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Agenda item 20

MSC 87/INF.3
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GENERAL CARGO SHIP SAFETY

IACS FSA study – Step 1 (Evaluation of Historical Data)

Submitted by International Association of Classification Societies (IACS)

SUMMARY	
Executive summary:	This document provides in the annex the report of the Evaluation of Historical Data (FSA Step 1) from the FSA study that has been conducted by IACS regarding General Cargo Ship Safety.
Strategic direction:	5.2 and 12.1
High-level action:	5.2.1 and 12.1.2
Planned output:	12.1.2.2
Action to be taken:	Paragraph 3
Related documents:	MSC 77/25/4; MSC 85/19/1; MSC 86/INF.4 and MSC 87/20/1

1 At MSC 77, the issue of General Cargo Ship Safety was brought before the Committee by RINA (MSC 77/25/4). IACS has been carrying out an FSA study on General Cargo Ships. The results of step 1 (Evaluation of Historical Data) were submitted to IMO (MSC 85/19/1 and MSC 86/INF.4) and have recently been updated to include two additional years of historical data so that it now represents the period 01/01/1997 to 31/12/2008, as set out in the annex.

2 As reported in MSC 87/20/1, subsequent to undertaking this step 1, the casualty records for general cargo ships have been investigated by IACS and the risk model developed for ships with a gross tonnage of 500 or above and built after 1982. This risk model (step 2 of an FSA) is reported, as set out in document MSC 87/INF.4.

Action requested of the Committee

3 The Committee is invited to note the report as set out in the annex and take it into account, as appropriate, in its further consideration of this issue.

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IACS
INTERNATIONAL ASSOCIATION OF CLASSIFICATION SOCIETIES LTD.

Date 2010-01-07

ANNEX I

Formal Safety Assessment of General Cargo Ships – Preparatory Step (Step 1)

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1 Abstract

In this report the results of the evaluation of historical data for *General Cargo Ships* are summarised. This is a preparative step for a Formal Safety Assessment (FSA) for this ship type. The objectives of the analysis and evaluation are the determination of frequencies for different consequences of accidents and the identification of items that should be a focus of the subsequent analysis. The historical data used in the present analysis are taken from the databases for casualties and ship register provided by Lloyds Register Fairplay (LRF) for ship sub-categories specified with different StatCode5v. The dataset is restricted to vessels which are classed as general cargo ship, with a gross tonnage greater than 499 and with a due or delivered date specified by LRF later than 1981-12-31. In the final calculation of accident frequencies only IACS ships are considered. This is due to assumed under-reporting of accidents for ships that are not classified by an IACS society.

2 Introduction

The issue of general cargo ship safety was noted at IMO in 2006 in the submission by Russia (MSC 82/21/19, 2006). This submission highlights the disparity between the fraction of general cargo ships of the world fleet (17 % in number of ships) and the share of this ship type of all total losses (42 %) and of all fatalities (27 %) for the period 1999 to 2004. It was further explained that approximately 73 general cargo ships were lost each year in this period. Additionally, it was stated that in 2004, based on Paris MoU statistics, general cargo ships had the second highest rate of port State control inspections with deficiencies (60% of inspections of general cargo ships compared with an average of 54% for all types of ships) and detentions (8% of inspections of general cargo ships compared with an average of 6% for all types of ships).

At MSC 83 several additional papers that focus on general cargo ship safety were submitted. In these submissions the safety with respect to other ship types (MSC 83/20/1, 2007; MSC 83/20/5, 2007), the causes of total losses of general cargo ships and the causes of fatalities on general cargo ships (MSC 83/20/3, 2007) are further highlighted. According to the cited submissions, occupational risk contributes with 63 % (MSC 83/20/3, 2007) of the total risk.

The importance of general cargo ship safety was also highlighted by the EMSA *Maritime Accident Review 2008* (EMSA, 2009).

To bring forward the discussion of general cargo ship safety, IACS started a project on the statistical analysis of general cargo ship safety. This report summarises the results of the initial review of accident data and fleet data which provide the basis for further analyses within a FSA.

For this analysis the LRF PC-ship register of 2007 and the LRF casualty database of 2007 are used. Both provide one of the most extensive databases in their fields. However, in the present analysis some issues regarding the use of databases for the determination of statistical parameters are identified, most notably

- Underreporting,
- Unrecorded change of certain properties over time (e.g. class, ship type).

It should be noted that these issues are considered general problems of databases in this area of industry, and are not believed to be unique for LRF databases.

This report contains an update of the investigation submitted to IMO (MSC 86/INF.4) and considers the historical data until 2008-12-31.

The focus of a statistical evaluation of historical data is to provide a snapshot for a specific period. The consistency between statistics and reality is mainly influenced by the completeness of the data used. Incomplete casualties records, e.g. caused by underreporting, yields lower accident frequencies than in reality and thus results in a more optimistic evaluation. In order to reach a complete consideration of casualty reports comprehensive capturing of accident information is required. With respect to the world wide operation of ships the acquisition of accident data inclusive their causes and their consequences require a sophisticated system. The analysis of casualty reports performed within the scope of this project indicates that presently no consistent acquisition with respect to flag or class can be achieved. The reasons for this inconsistent data acquisition are unknown. It is also concluded that the present casualty databases are affected by underreporting. For instance, one group of ships with a strong indication of underreporting in the database used is the ships operating in national waters and without assignment to one of the major classification societies.

Additionally, the correct determination of ship-years also influences the accident frequency. For the calculation of accident frequencies the number of ship years is required. For this report the calculation of ship years is based on the dates of "due or delivered" and "scrapped or lost" considering the operating date (and not only the year). The presently available data permit the accurate calculation of ship years and thus the frequencies, for instance, for a ship type. However, focussing on smaller groups, e.g. for single societies, this is not possible because the database reflect only the present class assignment, and does not keep track of class changes. Such discrepancies were detected when IACS member societies compared LRF data to own records.

The first analyses give strong indications of underreporting for ships of non IACS societies. Consequently, to minimize the effect of under-reporting for this analysis only the data for IACS ships are considered to be representative for general cargo ships. For ships larger than 20,000 GT this assumption has no or limited effects as nearly 100 % of these ships are classified by IACS member societies. The results of the first analyses lead to the following definition of scope for the update:

- Ships "due or delivered" after 1981-12-31 and before 2009-01-01 (corresponding to a maximum ship age of 27 at the end of the investigation period);
- A gross tonnage greater than 499;
- Classed by IACS society (based on the assignment in LRF 2009);
- Casualty reports for IACS classed ships and classified as "severe" accident.

The statistical data in terms of accident frequency are produced for:

- the size categories:
    - $500 \leq GT < 1{,}000$;
    - $1{,}000 \leq GT < 20{,}000$;
    - $20{,}000 \leq GT$.
- the accident categories:
    - All severe (accidents leading to structural damage, rendering the ship un-seaworthy (penetration of hull underwater), immobilisation of main engines, extensive damage, breakdown, actual loss and any other situation resulting in damage or financial loss considered to be serious);
    - Total loss;
    - Killed and missing.

As mentioned above occupational risk is the main risk category with respect to safety (MSC 83/20/3, 2007). This aspect is further investigated and the results summarised in this report. Occupational risk data provided by the Norwegian Maritime Directorate (NMD) is considered. For the ship years, the abovementioned scope still holds but with the additional restrictions that only ships registered to Norway (NOR) or in the Norwegian International

Register (NIS) are considered. Furthermore, in these analyses only personal accidents, i.e. only accidents involving individuals and not the ship itself is considered.

3 General Cargo Ship and the Database

The focus of this analysis is the ship type "General Cargo Ship". LRF provides definitions of all ship types in the LRF database by means of "StatCode5v". An overview of the ship type classification by LRF is shown in Figure 3-1. For the analysis of the ship type "General Cargo Ship" the sub-types "General Cargo" (A31A), "Palletised Cargo Ship" (A31B) and "Deck Cargo Ship" (A31C) are considered. For these sub-types further sub-categories are defined within LRF (Figure 3-1). Based on this classification the following ship sub-types are considered in the analysis for "General Cargo Ship":

- General cargo ship (with RoRo facilities) A31A2GA;
- Open hatch cargo ship A31A2GO;
- General cargo/tanker (Container/oil/bulk – COB ship) A31A2GS;
- General cargo/tanker A31A2GT;
- General cargo ship A31A2GX;
- Palletised cargo ship A31B2GP,
- Deck cargo ship A31C2GD,

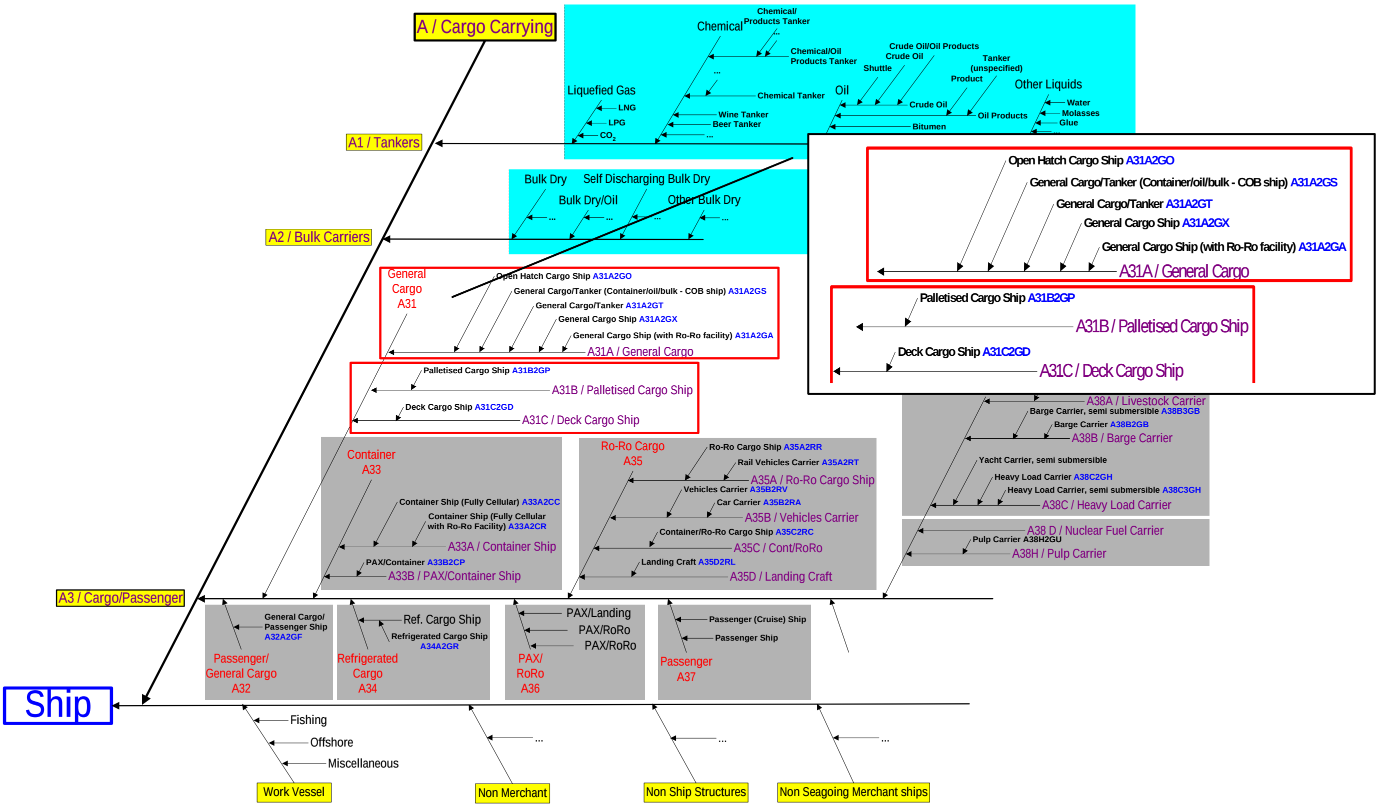

Figure 3-1: Classification of ship types using StaCode5v of LRF.

For these ship sub-types LRF provides the following definitions summarised in Table 3-1.

Table 3-1: Definition of sub-types of general cargo ships corresponding to StatCode5v (LRF)		
StatCode5v	**Name**	**Description / Definition**
A31A2GA	General Cargo Ship (with Ro-Ro facility)	A general cargo ship with the additional capability to be loaded and unloaded by ro-ro access to a limited portion of the cargo space
A31A2GO	Open Hatch Cargo Ship	A large single deck cargo vessel with full width hatches and boxed holds for the carriage of unitised dry cargo such as forest products and containers. Many are fitted with a gantry crane
A31A2GS	General Cargo/Tanker (Container/oil/bulk - COB ship)	A general cargo ship with reversible hatch covers; one side is flush and the other is fitted with baffles for use with liquid cargoes. Containers can be carried on the hatch covers in dry cargo mode
A31A2GT	General Cargo/Tanker	A general cargo ship fitted with tanks for the additional carriage of liquid cargo
A31A2GX	General Cargo Ship	A single or multi deck cargo vessel for the carriage of various types of dry cargo. Single deck vessels will typically have box shaped holds. Cargo is loaded and unloaded through weather deck hatches
A31B2GP	Palletised Cargo Ship	A single or multi deck cargo ship loaded and unloaded by way of pallets lift(s). There are no weather deck hatches
A31C2GD	Deck Cargo Ship	A vessel arranged for carrying unitised cargo on deck only. Access may be by use of a ro-ro ramp

The selection of all ships without size limitation (greater than 99 GT[1]) and using the above mentioned sub-type criteria yield 22787 ships. This group does *not* contain:

- All ships scrapped or lost before 1997-01-01;
- All ships coming into service (due or delivered) after 2008-12-31;
- All ships on order;
- All ships cancelled, pending, input errors.

The breakdown of the ship sub-types of these reports is summarised in Table 3-2. It can be seen that 97 % of all general cargo ships that were active between 1996 and 2007 belong to the category A31A2GX. It is believed that all ships which cannot be assigned to another sub-type are found in this category. For the ship type A31A2GS no active ships are listed in LRF.

[1] Minimum size considered in LRF database

Table 3-2: Number of ships per StatCode5v category and active between 1996 and 2009 (GT > 99)							
Sub-type	A31A2GA	A31A2GO	A31A2GS	A31A2GT	A31A2GX	A31B2GP	A31C2GD
No. of ships	129	255	0	16	22110	69	208

LRF provide a variety of data for the ships e.g. IMO number, class, ship size etc. In the data field "Classed By" the present classification is specified. A classification society is defined by LRF as an organisation that publishes and overseas rules for the construction and maintenance of ships. Twenty-four classification societies were found in LRF, which are in alphabetic order:

American Bureau of Shipping
Biro Klass Indonesia
Bulgarski Koraben Registar
Bureau Veritas
China Classification Society
China Corp Register
Croation Register
Det Norske Veritas
Germanischer Lloyd/East German Register
Hellenic Register
Indian Register
Jugoslavia Register
Korea Class Society
Lloyd's Register
Nippon Kaiji Kyokai
Polish Register
Registro Cubano
Registro Italiano Navale
Rinave Portugesa
Romanian Register
Russian Maritime Register of Shipping
Korean Register of Shipping[2]
Turk Loydu
Vietnamese Register

(The ships of the former East German Register are still in the LRF database. Due to the handling during the unification process of Germany these ships are considered Germanischer Lloyd ships.)

Several of the ships covered by Table 3-2 are believed to operate in national waters only, and almost no accidents to these ships are recorded in LRF. These ships are not equally distributed over the flags. For instance, of the 1,168 presently active ships built after 1981, with a gross tonnage greater than 499 GT and with "Class Unknown"[3], 578 ships are assigned to only four flags (Cambodia, China, Panama, Japan). In order to include these ships in the data analyzed, the accident statistics must be reported to different channels.

It is worth noting that the LRF database contains no data concerning the classification society for a significant amount of ships (12,637 of 22,787). The comparison with the data for the period 1982 to 2006 shows that still new ships appear in the category "Class Unknown". The distribution of the ships "Class Unknown" with respect to year built and ship size (gross tonnage) was further analysed. An overview for all ships coming into service before 2009

[2] The official name is 'Korean Register of Shipping'

[3] Ships with no class assigned in LRF

(> 99 GT, not scrapped or lost before 1997) with respect to the size categories specified for this analysis is summarised in Table 3-3. This overview shows that the size category of ships smaller than 500 GT in particular is affected by the missing information of class. 87 % of all ships with no class assigned belong in this group. However, also 71 % of the ships between 500 GT and 1,000 GT, 39 % of the ships between 1,000 GT and 20,000 GT as well as 3 % of the ships greater than or equal to 20,000 GT had no class assigned in the database.

Table 3-3: Proportion of ship reports for "Class Known" and "Class Unknown" classified into ship size categories (ships delivered before 2009 and not scrapped before 1997)

	100 ≤ GT <500	500 ≤ GT < 1,000	1,000 ≤ GT < 20,000	20,000 ≤ GT	Σ
Class Known	882	666	8272	331	10151
Class Unknown	5793	1623	5208	12	12636

3.1 Investigation of database

To investigate if some characteristics could be identified for the class assignment the number of ships built per year is determined (Figure 3-2). This figure shows that a significant number of general cargo ships are built before 1980 (11,765), where some of them are built in the first decade of the last century. These ships mainly belong to the group "Class Unknown". The maximum commissioning of general cargo ships in this group is observed for the year 1977 with 446 ships delivered in this year (followed by the years 1970 with 436 and 1971 with 430). After 1997 this figure is declining until today to about 50 to 70 ships per year. The group "Class Known" mainly consist of "younger" ships with a maximum of annual commissioning in 1985 with 384 units. Further, Figure 3-2 shows that after year 2000 about 80 % of all ships commissioned are classed by one of the 24 societies listed above.

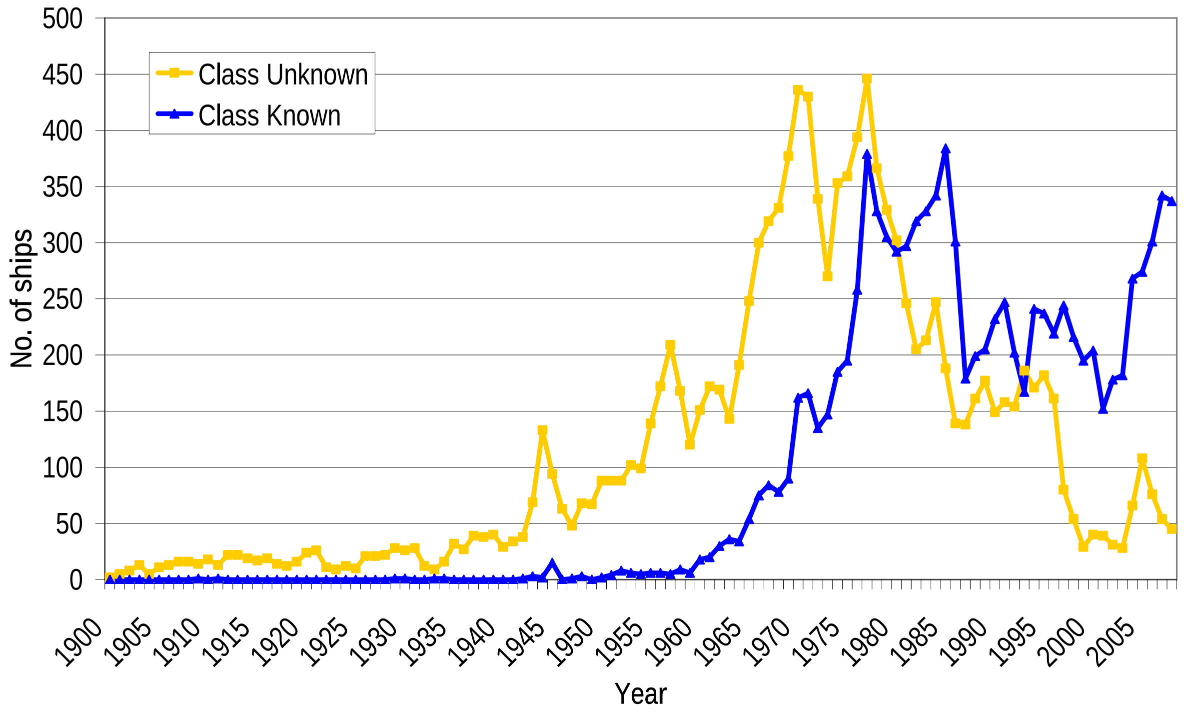

Figure 3-2: Number of ships built per year for the groups "Class Known" and "Class Unknown". All general cargo ships selected in LRF considered (neglected: 44 ships without delivery date).

Given that until the beginning of the 80's ship owners of general cargo ships had no preference for class societies not listed above, the distribution of "Class Known" and "Class Unknown" indicates a general trend to transfer older ships from the group "Class Known" to "Class Unknown". The update of the first analysis shows that this trend is unbroken.

It becomes obvious that the database for general cargo ships contains a significant number of ships (11632) that are built before 1980 (Figure 3-2). IMO regulations as well as class rules are subject to continuous improvement, for instance requirement of damage stability calculation for dry cargo vessels entering into force in 1992.

The focus of this analysis is to provide a basis for a Formal Safety Assessment. The intention of FSA is to identify safety deficiencies and to propose cost-efficient risk control options to reduce the risk as low as reasonably practicable. To reach this goal a mostly homogenous group of ships is essential.

Thus and due to the limited available information concerning the ships of the group "Class Unknown" with respect to survey and building rules, all ships built before 1982 are excluded from further analysis. Additionally, also ships smaller than 500 GT are excluded from the next steps of the analysis, because the complete SOLAS is only required for ships greater than or equal to 500 GT. After the exclusion of all ships built before 1982 and smaller than 500 GT 7,477 ships remain (Class Known: 6143, Class Unknown: 1334).

Furthermore, because of the possible access to additional information provided by the class societies involved in this analysis and for minimizing the effects of under reporting on the analysis results, only ships classified by an IACS society in 2008 and all casualty reports for ships belonging to an IACS society at the date of incident are considered in this investigation. This group consist of 5114 ships that were active between 1997-01-01 and 2008-12-31. Of these about 93 % (4764) belongs to the ship type A31A2GX. Due the small number of ships in the ship type categories A31A2GA, A31A2GO, A31A2GT, A31B2GP and A31C2GD the StatCode5v categories are not further considered in this analysis.

Figure 3-3 shows the number of ship years with respect to the age determined for the specified period (1997 to 2009). The age of a ship is calculated with respect to the 31st December of each year. Due to selection criteria for the sample (built after 1981) the maximum age is limited to 27. Figure 3-3 shows for the whole fleet a relatively constant number of ship years per age class up to about 15 years of age (between 1600 ship years and 2100 ship years). Above the age of 15 the ship years per age class decreases continuously with increasing age. This observation is explained by

- scrapping of older ships,
- change of class: based on the investigations summarised above it is concluded that older ships often change class to a non-IACS society or another organisation and, hence, are not considered in the sample.
- The specification of the sample which considers only ships built after 1981, which means that only ships delivered in 1982 can contribute to the ship years for age 27, while only ships delivered in 1982 and 1983 can contribute to the ship years for age 26, and so on.

For the size class 500 GT to 1000 GT a deviating figure is observed. Here the number of ship years is continuously increasing from the age of one to about 15 years and then following the general trend. This could be an indication of a decrease in the new building for this size category or that new ships are mainly not classed by IACS societies.

For the ships greater than or equal to 20,000 GT the maximum number of ship years per age class is 70, which is reached for the age class one. Afterwards the number of ship years per age class is decreases to about 20 ship years at the age of 8. Above the age of 8 the number of ship years is alternating about this value until an age of 21. The maximum age is 27 years.

More detailed results with respect to the development of the fleet age (mean age per year) are broken down into the three size categories and are shown in Figure 3-4 to Figure 3-6. To indicate the spread of ship age about the mean value the standard deviation is plotted for each year.

For the largest group of the sample (1,000 ≤ GT < 20,000, Figure 3-5) these results show that the IACS fleet has presently a mean age of about 13 years. This value is nearly constant since 2005. However, as shown in the figure the standard deviation is still increasing which indicates that the number of older ships is still growing.

Due to the fact that the number of new ships is decreasing for the size category 500 GT to 1000 GT (Figure 3-4) it is understandable that the average age is continuously growing and presently reaching 18.

For general cargo ships greater than 20,000 GT the investigation shows an average age alternating about nine years for the whole observation period.

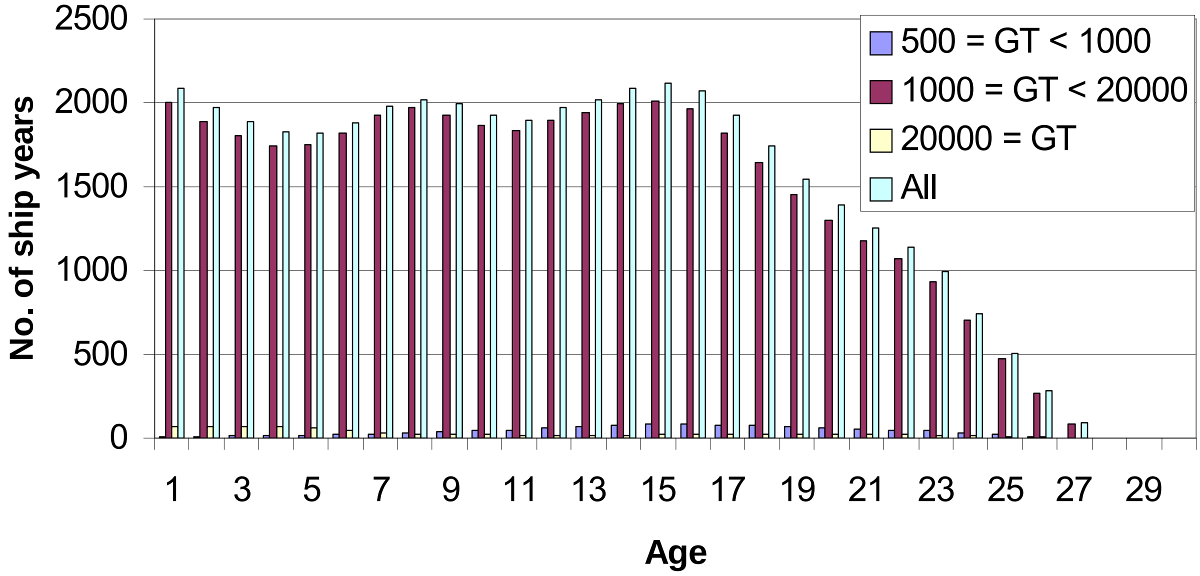

Figure 3-3 Number of ship years observing the given age within the period from 01.01.1997 to 31.12.2008. Ships (A31A2GX) built after 1981 and classed by IACS societies.

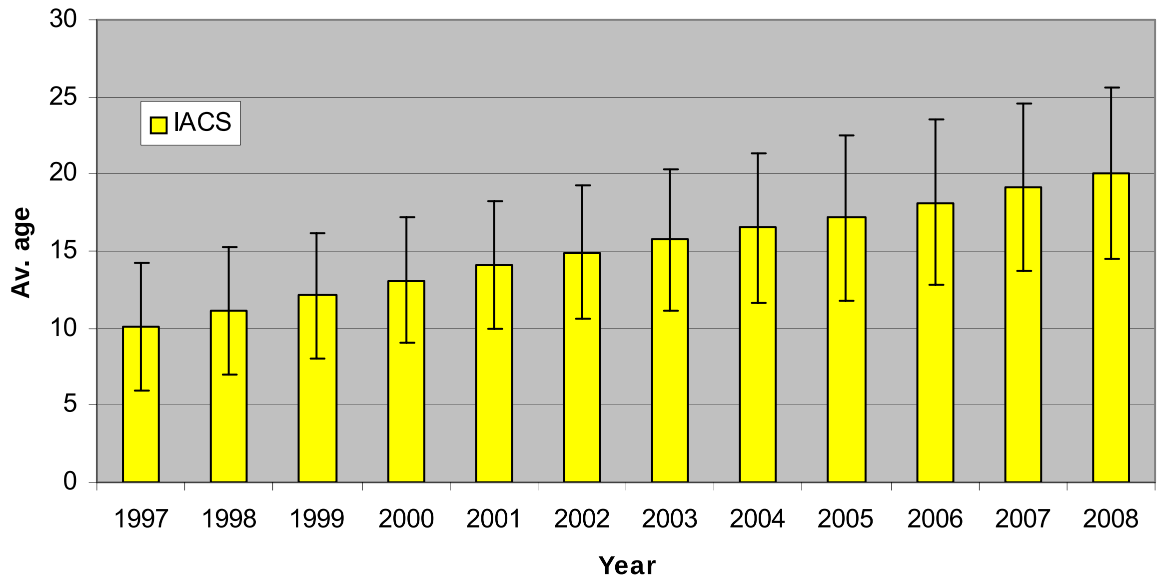

Figure 3-4: Average age of the ships between 1996 and 2009 (± one standard deviation) for IACS class ships of size 500 ≤ GT < 1,000.

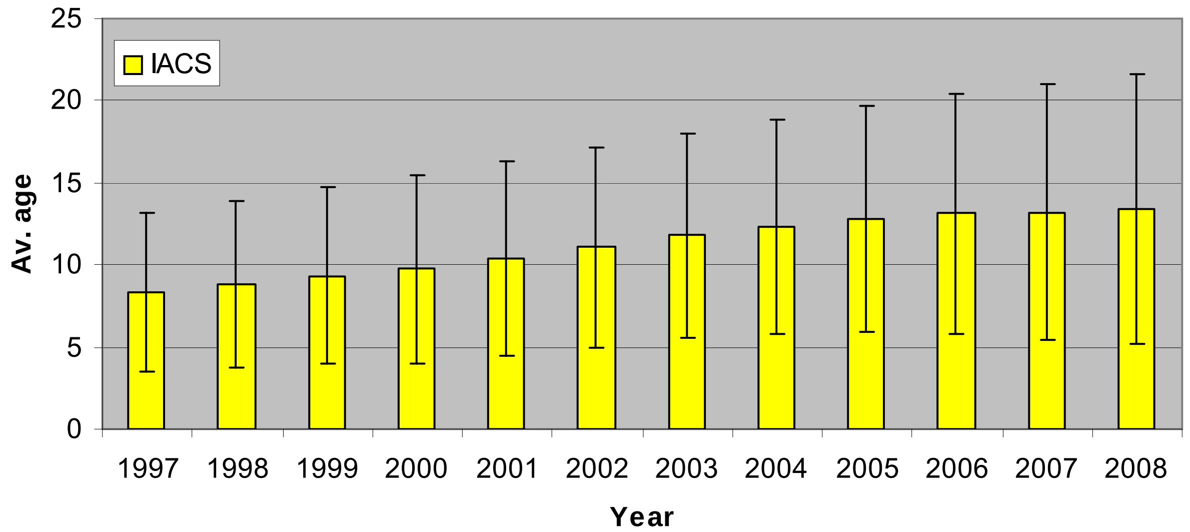

Figure 3-5: Average age of the ships between 1996 and 2009 (± one standard deviation) for IACS class ships of size 1,000 ≤ GT < 20,000.

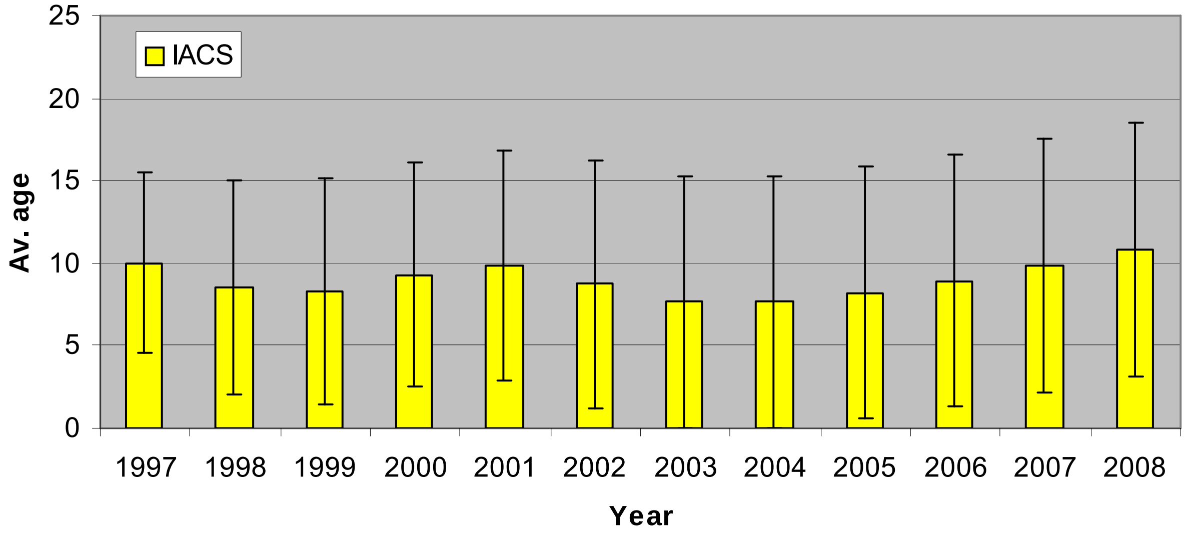

Figure 3-6: Average age of the ships per year (± one standard deviation) for IACS class ships of size ≥ 20,000 GT.

3.2 Casualty reports

The number of accidents is determined using the LRF casualty database (version 2009-03-26). Only accidents classified as severe and for ships classed by an IACS society at the date of incident are considered (1,462 accidents). A comparison of the LRF casualty reports with the reports in GISIS for “collision” and “wrecked/stranded” shows that GISIS contains about one third of the LRF reports. However, about 50 % of the GISIS reports contain the basic accident data like date and location and no further information with respect to the course of events.

Table 3-4 shows the number of casualty reports for the different ship size categories. The vast majority of reports (1400) are for the ships with a gross tonnage greater than 1,000 and below or equal to 20,000. This is in agreement with the number of ship in this size category. In the last two years the number of casualty reports increased by 462.

Table 3-4: Number of casualty reports for the different ship size groups of IACS class ships and for the period 1997-01-01 to 2008-12-31.

500 ≤ GT < 1,000	**1000 ≤ GT < 20,000**	**20,000 ≤ GT**
51	1400	11

In the LRF casualty reports accident categories are distinguished as follows:

- Collision (CN)
- Contact (CT)
- Foundering (FD)
- Fire and Explosion (FX)
- Hull and Machinery (HM)
- Missing (MG)
- Miscellaneous (XX)
- War loss (LT)
- Wrecked or stranded (WS)

For the size category 1,000 ≤ GT < 20,000 the location of accident was investigated for the accident categories CN and WS. The information provided by LRF in terms of Marsden Grid shows that 72 % of all collision accident and 63 % of all grounding took place in only ten Grid rectangulars (**Table 3-5**). The results are shown in Figure 3-7for collision and in Figure 3-8 for wrecked/stranded

Table 3-5: Number of casualty reports CN and WS for the "top ten" locations and size category 1,000 ≤ GT < 20,000 (1997-01-01 to 2008-12-31).

Collision	Marsden Grid	%	Wrecked/Stranded	Marsden Grid	%
46	216	20.1%	52	215	16.7%
29	215	12.7%	37	216	11.9%
25	132	10.9%	21	181	6.8%
24	131	10.5%	18	131	5.8%
11	178	4.8%	13	178	4.2%
7	181	3.1%	13	250	4.2%
7	177	3.1%	12	142	3.9%
6	99	2.6%	11	177	3.5%
5	141	2.2%	11	252	3.5%
5	130	2.2%	9	251	2.9%

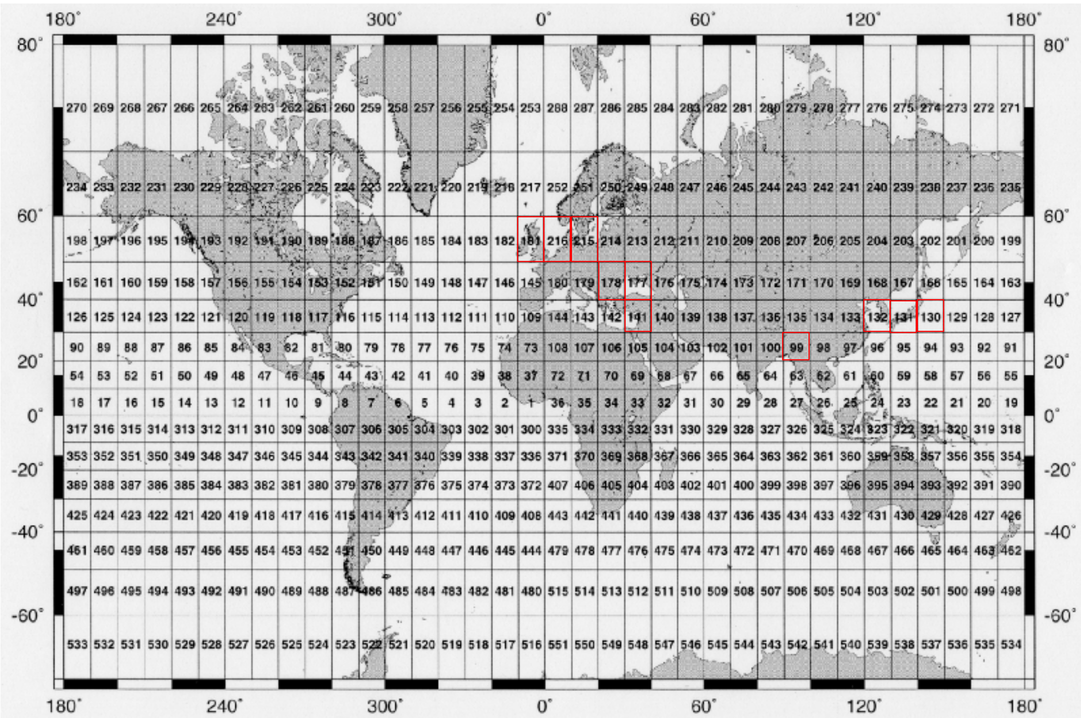

Figure 3-7: "Top ten" locations for collision accidents shown in Marsden Grid. (Size category 1,000 ≤ GT < 20,000; period 1997-01-01 to 2008-12-31)

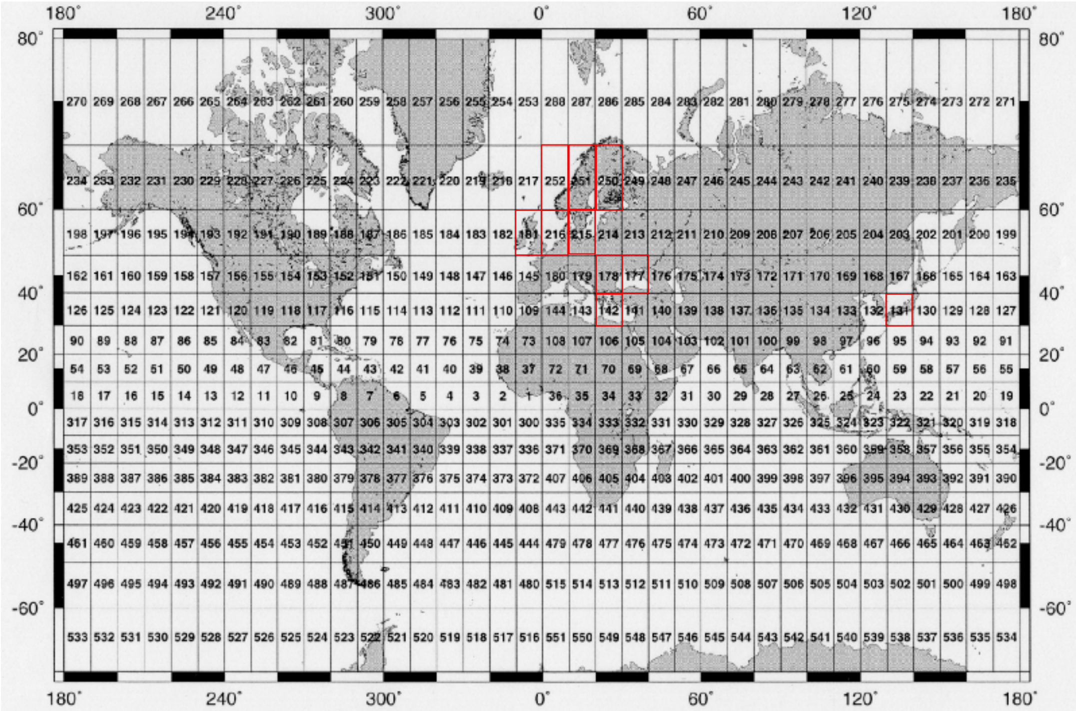

Figure 3-8: "Top ten" locations for collision accidents shown in Marsden Grid. (Size category 1,000 ≤ GT < 20,000; period 1997-01-01 to 2008-12-31)

The development of the accident numbers broken down into the accident categories was investigated (Figure 3-9). After 2003 the total number of accidents per year increased mainly driven by collision (+ 430 %), wrecked/stranded (+ 140 %), hull/machinery (+130 %), contact (+ 125 %) and foundering (100 %). Actual, the annual number of accidents is about 230.

This development is in contrast to other ship types, for instance, large crude oil tanker (DWT > 60,000 tonnes) (Figure 3-10). For crude oil tanker a significant decrease in the total number of accident as well as for the accident frequency is observed whereas for General Cargo Ships the total number of accidents increases. This development is a result of the growing IACS fleet as well as an increase of the accident frequency. The development of the annual accident frequency is investigated in Section 4.1 and plotted in Figure 4-1.

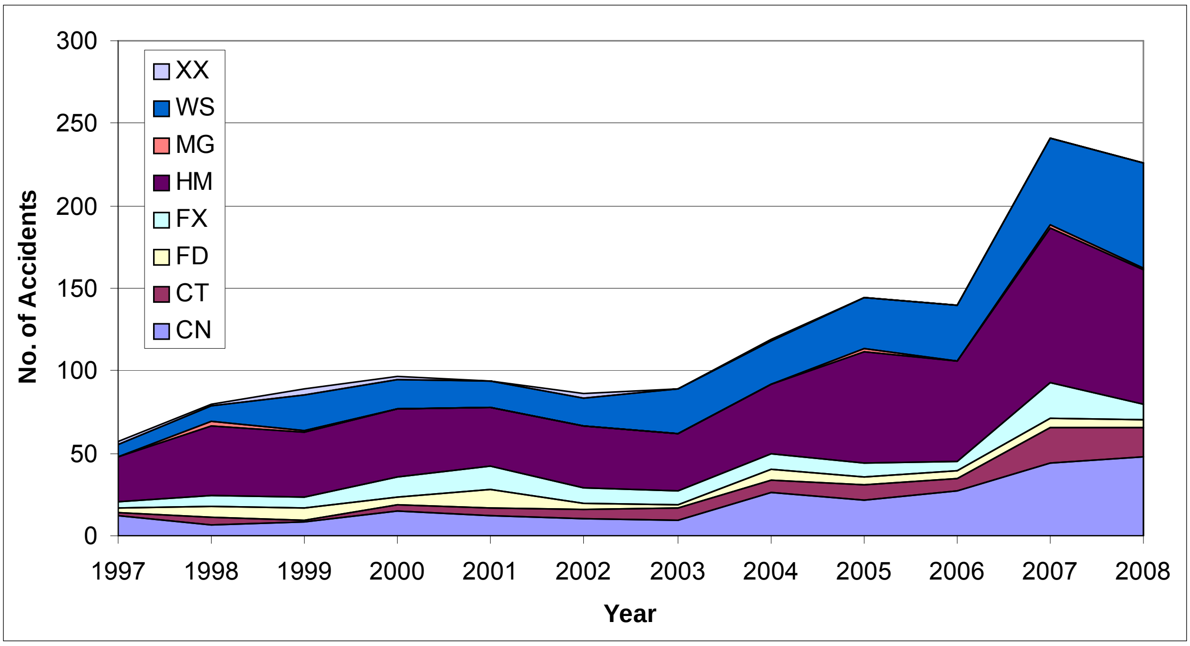

Figure 3-9: Development of annual accident numbers broken down into the accident categories (all size categories, IACS classified ships, period 1997-01-01 to 2008-12-31).

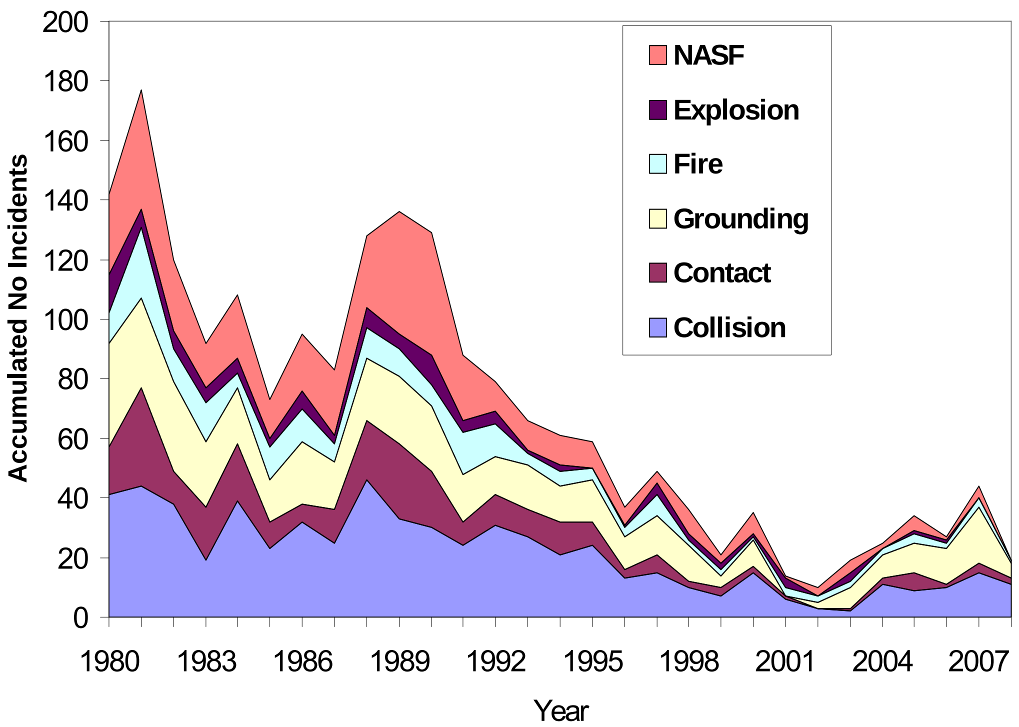

Figure 3-10: Development of annual accident numbers for crude oil tanker (DWT > 60,000 tonnes) broken down into the accident categories (all size categories, IACS classified ships, period 1997-01-01 to 2008-12-31).

The breakdown of the casualty reports into these categories for the three size categories is shown in Figure 3-11 to Figure 3-13. Each diagram shows the relative contribution of each accident category.

Figure 3-11 shows the diagram for ships greater than 499 GT and smaller than 1,000 GT. The biggest contribution is observed for "hull and machinery" (42 %), followed by "wrecked stranded" (20 %), "contact" (12 %), "foundered" (10 %) and "collision" (10 %). The comparison with the investigation for 1990 to 2006 showed a bigger portion for the accident category "wrecked stranded" (15 %). All other accident categories show only small changes. However, for the evaluation of these results the small number of casualty reports (51) must be taken into consideration. With respect to accident consequences, one fatality and five total losses were reported.

The corresponding results for the ships greater than 999 GT and smaller than 20,000 GT are shown in Figure 3-12. Again, the biggest contribution is observed for the category "hull and machinery" (43 %), followed by "wrecked stranded" (22 %) and "collision" (16 %). Compared to the smaller ship size category the accident categories "foundered" and "contact" have a significantly smaller relative portion. Compared to the investigation for 1997 to 2006 only negligible small changes are observed.

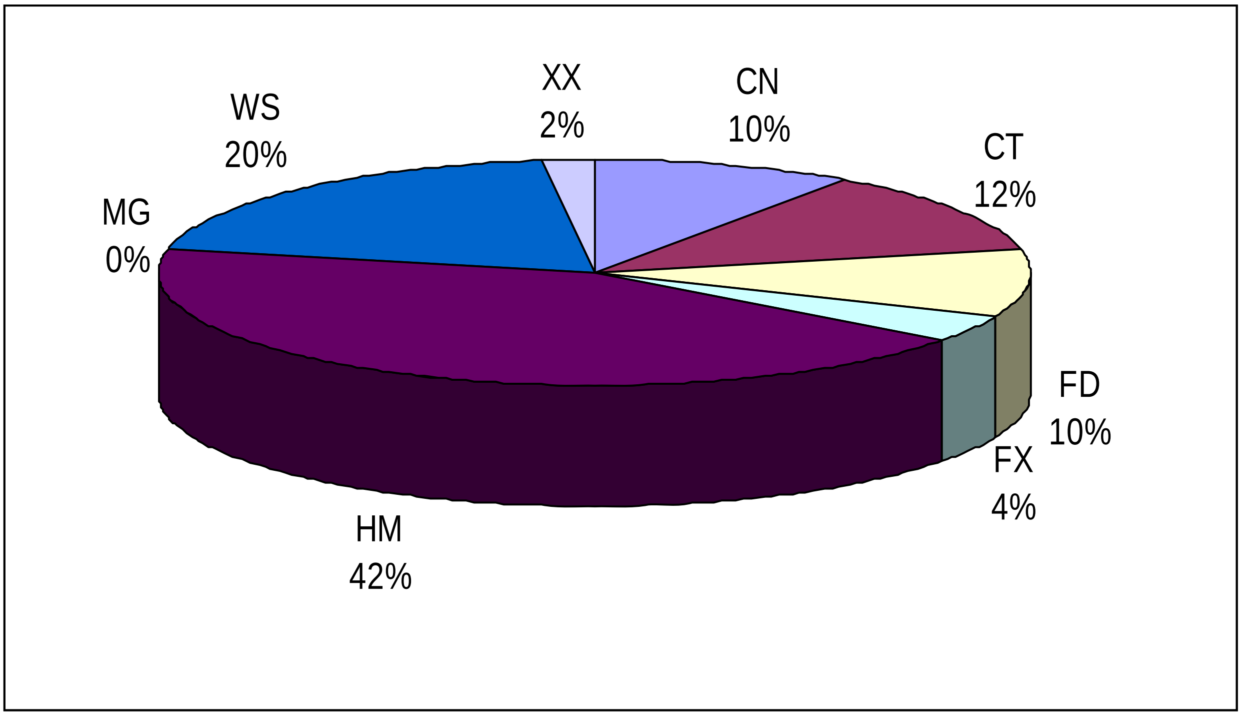

Figure 3-11: Relative distribution of casualty reports over the different accident categories for IACS class ships of size 500 ≤ GT < 1,000.

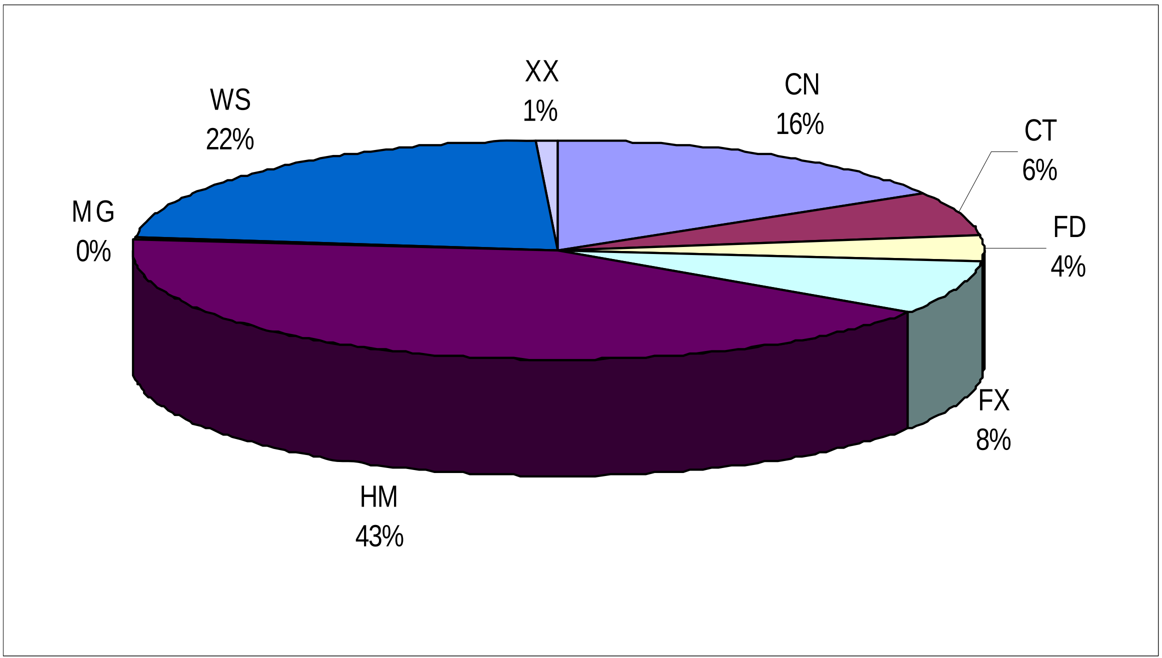

Figure 3-12: Relative distribution of casualty reports over the different accident categories for IACS class ships of size 1,000 ≤ GT < 20,000 GT.

Finally, Figure 3-13 shows the results for the size category with ships greater than 19,999 GT. Deviating form the other size categories the biggest contribution (46 %) is observed for "collision", followed by "wrecked stranded" (18 %) and "contact" (18 %). However, as mentioned for the ships smaller than 1,000 GT, the small number of casualty reports (11) must be taken into consideration. With respect to accident consequences, no fatalities or total losses were reported.

The presented results show that

- the main accident category is "hull machinery" (41 %) followed by "wrecked stranded" (22 %) and "collision" (16 %);
- the average relative contribution of "fire explosion" is about 8 %;
- the average relative contribution of "foundering" is about 4 %.

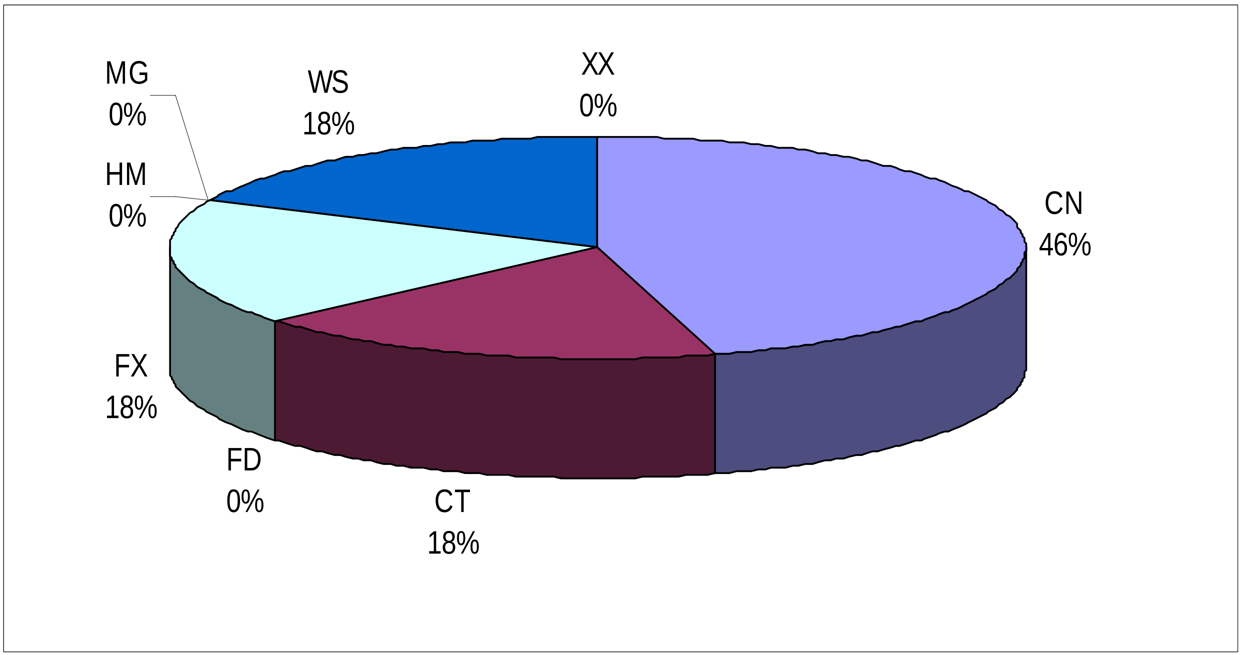

Figure 3-13: Relative distribution of casualty reports over the different accident categories for IACS class ships of size 20,000 ≤ GT.

Figure 3-14 shows the development of the casualty reports for the three size categories for the period 1997 to 2008. For the ships between 999 GT and 20,000 GT a nearly continuous increase in the annual reports from about 50 to 220 is observed which is an increase of about 300 % (ref. also to Figure 3-9). In the same period the annual number of ship years for this size category increases by only 63 %. Remarkable is the “jump” of about 80 casualty reports observed between 2006 and 2007. Also, for the ships greater than 20,000 GT an increase is observed, but the absolute numbers are too small to avoid statistical uncertainty and thus further interpretations are not possible.

Figure 3-15 shows the annual number of accident outcomes with respect to “fatalities” and “total loss” for ships between 999 GT and 20,000 GT, and thus provides a more detailed insight beyond the simple number of accidents. As shown, the increase of severe accidents over the whole period is decoupled from the development of “fatalities” and “total loss”. Thus, it is concluded that the increase in the number of casualty reports is most likely a result of improved reporting between after 1997, rather than an increase in severe accidents.

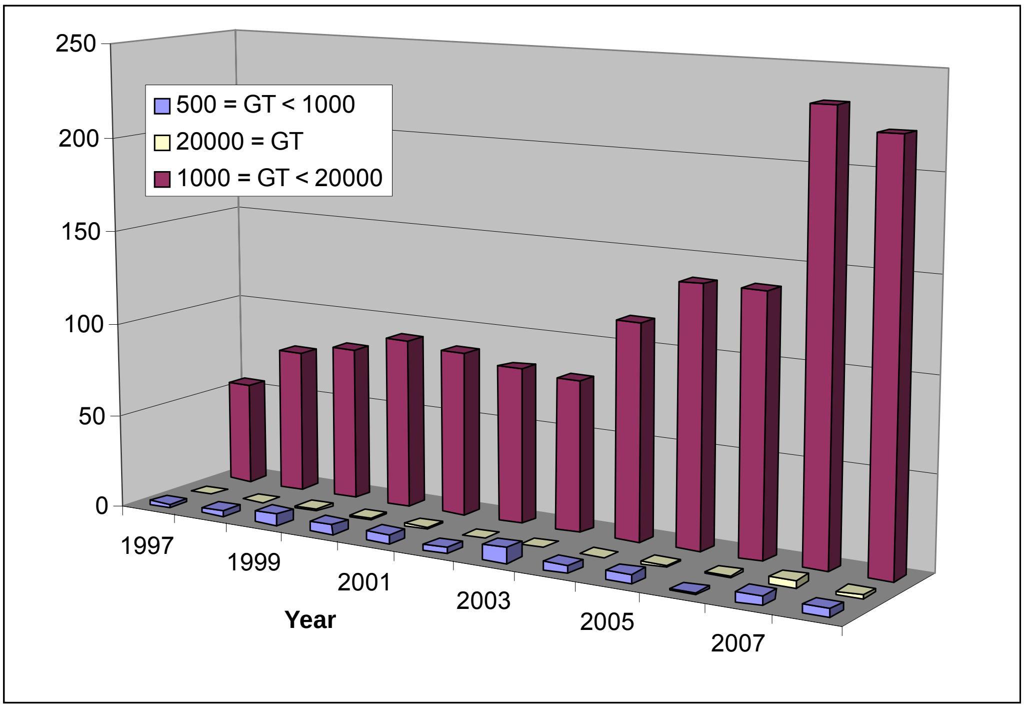

Figure 3-14: Number of casualty reports (category severe accidents) per year for IACS classed ships broken down by the three ship size categories.

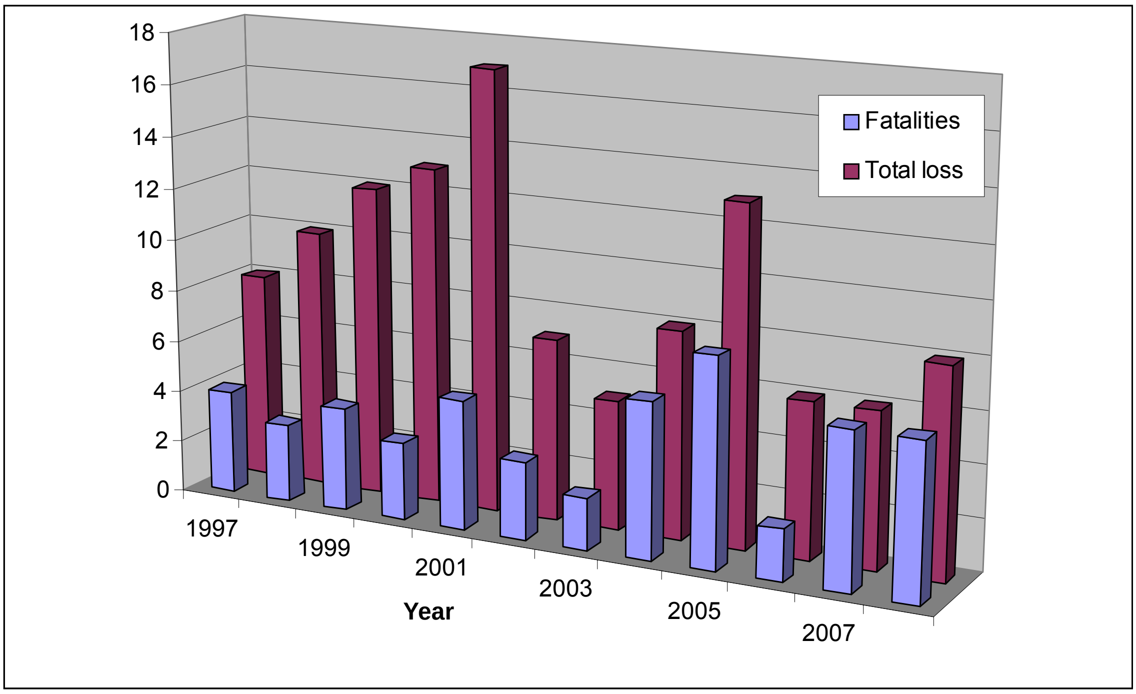

Figure 3-15: Number of casualty reports per year for categories "fatalities" and "total loss" for IACS classed ships together for all size categories.

3.3 Ship years

The number of ship-years is determined on the basis of the ship reports in the LRF database. The ship-years are calculated using the dates given in the columns “Due or Delivered” and “Scrapped or Lost” taking into consideration the exact date provided in these fields. E.g. if the “Due or Delivered” date given is 1. July in a particular year the ship-year value is 0.5. The annual number of ship years broken down in the size categories is shown in Figure 3-16. For the size categories below 1,000 GT and above 20,000 GT only small changes in the annual number of ship years is observed with respect to the previous study (MSC86/INF.4), however, for the size category 1,000 ≤ GT < 20;000 a continuous increase from about 2,700 ship years in 1997 to about 4,400 ship years in 2008 is observed. Differences with respect to the previous investigation (MSC86/INF.4) could be traced back to the selection criteria and the different time intervals. In total 43,222 ship years are calculated on basis of LRF database which means that the additional two years covered by this investigation contribute about 5,200 ship years. This increase is smaller than a simple addition of the ship years for 2007 and 2008 (about 8000 ship years) because all ships that left IACS classes within the last two years are not longer considered.

As mentioned in the introduction the presently available data allow no tracking of class changes and thus this could not be taken into consideration. However, the distribution shown in Figure 3-2 indicates, that there is a trend to transfer older ships from “Class Known” to “Class Unknown”, and thus it is concluded that the number of ship years is conservative with respect to accident frequency[4].

Figure 3-17 shows the number of ship years versus the age of the ships broken down into the size categories. Until an age of about 17 years no particularities of the total fleet are observed. Then the number of ships year continuously declines until the maximum age considered is reached (only ships built after 1981 are considered).

[4] Conservative because the ship years are underestimated and hence the risk overestimated.

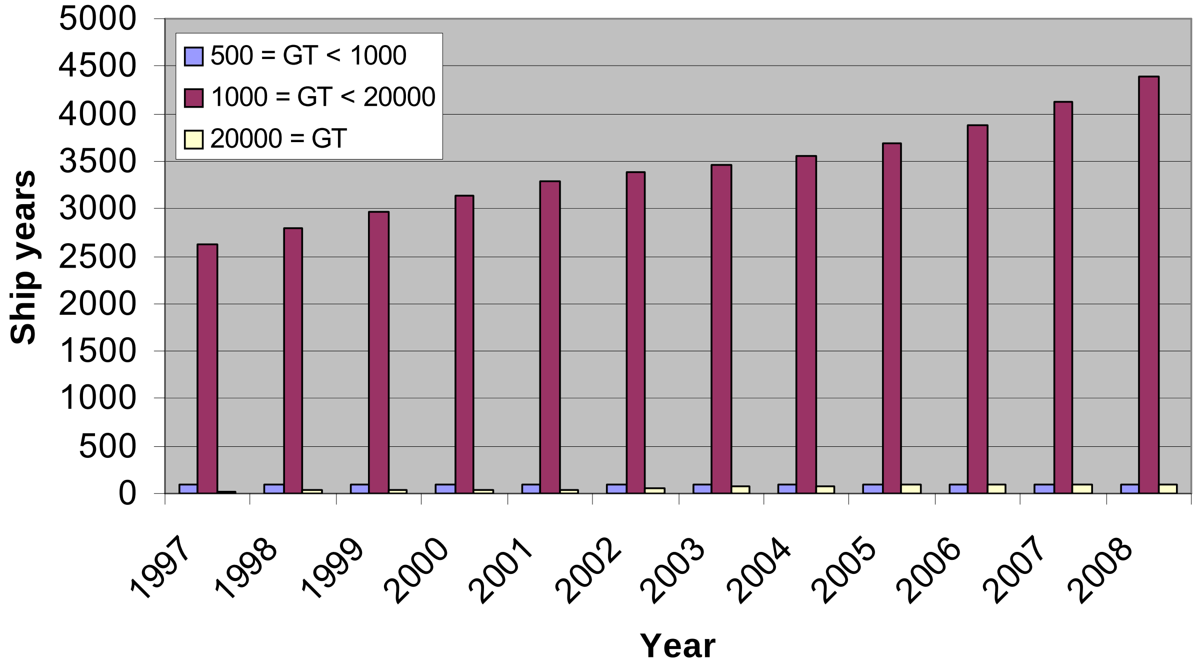

Figure 3-16: No. of ship years versus year for IACS class ships, broken down by size categories.

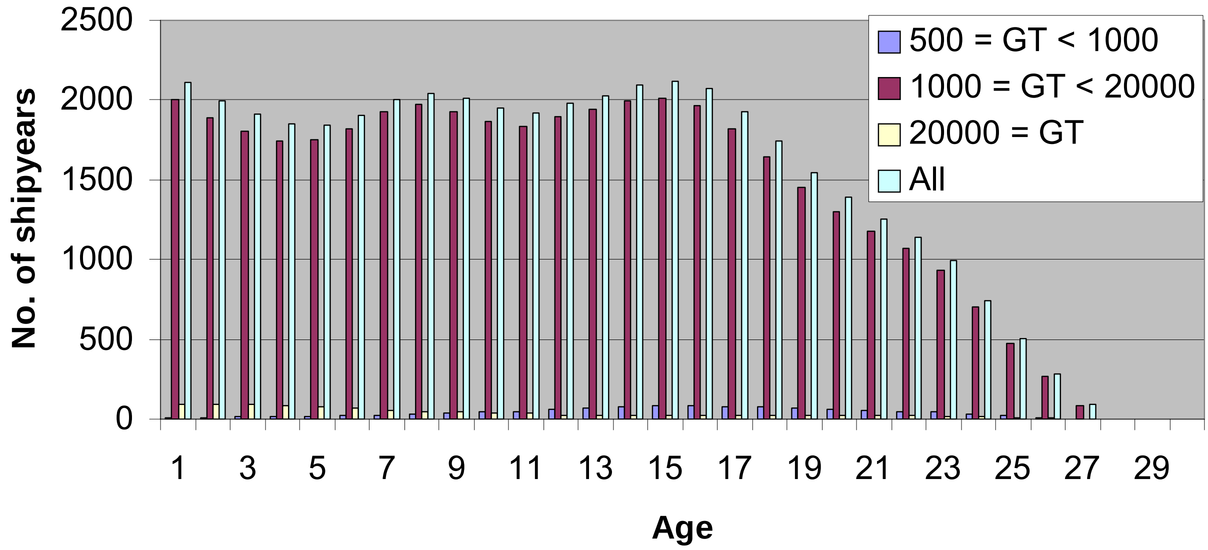

Figure 3-17: No. of ship years versus ship age for the IACS class ships, broken down by size categories.

4 Statistical Analysis of General Cargo Ship Casualty

The casualty reports are analysed with respect to total losses, fatalities (and missing) and severe accidents; and the accident frequencies are calculated. The results are summarised in this chapter.

4.1 Severe accidents for period 01.01-1997 to 31.12.2008 per ship year

The average accident frequency for the IACS classed ships is calculated to $3.4 \cdot 10^{-2}$ which is an increase of 26 % compared to the previous investigation. For to the fleet size in 2008 this equates to 155 accidents per year. The annual distribution of severe accidents in terms of absolute numbers is already shown in Figure 3-14. The details for this period are shown in Figure 4-1 for all size categories, by plotting the average annual frequency and the 95 % confidence interval[5]. It can be observed that the annual frequency increases after 2002, whereas the uncertainty represented by the confidence interval is nearly constant. In 2006 the average annual frequency is about 35 % higher than the ten years average.

The corresponding graphs for the three size categories are shown in Figure 4-2 to Figure 4-4.

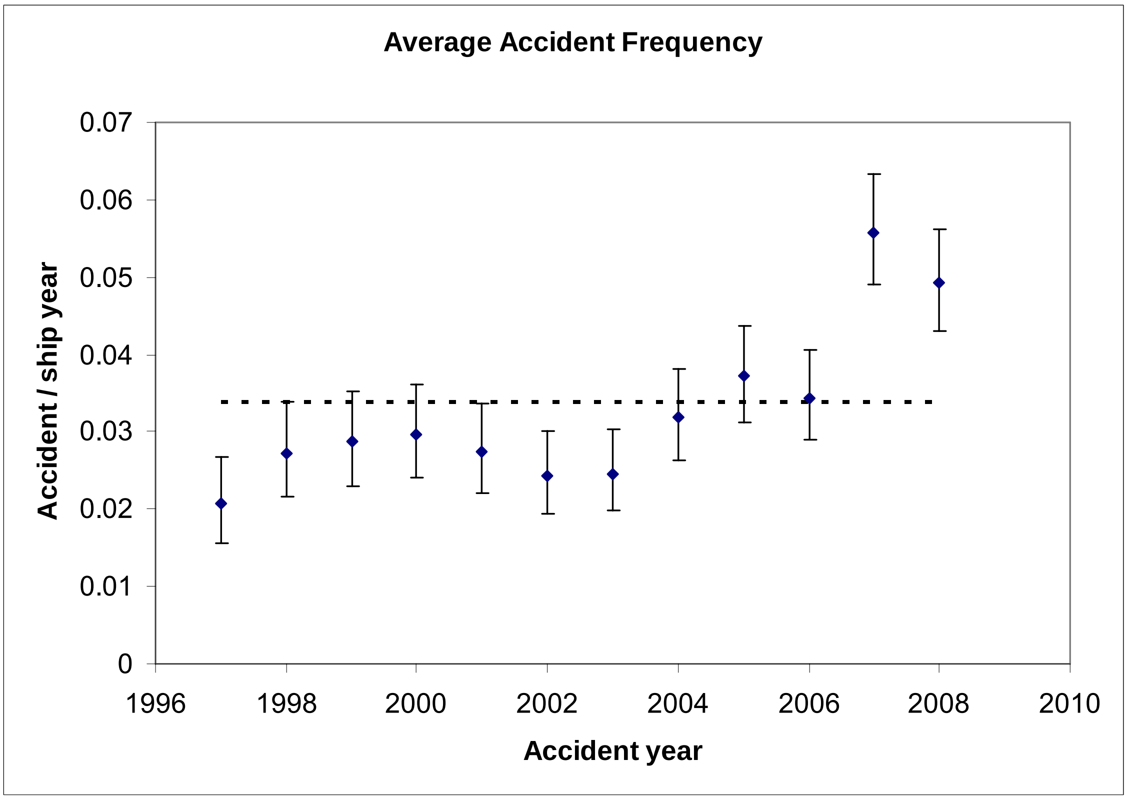

Figure 4-1: Annual frequency of accident for the IACS class ships (average of all size categories) with 95 % confidence interval. Additionally the ten year average is plotted.

[5] 95 % confidence interval = 95 % of all values are in this interval.

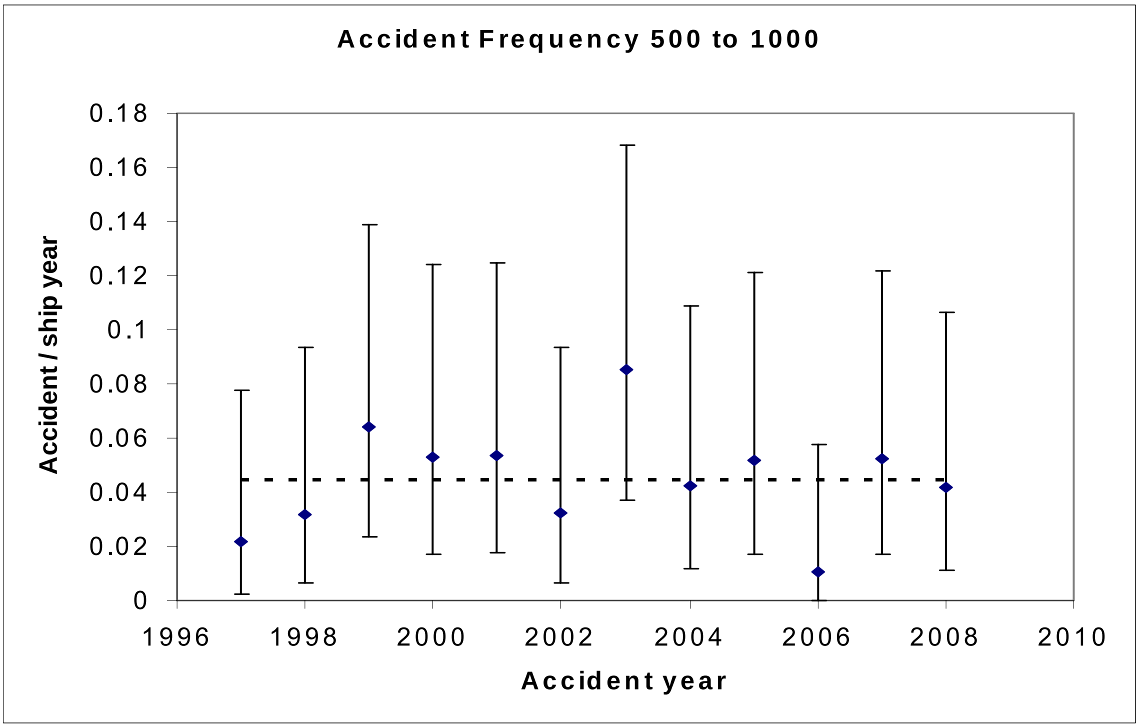

Figure 4-2: Annual accident rate for IACS class ships and the size category 500 ≤ GT < 1,000 and with 95 % confidence interval. Additionally the ten year average is plotted.

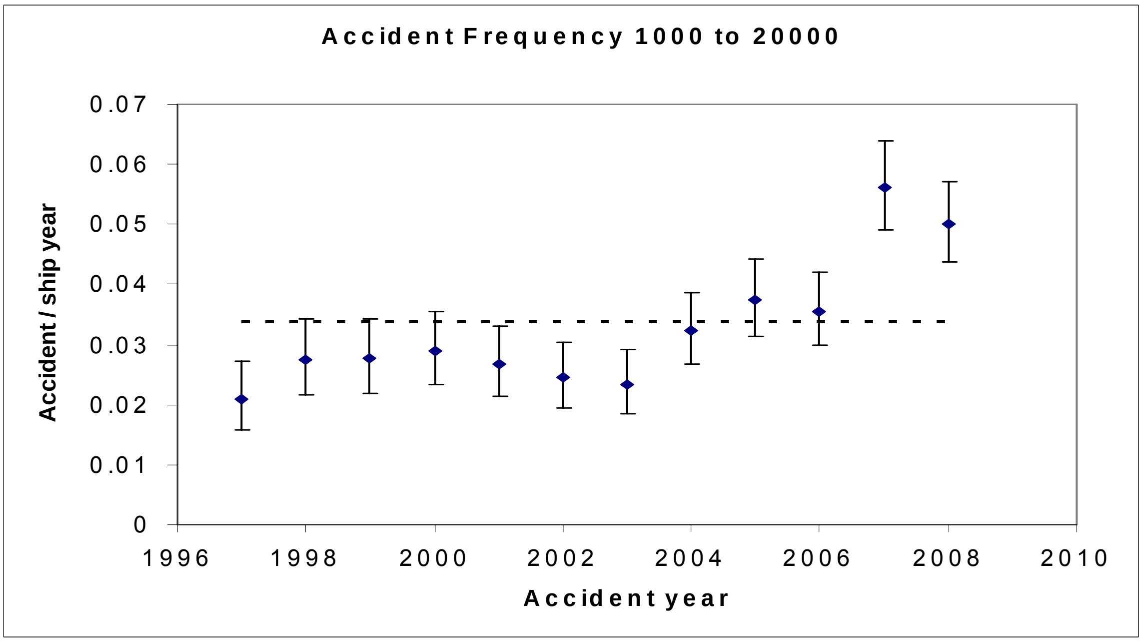

Figure 4-3: Annual accident rate for IACS class ships and the size category 1,000 ≤ GT < 20,000 and with 95 % confidence interval. Additionally the ten year average is plotted.

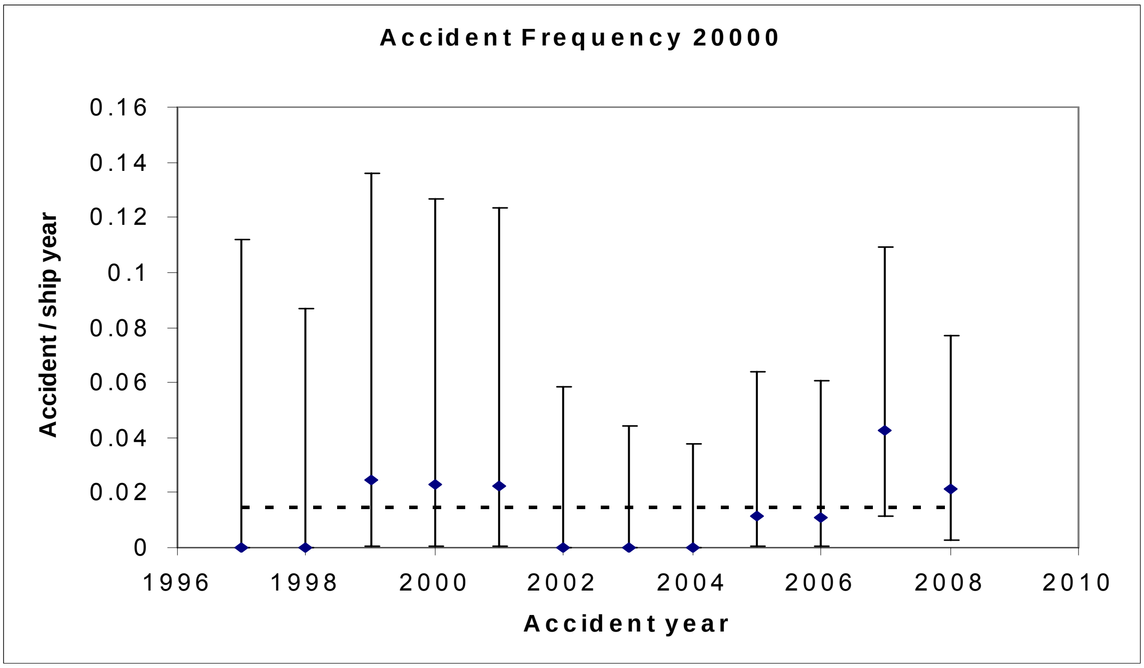

Figure 4-4: Annual accident rate for IACS class ships and the size category 20,000 ≤ GT and with 95 % confidence interval.

4.2 Total losses per ship year

In the period 1997 to 2008 118 total losses were reported by LRF and hence nine more than determined by the previous study. In order to identify the most serious accident category resulting in a total loss, the databases were analysed with respect to the accident category for total loss. The analysis of the casualty reports for the IACS classed ships shows that for the size category 1,000 ≤ GT < 20,000 accidents for which the accident category is reported to be "foundering" accounts for only 4 % of all accidents (Figure 3-12), but 43 % of all total losses making it the most serious accident category (Figure 4-5). The accident category "wrecked stranded" accounts for 22 % of the accidents and for 21 % of all total losses. Similar figures are observed for the category "collision" (16 % and 19 %). The values for the accident category "fire/explosion" underline the importance of this accident category with respect to total loss (8% and 11%). These results are in good agreement with the data submitted for the period 1990-2001 in MSC 83/20/3.

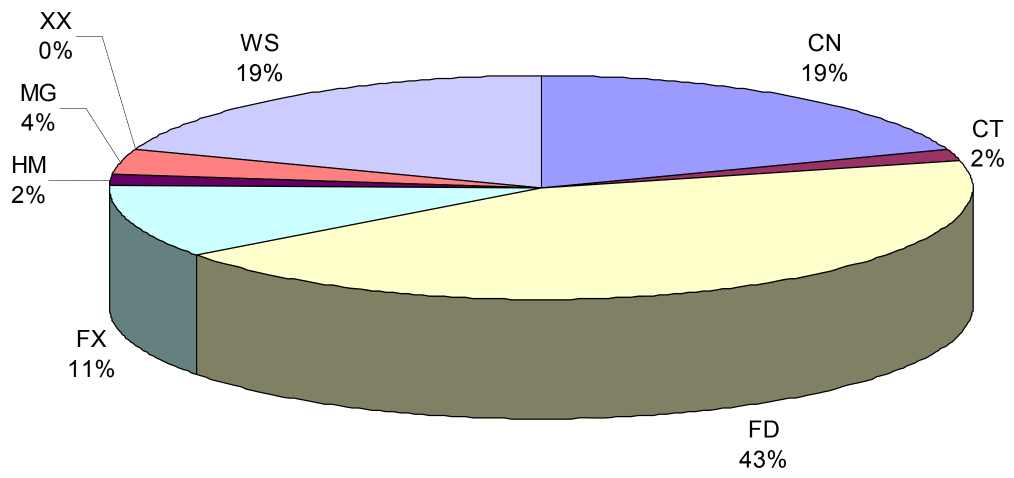

Figure 4-5: Relative distribution of the different accident categories in respect of "total loss", and for IACS class ships of size 1,000 ≤ GT < 20,000.

Using all ship years (43,222) the average "total loss" frequency for the period 1997 to 2008 is $2.7 \cdot 10^{-3}$. This rate is comparable to the total loss rate for bulk carrier for 1995 to 2000 given in MSC 83/20/1.

More details for this period are shown in Figure 4-6, by plotting the average annual frequency of "total loss" for all size categories together and with the 95 % confidence intervals. For all years before 2002 the mean total loss rate is continuously above the year average, but for 2002 and after this rate is below the ten year average with the exception of 2005. Furthermore, the confidence intervals for 2002 and after are narrower than for the interval 1996 to 2001.

The corresponding graphs for the three size categories are shown in Figure 4-7 and Figure 4-9. Due to fact that for the size categories 500 ≤ GT < 1,000 and 20,000 ≤ GT only contain a small number of ship years and few "total loss" reports (5) are available, the results are affected by a large statistical uncertainty (expressed by the large confidence intervals). It is noteworthy that in the ten year period from 1997 to 2008 there were no total losses for general cargo ships built after 1982 greater than 20,000 GT.

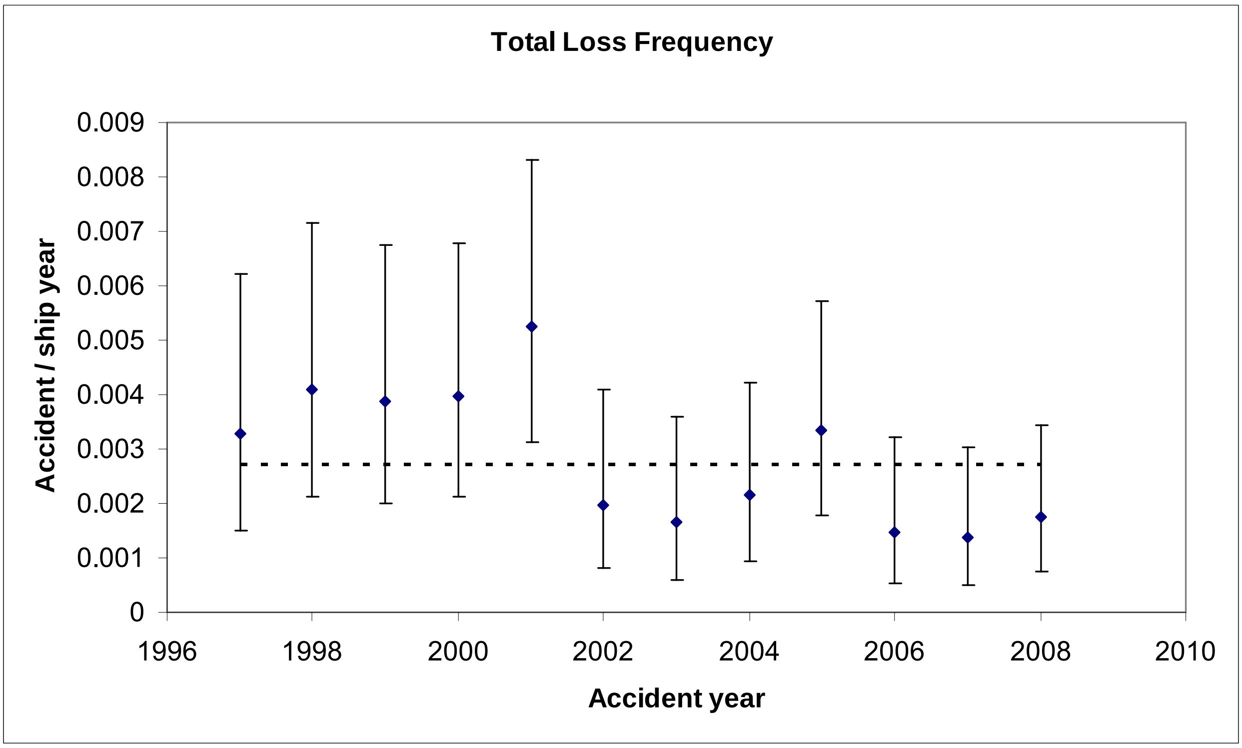

Figure 4-6: Annual frequency of "total loss" for all size categories of IACS class ships and with 95 % confidence interval. Additional the ten year average is plotted.

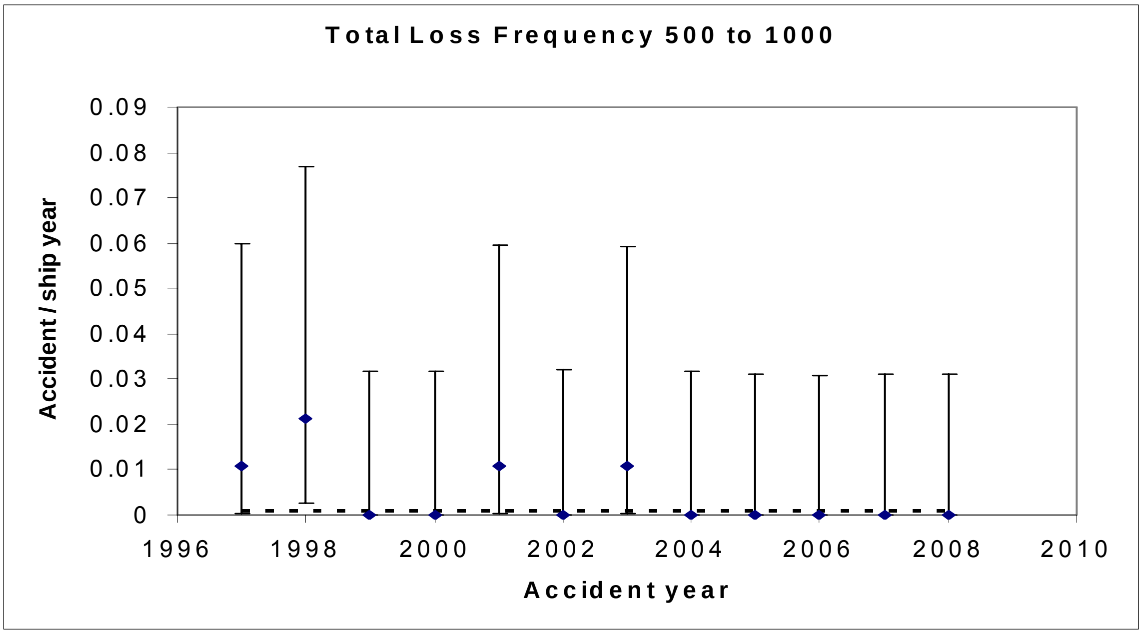

Figure 4-7: Annual frequency of "total loss" for IACS class ships of the size category 500 ≤ GT < 1,000 and with 95 % confidence interval. Additionally the ten year average is plotted.

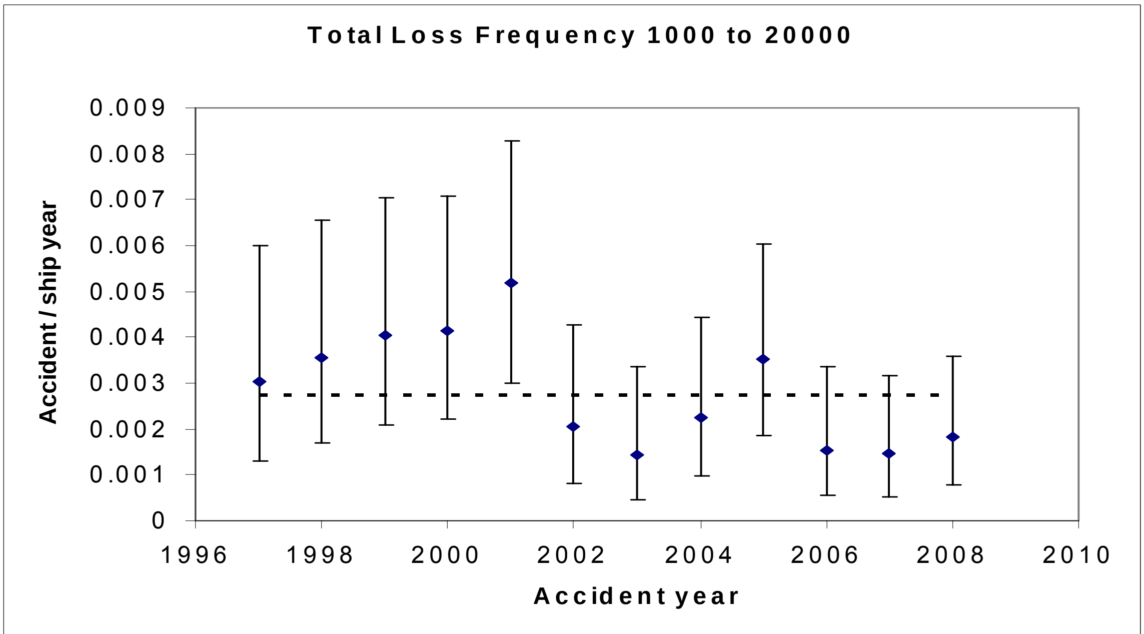

Figure 4-8: Annual frequency of "total loss" for the IACS class ships of the size category 1,000 ≤ GT < 20,000 and with 95 % confidence interval. Additionally the ten year average is plotted.

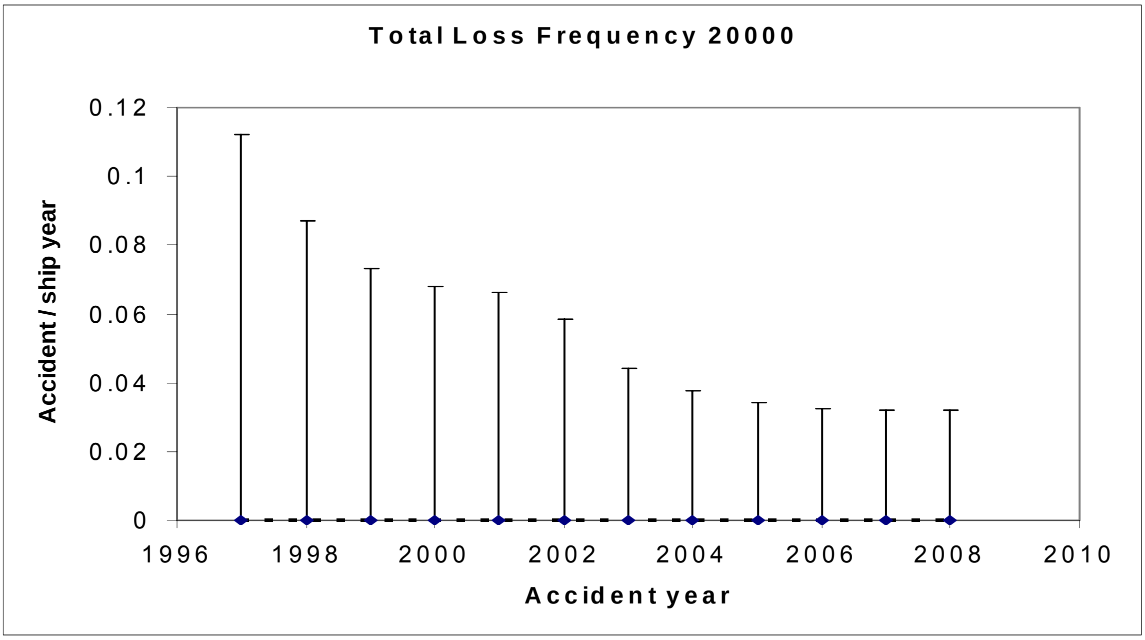

Figure 4-9: Annual frequency of "total loss" for IACS class ships of the size category 20,000 ≤ GT and with 95 % confidence interval.

4.3 Fatalities for period 1997-01-01 to 2008-12-31 per ship year

For the investigation summarised in this section the accident outcomes “killed” and “missing” are merged to the group “fatalities”. The total number of fatalities for the period 1997-01-01 to 2008-12-31 for ships being classified by an IACS society at the date of incident is 417. So, additional 101 fatalities have been added for the last two years as compared to the reporting in MSC86/INF.4. The number of accidents with fatalities is 54 (+8 in last two years) and yields an average number of fatalities per accident of 7.8. The maximum number of fatalities in a single accident is recorded as 22.

The results of the investigation of the casualty reports with respect to the consequence “fatalities” and for the ship size category 1,000 ≤ GT < 20,000 is shown in Figure 4-10. This figure shows the results based on the number of fatalities. The result of the investigation of the origin of “fatalities” is dominated by the contribution from the “foundering” accident category. The average number of fatalities per accident and accident category is summarised in Table 4-1. Thus, the highest numbers of fatalities per accident are observed for “missing and “wrecked stranded”.

For the period 1997-01-01 to 2008-12-31 only one fatality was reported for each of the size categories 500 ≤ GT < 1,000 and for 20,000 ≤ GT.

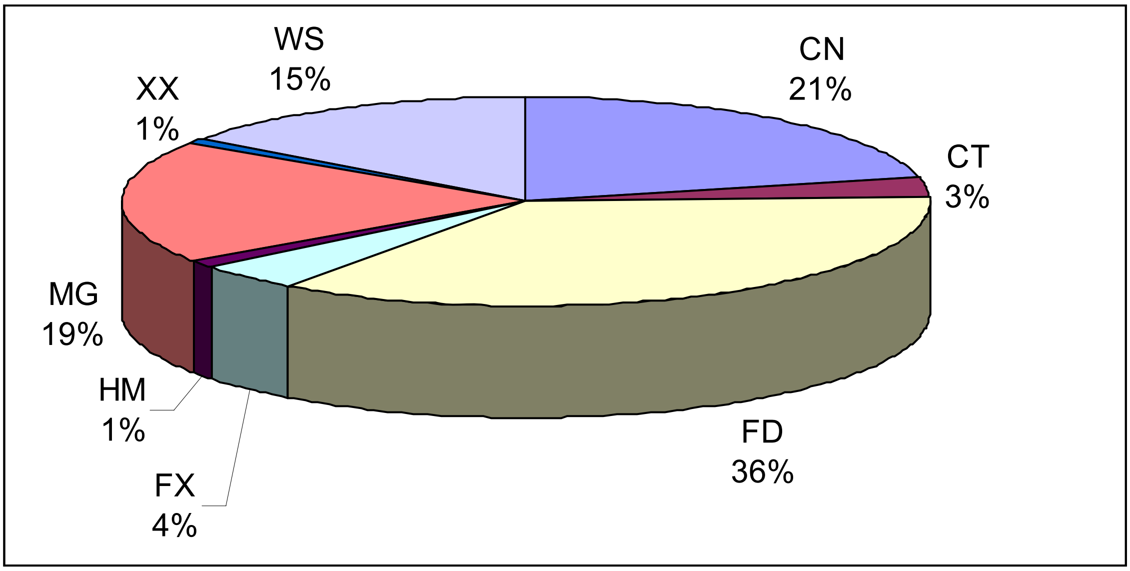

Figure 4-10: Relative distribution of the different accident categories in respect of “fatalities”, and for IACS class ships of size 1,000 ≤ GT < 20,000.

The average “fatality” rate of the twelve year interval is calculated to $9.6 \cdot 10^{-3}$. With respect to the fleet size in 2008 this equates to 44 fatalities per year. Thus the average annual fatality rate increases by 6 within the last two years.

The mean individual risk from ship accidents for all size categories due to accidents involving general cargo ships of IACS class built after 1981-12-31 in the period from 1997-01-01 to 2008-12-31 is shown in Figure 4-11.

Table 4-1: Number of accidents with fatalities and average number of fatalities per accident broken down into accident categories and for the period 1997-01-01 to 2008-12-31 and ships 1000 ≤ GT < 20,000.

Category	No. of accidents	Total no. of fatalities	Av. No. of fatalities / accident
CN	11	88	8
CT	4	12	3
FD	20	149	7.45
FX	5	17	3.4
HM	1	5	5
MG	5	80	16
XX	1	3	3
WS	5	61	12.2

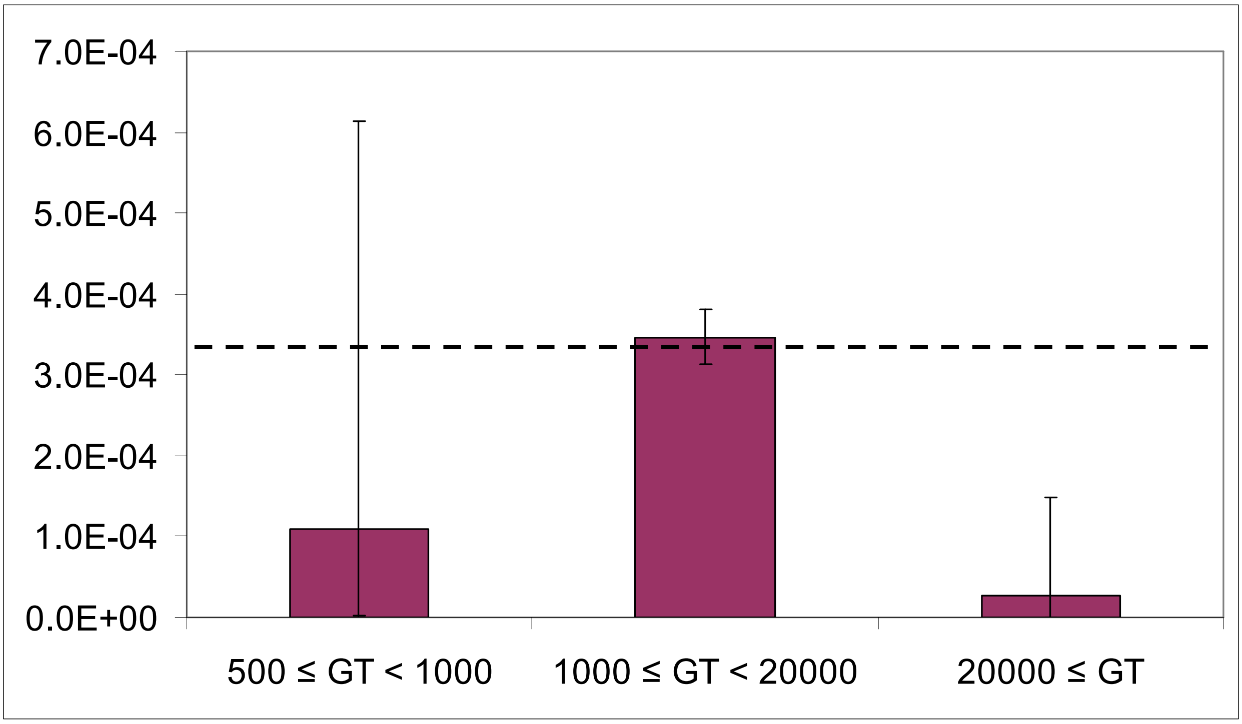

Figure 4-11: Individual risk due to accidents involving the ship for general cargo ships of IACS class built after 1981-12-31 in the period from 1997-01-01 to 2008-12-31. The stapled line is the mean risk for all sizes, and the thin vertical lines are 95 % confidence intervals.

The annual "fatality" frequency for all size categories is shown in Figure 4-12 in combination with the 95 % confidence interval. The results show neither a clear tendency for the average frequency nor for the uncertainty. It becomes obvious that

- 1998 with three accidents (two MG, one WS) with in total 46 missing and 5 killed of ships due or delivered 1985, 1990 and 1991;
- 2004 with three accidents (two FD, one WS) with in total 10 missing and 34 killed of ships due or delivered 1983, 1990 and 1992;
- 2005 with six accidents (three FD; two CN; one WS) with in total 47 missing and 10 killed of ships due or delivered 1982 (two), 1983, 1984 (two) and 1997;
- 2007 with six accidents (two FD; CN, CT, FX, MG) with in total 35 missing and 13 killed;
- 2008 with six accidents (two FD; CN, CT, FX, MG) with in total 51 missing and 19 killed

have been bad years with respect to crew safety. These five years contribute 152 fatalities and thus about 50 % of all fatalities in only 30 % of the accidents with fatalities (total 52). The minimum annual fatality rate is $1.9 \cdot 10^{-3}$ (2003) and the corresponding peak value $1.7 \cdot 10^{-2}$ (1998).

The corresponding graphs for the three size categories are shown in Figure 4-13 and Figure 4-15.

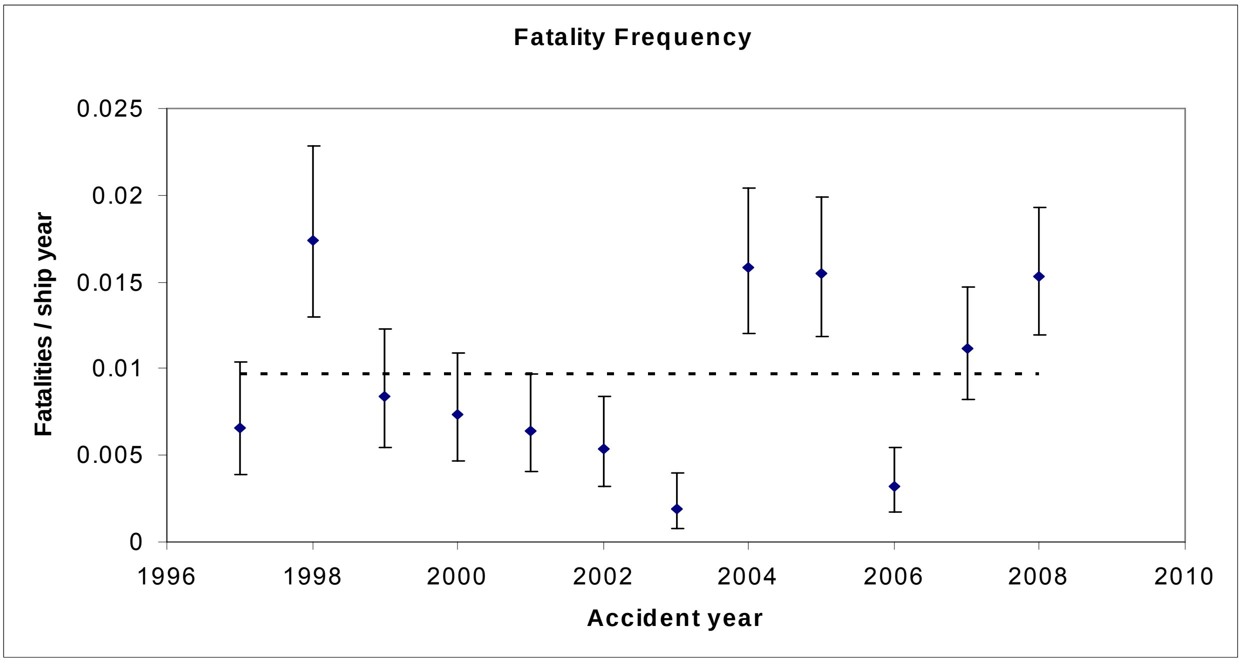

Figure 4-12: Annual frequency of “fatality” for IACS class ships and all size categories with 95 % confidence interval. Additionally the twelve year average is plotted.

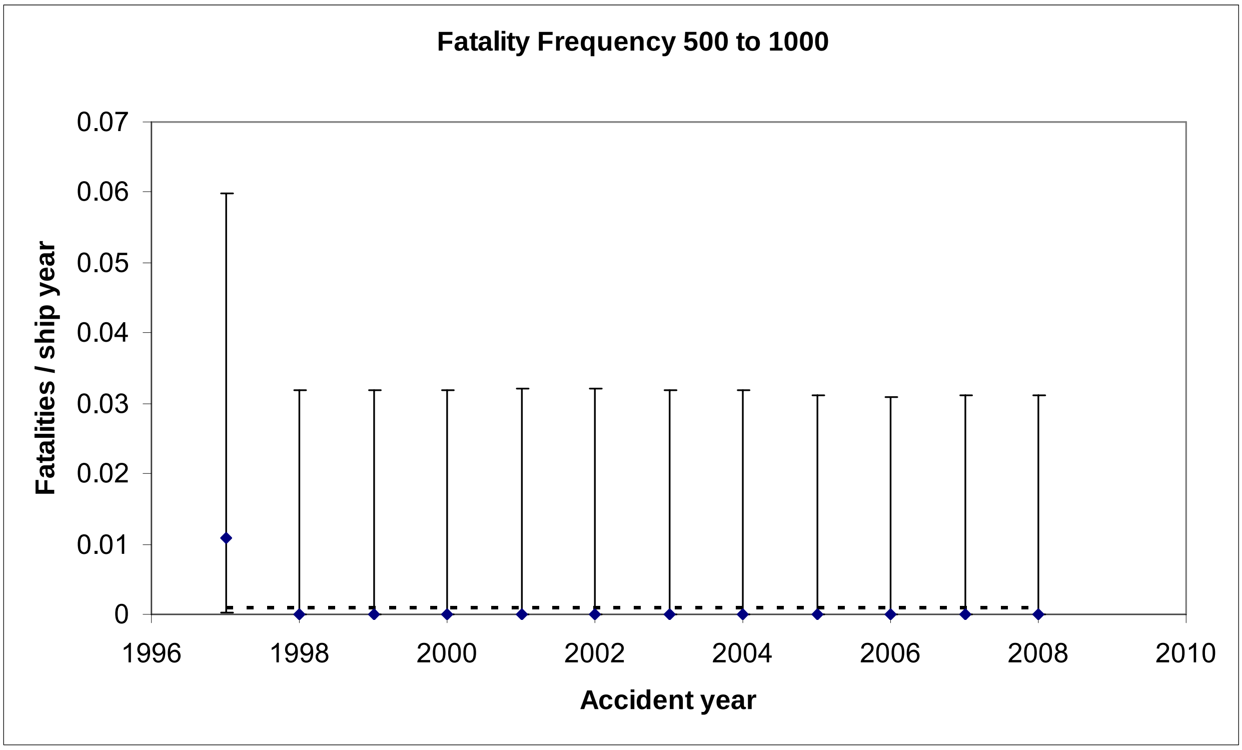

Figure 4-13: Annual frequency of "fatality" for IACS class ships of size category 500 ≤ GT < 1,000 and with 95 % confidence interval.

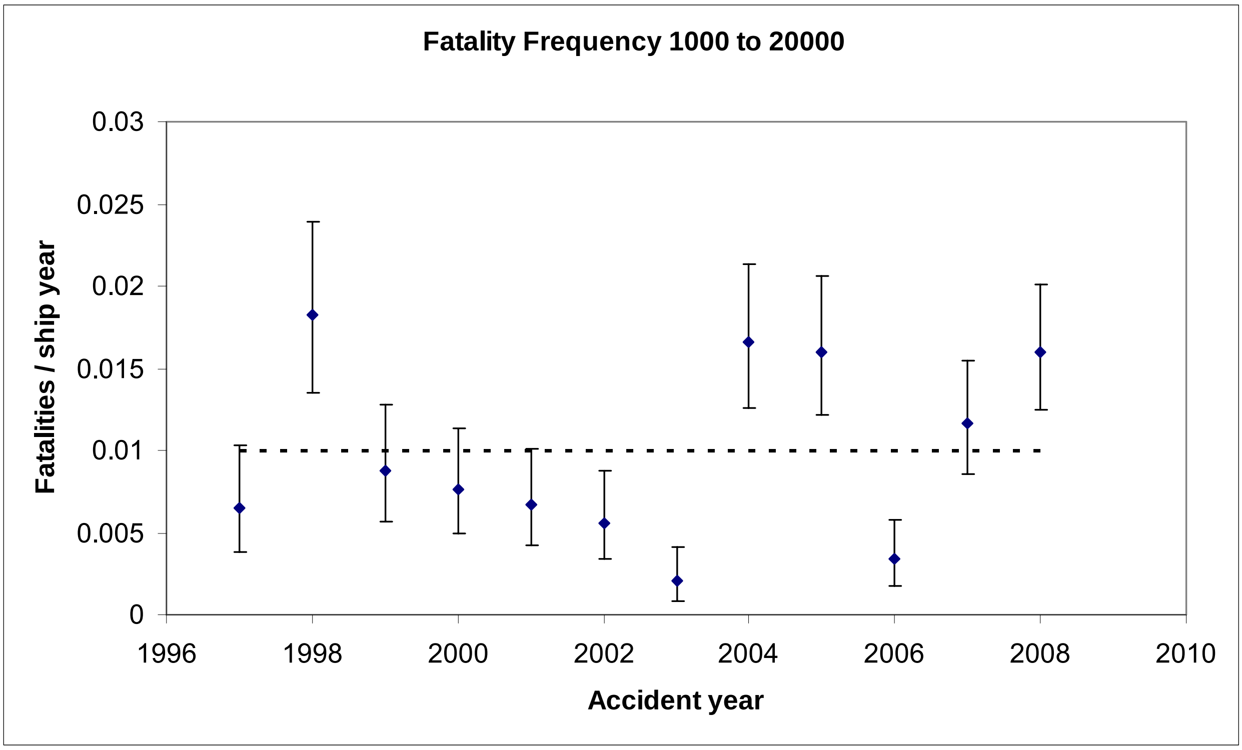

Figure 4-14: Annual frequency of "fatality" for IACS class ships of size category 1,000 ≤ GT < 20,000 and with 95 % confidence interval. Additionally the ten year average is plotted.

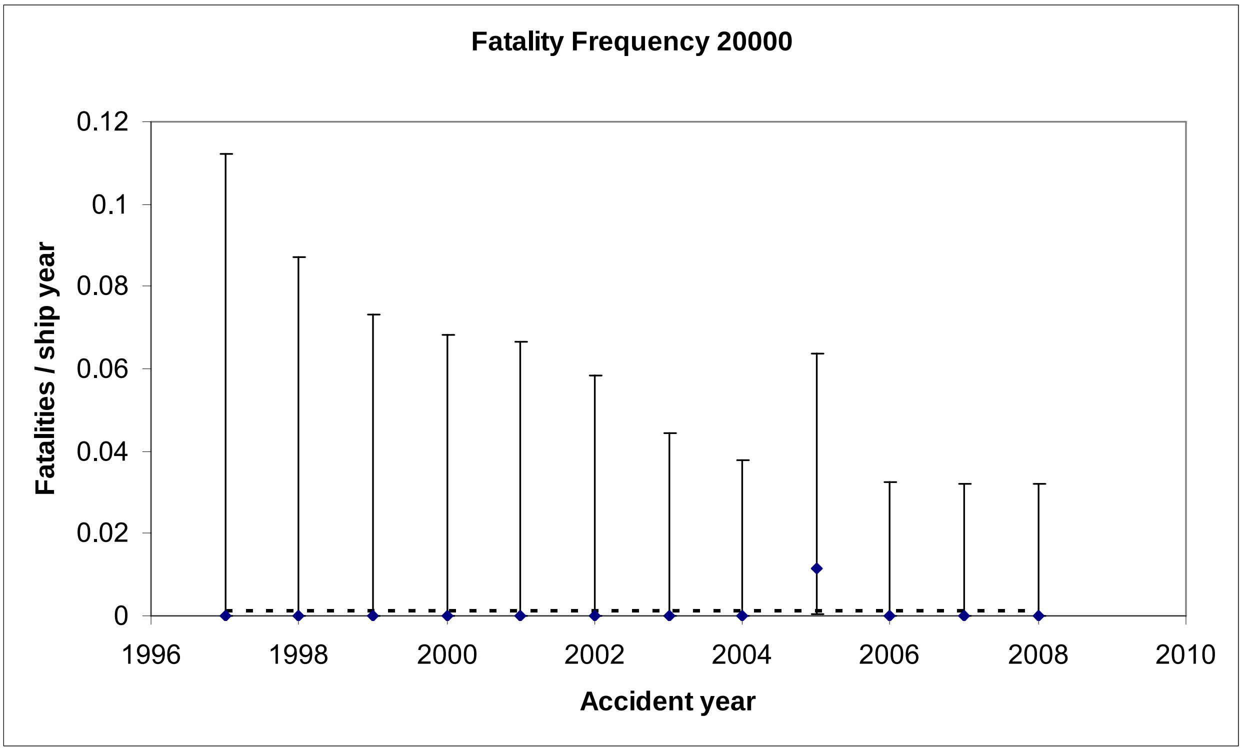

Figure 4-15: Annual frequency of "fatality" for IACS class ships of size category 20,000 ≤ GT and with 95 % confidence interval.

To make reasonable estimates for the individual risk representative figures for the number of crew on board are needed. Tabulated values for the number of crew onboard general cargo ships of different sizes have been retrieved from Spouge (2003) for the size categories 500 ≤ GT < 1,000, 1,000 ≤ GT < 5,000, 5,000 ≤ GT < 10,000 and GT ≥ 10,000. Unfortunately, these size categories deviate from the breakdown used earlier in this report. To remedy the situation, the number of crew in the 1,000 ≤ GT <20,000 size segment is chosen so that the overall individual risk is the same for both size categorisations, and are given in the top row of Table 4-2.

Furthermore, in this report it is assumed that each crew only serves onboard half of the time the ship sails. Therefore, during one year, two times the number of crew has been exposed to risk. The crew exposure is the number of crew having been exposed to risk per year times the number of ship-years. The risk of a fatality as observed by an individual is the total number of fatalities divided by the crew exposure. These figures can be found in Table 4-2.

Table 4-2: Number of crew on GCS, the number of ship years, the number of fatalities due to ship accidents, the calculated crew exposure and individual risk for general cargo ships of IACS class built after 1981-12-31, during the twelve year period from 1997-01-01 2008-12-31

	$500 \leq GT < 1\,000$	$1\,000 \leq GT < 20\,000$	$20\,000 \leq GT$	All
Number of crew	4	14.5	25	14.7
Ship years	1,136	41,330	756	43223
Fatalities	1	415	1	417
Crew exposure	9,087	1,198,583	37,824	1,245,494
Individual risk	$1.1\cdot10^{-4}$	$3.5\cdot10^{-4}$	$2.6\cdot10^{-5}$	$3.4\cdot10^{-4}$

The individual risk of fatality due to an accident involving the ship is $3.4\cdot10^{-4}$, with 95 % confidence limits at $3.0\cdot10^{-4}$ and $3.7\cdot10^{-4}$. This value is in the area of tolerable risk as proposed in MSC 83/INF.2 (maximum tolerable individual risk is 10^{-3} and the maximum negligible individual risk is 10^{-6})

The FN diagram for the societal risk for crew members is developed for all size categories together (Figure 4-16). The boundaries for negligible and intolerable risk are determined on the basis of an estimated average turnover of about USD 4.5 million per ship and a crew of 20. In MSC 72/16 (2000) a q-value of one fatality per billion dollar GNP is given. The average annual growth rate of the GNP in the last decade was about 3 %. Further, assuming an annual improvement of 2 % with respect to safety of worker (decrease of fatalities), a modified q-value of 0.68 is calculated. Thus, general cargo ships are in the upper part of the ALARP "region". However, the boundary to intolerable risk is not touched.

Based on the statistical investigation the potential loss of live (PLL) for crew member yields $9.2\cdot10^{-3}$. This PLL is nearly in the same range as for LNG ($9.32\cdot10^{-3}$) and for container ships ($9\cdot10^{-3}$).

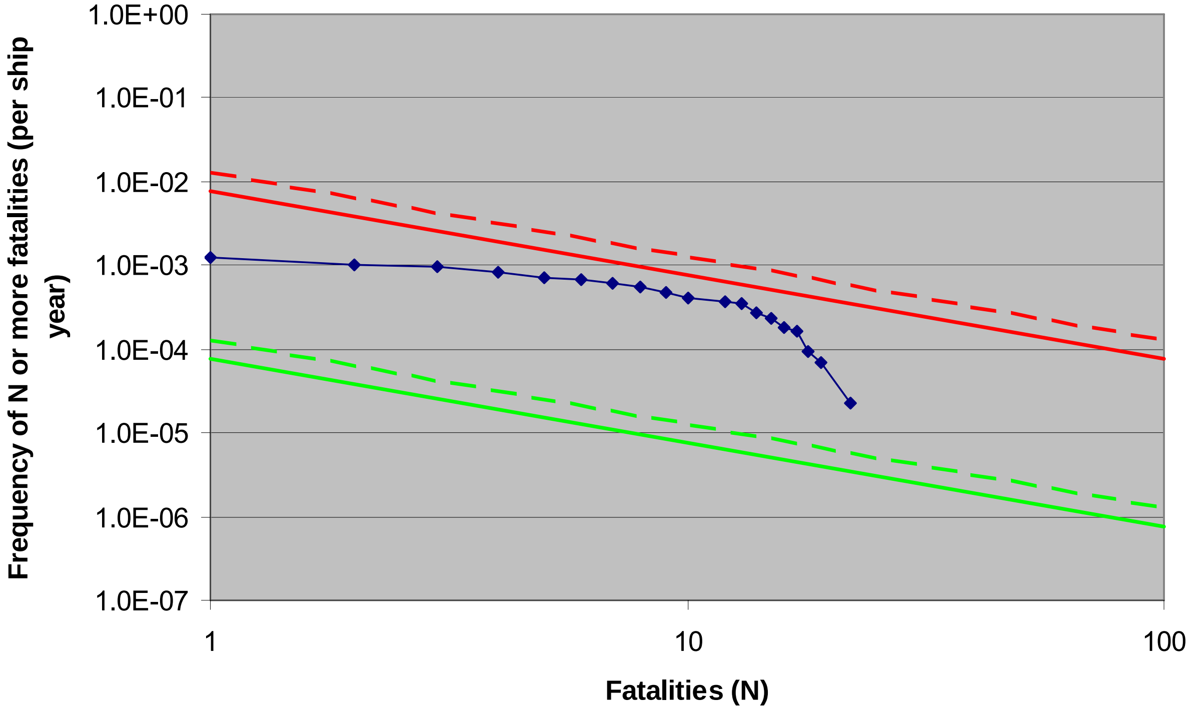

Figure 4-16: FN diagram for IACS class general cargo ship. Boundaries for intolerable and negligible risk calculated on basis of MSC 72/16 using updated figures for economic value and two q-values (dashed line: 1 and continuous line: 0.61).

4.4 Severe accidents per year built

Another aspect analysed is the relation between accident and building year of the vessels. Figure 4-17 shows this relation in terms of accident frequency per year built for all size categories and all accident categories combined. No clear tendency is observed. However, it should be mentioned that the results in Figure 4-17 are affected by the observed change from IACS classes to no class because the ship years are determined for the actual class assignment whereas for the accident the class assignment at the date of accident is used. The observed class change lead to a smaller number of ship years for the selected group of ships and hence to higher accident frequencies.

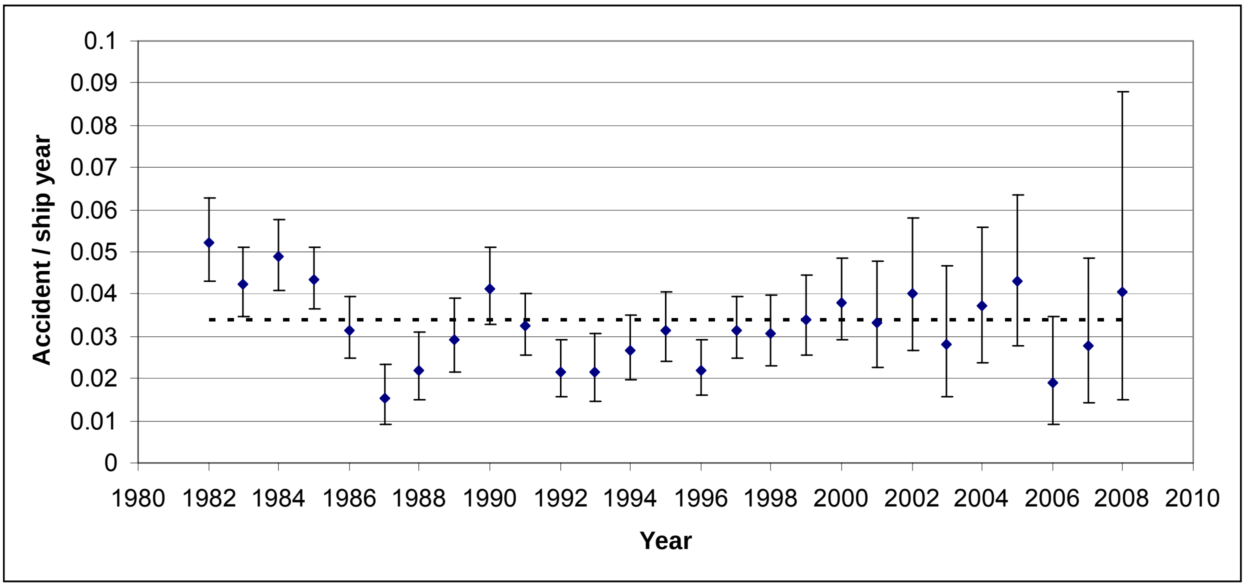

Figure 4-17: Accident frequency of IACS class ships per year built for all size categories together and 95 % confidence interval.

4.5 Age distribution at time of severe accident

Figure 4-18 shows the relation between accident frequency per ship year and the age at the time of accident for all size categories and all accident categories combined. With respect to the mean value ships up to an age of 14 show a similar accident frequency which is lower than the average. For ships older than 14 years up to the age of 24 years the accident frequency is higher than the average. However, the confidence interval increases also for this age interval.

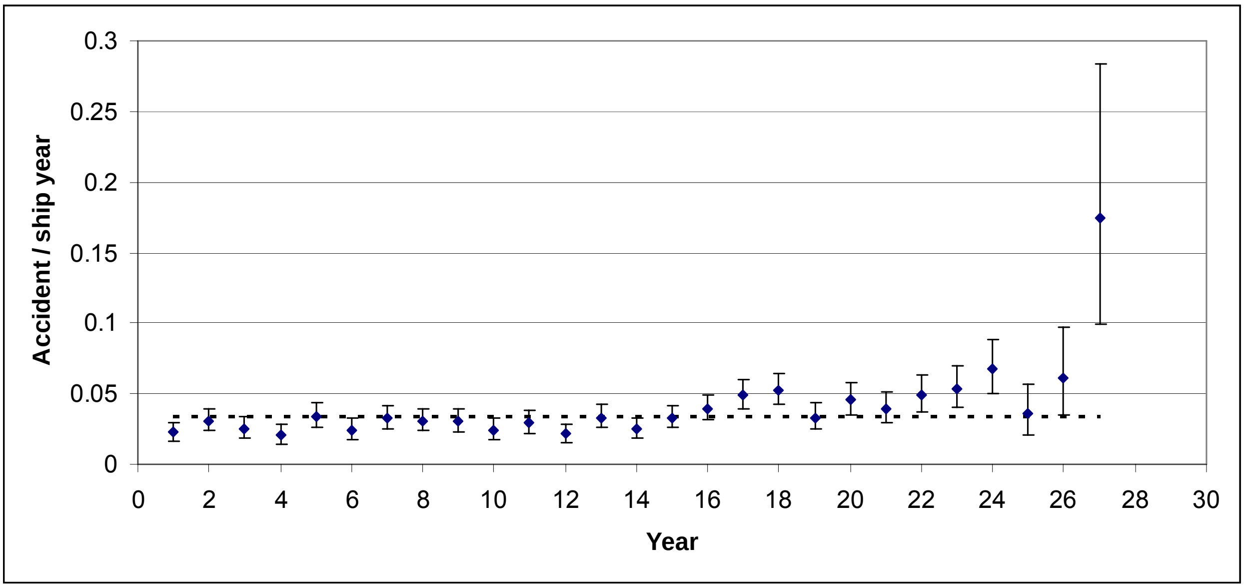

Figure 4-18: Accident frequency per age at date of incident of ship for IACS class ships of all size categories together and 95 % confidence interval.

5 Occupational risk

The importance of occupational risk in the context of risk evaluation for crew on general cargo ships was noted, for instance in MSC 83/20/3. Presently, the collection of occupational accidents is primarily done by national administrations and no international database is available. Thus, the importance of occupational accidents is investigated by data received from the Norwegian Maritime Directorate (NMD). This database contains information on all reported accidents occurring either in Norwegian territorial waters or on ships registered to Norway (NOR) or in the Norwegian International Register (NIS). Data from the period 1997-01-01 to 2006-12-31 were used. The database contains reports on both ship accidents and personal accidents happening to crewmembers onboard the ship without jeopardizing the safety of the ship itself. The latter type of accidents will from now on be referred to as personal accidents.

Considering only personal accidents occurring on NOR and NIS registered general cargo ships of 500 GT or above, built after 1981-12-31 and occurring within the time period from 1997-01-01 to 2006-12-31, there were in total 169 personal accidents were one or more crewmembers were injured or killed. The personal accidents resulted in 9 fatalities and 160 in injuries. All accidents occurring on ships not registered in NOR or NIS, but occurring in Norwegian waters, have been disregarded to avoid problems with respect to the exposure.

In the scope of our study there were 24 NOR registered ships and 70 NIS registered ships contributing with 210.1 and 642.2 ship-years respectively, for a total of 852.3 ship-years representing 2 % of the total ship-years of this analysis. The figures are summarized in Table 5-1.

Table 5-1: Number of non-serious injuries, serious injuries and fatalities onboard the 94 NOR or NIS registered general cargo ships in the period from 1997-01-01 to 2006-12-31.				
	Ship years	**Non-serious injury**	**Serious injury**	**Fatality**
500≤ GT <1,000	20.0	2	5	0
1,000≤ GT <20,000	545.7	22	53	3
20,000≤ GT	287.3	38	40	6
Total	853.0	62	98	9

As with individual risk due to accidents involving the ship, the number of crew for each size category is not known. The best figures for number of crew known are the one shown in **Table 4-2**. The problem of unequal size categories is resolved in the same way as before. The results are shown in **Table 5-2**.

Table 5-2: Number of crew, the number of ship years, the number of fatalities due to occupational hazards, the calculated crew exposure and individual risk for general cargo ships of IACS class and NOR or NIS registry, built after 1981-12-31, during the ten year period from 1997-01-01 to 2006-12-31				
	500 ≤ GT < 1,000	**1,000 ≤ GT < 20,000**	**20,000 ≤ GT**	**All**
Number of crew	4	13.4	25	17.1
Ship years	20.0	545.7	287.3	853.0
Fatalities	0	3	6	9
Crew exposure	160.0	14,657.8	14,365.0	29,182.8
Individual risk	0.0	$2.0 \cdot 10^{-4}$	$4.2 \cdot 10^{-4}$	$3.1 \cdot 10^{-4}$

The individual risk due to occupational hazards is shown in Figure 5-1, along with 95 % confidence intervals.

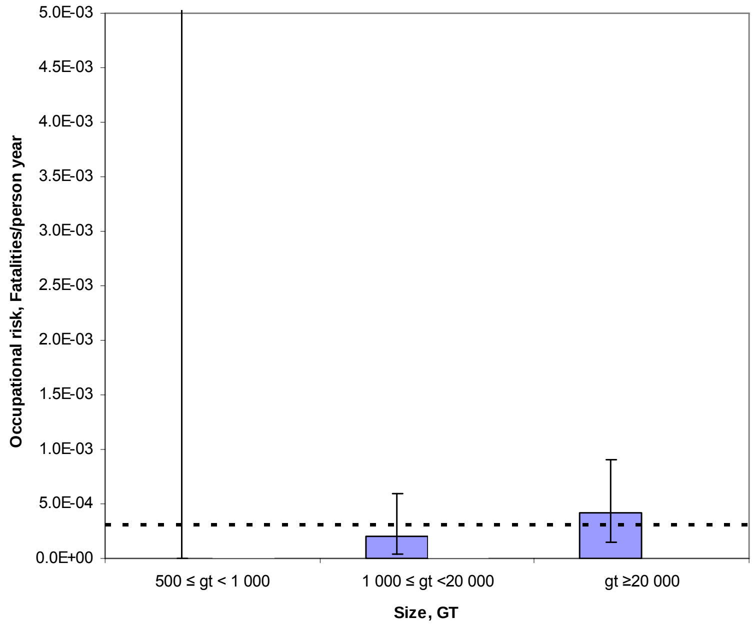

Figure 5-1: Individual risk due to occupational hazards for general cargo ships of IACS class and NOR or NIS registry, built after 1981-12-31 in the period from 1997-01-01 to 2006-12-31. The stapled line is the mean risk for all sizes, and the thin vertical lines are 95 % confidence intervals. The confidence interval for the 500 ≤ GT < 1,000 size segment has been cut short to maintain the readability of the figure, the upper limit is at $2.3 \cdot 10^{-2}$.

For the occupational risk there seems to be an increasing trend for larger ships. However, as the confidence intervals clearly shows, this trend can easily be explained by mere stochastic variation. The number of ship years for the smallest size segment is probably too low to give an indication of the occupational risk for these ships. This is partly confirmed by the large span of the confidence interval for this size segment. Based on the data at hand there is no evidence to support the claim that there are fewer or more accidents in either size segment.

The individual risk due to occupational hazards is $3.1 \cdot 10^{-4}$, with 95 % confidence limits at $1.4 \cdot 10^{-4}$ and $5.9 \cdot 10^{-4}$. Taking the uncertainty of the result into account, it is fair to say that the individual risk due to occupational hazards is about equal to the individual risk due to an accident involving the ship.

The personal accidents resulted in 174 injuries. The NMD database is somewhat inaccurate with respect to the severity of the injuries. However, one column includes entries indicating the length of the period the crewmember is dismissed from work after the injury. In this investigation, injuries where crewmembers have been dismissed for 72 hours or more are considered a serious injury. Injuries leading to a dismissal from work less than 72 hours are considered non-serious injuries, and are not considered further. In total there were 98 serious injuries.

The occupational risk of a serious injury based on the data from NMD has also been calculated and the results are given in Table 5-3.

Table 5-3: Number of crew, the number of ship years, the number of serious injuries, the calculated crew exposure and individual risk for general cargo ships of IACS class and NOR or NIS registry, built after 1981-12-31, during the ten year period from 1/1-1997-01-01 to 2006-12-31.

	500 ≤ GT < 1,000	1,000 ≤ GT < 20,000	20,000 ≤ GT	All
Number of crew	4	13.4	25	17.1
Shipyears	20.0	545.7	287.3	853.0
Serious injury	5	53	40	98
Crew exposure	160.0	14,657.8	14,365.0	29,182.8
Individual risk	$3.1 \cdot 10^{-2}$	$1.2 \cdot 10^{-3}$	$2.8 \cdot 10^{-3}$	$3.4 \cdot 10^{-3}$

Figure 5-2 shows the risk of serious injury due to occupational hazards for each size segment, the average risk of serious injury, and 95 % confidence intervals. For the two largest size segments there seems to be no difference between the observed risks. There seems to be a much higher risk of serious injury onboard ships in the 500 ≤ GT < 1,000 size segment. However, as previously pointed out for the risk of a fatality, the sample size is too small to draw a definite conclusion.

The total occupational risk of a serious injury due to occupational hazards is $3.4 \cdot 10^{-3}$, this is about a factor 10 higher than the risk of a fatality due to occupational hazards. The high limit for the 95 % confidence interval is at $4.1 \cdot 10^{-3}$, and the low limit is at $2.7 \cdot 10^{-3}$.

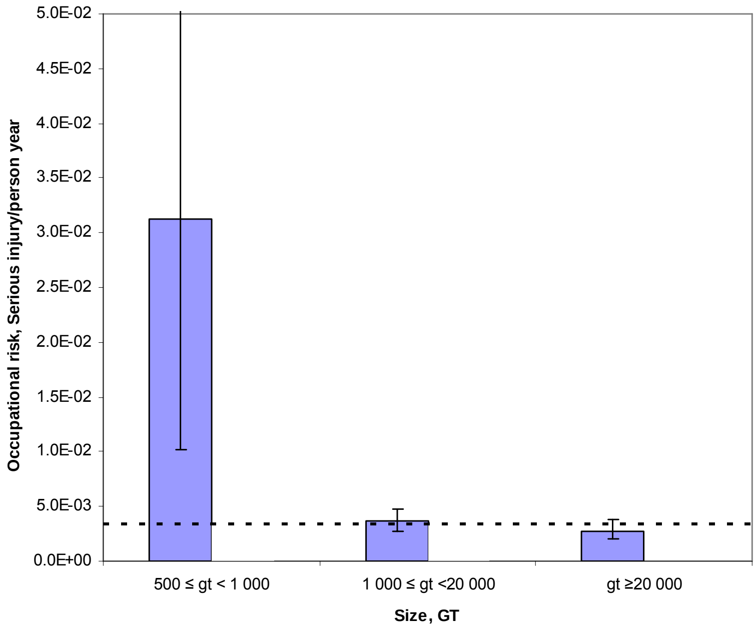

Figure 5-2: Individual risk of serious injury due to occupational hazards for general cargo ships of IACS class and NOR or NIS registry, built after 1981-12-31 in the period from 1997-01-01 to 2006-12-31. The stapled line is the mean risk for all sizes, and the thin vertical lines are 95 % confidence intervals. The confidence interval for the 500 ≤ GT < 1,000 size segment has been cut short to maintain the readability of the figure, the upper limit is at $7.3 \cdot 10^{-2}$.

A Danish study (Hansen H. L. et al., 2001) on occupational accidents onboard the Danish Merchant fleet covering the period from 1993-1997 give support for the figures presented by the NMD. This study considered 502 ships over the five year period from 1993-1997. The study reports a total of 1993 personal accidents, of which 209 lead to more than 5 % disability and 27 are fatalities. This study reports an overall occupational risk of fatality of $8.6 \cdot 10^{-4}$ and an occupational risk of an injury leading to more than 5 % disability (which for the purposes of this comparison, will be considered as a serious injury) of $6.7 \cdot 10^{-3}$. Though these rates are somewhat higher than what has been found in this analysis ($3.1 \cdot 10^{-4}$ and $3.4 \cdot 10^{-3}$ for the fatalities and the serious injuries respectively), the figures are comparable. The risk, as evaluated in the Danish study, is about twice as high as what has been found in this analysis, but in both cases it has been found that the risk of a serious injury is about ten times higher than that of a fatality. The figures in the Danish study are believed to be more accurate, as more exact data on crew exposure were available for this study and the accident data were extracted from insurance data, which implies that the involved parties in an accident has a high incentive for reporting.

6 Conclusion

This report summarises the results of an evaluation of historical data and determination of characteristic data for the ship type *general cargo ship* for the period 1997-01-01 to 2008-12-31. The evaluation is based on a group of ships selected using the following criteria:

- Ships "due or delivered" after 1981-12-31 and before 2009-01-01;
- A gross tonnage greater than 499;
- Classed by IACS society (based on the assignment in LRF 2009);
- Casualty reports classed "severe" and with IACS class assignment at date of incident.

This selection is considered to be representative for this ship type.

All data are taken from the Lloyds Register Fairplay PC-Register and Lloyds Register Fairplay Casualty database. LRF distinguishes seven sub-categories in the category general cargo ship. About 95 % of these ships belong to the sub-category *a single or multi deck cargo vessel for the carriage of various types of dry cargo* (A31A2GX). This group is considered for the main part of the statistical analysis. The considered fleet consists of 4,764 vessels and yield 43,222 ship years. Characteristic data with respect to the accident categories "total loss" and "fatality" (fatality covers the outcomes "killed" and "missing") are determined for the size categories:

- $500 \leq GT < 1,000$;
- $1,000 \leq GT < 20,000$;
- $20,000 \leq GT$.

The vast majority of ships and ship years are found in the size category $1,000 \leq GT < 20,000$. In total 1,462 casualties were reported in LRF for this selection taking into consideration the accident categories *collision, contact*, *foundering*, *fire and explosion*, *war loss*, *missing*, *hull and machinery*, *wrecked or stranded* and *miscellaneous*. Important accident categories with respect to the number of accidents are *hull and machinery*, *wrecked stranded* and *collision,* which account for about 80 % of all accidents. It is observed that the annual number of casualty reports increases between 1997 and 2007 from 57 to 241. In 2008 226 casualties were reported in LRF. In the same period the number of casualty reports for fatality and total loss does not increase. Thus, it may be concluded that the accuracy of reporting is improved between 1997 and 2008. For this period the average number of accidents per year is 122 which equates to an accident frequency of $3.4 \cdot 10^{-2}$ per year. On average the annual accident frequency increases for the period in focus. Based on the actual fleet size and the average accident frequency of the last twelve years the annual number of accident is estimated to 155.

The vast majority of total losses (118) are caused by the *foundering* (43 %) followed by wrecked stranded (19 %) and collision (19 %). The average annual frequency with respect to total loss is equal to $2.7 \cdot 10^{-3}$. This rate is comparable to the total loss rate for bulk carrier between 1995 and 2000 (MSC 83/20/1). It is noteworthy that there were no total losses for general cargo ships greater than 20,000 GT and built after 1982 in the twelve year period from 1997 to 2008. For the age range analysed, no clear tendency with respect to relation of accidents and year built are observed.

For the investigated general cargo ships classified by IACS societies 417 fatalities were reported for 54 accidents between 1997 and 2008, which yields an average number of fatalities per accident with fatalities of 7.7. The average number of fatalities per accident is about 0.3. The fatality rate per ship year is of $9.6 \cdot 10^{-3}$ (or 124 ship years per fatality). Five years are identified (1998, 2004, 2005, 2007 and 2008) where the fatality frequency is significantly higher than the average. These years contribute about 70 % of all fatalities in 55 % of the accidents with fatalities. Assuming an average crew of 14.7 per ship and an average annual stay of six months per crew member (50:50 scheme) the calculated individual risk is $3.4 \cdot 10^{-4}$. This value is the area of tolerable risk as proposed in MSC 83/INF.2 (The maximum tolerable individual risk is 10^{-3} and the maximum negligible individual risk is 10^{-6}). The calculation of potential loss of live for crew member yields $9.2 \cdot 10^{-3}$. The comparison with the outcomes of the FSAs for LNG (MSC 83/INF.3, 2007: $9.32 \cdot 10^{-3}$), for Container (MSC 83/INF.8, 2007: $3.52 \cdot 10^{-3}$) and crude oil Tanker (MEPC 58/INF.2, 2008: $1.26 \cdot 10^{-2}$) shows that the risk with respect to life of a crew member on a general cargo ship is similar.

The FN diagram developed on the basis of an average ship size and using the economic data of 2007 (conservative data in relation to 2008 because presently extremely high rates are achieved, non conservative in relation to 2009 because presently extremely low rates are achieved). As shown, general cargo ships are in the upper region of the ALARP "region". However, the boundary to intolerable risk is not touched.

The importance of occupational risk in the context of risk evaluation for crew on general cargo ships was noted (for instance in MSC 83/20/3). On the basis of data received by the Norwegian Maritime Directorate occupational risk is investigated with respect to ships registered to Norway or the Norwegian International Register. The results of the investigation show that the fatality rate for occupational accidents is about 20 % higher than for ship accidents (occupational: 55 %; ship accident: 45 %). This corresponds well with values presented in MSC 83/20/3 (60 % to 40 %).

7 References

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8 Glossary

Abbreviation	Description
CN	Collision
CT	Contact
FD	Foundering
FX	Fire / Explosion
LT	War Loss
MG	Missing
HM	Hull / Machinery
WS	Wrecked Stranded
XX	Miscellaneous
IACS	International Association of Classification Societies
LRF	Lloyd's Register Fairplay
FSA	Formal Safety Assessment
LNG	Liquefied Natural Gas
MSC	Marine Safety Committee
MEPC	Marine Environment Protection Committee
GNP	Gross National Product