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Stability, safety and operability of small fishing vessels

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ABSTRACT

In this paper, the relationship between stability, safety and operability for small fishing vessels is investigated. To this aim, a relevant set of small fishing vessels is selected. These have similar main dimensions and capsized in stability related accidents between 2004 and 2007. The stability and operability characteristics of such vessels are confronted with those of the vessels that had been decommissioned in order to build them, operated by the same crews, in the same areas and using the same fishing gear types. Such vessels are considered as reference safe vessels since their operational life came to an end without any hazards. With regard to stability, fulfilment of the intact stability criteria in force when the vessels were designed and built is verified. Operability criteria are selected and their fulfilment is analyzed for a range of sea states, headings and velocities using linear seakeeping analysis. In light of this analysis, operability is discussed as a valid indicator of ship safety. This step is considered relevant prior to analyzing these sets of vessels through second generation stability criteria under development by the International Maritime Organization, a subject of immediate future research.

1. Introduction

Commercial fishing is one of the most hazardous occupations today, with fatality rates being widely documented in the specialized literature. In the US, they are around 130 fatalities per year for every 100,000 fishing sector workers, compared to 4 for the rest of the sectors (Lincoln and Lucas, 2010); similar alarming figures are reported in the UK (UK MAIB, 2010).

In Galicia, the region of Spain where the fishing sector is most prevalent, with more than one half of the fishing fleet and workers of the whole country, fishing accounts for a very high number of fatal accidents during the working day, second only to the construction sector which employs a much larger percentage of the Spanish working force. It can be seen that most of the casualties happen in vessel-related accidents (or maritime accidents) and among these, losses due to stability problems (capsizing or large heeling) account for half, mainly in vessels of length below 24 m (Míguez González et al., 2012). This analysis is consistent with Jin et al. (2001) who demonstrated that capsizing is the type of accident where crewmembers have the highest probability of dying.

Between November 2004 and September 2007, five Spanish-flagged fishing vessels capsized due to loss of stability resulting in a large part of their crew dead. Examining the five accidents side by side, it is noticeable that the vessels had similar characteristics, in particular that their lengths ranged between 15 and 24 m and that they had all been built between 1999 and 2001 in accordance with a recent tonnage distribution regulation (Mata-Álvarez-Santullano and Souto-Iglesias, 2013).

The shipowners, masters and crews of the capsized vessels were the same that had been operating the vessels decommissioned in order to build the lost ones. The decommissioned vessels are referred to hereinafter as “predecessors”. Moreover, it can be reasonably argued that the uses of the capsized vessels were analogous to the predecessors' since they operated in the same area, using the same fishing gear and in the same social framework. The predecessors had been in service for many years, while the five fishing vessels which succeeded them sank, after a short operational life, in stability related accidents. It may therefore be interesting to try and study the differences, at various levels, of these two sets of vessels.

All these lost vessels complied with the IMO (International Maritime Organization) stability regulations, implemented in 1970 in the Spanish legislation. Despite this fact, the lack of stability caused all accidents. Given the growing complexity and specialization of vessels and also given that the current stability criteria could not properly cover part of the dynamic phenomena present in several stability related accidents, the IMO has recognized that

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Nomenclature

B	breadth [m]
D	depth to main deck [m]
DISF	displacement [t]
GM	transversal metacentric height [m]
KG	center of gravity height over base line [m]
LBP	length between perpendiculars [m]
LOA	length overall [m]
T	mean draft [m]
RT	register tonnage
VA	vertical acceleration [m/s^2]

the current stability framework can be improved. It has therefore established working groups to develop the so called "Second Generation Intact Stability Criteria" (SGISC) (IMO, 2008). This new regulation is still under development and has not yet been approved by the IMO. Surely those works will constitute the basis for future stability regulations, which sooner or later will apply to fishing vessels. The proposed new stability regulation under discussion contemplates the use of CFD codes to assess the ship vulnerability to some stability failure modes. Nevertheless, the IMO working group undertaking this task, has not yet agreed on the stability direct assessment methodologies, that is, the seakeeping calculations with CFD codes are put in question by some delegations, mainly due to the lack of validation of the codes (IMO, 2013, 2012).

Mantari et al. (2011) looked at the links between stability and safety by considering the actions of fishing gear, wind and beam waves from the perspective of intact stability. They compared the inclining and righting arms for different operational conditions and evaluated the balance of energy of these external forces. They came to the conclusion that the inclining moments deriving from the fishing gear are, in many occasions, at least as important as the heeling moments produced by rough weather scenarios.

The links between safety and seakeeping has been analyzed by some authors under several approaches. Tello et al. (2011) proposed a methodology based on seakeeping calculations for the analysis of fishing vessels operability. They studied several vessels of the Portuguese fishing fleet, proposing operability criteria with their corresponding limiting values. They concluded that roll and pitch criteria are the most often exceeded ones, and identified some trends in hull shape that optimize the fulfillment of those criteria.

The idea that arises is that the relationship between safety and operability needs to be studied.

The masters operate their ships when motions experienced onboard are below certain levels and interrupt fishing operations only when those are surpassed and operation is not possible. They are hence the first to assume that a ship with a larger operability range is a safer ship. This relation needs a rigorous assessment, which we aim at conducting in this paper by analyzing the aforementioned reference case studies, namely, by comparing some stability and operability characteristics between the five vessels lost and their predecessors. It is worth noting that this work does not intend to model specifically the accidents suffered by the lost vessels, neither to assess their stability in rough weather. The aim of the paper is to investigate the relationship between the regulatory stability and operability of these two relevant sets of vessels as one necessary step in understanding the limitations and prospects of the former.

The paper is organized as follows: methodology of the analysis is first presented by briefly reviewing IMO regulations on stability and by selecting operability criteria for a seakeeping analysis. Second, the case studies are presented looking at their main dimensions, weights, etc. Third, results for intact stability and operability based on seakeeping analysis are presented and compared between the families of new vessels and decommissioned ones. Finally a discussion is provided concerning the limitations of the IMO transversal stability criteria with respect to prevention of stability failure and the suitability of operability based criteria to help in fishing vessels safety assessment.

2. Methodology

2.1. General

Five fishing vessels that sank due to stability failure are studied. The studied fishing vessels are similar in size, relatively small (LOA between 16 and 20 m), built between 1999 and 2001, and were lost from comparable stability causes between 2004 and 2007. Building any of these vessels meant that one or more existing fishing vessels had to be decommissioned refraining the tonnage of the whole fishing fleet from increasing, according to the European fishing effort regulations in force. In the five cases studied more than one vessel had to be decommissioned, The largest among the decommissioned vessels will be the selected "predecessor" of the capsized fishing vessel and will be considered a reference safe vessel for comparisons. Normally, and what was the case for the considered pairs of vessels, a fishing vessel and her "predecessor" share many characteristics such as master, crew, fishing zones, gear type, base port, etc., since the shipowner is usually the same person.

For each lost fishing vessel and her respective predecessor, a characteristic loading condition is established. Each vessel has been studied in one loading condition only, chosen from the available information, normally being the full load condition. In the case of vessels for which no stability booklets were available (most predecessors) using the best available information a loading condition close to the full load is estimated. Then, stability and operability calculations for both vessels are performed.

2.2. Regulatory stability

2.2.1. General

The vessels stability is checked against the IMO stability criteria for fishing vessels proposed in the "Code on intact stability for all types of ships covered by IMO instruments", approved by the IMO Assembly Resolution A.749(18).

Spain adopted these stability criteria in 1970 which were therefore mandatory when the five vessels studied were designed and built. Since it was not mandatory when the five predecessors were built, the IMO Severe Wind and Rolling Criterion (weather criterion) has not been considered in the present study. Regarding the five lost vessels, according to the Spanish stability regulations, compliance with the weather criterion has to be checked only if the area under the stability curve up to 30° is below 0.065 m rad in the most unfavorable loading condition. All five vessels concerned had larger area stability curves and therefore the previously mentioned weather criterion did not apply in any case.

Intact stability calculations have been performed with state of the art naval architecture software, considering free trim. No free surfaces in tanks have been considered. The center of gravity has been considered to be at midship. For the cases where the stability