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Analysis and Proposals on the Operations of Vessels to Reduce Accidents in Fishing Craft from Spain.

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ABSTRACT

Artisanal fishing has been and remains one of the sectors with the highest accident rate in our country. According to serious studies in artisanal fisheries in the area of Galicia accidents are the small boats those that have the strongest claims. It is also observed that accidents occurred during operations of gear retrieval. Faced with this problem is to conduct a study that will further knowledge of the conditions in which the accident occurred, then to carry out the necessary measures to reduce the number of fatalities in this sector proposals.

1. Introduction

Fishing was in the past and remains today one of the important productive sectors of Spain, 1,011 thousand tons at December 31 2013. This important sector develops, and is divided into 4 main modes, Siege, Trawl, Longlines, Minor Arts (artisanal fishing) and a fifth that encompasses all other less important modes. From the point of view of consumption, according to the Spanish Ministry of Agriculture, only products from aquaculture represented 258 thousand tons in 2013. Overall, we see that Spain is a major consumer of fish, both imported and domestic, but Spain also exports in large quantities, valued, according to MAGRAMA, in 2946 million euros in 2013.

Statistical fleet data and economic data about the fishing activities are published by the Ministry of Agriculture and Fisheries, Food and Environment (MAGRAMA), dependent on the Government of Spain. This official body is regulated in Royal Decree 415/2016, of November 3, which restructures the ministerial departments (BOE 04-11-2016) and creates the Ministry of Agriculture and Fisheries, Food and Environment. Its article 11 provides for its powers:

1. The Ministry of Agriculture and Fisheries, Food and Environment is responsible for proposing and implementing the Government's policy on agricultural, livestock and fishery resources, the agro-food industry and rural development. Likewise, it is the responsibility of the Ministry to propose and implement the Government's policy on the environment.
2. This Ministry has, as a higher body, the Secretary of State for the Environment.

The Ministry of Agriculture and Fisheries, Food and Environment is the Department competent in the field of the General State Administration for the proposal and implementation of the Government's policy on:

- Fight against climate change.
- Protection of natural heritage, biodiversity and the sea.
- Water.
- Rural development.
- Agricultural, livestock and fishery resources.

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- Agro-food industry.

Besides being an important industry in Spain, fishing is also characteristic for the large number of accidents recorded. The accident rate in the fisheries sector worldwide has been the subject of study and concern for different countries, including ours. Levels of fishing accidents fired alarms because they are above many sectors of our society, including construction (see Figure 1).

Figure 1: Casualties per year as a function of time. Fishing gives a much higher figure than other heavy duties as construction.

Source: National institute of health and hygiene in the work. Department of research and information.

For years, organizations from several countries launched various measures aimed at reducing the high accident rate that was collected in inshore fisheries. These measures, even today in continuous development, address specific issues on the construction of ships, control and prevention of the values of the ship's stability, training and awareness of fishermen, among others.

The different lines of action against accidents have resulted in the creation of programs that control at all times the stability of the ship, rules to avoid types of undesirable vessels from a constructive point of view, talks in brotherhoods to educate the fishermen on the risks and training in the use and operation of equipment and safety on board. All these actions have significantly reduced accidents in fishing, however accident figures remain still high, much higher than the construction sector.

The main objective of this work is to search, by an elaborate study of maritime accidents in the artisanal fisheries sector of the Spanish coast, for the relationship between these and the operation of the vessel. For instance, if it is shown that most accidents occur during operation of hoisting gear, measures could be taken to avoid accidents. Once the relationship between accident and operation of the ship is given, there could be developed one or more measures acting on the operation of the vessel with the intention of reducing the number of human losses. The methodology of this research will be based on the analysis of the different studies published on maritime accidents in the fishing sector. In this analysis we want to obtain information about all aspects of operating the vessel.

2. Data and Boundaries of the Problem

The article 94 of the United Nations Convention on the Law of the Sea (Montego Bay, Jamaica, 1982) urges States to investigate any maritime accident or any incident of navigation on the high seas involving vessels with own pavilion.

Similarly, regulation 21 of Chapter I of the Annex to the International Convention for the Safety of Life at Sea (SOLAS, 1974/1978) obliges the administrations of Contracting Governments to investigate any accident suffered by any vessel entitled to fly Its flag and subject to the provisions of the agreement itself, provided that such research can contribute to the introduction of changes in the rules contained therein.

For its part, Council Directive 1999/35 / EC of 29 April 1999 on a system of mandatory surveys to ensure the safe operation of scheduled ro-ro ferry services and high-speed passenger craft, Incorporated into Spanish law by Royal Decree 1907/2000 of 24 November, obliges the Member States to adopt provisions enabling them and other Member States with a significant interest to participate, collaborate or carry out research on Accidents and incidents involving a ro-ro ferry or a high-speed craft.

Finally, Directive 2009/18 / EC of 23 April 2009 laying down the fundamental principles governing the investigation of accidents in the maritime transport sector, establishes the obligations of EU Member States on research of maritime accidents. This Directive entered into force on 17 June 2011 and has been transposed into the Spanish legal system through two instruments:

1. Articles 265 and 307 (n) of the Consolidated Text of the Law on State Ports and Merchant Marine, approved by Royal Legislative Decree 2/2011, of September 5. Among other considerations, the Law provides the CIAIM Investigators with the status of public authority. It also establishes a specific sanctioning regime for non-compliance with the provisions relating to the investigation of maritime accidents contained in the Law.
2. Royal Decree 800/2011, of 10 June, regulating the investigation of maritime accidents and incidents and the Permanent Commission for the Investigation of Maritime Accidents and Incidents (published in the Official Gazette of June 11, 2011). It contains the other provisions and rules of operation of the Commission, and entered into force on 17 June 2011.

The Permanent Commission for the Investigation of Marine Casualties was created by order of this Ministry of April 14, 1988, with the purpose of determining the technical causes of maritime accidents occurring in the waters in Spain exercising sovereignty, sovereign rights or jurisdiction, as well as on national vessels included in the scope of Royal Decree 1661/1982 of 25 June, and to formulate recommendations to avoid similar accidents in the future.

The Commission was regulated by Ministerial Order of May 17, 2001. It was directly attached to the General Directorate of the Merchant Navy, and its president was the Deputy Director General for Traffic, Safety and Maritime Pollution.

The information on very serious maritime accidents in Spain, as well as other information of interest, is then collected and published by the Commission for the Investigation of Marine Incidents and Incidents (CIAIM).

The Permanent Commission for the Investigation of Maritime Accidents and Incidents (CIAIM) is a collegiate body attached to the Ministry of Public Works, which is responsible for investigating maritime accidents and incidents occurring on or by Spanish civilian vessels, or by foreign civilian vessels When they occur within internal waters or in the Spanish territorial sea, as well as those occurring outside the Spanish territorial sea when Spain has interests of consideration.

The investigation has an exclusively technical character, its final purpose is to establish the technical causes that produced it and formulate recommendations that allow the prevention of future accidents and incidents, not being directed at any moment to determine nor establish guilt or responsibility of any kind.

The results of the investigation are reflected in a report that includes factual information regarding the accident or incident, an analysis of the accident, conclusions and recommendations on safety. These recommendations constitute the most appropriate means of proposing measures to increase maritime safety.

The Standing Committee shall investigate:

- Very serious maritime accidents: these include those involving the total loss of a ship, the loss of human life, or serious damage to the environment.
- Other maritime accidents and incidents, where research can provide lessons for maritime safety.

CIAIM has its own personnel and means suitable for the development of its activity, as well as with the timely collaboration of specialized technical advisers and agencies. This organization is regulated by Article 265 of the Revised Text of the Law on State Ports and Merchant Marine, approved by Royal Legislative Decree 2/2011, and by Royal Decree 800/2011.

2.1. Types Of Vessels More Frequently Implied In Accidents

Fishing is a very broad sector that includes different procedures developed in various areas, with different kinds of ships and time slots variables. The information currently available, is derived from the different parts of accident that processed the day of the incident by the administration.

It is observed in the study of 100 serious accidents between 2008 and 2013 carried out by the Commission for Investigation of Accidents and Maritime Incidents, that of these 100 events, 37 occurred in dedicated artisanal fishing or small-scale gear vessels. On the other hand, the data shows that 44% of ships that suffered accidents were aged over 15 years, 56% had a length of less than 15 meters and with respect to the construction material, the percentages are almost equal between steel, wood and GRP (Glass Fiber Reinforced Polymer).

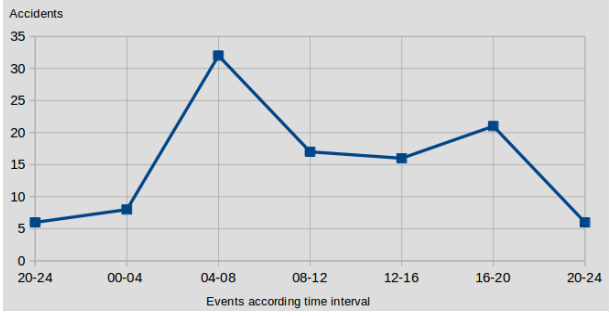
2.2. Maritime Area of Accidents

In the above mentioned study of the 100 major accidents in Spain, we note that 33% of the accidents occurred in the area of Galicia, 25% of them occurred in the area of the Mediterranean Sea and 14% in the Bay of Biscay. However, unlike what might be expected, 45% of the ships that suffered the accident were dedicated to local fisheries, 29% to coastal fishing and 21% for other fishing activities. That is, the closer to the coast was the fishing vessel, the higher the percentage of accidents.

2.3. Time When the Accidents Happened

Of the 100 serious accidents studied, these are most frequently seen in the months of July and November with percentages of 14% and 13% respectively. As regards the day on which occurred the highest number of accidents, it was on a Thursday. As for the time of the events recorded, we found that between 4 and 8 am there were 32% of accidents and 21% in the afternoon in a time slot between 16:00 and 20:00 hours (see Figure 2). Both the day of the week that includes more accidents, and the hours at which they occur, could suggest the routine and especially fatigue plays an important role in the cause of accidents. Also we think that overconfidence in handling machinery can influence. In any case, the number of accidents in each interval is not very high, and being due to diverse causes, they presumably would have a normal distribution, making the differences a relatively low significance, with standard deviations expected in figure 2 around 6 events.

Figure 2: Number of events according time interval at which they happened.



Source: Authors

2.4. Crew of the Implied Vessels

With regard to provisions carried by the vessels involved in the study, it follows that the larger the crew, the fewer the accidents, noting that 53% of the vessels had an allocation of less than 5 crew members, 24% from 5 to 10, and 23% were carrying a crew of more than 10. As in the previous point, we believe that as we increase the crew, the division of labor makes the crew exercise their profession less affected by fatigue, more attentive and less overconfident.

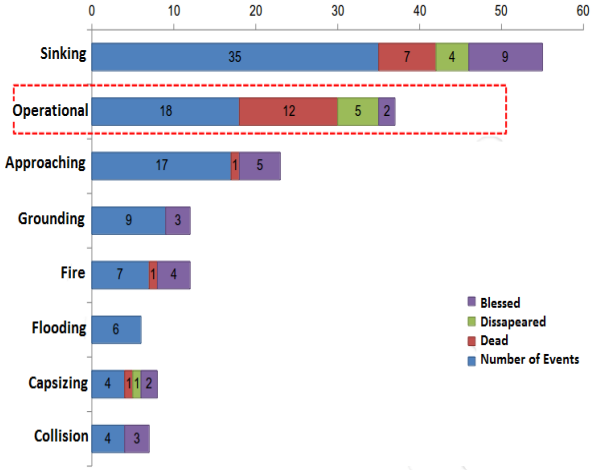
2.5. Activities When the Accidents Happened

Concerning the different origins of the events collected in the study of accidents, the highest percentage corresponds to those activities related with navigational watch, including the collisions, groundings and sinking, which collect 30% of the total. The second most important activities when the studied

accidents happened are related to deck operations, the operational activity that led to the sinking of the ship or to capsizing, with 27% (see Figure 3). Again, it may be that the crew fatigue, routine, overconfidence in handling machinery, are some of the circumstances that may have influenced accidents encompassed in this type.

Besides the origins exposed in the study, there are others that we believe may influence an accident situation. First, we have a risk of weight accumulation on deck during operations, causing a rise in the center of gravity and therefore a loss of stability. During operations of the recovery of fishing gear, these are placed on the deck, aft towards the bow, until everything is on board. Depending on the length of the arts, the speed of turning machines for networks, and depth, these operations have a variable duration. Time is an important parameter when weather conditions change as they may worsen considerably. Also it is related to exposure to danger, as the networks on board in a high place, cause a loss of stability.

Figure 3: Causes of accidents by number (in horizontal axis)



Source: Authors

In second place, we have the potential smearing that can occur during these operations. The smearing is known as the situation in which the gear is hooked on the bottom, either a rock, a wreck or other object fixed to the bottom of the sea. When this kind of situation happens, the main problem might seem to be the breakage or loss of a part of the arts. However, when during hauling operations it is found a situation of smearing, and there are high waves, the boat is in increased danger of capsizing.

To understand the danger that the boat suffers in smearing when there are high waves, imagine the surface line fixed in an instant on the wave step. The fishing gear is attached to the bottom of the sea and cannot be released. The crew stretch and pull the art, veered to try to lose, therefore this is reducing the distance between the toner and the point where the art is hooked to the bottom.

Finally, in this situation, we increase the surf. Automatically the boat, because the buoyancy rises along with the wave but being attached to the background art, starts to heel to the toner band. When the wave is increased and fishing gear is not hoisted, which sometimes is difficult, the continuous ship heeling goes to a point where the accelerations suffered as a result of sea state and operation of machines, represent considerable forces of inertia which can contribute to destabilizing the boat.

2.6. Sea Conditions and Weather

In the study of the 100 serious accidents in Spain between 2008 and 2013, there is a comprehensive breakdown of the different causes and circumstances, among which weather conditions surprises with 38% of the causes, being wind, sea, fog, waves and rain. This point we consider is of great importance. We should note that most accidents occurred in vessels less than 15 meters and relatively close to the coast. In this type of ships and adverse weather conditions, ships suffer hard accelerations, in principle expected in the initial design of the vessel, but, which together with the fatigue, routine and overconfidence of the crew, may influence the stability and promote accidents. As has been commented, recovery of the fishing gear might produce some reduced stability of the vessels, which combined with bad sea conditions could result in accident. However, this point needs a detailed investigation, as a rule the worst weather conditions occur in the winter months and instead accidents occurred more frequently in the months of July and November. See Table 1, Figure 4.

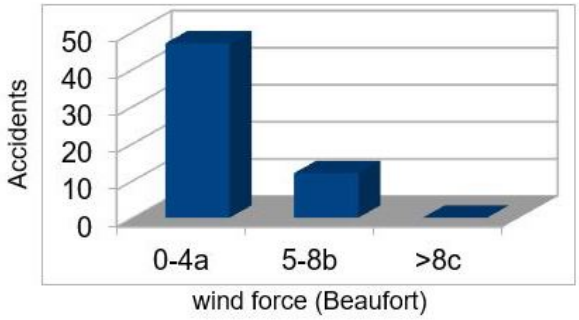
Table 1: Wind force at the moment of the accidents

Wind force	$0-4^a$	$5-8^b$	$>8^c$	$Total^d$
Accidents	47	12	0	59
%	79,66	20,34	0,00	100,00

Source: Authors
Where:
a = wind force 0 to 4 Beaufort Scale.
b = wind force 5 to 8 Beaufort Scale.
c = wind force up to 8 Beaufort Scale.
d = Total accidents and percentages.

On the other hand, if we analyze the meteorological data of the different investigations of each accident that occurred in the fishing sector and in the modality of the minor arts, we observe that practically 80% of the accidents occur in meteorological conditions of wind comprised between force 0 and 4 Beaufort scale, with 79.66%. In the Beaufort scale, from 5 to 8, 20.34% of the accidents occurred and there were no accidents with a force greater than 8 on the Beaufort scale.

Figure 4: Wind force / accidents (vertical axis)



Source: Authors

Within the study of the meteorological conditions, among other data we have collected the direction of the wind at the time of the accident. We have grouped the directions included in the four quadrants, according to their component, North, South, East and West. The data, like the previous ones, are extracted from the research published by CIAIM, in the fishing sector and in the modality of minor arts.

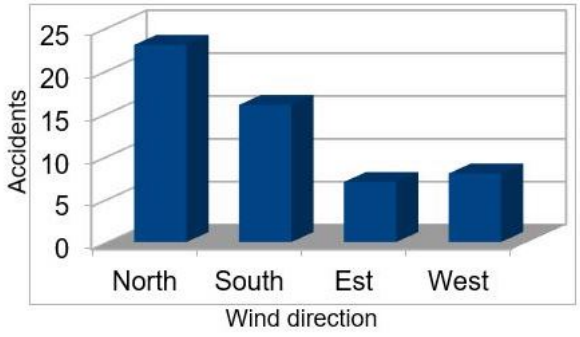
It is observed that the predominant wind direction in 42.59% of the accidents was of North component. The accidents happened when the wind blew of component south, they represent the 29.63 of the total. The percentages of accidents occurred when the winds blew of West and East component, represent 14.81% and 12.96% of the total. See Table 2, Figure 5.

Table 2: Wind direction / accidents

Wind direction	North	South	East	West
Accidents	23	16	7	8
%	42,59	29,63	12,96	14,81

Source: Authors

Figure 5: Wind direction at the moment of the accident



Source: Authors

In a more in-depth study of these meteorological data, this wind direction could be established referred to the ship, taking into account the different national chisels, in which direction the coast is, with respect to the north and the direction of the wind with respect to this one. Obtaining such information would allow to determine the angle of incidence on the vessel and to check whether the wind direction was perpendicular to the ship or not.

2.7. Depth of the Accidents

We have sampled 59 serious and very serious maritime accidents that occurred between 2008 and 2013 in the fishing sector and in the small gear modality with the objective of observing in an approximate way, in which depths the accidents have occurred. The accidents were selected as those whose depth could be obtained appropriately. To this end, these accidents have been located on the chart and from this the depths have been obtained. It should be added that this sample includes all types of events, fire, collision, stranding, boarding, rollover, grounding, capsizing, flooding and operational.

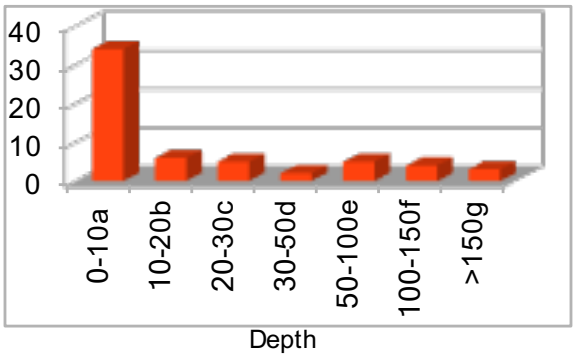
As can be seen in Table 3 and Figure 6, the highest number of accidents recorded in this sample occurred between 0 and 10

Table 3: Number of Accidents by depth.

Depth	Accidents	%
0 – 10[a]	34	57,63
10 – 20[b]	6	10,17
20 – 30[c]	5	8,47
30 – 50[d]	2	3,39
50 – 100[e]	5	8,47
100 – 150[f]	4	6,78
< 150[g]	4	5,08

Source: Authors
Where:
a = Depth 0 to 10 meters.
b = Depth 10 to 20 meters.
c = Depth 20 to 30 meters.
d = Depth 30 to 50 meters.
e = Depth 50 to 100 meters.
f = Depth 100 to 150 meters.
g = Depth up to150 meters.

Figure 6: Accidents by depth



Source: Authors

meters, in particular 34, representing 57.63% of the total. We then observe that in the depth of 10 to 20 meters the number is reduced to 6 accidents that represent a 10.17% of the total. As we increase the depth, even being predictable higher seas, the number of accidents is gradually reduced.

As a summary, it can be said that more than half of the accidents happen where depth is less than 10 meters, and more than two third of the accidents happen in depths lower than two lengths of the implied boats.

2.8. Consequences of the Accidents

The result of the 100 accidents studied, was that 80 people suffered personal injury, with a result of 22 dead, 10 missing and 48 injured in varying degrees. Regarding the cause of death as many of them occurred in accidents related to the operation of the ship, with 12 people dead and 4 missing. The second cause was the collapse that collected between 2008 and 2013, 7 dead and 4 missing.

3. Conclusions

We have analyzed the study of 100 serious accidents between 2008 and 2013 carried out by the Commission for Investigation of Accidents and Maritime Incidents. It has to be

mentioned that of these 100 events, 37 occurred in dedicated artisanal fishing or small-scale gear vessels. On the other hand, the data shows that 44% of ships that suffered accidents were aged over 15 years, and 56% had a length of less than 15 meters. The risk for small vessels and artisanal or small-scale fishing gear vessels seems to be too high, maybe from difficulties to accomplish preventive measures, and sometimes overconfidence of the crews.

It is important that this research is addressing the issue of prevailing weather conditions when the accidents occurred, and which would provide information on the relationship between these and the accidents. In the study of severe accidents in Spain a mention of the weather conditions is generic, but does not detail what conditions were in the exact site, waves, wind, swell. In any case, it should be pointed out that a large part of accidents happened with moderate winds (Beaufort scale less or equal to 4). Moreover, it includes in them the fog and rain, conditions that are not expected to affect the stability of the ship or generate accelerations on the ship. The observation of the data reveals correlation of diverse causes:

In first place, a higher percentage of accidents occur to small vessels, and reduced crews. The support from one member of the crew to other diminishes the possibility of accidents. The overconfidence existing in reduced crews has to be avoided.

In second place, the fact that the nearer to the coast, the higher the percentage of accidents, points out also to the overconfidence effects. Also, the analysis of the sea depth at the place of the accidents (for those for which this could be appropriately determined) shows that near half of accidents happened at depths less or equal to 10 m. Probably the increased height of waves as depth is reduced is involved, as well as overconfidence could be accounted for.

In third place, the time intervals at which a large number of accidents happen, seem to point to a fatigue of the crew, and maybe also to operation with overconfidence, even though statistics is not very relevant in this point.

In fourth place, operation and dynamic effects might increase strongly the risk of accident, by destabilization of the ship. Weights placement and deck operation should be conducted consciously. Hoisting is a dangerous action. Smearing and dynamic effects by large waves (weather effects) can produce a loss of stability.

To avoid some of the accidents by the operation and by dynamic effects, it seems that automatisms and automatic control of the machinery can help, sensing weather (waves), accelerations, actual stability of the ship, loads, and forces the machines provide.

Besides weather conditions, a considerable number of causes of accidents seems to have overconfidence as an induction factor. Awareness and formation of fishermen should be the best way to reduce these accidents.

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