Comprehensive Review of the Maritime Safety Regimes

Present Status and Recommendations on improvement

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Abstract

This report presents a comprehensive review of the maritime safety regimes and provides recommendations on how to improve the system. The results show a complex legal framework which generates a high amount of inspections and overlapping of inspection areas where no cross-recognition is established by the various stakeholders. While the safety system seems to be successful in eliminating substandard vessels and while average insurance claims costs are substantially lower for inspected vessels than not inspected vessels, the results indicate that the economic conditions of the shipping market also have an effect on safety quality besides the frequency of inspections. No significant differences can be found between industry inspections and port state control inspections with respect to decreasing the probability of casualty. The system could be made more effective by combining data sources on inspections and use them respectively to improve risk profiling and to decrease the frequency of inspections performed on ship types such as tankers. The results further indicate a lack of proper implementation of the International Safety Management Code (ISM code) and conventions with reference to working and living conditions of crew (ILO 147). A revision of the ISM code and more emphasis on enforcement of ILO 147 could further enhance the level of safety at sea.

The authors would like to thank several inspection regimes for their cooperation in providing inspection data and in allowing the observation of surveys and inspections on 26 vessels. In addition, the authors would like to acknowledge the data providers for the casualty data, Clarkson's for the economic data as well as two P&I Clubs in making data on insurance claims available.

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1. Introduction

In this paper we consider the inspection system in the maritime industry, by which we mean the summary of all safety inspections that are performed onboard commercial vessels such as mandatory and non-mandatory inspections, surveys and audits. We provide a critical review of the status of the present system and give recommendations on how to improve it. With inspection system, we mean the summary of all safety inspections that are performed onboard commercial vessels such as mandatory and non-mandatory inspections, surveys and audits.

The topic of the effectiveness of port state control has been treated in literature from various angles. Payoyo (1994) gives an overview of the implementation of international conventions through port state control and concludes that port state control (Paris MoU) has been successful in eliminating substandard vessels. Carriou et al. (2007) offers an econometric analysis on the effectiveness of inspections but bases the analysis only on data from one country (Sweden) and therefore ignores the effect of other countries in other regimes or industry inspections performed in the name of safety. From a system's perspective, Wang (2001) offers a review of IMO's status on formal safety assessment which is a relatively new approach for the shipping industry and not yet used extensively.

We use qualitative and quantitative analysis to cover the topic at hand. For the qualitative part, inspections on 26 vessels were observed and the area of inspections compared. For the quantitative part of this article, we partly re-use the same dataset as used in Knapp and Franses (2007a) but complement it further with additional data on variables of interest including an indicator of the economic status of the shipping industry. The underlying dataset is a combination of port state control inspection data from various port state control (PSC) regimes[2] of 183,819 inspections (1999 to 2004), casualty data from three different sources (IMO, Lloyd's Maritime Intelligence Unit and Lloyd's Register Fairplay) and vetting inspection data from two vetting regimes. This dataset is then complemented by insurance claim data from two P&I Clubs who would like to remain anonymous and the Clarkson's Shipping Index (Earnings per day) and second hand prices of vessels.

Through regression analysis, we measure the effect of port state control inspections of six regimes, vetting inspections from two regimes and audits performed for the International Safety Management Code (ISM). In addition, we also analyze the effect of ratification of international conventions of the International Maritime Organization (IMO) and the International Labor Organization (ILO) by flag states.

This article builds on the quantitative findings but complements it with the qualitative analysis of the complexity of the safety regimes and an in-depth analysis of the various types of inspections that are performed onboard the vessels, their associated costs, frequencies and compares them with insurance claims. This is to provide a more detailed picture of the situation at hand and to give recommendations on how to improve the system.

In section 2, we therefore provide an analysis of the complexity of the maritime safety regime which is followed by a summary of all inspections that are performed in the name of safety in section 3. Section 4 provides a summary of inspection frequencies, their costs and insurance claims while section 5 complements descriptive statistics with the results from regression analysis and measures the effect of inspections on the probability of casualty per frequency of

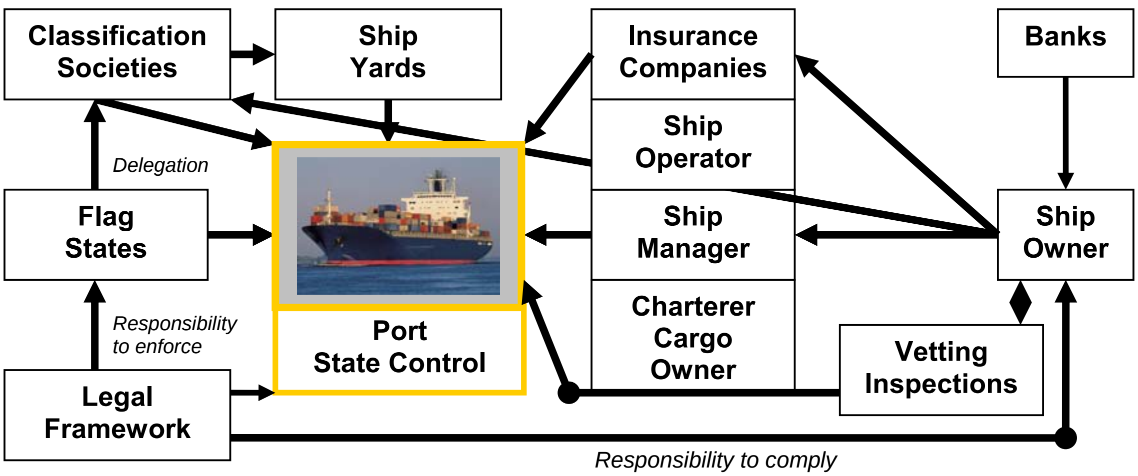
[2] Paris Memorandum of Understanding (MoU), Caribbean MoU, Viña del Mar Agreement on PSC, the United States Coast Guard, the Australian Maritime Safety Authority, Indian Ocean MoU.

inspection. Section 6 presents our conclusions and gives recommendations on how to improve the system.

2. The complexity of the safety regime

Figure 1 provides an overview of the players of the safety regime. The legal framework is created by three major international organizations namely, the United Nations (UN), the International Labor Organization (ILO), and the International Maritime Organization (IMO) and by country-specific legislation[3]. The classification societies provide the technical expertise during ship building and technical maintenance of the vessel. In addition, classification societies can be authorized to perform statutory surveys on behalf of flag states that have the responsibility to enforce their legal base which can be a combination of the international conventions of which the flag state is signatory and/or its own legal base. The ship owner has the responsibility to comply with the combined legal bases.

Figure 1: Players of the Safety Regime in General



The line between the actual ship owner, operator or technical manager of the vessel is not completely clear in shipping and therefore complicates enforcement of the legal instruments. The reason of the existence of the port state control regime derives from the fact that a certain percentage of ship owners and flag states use the legal "loophole" created by the international legal framework and try to save costs by operating below the minimum safety standards. This can cause accidents and damage to the environment, the cargo and human lives. Worldwide, there are currently ten safety regimes in place to cover most of the coastal states.

Port state control can best be described as the second line of defense while flag states should be the first line of defense in eliminating substandard vessels. This set-up further creates a highly political legislative process on the international level where technicalities are often ignored and political decisions prevail. A clear example thereof is that none of the ten existing port state control regimes recognizes the inspections performed in another regime. In addition, such recognition is also not guaranteed within the same regime. This further leads to an impairment of targeting vessels for inspections since only inspections of one regime are taken into account within this particular regime and all others are ignored.

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[3] This could be for instance the *"acquis communautaire"* for the European Union or OPA 90 for the US or any other country specific legislation.

In addition to port state control to eliminate substandard vessels, the industry solution to this problem is represented by the vetting inspections which are performed so far on oil tankers, chemical tankers and bulk carriers. The vetting inspections are primarily geared to cover the cargo owners from legal claims in case of an accident. These types of inspections create a strong commercial incentive for the ship owner to comply to the vetting inspection requirements since the outcome of these inspections will determine if the ship gets cargo or not. None of the vetting inspection regimes recognizes inspections which were performed in another regime nor does port state control accept or use these inspections to enhance risk profiling of their own systems. It leaves the industry with a high level of inspections to the detriment of the crew onboard vessels. All of these inspections are performed in the name of safety but in reality derive from various motivations and stakeholders' interests.

The International Maritime Organization is promoting the harmonization of port state control inspections at a global level and in 2006, the port state control regimes could for the first time attend the flag state implementation sub-committee meeting (FSI) as a member of the organization. A working group in the harmonization of PSC was established including the revision of deficiency codes but little progress was made so far. Given this situation, the next section will give an overview of all inspections that are performed.

3. Overview of inspections performed

This section provides an overview of the different kind of inspections, surveys and audits that are carried out on ships and compares their inspection content in order to identify overlapping areas. Security related inspections are only listed for the sake of information but are not further taken into consideration in the rest of the article since its main emphasis is safety.

3.1. General overview of inspection exposure

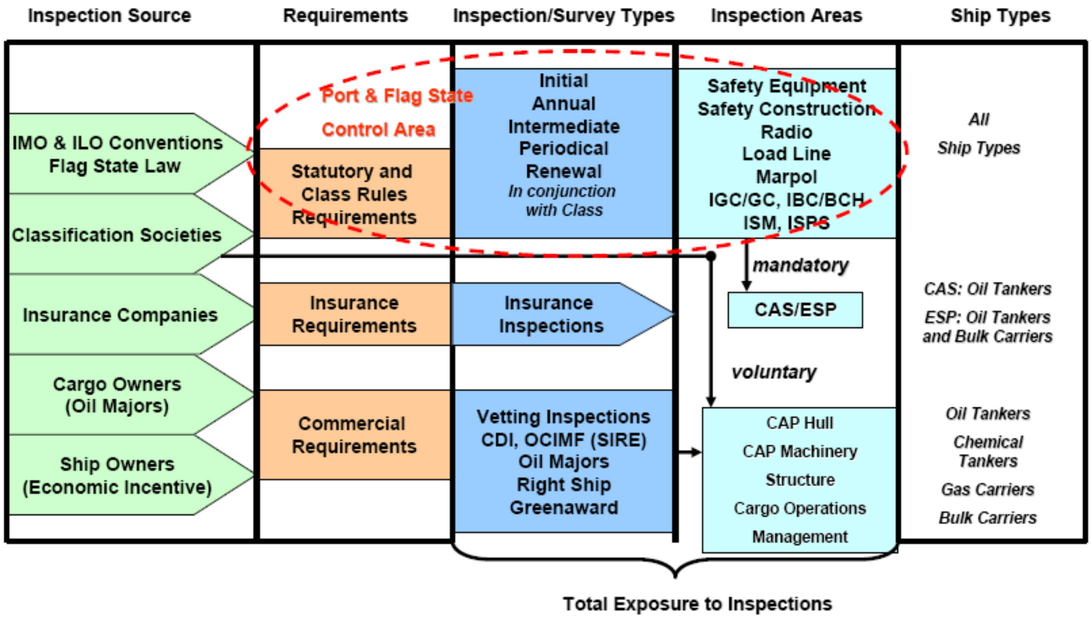
An overview of the total exposure to inspections is given in Figure 2 which provides information about the inspection source, the requirements with deriving inspection types/surveys and inspection areas. The last column lists the ship types since inspections vary according to ship types. One can easily see from this graph what the port state and flag state control area is as compared to the influence of industry inspections.

The inspection requirements can originate from various sources such as port state control, flag state inspections, ISM and ISPS[4] audits or classification surveys on behalf of a flag states (acting as recognized organization) or for the vessel to remain in class[5]. Insurance companies such as P&I Clubs perform their own inspections for insurance coverage purposes. Most inspections however are performed by the industry and are called vetting inspections performed on oil tankers, chemical tankers, gas carriers and bulk carriers on behalf of oil majors or other cargo owners or on behalf of the ship owner. (CDI, OCIMF, Rightship, Oil Majors)[6]. Only one system provides actual commercial incentives for an inspection (Greenaward Foundation).

Port state control and flag state inspections cover the statutory requirements. Classification societies perform most of the surveys based on statutory requirements and by authorization of a flag state.

[4] ISM = International Safety Management, ISPS = International Ship and Port Security
[5] A ship does not necessary have to be in "class" in order to trade but it is highly recommended.
[6] CDI = Chemical Distribution Institute, OCIMF = Oil Companies International Marine Forum

Figure 2: Summary of Total Inspection and Audit Exposure



Source: compiled by author from various legal sources and inspections
Note: CAS = Condition Assessment Scheme, ESP = Enhanced Survey Program, CAP = Condition Assessment Program

IMO has tried to synchronize the various types of inspections through the "Harmonized System of Survey's and Certification" and in essence, four types of mandatory inspections can be identified and are shown in the graph which covers the inspection areas listed next to the inspection types. Depending on the type of survey (e.g. initial, annual, renewal, etc.) the content and intensity of the inspection areas is changed accordingly. In addition to the mandatory inspection types and areas, two mandatory survey programs are identified and are also normally provided by the classification societies. The first one is *CAS (Condition Assessment Scheme)* based on MARPOL and the second is the *ESP (Enhanced Survey Program)* based on SOLAS[7].

Besides the items listed above, two types of audits are identified in Figure 2 - the *ISM* (International Safety Management) audit and the *ISPS* (International Ship and Port Security) audit which are both SOLAS requirements. This certification is split into a shipboard part and a company part where the shipboard part has to be completed every five years with one intermediate audit half way). Some flag administrations have not yet authorized classification societies to perform these audits but many flag states have done so and this area is therefore also widely covered by classification societies.

Cargo owners have considerable power through their vetting inspections for certain ship types. It becomes clear from the graph that the targeted ship types are chemical tankers, oil tankers, gas carriers and bulk carriers for the industry inspections while inspections based on statutory

[7] The Condition Assessment Scheme originated from an amendment to Annex I of MARPOL Annex I (Regulation 13G) and can be applied to single hull tankers above 15 years of age. It is intended to complement the requirements of the Enhanced Survey Program of SOLAS which applies to bulk carriers and oil tankers. Both require a different scope of survey depending on the age of the vessel including thickness measurements and rate the coating conditions of the tanks as GOOD, FAIR and POOR which is sometimes important information for vetting inspections.

requirements are valid for all ship types. The various inspection systems do reference each other but there is no cross-recognition.

CDI inspections originate from the ship owner and are therefore owned and paid by the ship owner. Inspections are based on a standardized questionnaire covering all areas of shipboard operations and are split up into "statutory requirements" (based on the international conventions), "required" (as per industry Code of Practice) and "desired" (required by CDI participants or users of the reports) requirements. An inspection normally takes around 8-10 hours where particular emphasis is placed on cargo operations and the competence of crew. CDI inspections are primarily performed on chemical tankers.

Sire inspections are performed by OCIMF (Oil Companies International Marine Forum) and originate from cargo owners. The inspections also cover more or less the same areas as CDI with a heavy influence on cargo operations and can take 8 to 10 hours. Ship Owners have some time to comment to the issued report before it becomes available online. These types of vetting inspections are primarily for oil tankers. While the standardized questionnaire serves as a basis, some oil majors have additional requirements and will add these requirements during an inspection which can be confusing for the ship owners and their crew since no split between statutory requirements and other requirements is made. In addition, oil majors normally perform their own inspections where the basic requirements are according to the SIRE inspections but additional requirements per oil major are added to the inspection and are not published in the SIRE report.

Rightship is a ranking system which combines information obtained through vetting inspections, port state control, casualties, ship particular information and ship owner information. It ranks vessels according to a rating score (1 to 5 stars where 5 stars represents a very good vessel with low risk). It is based on a joint venture between BHP Billiton Freight Trading and Logistics and Rio Tinto Shipping. The inspections cover tankers and bulk carriers but are primarily for dry bulk carriers. A Rightship Inspection can take from 8 to 48 hours and covers all aspects of shipboard operations in addition to ship structure and cargo handling equipment including hatch covers which is important for dry bulk carriers. Inspectors perform ballast water tank inspections and evaluate the conditions of the cargo holds.

The last kind of inspection that is performed on vessels (oil tankers) originates from the Greenaward Foundation. These inspections are paid by the ship owner. An initial inspection will take approx. 9 hours and cover all aspects of shipboard operations. In addition to the shipboard audit, an office audit (2 days) is performed to evaluate the shore based management systems and support to the vessels. After successful completion, the ship receives a certificate (Greenaward) and the ship owner can obtain discounts on harbor dues from ports participating in the program. Once the vessel is "Greenaward Certified", it needs to undergo annual or intermediate surveys to remain certified. The Greenaward Foundation is a non-profit foundation. Over the years, the Greenaward Certificate has not yet been officially recognized by port state control regimes. The approach is more complete and includes shore-side and ship-side elements of the operations.

In addition to the statutory requirement for CAS and ESP, some oil majors ask a ship owner to participate in *CAP (Condition Assessment Program)* for either hull or machinery. Those programs are offered by classification societies and are purely voluntary and provide the ship owner with a rating (CAP 1, 2 or 3 where CAP 1 represent the best rating) which is important for some oil majors. There is an overlapping of CAP with CAS where the main difference is that

CAS is a statutory requirement and its end users are the flag states while CAP is a voluntary program required by oil majors who decide on the minimum of the CAP rating.

3.2. Detailed comparison of inspection areas

This subsection provides a comparison of the inspection areas that are performed onboard ships (excluding security) and will only concentrate on inspections performed on ships. It will identify the areas that are overlapping. An inspection matrix was compiled based on the observation of 26 inspections on various vessels and interviews with the inspectors and can be seen in appendix 1 for easier reference.

The table is split into the main areas of inspection such as an administrative part, living and working conditions onboard the ship, the safety management system, areas related to safety and fire appliances, navigation and communication, ship and cargo operations including pollution prevention, machinery related areas and stability and structural related areas. The source of inspection is listed when applicable which can be a combination of the international conventions plus flag state requirements and additional industry requirements besides the statutory requirements. Next, the parties performing the inspections are identified and their coverage is indicated. The last column provides guidance on the crew that is involved in the inspections. For some vetting inspections and class surveys, the ship superintendent will normally also be onboard the vessel to assist the crew.

One can see from the table, that certificates are referenced by everybody and that the main areas of inspections are more or less covered by all types of inspections. Living and Working Conditions of the crew are mainly covered by the inspection rounds and the actual living space of the crew (their cabins and other facilities) is hardly inspected.

The industry inspections such as CDI/OCIMF, Rightship and Greenaward pay more attention to ship and cargo operations and spend considerably more time with crew members to interview them on operational issues. These items are primarily referenced during port and flag state inspections. Drills might be performed by some safety regimes such as the USCG or flag states but are not performed frequently by other inspectors and the inspection of the lifeboat primarily emphasizes the overall condition of the lifeboat, its launching devices and embarkation procedures as well as the lifeboat equipment. The inspection of safety and fire appliances is also covered by all types of inspections. For some items, the inspection might go into more details and entail the actual testing of the equipment which is merely performed during class surveys while others will only refer to expiry dates of the last survey/inspection that was performed shore side (e.g. for life rafts). Items related to navigation and communication is also covered by all inspection types including chart corrections, passage planning, nautical publications and the overall impression of the officer on watch with reference to the handling of the equipment (radar, echo sounder, radio equipment, etc.)

Difficult to inspect is the safety management system since it draws from all areas. All inspections do cover some ISM related questions and the actual validity of the presented paperwork only becomes evident after a general deck round and interview with crew members. It might be that the paperwork related to ISM is in compliance but not implemented onboard. Inspection systems such as the vetting inspections do emphasize more on this aspect where Greenaward also performs company audits shore-side. Authorized classification societies or flag states perform separate audits to ensure that the safety management system is implemented in practice but inspections, due to the time constraint in conducting surveys, are normally only looking at the surface.

As mentioned earlier, ballast water tank and cargo holds inspections are difficult to perform and are primarily done by classification societies. Rightship pays more attention to actual physical inspections while port states will only proceed either required by their policies (e.g. expanded inspections in the EU) or when perceived necessary. The various programs (ESP, CAS or CAP) for the conditions of coatings in the ballast tanks and cargo tanks (when applicable) are normally only referenced and physical inspections thereof are kept to a minimum.

The table gives a good indication of some of the overlapping of the inspections that are performed on ships from port states, flag states, vetting inspections and other industry inspections.

4. Inspection Frequencies, Costs and P& I Club Insurance Claims

This section provides an overview of inspection frequencies, their associated costs and insurance claims in order to add an economic dimension to safety inspections. Table 1 gives an overview of the frequency of inspections and their estimated yearly costs. The estimated inspection costs of a port state control inspection is USD 747 per inspection and is an average figure of inspections with zero deficiencies versus inspection with deficiencies including a 20% administrative charge[8]. Total estimated port state control costs for inspection with zero deficiencies are USD 12,5 Million per year (USD 15 Million including administration) or USD 34,3[9] Million for all inspections (zero and no zero deficiencies). There is no reliable estimate of the total benefit of port state control to society.

Table 1: Summary of Inspection Frequency, Allocated Time and Costs (USD/year)

in USD	Estim. Frequency	Time (hrs)	Estim. Costs	Estim. Costs	Estim. Total Cost
Inspection Type	**yearly*)**	**Allocated Onboard**	**Shore Side/Insp.**	**Ship Side/Insp.**	**Per Year**
Port State Control	2	5	747	288	2,070
Flag State Control	1	8	747	441	1,188
Class Annual Survey	1	10	10,362	517	10,879
ISM Audit	0.5	9	2,682	487	1,584
Insurance (P&I Club)	0.5	8	3,048	441	1,744
Industry Inspections: Tankers	6	10	17,663	566	29,702
Industry Inspections: Bulk	1	10	6,250	566	6,816
Industry Inspections: Other	0	0	0	0	0
Total Tankers	**11**	**50**	**35,248**	**2,739**	**47,166**
Total Dry Bulk	**6**	**50**	**23,835**	**2,739**	**24,280**
Total Other Ship Types	**5**	**40**	**17,585**	**2,173**	**17,464**

*Note: compiled by author, *) the ISM Audits and P&I Club Inspections are not performed yearly; For Industry Inspections, administrative portion of 20% are added which might be higher in reality due to substantial amount of preparation work*

The surveyor costs differ across countries and this change is not taken into consideration as data from 53 countries are in the total port state control inspection dataset. In reality, the presented figures might therefore somehow differ and most probably be lower as they are based on average

[8] As per information obtained from the Maritime and Coast Guard Agency, UK
[9] According to Knapp, S. (2006), page 34 and based on data from the Maritime and Coast Agency in combination with 183,000 inspections.

costs of a developed country. For the purpose of this study, the figures should merely give an overall indication on the costs associated with port state control and to give a conservative estimate. The same figure is then used for flag state inspections.

The remaining data is a summary from several sources from the shipping industry such as classification societies and ship owners of which the companies would like to remain anonymous. The table is split up into three groups. The estimated total frequency of inspection for tankers (oil and chemical tankers) is estimated to be at 11 inspections per year which can of course vary per ship type and age of the vessel. As the age increases (above 10 or 15 years), the frequency of industry inspections can increase. For dry bulk carriers, the inspection frequency is estimated to be 6 inspections and for all other ship types it is estimated to be as 5 inspections.

Shore based costs include the costs for an inspection itself including travel expenses as well as an administrative portion of preparing the inspections and to comment on the inspection reports which can take considerable amount of time on the ship operator's or owner's side. Total yearly costs per vessel associated with inspections vary from USD 47,166 for tankers to USD 17,464 for other ship types which are not part of the industry vetting inspection system. These costs represent total costs where the ship owner's portion would be the portion without port state control and without the flag state inspections.

It is difficult to bring these costs in relation to the costs that are associated with casualties. One attempt was made to gather insurance claim data but only two sources from the industry could be obtained of P&I Clubs[10] who were willing to provide claim figures for the years 2000 to 2004 per ship type and claim category. An average claim figure per ship was calculated and is presented in Table 2.

Table 2: Average P&I Club Claim Figures per Vessel and Year (2000 to 2004)

Average Claim in USD (2000 to 2004)	**Cargo/GA**	**Collision**	**Contact**	**Personnel**	**Pollution**	**Other**	**H&M**	**Average ST**
GG & Container	9,794	36,071	18,084	14,396	46,796	16,303	151,181	41,804
Dry Bulk	14,767	58,311	9,955	11,495	51,078	73,207	182,399	57,316
Tanker	42,936	88,277	21,079	18,216	272,016	44,596	609,252	156,624
Passenger	1,885	56,142	9,209	15,310	18,616	9,015	883,549	141,961
Other	9,231	18,801	478	6,446	6,886	38,357	557,692	91,127
Average/vessel	**15,722**	**51,521**	**11,761**	**13,172**	**79,078**	**36,296**	**476,815**	**97,766**

Note: compiled by author, GA = general average H&M = Hull and Machinery

In reality, the figures are higher than presented in the table due to the fact that the claim figures are based on actual claims above the deductible. The deductible can vary per ship type, size or ownership of the vessel. In addition, it varies considerably between hull and machinery (H&M) and other P&I club claims[11]. The figures presented in the table can therefore only be seen as a very rough idea of the magnitude of casualty claims per ship type.

[10] The P&I Clubs wish to remain anonymous.

[11] As per industry sources, the deductible for Hull and Machinery can be between USD 50,000 to 250,000 and for P& I Clubs between USD 5,000 – 30,000 for personnel and USD 10,000 to 100,000 for all other claims.

The inspection costs and insurance claims are further summarized in Table 3 which also gives the percentage to total inspection costs for all vessels and the average per vessel per year. The result indicate that the total average inspection costs per ship of USD 24,768 seems to be reasonable in relation to the average insurance claim costs of USD 97,766 which in reality might be an even higher figure. If one compares the percentages of the inspection costs to the total with the percentage of insurance claims for each ship type, one can observe that the two percentages are not necessarily in line for passenger vessels where the insurance claims (29.1%) are substantially higher than the inspection costs (14.1%). For tankers on the other hand, the higher inspection costs (38.1%) seem to be in line with the insurance claims (32%).

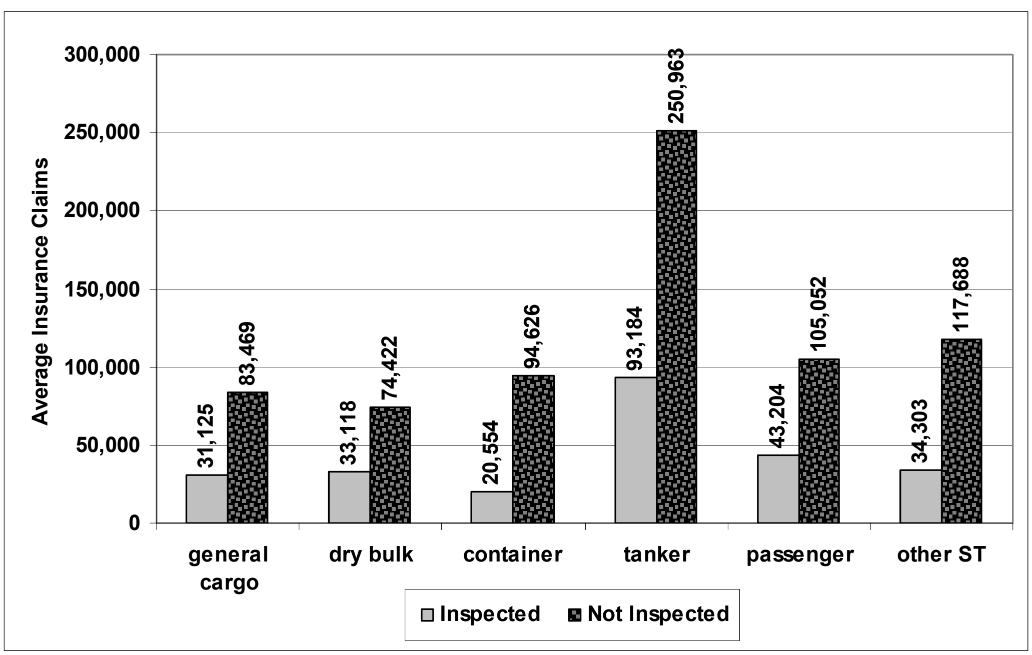
Table 3: Average Inspection Costs versus Insurance Claims in USD (2000 to 2004)

In USD per vessel	Inspection Costs	% to total	Insurance Claims	% to total
GG & Container	17,464	14.1%	41,804	8.6%
Dry Bulk	24,280	19.6%	57,316	11.7%
Tanker	47,166	38.1%	156,624	32.0%
Passenger	17,464	14.1%	141,961	29.1%
Other	17,464	14.1%	91,127	18.6%
Total All Vessels	**123,838**	**100%**	**488,832**	**100%**
Average per Vessel/year	**24,768**		**97,766**	

Source: compiled by author

In order to get an impression about the difference in insurance claims of vessel that were inspected with vessels that were not inspected, Figure 3 combines the inspection data set with the casualty dataset and insurance claims data and present the average claim figures of inspected versus non inspected vessels per ship type.

Figure 3: Average Claims of Inspected versus Non-Inspected Vessels per Ship Type in USD



Based on inspections from 1999 to 2004

The graph was produced the following way. The total casualty dataset was combined with the insurance claim costs as listed previously in Table 2 and then aggregated per IMO number in order to obtain an average claim amount per ship since one ship can have more than one type of claim.

The result was then merged with the inspection dataset in order to identify if a ship has been inspected or not inspected. The result is then given in Figure 3 and one can easily see that not inspected vessels have higher average claim costs than inspected vessels. The difference is highest for tankers and other ship types and lowest for dry bulk vessels. For tankers this can easily be explained due to the heavy exposure to vetting inspections. If one would aggregate these figures further and make them independent of ship types, the average claim of inspected vessels would be USD 42,819 versus USD 143,386 for a non inspected vessel which is roughly 3.3 times the costs of inspected vessels. These figures seem to indicate that insurance claims costs are substantially lower for inspected vessels than for not inspected vessels.

5. The Effect of Inspections to Decrease the Probability of Casualty

The last part of this article is based on the probability of casualty (very serious, serious and less serious) per frequency of inspection and is based on a model that extends the one used in Knapp and Franses (2007a) and which is based on a dataset of the world fleet for the time period 1999 to 2004. The casualties are grouped according to IMO MSC Circular 953 of December 2000 and are grouped into very serious, serious and less serious casualties.

The total inspection information is merged with casualties per IMO number and is then complemented with economic data. The whole dataset is then aggregated by IMO number to provide average values for certain variables or sums of inspections per vessel. This distinction will be explained later on in detail. A separate model is created for each type of casualty and provides the partial effect of a list of variables which should give an indication of the effectiveness of the safety regime in addition to economic variables.

Variables of particular interest are the ratification of legal instruments by a flag state or a country of the beneficial owner, the ratification of the Merchant Shipping Conventions (ILO 147 and its Protocol), the inspection variables (port state control and vetting inspections), the ISM audit and economic variables. ILO 147 is of interest because it provides the basis for shipboard conditions of employment and living conditions. These variables were not included in Knapp and Franses (2007a) due to lack of data at that time.

The models provide the estimated probability (P) of casualty (one model per type of seriousness) and are based on binary logistic regression. For a detailed explanation of the binary logistic regression which is a standard econometric technique, one can refer to Franses and Paap (2001, Chapter 4). The dependent variable (y) in this case is “casualty” (1) or “no casualty” (0). The model is presented in Equation 1 where the term $x_i\beta$ changes according to the model in question and is given in Equation 2. The variables are listed in Table 4 for further reference.

The variables are based on an aggregated dataset (per IMO) and the variable type (D for dummy or C for continuous) and its aggregation (a for average or s for sums) is listed for further detail in the second last column of the table. The probabilities produced are for any individual ship (i) and the rest of the notation is defined as follows: ℓ represents the variable groups, n_ℓ is the total number of variables within each group of ℓ and k is an index from 1 to n_ℓ.

Equation 1: Probability of Casualty per seriousness

$$P_{\mathrm{i}} = \frac{\mathrm{e}^{(x_i\beta)}}{1+\mathrm{e}^{(x_i\beta)}}$$

Equation 2: Definition of term $x_i\beta$

$$\begin{aligned}x_i\beta = {} & \beta_0 + \beta_1 \ln(\mathrm{AGE}_i) + \beta_2 \ln(\mathrm{SIZE}_i) + \sum_{k=1}^{n_3-1}\beta_{3,k}\,\mathrm{ST}_{k,i} + \beta_4\,\mathrm{STInd}_i \\ & + \sum_{k=1}^{n_5-1}\beta_{5,k}\,\mathrm{CL1}_{k,i} + \sum_{k=1}^{n_6-1}\beta_{6,k}\,\mathrm{CL2}_{k,i} + \beta_7\,\mathrm{CLInd}_i + \beta_8\,\mathrm{CLWdr}_i \\ & + \beta_9\,\mathrm{CLRein}_i + \beta_{10}\,\mathrm{CLSurv}_i + \beta_{11}\,\mathrm{ISM}_i + \sum_{k=1}^{n_{12}-1}\beta_{12,k}\,\mathrm{DoC}_{k,i} \\ & + \beta_{13}\,\mathrm{DocInd}_i + \sum_{k=1}^{n_{14}-1}\beta_{14,k}\,\mathrm{FS}_{k,i} + \beta_{15}\,\mathrm{FSInd}_i + \sum_{k=1}^{n_{16}-1}\beta_{16,k}\,\mathrm{OWN}_{k,i} \\ & + \beta_{17}\,\mathrm{OWNInd}_i + \sum_{k=1}^{n_{18}-1}\beta_{18,k}\,\mathrm{SY}_{k,i} + \beta_{19}\,\mathrm{LIOWN}_i + \beta_{20}\,\mathrm{LIFS}_i \\ & + \beta_{21}\,\mathrm{ILO47}_i + \beta_{22}\,\mathrm{ILOPro}_i + \beta_{23}\,\mathrm{DH}_i + \beta_{24}\,\mathrm{RS}_i + \beta_{25}\,\mathrm{CDI}_i \\ & + \beta_{26}\,\mathrm{PSC}_i + \beta_{27}\,\mathrm{GR}_i + \beta_{28}\ln(\mathrm{CSI}_i) + \beta_{29}\ln(\mathrm{SH}_i)\end{aligned}$$

One could argue that the dataset contains too many observations where y = 1 (casualties) versus 0 due to the construction of the dataset since casualties of a six year time period are merged against the world fleet as per a certain time frame. The underlying question of concern would be if this can have a significant effect on the results? As shown in Cramer, Franses and Slagter (1999) where this was tested for various sizes of a reduced dataset of zeros, no significant explanatory power could be found in adding additional zero's (ships with no casualties) to the dataset at hand.

From Table 4, one can easily see that there are my variables which can measure the effect of inspections on the probability of casualty apart from regular ship particular information. Changes in ship particulars such as change of ownership, class withdrawals, the ship yard country where the vessel was primarily built or inspections performed by other safety regimes (be it port state control or vetting inspection regimes) all can have an effect. One therefore has to take a comprehensive approach including indicators of the economic situation of the shipping market which was introduced by using the data from Clarkson's. Even in the original dataset used in Knapp and Franses (2007a), not all safety regimes are present but the inspection coverage lies by 60% of the ships eligible for inspections.

Quasi-maximum likelihood (QML) is used as method of estimation (Greene, 2000, page 823) in order to give some allowance for a possible misspecification of the assumed underlying distribution function. The key statistics are presented in appendix 2 for the logit model. For the probit model we essentially find the same qualitative results. The rest of the statistics such as the McFadden R^2 and the hit rate show acceptable results for all three models.

Table 4: List of Variables Used in Models

			Variable Type	Total
		Total Number of Variables		n_ℓ
Variable	**ℓ**	**Casualty (Very Serious, Serious, Less Serious)**	**0/1**	**1**
Ln(AGE)	1	Vessel Age at the time of casualty(or inspection)	C	1
Ln(SIZE)	2	Vessel Size in gross tonnage	C	1
ST	3	Ship Type	D(a)	6
STInd	4	Indicates if ship type changed since construction	D(s)	1
CL1	5	Classification Societies Group at time of casualty (or inspection)	D(a)	3
CL2	6	Recognized Organization Group at time of casualty (or inspection)	D(a)	3
CLInd	7	Indicates if classification society changed over time	D(s)	1
CLWdr	8	Indicates if classification society withdrew	D(s)	1
CLRein	9	Indicates if classification was re-instated	D(s)	1
CLSurv	10	Indicates if classification survey was overdue	D(s)	1
ISM	11	Indicates if ship was audited for ISM	D(s)	1
DoC	12	Document of compliance company group	D(a)	5
DoCInd	13	Indicates if DoC company changed	D(s)	1
FS	14	Flag State Group at the time of casualty/inspection	D(a)	4
FSInd	15	Indicator if flag changed over time	D(s)	1
OWN	16	Ship Owner Countries	D(a)	5
OWNInd	17	Indicates if ownership was changed over time	D(s)	1
SY	18	Country Groups where ship was primarily built	D	7
LIOWN	19	Number of legal instruments owner country rectified	C(s)	1
LIFS	20	Number of legal instruments flag state has rectified	C(s)	1
ILO47	21	Indicates if flag has ratified ILO convention 147	D(s)	1
ILOPro	22	Indicated if flag has ratified Protocol to ILO 147	D(s)	1
DH	23	Double Hull	D	1
RS	24	Total # of inspections by Rightship	C(s)	1
CDI	25	Total # of inspections by CDI	C(s)	1
PSC	26	Indicated total # of inspections by PSC	C(s)	1
GR	27	Ship certified by Greenaward	D(s)	1
LN(CSI)	28	Clarkson's Index (Earnings/day)	C	1
LN(SH)	29	Secondhand prices of ships	C	1
		Total for the whole dataset (split into seriousness)		**56**

C = continuous, D = dummy of categorical variables, s=sum, a=average

The models were reduced using a 1% significance level and the coefficients for the inspection variables (port state control and vetting inspections) were tested using the Wald Test for testing restrictions[12] in order to see if the mean varies across the regimes. The null hypothesis (h_o) for testing the restrictions states that the means do not vary across the regimes. The hypothesis cannot be rejected for very serious casualties (*p- value 0.9137*) and serious casualties (*p-value 0.0367*) but it can be rejected for less serious casualties (*p-value0.0039*) for the three variables in question at 1% significance level. This result confirms that there is no difference in the effect of port state control inspections and vetting inspections in decreasing the probability of a very serious casualty and a serious casualty. The result is not surprising given the amount of overlapping in inspection areas identified in the qualitative part of this article.

[12] based on Wald Test for Testing Coefficient Restrictions, a standard procedure in Eviews

The remaining variables of interest can be found in Table 5. One can see that the partial effect of the ratification of legal instruments by flag is negative for all three types of casualties while it is positive for the country of ownership and the ISM audit. The result for the ISM is very interesting as it confirms that there is lack of proper implementation of the ISM code which has also been identified by Knapp and Franses (2007b&c) when they look at the effect of deficiencies found during an inspection. Another interesting result is the negative coefficient for the parameter indicating if a vessel's class was re-instated which shows the effect of a classification society's inspection before a vessel is re-instated. This effect is not significant for serious casualties.

Table 5: Partial Effects of Variables of Interest

Variable of Interest	very serious Coefficient	serious Coefficient	less serious Coefficient
Class Reinstated	-1.1232	n/s	-0.2207
ISM audited	0.2000	0.0303	0.0279
Legal Instrument ratified: Flag	-0.0247	-0.0512	-0.0569
Legal Instrument ratified: Owner	0.0410	0.0626	0.1024
ILO 147 ratified by flag	n/s	0.3845	0.5904
ILO 147 Protocol ratified by flag	n/s	0.2377	0.2452
Total number of inspections Rightship	-0.4046	-0.1034	-0.1136
Total number of inspections CDI	-0.3862	-0.0823	n/s
Total number of inspections PSC	-0.3563	-0.0509	-0.0485
Greenaward Certified	n/s	n/s	n/s
Clarksons' Index (Earnings/day)	-1.6224	-0.7182	-0.6167
Secondhand prices of ships	6.0022	2.5263	n/s

Note: n/s = not significant at a 1% level,

Ratification of ILO convention 147 and its protocol is not significant for very serious casualties and positive for serious and less serious casualties. This can be interpreted as a lack of enforcement of the ILO convention which is confirmed by the qualitative findings of this article as very little emphasis is placed on this area during the inspections.

The rest of the inspection variables are all negative compared to ships that were not inspected at all or inspected by another port state control regime or vetting inspection regime and is strongest for very serious casualties compared to serious and less serious casualties. For the Greenaward Foundation, certification of a certain vessel does not come out to be significant which might be due to the small number of ships (around 170 vessels) that are certified.

Finally, the economic variables indicate that an increase in earnings have a negative effect on the probability of casualties based on the time period 1999 to 2004. This can indicate that when the shipping market is good, more money is spent on safety. The effect is strongest for very serious casualties. The opposite is true for the second hand prices of vessels which show a positive effect. As second hand prices of vessels increase, the probability of casualty increases respectively.

Visualization of Results

The last part of this section will provide a visualization of the results, in particular the effect of inspections per seriousness of casualty. Figure 4 is based on a high risk ship profile of a tanker and shows how the probability of casualty decreases per number of inspections. For very serious casualties, the probability is also shown with no inspections. This can be produced for any particular vessel given its ship particulars, their changes over time and inspection history. For this graph, the average probability of all three inspection regimes is shown since no significant difference was found through the Wald Test for testing of the differences in the coefficients for very serious and serious casualties. For less serious casualties, only two regimes remain to be significant (port state control and Rightship) and for the sake of simplicity, they are also combined to an average probability. One can easily see the stronger effect for very serious casualties and the weaker effect for the other two.

Figure 4: Probability of Casualty per Frequency of Inspection

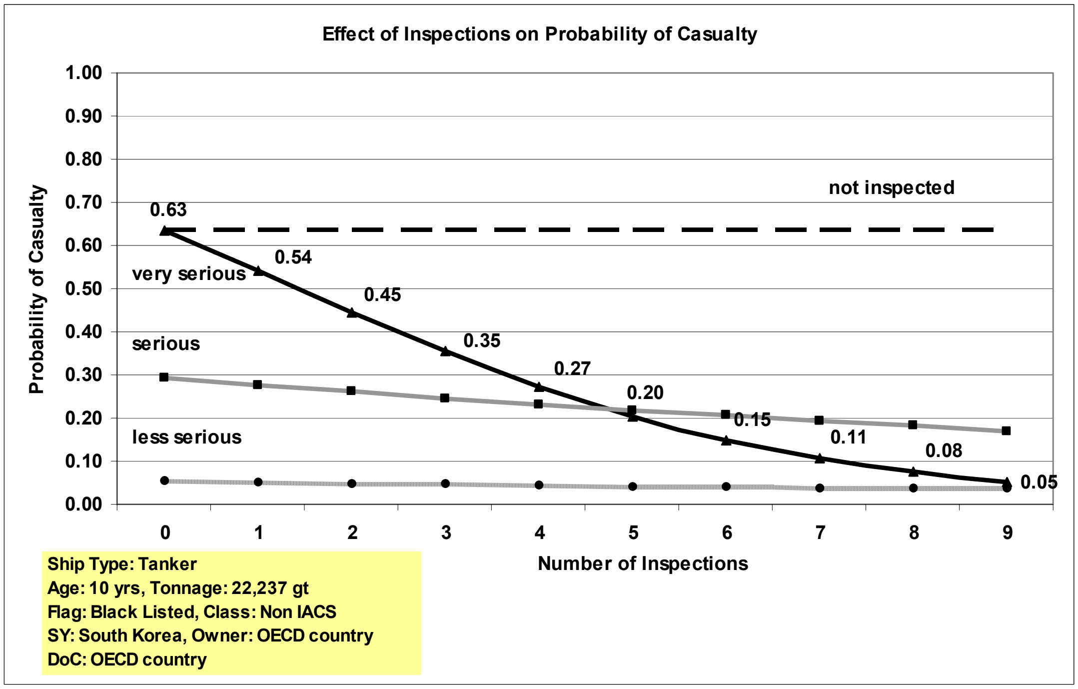


Figure 5 then provides a refined view for the probability of a very serious casualty per ship type. The same ship profile is used for this graph for the base probability. This is then complemented by the ship type and the type of inspections that are performed. All ship types have to undergo port state control inspections while tankers are exposed to all vetting inspections and dry bulk carriers to inspections from Rightship in particular. The result is given in the graph where one can easily see that tankers and dry bulk carriers show a steeper curve compared to the other ship types since it shows the combined effect of all the inspections that are performed on tankers.

While container vessels are not yet exposed to vetting inspections intensively, they show the same base probability (at inspection frequency zero) as tankers and dry bulk carriers. The base probability is slightly higher for general cargo vessels and passenger vessels and decreases slower compared to the other ship types.

The last graph visualizes the effect of earnings expressed through the Clarkson's Shipping Index for all three types of casualties. One can easily see in Figure 6 that the probability of a very serious casualty increases strongly as earnings increase while the effect is much weaker for serious and less serious casualties.

Figure 5: Effect of Inspections per Ship Type

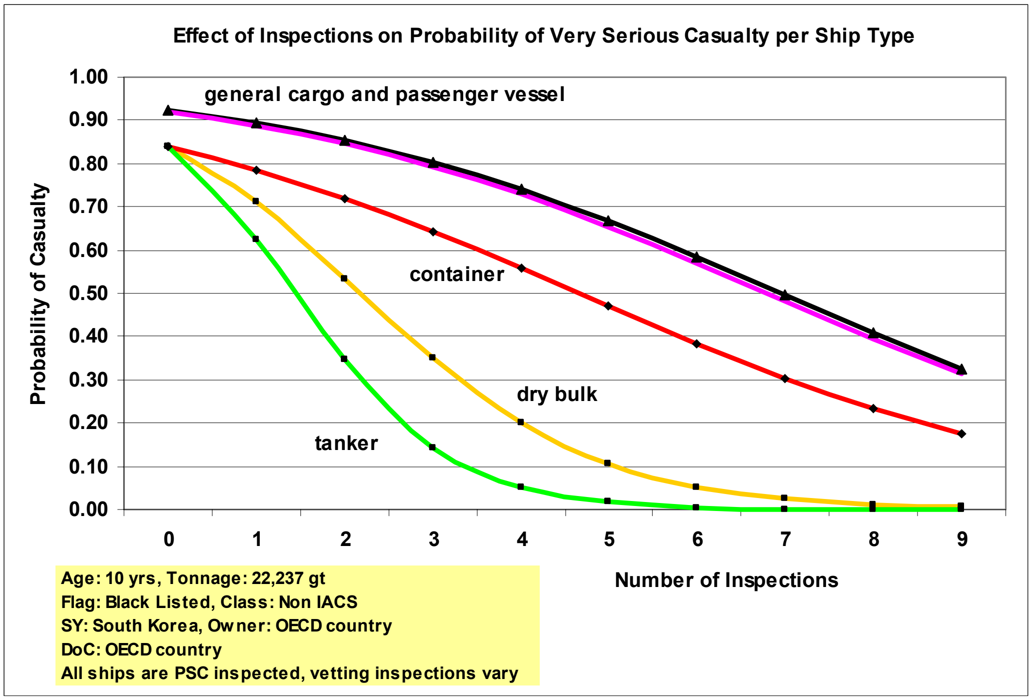
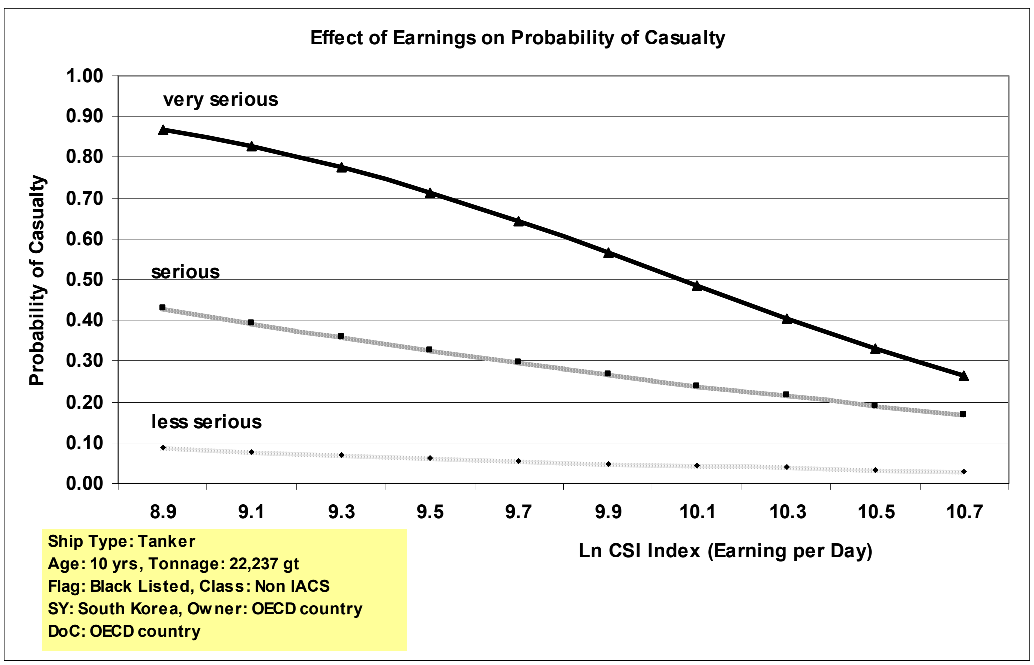


Figure 6: Effect of Earnings on the Probability of Casualty



The figures provide an interesting result. It indicates that the economic situation of the shipping market seems to have an effect of the safety quality of a vessel. In addition, no significant difference between inspections can be found and there seems to be an optimum of inspections to be performed in the name of safety. The fact that the two lines in Figure 4 cross can further indicate that the benefit of inspecting a vessel by decreasing the probability of casualty is partly offset by a higher probability of a serious casualty.

A reflection of this result could be that if too many inspections are performed fatigue of crew due to the increased work load during port operations increases. This argument can be supported by the result of the qualitative analysis which has shown the high amount of inspection frequencies and hours that are allocated onboard for inspections (up to 10 hours) per inspection which are performed during critical port operations. It can further be supported by the lack of enforcement of ILO 147 which was clearly shown by the regression results.

6. Conclusions and Recommendations

This article provided a comprehensive overview of the overall complexity of the safety regimes from various angles based on qualitative and quantitative analysis. Quantitative analysis has shown that there is a negative effect of inspections towards the probability of casualty and that the ratification of conventions further implies enforcement since its effect is also negative towards the probability of casualty. This does hold not to ILO 147 and its protocol or ISM audits. Average estimated insurance claims are significantly higher than inspection costs which further implies that the system overall is successful in eliminating substandard vessels. However, there is room for improvement of the safety system.

The lack of trust in the industry between flag states, port states, classification societies, insurance companies and cargo owners has created a playground for many inspections which are performed on certain ship types (oil tankers, chemical tankers and dry bulk carriers) in the name of safety and during critical port operations. Total inspection costs per vessel per year are estimated to vary from USD 47,166 for tankers to USD 17,464 for other ship types while the frequency of inspections can also vary considerably but is estimated to be at 11 inspections per year for tankers, 6 for dry bulk carriers and 5 for all other ship types.

The areas that are inspected in all of these inspections show a considerable amount of overlapping between statutory and industry driven inspections. In addition, no significant difference in the effect of these inspections towards decreasing the probability of casualty can be found.

The various types of inspections and the combination of statutory inspection and industry inspection requirements can add confusion to onboard operations due to conflicting requirements. With shortened time in ports, inspections can increase the working hours of shipboard personnel considerable and thereby increase fatigue and possibly offset the positive effect of the inspection.

In addition, the safety regimes do not accept port state control inspections that are performed in another regime or refer to industry inspections despite the fact that the effect of inspections on decreasing the probability of casualty has been quantified for various regimes including one vetting inspection regime. The inspection data is further not taken into consideration when targeting vessels which impairs the ability to correctly target vessels that could benefit from an inspection.

The underlying question is how the functioning of the safety regimes can be improved and how the money which is allocated to port state control or other inspections can be better used to eliminate substandard ships?

One could argue that the money allocated to port state control inspections with zero deficiencies could better be used to create a better framework to harmonize port state control activities by assisting emerging regimes. While this initiative was partly supported by the flag state sub-committee meeting at IMO in June 2006, process is very slow and impaired by politics. IMO's Global Integrated Ship Information System (GISIS) contains a port state and casualty module which could easily combine data on all inspections and casualties but lacks acceptance from the member states and data is partly not submitted to the database. Port state control regimes are not yet open to accept inspections that were performed in other regimes or to take information of industry inspection into account despite the fact that the effects towards decreasing the probability of casualty could be measured. This lack of cooperation further impairs the possibility to enforce the rectification of deficiencies since each regime only looks at its own data.

In conclusion, while the maritime safety system seems to be successful in eliminating substandard vessels, the system could be made more effective by combining data sources on inspections and to use them respectively to improve risk profiling and to shift inspection efforts to the ships and regions of the world where they are needed most. This would imply to overcome the various political barriers in the shipping industry and would call for more cooperation between regulators and the industry. Improved risk profiling and sharing of inspection data through GISIS could further help to decrease inspection frequencies onboard ships that are over-inspected. Finally, more emphasis should be put on the human factor onboard ships such as crew working and living conditions which are mostly not taken into consideration during the inspections.

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Appendix 1: Inspection Matrix – Comparison of Main Inspection Areas of Safety Inspections/Surveys/Audits

Compiled by author **Inspection Matrix - Main Areas of Inspection**	**Source of Inspection**			**Party performing the inspection/survey/audit**								
				Port & Flag State or Class				**Industry**				
Legend: x = part of inspection round r = referred during inspection i = actual physical inspection/testing/interviews s = depends on situation, for class on the type of survey (annual, intermediate, renewal)	**International Conventions (statutory)**	**Flag State**	**Add. Industry Requirements**	**Port State (more detailed insp.)**	**Flag State**	**Class Surveys**	**ISM (emphasis on the system)**	**Insurance (P&I Clubs)**	**CDI/OCIMF**	**Rightship**	**Greenaward (Shipside Part)**	**Ship Crew Involved**
	Average Time onboard (hrs.)			**6-8**	**8**	**24-48**	**8**	**8**	**8-10**	**8-48**	**9**	
Registration & Administration (Certificates)												
Statutory Certificates	various	x		r	r		r	r	r	r	r	
Crew Certificates (plus Endorsements)	SOLAS/STCW	x		r	r		r	r	r	r	r	
Crew Nationality			x							r		
Medicals		x		r	r		r	r	r	r	r	Master, Chief Officer
Other Certificates for Equipment Testing	various	x		r	r		r	r	r	r	r	
Previous Port State Control/Flag State Reports			x		r		r	r	r	r	r	
Vetting Inspection Reports			x							r	r	
Living and Working Conditions												
Accommodation	ILO	x		x	x			x	x	x	x	
Food (Inspection of Freezers and Galley)	ILO	x		x	x			x	x	x	x	
Living Conditions/Public Spaces	ILO	x		x	x			x	x	x	x	
Rest Periods and Watch Keeping Hours	STCW	x		r	r		r	r	r	x	r	
Safety Signs, Protection Equipment	SOLAS			x	x	x	x	x	x	x	x	Chief Officer, Third Officer, Cook
Gas Detection and Calibration	SOLAS/ISM			x	x	i	x	x	x	x	x	
Decontamination showers and eyewash on deck	SOLAS/ISM			x	x	i	x	x	x	x	x	
Mooring Arrangements Safe & Maintained	SOLAS/ISM	x		x	x	x	x	x	x	x	x	
Hospital and Medical Attention		x		x	x	x	x	x	x	x	x	

Appendix 1 continued

Inspection Matrix - Main Areas of Inspection

Legend:
x = part of inspection round
r = referred during inspection
i = actual physical inspection/testing/interviews
s = depends on situation, for class on the type of survey (annual, intermediate, renewal)

Inspection Matrix - Main Areas of Inspection	Source of Inspection			Party performing the inspection/survey/audit								
				Port & Flag State or Class				Industry				
	International Conventions (statutory)	Flag State	Add. Industry Requirements	Port State (more detailed insp.)	Flag State	Class Surveys	ISM (emphasis on the system)	Insurance (P&I Clubs)	CDI/OCIMF	Rightship	Greenaward (Shipside Part)	Ship Crew Involved
Management ISM												
Safety Management System/Master's Authority	SOLAS/ISM	x		r	r		i	r	r	r	i	
Safety & Environmental Policy	SOLAS/ISM	x		r	r		i	r	r	r	i	
DoC Company and Designated Person Ashore	SOLAS/ISM	x		r	r		i	r	x	r	i	
Company Internal Audits	SOLAS/ISM	x		r	r		i	r	x	r	i	
Records of Incidents/Near Misses/Accidents	SOLAS/ISM	x		r	r		i	x	x	r	i	
Maintenance Routines, Non-conformities	SOLAS/ISM	x		r	r		i	r	x	r	i	
Operational Safety - Safety Procedures (Hot Work, Entry into enclosed spaces)	SOLAS/ISM	x		r	r		i	r	r	r	i	Master, Chief Officer, Third Officer
Safety, Fire and Abandon Ship Drills	SOLAS/ISM	x		i(s)	i(s)		r	r	x	r	i	
Onboard Communication satisfactory				x	x		x	x	x	x	x	
Crew Familiarization	ISM	x			x		i	r	x	i	x	
Company Drug and Alcohol Policy and Testing			x					r	x	r	x	
Crew Working Experience			x						x	i	x	
Manning and Training Policy			x					r	x	i	x	
Security Related Items	SOLAS/ISPS			x	x				x	x	x	
Safety and Fire Appliances												
SOLAS Training Manuals	SOLAS	x		x	x	x	x	x	x	x	x	
Muster Lists and Emergency Instructions	SOLAS	x		x	x	i	x	x	x	x	x	Chief Officer, Third Officer
Lifesaving Appliances (Lifejackets, Immersion Suits, etc)	SOLAS	x		i	i	i	x	i	i	x	x	
Lifeboat, Life rafts, Equipment and Launching	SOLAS	x		i	i	i	x	i	i	x	x	

Appendix 1 continued

Inspection Matrix - Main Areas of Inspection

Legend:
x = part of inspection round
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Inspection Matrix - Main Areas of Inspection	Source of Inspection			Party performing the inspection/survey/audit: Port & Flag State or Class				Industry				
	International Conventions (statutory)	Flag State	Add. Industry Requirements	Port State (more detailed insp.)	Flag State	Class Surveys	ISM (emphasis on the system)	Insurance (P&I Clubs)	CDI/OCIMF	Rightship	Greenaward (Shipside Part)	Ship Crew Involved
Rescue Boat and equipment	SOLAS	x		x	x	i	x	x	x	x	x	
Pilot Ladder, Embarkation Ladders for Lifeboats	SOLAS	x		i	i	i	x	i	i	x	x	
Oxygen & Acetylene Storage, CO2 room	SOLAS	x		i	i	i	x	i	i	x	x	
Fire Control Plan	SOLAS	x		r	r	i	x	r	r	r	r	
Fire Fighting Equipment and Detection	SOLAS	x		i	i	i	x	i	i	x	x	
Fireman's outfit, breathing apparatus, air bottles, EEBD	SOLAS	x		x	x	i	x	x	x	x	x	
Fire/Foam Hydrants	SOLAS	x		x	x	i	x	x	x	x	x	
Industry Guidelines/Publications			x					x	x	i	x	
Navigation and Communication												
Company Navigation Procedures	STCW	x		x	x	x	x	x	x	x	x	
Bridge Standing Orders	SOLAS	x		x	x	x	x	x	x	x	x	
Passage Planning	STCW	x		x	x	x	x	x	x	x	x	
Chart Corrections	SOLAS	x		x	x	x	x	x	x	x	x	
Nautical Publications up to date	various	x	x	x	x	x	x	x	x	x	x	
Navigational Equipment Working (GPS, Speed Log, Radar, Echo Sounder, Compass, Navtex etc.)	SOLAS	x		x	x	i	x	x	x	x	x	Chief Officer, Second Officer
Dead man Alarm (when applicable)		x		x	x	x	x	x	x	x	x	
Guidelines for the prevention of fatigue			x							r		
Crew knows how to operate equipment	STCW	x		x	x	x	x	x	x	x	x	
VDR/AIS	SOLAS	x		x	x	i		x	x	x	x	
Compass Error Log	STCW	x		x	x	x		x	x	x	x	

	Appendix 1 continued **Inspection Matrix - Main Areas of Inspection**	**Source of Inspection**			**Party performing the inspection/survey/audit**								
					Port & Flag State or Class				**Industry**				
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	Compass Deviation Card	SOLAS	x		x	x	x		x	x	x	x	
	Navigation Lights	COLREG	x		x	x	i		x	i	x	x	
	GMDSS Operations and Testing	SOLAS/STCW	x		x	x	i		x	x	x	x	
	EPIRB and SART	SOLAS	x		x	x	i		x	x	x	x	
Ship and Cargo Operations including Pollution Prevention													
	Loading and Stability Manuals	IBC/BCH	x		r	r	r	x	r	r	x	x	
	Cargo loading limitations	IBC/BCH	x		r	r	r	x	r	r	x	x	
	Damage/survival stability guidelines	IBC/BCH	x		r	r	r	x	r	r	x	x	
	Procedures and Arrangement Manual	MARPOL	x		r	r	r	x	r	r	x	x	
	High level alarms operative	IBC	x		x	x	i	x	x	x	x	x	
	Bilge Alarms	SOLAS	x		i	x	i	x	i	i	x	i	
	Portable or fixed gas detection systems	SOLAS	x		x	x	i	x	x	x	x	x	
	Inert gas system or other systems to blanket cargo				x	x	x	x	x	x	x	x	Chief Officer, Chief Engineer
	15 ppm Alarm	MARPOL	x		i	i	i	x	i	i	x	i	
	Oil-Mist Detector	SOLAS	x		i	i	i	x	i	i	i	i	
	SOPEP, SMPEP	MARPOL	x		r	r	r	x	r	r	x	x	
	Cargo Record Book, Oil Record Book, Garbage RB	MARPOL	x		r	r	r	x	r	r	x	x	
	Tank cleaning and washing including COW	MARPOL	x		r	r	x	x		x	x	x	
	Industry Guidelines/Publications			x					x	x	x	x	
	Cargo Operations in General including Pump Room	various		x	x	x			x	i	x	x	
	Cargo Transfer Operations	various		x	x	x			x	i	x	x	

	Appendix 1 continued **Inspection Matrix - Main Areas of Inspection**	**Source of Inspection**			**Party performing the inspection/survey/audit**								
					Port & Flag State or Class				**Industry**				
	Legend: x = part of inspection round r = referred during inspection i = actual physical inspection/testing/interviews s = depends on situation, for class on the type of survey (annual, intermediate, renewal)	**International Conventions (statutory)**	**Flag State**	**Add. Industry Requirements**	**Port State (more detailed insp.)**	**Flag State**	**Class Surveys**	**ISM (emphasis on the system)**	**Insurance (P&I Clubs)**	**CDI/OCIMF**	**Rightship**	**Greenaward (Shipside Part)**	**Ship Crew Involved**
	Fuel Testing, sulphur content measurement			x								r	
	Anti-fouling system for hull coating (TBT free)	MARPOL	x			r				r		r	
	Additional Oil Pollution Prevention Measures			x						r		r	
Machinery Related Areas including Engine Room													
	Engine Room Standing Orders	SOLAS/ISM	x		x	x	x	x	x	x	x	x	Chief Engineer, First or Second Engineer
	Planned Maintenance System	SOLAS	x		r	r	i	x	r	i	x	x	
	Emergency Steering Gear	SOLAS	x		i	i	i		i	i	i	i	
	Emergency Fire Pump	SOLAS	x		i	i	i		i	i	i	i	
	Emergency Generator	SOLAS	x		i	i	i		i	i	i	i	
	Emergency Batteries	SOLAS	x		x	x	x		x	x	x	x	
	Testing of Black Out and Reverse Polarity				i(s)		i			i(s)	i(s)	x	
	Overall Cleanliness and Appearance of ER				x	x	x	x	x	x	x	x	
Stability & Structure													
	ESP, Thickness Measurements	SOLAS	x		r	r	i(s)	r	r	r	r	r	Master, Chief Officer, Chief Engineer
	CAS (Condition Assessment Scheme)	MARPOL	x		r	r	i(s)	r	r	r	r	r	
	Inspections of Ballast Tanks, Cargo Tanks, Void Spaces, Cofferdams for Condition of Coating/Corrosion	SOLAS/MARPOL			x	r	i(s)	r	r	x	i	r	
	Rating System for Condition of Coating/Corrosion	as per ESP/CAS	x		r	r	i(s)	r	r	r	i	r	
	Conditions of Hull and Superstructure	Good/Fair/Poor	x		x	x	i(s)	x	i(s)	x	i	i	
	Class Conditions and Memoranda			x	r	r		r	r	r	r	r	

Appendix 2: Key Statistics of Final Models: Probability of Casualty

	Very Serious		Serious		Less Serious	
# observations in final model	0 =	37738	0 =	37738	0 =	37738
	1 =	772	1 =	3385	1 =	2221
	Total =	38510	Total =	41123	Total =	39959
# of outliers	61		nil		nil	
Cut Off	0.020		0.082		0.056	
	LOG	**PRO**	**LOG**	**PRO**	**LOG**	**PRO**
Mc Fadden R2	0.399	0.394	0.182	0.181	0.153	0.152
% Hit Rate y=0	84.58	83.15	77.35	75.93	73.67	71.69
% Hit Rate y=1	80.57	83.03	67.18	69.13	67.81	70.01
% Hit Rate Tot	84.50	83.14	76.52	75.37	73.34	71.59
HL-Stat. (df=8)	10.26	78.85	12.37	16.57	19.44	23.27
p-value	0.2469	0.0000	0.1253	0.0349	0.0127	0.003