



Maritime accidents in Fishing Craft in Spain. A Peltzman effect?

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ABSTRACT

Fishing has always been a basic activity in different societies, being one of the most dangerous jobs. Facing the problem of the high number of accidents and casualties in the Spanish fishing sector, we present an observational study and statistical analysis from reports of the maritime accidents that happened from 2000 to 2020. The reports of the accidents had been published by the Spanish Marine Accident and Incident Investigation Standing Commission, CIAIM. The research has been done in order to understand the causes and factors that have conducted to the accidents, trying to suggest and publish, from those causes, some recommendations to reduce or even avoid them. Up to 2020, it seems that some “Peltzman effect” is in place, as the number of accidents does not decrease even with the measures taken. Some conclusions and indications for maritime policy are suggested in this study.

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1. Introduction.

Worldwide, fishing is considered a dangerous activity, maybe the most dangerous in a time of peace during a large span of time [Roberts, 2010]. The Food and Agriculture Organization of the United Nations (FAO) carried out a study that was published in the form of a circular [Petursdottir, 2001] in which the accident rate of the fishing sector compared to other productive sectors worldwide was studied. The results confirmed that fishing is one of the sectors with the highest number of fatalities compared to other sectors, even as previous measures such as that promoted by the International Maritime Organization (IMO) [see, IMO 1975a, IMO 1975b] were taken. After recognizing the need for attention to the safety of commercial fishing vessels, the IMO organized an international conference, which culminated in the Torremolinos International Convention for the safety of fishing vessels in 1977 [IMO 1977]. It established uniform principles and rules regarding the design, construction, and equipment for fishing vessels of 24 m (79 ft) in

length and over. The IMO Convention on Standard of Training, Certification and Watch Keeping for Seafarers (STCW) 1978 is another important legal body. Although the STCW 1978 specifically exempts fishing vessels, it has inspired efforts to develop personnel qualification standards [IMO 1978] (the more recent STCW 95 also exempts fishing vessels). Further on, IMO continued emitting voluntary guidelines for characteristics of fishing vessels [IMO 1980], and guidance for fishermen’s training and education [IMO 1988].

The FAO circular [Petursdottir, 2001] also made it clear that the problem of accidents in fishing was not a problem of a specific region or country, but that the same problem could be observed in different countries with different development rates, among which are Australia, where between 1982 and 1984 it exceeded 18 times the national casualty rate, Denmark from 1989 to 1996 exceeded 25-30 times the accidents on land, the United States in 1996 exceeded the national average by 40 times, among other countries that in 1997 exceeded the rate national average in several times, such as the Republic of Korea (15x); Estonia (11x); Italy (21x); Lithuania (11x); Poland (9x); Spain (6x) (see later comment); and Canada (3.5x). Nowadays, FAO estimates that more than 32000 fishers die annually when doing their job [FAO 2022].

Many countries’ governments opt for the creation of specific bodies and even non-official bodies to monitor, give recommendations and try to control this high rate of accidents.

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These organizations issue guides [Maritime & Coastguard Agency, 2020], codes [FAO, 2005], and recommendations (even from insurance companies, such as MAPFRE, [Tasende, 1998]) to be followed by fishers, with the aim of reducing accidents. The rate of accidents might have been reduced in some cases [McGuinness, 2013] but, despite institutional efforts in the application of measures and training of fishing professionals, accidents persist.

According to a study of the University of Quebec, it is concluded that some of the possible causes of accidents, even after taking measures by the institutions, may perhaps be due to the normalization of the problem within the sector and come to be understood as part of the fishing culture, by the same fishers [Sverre, 1989].

The FAO circular 966 appeared in 2001 [Petursdottir, 2001], and it is also possible to find records in European countries and the United States that confirm what was already announced in 2001 by FAO. The European Union has a database that collects accidents as it happens in some countries, including Spain [Núñez-Sánchez, 2019].

Many analyses and scientific works have been devoted to the determination and understanding of the important characteristics and traits of accidents in the commercial fishing sector, to focus on and find preventative measures to reduce the high number of accidents. In Norway, it was found that the trawler fleet contributes predominantly to the accidents, while small coastal crafts have had lower reported injuries, but some under-reporting of minor accidents was found [McGuinness, 2013]. The analysis of accidents on the northeastern coast of the United States found that during the time span from 1981 to 2000, the rate of accidents had been reduced, the accidents were more probable with high winds, distribution was more intense in the Northernmost zone, and medium size vessels contributed to the larger proportion of events [Jin, 2005].

Luo and Xin [Luo, 2019] concluded in their study about research developments on maritime accidents of fishing that the main focus in research on maritime accidents during the last 50 years has seen an apparent change in the perceived cause of the accidents: from stability and limits on the craft (Naval Architecture) to more complex, involving human behavior, and they state that the future of research will be more multidisciplinary (including human behavior, shipping market behavior, interactions with the natural environment because of pollution concerns...). In fact, from the analysis of 4104 maritime accidents that happened from 2011 to 2018, it is considered that 68% had a relation to the human factor [Shi, 2021]. Also, from the analysis of 513 cases of ship collisions, [Ugurlu, 2022] concludes that the expected decrease in the number of maritime accidents has not occurred, collisions are mostly related to the violation of COLREG (avoidance of collision) rules, and most are due to human error. Occupational accidents in fishing from two ports in Portugal have been analyzed by [Antão, 2008]. The authors conclude that, in the analyzed cases, the so-called “macho attitude” and “risk-taking behaviors” within their activity, together with the traditional wage system (dependent on captures) influence strongly the occupational accidents, inducing the crews of seiners and long-liners to accept higher risks on their work

(fishing), besides the risks inherent to regular work and navigation.

Also, the societal risks to establish whether the current fishing vessels situation is acceptable in the EU and in the rest of the world, and the necessary risk reduction has been analyzed by [Núñez-Sánchez, 2020]. They conclude that although the fatalities per industrial fishing vessel per year in the EU have been reduced due to the introduction of new industrial fishing vessels, the current situation is not yet acceptable. On the one hand, there is a need for standardized accident reporting and analysis of information to measure risk reductions in terms of fatalities and to develop suitable risk models for long-lasting and measurable regulations; on the other hand, in any case, the number of fishing accidents is deemed too high.

The aim of this work is to summarize the determination of important characteristics and traits of accidents in the Spanish fishing sector, trying to obtain clues about how to reduce maritime and fishing accidents. Here, data from Spanish CIAIM (“Comisión Permanente de Investigación de Accidentes e Incidentes Marítimos”, [CIAIM]) reports have been extracted and built into a database, and some statistical analysis is done to try to describe and visualize the main problems of fishing, in order to propose corrective measures trying to reduce the accident rate when possible. Some conclusions and indications are extracted from the study, which could be clues for other countries.

The paper begins with an introduction to the accident problematics in the fishing sector, and continues with the methodology and legal background of accident investigation, explaining the data processing. The following part enters directly to discuss the results from the analyzed data. The last part conducts directly to the conclusions and recommendations for trying to reduce the accident rate.

2. Methodology.

As a justification for fishing being considered a dangerous activity, we can mention that, in Spain, the number of officially notified work accidents in 2013 was on average for all sectors, 3009 per 100000 workers; while it was 6994 per 100000 workers on fishing, according to [Titulaciones Pesqueras, 2013]. In 2018, the number of paid leave as a consequence of accidents was 6586 per 100000 in fishing [Mites 2020]. A large number of work accidents happen in fishing, so we concentrate on maritime accidents in fishing.

We have used the reports from the official Spanish Commission in charge of maritime accidents, published from the start of the investigations by a Commission in 2000-2001. From 2001 to 2008, the Commission had the name “Comisión Permanente de Investigación de Siniestros Marítimos”. At the end of 2008, there was a change in regulations and uses due to EU harmonization, and more resources were allocated to investigate maritime accidents. The Commission became the Spanish Marine Accident and Incident Investigation Standing Commission, CIAIM [CIAIM]. Actually, each report from the Commission is a description and investigation of the causes of each accident or incident, to learn and try to avoid similar facts, and

this means there is an investigation time from the accident to the publication of the research, which can reach to several years in some cases due to the complexity of the facts. The reports from the Commission are made public to try to reduce the number of accidents from the lessons learned. The Commission also uses to advice on how to try to avoid maritime accidents and suggests rules and norms to try to avoid accidents. The Spanish INSHT (Instituto Nacional de Seguridad e Higiene en el Trabajo, Spanish for National Institute for Safety and Hygiene at Work) publishes norms, such as NTP (Normas Técnicas de Prevención, Spanish for Technical Norms for Prevention of accidents) based on Social Security data and CIAIM data to try to reduce accidents and problems. The NTP are directed to workers, but also to enterprises, employers, producers of devices and machinery to be used, and to lawyers. Concerning the fishing, see [INSST_Norms, 2022]

The commission produces reports for the cases where the maritime reason is directly involved; they cover for instance death or considerable injuries from man overboard, boarding, collisions, capsizing (overturn), pollution facts... as indicated in the definitions, but might ignore, for instance, some non-fatal injuries from unloading machinery used in berthed vessels, if these had not further (or maritime) consequences. According to the decree [RD 862/2008] and further amendments, a maritime accident is an event that has outcomes:

- Death or considerable injuries to a person(s) because of the operations of a ship (boat) or related to the operations of a ship;
- Disappearance of a person(s) on board a ship, because of the operations of a ship or related to the operations of a ship;
- The loss of a ship, or the need to abandon the ship;
- Grounding, boarding, or serious damage to a ship(s);
- Serious material losses (as a fire) caused by the operation of a ship, including failures that produce a ship to be towed to port (see later explanation);
- Serious damage to the ambient (pollution) as a result of damage suffered by ships, because of their operation or related to their operation.

In fact, “accidents” that consist of a ship losing propulsion or control, but which can be towed to port without further consequences (as it happens many times with fishing craft because of ropes or nets being chased by the propellers), may not be subject to a further investigation from CIAIM. Also, recreational and sports vessel incidents are not usually investigated by the Commission if they don’t have serious consequences or affect third parties. The boundaries are that minor accidents or incidents that could show relevant lessons to avoid future accidents might not be sufficiently followed and reported, as resources are finite, but major accidents are always investigated.

The policy to prevent accidents in fishing should be based on studying the incidence that each of the contributing factors

has on the accident rates. A possible way to approach this is by establishing a maritime accident investigation with the following characteristics:

- Comprehensive, in the sense of examining accidents from multiple facets.
- Independent from other investigations. Not intended to establish blame or economic responsibility.
- Providing a taxonomy that allows classifying the contributing factors for statistical analysis.

At the European level, there exists a regulation that harmonizes the investigation procedures and fulfills those requirements. [Directive 2009/18/EC of the European Parliament and of the Council]. It establishes for European countries the obligation to investigate marine accidents and to notify the Commission on marine accidents and the data resulting from safety investigations in the European Marine Casualty Information Platform (EMCIP).

The EMCIP is built based on a determined investigation analysis method. The accident analysis method lying below EMCIP is the ECFA (Events and Casual Factors Analysis) method, which is extensively described in the scientific literature on accident investigation [Buys and Clark, 1995]. Under the ECFA scheme, behind the accidental events identified leading to the casualty, there are contributing factors that must be identified and corrected to prevent the occurrence of similar accidents.

EMCIP’s taxonomy is adapted from existing models used in other transport modes and is oriented towards merchant marine traffic, but its use in the fishing sector is not always straightforward [Mata-Alvarez-Santullano, 2015].

From each accident report from the Commission (CIAIM), 50 data were extracted (when available) and structured in 4 blocks. The first block is intended to group data on the ship, such as length, beam, GT, the construction material, the construction date of the ship, number of crew, use, and modality (fishing, merchant navy, recreational) of the ship. The second block had the data referring to the accident, such as position, depth, time, tasks being carried out, injured/death/disappeared people, damage to the ship, pollution, etc. The third block groups the meteorological data, including visibility, wind and its direction, swell, etc. Finally, a fourth section includes the (probable) cause of the accident, why it happened, and the origin, as established after the investigation. The data intends to join sufficient information on the accidents to analyze them statistically, and from the analysis, try to propose the necessary measures to reduce the accident rate.

From the extracted data, a database has been built using Excel [Microsoft Office], and filtering has been used to select specific data to analyze and to try to extract conclusions. Some checks have been done with Minitab statistical software [Minitab]. IBM SPSS 27 statistical package [SPSS] has been used to verify some statistical facts. It has to be remembered that as the number of accidents is not very large in statistical terms, any statistical result has to be interpreted with care. In the following section, we summarize the most important findings of the analysis.

3. Results and analysis.

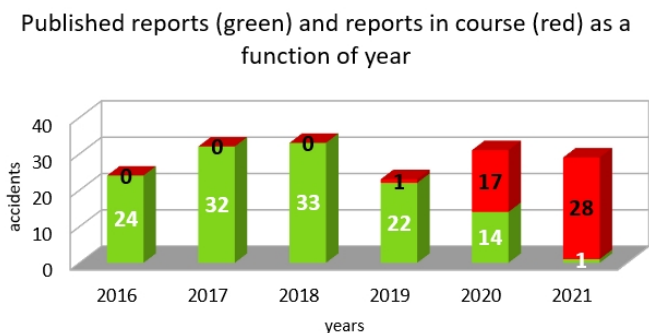
In the first general data analysis, we checked the evolution of the number of vessels involved in accidents over the 16 years of the period, which allowed us to observe a much lower number of accidents registered between 2001–2008, between 4 and 18 per year, on average. Then, starting in 2008, reported accidents increased considerably, reaching 40 accidents in 2013. We believe that this increase in reported accidents is due to the restructuring that the Commission received in 2008, in which more resources were allocated to the investigation of maritime accidents, related to the European Directive [Directive 2009/18/EC of the European Parliament and of the Council. Then, probably, the number of accidents kept in mind in the FAO circular [Petursdottir 2001] in 2001 might be under-reported, some accidents being considered only “minor” work accidents; the real figure could be some 2.2 times higher (near 40/18), and then maritime fishing accidents maybe were near 13x proportion respect to accidents on average trade in Spain prior to the year 2000, nearer to the average figures indicated by other EU countries with similar characteristics. In any case, CIAIM reports from 2000 to 2008 should better be considered separately.

In the analysis of the reported data on maritime accidents, at a general level, we center on the period 2008–2016, because it seems that the accidents were more regularly detected, rigorously studied, and reported. Then, accidents published later than 2016 are analyzed separately.

3.1. General results.

It has been selected to represent the number of published and in-course reports by the CIAIM between 2016 and July 2020 (Figure 1). As of July 2022, only two accident reports involving fishing vessels in 2020, appear in the data entered, while up to 2008 there is an irregularity in the number of accidents investigated, as discussed previously. The time involved in investigating each accident before publishing the reports might be due to the complexity of the accident, the difficulties in obtaining some data, and the diverse actors involved (fishermen, skippers, enterprises, port authorities, insurance companies...). So, we will analyze data from October 2008 to July 2016, and check for regularity of data from 2016 to the end of 2019.

Figure 1: Published CIAIM reports and reports in course as a function of the year.



Source: Authors.

In the first filtering (by sectors), a total of 296 accidents involving 346 vessels were analyzed (during the years 2008–2016), of which 197 were fishing vessels, 115 merchant vessels, 32 recreational vessels, and 2 other (hydrographic vessels involved in boarding accidents), which confirmed that the Fishing was the sector with the highest number of serious accidents recorded.

Of the 346 vessels that had accidents during the studied time interval, Table 1 indicates the kind of facts that produced the accidents according to the CIAIM reports and the number of vessels involved. It has to be noted that for the fishing vessels, pollution is noted in a separate way.

Table 1: Facts. Total number of vessels involved, 346; Number of fishing vessels involved, 197.

Facts	Total number of vessels	Number of fishing vessels
Boarding	100	32
Capsizing (overturning)	48	38
Collision	24	10
Engine failure	1	-
Entrance of water/taking in water	5	5
Fire	26	19
Flooding	46	40
Grounding	14	3
Maritime incident	1	-
Operational	38	27
Other	4	2
Pollution	6	-
Run aground	29	21
Steering failure	1	-
Structural failure	3	-
Total	346	197

Source: Authors.

It should be expected that, with the appropriate watch in navigation, plus good electronic aids, accidents like “Boarding”, “Collision”, “Grounding” and “Run Aground” should be minimal, but in fact, they add to nearly 50% of the accidents. Then, the first conclusion on maritime accidents is that appropriate and careful watch in navigation has to be improved, and electronic/electro mechanic/TIC and navigational aid systems should be appropriately used to improve the actual situation, as well as sufficient redundancy and checks on the decision-making processes on navigation. Note that, even with the number of accidents in maritime transport (by the merchant navy), this method of transport has to be considered one of the safest, due to the very large amount of goods transported.

From the comparison of the number of vessels involved in each fact (the total comprises also fishing sector), it appears that “Entrance of water/taking in water” is exclusive to the fishing sector (5/5), “Flooding” is nearly exclusive (40/46), “Capsizing” (38/48), “Run aground” (21/29) (Note: “Run aground” is considered more violent than “Grounding”) and “Operational” (27/38) are also much increased by accidents in the fishing sector.

On the other hand, there exist some accidents with causes such as “Engine failure”, “Steering failure”, and “Structural

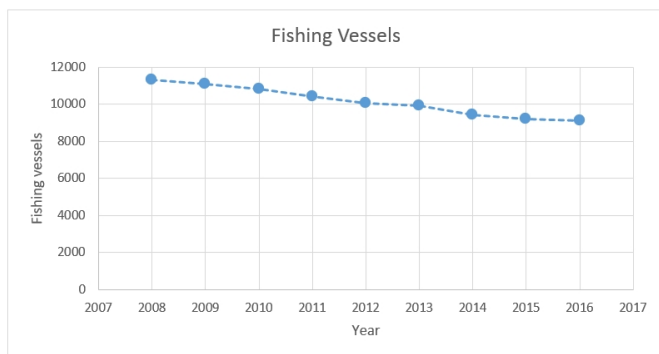
failure”, which might involve maintenance failures, but its number is quite low compared to other facts, indicating relatively correct maintenance and surveillance at the actual level. It seems that if maintenance is improved by regulations and inspections, some direct reduction in the number of accidents could happen. However, some indirect effects could be present: any malfunction of equipment, even a minor question, would attract the attention of the seafarers, and then produce a loss of attention to navigational and/or operational watch, increasing the probability of incidents and accidents, especially in vessels with reduced crews.

3.2. Fishing accident results for the period 2008-2016.

- Number of fishing vessels.

The number of accidents per year should be referred to as the number of active fishing vessels. According to the Spanish Minister, in 2009 there were 11100 fishing vessels [Miteco Pesca, 2009]; in 2019, according to [CEPESCA 2019]] there were 8972 registered fishing vessels, employing directly 31473 fishermen (i.e. 3.5 people per vessel on average). Total catches were near 900000 metric tons. Figure 2 shows the number of Spanish fishing vessels as a function of time. However, according to the Spanish government, there are, as of 2015, around 12% of inactive registered fishing vessels, mostly due to environmental conservation efforts [Registro Flota, 2017].

Figure 2: Number of Spanish fishing vessels as a function of time.



Source: Authors.

As the number of vessels decreased by only 20% during the analyzed time span (a much larger reduction in the number of vessels, installed power, and Gross Tonnage happened before the studied period, because of EU and sustainability concerns), in this work we will give total figures in each case, and the effects of fleet reduction should be taken into account separately. The fishing mode of the vessels as of the year 2017 is indicated in table 2. It has to be noted that there is a very large number of minor fishing gear, which will be practiced in small vessels with a very short crew.

Table 2: Number of vessels according to the fishing mode, as of 2017 [Registro Flota, 2017].

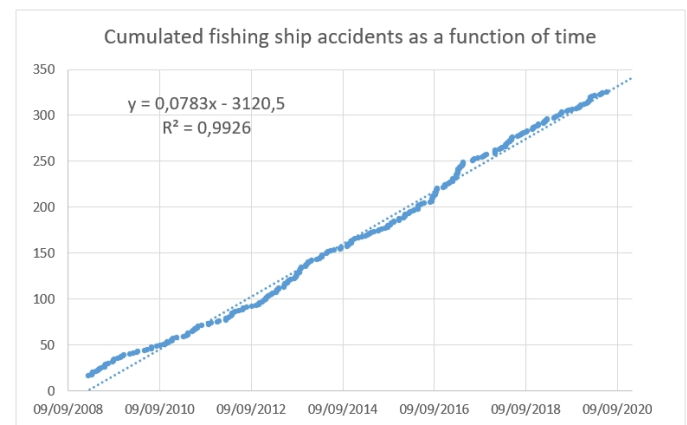
FISHING MODE	NUMBER OF CRAFT	PERCENTAGE
Trawlers	944	10,32
Purse seiner	595	6,51
Long liners	379	4,14
Gillnetters	67	0,73
Fixed gear	55	0,60
Minor fishing gear	7100	77,70
TOTAL	9146	100

Source: Authors.

- Rate of accidents and casualties.

The Figure 3 represents the cumulated number of accidents with fishing vessels as a function of time, from Oct. 2008 to July 2020. The starting point is the total reports on fishing from the Commission from 2000 to Oct. 2008.

Figure 3: Cumulated fishing vessels accidents as a function of time (dotted line, linear fit. In the given equation, x is the time in days from a fixed reference time in the year 2000).

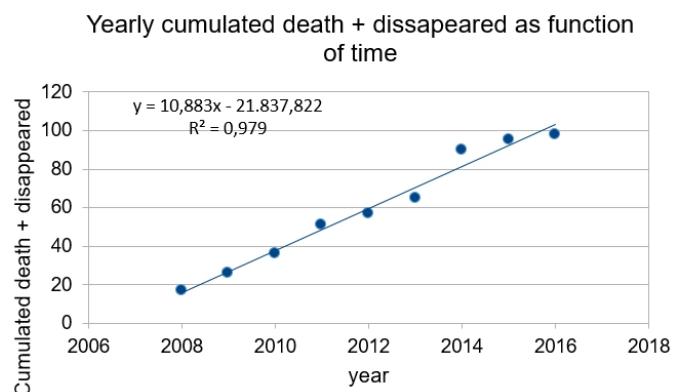


Source: Authors.

The practically linear increase of cumulated accidents as a function of time allows for a linear regression, which is indicated by a dotted line. The slope of this line indicates a mean time of nearly 13 days between accidents, and the high regression coefficient ($R^2 = 0.993$) indicates a low dispersion and a constancy of behavior.

Figure 4 indicates the evolution of cumulated death and disappeared people in fishing accidents, from 2008 to 2016. The rate indicated by the straight line in the figure corresponds to nearly 11 people/year, 1,43 (+/-0,49) death or disappeared persons per thousand vessels, per year. Roughly, for every 25 fishers working an average of 30 years there would be a casualty (dying or disappearing in their job).

Figure 4: Yearly death and disappeared cumulated people from 2008 to 2016. (dots at end of year. In the equation, x is time in days from a given reference time, starting in 2008 with the death + disappeared from Commission reports 2000-2008).



Source: Authors.

The high values of the coefficient R in Figure 3 and Figure 4 mean a significant relation: accidents increase linearly with time, as so does the death and disappeared people. The constancy on time gives an introduction to a political matter: If people on board cannot do it better given the conditions, political enforcement to increase redundancy, for instance, by the use of more seafarers per vessel, more resources, and/or the use of electronic, electro-mechanic aids, even vessels with some self-manning capability (not an actual automatic pilot; self-manning in the sense of being able to change course and avoid collisions, boarding, grounding...), should be considered to reduce accidents.

The time distribution of accidents was also checked with Minitab software, the results indicate that it is not possible to discard the null hypothesis of a Poisson distribution for the counting of accidents ($p=0.54$ with the number of accidents per month; $p=0.90$ with the number of accidents per three months, both p 's >0.05 or 95% confidence interval), that is, a “constant rate” as it happens with radioactive decomposition at a constant quantity of the radioelement.

- Losses of ships.

If we look at the fishing ships that had sunk, whether they are later recovered or not, the figure rises to 151 ships, which in percentage is about 75% of the total from 2008 to 2016. In other words, three-quarters of the affected fishing vessels sank because of the accident, which is a terrible figure.

- Accidents in vessels by the length of the craft.

Table 3 shows the total number of vessels that had accidents in the considered period 2008-2016, as a function of the length of the vessels. The average length of all vessels that had accidents is 49,6 m; the quartiles are: 11,39 m (Q1); 22,40 m (Q2 or median); 82,26 m (Q3).

From the original data, referring to the fishing vessels that had accidents, the average length is 19,8 m, but the quartiles are: 10,33 m; 15,70 m; 24,85 m. So, 50% of the vessels that

Table 3: Number of vessels that had accidents as a function of their length.

Length (m)	0-10	10-15	15-20	20-25	25-30	30-50	50-100	100-150	>150
Number of vessels	68	60	29	34	27	25	39	41	23

Source: Authors.

had accidents had lengths less or equal to 15,7 m. This indicates a high amount of accidents for small lengths. but the number of fishing vessels in that category is around 70% of the total, then the probability to have accidents appears lower for small vessels, but a large number of small vessels produces a high number of accidents happening on small craft. This has to be compared to results from [D. Jin, 2005], that state that accidents have a lower probability on small fishing vessels. The proportion of relatively small craft is very large in the Spanish fishing sector, and then a large number of accidents follow.

- Fishing grounds.

The distribution of registered fishing accidents by place is shown in Figure 5. It suggests a further study of what happens in the different fishing grounds.

Figure 5: Geographical places where registered fishing accidents happened.



Source: Authors.

Concerning the fishing grounds, the Table 4 shows that there are a large number of fishing accidents (CIAIM reports from 2008 to 2016) in the Cantabrian-Northwest fishing ground, but there are also a large number of fishing vessels there.

A somewhat higher accident rate per vessel on North Atlantic, Other Countries and International Waters might be related to the fact that these vessels spend continuous time sailing and fishing, and come to port at longer intervals than the smaller vessels near the coast, which mostly come back home once a day and spend many hours a day at port. Most probably, the vessels in North Atlantic, Other Countries, and International Waters spend a larger proportion of time working at sea than the coastal vessels, besides the weather conditions. In [Jin. 2014] it is found that in North Atlantic fishing grounds, weather (wind) had an influence on the number of accidents.

On the other hand, the low accident rate in Canary Islands

Table 4: Fishing grounds, registered fishing vessels in the grounds from 2017 data, and fishing accidents on each fishing ground (Accidents/Vessels refer to accidents from 2008 to 2016).

Fishing Ground	Vessels	Fishing Accidents	Accidents/Vessels
Cantabrian-Northwest	4790 (52,37%)	103 (52,3%)	2,1%
Mediterranean	2468 (26,98%)	46 (23,4%)	1,9%
Gulf of Cadiz	773 (8,45%)	15 (7,6%)	1,9%
Canary Islands	738 (8,07%)	6 (3,0%)	0,8%
North Atlantic, Other Countries and International Waters	377 (4,12%)	9 (4,6%)	2,4%
TOTAL	9146 (100%)	197 (100%)	2,2% Average

Source: Authors.

fishing ground might be due to continuous good weather and relatively low swell in that area, but also it is possible some underreporting of accidents in the first years of the period (4 of the 6 registered accidents were after 2014). In any case, the low number of registered facts (??) makes any statistical inference weak.

As more than 75% of the accidents were reported in the fishing grounds of the Cantabrian-Northwest and Mediterranean, we study in more detail the accidents on these fishing grounds, which have nearly 79% of registered fishing vessels.

3.2.1. Analysis of Cantabrian-Northwest and Mediterranean grounds fishing accidents.

To get a representative picture of the accidents, the following main items on the Cantabrian-Northwest and Mediterranean grounds are analyzed here: Type of accident, Age of the vessels, Fishing gear, Hull material, Preferred time of accidents (if any), Site of the accidents, People per vessel, Depth at which accidents occurred, and Meteorology (visibility, wind, swell).

- Type of accident.

The number of vessels that had different accident types are represented in Table 5 for the Cantabrian-Northwest and Mediterranean fishing grounds.

Table 5: Types of accidents for the Cantabrian-Northwest and Mediterranean fishing grounds.

Facts	Number of fishing vessels (Cantabrian-Northwest)	Number of fishing vessels (Mediterranean)
Boarding	13	13
Capsizing (overturning)	26	-
Collision	6	3
Entrance of water/taking in water	4	5
Fire	2	9
Flooding	14	10
Grounding	3	-
Operational	16	3
Other	2	-
Run aground	17	3
Total	103	46

Source: Authors.

Boarding is the most common accident, followed by capsizing (overturning) and flooding. From 103 fishing craft that had accidents in the Cantabrian-Northwest fishing ground, 39 were in the form of Boarding, Collision, Grounding, or Running aground, i.e., 38%, which is less than the 49% previously obtained with all ships. It should be taken into account that, even if this appears to suggest that actually, the fishermen follow a navigation watch that seems to be even better than the general fleet, this hypothesis might be false: the operational tasks of fishing, and the high number of Capsizing accidents on fishing, could most probably be responsible for the apparent difference.

For the Mediterranean ground, 19 accidents were in the form of Boarding, Collision, Grounding, or Running aground, which made up 41% of fishing vessel accidents. No Capsizing happened in the studied period. The prevalence of trawlers could be related to this fact, even though the numbers are relatively low, and then any statistical inference would be weak.

Also, from the 48 vessels suffering accidents of Capsizing (overturning) from the general database (14% of 346 ships with accidents), 38 fishing vessels capsized, and 26 fishing vessels from the Cantabrian-Northwest fishing ground suffered Capsizing (25% of 103 ships with accidents). It is very strongly suggested that either these kinds of vessels had non-appropriate construction or engines for the tasks, or some operational tasks were performed in a too-risky way. The results for the number of “Capsizing” accidents on fishing vessels, have to be compared with the publication [F. Mata-Alvarez-Santullano 2015], where 28 “Capsizing” accidents on Spanish vessels were identified in the period 2008-2014. The rate of “Capsizing” is practically constant. It is to be noted that in the mentioned publication, the causes of capsizing for fishing vessels were analyzed from the reports of the accidents, to try to improve the situation. Some factors were identified as causes of the facts leading to Capsize: Lack of safety awareness, Lack of training, Lack of safety culture, and Economic conditions (pushing fishers to risk too much to catch prey). Unfortunately, the conditions seem to have changed very little or none at all.

Concerning pollution, in the Cantabrian-Northwest ground, there was no data for 45 cases, no pollution was notified for 41 cases, and pollution was reported in 17 accidents. In the Mediterranean ground, there was no notified data for 21 events, no significant pollution was notified for 12 cases, and pollution was reported in 13 accidents. Taking into account the relatively high number of fishing vessels that sunk, maybe the description of pollution on the reports was smoothed (underestimated) by other relevant facts.

- Effect of the age of vessels:

In the Cantabrian-Northwest ground, vessels that are less than 30 years old, had 69% of accidents, while in the Mediterranean area, vessels more than 30 years old had 41% of accidents (see Table 6). Actually, more than half of the Spanish fishing vessels are 30 years old or more (average 34 years old) [Estadística 2022]. Then, the result for the Mediterranean ground seems more “rational”, in the sense that newer vessels have a slightly lower accident rate (even if the statistical con-

fidence is not strong), but in the Cantabrian-Northwest, newer vessels had more accidents than expected. Both areas give very different data, it seems that the average age of the fleet on each ground is very different. In fact, the average age for trawlers is 25 years old, while vessels with minor fishing gear have an average age of 37 years old. It could be also that in the Cantabrian-Northwest there is overconfidence in newer vessels.

Table 6: Fishing vessels that had accidents, as a function of their year of construction.

Construction	< 1970	1970-80	1980-90	1990-2000	>2000	Total
Cantabrian-Northwest	7	6	20	44	26	103
Mediterranean	11	2	14	0	19	46

Source: Authors.

- Fishing gear.

Table 7 indicates the number of ships that had accidents in the considered period, in the Cantabrian-Northwest ground and in the Mediterranean ground. The differences among the grounds are considerable, in the Cantabrian-Northwest, near 65% of accidents correspond to Minor fishing gear, and less than 14% to trawlers, while in the Mediterranean ground, near 61% correspond to trawlers and less than 22% correspond to Minor fishing gear, reflecting the different composition of the fleet in each ground.

Table 7: Number of vessels that had accidents in the Cantabrian-Northwest ground and in the Mediterranean ground, by fishing mode.

FISHING MODE	Cantabrian-Northwest	Mediterranean
Trawlers	14	28
Purse seiner	11	5
Long liners	7	3
Gillnetters	3	0
Other	2	0
Minor fishing gear	66	10
TOTAL	103	46

Source: Authors.

- Hull Material:

Concerning the hull material of the ships that had accidents in the Cantabrian-Northwest grounds, there were 40 wooden hulls, 38 steel hulls, and 25 fiberglass-reinforced polymer hulls. On the other hand, in the Mediterranean ground, the ships that had accidents were: 15 wooden hulls, 3 steel hulls, and 28 fiberglass-reinforced polymer hulls. The figures suggest that in the Cantabrian-Northwest ground, the number of accidents on wooden hulls reflects either a too-aged fleet or the existence of non-appropriate vessels.

An estimation of the hull material of the total number of Spanish fishing ships (random sampling data and selecting active vessels from: [servicio.pesca, 2022]), gives a relation of

about 1 of steel by 2 of wood by 5 of fiberglass reinforced polymer. It has to be stated that this could be not very near to actual values, as fishermen tend to name the vessels in a traditional manner and could be not randomly distributed in terms of spelling. The database is ordered by spelling (alphabetically), and the random search was done by spelling. In any case, this should be considered a first-gross approach. Then, it seems that the steel ships have a somewhat higher probability of accidents, but it should be remembered that these vessels are regularly larger ships, working more proportion of time, far from shore, and finding worse weather conditions. On the other hand, wooden vessels really seem to suffer a much larger proportion of accidents compared to fiber-reinforced polymer ones.

- Preferred time intervals of accidents.

The time dependency of accidents during the year shows a nearly constant rate, see Figure 3 (not fewer accidents in summer as would have been expected from weather conditions). The Kolmogorov-Smirnov test (from SPSS-27) was applied to the distribution of accidents per month on the Cantabrian-Northwest ground, and the normality of the (random) distribution could not be negated. For the Mediterranean ground, fewer accidents happened and even if apparently the normality of the distribution of accidents could not be negated, the statistical force is lower. The apparently random (Normal) distribution of events during the months maybe indicates that meteorological forecasts are taken into account by fishermen in bad weather, and overconfidence in good weather could make its toll, equilibrating the number of accidents in all months.

The same tests were also applied to the distribution of accidents during the months, taking the intervals every 5 days (i.e., accidents from 1 to 5 of the month, from 5 to 10, and so on). The result was also that a normal (random) distribution of events cannot be excluded. However, concerning weekly dependence, it was observed that the fishing accidents per day decayed strongly during the weekend. This should be related to the regular activity of fishers in local or coastal working (conditioned by the local commercialization of fish).

On the other hand, the hourly distribution of accidents during the days was also checked. Concerning that, there is fluctuation during the 4 hours' time intervals established in the merchant navy: From 0 to 4 h, from 4 to 8 h, and so on. The oscillation in the number of accidents per interval could be interpreted as due to the daily schedule of coastal fishing vessels, the larger number of accidents happens from 4:00 to 12:00 hours, or from 4:00 to 16:00 hours, in both studied grounds, but in the Mediterranean, only 5% of accidents were out of the time frame from 4:00 to 16:00, while in the Cantabrian-Northwest, nearly 30% of accidents was outside the 4:00-16:00 h. It is probably due to the fact that in the Mediterranean, almost all fishing vessels come back to port every day, while in the Cantabrian-Northwest ground, there is a part of ocean fishing that stays some days at sea. Then, the regularity of the time of accidents seems attributable to the commercial requirements of having the fish the same day it was fished, on working days.

- Place (site) of the accident.

Table 8 shows the qualification of the sites where the accidents happened, for the Cantabrian-Northwest and Mediterranean grounds, according to the reports from the CIAIM. It can be seen that in the Cantabrian-Northwest ground, most accidents happened near the shore, Open seas represent only 41% of cases, while for the Mediterranean ground, nearly 72% of accidents happened on Open seas.

Table 8: Qualification of sites where accidents happened.

Sites	Lowlands	Rocky lowlands	Beach	Sand	Open seas	Port	Rocks	No data	Total
Cantabrian-Northwest	27	1	6	1	42	6	10	10	103
Mediterranean	3	-	4	-	33	3	3	-	46

Source: Authors.

- People per vessel.

Table 9 shows the number of people on the fishing vessels that had accidents in the Cantabrian-Northwest and Mediterranean fishing grounds. As can be seen, in the Cantabrian-Northwest, many vessels have only 1 or 2 people on board (nearly 40% of vessels). Usually, reduced crews operate on small vessels which do not sail very far away, and there is a large number of small vessels, so the accident rate per vessel might be reduced for small vessels, but the total number of accidents is relatively high and finds many accidents with a reduced crew. The reduced number of the crew might produce reduced possibilities of redundancy in operations and might be related to failures on navigational watch, which is mentioned in some CIAIM reports [CIAIM]. On the other hand, on the Mediterranean fishing ground, it's more usual that vessels that suffered accidents had 3 or more people on board.

Table 9: Number of people in the fishing vessels that had accidents in the period 2008-16.

People per vessel	No data	1	2	3	4	5	6	>6
Vessels that had accidents (Cantabrian-Northwest)	1	7	34	14	4	8	5	30
Vessels that had accidents (Mediterranean)	1	2	6	12	10	7	1	7

Source: Authors.

- Depth at which accidents occurred.

Table 10 shows the number of fishing vessels that suffered accidents at given sea depths. It can be seen that nearly 40% of accidents (42) happened at low depths (< 10 m) in the Cantabrian-Northwest ground, while less than 20% happened in the Mediterranean ground. 57% of accidents happened at depths larger than 50 m in the Mediterranean ground. The difference might be due to the prevalence of trawlers in the Mediterranean ground, compared with the (large) prevalence of minor fishing gear in the Cantabrian-Northwest ground.

Table 10: Depth at which happened accidents.

Depth (m)	0-10	10-15	15-20	20-30	30-40	40-50	>50
Number of vessels (Cantabrian-Northwest)	42	3	5	6	2	9	36
Number of vessels (Mediterranean)	9	1	0	5	3	7	21

Source: Authors.

- Meteorology.

The meteorological aspects show that, rather surprisingly, visibility was better than 5 km for 80% of the selected (fishing vessels) accidents on the Cantabrian-Northwest ground, and for more than 90% of the accidents on the Mediterranean fishing ground, even if apparently some 40% of accidents happened after undue navigational watch.

Given that visibility was good, the effect of wind force (wind speed) and swell was looked for. It was found that in both grounds researched, more than 70% of the accidents happened with weak winds, winds of less than 15 knots. Concerning the swell, 65% of accidents on the Cantabrian-Northwest ground happened with less than 3 m height swell. For the Mediterranean ground, only 6 cases reported the swell at the time of the accident, and all reported cases were less than 2 m in height. In fact, as many accidents happen near the shore, the effect of swell amplitude increases as depth decreases most probably is involved, and the CIAIM has made some publications advising of the risks involved [CIAIM 2020].

It's relatively surprising to find that, statistically, the conditions for accidents on these grounds are opposite to what is believed in general and what is shown in the movies, for instance, in *The Perfect Storm* [S. Junger, 1997; W. Petersen, 2000]: Actual accidents tend to happen in good weather. This fact seems in agreement with [Lee Myung Kyu, 2019], in Korea. Also, the study in [C. Maceiras, 2021] points out that the weather is not relevant to determine the type of accident in Spain. The human factor, showing overconfidence, and sometimes disregarding the navigational watch, might be the reason for the vast majority of fishing accidents, at least in Spain. This is quite real, but maybe it is not the only cause, as some authors had found that, for instance, in the North Atlantic, strong winds are related to the probability to have an accident in trawlers [Jin. 2014].

3.3. Reported accident results for the period 2016-2019.

Some trends can be observed from the publications from July 2016 to the end (November) of 2019, just before the COVID-19 pandemic. The distribution of accidents by fishing grounds cannot be said to be very different from previous years, the most recurrent place is the Cantabrian-Northwest fishing ground, followed by the Mediterranean, and then by International waters.

Referring to the modality or fishing gear of the vessels that suffered accidents, 35% were of minor arts, and 26% were trawlers, with smaller quantities for the remaining fishing gear. The mode with the highest accident count was minor arts, as it happened in the period 2008-16.

The depth at which the accidents happened has been also analyzed. The same as the data from 2008-2016, shallow depths are the places where most fishing accidents happen, followed by depths larger than 50 m. Also, fishing accidents tend to happen near to the coast, as in the previous studied period. The meteorological data shows that the majority of fishing accidents happened with low winds (less than 15 knots) and good visibility, as in the previously analyzed time interval.

Referring to the cause of the accidents, the most common occurrence was capsizing (overturning), followed by boarding,

taking in water, operational, and fire. It has to be noted that the main causes seem very much the same as what happened in the previous time interval analyzed (2008-2016). With mainly low winds, overturning could be caused by local increases of the surge, by not well-controlled loading (of fish and gears), or even by non-appropriated machine operation, the same as in the previous period.

Then, even from incomplete data for the 2016-2020 period, it can be stated that the behavior of the accidents on fishing in Spain is very near that of the period 2008-2016.

4. Discussion on proposals to reduce accident rate.

According to the Ports of Spain Board [Puertos Estadísticas, 2016], the statistics show for the year 2016 a traffic of 151564 merchant ships (entrances and exits of large ports; local, and small ports are not included). The roughly 9000 fishing ships could produce local traffic not far from the merchant fleet with their regular working, even if merchant ships travel much more miles and carry much more load (cargo). The high number of accidents in fishing shows the requirement of a good navigational watch, the difficulties with operational actions (on fishing), the effect of a large number of vessels, and also the effects of the training and the qualification asked of the fishermen. Then, first of all, it is important to reduce the accidents in general seafaring, as a considerable number of them are due to facts that could be avoided with appropriate navigational watch and training. The measures to be proposed on the fishing accidents problem to reduce the damage and the number of casualties revolve around the training of crews, increase of automation, smart electronic aids to avoid boarding, collisions, grounding events, revision of current safety regulations, and others aimed at avoiding the capsizing of boats. These could be automatic stabilization systems or other similar systems that avoid loss of stability, but appropriate training and safety knowledge could be the best way.

Furthermore, increasing the redundancy of the procedures followed by fishing ships might be a way to improve the navigational watch. Merchant ships have to carry cargo and/or passengers from port A to port B, but fishing craft usually goes from port C to the fishing ground, operate (fish) and come back to port C (sometimes to port D). The operations and the arrangement of the result of fishing, and the paperwork required to disembark, tend to superimpose other tasks to the navigation and could produce a non-appropriated navigational watch (as is reported in some of the studied accident cases, see [report Fairell, 2017]). To ask to increase the minimum crew to operate commercial fishing could be difficult or non-economic (non-sustainable economically) in some cases.

On the other hand, limiting access to some places according to meteorology (as a large proportion of accidents on fishing craft happen on relatively shallow water) seems non-appropriate (mainly because many local fishing departs from ports that could be considered shallow waters), but maybe messages to mobile devices might advise how dangerous could be the situation depending on swell and wind directions combined. Only one of these factors seems to have a relatively reduced influence,

and in fact, many accidents happen with reduced winds and low height swell, but wave height may be different in different places, according to winds and Geography (depth).

Further automation with limits of operation might be complex, but the increase in technology could be a good deal to reduce the number of accidents. As the number of boarding, collision, grounding, and run aground cases is high, any electronic, automatic measures and advice on the steering (and powering) of the vessels that tend to avoid collisions and groundings are candidates to reduce accidents. Also, devices to advise against reduced stability or dangerous machinery operations maybe could help in some cases. The IoT and automatic processing of data ("Industry 4.0") to advise seafarers should be promoted to reduce navigational and operational risks.

In any case, safety regulations, even if carefully proposed, might encounter what is called "The Peltzman effect" [S. Peltzman, 1975] stating that, in the case of automotive accidents on land, increasing (apparently in a strong way) safety does not decrease very effectively deaths, a pattern consistent with what is called "optimal" driver response to the regulations i.e., drivers assume that the situation is safer with new regulations and/or mechanisms and assume further risks to increase benefits, as has been observed in [R.S. Sobel 2007; A.T. Pope, 2010]. In the maritime, the use of electronic aids, such as global positioning system (GPS), electronic charts display information system (ECDIS), and automatic identification system (AIS) has increased a lot in the last 20 years, and in Spain, there have been recommendations from CIAIM (see, for instance, [CIAIM 2020]) and other organisms [INSST_Norms, 2022] to increase safety in fishing, and the number of accidents and casualties in fishing has not decreased.

Nevertheless, in the long run, and in mature fields such as motor vehicles in the US, the density of casualties (casualties by 100000 people) finally decreases slowly with time, as achieved for instance with mandatory seat belt use and other rules and devices (such as airbags installed) in the period 1960-2020 [injuryfacts.nsc 2020]. The data found on fishing in Spain, which shows almost no decrease in accidents during nearly 20 years, could be coherent with this effect. So, further rules and devices have to be implemented to achieve a significant decrease in the density of accidents and casualties, and policies have to center also on training (and continuous training) and promoting a culture of safety.

Conclusions.

A study of maritime accidents on fishing craft from Spain has been done, from 2008 to 2020, using reports from the CIAIM official commission [CIAIM]. The analysis shows a nearly time-constant accident rate during the year at any month. Weekends appear marked by the commercialization of fish, the same as the hourly distribution of accidents during the day. Reports contain too little data on pollution from accidents.

The kind of accidents most repeated in fishing is not exactly the same as in the merchant navy. In any case, accidents such as boarding, collision, and grounding, which would seem

avoidable in most cases with a good navigational watch, exist also in fishing to a considerable extent. However, capsizing (overturning), operational, and water entrance accidents affect especially fishing vessels.

Rather surprisingly, most accidents happen in good weather, and many occur also in reduced depths of water and near the shore (these may be conditioned by the desire to reach fish). The human factor is important in the occurrence of accidents.

We have found that it seems that many accidents have a starting point in excess of confidence by the fishermen, maybe many times having a non-appropriate evaluation of risks and safety awareness, giving the surprising result that many accidents happen with good visibility, low swell, and low winds. Life-long training is clearly needed for seafarers, on one hand, to encompass new systems at work in fishing and navigation, but also to actualize and remember the combined risks, the safety awareness, and the need to perform good navigational watch. The actual situation displays too many accidents and too many dead/disappeared people.

As a final conclusion, it seems that to reduce fishing accidents it is necessary to increase the care with Navigational watch and operations, address overconfidence, and pay attention to possible training complacency (an increase in the safety awareness of fishermen is needed), as well as to the economic factors. The quantity of accidents really seems to be a cultural, behavioral, and economic effect. If the fishers' operation cannot be strongly improved by training people and increasing the culture of safety and non-accidents, devices and machines (mechanical, electromechanical, using modern electronics and information technologies...) maybe could do some of the tasks to increase safety. In the long run, seat belt use and other measures have reduced casualty density in road accidents [injury-facts.nsc, 2020]. Then it has to be said that the Peltzman effect should be a transitory effect, and in the long run accidents and casualties tend to reduce with the enforcement of safety measures. It should be expected that technical improvements for increased safety and constancy of training, measures and policies have to provide a decrease in casualties and accident rates in fishing.

Declaration of interest.

The authors have no commercial interest in the subject. A. Torne is a former fisherman.

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