per year (UK MMO (Marine Management Organisation) 2011).

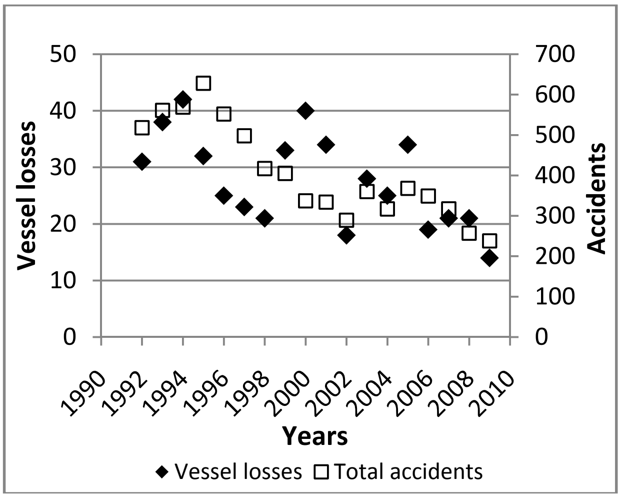

Fig. 2 Number of fishing vessel loses and accidents (UK registered fleet, 1992-2009).

This is confirmed by the reduction of the total number of accidents, which has also significantly decreased from 550 in 1995 to around 200 in 2009. The decreasing trend can be explained by the latest improvements in the training offered to fishermen and workers onboard fishing vessels as well as the latest developments regarding the awareness about safety culture. Other contributing factors also include the enhancement in the maintenance regime concerning the subject vessels together with improving the overall design in terms of stability issues [23]. Related to the above, another interesting feature of the UK based fishing vessel fleet is the number of injuries and fatalities occurring during the same time period, that is from 1992-2009 (Fig. 3).

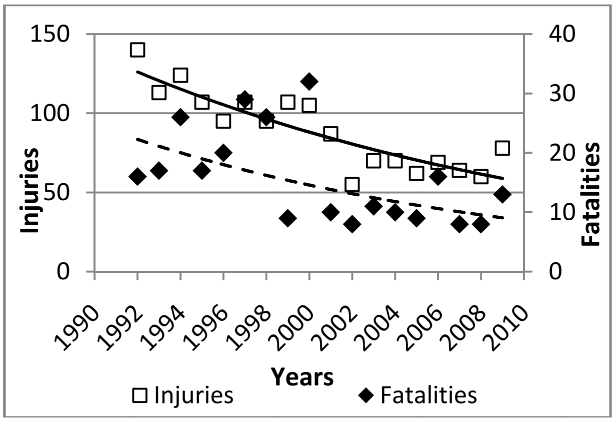

Fig. 3 Fishing vessel injuries and fatalities for the UK registered fleet (1992-2009) and associated trendlines.

As is shown, the overall trend of injuries and fatalities is proportional to the decrease in the total number of accidents and loss of vessels presented in Fig. 2. However, another interesting feature that requires further examination is the number of vessel losses, fatalities and injuries with respect to the total number of fishing vessels (per thousand vessels). These results are shown in Fig. 4.

As can be seen, the trend of the vessel losses is within an almost constant range of three to four vessel losses per thousand vessels each year since 1996. An almost constant ratio is also evident for the fatalities and injuries throughout the same time-frame as well (around two fatalities and 10 injuries per thousand vessels, respectively). The above results supplement the ones presented in Fig. 3, in which it is shown that the number of vessel losses, fatalities and injuries has been declining for the past 20 years. However, it is demonstrated that the relevant ratios per 1,000 vessels have remained almost unchanged for the same time period despite the efforts that have been initiated from all interested national and international stakeholders.

In this respect, further examination is deemed necessary showing the distribution of the total number of fishing vessels involved in various incidents per vessel type (Fig. 5). As observed, the majority of the vessels involved in incidents are trawlers (64.16%) followed by potters (21.39%) and netters (5.59%). This is in-line with the study of Perez-Labajos et al. [24] on the most frequent fishing vessel type accidents. In addition to the above, further investigation is performed in terms of the fishing vessel incidents per location and year as shown in Fig. 6.

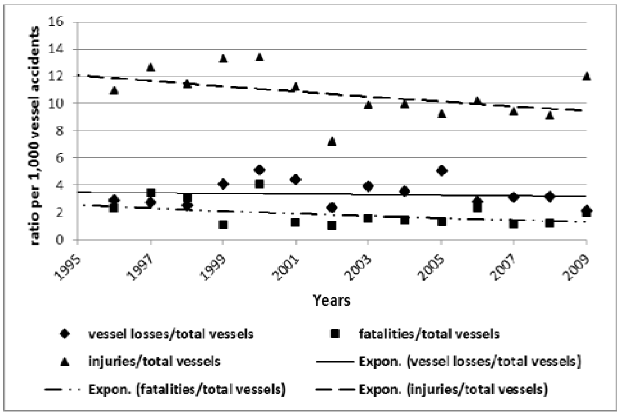

Fig. 4 Ratio of vessel losses, fatalities and injuries per 1,000 fishing vessels and related trendlines.

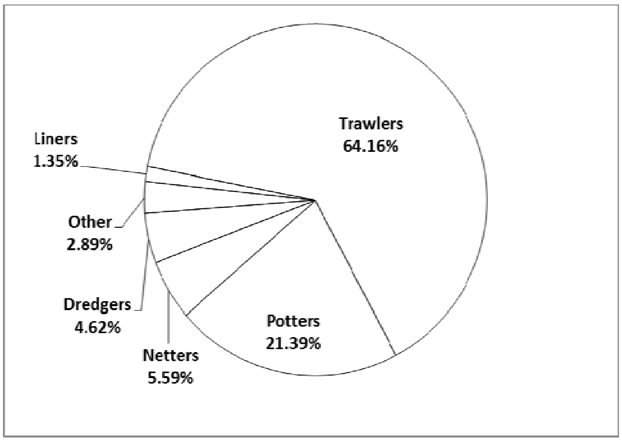

Fig. 5 Distribution of total number of fishing vessels per vessel type.

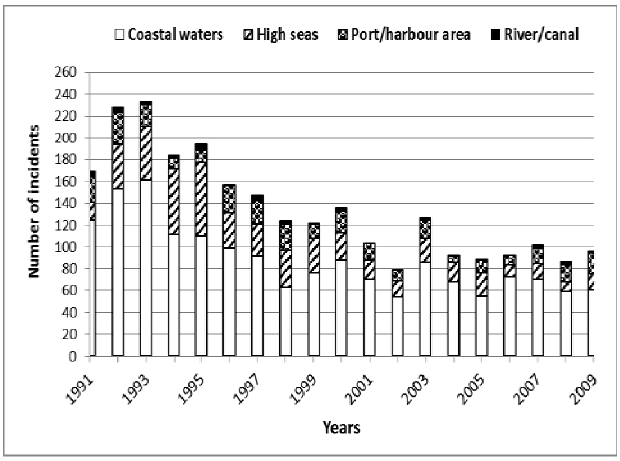

Fig. 6 Distribution of fishing vessel accidents and near misses per location and year.

As can be seen, the majority of fishing vessel accidents has occurred in coastal waters, in which the overall trend has shown decreasing results with peak points in some cases (especially in 1993, 2000 and 2003). The incidents taking place in high seas are second next, following a similar pattern. This can be justified by the exposed nature of these areas compared to the more sheltered and accordingly safer river/canal and the port/harbour waters. In this respect, the majority of these which occur in coastal waters involves maller vessels, which do not operate in long distance open sea areas. Additionally, the total number of fishing vessel incidents per vessel type and location is demonstrated in Fig. 7.

As is shown, the majority of incidents in all vessel categories have also occurred in coastal waters (i.e., including trawlers, potters, netters, dredgers and liners). Moreover, it may be deduced that the river/canal areas do not seem to be a critical location for fishing vessel incidents. Furthermore, it is also important to investigate the actual time that the accidents and near misses have taken place in order to examine whether there exist any variations in the timing of fishing vessel accidents or near misses occurring. This can be considered in the light of the potential impact of human factors such as fatigue and inattention, which deteriorate especially when working during night shifts [25-27]. The latter is examined in terms of the crew 4-hour shifts onboard the subject vessels and is presented in Fig. 8.

As can be observed, the number of incidents occurring during the midday hours (12:00-16:00) are the most frequent ones (21.85%) followed by the 08:00-12:00 shift (21.68%). The third highest ranked crew shift with the most incidents occurring is the 16:00-20:.00 one (16.75%) closely followed by the 04:00-08:00 shift (16.11%). Overall, it is observed that the number of incidents per day and night shifts in total (day shifts: 08:00-20:00, night shifts: 20.00-08.00) is quite similar (60% and 40%, respectively). Moreover, although the actual number of fishing vessels' incidents during day shifts is slightly higher than the one during the night shifts, it is difficult to provide a measure (e.g., relative ratios) of incidents occurring throughout the day or night operations due to unavailable relevant data, thus not allowing further research into the actual rate of incidents during the night shifts compared to the ones during the day shifts.

3.2 Further Investigation of the MAIB Database—AC (Accident Categories)

So far, the examination of the MAIB database has enabled the generic study of the UK registered fishing vessel fleet for a period of 19 years and has highlighted its specific characteristics. In this section, the fishing vessel accidents and near misses are examined in further detail with regards to the underlying

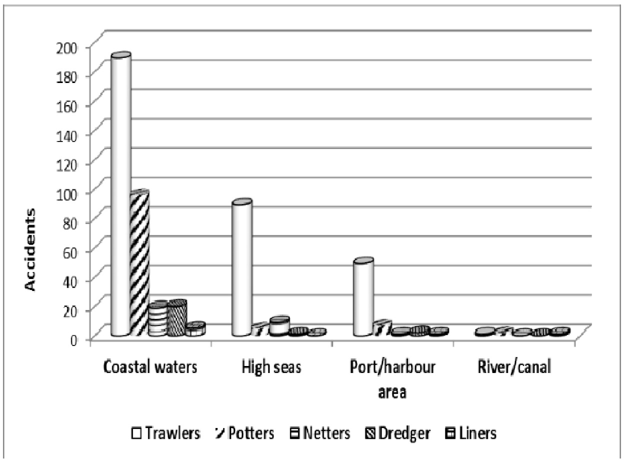

Fig. 7 Number of fishing vessels incidents per vessel type and location.

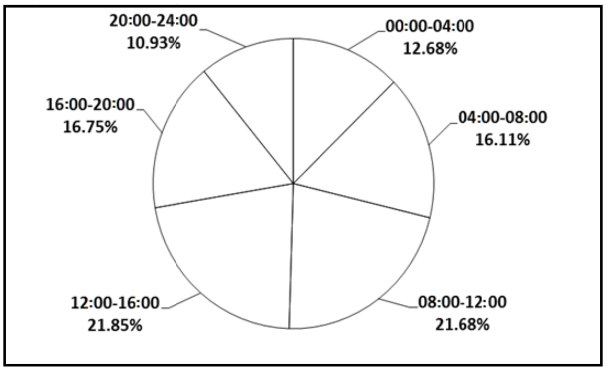

Fig. 8 Total number of incidents per crew shift (4-hour shifts).

factors and sub-factors in order to comprehend the conditions in which these take place and provide suggestions for further improvement. At first, an initial categorisation of the analysis of the AC per different location (i.e., coastal waters, high seas, port/harbour areas and river/canal) is shown in Fig. 9.

In this respect, the AC includes the initial subdivision for which the accident occurred. This can be either a "human" or "technical" factor. By "human factor", the overall human-initiated and related factors are mentioned including: apart from the obvious ones such as "crew" and "people"; other human related activities such as "working environment", "company" and "organisation". In the case of the "technical factors", the "cargo", "design and construction", "external causes" and "material/mechanical defect" are included among others. As is shown, the "human factor" outnumbers the "technical factor" category by far (89% compared to 11%; respectively).

More explicitly, in the case of "coastal waters", the contribution of human factors is 63.06% compared to 7.01% of technical factors, almost 9 times more incidents in this specific area. This is more or less the same in the case of the rest of the locations examined. The incidents attributed to human factors are greater for the other locations as well (13.81% vs. 1.7% for the "high seas", 11.21% vs. 2% for the "port/harbour area", 1.1% vs. 0.1% for the "river/canal"). In more detail, the total number of recordings of "human factor" corresponding to coastal waters, high seas, port/harbour areas and river/canal is 630, 138, 112 and 11, respectively. In comparison, the "technical factor" recordings for the same locations shown in the database are 70, 17, 20 and 1, accordingly.

Moreover, when comparing the results between the accidents and near misses attributed to "human" and "technical" factors for each location, it can be observed that the various ratios developed are very similar (Fig. 10). In this respect, coastal waters present a ratio of 90% "human" and 10% "technical" factors, high seas 89.03% and 10.97%, port/harbour areas 84.85% and 15.15% and river/canal 91.67% and 8.33%, respectively. In this case, the ratio of accidents and near misses attributed to human and technical factors can be seen that is not influenced by the location that this has occurred.

3.3 Further Investigation of the MAIB Database—AF

Moreover, the investigation of the MAIB database is expanded in order to identify the principal AF for the subject vessels. This is demonstrated in Fig. 11, which describes the distribution of fishing vessel accidents and near misses per principal AF.

As can be seen, 48.8% (775 recordings) of the AF belongs to the group categorized as "people". "People" is defined by MAIB as "an individual related to the investigation". The next major category can be grouped as the "system", one including the "crew factors",

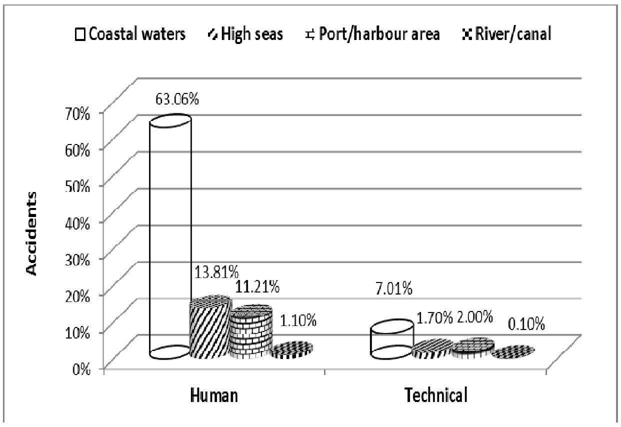

Fig. 9 Fishing vessel accidents and near misses per AC (human and technical) and location.

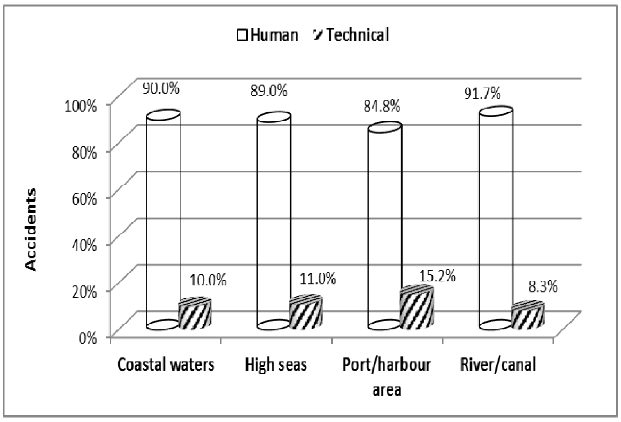

Fig. 10 Fishing vessel accidents and near misses ratio per "human" and "technical" factors and location.

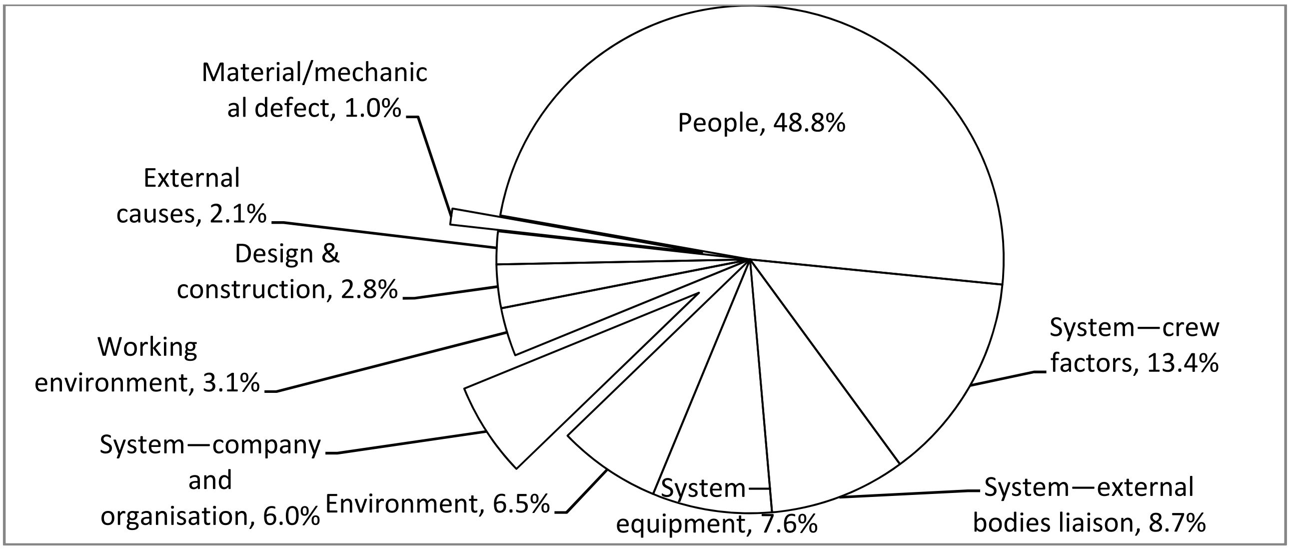

Fig. 11 Distribution of fishing vessel accidents and near misses AF.

"external bodies' liaison", "equipment" and "company and organization" (the definition of the various "system" sub-categories is given in Appendix). All these sub-categories constitute the second largest category (35.7%—567 recordings) followed by the "environment" (6.5%—104 recordings) and "working environment" (3.1%—49 recordings) accordingly. At this point, it is important to highlight that there may be overlapping accident factors among recordings in the MAIB database as it may be the case that an incident/accident could be related to more than a single factor. However, at the time of preparing this paper, it was not possible to retrieve such information, which would render the present study even more beneficial.

Following the above line of thought, the distribution of the mentioned AF is examined in Figs. 12 and 13 in order to investigate the extent of the influence of the given main sub-categories (i.e., "people" and "system") in the fishing vessel accidents throughout the observed time period.

As shown in Fig. 12, the distribution of the total number of AF "people" attributed to the overall number of fishing vessels accidents per year has been more or less stable for a period of ten years (1991 to 2006). Since then, it significantly increased with a peak recording in 2007. At this point, it would be beneficial to clarify that the number of "people" AF per year shows the total number of AF throughout the specific year.In this respect, it may be the case that more than one "people" AF has been assigned to one single fishing vessel accident and accordingly more "people" AF than actual accidents have been recorded in the MAIB database. Bearing in mind the advances in the fishing vessel equipment, machinery and hull reliability over the last few years, the importance of the human factor and human performance related to fishing vessel accidents is even more highlighted.

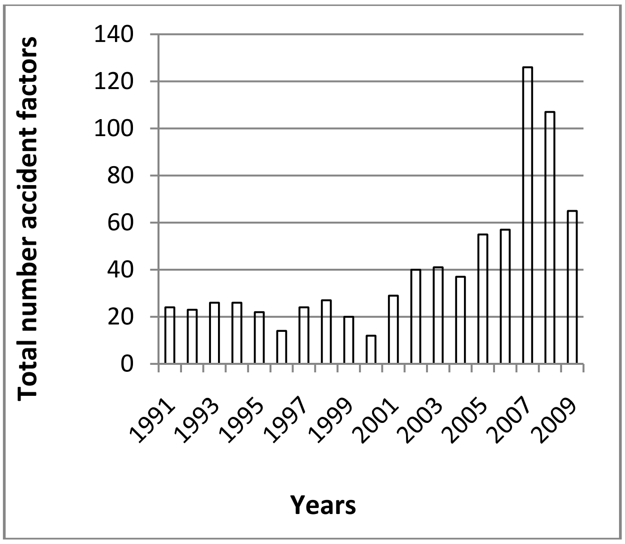

Fig. 12 Distribution of total number of AF "people" attributed to the overall number of fishing vessels accidents per year.

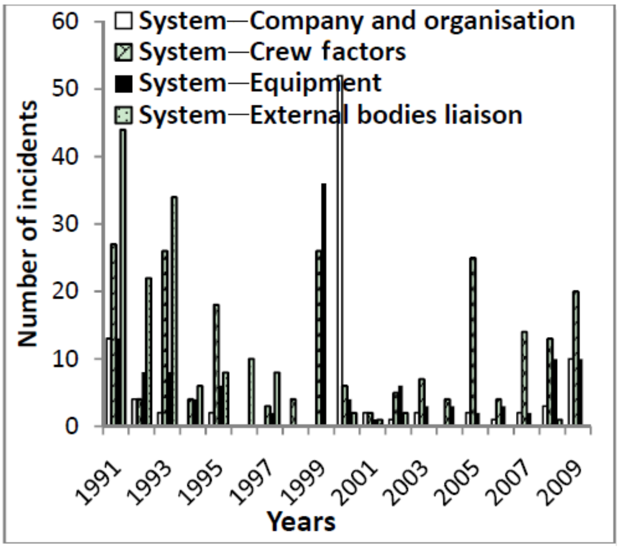

Fig. 13 Distribution of AF "system" per year.

In the case of the "system" AF (Fig. 13), there is also an initial declining trend for all of the sub-categories in the first years of consistent recording (1991 to 1999) which has been increased dramatically in 1999 and 2000. The latter is due to better incidents recording procedures, which has permitted cataloguing all the accidents occurring with more details than the previous years.

Since 2000, an increasing trend is also observed, especially in the case of the "crew" and "company and organisation" underlying factors. This also portrays the significance and the influence of not only the crew but also of the vessel management. However, one needs to consider that in the majority of cases, the owner and subsequently manager of a fishing vessel is her captain who participates in the everyday hurdles of the vessel operation together with her crew as well.

Furthermore, the distribution of the AF categories is also expanded in terms of their occurrence on the specific vessel types examined previously; that is the "trawlers', "netters' and "potters' (Table 2). This is performed in order to examine whether any variations exist amongst the various vessel types. As can be observed, "people" is the predominant AF for all fishing vessel types (38.98% for "trawlers", 44.40% for "potters" and 61.34% for "netters", respectively). "System" is the next most important AF for all three vessel types, with "external bodies' liaison" being the most significant for the "trawlers" (14.29%) and the "netters" (15.13%) while being the last one in the "potters" (0.43%). "System-crew factors" is another important AF for all vessel types (13.66% for "trawlers", 18.97% for "potters" and 5.88% for "netters", respectively). The small number for all AF for the "netters" can be attributed to the overall lower number of incidents regarding the specific category of vessels. Another interesting feature of Table 2 is that the "working environment" as well as the "design and construction" AF are quite low in the major accident factors list in terms of the actual number of incidents being registered and attributed to them. This may be attributed to the effectiveness of the rules and guidelines issued by different administration bodies during the past few years as these have been introduced for the enhancement of the stability issues [16] and overall conditions onboard the fishing vessels [27-29].

3.4 Further Investigation of the MAIB Database—ASF

So far, the main contributing fishing vessels AF have been examined. However, the fundamental question on which are the very specific reasons for the occurrence of the fishing vessel accidents and near misses still remains. This is answered by investigating the underlying ASF as recorded in the MAIB database.

Table 2 AF per vessel type (trawler, potter, netter).

AF (Accident factors)	% Trawlers	Potters	Netters
People	38.98	44.40	61.34
System—external' bodies liaison	14.29	0.43	15.13
System—crew factors	13.66	18.97	5.88
System—company and organization	11.80	2.59	1.68
Environment	9.01	21.55	n/a
System—equipment	5.90	3.88	3.36
Working environment	2.33	1.29	4.20
External causes	2.02	1.29	3.36
Design and construction	1.40	4.74	3.36
Material/mechanical defect	0.62	0.86	1.68

These are initially examined as per different vessel type and location in which these have occurred. At first, the ASF per vessel type are shown in Tables 3-5.

As is shown in Table 3, the "non-compliance" ASF is the main causal factor for the "trawler" (almost 14%). This factor appears to be the most common underlying accident sub-factor in fishing vessel incidents and is considered mostly human factor related. Unfortunately, not following or fulfilling the applicable regulations is common in the fishing vessels and is attributed to the very specific nature of fishing as discussed by Bosma and Turan [30]. For example, it is reported that for 55 accidents for every 1,000 fishing vessels, safety standards onboard the vessels are still below the level where they are supposed to be according to national and international regulations. A good example is given in the same study [30] where a 36 meter UK registered fishing vessel flooded and sunk during fishing operations after water penetrated into accommodation areas through a water tight door which was supposed to be kept shut. According to the results of the survey conducted, shockingly 90% of participants mentioned that they went to sea under influence of alcohol; similarly 53% admitted consuming alcohol during fishing. Moreover, 50% of participants admitted use of other substances at sea which clearly violates the Section 78 of Railways and Transport Safety Act-Navigating the vessel under influence of alcohol. These can be overcome by being more stringent on the relevant regulations as well as conducting awareness training so as to introduce a proactive approach towards this causal factor.

Table 3 UASF (Underlying Accident Sub-Factors) per vessel type (trawler).

ASF	%	Count
Non-compliance	13.97	88
Inadequate resources	9.05	57
Heavy weather	8.41	52
Procedures	8.10	50
Fatigue	6.51	40
Perception of risk	5.24	32
Competence	4.29	27
Poor decision making/information use	4.29	27
Management	3.65	20
Complacency	3.02	19

Table 4 UASF per vessel type (netter).

UASF	%	Count
Non compliance	14.71	17
Violation of procedures	14.71	17
Perception of risk	13.73	16
Complacency	7.84	9
Visual environment	4.90	6
Competence	3.42	4
Equipment not available	3.42	4
Inattention	3.42	4
Other vessel	3.42	4
Outside operational design limits	3.42	4

Table 5 UASF per vessel type (potter).

UASF	%	Count
Equipment (misuse, poorly designed)	19.91	45
Training	13.27	30
Competence	8.41	19
Culture	7.52	17
Complacency	5.31	12
Inattention	5.31	12
Procedures inadequate	4.42	10
Design inadequate	3.98	9
Fatigue	2.65	6
Perception of risk	2.65	6

Moreover, "inadequate resources" (9.05%) is the second largest contributing sub-factor for trawlers and can be defined as the resources needed to complete a job effectively and safely (such as time, finance and personnel). The latter is related to manning procedures onboard the fishing vessels, while the insufficient time refers to the inadequate time allowed for crew hand-over procedures, which in turn may result in the crew not allocating enough time for task requirement updates. In addition to the above, "heavy weather" is still a main factor for trawler accidents (8.41%). This can be justified by the very nature of the type of work that trawlers undertake, while sailing and working in the open seas with harsher weather conditions. In addition to the above, the next most important factor is the "procedures" (8.10%) and "fatigue" (6.51%).

The “perception of risk” (5.24%) is still high in the list referring to the subjective judgment that people make about the severity of a risk and can be improved by introducing further training in the fishing sector [21].

In the case of the “netters”, they present similar ASF to the “trawlers”. These refer to “non-compliance” (14.71%), “violation of procedures” (14.71%) and “perception of risk” (13.73%). Especially regarding the “violation of procedures” sub-factor, it is directly related to the crew not following the right procedures (“cutting corners”) and endangering the operation of the vessel as well as of the crew working onboard. Furthermore, “complacency” (7.84%) is the next most important sub-factor for this type of vessel including the incidents related to individuals which are not satisfied with a standard of performance.

Moreover, Table 5 shows the ASF for the “potter” fishing vessels. In this case, “equipment” (19.91%) is the main underlying sub-factor followed by “training” (13.27%) and “competence” (8.41%). The “equipment” ASF is a combination of several categories including equipment not available, badly maintained or misused. It is clear from the above the direct link of the human element in this sub-factor (badly maintained or misused equipment by crew onboard the vessel). However, the lack of training can be addressed through the implementation of training programmes regarding the day-to-day vessel operations so as to improve the overall education and performance of the crew and make them familiar with the technological innovations present in their everyday life [31]. In the case of crew “competence”, it is an expected result for this vessel type as these vessels are smaller in size and are not covered by the same regulations and guidelines regarding the competency certificates as for the bigger vessels (longer than 24 m in length). With regards to the above, it would be helpful if the crewmembers’ competence level is assessed, recorded and updated by the local authorities (e.g., MCA) at regular intervals bearing in mind the specific particularities of the fishing industry. Additionally, in order to examine whether the above mentioned underlying sub-factors are influenced by the location in which the accidents has occurred (that is near-shore or in offshore waters), the analysis of the ASF according to the specific locations is shown in Tables 6-8.

In this case, it can be observed that the results regarding the ASF per location differentiate significantly. While “non-compliance” is the main sub-factor for the coastal waters and high seas (7.18%

Table 6 Top 10 of the UASF per location (coastal waters).

UASF	%	Count
Non-compliance	7.18	95
Heavy weather	6.65	88
Equipment	6.35	84
Fatigue and vigilance	5.22	69
Inadequate resources	4.69	62
Perception of risk	4.54	60
Competence	4.38	58
Inattention	3.70	49
Poor decision making/information use	3.33	44
Procedures inadequate	3.33	44

Table 7 Top 10 of the UASF per location (high seas).

UASF	%	Count
Non-compliance	17.45	41
Perception of risk	13.19	31
Violation of procedures	12.34	29
Visual environment	5.11	12
Procedures inadequate	4.26	10
Fatigue and vigilance	3.40	8
Manning (rotation /watches)	2.98	7
Perception abilities	2.55	6
Unsafe working practices	2.55	6
Poor decision making/information use	2.55	6

Table 3 Top ten of the UASF per location (port/harbor area).

UASF	%	Count
Culture	8.75	14
Poor decision making/information use	8.75	14
Complacency	8.13	13
Fatigue and vigilance	8.13	13
Inattention	6.25	10
Competence	5.00	8
Visual environment	4.38	7
Perception of risk	3.75	6
Procedures inadequate	3.13	5
Heavy weather	2.50	4

and 17.45%, respectively), it is not included at all in the list of the highest ranked ASF for the port/harbour areas. This can be attributed to the fact that the port/harbour areas are more difficult areas to navigate and furthermore more closely invigilated compared to the other two locations and thus crew awareness is greater. In terms of the other ASF, "heavy weather" is the second most important factor for the coastal waters (6.65%) followed by "equipment" (6.35%) as well as 'fatigue and vigilance" (5.22%).

For the "heavy weather" sub-factor, the safety procedures in place as well as the mandatory personal safety equipment may assist in reducing the incidents pertinent to this factor especially when referring to the exposed sea environment in the coastal areas. Regarding the "equipment" ASF, it refers to badly maintained, misused or poorly designed equipment onboard the vessels. The first can be rectified with appropriate maintenance procedures in place and close adherence to the planned maintenance system of the vessel although such a procedure is not formalised to the extent it is implemented in the case of bigger merchant vessels (e.g., tankers, container ships, cruise vessels). On the other hand, regular checks of the machinery and fishing-working equipment should be part of the best-practice guide for such vessels. In addition to the above, the ASF of misused and poorly designed equipment can be addressed with careful usage and planning of the equipment onboard, including potential use of software equipment.

Moreover, "fatigue and vigilance" refers to the crew's incapacity to maintain a sufficient level of attention so as to monitor the progress and control of the vessel adequately. This can be due to a number of reasons such as not enough rest-hours [32] as well as the generation of noise which affects the vigilant performance of the crew [33]. For the high sea areas, apart from the "non-compliance" factor, the "perception of risk" is also high in the relevant list (13.19%) followed by "violation of procedures" (12.34%) and "visual environment" (5.11%). As mentioned before, these accident sub-factors are relevant to the specific nature of the fishing industry, which is still highly dominated by the personal working and management conditions onboard the fishing vessels.

On the other hand, in the case of port/harbour areas, the ASF are mostly related to the specific conditions prevailing in such areas. That is, more personally attributed factors such as the "culture" (8.75%), "poor decision making/information use" (8.75%), "complacency" (8.13%), "fatigue and vigilance" (8.13%) and "inattention" (6.25%). "Culture" refers to the "characteristics derived from nationally ethnic backgrounds that influence interactions with other crew members or attitudes to safety" [34].

Additionally, "poor decision making/information use" accounts for the identification and choice among different options by the decision-maker, in which case, the captain of the vessel, who faces more difficult situations when the vessel sails in the demanding (from a navigational point of view) operational environment of the port/harbour area. In this case, adequate procedures and sufficient training so as to familiarise the captain of the vessel are needed. "Complacency" on the other hand denotes the "organisation/individual is inappropriately satisfied with a standard of performance" [34] while "fatigue and vigilance" addresses the inability of the crew control on the operations of the vessel.

Regarding the "inattention" sub-factor, it considers among others the improper lookout and especially non-monitoring of the navigational displays in the constrained for navigation port/harbour areas. In this case, maintaining the resting periods between the working shifts is paramount as well as avoiding fatigue and inattention contribution factors. As can be observed, the ASF for the port/harbour area are all directly related to the human factors side of accidents, highlighting the importance of addressing these factors compared to other incident locations.

4. Discussion

The research study in hand has examined the specific characteristics of the fishing vessel industry including legislative and administrative rules and regulations in UK and internationally. In addition to the above, the analysis of the UK MAIB database has taken place for a period of 19 years. At first, it is shown that fishing vessel incidents form a big part of the database recordings (30.98%) which signifies the initial need for further investigation on the subject accidents and near misses. When observing the total number of the UK registered fishing vessel fleet as well as the corresponding GT, it can be seen that both these figures are in a declining trend over the years, showing the decrease in the number of bigger fishing vessels employed in the fishing industry. The number of vessel losses and total accidents has been decreasing throughout the years as well as the total number of fatalities and injuries. The latter may be attributed to the improvements on the training of professional fishermen, the safety culture being developed over the years, the improvement in the overall maintenance planning as well as the improved stability design of the fishing vessels.

However, further examination on the vessel losses, injuries and fatalities over the total fishing vessel number shows that they have remained alarmingly unchanged for the same time frame despite the national and international efforts. In this respect, further analysis on the MAIB database is performed in a number of different areas, including the distribution of accident and near misses per fishing vessel category. With regards to the above, trawlers are the ones involved most (27.8%) followed by potters (8.3%) and netters (4.2%).

Moreover, when examining the accidents and near misses per location and year, the majority has occurred in coastal waters followed by high seas; this is explained due to the exposed nature of these areas compared to the more sheltered waters of port/harbour and river/canals areas. On top of the above, most of the accidents and near misses in all vessel categories have occurred in coastal waters while only a few of them have taken place in port/harbour and river/canal areas. Furthermore, when examining the time of their occurrence (based on the 4-hour day and night shifts), it is hard to conclude on the existence of a significant relationship between the number of accidents and time of the day; thus, it is shown that they are not influenced by the crew working schedule.

When examining the underlying factors for the fishing vessel accidents, the "human factor" is attributed to the majority of accidents (89%) compared to just 11% for the "technical factor". Furthermore, the "human factor" is the predominant one when examining the incidents per location as well as vessel type. This trend also highlights the need for further investigation into the fishing vessel accident and near misses. This is performed by an in-depth examination of the underlying AF for the "human factor" category. In this case, "people" is the major underlying AF (48.8%). Having a look at the overall distribution over the years, it is observed that after a constant rate till 2001, it has increased significantly till 2007 and started declining since then. Regarding the "system' factor (35.7%), it includes the "crew factors", "external bodies' liaison", "equipment" and "company and organization" and presents a similar trend through the years, especially regarding the crew and the vessel management.

The results regarding the AF for the various vessel types are also similar to the above (i.e., trawlers, etc.). In this respect, "people" is the predominant AF for all the fishing vessel types (38.98% for "trawlers", 44.40% for "potters" and 61.34% for "netters', respectively), followed by the "system" AF. In this case, the low results for the "working environment" and the "design and construction" may be explained due to the introduction of various guidelines especially in the last 10-15 years [27-29].

In addition to the above, more details regarding the very specific contributing accident factors are given when examining the underlying ASF. In this respect, the ASF per vessel type display that “non-compliance” is the main causal factor for the “trawler” and “netter” followed by “inadequate resources”, “heavy weather” and “perception of risk”. For the “potter” vessel type “equipment”, “training” and “competence” are the main ASF and can be dealt with the implementation of training programmes regarding the day-to-day vessel operations as well as if the crewmembers’ competence level is assessed, recorded and updated at regular intervals [35].

As for the ASF with regards to the accidents location, variations are observed between the coastal and high seas areas and the port/harbour areas. This is due to the fact that the port/harbour areas are more difficult areas to navigate in and accordingly crew awareness and vigilance is greater. However, the particular ASF can be improved by a number of measures in place. These include safety procedures and mandatory personal safety equipment (“weather”), regular checks and following the planned maintenance procedures of the vessel (“equipment”), adequate procedures and sufficient training for the captain of the vessel (“poor decision making/information use”), keeping the resting periods between the working shifts (“fatigue and vigilance”) [36], adhering and making sure that the introduced rules and regulations are followed (“non-compliance”) and integrating the various nationality issues in everyday life onboard the fishing vessels (“culture”) as also suggested by Branagan and Turan [31].

5. Conclusions

The present paper clearly shows that although there have been significant efforts for the prevention of fishing vessel losses, injuries and fatalities in the UK sector, there is still some way to go in order to make this industrial sector a safe and secure place to work. In this respect, the research study herein highlights the human factors side of the accidents and near misses that fishing vessels are involved in. The latter takes place through the examination of the MAIB database for a period of 19 years. The present study reveals that although the actual number of vessel losses and accidents has been decreasing throughout the years, the rate of injuries and fatalities per vessel has remained alarmingly stable over the timeframe examined in the MAIB database despite the efforts of all national and international regulatory authorities.

The study herein also demonstrates that trawlers are the ones involved most (27.8%) in incidents/accidents followed by potters (8.3%) and netters (4.2%). Moreover, the majority of incidents/accidents has occurred in coastal waters and high seas due to the exposure of fishing vessels to more adverse weather conditions than the protected areas near ports and river/canals. The crew working pattern does not seem to influence the rate of incidents/accidents onboard fishing vessels as it was shown that over the regular 4-hour crew shifts there is not much differentiation.

Human factors dominate the results showing the influence to fishing vessels incidents/accidents by 89% compared to 11% attributed to technical factors. In this respect, it was shown that “people” as well as “system” factors are related to the majority of incidents/accidents per different type of fishing vessels such as trawlers, potters and netters. The study of the MAIB database also revealed that the introduction and application of UK and international legislation has reduced the incidents/accidents due to “working environment” and vessel “design and construction”. However, when examining the accident sub-factors, the “non-compliance”, “inadequate resources”, “heavy weather” and “perception of risk” are the main causal factors for the majority of fishing vessels.

With particular relevance to the AF and ASF, improvements were also suggested in terms of safety procedures and mandatory personal safety equipment implemented, regular checks and follow-up of the planned maintenance schedule on board, adequate procedures and sufficient training for the captain and vessel crew, maintaining the resting periods between the working shifts, adhering to the national and international rules and regulations while also taking into account the cultural issues that may occur through everyday life onboard.

A further suggestion is related to the update of the MAIB database in order to provide consistency of the incident recordings and avoid data duplications. Furthermore, the assessment of fishing vessel incidents/accidents can be performed by employing a structured and rigorous approach such as the FSA (Formal Safety Assessment) concept already, which is applied in the merchant marine sector [17]. FSA is "a rational and systematic process for assessing the risks associated with shipping activity and for evaluating the costs and benefits of IMO's options for reducing these risks" [37] and has been already applied in the case of merchant shipping including tankers, container and passenger ships among others. With it, a systematic methodology for dealing with fishing vessel accidents may take place considering various steps such as the identification and assessment of potential hazards related to fishing vessels as well as the consideration of risk control options. Moreover, the assessment of the cost-benefit ration of the suggested risk control measures can be performed leading to recommendations for the decision-makers to suggest and apply. Furthermore, it is also important to mention that the identified underlying human factors can be addressed with training programmes which effectively pursue the safety culture environment as in other sectors of the maritime industry.

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Appendix

System—crew factors: the interaction of the crew, the internal organization and the way in which individuals work together as a team, all impact on the likelihood of a human error on board ship;

System—external bodies' liaison: factors related to certificate fraud, non-compliance with regulations, policies or practices from any marine administration, manufacturers' equipment design;

System—equipment: related to the equipment of the vessel;

System—company and organization: management failures contributing to the occurrence of the incident event.