Analysis and discussion of maritime accidents in the Spanish fishing sector.

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Abstract

In recent years, we have studied the serious and very serious maritime accidents registered by the Spanish fishing sector in all its modalities and areas. In several cases, the results obtained are different from the hypotheses initially raised.
At a global level, the problem of fishing accidents is observed practically all over the world, regardless of the level of development and there are various theories about them, but it does not cease to surprise that maritime transport is one of the forms of transport with the lower ratio of accidents referred to the transport carried out, while in the fishing sector the accident rate is much higher than in other industrial or productive sectors.
Regarding the influence of the meteorological conditions, we observe that the maritime accidents of fishing boats in Spain occur mostly on theoretically good days, meteorologically speaking, in which the wind was very low, and the visibility was excellent, but the swell was considerable. On the other hand, the greatest number of accidents is concentrated on small vessels, in places very close to the coast, and in shallow depths. The combined effect of waves of considerable height, together with the decrease in the depth, causes them to rise, even more, this being one of the most determining factors of accidents in terms of the possibility of capsizing (overturning), which is the majority cause of accidents in small ships. Another significant fact is that mechanical causes are declared as affecting a very small number of accidents, which suggests that human error could be very present in the cause of accidents, especially on collision, boarding, and run aground accidents. Analysing the set of accidents, it can be seen that their typology is very varied, both at the level of the area, geographical location, modality, as well as the type of event and type of ship. All these facts make it

difficult to think about the proposal and development of measures, besides the actual prescriptions, to avoid accidents, or to reduce the accident rate, which continues to be high and shows no signs of reducing when analysing the time series.

1 INTRODUCTION

The sea, and especially fishing, was always a marginal and dangerous occupation (ILO, 1999), since ancient times, which was only occupied by those who "had nothing else", neither land for cultivation nor the possibility of work in other trades on the mainland. It is very surprising that, even with the best and varied training of crews (European Guide for the prevention of accidents at sea and the safety of fishermen, 2007), together with the advancement of safety technology (Convention on the work in fishing, 2007 (C188)), (Torremolinos International Convention on the Safety of Fishing Vessels, 1977 (SBP) of the IMO) and the measures implemented by the authorities derived from the investigations (RESOLUTION MSC.255(84)), the fisherman's trade continues to be one of the most dangerous to which a person can choose, above jobs carried out on land (US BUREAU OF LABOR STATISTICS, 2009), (MAIB, 2010), (HSA, 2014), (EMSA, 2015), which had always been considered dangerous.

The active fishing fleet (Census of the operational fishing fleet, 2017), in Spain is very numerous and is characterized by having a large number of small vessels and fewer of other larger lengths that are distributed throughout the territory, but in regions specific, either by tradition or by available fishing resources, are concentrated in greater numbers. The crews of the fishing vessels are generally seafarers with a low or medium level of education, who have probably been following a way of life that has been the livelihood of several generations of the same family.

The large number of serious and very serious maritime accidents that have occurred in the Spanish fishing sector (CIAIM, 2020) and its high accident rate are the reasons that led us to investigate the causes and attempt to propose measures aimed at reducing thereof. That said, the fishing sector is very complex, in terms of fishing zones, type of vessel or modalities, which makes a specific structure of the data necessary to carry out a correct analysis of the information. Given the above, the task was not easy, if not quite the opposite, a complex investigation and in-depth analysis of the data obtained from the published reports of each accident were expected.

There were several hypotheses that were raised at the beginning. After reading the document "analysis of the 100 very serious accidents in fishing" (Moreno Reyes, Francisco José; Gómez-Cano Alfaro, María. 2014), we observed that the most affected modality was that of minor gear and that the most redundant cause It was the capsizing of the boat. On the other hand, we knew from the census of the operational fishing fleet (Censo fleet pesquera operativa, 2017) that the smaller gear vessels were small, that is, small in length. Small vessels, together with capsizing as the main cause of the accident, made us think that, by moving away from the coast, inclement weather could cause the vessel to capsize, but to prove it, we needed the accident data, which we obtained from the CIAIM publications, as an official source, with the advantages and limitations that this may entail. Given this hypothesis of the possible relevance of meteorology, the possibility of modeling a ship was raised and also to avoid capsizing, the possibility of installing a stabilization system was considered. From this point on, everything was open to new hypotheses or new conclusions, and it was essential to create an accident database, as detailed as possible, in order to prove or affirm our initial hypotheses.

The creation of the database was a tedious job, that as it was being built, it was observed in concrete data related to meteorology, that the initial hypotheses were not supported anywhere, and new hypotheses were opened that we would never have thought of in view of the first analyzed accident studies. The completion of the database until 2016, made it possible for us to analyze all kinds of aspects of the event, in search of the causes and we found some evidence that was repeated in many cases, but the fact that experienced sailors were involved in accidents, in days, that meteorologically speaking were considered as good, had us disconcerted. It was necessary to delve deeper into the understanding of the accident to understand why these accidents happen, in situations that are apparently good.

2 Methodology.

The maritime accidents analyzed were 296 in the period 2000-2016 in a first phase, of which 196 corresponded to fishing vessels. Even knowing that fishing vessels would be the most affected, based on published studies, we had to determine the exact amount, by sectors, to later focus on those related to fishing vessels. In the second phase, the accidents published from the last period to the end of 2019 were analyzed, with the aim of observing how the number of accidents behaved and other relevant aspects for the investigation. This period is less relevant, since only 31 accidents had been published during the period, which is little information to draw firm conclusions.
The data structure was initially established in 5 blocks. In the first called "registration data", it contained: the number of the ship, the number of the accident and the number of the investigation file. The reason why the ship was numbered was because in situations where more than one ship was involved, only 1 accident was counted. Throughout the analysis, the criterion of affected ships and no accidents occurring for this reason was always maintained. The second block called "data referring to the ship" contained: name of the ship, registration, identification number of the ship, length, beam, depth (in meters), gross tonnage, hull material, sector, modality, year of construction, crew on board and place where the accident occurred, does not refer to the geographical position, but to the place, normally in distance from a known point on the coast.
The third block called "data referring to the accident", contained: type of ship voyage, weights on board, date of accident, time of accident, accident classification, geographical position, depth, type of area, operations carried out during the accident , state of the ship, damage to the ship, damage area, type of event, injured, deceased, missing and pollution produced by the ship.
The fourth block called "meteorological data" contained: wind force in Beaufort scale, wind force in knots, wind direction in degrees, wave height in Douglas scale, period of the wind wave, height of swell, swell direction, swell period, visibility, and tide state.
Finally, the fifth block, called "data referring to the analysis of the accident" contained: cause of the accident, produced by, due to, conclusions and recommendations. With all these data for each of the 296 accidents, the database of maritime accidents that occurred between the period 2000-2016 was created, which served us to carry out an analysis of the accidents.

3 Data analysis.

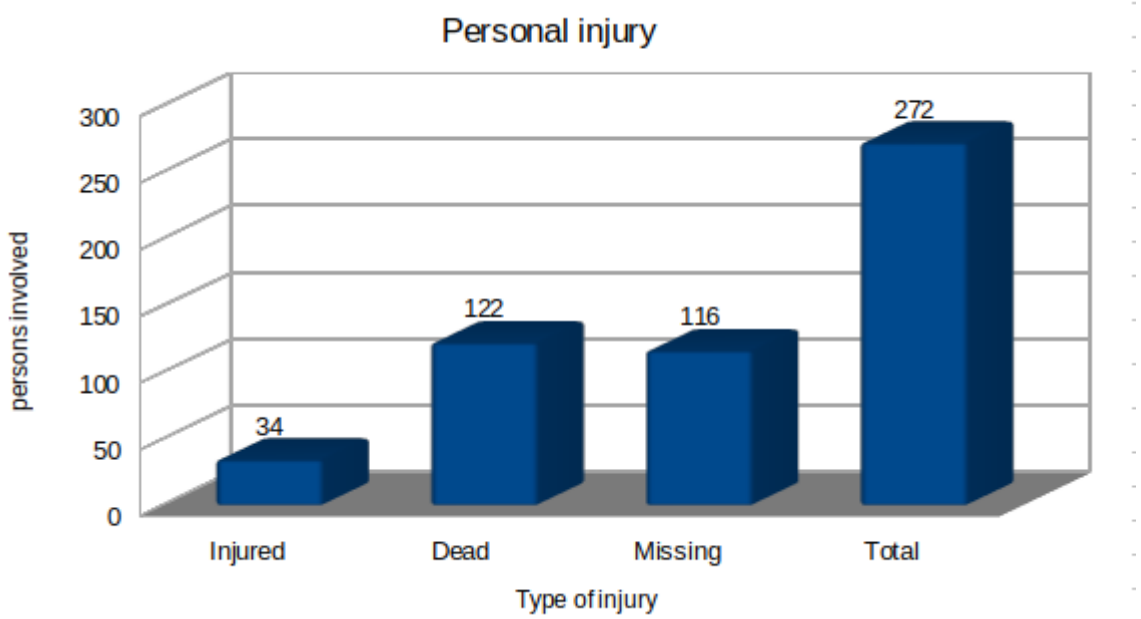
In this section we have included a summary of the results of the analysis that we obtained as the analysis was completed.

3.1 Initial data analysis.

The data obtained for the analysis of the accidents have been obtained from the investigations published by the CIAIM during the period 2000-2016. The initial analysis was carried out on 296 accidents, in which 346 ships were involved, of which merchant ships (115) account for 33.24% of the total, accidents occurring in fishing and aquaculture (197) account for 56.94% of the total, recreation (32) 9.25% and finally the others (2) with 0.58%. for the period 2000-2016, 197 accidents were recorded only in the fishing sector and between 2008-2016, only in fishing, 190 accidents were recorded, hence only the data by fishing grounds between 2008-2016 were analyzed.

Fig.1. Personal injury (2000-2016). Source. Authors.

In the analyzed period, we also observed that serious accidents, sinking and total loss accounted for a total of 211 vessels. On the other hand, we obtained the damages on people, with the result of 238 dead and missing people (122 and 116, respectively). The large number of deceased and missing, with respect to the injured, made us think that the accidents had to develop quickly and violently, based on the fact that there was no time to abandon ship.



In this first data filtering, the accidents were studied according to the year in which they occurred, to determine the evolution. When preparing the graphs, it was appreciated that from 2008 the accidents suffered a considerable increase. Everything indicates that the increase was not due to the fact that there had been more accidents, but rather that more resources would have been allocated for the investigation, which did not represent a natural increase in the number of accidents. Due to the little record between 2000-2007, we decided to disregard these accidents as unrepresentative and analyze only the period 2008-2016 in the fishing sector.

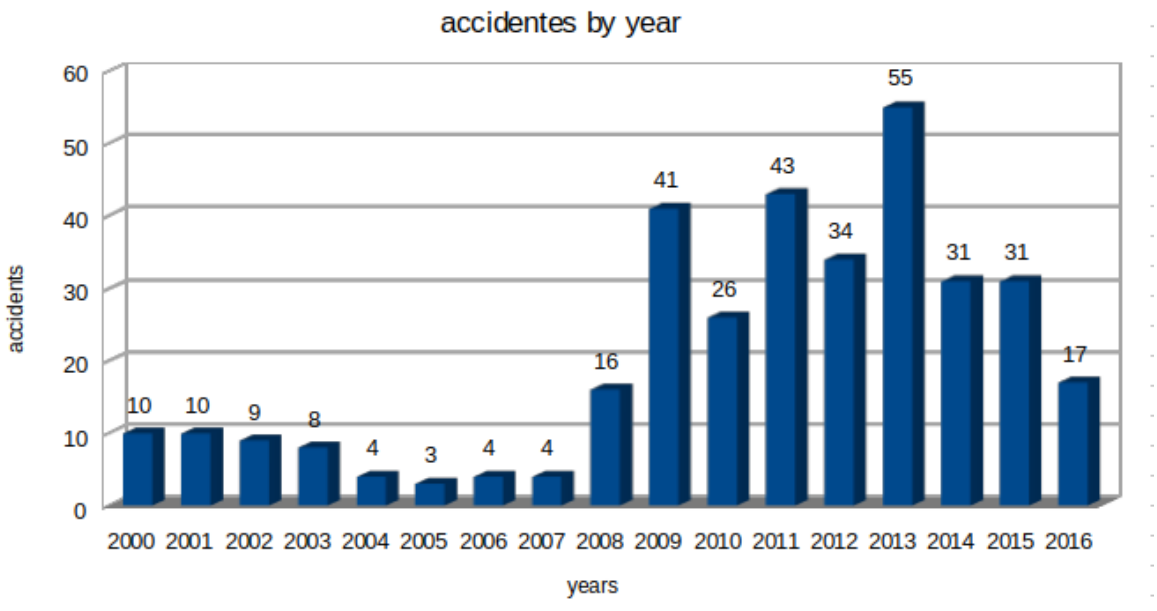


Fig.2. Accidents by year (2000-2016). Source: Authors.

The analysis of the data, in the first place, confirmed that most of the accidents that occurred had affected fishing vessels (196). In this first analysis, not all the data of each accident was filtered, since the objective was to determine in which sector there were more accidents. Once the data analyzed by the INHT (Moreno Reyes, Francisco José; Gómez-Cano Alfaro, María. 2014) was confirmed, in which it was appreciated that the fishing sector was the most affected of all, in terms of maritime accidents, we focused only in analyzing in detail the accidents in the fishing sector.

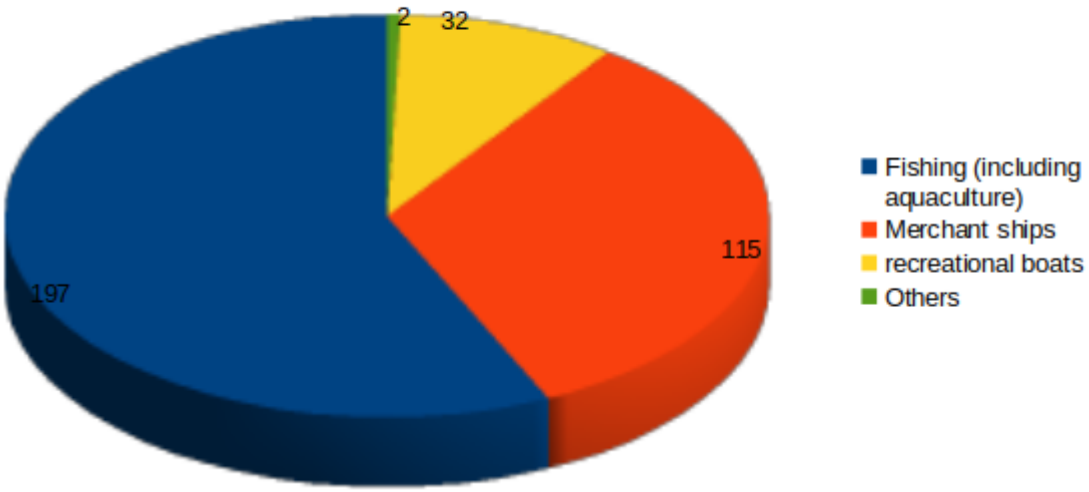


Fig.3. Ships involved by sector (2000-2016). Source: Authors.

Another interesting fact at a general level was the analysis of the type of event that occurred in the accidents. The data obtained show that in the general set, the most common type of accident was collision (100), followed by rollover (48), flooding (46) and operational type (38), followed by more types with less number. of affected ships. This filtering also showed that there were only 2 accidents due to faults in the machine or the steering system, which did not suggest that in the causes of the accidents, we could find human error as one of the most common causes, along with others.

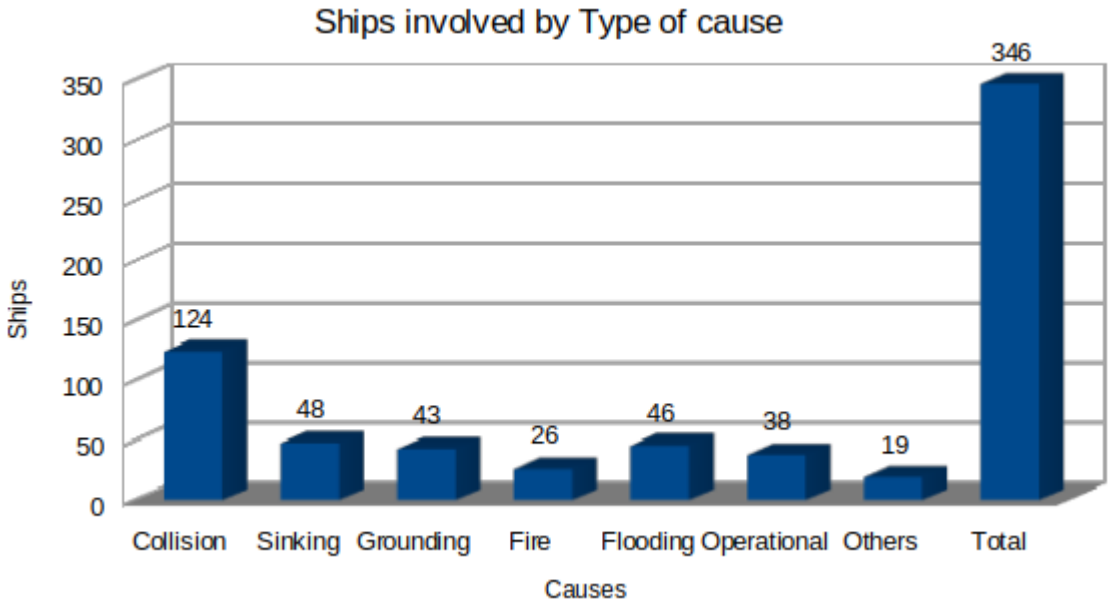


Fig.4. Ships involved by type of cause (2000-2016). Source: Authors.

3.2 Analysis of the fishing sector.

The analysis of the fishing sector presented a complicated task, due to the large amount of data, and the distribution of accidents, which is not homogeneous throughout the country. It was soon realized that filtering the accidents in a general way was not very attractive, because, depending on the area, the concentration of vessels, the type of accident and, above all, the number of accidents, it was inconclusive. There were areas, such as the Canary Islands, in which hardly any accidents were recorded. Then we found areas that did include accidents, but the types of ship did not match, nor did the type of event. Given this scenario, we decided to group the accidents by fishing grounds, Cantabrian-Northwest (99), Mediterranean (44), Canary Islands (6), Gulf of Cadiz (14), North Atlantic (9) and International waters (18) in the period 2008-2016. When making this division, it was appreciated that there were certain fishing grounds that we had to consider separately due to the small number of records (Canary Islands, Gulf of Cadiz, International Waters and North Atlantic) and initially focus on the Cantabrian-Northwest and the Mediterranean, which between the two, accumulated most of the accidents recorded in the fishing sector.

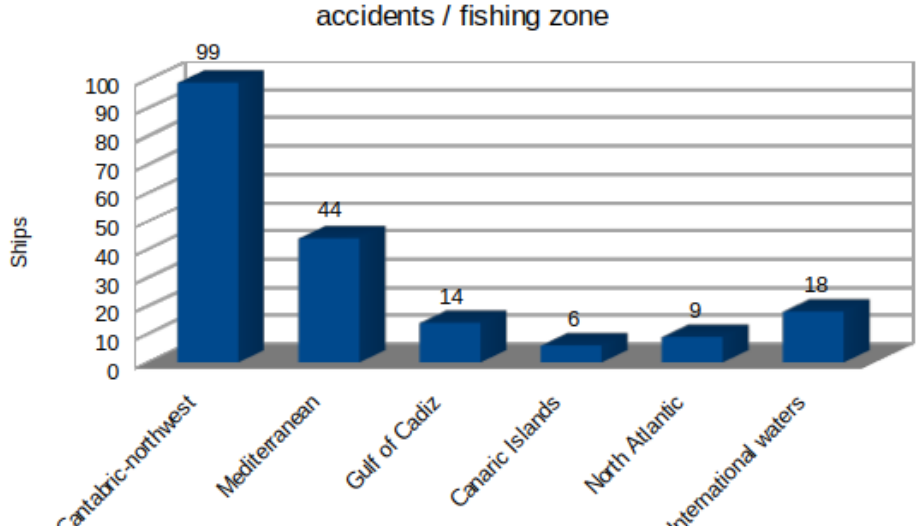


Fig.5. Ships involved by fishing ground. (2000-2016). Source: Authors.

Once the fishing grounds to be analyzed and the data of each accident have been configured, we begin the detailed analysis of the 143 accidents distributed in the Cantabrian-Northwest and Mediterranean fishing grounds occurred in the period 2008-2016. The analysis was mostly done via consecutive filtering of data. During the analysis we were looking for data that would show us how the accidents could have occurred and we did not find clear evidence of aspects that could be decisive in the cause of the accident, in data related to the construction of the ship (length, beam, construction material, stability , age, etc.). Nor do we appreciate that the causes were related to the geographical area in which the accident occurred.

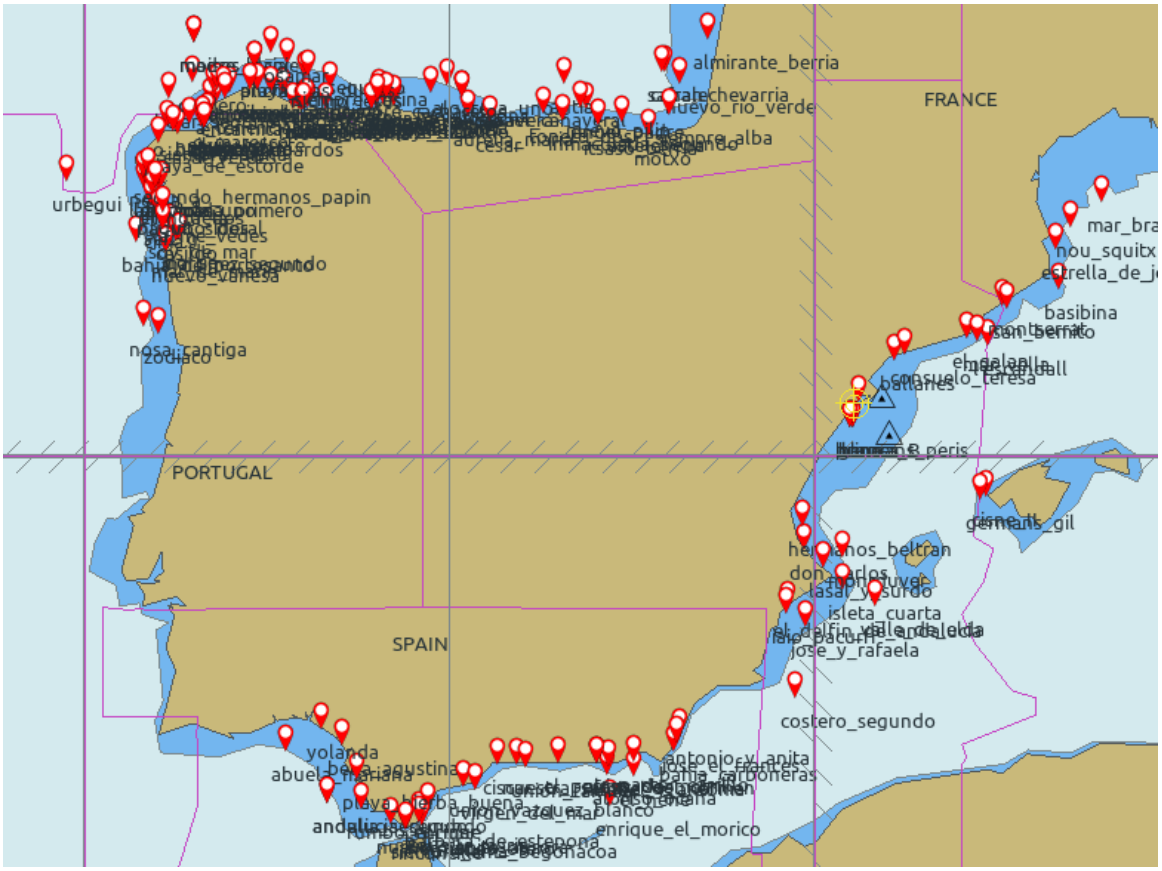


Fig.6. Geographical distribution of accidents in fishing vessels (2008-2016). Source:Authors.

To make sure that the specific geography (bottom orography) of some place had a key importance in the accident, we placed all the accidents with geographic coordinates in a digitized map and we did not appreciate any concentration of accidents due to the orography, but when locating them we observed that most were in very shallow areas (Torné, Alfredo, Isalgué, Antonio, Martínez, Xavier. 2016).

3.3 Meteorological data.

Regarding the weather, we believe that it is a relevant aspect in achieving the accident. We appreciate evidence that in the Cantabrian-Northwest, capsizing accidents occurred on days with little wind (0-4 Beaufort) and that they occurred very frequently in shallow places (0-10 m) and that the type of fishing Hardest hit were the minor arts. (Torné, Alfredo, Isalgué, Antonio, Martínez, Xavier. 2016). Continuing with the analysis of the meteorological data, we appreciate a surprising fact, the height of the background wave. The analyzed accidents showed that a large number of accidents occurred when the swell wave was 1-3 meters, but it decreased much above 4 meters, which did not lead us to suppose that the accidents did not occur on days of low significant wave height, nor on days where the significant wave was clearly high. So, we think that accidents occur on those days where the predicted wave height is at least average, or "doubtful", in terms of its danger, for the perception of the fisherman.

3.4 Data relating to the time, day of the week, and month of the year.

We did appreciate subtle indications of dependence on the day of the week, which we observed that the accidents increased slightly towards the end of the week, which we assume was due to the accumulated fatigue of the work week, but instead it was not determined that the time of the event was a significant piece of information, since most of the accidents occurred during the hours in which the vessel was fishing (0400-0800). (Torné, Alfredo, Isalgué, Antonio, Martínez, Xavier. 2020).

The day of the month in which the accident occurs, did not show significant data of having a direct relationship with the accidents, observing a very homogeneous distribution throughout the month.

On the other hand, it was very curious to observe that the month of the year does not intervene practically in the frequency of accidents either, that is, the distribution of accidents throughout the year is very homogeneous.

3.5 Faults due to steering or propulsion systems.

As for the causes of accidents, both in the Cantabrian-northwest draft and in the Mediterranean, it was observed that in almost none of the accidents analyzed were the causes related (assigned in the reports) to failures in the steering or propulsion systems, which makes us suspect that communication error or other human errors exist in a large number of maritime accidents, in any case, it is difficult to affirm that the cause of a specific accident is due to a single aspect of those analyzed, if not everything points to it being more of one, which combined at some specific time cause the accident to occur.

3.6 Differences between fishing grounds.

Another piece of information that appeared was that the type of accident recorded in the Cantabrian-Northwest and the Mediterranean had nothing to do with each other, as the modalities of the vessels involved were different (small gear, Cantabrian-Northwest, and Mediterranean bottom trawling).), nor the type of event (capsizing, Cantabrian-Northwest and collision in the Mediterranean). No relationship can be established between the causes and the accident vessels in the Cantabrian-northwest fishing ground and the Mediterranean. This fact forces us to treat the accidents of each setter separately and not treat it in a single group of accidents in the fishing sector, especially in the proposal of measures, since they will be different depending on the specific setter.

4. Discusion.

With regard to the accident rate in the fishing sector, it is observed that the problem is not only at a Spanish level, but at a European level, saving the differences in modality and type of vessel, this problem is also appreciated. In the United Kingdom, accidents in the fishing sector are also a problem, as can be deduced from the analyzes carried out by the (MAIB, 2014). In the United States (U.S. BUREAU OF LABOR STATISTICS, 2012), Japan, and many other countries (Petursdottir & Hannibalsson & Turner, 2001), similar data confirm that accidents and human losses in fishing are a global problem.

There are many efforts and resources invested in mitigating these effects by the Administrations of many countries and Official Organizations, carrying out investigations, proposing safety measures, training fishermen more and specifically, but even so, accidents continue to happen, which which makes the proposal

of measures complicated. If it is true, that the efforts are not in vain, since, if the current resources were not invested, the accident rate would most likely be much higher. To conclude, we will provide data on the seriousness of the problem at the Spanish level: in the Spanish fishing sector, more than 1 person per month dies on average, and there is practically a maritime accident (investigated and reported by CIAIM) every 15 days.

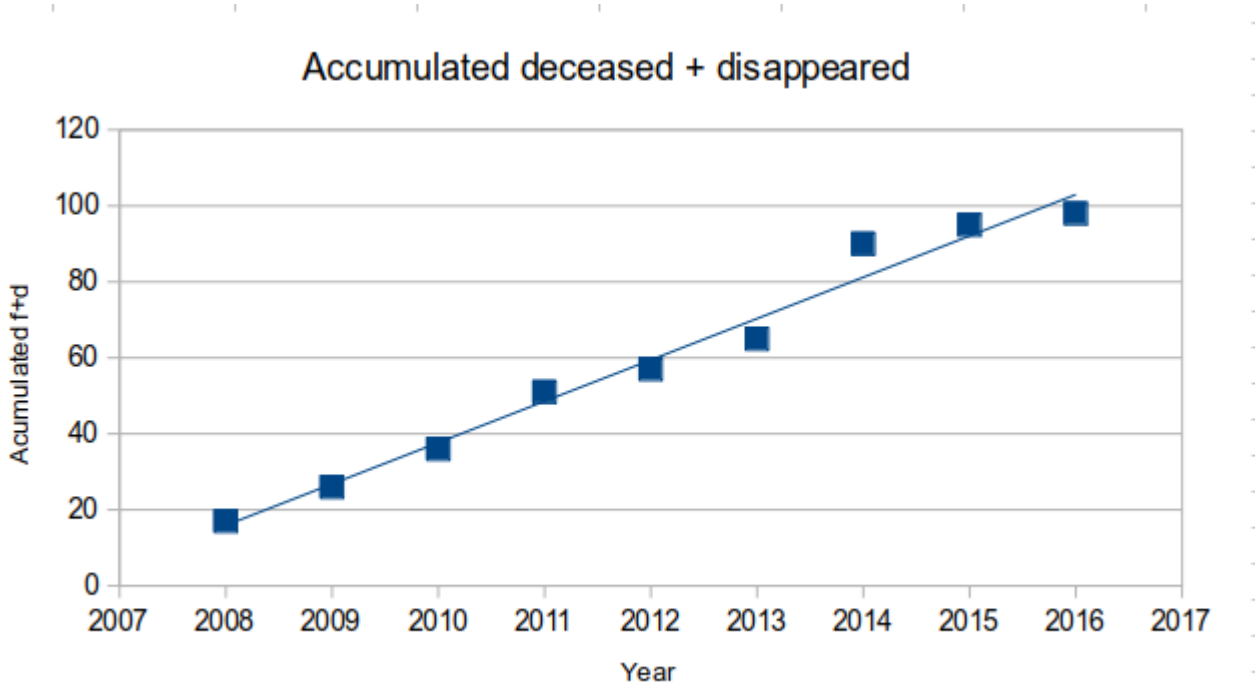


Fig.7. Accumulated deceased + disappeared (2008-2016). Source:Authors.

On the other hand, the probability of an accident occurring was analysed, and everything indicates that it is very likely that accidents will continue to occur in the short term. One measure that could contribute to the safety of fishing vessels would be to implement an emergency evaluation system (Cruz, Josep Antoni, Rodrigo, Jaime 2021).

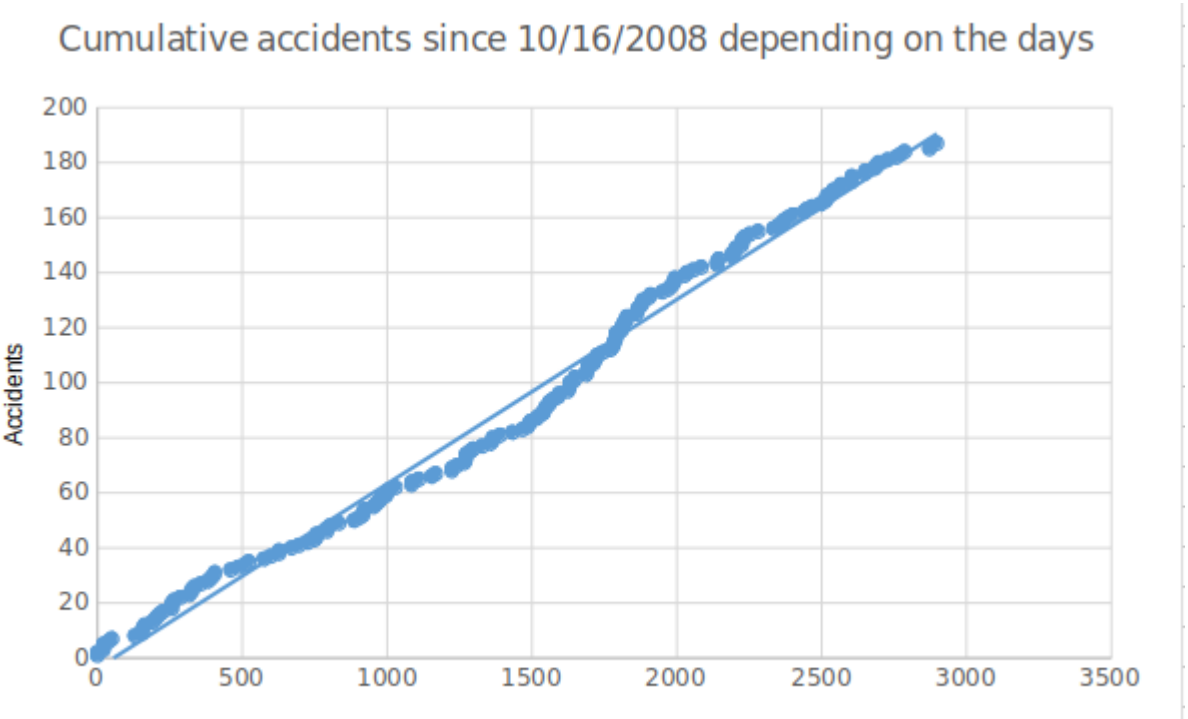


Fig.8. Accumulated accidents (2008-2016). Source: Authors.

We are facing a global problem, which is complicated to solve. Given this scenario, proposing measures to reduce them is complex. Several proposals were initially considered, but all focused on the prohibition of fishing in specific areas, which is intuited inappropriate and unfeasible, at the same time that it would be difficult to adapt or rejected by the fishermen's collective. That said, we come to the conclusion that a measure to reduce accidents, specifically in the Cantabrian-Northwest, should be informative and not prohibitive. It can be seen that accidents do not occur on good days or bad days, but instead occur on "doubtful" days, meteorologically speaking. We believe that the majority of accidents in the Cantabrian-Northwest fishing ground are caused by overturning, in shallow areas and when the swell is 3 or more meters of predicted wave. These days, we believe that the sum of the energies of the waves create, from time to time and unpredictably, a larger wave, which is what, together with the shallow depth, triggers the accident. So, given these data, we could notify fishermen via mobile phone and in real time, which days are the meteorological buoys are registering a certain wave height, which we could consider as dangerous.

As we have said, the greatest concentration of accidents in the Cantabrian-Northwest fishing ground is concentrated in small vessels, also in part because there is a greater number of vessels operating in that area, of such dimensions. However, the accident rate is higher on ships operating in North Atlantic waters, but the number of accidents is much lower. Given this fact, we decided to analyze the areas with a higher volume of accidents, not the ships that had a higher accident rate.

5. PROPOSAL OF MEASURES TO REDUCE THE ACCIDENT RATE.

The proposal of measures is perhaps the most complicated part of the investigation to carry out. We start from the basis that, according to the data obtained from the accident analysis, it is difficult to formulate effective proposals, due to the type of ship, type of accident, etc. Given this complexity, it is decided to propose measures based on the specific type of accident, focusing on those with a greater record.

The type of event that causes the most accidents and, consequently, the most deaths, is capsizing and most accidents occur in the Cantabrian-Northwest fishing ground. To propose an effective measure, we used the geographical positions to delimit some areas where we could exclude fishing vessels during these dangerous days. It was soon observed that due to the orography of the coast it was practically impossible to delimit a line around 10 meters deep, to prohibit the entry of ships on days considered dangerous. Then, we opted for another system that instead of prohibiting consists of warning the fisherman of these dangerous days. The system would consist of an application that gives a warning in real time to the fisherman's mobile phone, when the meteorological buoys detect a series of significant wave readings between 2.5 and 5 meters. Upon receiving the warning, the fisherman could know that he is at risk and choose not to fish that day, choose to do so at higher depths (or in another location) or take precautions and risk suffering an accident. We are aware that the algorithm should be worked on to make it a reliable system, but we are convinced that it could mitigate maritime accidents.

On the other hand, with the intention of proposing a measure that would reduce accidents in the Mediterranean fishing ground, the most redundant type of event was first observed, which turned out to be collision. It was noted that the accidents in the Mediterranean did not affect the same types of vessels or the type of fishing and not even the event that caused it. Knowing the cause of the event, in the first place, the visibility hypothesis was considered, which was ruled out when we discovered that in almost all the collision accidents in the Mediterranean, visibility was more than 10,000 meters. Given this scenario, it was assumed that the crew leave the navigational watch during fishing or navigation tasks back from the fishing area to the port. So, we came up with the idea of implementing an alarm system similar to the one that activates a car when we don't have our seat belt fastened. It consists of a variant of the system already implemented in merchant ships called "dead man", which when it does not detect movement (active presence) on the bridge activates an alarm that warns of the absence of personnel on the bridge, either due to illness or by negligence. Said alarm would sound in the stern part, with a high decibel level, to warn the crew that the navigational watch has been abandoned. This must not stop, until it stops from the wheelhouse.

As for the flooding accidents, it was observed that many of them were caused by breaks or decoupling of the refrigeration system pipes that were fastened with steel flanges. At the same time, it was determined that many of these accidents occurred at the temperature change stations and we estimate that perhaps these temperature changes could loosen said flanges due to the effects of the expansion of materials and pipes of the refrigeration system. That said, the proposal was every change of season, especially from hot to cold and vice versa, to check and tighten all the flanges of the refrigeration system or other systems of the ship that can cause a flood due to detachment of pipes.

In another line, now in accidents that occurred in the waters of the North Atlantic, we appreciate that many accidents were due to blows and falls into the sea with the gates or other fishing elements caused by the breakage of chains, cables or shackles. It is not defined when the joining materials (chains, shackles, cables) should be replaced, but given the evidence, a review or preventive change of the material should be established from time to time, regardless of the state of the material. Perhaps this measure would reduce breakage and therefore accidents.

6. CONCLUSIONS.

The analysis of results suggests that there is too little redundancy per reduced crew compared to the navigation and fishing requirements.

The accidents that occurred are distributed to a greater extent in the Cantabrian-northwest than in the Mediterranean, these two being the most significant. The other fishing grounds collect insignificant data.

In the Cantabrian-northwest fishing ground the most frequent cause of accidents is capsizing, while in the Mediterranean the most frequent cause is collision. On the other hand, it is observed that a greater number of "very serious" accidents is recorded in the Cantabrian-northwest fishing ground. The accident number is much higher in the Cantabrian-northwest than in the Mediterranean.

The accidents that have occurred in the northwestern Cantabrian Sea mostly occur in small-sized minor gear vessels and in shallow areas near the coast. On the other hand, the accidents that occur in the Mediterranean, most of them, are in larger trawling vessels, and occur far from the coast and the most recurrent cause is collision.

In view of the data obtained in this investigation, it can be seen that the problem of fishing accidents remains constant, with a slight decrease due to the reduction of the fleet. The probability of suffering an accident also remains high and fairly constant, even taking into account the reduction in the operational fishing fleet.

The geographical position data shows that the majority of affected vessels carried out their fishing activities near the coast (local trips), including accidents in or near port. Observing the positions of the accidents, apparently, there is no zone of special incidence, which must be studied in detail. The distribution of accidents along the coast is quite homogeneous.

Accidents due to capsizing (the majority in the Cantabrian-northwest) occur in shallow places under the keel, combined with expected swell conditions of around 3 meters, when the vessel is fishing. They affect small vessels and their fishing activities are carried out in the form of minor gear. The winds at the time of the accident are soft. A slight increase in accidents can be seen at the end of the week.

Collision accidents (majority in the Mediterranean) occur in deep, open seas, on days with good visibility, and on vessels engaged in bottom trawling. It affects ships of medium lengths. The winds at the time of the accidents are light. A slight increase in accidents can be seen at the end of the week and also a slight increase in the months of November and December, but not very significant.

If additional measures are not taken to those currently in force, the accident rate in the fishing sector is estimated to continue to be high, along with the number of victims. It is estimated that the proposed accident reduction measures could help reduce accidents, if they are ever implemented.

Regarding the construction aspects of the vessels, with the current data and statistics, it has not been possible to directly and reliably correlate the construction material or the age of the vessel with the accident.

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