TRANSNAV International Journal on Marine Navigation and Safety of Sea Transportation
Volume 2
Number 3
September 2008

Total Losses of Fishing Vessels Due to the Insufficient Stability

P. Krata
Gdynia Maritime University, Gdynia, Poland

ABSTRACT: The paper presents the statistic data analysis of total losses of the fishing vessels. The emphasis is put on the total losses caused by the insufficient stability of considered ships. The research is focused on the fishing vessels, which are relatively small ones in marine industry, so they are most affected by the wind and rough sea. The correlation between type of the vessel, its size, the shape of its hull and the capsizing statistic is presented. The regularities noticed in course of statistic analysis allows to formulate the suggestions regarding the influence of some hydrodynamic phenomena on the safety of fishing vessels and the number on their total losses at the sea.

1 INTRODUCTION

Fishing vessels, especially small fishing vessels, are the largest class of marine professional vessels. This group of ships has been built and operated for ages but it still generates the great danger for the crew, ships and environment. The huge number of accidents and serious disasters occur in spite of the development of naval architecture, weather forecasting, means of communication, etc. The total losses of ships and losses of human lives are sad facts, therefore any investigation of the accidents' reasons and any attempt to improve present situation are worthy to be undertaken.

2 STATISTICS OF FISHING VESSELS' TOTAL LOSSES AND LOSSES OF HUMAN

The total losses statistics presented in this paper are based on data collected by last three decades of twentieth century. Hundreds of marine accidents where fishing vessels were involved were taken into consideration. The main source of the accidents information are The Casualty Returns of Lloyd's Register of Shipping and The Lloyd's Weekly Casualty Reports. All considered ships were over 500 gross registered tonnage and they were divided into groups up to different criteria (Achutegui, Mendiola & Azofra 2000).

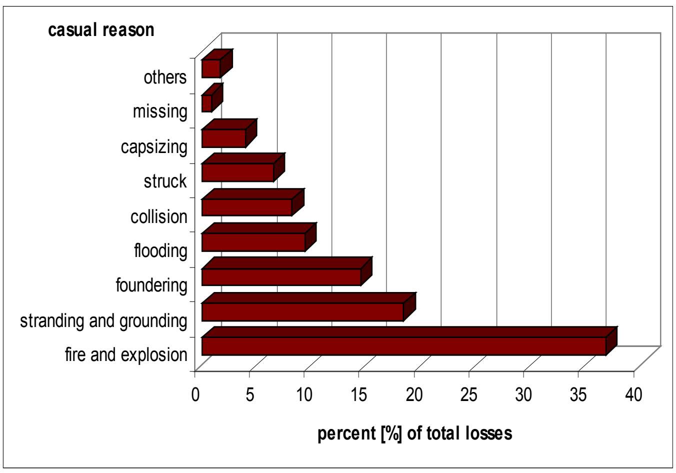

Fig. 1. Distribution of the reason of fishing vessel total losses (source - own study based on data published in (Achutegui, Mendiola & Azofra 2000))

The distribution of the reason of analyzed fishing vessels' total losses is shown graphical in figure 1.

The loss of stability involving capsizing of the ship is one of the rarely noticed reason of the total losses. Its rate is only 4% of all casual causes. Although the rate of capsized vessels is much higher in the group of smaller ships, not considered in presented statistics.

Regardless the danger to the ship, the fishing vessels operations affect the safety of crew working on board. Commercial fishing industry is one of the most dangerous and deadly. Fishers in the United States in 2000 were ranked as the second in deaths per thousand workers, right behind timber cutters. In recent studies performed by Roberts of the University of Oxford in 2002 fishers had the most dangerous job in Great Britain (Womack 2002). The statistic data confirms such judgment. The insufficient stability of ships is one of the most important reason of deaths on board of fishing vessels. The distribution of causes for loss of human life during fishing vessels' total losses is shown in figure 2.

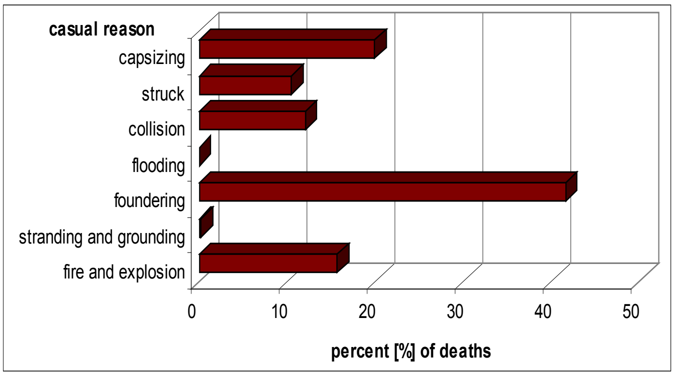

Fig. 2. Distribution of the causes for deaths during fishing vessel total losses (source - own study based on data published in (Achutegui, Mendiola & Azofra 2000))

Fig. 3. Distribution of the causes for deaths per one fishing vessel total loss (source - own study based on data published in (Achutegui, Mendiola & Azofra 2000))

Capsizing is the second often reason of the loss of human life, although it causes only 4% of all total losses of fishing vessels. The rate of deaths during capsizing reaches almost 20%. The rate of death per one ship's loss is even worse. It is 7,07 loss of human being per one fishing vessel lost, when the average rate is 1,40 only. The distribution of the causes for deaths per one fishing vessel total loss is shown in figure 3.

The comparison of the average rate of deaths and the characteristic high rate noticed for capsizing, shows the level of threat during the capsizing and generally the condition of insufficient stability. The rate of deaths per one capsizing disaster, which is over five time higher than average one, justify further consideration of this relative rare phenomenon.

3 ANALYSIS OF CAPSIZING STATISTIC

As the ship's capsizing is the type of disaster which cause lots of deaths, the detailed analysis in particular groups of fishing vessels were made. All cases of capsizing reported in official data were divided into typical sets by three criteria: the type of fishing vessel, the gross register tonnage and the age.

The distribution of capsizing rate by the type of the vessels is shown in figure 4. The symbols used in the graph are following: MST - motor stern trawlers, MT - motor trawlers, MFV - motor fishing vessels, MSTFF - motor stern trawlers fish factory, StT - steam trawlers. The names of vessels types correspond with the division used for statistic data collecting (Achutegui, Mendiola & Azofra 2000).

The predominating group of capsized fishing vessels represents motor stern trawlers and the second one motor trawlers. Those both types of ships suffered over 71% of all capsizing. It is characteristic for both of them, that the freeboard is relatively small. Additionally the stern trawlers have low and almost open stern, what is necessary for the type of fishing operations. The coexistence of such shape of the trawlers hull and the high rate of capsizing should be underlined.

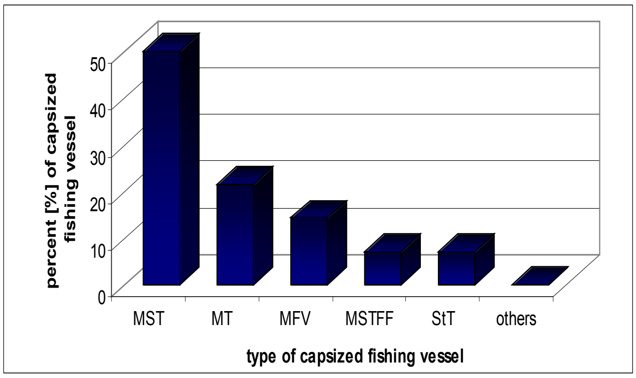

Fig. 4. Distribution of capsizing rate by the type of lost vessel (source - own study based on data published in (Achutegui, Mendiola & Azofra 2000))

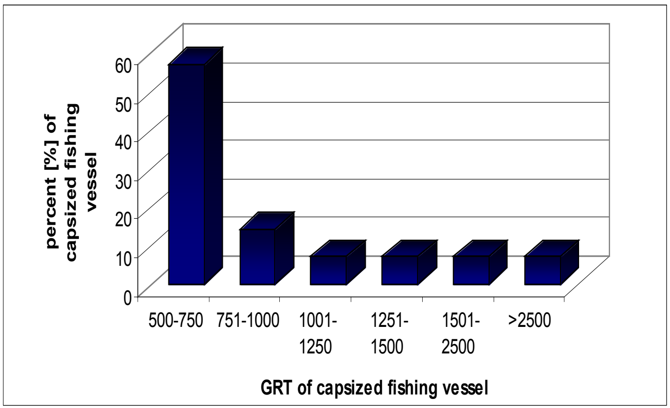

Fig. 5. Distribution of capsizing rate by GRT of lost vessel (source - own study based on data published in (Achutegui, Mendiola & Azofra 2000))

The next step was taking into consideration the size of the capsized fishing vessels. Six sizes up to the gross register tonnage were established. The distribution of capsizing rate by the GRT of fishing vessels is shown in figure 5. There is the strong relationship between the size of considered vessels and the rate of its capsizing. Over 57 % of capsized ships were under 750 GRT. The vessels of size smaller than 500 GRT were not taken into consideration.

The last factor taken into consideration was the age of the capsized fishing vessels. Six age categories were established: ships from 0 to 5 years old - "new", 6 to 10 years old - "relatively new", from 11 to 15 years old - "middle age", 16 to 20 years old - "relatively old", 21 - 25 years old were considered as "old" and over 25 years old - "very old". The distribution of capsizing rate by the age of fishing vessel is shown in figure 6.

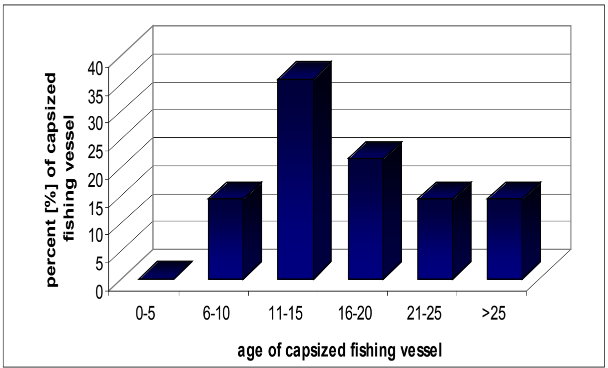

Fig. 6. Distribution of capsizing rate by the age of lost vessel (source - own study based on data published in (Achutegui, Mendiola & Azofra 2000))

The highest rate of capsizing was noticed for middle age ships (almost 36% of all capsized fishing vessels). The second most inflicted to capsizing group of vessels are relatively old ones. The figure 6. shows, that there is no rule - the older the worse.

4 CAPSIZING AS THE EFFECT OF INSUFFICIENT STABILITY

Number The capsizing is the fatal phenomenon caused by the insufficient stability of the ship in actual operating conditions. For fishing vessels 24 m or longer, the main mean for determining the intact stability is evaluating the characteristics of hull's static righting arm curve (Womack 2002). The principal stability criteria are contained in the IMO 1993 Torremolinos Protocol (IMO 1993). There are various versions of the protocol, adopted by different countries, but the major modifications to the IMO version are the addition of a minimum range of positive stability, typically 60° or more (Womack 2002).

The criteria adopted by IMO represent the simple static attitude towards complicated nonlinear dynamic behavior of the vessel. The weather criterion, which is the attempt of dynamic stability calculation, is based on the static righting arm as well. The vessels shall be able to withstand the effect of severe wind and rolling in associated sea conditions in which the vessel will operate (IMO 1993). But no dynamic evaluation of the rolling and wind guests take place in course of stability calculation. Additionally, when the stability of fishing vessel is to be evaluated, some important circumstances are omitted. First of all the influence of fishing gear's towing should be taken into consideration. The arrangement of additional forces affecting the trawler is shown in figure 7.

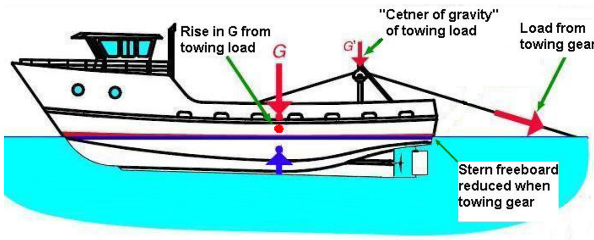

Fig. 7. The towing load affecting ship's stability (source (Womack 2002))

The stability of the vessel towing the fishing gear is reduced by some effects. The first is the rise of the center of gravity, due to fishing gear load placed virtually on the top of cable reels. The other reason for the stability decay is the lower freeboard, especially in the stern of the trawler. That may be the reason of the loss of relatively small ships, which capsize the most often (see statistic in figure 5). The next factor affecting ships' stability is the shift of load as the vessel heel. The negative effects of towing the fishing gear are shown in figure 8.

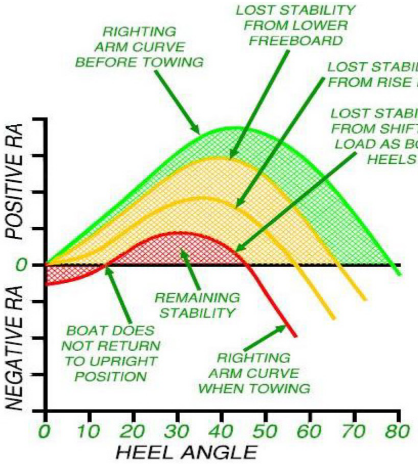

Fig. 8. Negative effects of towing of fishing gear (source (Womack 2002))

Another effect resulting the danger to fishing vessels may be the water trapped on deck and its dynamic influence (Jankowski & Laskowski 2006). Such situation is most likely during the towing of fishing gear by the small trawler. There is an accumulation of free board lowering (see figure 7) and the characteristic construction of stern trawlers having almost open stern for fishing operations. The water trapped on the deck may also come into the processing spaces, what considerably effects the ships stability and results deeper rolling on the seas. The example of such situation may be the capsizing of fishing vessel *Arctic Rose*. The disaster was described in details (Lieutenant 2002).

The fishing vessel *Arctic Rose* had been disappeared in the Bering Sea on April 2, 2001, killing all fifteen men onboard. The U. S. Coast Guard convened a Formal Marine Board of Investigation to determine what had happened to the vessel and why it had happened. According to the analysis, the most likely reason the *Arctic Rose* sank had been progressive flooding from the aft weather deck to the processing space and the flooding then progressed to the galley, fish hold, and engine room through non-watertight doors and hatches (Lieutenant 2002). The effect of loss of buoyancy of the superstructure on the static righting arm curve is shown in figure9. With the superstructure nonbuoyant, the angle of maximum righting arm is at the angle of deck edge immersion. With the superstructure buoyant, the angle of maximum righting arm is increased to the angle at which the top of the superstructure is immersed. However, if the superstructure cannot physically be kept watertight due to openings without closures and operational considerations, the buoyancy is lost (Lieutenant 2002).

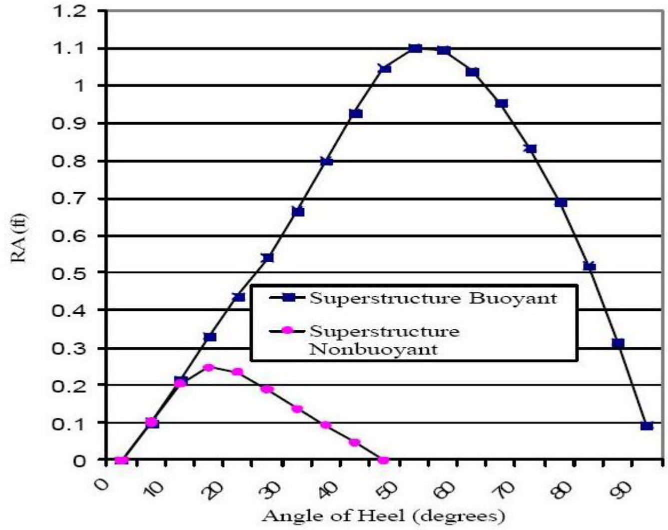

Fig. 9. Arctic Rose righting arm curve RA: openings closed - upper curve and openings remaining open - lower curve (source (Lieutenant 2002))

Additionally, water on deck often leads to progressive flooding into spaces inside the fishing vessel in which watertight doors and hatches have been left open, which is precisely the most likely scenario of the loss of the *Arctic Rose* (Lieutenant 2002). The sophisticated analysis of dynamic behavior of Arctic Rose containing the water inside its hull was performed. The results of the analysis are shown in figure 10. The great increase in rolling amplitude is evident.

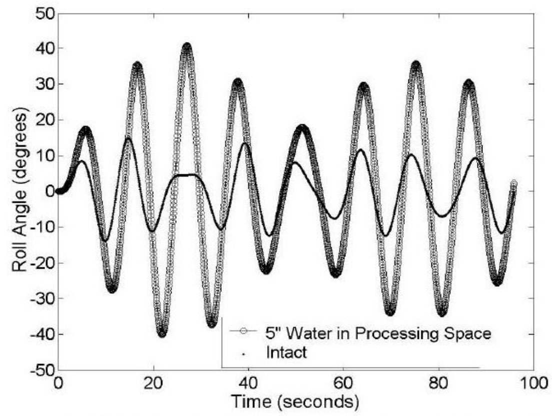

Fig. 10. Roll angle time history for Arctic Rose (source (Lieutenant 2002))

The improper use of passive anti rolling tanks may have the similar effect to the sloshing of water trapped on deck. It is described in (Transportation Safety Board of Canada 2006) when capsizing of small fishing vessel *Ryan's Commander* is analyzed. Just before the capsizing, the combined effects of beam seas and increasing gust wind force caused the vessel to roll slowly to port. The significant weight of some 1.6 tons of slack water in the anti rolling tank was not evenly balanced, as it also gravitated to the port side, and, with the liquids in the other tanks, contributed to the heeling effect. The accumulation of shipped water on the port side of the main deck continued until eventually it overcame the vessel's ability to right itself (Transportation Safety Board of Canada 2006).

5 CONCLUSIONS

The capsizing is not often occurring phenomenon at the sea, although it cause considerable number of fatalities. The statistic analysis of total losses of fishing vessels and the crew's deaths suggest several main factors related with the capsizing rate.

The first feature influencing the capsizing rate is the size of the vessel. Generally the smaller is the vessel, the bigger is the risk of capsizing. This is due o the scalability in vessel stability. It depends on the square-cubed rule; i.e. the heeling forces, which depend on water and wind impact areas, go up with the square of the dimensions, but the righting moment which depends on the displacement, goes up with the cube of the dimensions (Womack 2002). The vessel twice as large as another one has roughly eight times the righting energy as the smaller vessel if both have the same righting arm curve. Yet for the larger vessel the wind impact forces have only increased four times over the smaller vessel (Womack 2002).

The next circumstance exposing fishing vessels to the risk of capsizing is omitting in stability calculations the load of fishing gear being towed by the trawlers. The towing load results in lowering of freeboard and rising in the height of center of gravity.

Another factor is the influence of the water trapped on the deck of the vessel. This event is most likely on the small fishing vessel with low or open stern. The dynamic behavior of the shipped water, affects the ship's intact stability and it also may be the cause of flooding of the hull. The free surface effect appearing inside the fish hold, restricts the righting ability of the vessel considerably. The sloshing water may be able to lead to ship's capsizing, as presented in examples of *Arctic Rose* and *Ryan's Commander*.

The improvement of present situation could be significant modification of formal stability criteria applied for fishing vessels, especially for small fishing vessels. The first point should be getting rid of the same stability standards for the vessel of any size. There should be worked out the restrictions regarding the freeboard and obligatory advices for skippers with regard to dynamic behavior of the vessel on heavy seas and with water trapped on deck. The steady rise in the level of skipper's education is the point to be taken into consideration as well.

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