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Analysis of the main causes of Spanish fishing vessels sinking

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ABSTRACT

Throughout the history of mankind, fishing has been considered an almost inexhaustible source of food, and it was not until the second half of the 20th century that its regulation was contemplated. Over the centuries, fishing has been portrayed as a tough profession. There are many depictions of fishing vessels trapped by storms, and tragic moments for fishermen and their families are inevitable, such as the 1961 gale that affected northern Spain or more recent incidents like the sinking of the *"Villa de Pitanxo"* in 2022, where 21 people lost their lives. It appears that instead of decreasing, the number of sinking incidents has remained constant over the years. This article aims to uncover the causes of these events by analyzing various investigations conducted by the Permanent Commission for the Investigation of Maritime Accidents and Incidents, with the goal of revealing why fishing vessels continue to sink year after year.

1. Introduction.

In the world there are 4.1 million fishing vessels of all types [1], providing employment to over 200 million people who participate both directly and indirectly in fishing activities [2]. This industry is predominantly concentrated in Asia, where the demand for marine products is high, with countries like China, Indonesia, and India leading in fishing production [3].

Although the Spanish fleet cannot be compared with the Asian fishing superpowers, it stands as one of the most important fleets in the world, according to European statistics [4].

In 2021 the Spanish fishing fleet comprised, of 8 908 vessels boasting a combined capacity of 333,747 GT tonnage and 783,906 KW of power [5]. This sector generates approximately 953 million euros profit in Spain, supporting over 24 000 jobs [6]. Which represents approximately 1% of Spain's GDP, reaching 10% in regions where fishing is significant, such as Galicia or the Basque Country [7].

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Commercial fishing stands out as one of the most hazardous industries globally [8],[9]. In the United States, 130 fishermen perish annually per 100 000 workers in the sector during their workday, in stark contrast to the national average of approximately 4 deaths per year across all other sectors [10]. This alarming discrepancy underscores the extreme risks inherent in commercial fishing. Similar statistics are reported from the United Kingdom [11].

According to the report issued by the company Allianz, in 2022 out of the 38 ships sunk worldwide for various reasons, 6 were fishing vessels. Consistently, this type of ship leads the lists of maritime accidents [12].

In Spain, every year, the highest number of maritime accidents and incidents investigated by the Commission for the

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Investigation of Maritime Accidents and Incidents (CIAIM) is related to fishing vessels. For example, in 2022, out of the 291 vessels involved in events reported to the commission, 209 were fishing vessels, comprising 72% of the incidents [13]. These percentages are maintained over the years according to the commission's activity reports.

Therefore, Spanish fishing vessels maintain the trend of the rest of the world's fleets in terms of accidents and work accidents.

Fishing activity indeed takes place in a hostile environment, where economic pressure often forces work to be performed under extreme conditions, putting both fishermen and their vessels at risk [14]. Their income is directly proportional to their daily catch, which means that fishing vessels are consistently at the top of the list of maritime casualties.

According to sources from the organization responsible for fishing in Galicia, the autonomous community of Spain where the fishing sector holds the greatest economic significance, fishing has the highest number of fatal accidents, surpassed only by construction [15]. This reaffirms that fishing in Spain is consistent with the trends observed in fishing fleets worldwide.

One of the primary reasons for the sinking of these fishing vessels is stability loss, a widely studied phenomenon worldwide [16], [17]. However, the study should not only focus on ships sinking due to stability loss, as these are supposed to adhere to criteria outlined by the IMO in the *Torremolinos Convention* [18]. Accidents are often attributed to regulations, but they are also influenced by various other factors [14].

The Spanish fleet is not exempt from global concerns regarding human life loss within the sector. Infamous cases such as the sinking of the *"Virgen del Coral"* in 2000 remain vivid in the memory of the Spanish people. Other tragic incidents include the *"O Bahía"* (2004); *"Enrique el Morico"* (2004), *"New Pilin"* (2004), *"Always Casina"* (2005); *"New Nugget Aurora"* (2007), *"Lamb"* (2008), *"Landrove Brothers"* (2009), all occurring in less than a decade and resulting in a tragic toll of 39 deaths [19].

This study analyzes maritime accidents involving the Spanish fishing fleet by examining reports published by the CIAIM. The aim is to determine the main causes of fishing vessel losses.

2. Methodology.

The various studies carried out by the CIAIM on fishing vessels were used as a source for the study.

2.1. Permanent Commission for the Investigation of Maritime Accidents and Incidents (CIAIM).

The CIAIM is a collegiate organization affiliated with the Ministry of Transport and Sustainable Mobility of the Government of Spain. It is responsible for investigating maritime accidents and incidents involving Spanish civil ships, as well as foreign civil ships when they occur within internal waters or the Spanish territorial sea, or outside the territorial sea when Spain has significant interests

The CIAIM investigates:

- Very serious maritime accidents, defined as incidents resulting in total ship loss, loss of life, or significant environmental damage.
- Other maritime accidents and incidents which lessons in maritime safety can be derived.

The results of each investigation are documented in a report that includes factual information regarding the accident or incident, analysis, conclusions, and safety recommendations. These reports serve as the primary data source for the preparation of this study.

2.2. Selection of reports for evaluation.

The reports analyzed cover the period from the year 2008, the earliest available on the CIAIM website, to 2022. This study compares data from all investigations conducted by the Commission on fishing vessels during that timeframe. You can access the reports used through the following link: https://www.-mitma.gob.es/organos-colegiados/ciaim/investigaciones/2022.

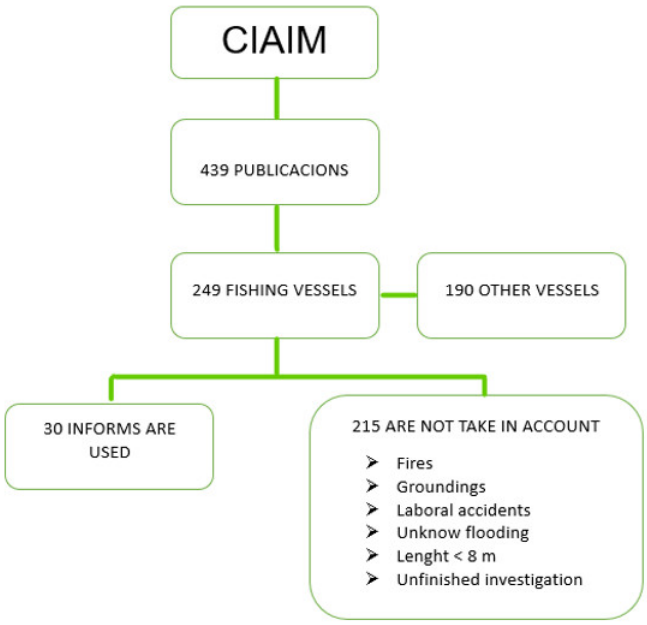
In total, over 14 years, the CIAIM conducted 439 investigations. Excluding cases unrelated to fishing vessels, the study focused on the remaining 249 reports. Following an initial review, reports were discarded if they did not meet the following criteria as a source of information:

- Unfinished investigation: In cases where a ship sinks to depths that prevent its recovery for subsequent administration study, the Commission cannot establish clear conclusions. Speculations about the most probable cause of the event are made in these instances.
- Fires: Although fires are a significant hazard for vessels, they are typically caused by crew negligence or mechanical failures and are therefore excluded from this study.
- Groundings: Often caused by human errors, lack of judgment, or mechanical failures.
- Occupational accidents: These include incidents such as crew members falling overboard or getting entangled with rigging, analyzed from the perspective of occupational risk prevention.
- Unidentified waterway as cause: These cases have diverse origins, and the CIAIM speculates on their appearance in most investigations based on statements from the skipper and crew. It's important to note that the clear cause of the sinking cannot be determined due to the vessel's inability to be recovered in many cases.
- Boats under 8 meters in length: Numerous cases involve small boats that typically capsize near the coast due to human error.

After applying these criteria, 30 cases were selected where the CIAIM thoroughly details the facts, leading to clear and

definitive conclusions regarding the causes of the sinkings. Figure 1 outlines the structure of the selected reports, and the supplementary material includes the names and access links to these 30 final reports.

Figure 1: Diagram depicting the reports examined in the study.



Source: Authors.

2.3. Data collection.

Once the selected reports were identified for analysis, the information was extracted into a database created using the Microsoft Excel application. This facilitated the identification of common factors contributing to the sinking of fishing vessels during the study period.

The data extracted into Excel includes the following categories: year of the event, year of construction, gross tonnage, name of the fishing vessel, length, beam, propulsion power, hull material, installation of closures, crew, type of fishing vessel, fishing gear, area of the accident, oceanographic conditions, cause of the accident, loss of the vessel, loading status and deaths.

It's important to note a legislative distinction regarding vessel length: fishing vessels less than 24 meters in length, primarily engaged in artisanal inshore fishing, are governed by Spanish regulations under Royal Decree 543/2007 [20]. In contrast, vessels exceeding 24 meters fall under international regulations established by the International Maritime Organization (IMO) under the *Torremolinos Convention* [18] which mandates safety standards. This distinction arose from variations in construction methods and fishing practices among different flag states presented at IMO assemblies.

Analyzing these cases requires differentiation due to varying vessel construction standards based on length. Factors such as freeboard, righting arm, and drainage ports, critical for ship safety, have different minimum requirements depending on vessel size and construction methods.

3. Results and Discussion.

The data extracted from the 30 reports analyzed are reflected in the following attached tables.

Table 1, in the column depicting the year of events, illustrates a notable peak in incidents involving fishing boats in 2009, with subsequent years consistently yielding 2 or 3 reports annually from the commission. This peak could be attributed to exceptionally adverse maritime conditions during that fateful year, or it may simply reflect the sporadic nature of such accidents.

On the other hand, regarding the construction years of the fishing vessels (Table 1), a distinction is made between vessels built before and after 1985. This year marks Spain's accession to the European Union and the subsequent adherence to the Common Fisheries Policy and EU construction standards. The majority of accidents occur on ships constructed after 1985.

Table 1: Results of the 30 studied cases extracted from the reports.

Year of event		Year of construction		Length		Hull Material	
2008	2	Before 1985	10	< 24 m	20	Steel	14
2009	8	After 1985	20	> 24 m	10	Wood	13
2010	3					GRP	3
2011	2						
2012	3						
2013	2						
2014	2						
2015	0						
2016	3						
2017	2						
2018	1						
2019	2						

Source: Authors.

The construction of modern fishing vessels is influenced by European policies that impose restrictions on the usable spaces below the last continuous deck, known as their net tonnage [21]. However, these regulations permit the installation of enclosed high spaces to enhance onboard conditions for fishermen during their work. For example, Figure 2 provides a visual demonstration of these high spaces installed on the last continuous deck of the ships.

Spanish vessels, as Spain is a member of the European Union (EU), are obligated to adhere to the Union's regulations concerning common fisheries. The EU, through Regulation No. 1380/2013 [22], establishes a set of measures for adoption by community fleets aimed at achieving sustainable and economically viable fishing practices that meet the demand for products within the EU's internal markets. To achieve this goal, the EU has implemented the Common Fisheries Policy, which regulates all aspects of community fleets, including resource exploitation, fishing techniques, and, to some extent, the construction standards of fishing vessels.

Figure 2: Constructive evolution of fishing vessels, the "Nuevo Padre" boat, an artisanal fishing boat of 16,5 meters in total length dedicated to bottom longline fishing.

Source: Authors.

One of the measures adopted to control fleets is the regulation of vessel tonnage, which aims to prevent excessive exploitation of resources. In addition to tonnage, another measure considered to control fishing effort is the propulsion power of the fishing vessels [23].

In Spain, regulations stipulate that to build a new fishing vessel, proof of scrapping a vessel of similar tonnage must be provided [24]. This policy aims to maintain fishing effort levels within specified limits. Consequently, shipowners often pressure engineers to design fishing vessels that maximize use of available spaces by reducing their draft. This allows for larger vessels with significant high spaces that do not count towards the maximum working tonnage. These spaces are frequently used by fishermen to store equipment, provisions, or fishing gear. However, this practice can lead to vessels operating with shallow drafts, making them more susceptible to weather conditions and tidal changes.

As a result of this practice, vessels often go out to sea overloaded and with compromised initial stability. This situation has been linked to incidents such as those involving the vessels *"Furacán"* (2009), *"Hermanos Landrove"* (2009) and *"Alvi"* (2018).

Moreover, the installation of these enclosed high spaces disrupts the natural drainage mechanisms traditionally present in vessels. This can lead to water accumulation in the fishing hold, exacerbating stability issues and increasing vulnerability to water ingress incidents. An example of such vulnerability is observed in the case of *"O Terror Dos Mares"* (2019).

It is essential to consider that in fishing vessels, the deck is typically exposed to water ingress, whether during navigation due to the vessels' shallow drafts or during fishing operations. This exposure to water ingress has always been a constant element in all types of fishing vessels, from trawlers to longliners.

On the other hand, the majority of accidents are concentrated in smaller vessels, specifically in 20 out of the 30 cases analyzed. These artisanal fishing boats often belong to family units that are economically reliant on fishing activity [25]. Consequently, skippers, who are frequently also the vessel owners, may take greater risks than their boats can handle. An illustrative example is the case of the *"Siempre Diana"* (2013), where the vessel's ability to withstand waves of 3 meters and winds of 22 to 27 knots was exceeded during a storm.

It can be concluded that in most of the investigated accidents, very adverse oceanographic conditions were not a significant factor. The maximum wave height observed in these events did not exceed 3 meters of significant wave height.

However, it has been noted that these boats are small, limiting their ability to withstand storms on the high seas. Several incidents occurred due to the impact of waves and strong winds, such as with the *"O terror Dos Mares"* (2019), the fishing boat *"Nuevo Santiago Primero"* (2016), and previously mentioned *"Siempre Diana"* (2013).

In the case of the fishing boat *"O Terror Dos Mares",* the water entered on the port side because the vessel crossed into the sea. The boat had a watertight structure at the stern not documented on her seat sheet, making her highly susceptible to wind and wave action. When the boat navigated into open waters, the waves began to affect the port hatch, through which water started entering, accumulating on the deck and flooding the engine room, which had its hatch open. This caused flooding of the fishing park, leading to a loss of transverse stability.

About half of the boats analyzed had wooden hulls (Table 1), a traditional and cheaper material compared to steel or fiberglass - reinforced polyester. The construction of these boats dates back to 1913, as seen with the *"Virgen del Mar"* (2011) and continues until 2002 with the *"Nuevo Santiago Primero"* (2016). Wooden hulls were the preferred material during the first half of the 20th century but have increasingly fallen into disuse, being replaced by steel for new fishing boats [25].

The main cause of the sinking of these wooden fishing vessels is the flooding of various compartments due to the breakage of one of the wooden strakes in various parts of the vessel. This was the case for the *"Unión Familiar"* (2011), *"Basibina"* (2012), *"Bearro Tercero"* (2013), *"Segundo Durán"* (2016) and *"Juan y Virgilio"* (2016). These breakages caused leaks that the crew could not bail out, resulting in the boats capsizing.

On the other hand, the remaining 10 cases involve larger fishing boats, which are mostly built of steel (Tabla 1). This significantly reduces incidents due to structural failures of the hull, unlike the smaller wooden fishing boats that are more prone to such events.

This statement does not imply that steel-hulled fishing boats are immune to sinking due to uncontrolled flooding. There are numerous reports of larger steel fishing boats sinking as a result of flooding in the engine room from unknown origins.

Additionally, compared to smaller boats, these larger vessels often leave port overloaded for long days of fishing on the

high seas. This overloading reduces their depth and stability, leading to incidents like the sinking of the *"Monte Galiñeiro"* (2009). The sinking of the *"Monte Galiñeiro"* (2009), although caused by a flash flood in the fishing park, was exacerbated by its normal operation while overloaded, significantly hastening its sinking and reducing the response time for the crew on board.

Another vessel that sank due to flooding in the fishing park was the *"Gure Uxua"* (2017), which capsized because its drainage ports were closed, preventing water evacuation. This led to diminished stability of the vessel, compounded by external navigation conditions, ultimately causing a loss of transverse stability and resulting in the vessel overturning within minutes. Similar incidents occurred with the *"José Almuiña"* (2008), or the *"Rosamar"* (2008), highlighting a recurring pattern among this type of boat.

Regarding hull materials, wooden and steel hulls remain predominant in the construction of fishing vessels, with similar usage figures. In contrast, the adoption of newer materials like Reinforced Polyester Fiberglass (PRFV) remains limited.

In Table 2, another set of data reveals that the crews of fishing vessels involved in accidents typically consist of fewer than 5 people, reflecting the smaller size of these vessels where crew numbers are naturally limited.

Table 2: Data regarding the endowment, type of fishing vessel and cause of the event in the analyzed reports.

Endowment		Type of fishing vessel		Cause of the event	
Less than 5	16	Artisanal fishing	11	Fishing park flood	8
Between 5 and 10	6	Trawler	11	Engine room flooding	6
Between 10 and 15	7	Purse seiner	4	Loss of stability	5
More than 15	1	Flyer	3	Structural failure	4
		Longliner	1	Flood	3
				Sea blow	2
				Adverse weather conditions	1
				Track of watter	1

Source: Authors.

From the analysis of various cases, it can be affirmed that the accident rate of fishing vessels is divided into two main categories: trawlers and vessels engaged in artisanal fishing. The latter category includes a variety of fishing gears, particularly used by small vessels over 24 meters in length.

Of the 30 cases analyzed, 11 involve trawlers. This method of fishing involves deploying nets into the water, which function as bags to capture the fish. Trawling is classified as active or mobile fishing gear because the vessels actively pursue the fish.

The operation of trawling is relatively straightforward. First, the nets are deployed into the water. Once fully extended, one or two boats drag the nets along the bottom, capturing everything in their path. These nets can operate either on the seabed (bottom trawl) or in the middle of the water column (pelagic trawl).

The greatest risk faced by these types of trawlers occurs during the hoisting of the codend. Current technology does not allow for precise determination of the weight being hoisted, relying instead on the experience of the crew and the skipper. Hoisting an excessively heavy codend can lead to capsizing, as evidenced by the case of the *"Senefand I"* in 2019. This vessel sank due to attempting to lift an overly heavy codend, which caused a pronounced list, allowing water to flow through the drainage ports and flood the fishing deck and adjacent compartments.

Trawlers are generally large vessels, most exceeding 24 meters in length, and they account for a significant number of fatalities. In the cases analyzed, there were a total of 20 deaths, with 9 occurring on trawling fishing vessels. Due to the nature of their fishing gear, these vessels are more prone to operational accidents and face greater risks when shipping the catch. Notable examples include the sinking of the *"Ficha Segundo"* (2010) and the *"Villa de Aguete"* (2009), both incidents directly related to the specific challenges of trawling.

With regard to the various causes of the sinking of the vessel, the most frequent are flooding of the fishing park, flooding of the engine room and loss of stability.

A significant proportion of the vessels in question feature enclosed spaces of considerable dimensions, as evidenced by Table 3. These spaces have been installed with the intention of enhancing the conditions of the fishermen on board, with the principal objective being to protect them from inclement weather. Consequently, their installation has been a popular choice among shipowners.

Table 3: Results extracted from the reports on the overloaded condition, installed high spaces and the deaths.

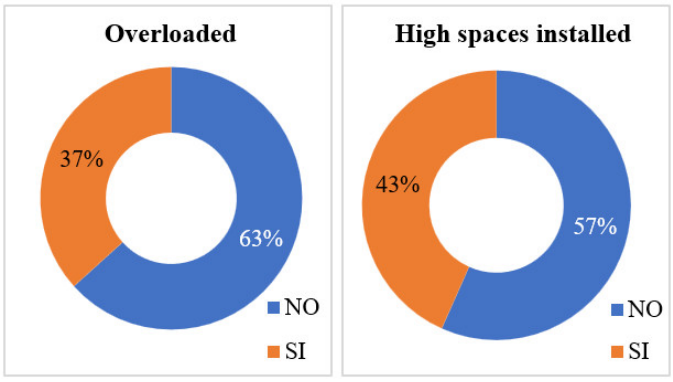
Overloaded		Installed high spaces		Deaths
Yes	11	Yes	13	20
No	19	No	17	

Source: Authors.

Furthermore, it is important to note the direct correlation between the installation of high watertight spaces above the main deck and the fact that many of the ships that capsized had the Plimsoll disc submerged. Figure 3 illustrates the correlation between the instances of vessels that were overloaded and subsequently sank, and those that had high-watertight spaces installed.

The data demonstrate a direct correlation between the departure of overloaded vessels and the presence of these closures on board. It is logical to conclude that the installation of these spaces provides fishermen with the opportunity to store a wider range of items on their boats, including butane bottles for the

Figure 3: Comparative graphs of vessels with installed and overloaded high spaces.



Source: Authors.

kitchen, provisions and fishing gear. These spaces were previously unavailable on their vessels.

This utilisation of spaces, however, has the potential to cause a series of extremely detrimental effects for boats. The first of these effects is the state of going out to sea overdraft due to overload, which reduces the depth of the vessel and compromises its freeboard, allowing entry in the event of the slightest change in the vessel's conditions. This is followed by the flooding of the fishing park and consequently the rest of the watertight areas through the drainage ports, which allows water to enter the vessel.

It is important to consider that the ship will experience fluctuations in its loading condition throughout the tide. While it is true that there is fuel consumption and other weights on board, in general, ships tend to arrive at port with more weight than they departed with, which is a consequence of the catches they have made. This further compromises the safety of the vessels.

To illustrate, in the case of the *"Landrove Brothers"*, the overload was such that they had to sail with the drain ports closed to prevent water from entering the vessel. These safety elements were designed to evacuate water from the deck in such situations, ultimately becoming integral watertight components of the vessel.

Furthermore, sailing with the drainage ports closed entails significant risks. These ports are essential safety elements designed to allow the free evacuation of water from the deck. When they are forced to remain closed due to a reduction in freeboard, they cannot perform this function, directly leading to dangerous conditions. In the event of flooding, the inability to evacuate water can result in a loss of transverse stability due to the formation of free surfaces, as seen in the cases of the *"Gure Uxua", "José Almuiña", "Ficha Segundo"*.

The installation and use of these heavy weights raise the center of gravity, thereby decreasing the distance between the center of gravity and the metacenter. This reduction leads to a decrease in the initial transverse stability of the fishing vessel. Consequently, even minor alterations can cause a significant loss of transverse stability, accelerating the vessel's sinking and reducing the crew's reaction time in an emergency.

In many cases, the boats ventured out overloaded for work, compromising their navigability at sea and reducing their stability. Finally, it is noteworthy that out of the 30 events analyzed, 20 fishermen lost their lives out of the total 195 involved in these accidents.

Conclusions.

The events investigated by the CIAIM and analysed in this article show a number of common pre-accident factors in several cases.

A large percentage of the boats, regardless of their length, went out to work with reduced stability because they were overloaded, exposing the vessel to the effects of the sea, water on the deck, shifting of the load or the effects of the fishing gear, elements that directly affect the stability of the boat. They suffer a loss of transverse stability, which in the end causes the boat to capsize quickly.

Small-scale fishing vessels, which are smaller and have a variety of fishing gear, are more prone to capsize due to adverse oceanographic phenomena. Skippers take unnecessary risks, resulting in boats that are unable to withstand the successive assaults of the sea.

Trawlers account for the highest number of fatal accidents, not only because of the causes mentioned above, but also because of the danger inherent in trawling gear. These vessels still do not have a method of knowing exactly how much weight they are going to lift, which sometimes results in overloading and sinking due to operational errors.

On the contrary, boats with wooden hulls are more likely to suffer events related to structural failure, due to the breakage or separation of the wooden strakes, causing flooding in some of the lower spaces of the boat, such as the living room. of machinery or the refrigerator used to store fish, which are unable to evacuate the water by themselves, causing the boat to sink due to progressive loss of buoyancy.

It is true that the harsh conditions of commercial sea fishing make the occurrence of accidents inevitable in a first analysis. However, in the cases analysed, there is an inappropriate combination of antecedent conditions, adverse circumstances and accidental or fortuitous factors that lead to the occurrence of accidents and that cause fishing vessels to remain at the top of the list of maritime accidents year after year.

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