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Review

Investigating Fishing Vessel Casualties in Peru: A Technical and Scientific Review to Support New Regulations

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Abstract: The reporting system for fishing vessel and crew casualties in Peru needs a disruptive change in order to know what the risks in terms of marine safety are, who should manage them, and how they should be managed. According to a technical review on accidents recorded by the Peruvian Direction of Captaincies and Coast Guards (DICAPI), it is evident there is a need to process the available information on casualties of fishing vessels and crew in the fishing industry since this information is not easy to analyze. Nevertheless, this paper provides the casualties reported between 2004 and 2010, and from 2013 to 2020. In order to understand the research endeavors and trends surrounding the safety of fishing vessels, a systematic review using VOSviewer was performed. After a deep analysis and study of the information available in Peru, as well as reports and regulations from the International Maritime Organization (IMO), Food and Agriculture Organization (FAO), International Convention for the Safety of Life at Sea (SOLAS), and the recent advances available in the scientific literature on the safety of fishing vessels and crew casualties around the world, this paper presents some proposals regarding the current Peruvian scenario that are expected to be considered in new regulations.

Keywords: safety; casualties; small fishing vessels; capsizing; stability

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1. Introduction

Peru finds itself among the top 10 primary and principal producers of fish, alongside China, Indonesia, India, and Vietnam [1]. Therefore, there needs to be a sole focus on Peru's fishing industry, particularly in terms of its occupational safety and health. The labor risks associated with the fishing business can negatively impact the lives of fishermen in various ways. For example, a report by the Department of Public Health in Massachusetts found that the fishing industry has the second-highest rate of deaths across a range of industries [2]. On the other hand, the pollution produced in the marine environment due to commercial fishing activity is also a problem [3–5].

However, accidents caused by the fishing industry do not only lead to loss of human lives [6], but also result in economic and material losses. Despite the well-known high levels of risk in the fishing industry, little is being done in Peru to address these issues.

Currently, there are no official reports available that accurately depict the real situation concerning casualties and crew accidents within the fishing sector.

The scarce existing information on this has been compiled by the DICAPI, which is, however, difficult to access and lacks structured and complete information. Due to this factor, one of the limitations of this study is that the analyzed data span from 2004 to 2010 and from 2013 to 2020, and exhibit discontinuity over time.

The Politics and National Plan of Security and Health of Peru (from 2017 to 2021) [7] provide generalized information about dangerous incidents and notifications of occupational illnesses according to economic activity (see Figure 1). However, it does not offer sufficient and specific information on these incidents, thus it is inadequate if measures are to be taken to improve marine safety. This improvement is necessary not only from the perspective of crew casualties, but also for fishing vessel casualties, given the immense correlation between the safety of both. The data presented in Figure 1 contradict the data described in [2]. Consequently, it can be asserted that there is an issue with the registration of crew and fishing vessel casualties in Peru. This discrepancy might arise from a lack of awareness regarding the IMO recommendations for defining casualties, which is the responsibility of the relevant competent authority. Additionally, personal factors, like omission, confusion, or a lack of understanding among the personnel tasked with recording the casualties, could contribute to this inconsistency.

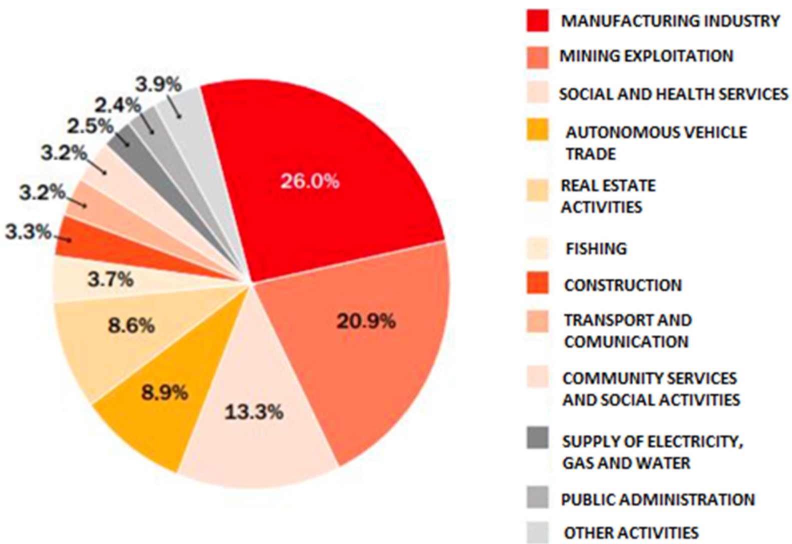

Figure 1. Dangerous incidents occurring within different economic activities.

In this paper, we undertake three primary activities:

(a) The first activity focuses on reviewing technical information related to fishing vessel safety in Peru. We provide previously unreported statistics on casualties involving fishing vessels, assess the current state of the artisan fishing industry in Peru, delve into the operational safety of fishing vessels, and examine genuine accident statistics related to these vessels. We also identify gaps that need to be addressed by the DICAPI.

(b) Subsequently, we conduct a bibliometric analysis of fishing vessel safety, utilizing data from Scopus. The fundamental objective here is to study and extract insights and key contributions regarding the safety of fishing vessels, particularly with respect to the concerns highlighted in the technical review described above.

(c) Building upon this information, we present a scientifically supported proposal that merits consideration from the relevant authorities.

2. Materials and Methods

The methodologies employed in this article encompass both statistical and bibliometric approaches. In the first part, we describe the actual scenario of the fishing sector in Peru along with some statistical studies. Furthermore, a formal request was obtained from the DICAPI containing information of the records of casualties involving fishing vessels along the littoral coast of Peru. Subsequently, the acquired information underwent a comprehensive process of organization, classification, evaluation, and filtering, culminating in the creation of statistical graphs depicting fishing vessel casualties. These graphs represent an original contribution, as they present data that have not been previously documented in the existing literature.

Then, a bibliometric analysis was performed, as in [8]. The bibliometric analysis served to systematically organize scientific articles in a comprehensive manner. Furthermore, a bibliometric database was structured to unveil and discern collaborative patterns among various countries, institutions, journals, and authors. Figure 2 delineates the sequence of steps necessary for formulating this bibliometric analysis and scrutinizing the interplay between scientific articles within a database. For this study, we utilized the SCOPUS database. Upon applying filters encompassing keywords, areas of interest, date ranges, and countries of origin, we obtained an Excel archive in CSV format. This archive offers the distinct advantage of compatibility with bibliometric software like VOSviewer 1.16.19. This is a free software that allowed us to study the relationship between a number of publications, their citations, their country of origin, and their authors, among other points. Additionally, the SCOPUS analyzer was used; this package presents the information through bar graphs and circular diagrams to provide visual information concerning key aspects within the obtained database.

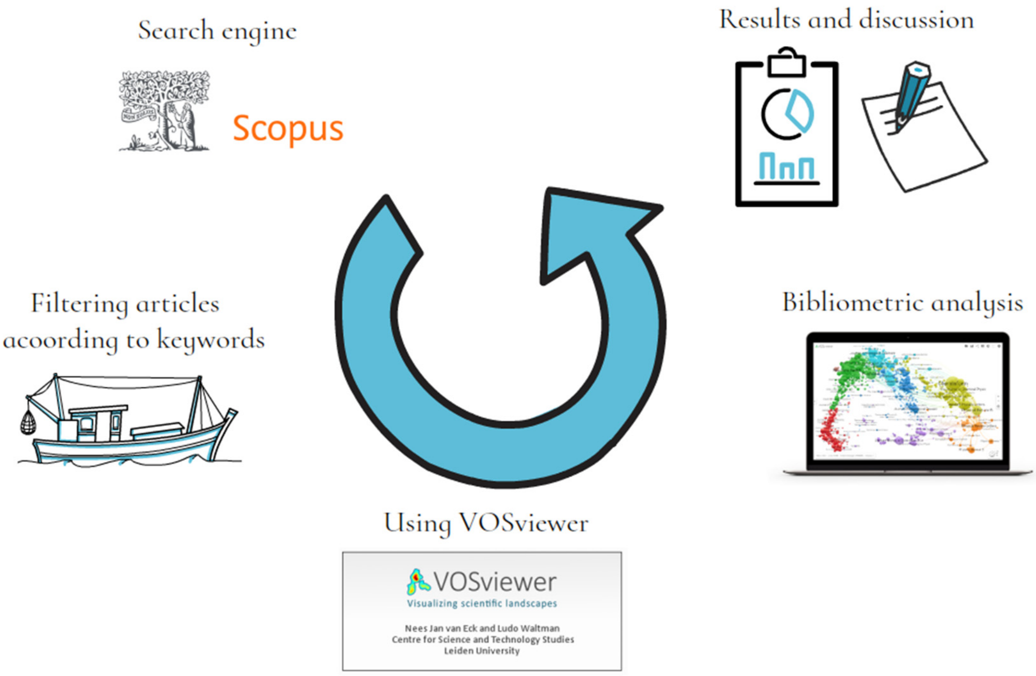

Figure 2. Steps followed according to the applied methodology.

Continuing this process, the subsequent steps involve filtering the database. Initially, a search was conducted in the SCOPUS database using designated keywords of interest: 'small fishing vessel'. Subsequently, a secondary filter was applied, incorporating keywords such as 'safety', 'accident', 'injury', and 'danger'. This additional refinement was considered necessary to ensure a higher level of specificity within the resulting database, with no other filters employed. Consequently, the obtained database predominantly focuses on articles aligned with our research interests, making further filters unnecessary. As a result of this process, a total of 236 articles specifically related to small fishing vessels were identified.

3. Results

3.1. Situational Status of Artisanal Fishing Vessels in Peru

Fishing vessels in Peru are categorized based on their storage capacity, as follows: (a) small artisanal fishing vessels, with a storage capacity of 10 m^3 or less; (b) fishing vessels with a length of 15 m or less and a storage capacity ranging from 10 m^3 to 32.5 m^3; and (c) industrial fishing vessels, encompassing those that do not fit the aforementioned definitions, essentially those with a storage capacity exceeding 32.5 m^3 [9].

Figure 3, as presented by IMARPE (the Maritime Institution of Peru) [10], highlights that Peru is home to around 17,920 fishing vessels (as per the ENEPA III census). Notably, these numbers are continuously increasing, as indicated by records in various census periods. These findings signify that, despite legal restrictions, the construction of artisanal vessels persists, as seen in Figure 3.

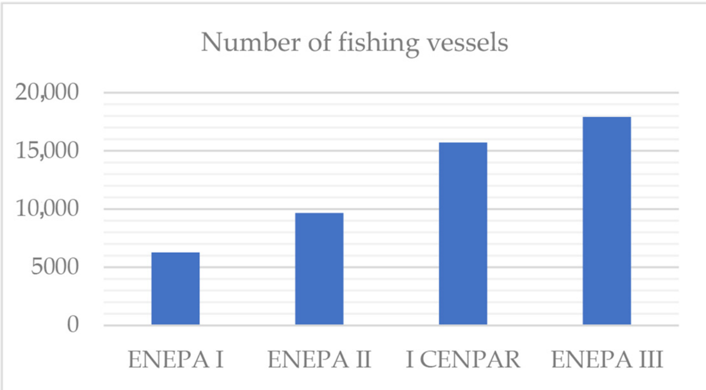

Figure 3. Total number of vessels across different census periods. Adapted from [10].

On the other hand, the Peruvian coast spans a vast expanse of 3080 km, providing a fertile ground for the flourishing of artisanal fishing activities. As indicated by ENEPA III [10], Figure 4 shows the current landscape, encompassing 87 landing sites that encompass various features, ranging from coves to beaches, distributed along the Peruvian coastline. However, it is worth noting that these areas lack the presence of a maritime authority. Consequently, fishermen often find themselves in the position of self-organization within guilds. In certain instances, these guilds receive support from non-governmental organizations (NGOs), which collaborate to notify maritime authorities in case of unforeseen casualties concerning fishing vessels.

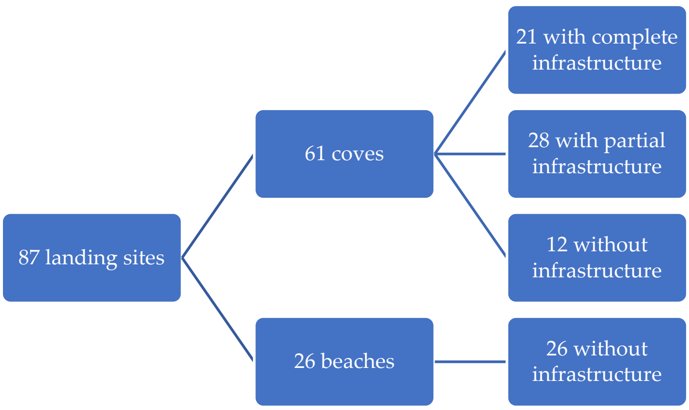

Figure 4. Areas of small fishing vessel disembarkation. Adapted from [10].

Stretching along the Peruvian Coast are fourteen port captaincies, situated in the following ports: Zorritos, Talara, Paita, Pimentel, Salaverry, Chimbote, Supe, Huacho, Callao, Pisco, San Juan, Mollendo, and Ilo [11]. These fourteen captaincies assume the responsibility of overseeing the functions of maritime law enforcement within their respective jurisdictions. They are equipped with the necessary resources to engage in search and rescue operations in response to potential vessel-related hazards. Additionally, these entities are tasked with registering casualties, which are subsequently compiled by the Direction of Captaincies.

3.1.1. Safety of Small Fishing Vessels

At the international level, two distinct sets of recommendations exist that cover the safety aspects of the fishing sector. The first set of recommendations focuses on regulating, ensuring, and enhancing the physical and emotional well-being of workers through the controlled management of their work environments, all aimed toward risk reduction. An example of this is the document "Guidelines on Training and Certification of Fishing Vessel Personnel" (FAO/OMI/ILO) [12].

The second approach places emphasis on regulating the technical aspects of vessels, encompassing their construction, structural integrity, stability, navigational capabilities, machinery, electrical installations, and fire protection [13].

Within the fishing industry, a distinction is made between crew and fishing vessel casualties. The interplay between these two categories is illustrated in Figure 5.

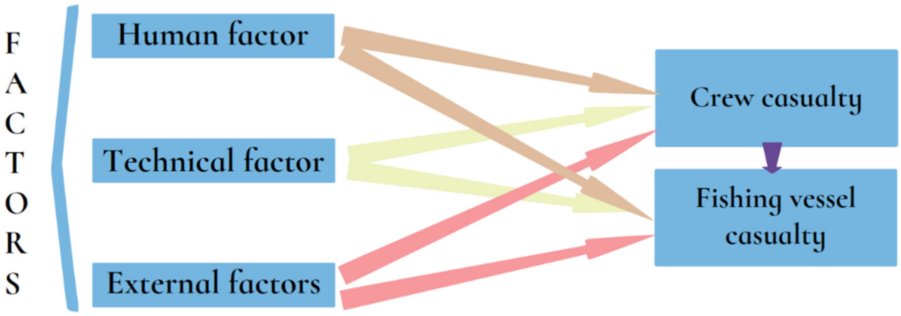

Figure 5. Accident factors of fishing vessel accidents.

In ref. [14], maritime accidents are classified into distinct causal types, with the accident frequency serving to underpin the observation that emergency management stands as a predominant factor in maritime accidents, as seen in Table 1. This term encompasses the crew's decision-making criteria in defining the consequences of maritime accidents, including incidents such as capsizing, sinking, fires, and close approaches.

Table 1. Types of causes of casualties [14].

Types of Causes	Frequency	% Causes	No. Accidents
Human factors	66	11.53	51
Work organization	76	22.49	45
Emergency management	81	23.96	37
Conditions of work spaces	50	14.79	34
Other causes	20	5.92	19
Prevention management	22	6.51	14
Service or protection facilities	12	3.55	11
Machines	8	2.37	4
Other work equipment	3	0.89	2
Total	338		

3.1.2. Statistics of Fishing Vessel Casualties

Figure 6 depicts the casualties experienced by Peruvian fishing vessels spanning from 2004 to 2010, sourced from a 2011 DICAPI database. It's important to note that the terminology for the casualties presented in Figure 6 remains unchanged in this paper. However, a notable observation arises: the terms used in Figure 6 do not align exactly with those typically found in fishing vessel casualty reports. For instance, the term "stranding" or "grounding" in Figure 6 might pertain to what is known as "allision". Similarly, instances categorized as "drifting" could potentially result from machinery damage or grounding.

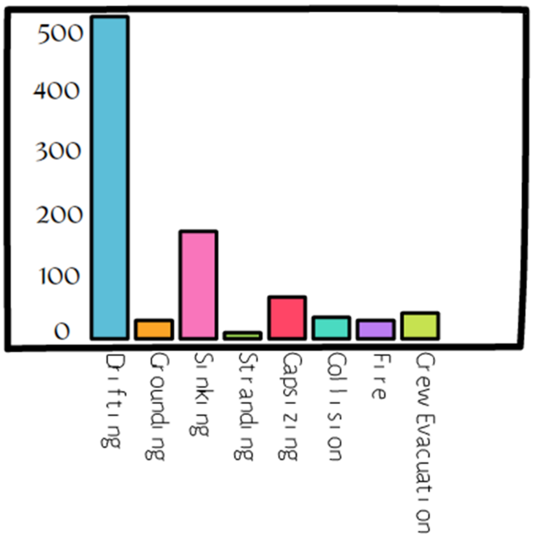

Figure 6. Casualties of Peruvian fishing vessels (artisanal and industrial fleets, period: 2004–2010).

In essence, fishing vessel casualties encompass a sequence of events culminating in the loss of the vessel. This sequence might entail crew evacuation (which should not be considered a fishing vessel casualty itself), followed by one of the commonly reported casualties such as flooding, fire and explosions, grounding, capsizing, collisions and contact, machinery damage, heavy weather damage, or others.

Interestingly, flooding is conspicuously absent from the data in Figure 6. This absence might stem from the nuanced nature of flooding events, which can often be part of a series of events. For instance, hull failure could precede flooding, ultimately leading to sinking [15]. Hence, a meticulous and accurate understanding of the origins of a vessel's casualty is imperative for a comprehensive fishing vessel casualties report.

Figure 6 reveal a total of 169 cases of sinking and 66 of capsizing within a span of 7 years. Despite its generality—encompassing both artisanal and industrial fishing fleets—these casualty numbers appear notably high in comparison to other nations. Of significant note, the total number of machinery damage and grounding casualties is 564. This could be attributed to inadequate vessel maintenance, gaps in technical marine knowledge among the crew, or both.

To truly comprehend the dynamics of fishing vessel casualties and to establish effective regulations, the implementation of a comprehensive scientific–technical reporting system for such incidents is absolutely imperative. Presently, there exists a discourse regarding the potential modification of the current Peruvian intact transverse stability regulations for industrial fishing vessels. However, regrettably, this process is hindered by the dearth of reports, data, and accurate information required to make decisions founded on technical and scientific insights.

This problem has significant implications, particularly in terms of the safety of fishing vessels. While these vessels pass the criteria set forth by the IMO, there is a misalignment with the existing Peruvian stability criterion to guaranty safety during fishing operations

"GM ≥ 0.9 m". As highlighted by Mantari et al. [16], this particular criterion lacks both scientific validation and technical support, presenting a substantial concern.

In essence, the establishment of a robust scientific–technical reporting mechanism is not only vital for regulatory decisions but also critical for enhancing the safety and stability of fishing vessels, and ultimately safeguarding the lives of those who operate within this industry.

Despite the concerted efforts undertaken by the Peruvian maritime authority to mitigate the incidence of accidents along the Peruvian coast, these numbers continue to surge [17]. Figure 7, derived from the work by Cipriano [17] and adapted here, illustrates the progressive escalation of these casualties. A recurring element across the majority of these cases is the occurrence of drifting.

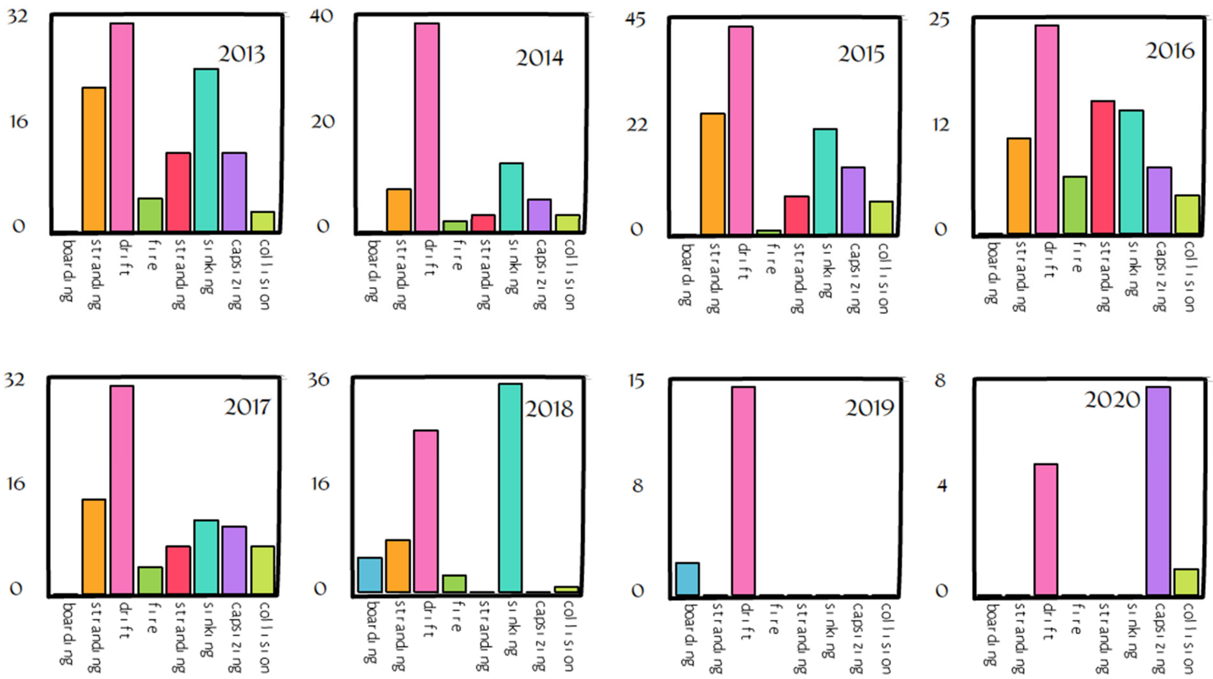

Figure 7. Peruvian fishing vessel casualties.

It is essential to underscore that these data do not distinguish between vessel lengths or categories, a pivotal consideration given that smaller vessels are more predisposed to accidents such as capsizing [18].

Furthermore, it is worth noting that not all maritime accidents are reported to the maritime authority. This suggests that the actual figures could indeed be higher, a deeply disconcerting prospect.

As previously mentioned, a substantial proportion of registered emergencies arise from drifting casualties. Drifting entails a vessel being carried along by external forces due to various factors. Often, machinery failure triggered by inadequate maintenance is a prominent contributor to this scenario [18]. In certain cases, drifting results from battery discharge, the deterioration of starting systems, or mechanical malfunctions of equipment.

Another prevalent casualty is sinking, frequently stemming from other casualties such as collisions, fires, and explosions [19]. The underlying causes of sinking can encompass water ingress through hull damage, deck inundation, or the flooding of enclosed spaces. Studies conducted on recreational vessels in Alaska reveal that a significant number of sinking incidents occurred due to inadequately sized bilge pumps or a lack of vessel maintenance [20]. Similar issues could potentially arise in small fishing vessels; yet, it remains uncertain whether the bilge pumps on Peruvian fishing vessels are suitably designed to prevent sinking in the face of hull damage or water infiltration, so it is necessary to conduct comprehensive studies on this subject.

Furthermore, the most prevalent type of casualty is vessel capsizing. This typically occurs due to insufficient vessel stability [21]. In the context of trawler boats, a notable cause of capsizing is the fishing net becoming entangled with the seabed [22]. In the Peruvian context, vessel capsizes are often attributed to overfishing, where an excessive quantity of fish caught in the net can lead to instability and, in certain instances, result in the vessel sinking [23]. Seabed-fastened capsizing scenarios may also occur, as discussed in [16].

Another significant casualty frequently recorded is grounding, which transpires when the vessel's bottom comes into contact with the sea floor. Grounding can be classified into two types: one arising from a deliberately induced accident, often undertaken to avert sinking, and the other stemming from negligence or unfamiliarity of the captain with the seabed. Grounding incidents tend to occur in rough, rugged, or shallow areas situated in proximity to the coast.

Collision and boarding constitute a smaller percentage of casualties, typically arising from reduced visibility due to factors like fog.

Lastly, although fires occur less frequently as the years progress, they are arguably the most perilous accidents in terms of vessel loss and potential fatalities [24]. Fires and explosions can originate from a variety of sources and locations. Byard et al. [25] caution against the risk of explosion in the engine room due to volatile fuel vapors not being adequately dispelled. Other common causes of fires on vessels include malfunctions of heating systems, kitchens, stoves, electrical failures, equipment failures, and human-caused electrical faults. The limited onboard resources to combat fires amplify the severity of the damage they cause, making this issue particularly demanding and warranting special attention.

The operational factor presents the highest level of risk for fishermen and the crew [26]. An important consideration regarding onboard accidents (operational accidents or crew casualties) is that they often necessitate the vessel to halt its operations, particularly due to limited onboard medical assistance. For instance, in Portugal, only the captain or one crew member receives specific training in first aid [27].

The elevated level of risk onboard fishing vessels can be attributed to a multitude of factors. For example, the crew operates continuously on an unstable surface [28]. Additionally, their work environment is surrounded by potentially hazardous objects, such as nets, wires, cables, cords, winches, anchors, and fish remnants [29,30]. Hand injuries resulting from the use of winches, machinery, wires, and knives, or from encounters with animals, are common occurrences [31,32].

In North Carolina [33], it was observed that a majority of non-aquatic accidents occurred in ports, during the embarkation and disembarkation of fish or bait containers. In Peru, there are currently 21 disembarkation sites, all categorized as coves (see Figure 4), that lack the necessary infrastructure for proper stowage of the harvested catch. This underscores the importance of studying the impact of inadequate infrastructure on the health and safety of workers in these disembarkation areas.

When discussing work or occupational labor, it is imperative to recognize that all forms of work can directly or indirectly impact health [34]. In the fishing industry, however, the risks are even more pronounced. The medical attention available for the crew is limited, so in cases of sickness, there exists a great difficulty to receive assistance and adequate treatment. Fishing is, therefore, a highly dangerous professional with high levels of morbidity, accidents, and mortality. In the fishing industry, there are various risk factors and the crew carry out their tasks permanently exposed to them. The INSHT (National Institution of Security and Hygiene in the Work of Spain) indicates that this prolonged exposure to harmful mediums can consequently cause the development of disorders and sicknesses of various types [35].

The crew remains constantly exposed to the harsh elements of weather and sea conditions, in addition to disturbances and impacts generated by the machinery and equipment onboard. Their prolonged exposure to high levels of noise can lead to gradual hearing loss, a concern particularly relevant for fishermen on small and medium-sized vessels, where noise levels can be more elevated.

Vibrations stemming from the operation of machinery and devices onboard pose another adverse impact. These vibrations can induce physiological and psychological effects on individuals due to significant relative deformations and displacements experienced by organs and tissues at certain frequencies [36]. Another recurring issue is that fishermen frequently exert considerable force to lift heavy loads and assume repetitive flexing postures. This physical strain is more pronounced in smaller fishing vessels, especially during embarkation and disembarkation activities. Over time, this can lead to musculoskeletal disorders and injuries among workers.

Numerous accidents and illnesses result in temporary or permanent losses of physical mobility and psychological well-being. This, in turn, diminishes the efficiency and productivity of each worker, leading to economic and social issues [34]. Table 2 outlines the prevalent occupational illnesses within a crew, highlighting the prominence of musculoskeletal issues, fatigue, and stress. A study by Franzeskou examining the health of Greek fishermen revealed that 71% suffered from musculoskeletal disorders, often stemming from bodily exhaustion [37]. Similarly, fatigue and stress also manifest with similar symptoms.

Table 2. Most frequent sicknesses in fishermen [37].

Item	Occupational Diseases
1	Musculoskeletal disorders
2	Fatigue
3	Stress
4	Pathologies of the cardiorespiratory system
5	Respiratory diseases
6	Digestive alterations
7	Dermatological affections
8	Ophthalmic damage
9	Mortality
10	Cancer
11	Noise and hearing damage

3.2. Bibliometric Analysis of the Safety Aspects of Small Fishing Vessels Worldwide

In Figure 8, it becomes evident that the earliest published article dates back to the year 1984. In stark contrast, the largest influx of publications addressing the current topic is observed to be in 2021. Figure 8 illustrates a compilation of these publications pertaining to the safety of small fishing vessels.

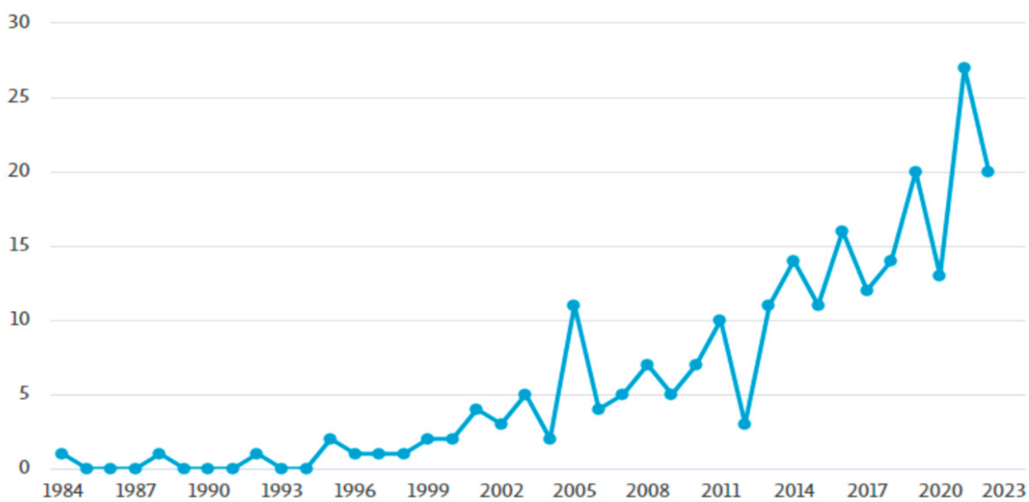

Figure 8. Total number of publications per year related to small fishing vessels.

Indeed, the United States takes the lead in this ranking with 28 publications cataloged in Scopus. Notably, a remarkable observation emerges: the scientific output concerning this subject exhibits an exponential trend.

Furthermore, Figure 9 reveals a compelling pattern wherein certain countries, namely prominent players in the global fishing industry, display a notably robust scientific engagement with the subject of small fishing vessels (notably China, Indonesia, the United States, and Norway). Curiously, paradoxically, both Peru and Chile are conspicuously absent from Figure 9. This discrepancy may potentially stem from the fact that relevant articles pertaining to this topic might exist outside of the scope of Scopus indexing.

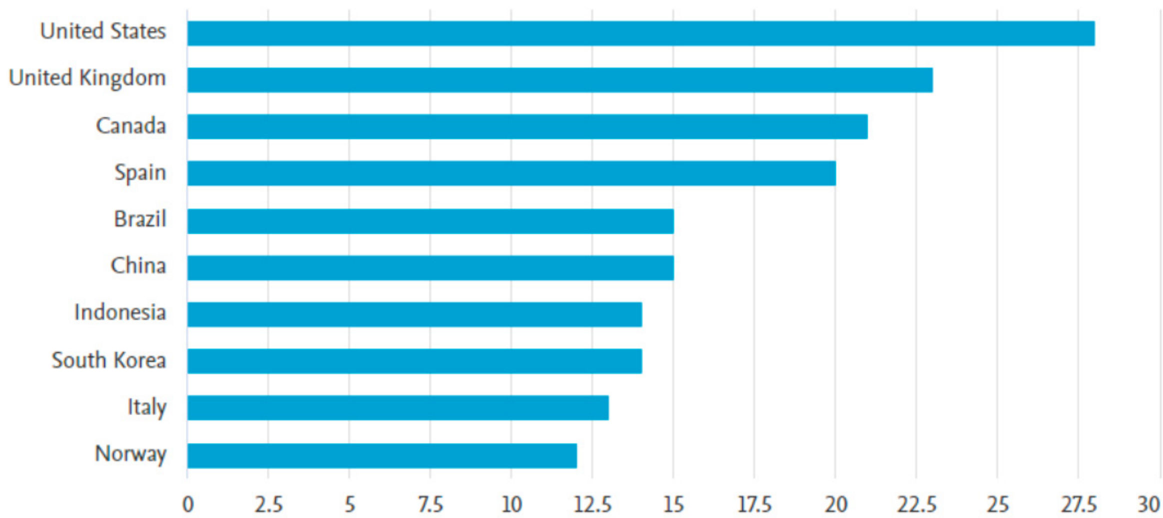

Figure 9. Total number of publications on small fishing vessels indexed in Scopus.

Figure 10 shows the database of scientific research on fishing vessels categorized by the area of knowledge. Notably, we can observe that articles affiliated with engineering constitute the most prolific segment, accounting for 33.3% of the total amount. It is pertinent to emphasize that within Figure 10, the existence of articles encompassing domains unrelated to our primary interest, such as computer science or social science, is apparent. These articles have been meticulously examined to establish their robust linkage with the core subject of our investigation, ensuring a comprehensive and cohesive research focus.

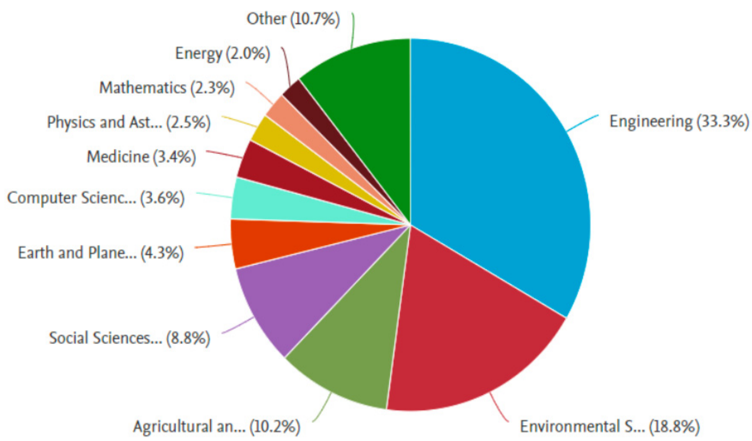

Figure 10. Distribution of articles concerning small fishing vessels according to the analyzed data.

Table 3, derived from the VOSviewer software, provides a classification of the refined database, ultimately revealing that Germany boasts the highest number of citations pertaining to safety in the context of small fishing vessels. A noteworthy aspect deserving attention is that, despite possessing a lower count of articles in comparison to several other nations within the top 10 in terms of fishing production, Germany's articles stand out due to their elevated citation count, even though this country does not have a significant sea border to influence their trade. This effectively renders Germany's contributions the most esteemed and valuable in contrast to their counterparts.

Table 3. The most cited countries in the context of research on small fishing vessels.

Country	Documents	Citations
Germany	7	1126
United States	27	984
Canada	21	462
Brazil	15	330
United Kingdom	23	327
United Arab Emirates	1	234
Italy	13	183
Portugal	12	164
Spain	20	153
Malaysia	9	151
Norway	12	150
Greece	5	121

Equally, the VOSviewer software facilitated us to perform a bibliometric analysis to understand the relationship that exists between these published articles and their citations. The indicators of this can be visualized based on the researcher's selection criteria. Figure 11 depicts a web-like representation wherein each country is symbolized by a circle denoting the amount of citations, with links connecting the countries based on these citations (the larger the circle, the more significant the citation connections; conversely, smaller circles indicate fewer connections). Spain and South Korea are both contributors to the scientific publications on the topic and have mutually cited each other. Greece and Spain are also present in scientific publications regarding this subject; however, they lack reciprocal citations.

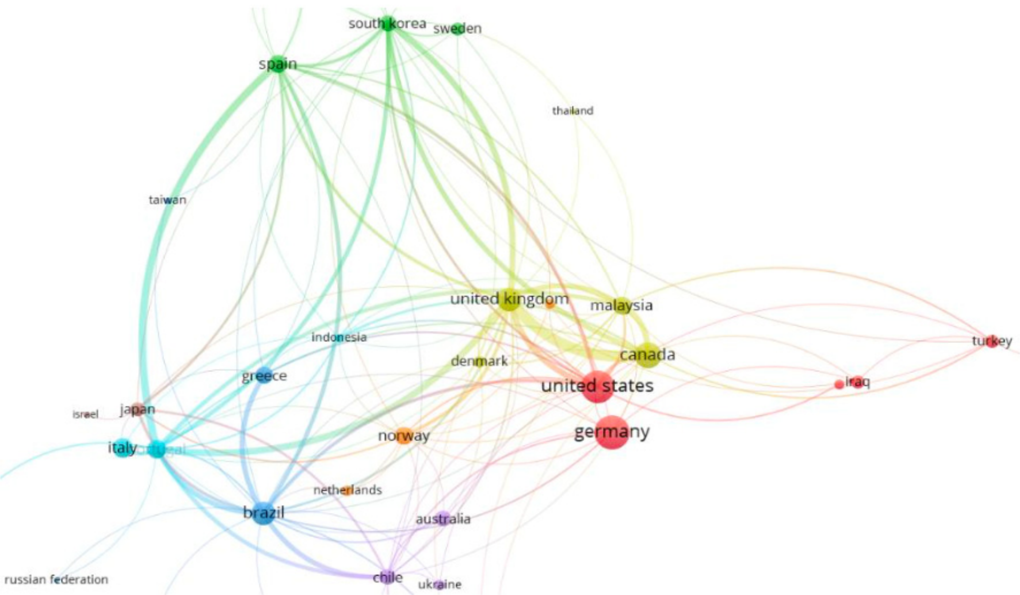

Figure 11. Most cited countries related to small fishing vessels.

Similarly, a bibliometric analysis has been conducted to explore the existing relationship between the quantity of published articles and their co-authorship across countries. Figure 12 illustrates a web-like visualization wherein each country is symbolized by a circle representing their number of publications, and the connections between the countries indicate the co-authorship of these publications (larger circles signify more scientific articles attributed to that country, and closer circles suggest a greater degree of co-authorship; conversely, smaller circles and greater distances between them indicate less articles and a lesser degree of co-authorship). Notably, Spain and Portugal exhibit notable scientific publications and share a well-established co-authorship relationship. This co-authorship can potentially be attributed to factors such as their geographical proximity and shared fishing traditions, or Spain's globally recognized possession of two towing tanks. Interestingly, when considering the United States and the United Kingdom, it is noteworthy that while there is a significant amount of scientific publications between them, there appears to be relatively fewer co-authorships, despite their common language.

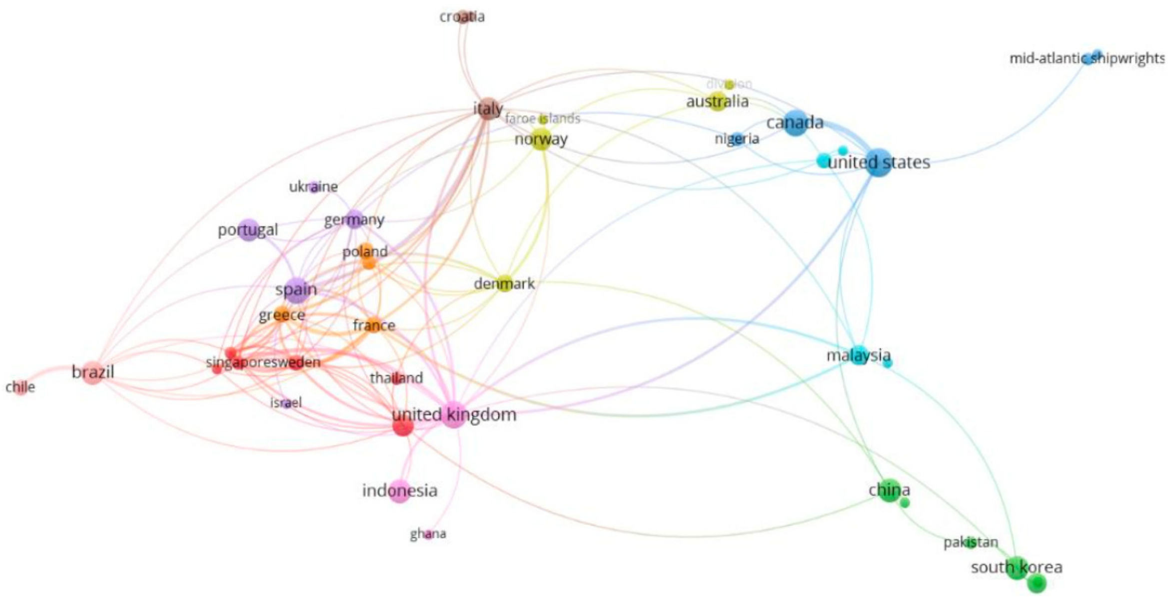

Figure 12. Co-authorship between countries of articles related to small fishing vessels.

Finally, Figure 13 displays a heat map derived from Figure 12. The color red draws attention to countries with a substantial number of publications, notably the United States and Spain. Meanwhile, shades of yellow and blue adorn the map's periphery, indicating countries with fewer published articles within the Scopus database. Notably, concerning this refined dataset, Chile and Brazil stand as the Latin American representatives.

Up to this juncture, a dense database has been evaluated including journals such as *Safety Science*, *Ocean Engineering*, *Reliability Engineering & System Safety* and *Accident Analysis and Prevention*, which are the most important journals on maritime accidents [38], and the substantial representation of the safety of small fishing vessels within the existing work is evident. Regrettably, Peru's scientific contribution in this field is lacking, drawing attention to the need for a comprehensive scientific evaluation of the current state of the Peruvian fishing sector. Such an evaluation will form the foundation for proposing strategies aimed at advancing the safety of fishing vessels in Peru.

Finally, it is advisable to extract a sample of the most influential papers from the analyzed database. Consequently, Table 4 presents a selected sample of 29 high-impact articles categorized into three topics: 'maritime accidents'; 'risks of small fishing vessels', which explores the significance and risks associated with small fishing vessels; and 'vessel safety and environmental impact', focusing on the environmental consequences of fishing vessel accidents.

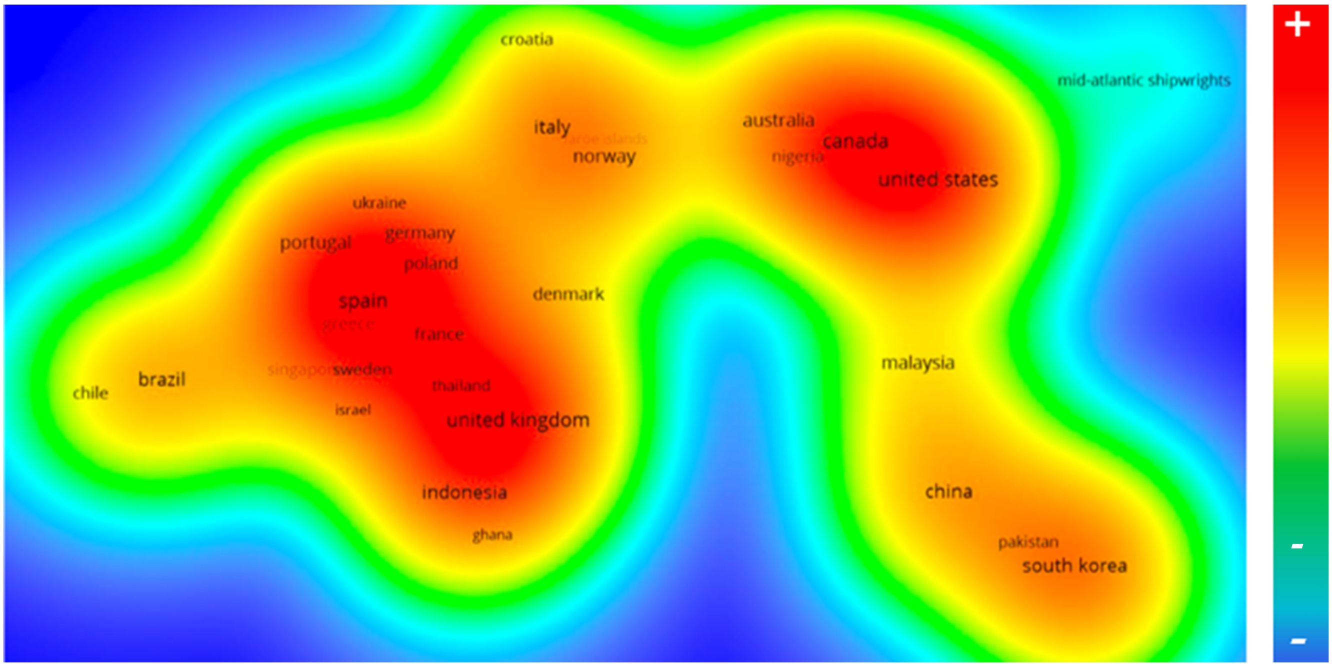

Figure 13. Heat map of countries sharing co-authorship of articles related to small fishing vessels.

Table 4. Sample of high-impact articles belonging to the analyzed database.

Nro	Topic	Title	Reference
1	Maritime accidents	"Incorporating multi-scenario underreporting rates into MICE for underreported maritime accident record analysis"	[39]
2		"A safety risk assessment for ship boarding parties from fuzzy Bayesian networks perspective"	[40]
3		"An analysis of severity of oil spill caused by vessel accidents"	[41]
4		"Decision Tree and Logistic Regression Analysis to Explore Factors Contributing to Harbour Tugboat Accidents"	[42]
5	Risks of small fishing vessels	"An operational risk awareness tool for small fishing vessels operating in harsh environment"	[43]
6		"Sickness Absence and Hospitalization among Workers on Board Norwegian Fishing Vessels"	[44]
7		"Risk perception in small-scale fishers and hyperbaric personnel: A risk assessment of hookah diving"	[45]
8		"Influence of ship dynamics modelling on the prediction of fishing vessels roll response in beam and longitudinal waves"	[46]
9		"Fishing for revenue: How leasing quota can be hazardous to your health"	[47]
10		"Occupational health outcomes for workers in the agriculture, forestry and fishing sector: Implications for immigrant workers in the southeastern US"	[48]
11		"Safety culture aboard fishing vessels"	[49]
12		"Fishing safety policy and research"	[50]
13		"Assessing the role of information and communication technologies in responding to 'slavery scandals'"	[51]

Table 4. *Cont.*

Nro	Topic	Title	Reference
14	Vessel safety and environmental impact	"Mapping vessel traffic patterns in the ice-covered waters of the Pacific Arctic"	[52]
15		"Application of Rough Set Theory and Bow-Tie Analysis to Maritime Safety Analysis Management: A Case Study of Taiwan Ship Collision Incidents"	[53]
16		"Managing weather & fishing safety: Marine meteorology and fishing decision-making from a governance and safety perspective"	[54]
17		"A hybrid model for marine accident analysis based on Bayesian Network (BN) and Association Rule Mining (ARM)"	[55]
18		"Trade-offs between physical risk and economic reward affect fishers' vulnerability to changing storminess"	[56]
19		"Safety in Coastal and Marine Tourism"	[57]
20		"Linking Datasets to Characterize Injury and Illness in Alaska's Fishing Industry"	[58]
21		"Towards safe navigation environment: The imminent role of spatio-temporal pattern mining in maritime piracy incidents analysis"	[59]
22		"Noise sources and hazardous noise levels on fishing vessels: The case of Newfoundland and Labrador's fleet"	[60]
23		"Exploring shipping accident contributory factors using association rules"	[61]
24		"Wind-borne illness from coastal seas: Present and future consequences of toxic marine aerosols"	[62]
25		"Health in fishing communities: A global perspective"	[63]
26		"Aquatic food security: insights into challenges and solutions from an analysis of interactions between fisheries, aquaculture, food safety, human health, fish and human welfare, economy and environment"	[64]
27		"A root cause analysis for Arctic Marine accidents from 1993 to 2011"	[65]
28		"Analysis of human errors in maritime accidents: A Bayesian spatial multinomial logistic model"	[66]
29		"Pattern investigation of total loss maritime accidents based on association rule mining"	[67]

4. Discussion

A recurring challenge in Peru is the prevalence of informality within the fishing sector. Many fishing vessel casualties and work-related accidents or crew casualties, even those without fatalities or that do not require search operations, often go unreported to the maritime authority. Various factors contribute to this, including: (a) vessels lacking the necessary certifications, or (b) vessel owners anticipating costly equipment requirements if accidents are reported. Additionally, there may be a lack of incentive to report such incidents. Figure 14 provides a summary of casualties reported in the database of the Peruvian Ministry of Labor [68].

It is true that it is important to know the number of casualties that occur within the fishing sector, but it is equally important to have a structured classification of these casualties. This classification allows us to discern the fundamental causes or predominant sources of accidents, allowing us to adapt solutions to address the most pertinent cases. Although the data from the Ministry of Labor can be useful for comparisons across various industrial sectors, they often fall short when it comes to making informed decisions aimed at mitigating or reducing maritime accidents, i.e., fishing vessels and crew casualties. Notably, the trends in fishing vessel casualties depicted in Figures 12 and 13 seem to contradict or show a lack of correlation with those reported in Figure 14.

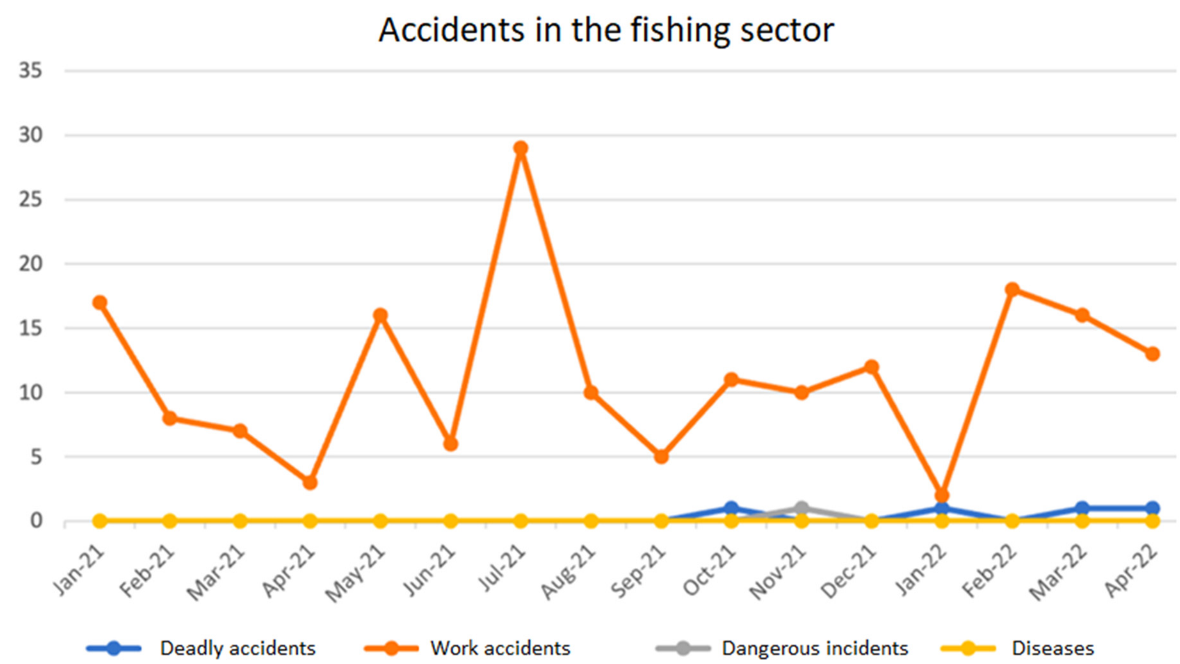

Figure 14. Fishing sector casualties. Adapted from [68].

The FAO recognizes the lack of information as a critical issue within its cooperation programs, particularly in the context of enhancing safety. The statistics offered by various Peruvian institutions are deemed to have low reliability. Furthermore, the DICAPI's records of fishing vessel casualties are influenced by the prevailing informality within this sector, leading to inaccuracies in the presented figures. Similarly, the statistics provided by the maritime authority lack clarity, detail, and precision, hindering the identification of the root causes of vessel accidents (similar to the information from the Ministry of Labor).

Information plays a pivotal role in planning, policymaking, administration, and research. If the data furnished by Peruvian government institutions are neither transparent nor dependable, this severely limits their ability to make informed decisions. Moreover, accessing such specific information is notably challenging. Currently, there are no comprehensive statistics available that could shed light on the actual state of the fishing sector or help to identify its underlying problems and challenges. As a result, the existence of formats for recording vessel casualties, along with their corresponding statistics, remains unknown.

In 2012, Peru recorded data on 44,161 artisanal fishermen, of whom only 67% possessed secondary education or higher qualifications [6,10]. According to the IMO, ensuring worker safety must involve heightening awareness, proper training, secure vessels, adequate equipment, and organized search and rescue procedures in order to manage risks. However, artisanal fishermen, often operating in developing countries with limited resources and small vessels, tend to be more vulnerable. Negligence and disregard of the workers themselves are often the main contributors to most fishing vessel casualties [13,18]. A positive note is that the Fisheries Development Fund of Peru (FONDEPES, in Spanish) offers training to fishermen across various domains. Nonetheless, the widespread population of fishermen along Peru's extensive coastline makes covering all territories effectively a challenging task.

Regarding the safety of fishing vessels, the authors advocate for a comprehensive scientific investigation and thorough technical assessment to propose a stability criterion, particularly in fishing operations, where it is suspected that capsizing and sinking casualties often occur when a high volume of fish is caught. However, conducting such a study necessitates extensive data, which, regrettably, are currently unavailable. The suggested course of action thus includes: (a) analyzing the existing data and supplementing as needed; (b) designing an effective fishing vessel casualties reporting system; (c) generating standardized data from past events in collaboration with engineers, scientists, vessel owners, and the DICAPI, aligning with IMO terminology, to better comprehend casualties like sinking and capsizing; and (d) implementing algorithms to calculate the intact transverse stability of fishing vessels in varying conditions, as demonstrated by Mantari et al. [69].

To conclude, the establishment of a fishing vessel casualties reporting system should encompass a comprehensive array of information. This includes details such as the precise time and location of the incident, vessel specifications, onboard equipment, the nature of the work-related accident or casualty, any underlying causes and contributing factors, the measures undertaken during search and rescue operations, as well as the aftermath and consequences of the casualty.

In this context, the emphasis on training for the safety of workers emerges as a pivotal factor in mitigating risks onboard vessels. Thus, the widespread implementation of safety training initiatives by FONDEPES holds considerable potential to significantly enhance the overall safety of fishing operations. This endeavor stands to benefit both the well-being of the workers and the maritime sector as a whole.

Research endeavors focusing on environmental, human, and ship casualties often find more economic incentives in other industries rather than in fishing vessel operations. This diverse research on environmental, human, and ship casualties [70–73] has yielded valuable insights and technologies for comprehending and averting casualties, which can also be effectively applied to enhance safety within the fishing vessel industry. Therefore, it is imperative to conduct extensive research in the realm of fishing vessel safety to gain a holistic understanding of the multifaceted casualty-related challenges involving the environment, human factors, and the fishing vessels themselves.

5. Conclusions

The current information on fishing vessel casualties and accident registration system in Peru is inadequate, lacking both availability and reliability. The maritime authority's casualty registry must be comprehensive and transparent, aligning with FAO, SOLAS, and IMO recommendations. This entails the development of user-friendly formats that can gather precise and detailed data, facilitating the identification of prevalent challenges in the fishing sector.

From an institutional standpoint, it is crucial for the maritime authority to possess effective tools for capturing vital information concerning casualties within the fishing industry. The reporting systems to be implemented could serve as essential tools for recording embarkation, fishing vessel, and crew casualties. Moreover, these formats should be designed with ease of completion in mind, ensuring they encompass a wealth of information without causing confusion or uncertainty for those filling them out.

New regulations governing the safety of fishing vessels during operations require accurate reports on fishing vessel casualties. These reports serve as foundational studies for understanding and preventing catastrophic events as envisioned by these new regulations. However, it is essential to first revamp safety within the fishing sector. This endeavor necessitates the involvement of technical experts, naval architects, oceanic engineers, and professionals from various fields. Addressing the safety challenges faced by mariners today is a complex task that demands a multidisciplinary approach.

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References

1. Merino, A. Los Mayores Productores de Pescado, Organización Para la Cooperación y el Desarrollo Económico. Available online: https://elordenmundial.com/mapas-y-graficos/los-paises-mas-pescado-producen/ (accessed on 1 July 2022).
2. Brown, M. Hooked on Safety: An Analysis of Commercial Fishing Safety and Training Opportunities. Ph.D. Thesis, Tufts University, Medford, MA, USA, 2018.
3. Chowdhury, A.; Naz, A.; Maiti, S.K. Distribution, speciation, and bioaccumulation of potentially toxic elements in the grey mangroves at Indian Sundarbans, in relation to vessel movements. *Mar. Environ. Res.* **2023**, *189*, 106042. [CrossRef] [PubMed]
4. Yilanci, V.; Cutcu, I.; Cayir, B.; Saglam, M.S. Pollution haven or pollution halo in the fishing footprint: Evidence from Indonesia. *Mar. Pollut. Bull.* **2023**, *188*, 114626. [CrossRef] [PubMed]
5. Öktener, A.; Bănăduc, D. Ecological Interdependence of Pollution, Fish Parasites, and Fish in Freshwater Ecosystems of Turkey. *Water* **2023**, *15*, 1385. [CrossRef]
6. Wang, X.; Xia, G.; Zhao, J.; Wang, J.; Yang, Z.; Loughney, S.; Fang, S.; Zhang, S.; Xing, Y.; Liu, Z. A novel method for the risk assessment of human evacuation from cruise ships in maritime transportation. *Reliab. Eng. Syst. Saf.* **2023**, *230*, 108887. [CrossRef]
7. Política y Plan Nacional de Seguridad y Salud en el Trabajo 2017–2021, Política y Plan Nacional de Seguridad y Salud en el Trabajo 2017–2021. Available online: https://www.trabajo.gob.pe/archivos/file/CNSST/politica_nacional_SST_2017_2021.pdf (accessed on 1 July 2022).
8. Garg, K.C.; Singh, R.K. A Bibliometrics Study of Papers Published in Library and Information Science Research during 1994 2020. *DESIDOC J. Libr. Inf. Technol.* **2022**, *42*, 57–63. [CrossRef]
9. Ley General de Pesca, Normas Legales Actualizadas, el Peruano, Decreto Ley 25977. Available online: https://diariooficial.elperuano.pe/pdf/0062/LEYGENERALDEPESCA.pdf (accessed on 1 July 2022).
10. Instituto del Mar del Perú, Ministerio de la Producción, Informe Imarpe ISSN 0378-7702 Inf Inst Mar Perú Vol 45 Nº 3 July–September 2018. Available online: https://repositorio.imarpe.gob.pe/handle/20.500.12958/3300 (accessed on 1 July 2022).
11. DICAPI–Dirección de Capitanías y Guardacostas, State of Ports [Ref. 2022]. Available online: https://www.dicapi.mil.pe/estado-de-puertos (accessed on 1 July 2022).
12. FAO; FAO/ILO/IMO. *Document for Guidance on Training and Certification of Fishing Vessel Personnel*, 2nd ed.; IMO: London, UK, 2001.
13. OMI. *International Torremolinos Convention for the Safety of Fishing Vessels*; OMI: Torremolinos, Spain, 1977.
14. Moreno, F. *Causas de los Accidentes Marítimos Muy Graves en la Pesca 2008–2013*; Instituto Nacional de Seguridad e Higiene en el Trabajo (INSHT): Madrid, Spain, 2014.
15. Dickey, D.H. *Analysis of Fishing Vessels Casualties (A Review of Lost Fishing Vessels and Crew Fatalities, 1992–2007)*; Compliance Analysis Division (CG5452), United States Cost Guards: Washington, DC, USA, 2008.
16. Mantari, J.L.; Ribeiro e Silva, S.; Guedes, C. Variations on transverse stability of fishing vessels due to fishing gear pull and waves. In Proceedings of the XXI Naval Architecture Pan-American Conference, Montevideo, Uruguay, 18–22 October 2009.
17. Cipriano, W. *Siniestralidad de Embarcaciones Pesqueras: Aplicación de los Nuevos Criterios de Estabilidad Intacta de Segunda Generación de la OMI*; Panamerican Institute of Naval Engineering: Alexandria, VA, USA, 2021.
18. Wang, J. An analysis of fishing vessel accidents. *Accid. Anal. Prev.* **2005**, *37*, 1019–1024. [CrossRef]
19. Perez-Labajos, C. Fishing safety policy and research. *Mar. Policy* **2008**, *32*, 40–45. [CrossRef]
20. Johnson, T.; Grant, S. Choosing and installing bilge pumps. *Pac. Fish.* **2001**, *22*, 44–47.
21. Krata, P. Total losses of fishing vessels due to the insufficient stability. *TransNav Int. J. Mar. Navig. Saf. Sea Transp.* **2008**, *2*, 311–315.
22. Roberts, S.E. Occupational mortality in British commercial fishing, 1976–1995. *Occup. Environ. Med.* **2004**, *61*, 16–23.
23. Mantari, J.L. Stability of Fishing Vessels in Waves and Wind. Master's Thesis, Naval Architecture and Marine Engineering, Instituto Superior Técnico, Centre for Marine Technology and Engineering (CENTEC), Technical University of Lisbon, Lisbon, Portugal, June 2010.
24. Jin, D.; Kite-Powell, H.; Talley, W. The safety of commercial fishing: Determinants of vessel total losses and injuries. *J. Saf. Res.* **2001**, *32*, 209–228. [CrossRef]
25. Byard, R.W. Commercial fishing industry deaths–forensic issues. *J. Forensic Leg. Med.* **2013**, *20*, 129–132. [CrossRef] [PubMed]
26. Saldarriaga, L. Análisis de la Formación Básica en Seguridad y Conductas de Riesgo en los Pescadores de Embarcaciones Artesanales de Talara, 2020. Bachelor's Thesis, Facultad de Ingeniería, Callao, Perú, 2021.
27. Antão, P.; Almeida, T.; Jacinto, C.; Soares, C. Causes of occupational accidents in the fishing sector in Portugal. *Saf. Sci.* **2008**, *46*, 885–899. [CrossRef]

28. Mirka, G.A.; Ning, X.; Jin, S.; Haddad, O.; Kucera, K.L. Ergonomic interventions for commercial crab fishermen. *Int. J. Ind. Ergon.* **2011**, *41*, 481–487. [CrossRef]
29. Piniella, F.; Fernández-Engo, M.A. Towards system for the management of safety on board artisanal fishing vessels: Proposal for check-lists and their application. *Saf. Sci.* **2009**, *47*, 265–276. [CrossRef]
30. Lincoln, J.M.; Lucas, D.L.; McKibbin, R.W.; Woodward, C.C.; Bevan, J.E. Reducing commercial fishing deck hazards with engineering solutions for winch design. *J. Saf. Res.* **2008**, *39*, 231–235. [CrossRef] [PubMed]
31. Norrish, A.E.; Cryer, P.C. Work related injury in New Zealand commercial fishermen. *Occup. Environ. Med.* **1990**, *47*, 726–732. [CrossRef]
32. Kucera, K.L.; Loomis, D.; Marshall, S.W. A case crossover study of triggers for hand injuries in commercial fishing. *Occup. Environ. Med.* **2008**, *65*, 336–341. [CrossRef]
33. Marshall, S.W.; Kucera, K.; Loomis, D.; McDonald, M.A.; Lipscomb, H.J. Work related injuries in small scale commercial fishing. *Inj. Prev.* **2004**, *10*, 217–221. [CrossRef]
34. OIT. *Prevención de las Actividades Peligrosas en la Pesca*; OIT: Klamath Falls, OR, USA, 2007.
35. Instituto Nacional de Seguridad de Higiene en el Trabajo (INSHT). *Casusas de los Accidentes Marítimos Muy Graves en la Pesca 2008–2013*; Government of Spain: Madrid, Spain, 2013.
36. Norwegian Centre for Maritime Medicine. *Knowledge Is Power and Should Therefore Be Shared*; Norwegian Centre for Maritime Medicine: Bergen, Norway, 2014.
37. Frantzeskou, E.; Kastania, A.N.; Riza, E.; Jensen, O.C.; Linos, A. Risk factors for fishermen's health and safety in Greece. *Int. Marit. Health* **2012**, *63*, 155–161.
38. Cao, Y.; Wang, X.; Yang, Z.; Wang, J.; Wang, H.; Liu, Z. Research in marine accidents: A bibliometric analysis, systematic review and future directions. *Ocean. Eng.* **2023**, *284*, 115048. [CrossRef]
39. Li, G.; Weng, J.; Wu, B.; Hou, Z. Incorporating multi-scenario underreporting rates into MICE for underreported maritime accident record analysis. *Ocean. Eng.* **2022**, *246*, 110620. [CrossRef]
40. Turna, İ. A safety risk assessment for ship boarding parties from fuzzy Bayesian networks perspective. *Marit. Policy Manag.* **2022**, 1–14. [CrossRef]
41. Cakir, E.; Sevgili, C.; Fiskin, R. An analysis of severity of oil spill caused by vessel accidents. *Transp. Res. Part D Transp. Environ.* **2021**, *90*, 102662. [CrossRef]
42. Fiskin, R.; Cakir, E.; Sevgili, C. Decision tree and logistic regression analysis to explore factors contributing to harbour tugboat accidents. *J. Navig.* **2021**, *74*, 79–104. [CrossRef]
43. Domeh, V.; Obeng, F.; Khan, F.; Bose, N.; Sanli, E. An operational risk awareness tool for small fishing vessels operating in harsh environment. *Reliab. Eng. Syst. Saf.* **2023**, *234*, 109139. [CrossRef]
44. Øren, A.; Thorvaldsen, T.; Sandsund, M.; Holmen, I.M. Sickness absence and hospitalization among workers on board norwegian fishing vessels. *J. Agromed.* **2019**, *24*, 357–363. [CrossRef]
45. Huchim-Lara, O.; Seijo, J.C. Risk perception in small-scale fishers and hyperbaric personnel: A risk assessment of hookah diving. *Undersea Hyperb. Med. J. Undersea Hyperb. Med. Soc. Inc* **2018**, *45*, 313–322. [CrossRef]
46. González, M.M.; Bulian, G. Influence of ship dynamics modelling on the prediction of fishing vessels roll response in beam and longitudinal waves. *Ocean. Eng.* **2018**, *148*, 312–330. [CrossRef]
47. Emery, T.J.; Hartmann, K.; Green, B.S.; Gardner, C.; Tisdell, J. Fishing for revenue: How leasing quota can be hazardous to your health. *ICES J. Mar. Sci.* **2014**, *71*, 1854–1865. [CrossRef]
48. Quandt, S.A.; Kucera, K.L.; Haynes, C.; Klein, B.G.; Langley, R.; Agnew, M.; Nussbaum, M.A. Occupational health outcomes for workers in the agriculture, forestry and fishing sector: Implications for immigrant workers in the southeastern US. *Am. J. Ind. Med.* **2013**, *56*, 940–959. [CrossRef] [PubMed]
49. Håvold, J.I. Safety culture aboard fishing vessels. *Saf. Sci.* **2010**, *48*, 1054–1061. [CrossRef]
50. Perez-Labajos, C.; Azofra, M.; Blanco, B.; Achutegui, J.; Gonzalez, J. Analysis of accident inequality of the Spanish fishing fleet. *Accid. Anal. Prev.* **2006**, *38*, 1168–1175. [CrossRef] [PubMed]
51. Marschke, M.; Andrachuk, M.; Vandergeest, P.; McGovern, C. Assessing the role of information and communication technologies in responding to 'slavery scandals'. *Marit. Stud.* **2020**, *19*, 419–428. [CrossRef]
52. Kapsar, K.; Gunn, G.; Brigham, L.; Liu, J. Mapping vessel traffic patterns in the ice-covered waters of the Pacific Arctic. *Clim. Chang.* **2023**, *176*, 94. [CrossRef]
53. Hsu, S.H.; Lee, M.T.; Chang, Y.C. Application of Rough Set Theory and Bow-Tie Analysis to Maritime Safety Analysis Management: A Case Study of Taiwan Ship Collision Incidents. *Appl. Sci.* **2023**, *13*, 4239. [CrossRef]
54. Finnis, J.; Reid-Musson, E. Managing weather & fishing safety: Marine meteorology and fishing decision-making from a governance and safety perspective. *Mar. Policy* **2022**, *142*, 105120. [CrossRef]
55. Özaydın, E.; Fışkın, R.; Uğurlu, Ö.; Wang, J. A hybrid model for marine accident analysis based on Bayesian Network (BN) and Association Rule Mining (ARM). *Ocean. Eng.* **2022**, *247*, 110705. [CrossRef]
56. Sainsbury, N.C.; Schuhmann, P.W.; Turner, R.A.; Grilli, G.; Pinnegar, J.K.; Genner, M.J.; Simpson, S.D. Trade-offs between physical risk and economic reward affect fishers' vulnerability to changing storminess. *Glob. Environ. Chang.* **2021**, *69*, 102228. [CrossRef]
57. Wilks, J. Safety in coastal and marine tourism. In *Tourist Health, Safety and Wellbeing in the New Normal*; Springer: Singapore, 2021; pp. 411–442. [CrossRef]

58. Syron, L.N.; Case, S.L.; Lee, J.R.; Lucas, D.L. Linking datasets to characterize injury and illness in Alaska's fishing industry. *J. Agromedicine* **2021**, *26*, 31–44. [CrossRef]
59. Li, H.; Yang, Z. Towards safe navigation environment: The imminent role of spatio-temporal pattern mining in maritime piracy incidents analysis. *Reliab. Eng. Syst. Saf.* **2023**, *238*, 109422. [CrossRef]
60. Burella, G.; Moro, L.; Colbourne, B. Noise sources and hazardous noise levels on fishing vessels: The case of Newfoundland and Labrador's fleet. *Ocean. Eng.* **2019**, *173*, 116–130. [CrossRef]
61. Weng, J.; Li, G. Exploring shipping accident contributory factors using association rules. *J. Transp. Saf. Secur.* **2019**, *11*, 36–57. [CrossRef]
62. Walsh, J.J. *Wind-Borne Illness from Coastal Seas: Present and Future Consequences of Toxic Marine Aerosols*; Academic Press: Cambridge, MA, USA, 2019. [CrossRef]
63. Woodhead, A.J.; Abernethy, K.E.; Szaboova, L.; Turner, R.A. Health in fishing communities: A global perspective. *Fish Fish.* **2018**, *19*, 839–852. [CrossRef]
64. Jennings, S.; Stentiford, G.D.; Leocadio, A.M.; Jeffery, K.R.; Metcalfe, J.D.; Katsiadaki, I.; Verner-Jeffreys, D.W. Aquatic food security: Insights into challenges and solutions from an analysis of interactions between fisheries, aquaculture, food safety, human health, fish and human welfare, economy and environment. *Fish Fish.* **2016**, *17*, 893–938. [CrossRef]
65. Kum, S.; Sahin, B. A root cause analysis for Arctic Marine accidents from 1993 to 2011. *Saf. Sci.* **2015**, *74*, 206–220. [CrossRef]
66. Sheng, T.; Weng, J.; Shi, K.; Han, B. Analysis of human errors in maritime accidents: A Bayesian spatial multinomial logistic model. *J. Transp. Saf. Secur.* **2023**, 1–17. [CrossRef]
67. Lan, H.; Ma, X.; Ma, L.; Qiao, W. Pattern investigation of total loss maritime accidents based on association rule mining. *Reliab. Eng. Syst. Saf.* **2023**, *229*, 108893. [CrossRef]
68. Monthly Statistical Bulletin—Notificaciones de Accidentes de Trabajo, Incidentes Peligrosos y Enfermedades Ocupacionales—Edición January 2021 until April 2022. Available online: https://www2.trabajo.gob.pe/estadisticas/estadisticas-accidentes-de-trabajo/ (accessed on 1 July 2022).
69. Mantari, J.L.; Ribeiro e Silva, S.; Guedes, C. "Intact stability of fishing vessels under combined action of fishing gear", beam waves and wind. *Ocean. Eng.* **2011**, *38*, 1989–1999. [CrossRef]
70. Huang, D.; Wang, Y.; Yin, C. Selection of CO_2 Emission Reduction Measures Affecting the Maximum Annual Income of a Container Ship. *J. Mar. Sci. Eng.* **2023**, *11*, 534. [CrossRef]
71. Huang, D.; Liang, T.; Hu, S.; Loughney, S.; Wang, J. Characteristics analysis of intercontinental sea accidents using weighted association rule mining: Evidence from the Mediterranean Sea and Black Sea. *Ocean. Eng.* **2023**, *287*, 115839. [CrossRef]
72. Cao, Y.; Wang, X.; Wang, Y.; Fan, S.; Wang, H.; Yang, Z.; Liu, Z.; Wang, J.; Shi, R. Analysis of factors affecting the severity of marine accidents using a data-driven Bayesian network. *Ocean. Eng.* **2023**, *269*, 113563. [CrossRef]
73. Wang, H.; Liu, Z.; Wang, X.; Graham, T.; Wang, J. An analysis of factors affecting the severity of marine accidents. *Reliab. Eng. Syst. Saf.* **2021**, *210*, 107513. [CrossRef]