Analysis of the Maritime Inspection Regimes – Are ships over-inspected?

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Abstract

The lack of trust in the maritime industry between all the industry organizations and regulators has created an inspection industry which is heavily controlled by oil majors in order to limit their liability. This report is an introductory part of a PhD project called *" The Econometrics of Maritime Safety – Recommendations to Enhance Safety at Sea"* which is based on 183,000 port state control inspections[2] and 11,700 casualties from various data sources. Its overall objective is to provide recommendations to improve safety at sea. This part identifies all inspections that are performed in the name of safety onboard vessels, their estimated costs and frequencies and brings them in relation with insurance claim costs from P&I Clubs. The probability of casualty is analyzed per frequency of inspection and detention. The results reveal that certain ships are inspected frequently and that over-inspection does not necessarily decrease the probability of having a casualty but can rather increase it.

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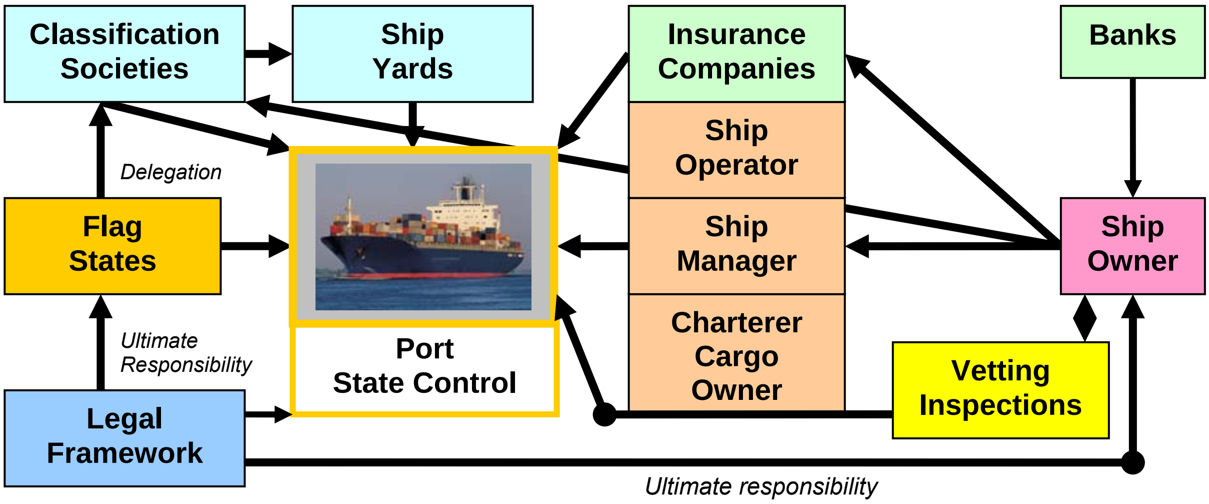
[2] The authors would like to thank the following secretariats for their kind co-operations: Paris MoU, Indian Ocean MoU, Viña del Mar Agreement on PSC, Caribbean MoU, Australian Maritime Safety Authority, the United States Coast Guard, Lloyd's Register Fairplay, Lloyd's Maritime Intelligence Unit, the International Maritime Organization (IMO), Right Ship and the Greenaward Foundation.

1. The Complexity of the System

1.1. The Players of the Regime

Figure 1 provides an overview of the players of the safety regime which at first side seems complex. The legal framework is created by three major international organizations namely, the UN, ILO, and the IMO[3] and country specific legislation[4]. 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 responsibilities on behalf of the flag states that have the ultimate responsibility to enforce their legal base which can be a combination of the international conventions of which the flag state is signatory or its own legal base while the ship owner has the ultimate 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. In an effort to gain some insight into the relationships, data from Lloyd's Register Fairplay was merged with the total dataset as explained previously. 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. According to the OECD the percentage of sub-standard ships in the world commercial fleet is estimated to be between 10-15%[5]. The industry solution to this problem is represented by the vetting inspections which are performed on oil tankers, chemical tankers and bulk carriers. The vetting 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.

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[3] UN: United Nations, IMO: Intern. Maritime Organization, ILO: Intern. Labor Organization

[4] This could be for instance the *"acquis communautaire"* for the EU or OPA 90 for the US or any other country specific legislation

[5] Peijs, K. (2003). Ménage a trois. Speech at *Mare Forum* (November 2003: Amsterdam)

The various types of inspections that are performed on ships including port state control inspections will be explained in detail later on.

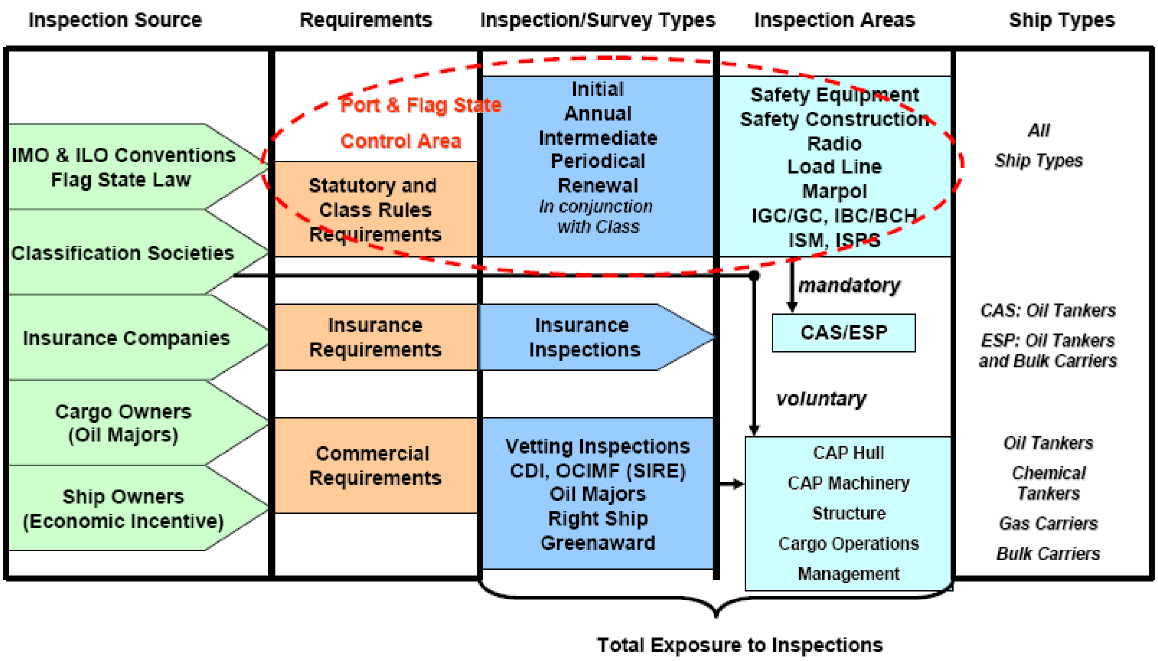
Port State control can be seen as a last resource of safety to eliminate substandard ships from the seas. Worldwide, there are currently ten safety regimes in place to cover most of the coastal states. Those regimes are as follows:

1. Europe and North Atlantic (Paris MoU)
2. Asia and the Pacific (Tokyo MoU)
3. Latin America (Acuerdo de Viña del Mar)
4. Caribbean (Caribbean MoU)
5. West and Central Africa (Abuja MoU)
6. Black Sea (Black Sea MoU)
7. Mediterranean (Mediterranean MoU)
8. Indian Ocean (Indian Ocean MoU)
9. Arab States of the Gulf (Riyadh MoU)
10. US (US Coast Guard)

1.2. Overview of Inspections in the Name of Safety

The following section will provide a short overview of the different kind of inspections and surveys that are carried out on ships besides port state control inspections. An overview of the total exposure to inspections is given in Figure 2.

Figure 2: Summary of Total Inspection and Audit Exposure[6]



Source: compiled by author from various legal sources and inspections

The inspections originate from various sources and are as follows:

- Port state control inspections and flag state control inspections

[6] Note: CAS = Condition Assessment Scheme, ESP = Enhanced Survey Program, CAP = Condition Assessment Program

- ISM and ISPS audits due to statutory requirements and which are still sometimes performed by the flag states but most of the time also delegated to recognized classification societies
- Classification surveys on behalf of flag states and to remain in class[7]
- Insurance companies such as P&I Clubs for insurance coverage purposes
- Industry inspections such as 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/SIRE, Rightship, Oil Majors)

Commercial incentives: These inspections are on request of the ship owner in order to obtain a quality certificate which will then help in obtaining commercial incentives

1.3. Mandatory Inspections/Surveys/Audits

Port state control and flag state inspections cover the statutory requirements. Classification societies perform most of the surveys based on the statutory requirements and by authorization of a flag state. The IMO has tried to synchronize the various types of inspections 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. An initial survey is a complete inspection before the vessel comes into service. 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.

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.

In order to facilitate the various mandatory inspections/survey types shown in Figure 2 and which need to be carried out, the IMO established the "Harmonized System of Survey's and Certification" which can be seen in summarized version in Table 1[8] where the following abbreviations are used[9]:

- *A – Annual:* general inspection of the items relating to the certificate to ensure that they have been maintained and remain satisfactory for the service for which the ship is intended.
- *P – Periodical or I - Intermediate:* inspection of the items related to the certificate in order to ensure that they are in satisfactory conditions and fit for the service for which the ship is intended. It is a more detailed inspection compared to the annual inspection and is called periodical with reference to the radio equipment and intermediate for all other types of surveys.
- *R – Renewal:* same as periodical but more detailed and leads to the issue of a new certificate and normally involves dry docking.

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[7] a ship does not necessary have to be in "class" in order to trade but it is highly recommended.

[8] Extract from IMO Resolution A 746 (18), page 246 and amendment

[9] Based on IMO Resolution A.746 (18), page 151 and amendment

Table 1: Summary of Harmonized System of Survey and Certification

Years	1			2			3			4			5	
Months	**9**	**12**	**15**	**21**	**24**	**27**	**33**	**36**	**39**	**45**	**48**	**51**	**57**	**60**
Certificates/Inspection Areas														
Passenger Ship Safety Cert.	R			R			R			R			R	
CS Safety Equipment Cert.	A			A or P			P or A			A			R	
CS Safety Radio Certificate.	P			P			P			P			R	
SC Safety Construction Cert.	A			A or I			I or A			A			R	
CF Gas (IGC/GC)	A			A or I			I or A			A			R	
CF Chemical (IBC/BCH)	A			A or I			I or A			A			R	
Load Line Certificate	A			A			A			A			R	
IOPP (Marpol Annex I)	A			A or I			I or A			A			R	
IPP (Marpol Annex II)	A			A or I			I or A			A			R	

Based on IMO Resolution A 746 (18)

Abbreviations: CS = Cargo Ship, CF = Certificate of Fitness, IOPP = Intern. Oil Prevention Pollution Certificate, IPP = Intern. Pollution Prevention Certificate for Carriage of Noxious Liquid Substances in Bulk

The table shows the time periods and within which time periods the different types of surveys can be conducted. It allows a harmonized approach between the various SOLAS and Marpol requirements. Passenger vessels have to follow stricter survey schemes (renewal surveys) than other ship types and a renewal survey has to be carried out each year versus every five years. Intermediate surveys come into the picture between the 2nd and 3rd year in order to decrease the inspection time required for a full renewal survey.

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.

1.4. Non Mandatory Inspections

Cargo owners have considerable power through their vetting inspections for certain ship types (oil tankers, chemical tankers, gas carriers and dry bulk carriers). Sometimes these inspections originate from the cargo owner or sometimes the ship owner will ask for the inspection in order to show a certain quality level for a potential cargo owner. Going through an inspection does not necessarily mean the ship is accepted for cargo. 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 requirements are valid for all ship types. The various inspection systems do reference each other but there is no cross-recognition. The following paragraphs will describe the systems further.

CDI (Chemical Industry Institute): CDI inspections originate from the ship owner and are therefore owned and paid by the ship owner. The owner requests a CDI inspection and the inspector is appointed to the vessel. 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. After the inspection, the report is uploaded to the CDI system and the ship owner can provide comments to the inspection results. After that, the ship owner can decide if the report goes alive or not and becomes visible for the CDI users.

***SIRE (Ship Inspection Report Program) and inspection from Oil Majors*:** Sire inspections are performed by OCIMF (Oil Companies International Marine Forum) and originate from cargo owners. The inspectors are appointed by OCIMF and the information is however owned by the cargo owner but partly made available to other OCIMF members who can obtain parts of the inspection results for a fee. 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: 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.

Greenaward: 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 is not yet 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 the 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 decides on the minimum of the CAP rating.

1.5. Comparison of Inspection Areas

The next section will provide a comparison between the various inspections (excluding ISPS) that are performed on the vessels and explained previously. It will only concentrate on inspections performed on ships and only highlight the main areas and items that are inspected in comparison with each other. The inspection matrix can be seen in Table 2 for easier reference and was compiled based on the experience the author collected by observing some inspections and the check-lists of some of the inspectors. The legend and color coding for the table is provided here below:

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

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.

The inspection normally starts with a short briefing of the master and review of the ship's certificates and crew certificates. This is followed by a deck round starting from the top (bridge) down to the main deck areas with stops at the life boats, safety lockers, fire fighting equipment. The bridge will also cover more detailed questions about passage planning, chart corrections and the checking of the navigational equipment, lights and radio equipment. Deck rounds can entail stops at the paint locker, the CO_2 room (if applicable), storage location for Acetylene and Oxygen Cylinders, the pump room (if applicable), the emergency generator, checking of fire hoses and lifebuoys, mooring arrangements and winches as well as visits to the forepeak. The last section of the inspection normally covers the cargo control room and the engine room with the testing of the emergency fire pump and emergency steering gear and a general round around the engine room including the areas used for welding. If ballast water tank inspections or inspections of the cargo holds are performed, the inspector will announce this in the beginning of the inspection so that it can be prepared accordingly. It is not easy to access ballast water tanks or cargo holds during normal cargo operations.

Table 2: Inspection Matrix - Main Areas of Inspection in Comparison

Note: Compiled by author				Party performing the inspection/survey/audit								
Inspection Matrix - Main Areas of Inspection	**Source of Inspection**			**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**
	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	Master, Chief Officer
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	
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	Chief Officer, Third Officer, Cook
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	
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	

Note: Compiled by author

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	Master, Chief Officer, Third Officer
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	
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	Chief Officer, Third Officer
Muster Lists and Emergency Instructions	SOLAS	x		x	x	i	x	x	x	x	x	
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	

Note: Compiled by author				**Party performing the inspection/survey/audit**								
Inspection Matrix - Main Areas of Inspection	**Source of Inspection**			**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	

	Note: Compiled by author				**Party performing the inspection/survey/audit**								
	Inspection Matrix - Main Areas of Inspection	**Source of Inspection**			**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**
	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 (for oil tankers) or other systems to blanket cargo (e.g. nitrogen)				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	

Note: Compiled by author				Party performing the inspection/survey/audit								
Inspection Matrix - Main Areas of Inspection	**Source of Inspection**			**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**
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												
Enhanced Survey Program, 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 (e.g Hatch covers)	Good/Fair/Poor	x		x	x	i(s)	x	i(s)	x	i	i	
Class Status Report/Outstanding Class Conditions and Memoranda			x	r	r		r	r	r	r	r	

The inspection is normally finished up with a round of the galley storage areas for food (dry store, freezers, etc.) and the crew mess and day room.

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 on 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 other will only refer to expiry dates of the last survey/inspection that was performed shore side (e.g. for life rafts).

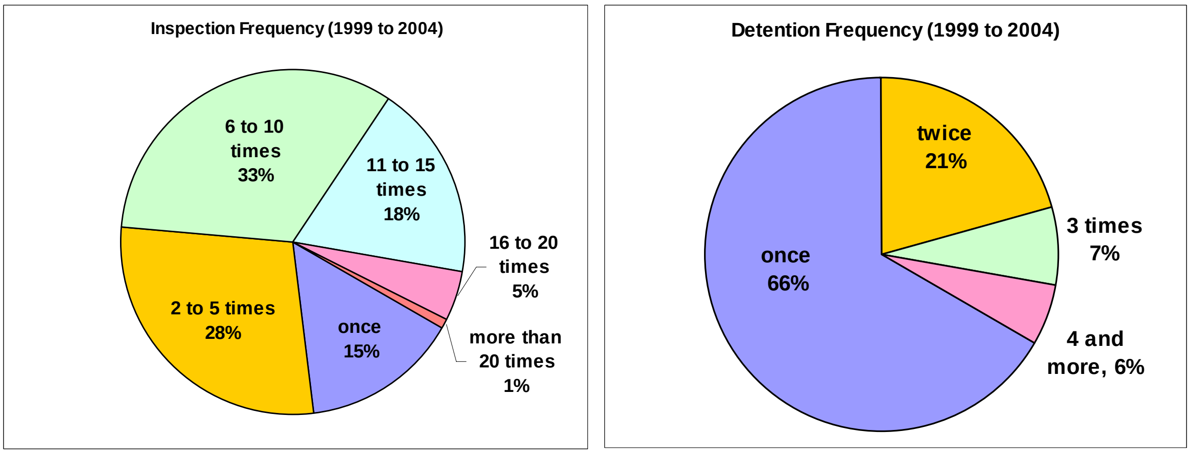
Items related to navigation and communication is also covered by all inspection types including chart corrections, passage planning, nautical publications and the overall impression of the officer on watch with reference to the handling of the equipment (radar, echo sounder, radio equipment, etc.)

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 is 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. The inspections performed by classification societies on behalf of the flag state to a certain extent have a different scope since they are the basis to extend or renew the validity of a certificate and are therefore statutory. The flag state inspections performed beside the surveys from classification societies primarily serve as a means to check the performance of classification societies as a recognized organization to conduct these surveys on behalf of the flag state.

The system generates a substantial amount of inspections performed on vessels with areas that are inspected and re-inspected frequently. In the case of port state control and based on the total dataset, one can see the total inspection and detention frequency in Figure 3 which is based on an average of four years[10] since not all regimes provided data for the whole time frame. Based on the 183,819 port state control inspections and 26,020 aggregated ships, this aggregates to 7 inspections within four years or approx. 1.7 inspections per year per ship.

Figure 3: Inspection and Detention Frequency of Vessels (1999 to 2004)



Source: Knapp (2006)

2. Summary of Costs of Inspections and Insurance Claims

Table 3 and Table 4 give an overview of the estimated costs of port state control inspections and other inspections that are performed onboard ships. The port state control inspections costs are divided into inspection with zero deficiencies and inspections with deficiencies who might take more amount of time onboard the ships. In addition, a 20% administrative charge[11] is added to the costs. The surveyor costs change from country to country and this change is not taken into consideration since data from 53 countries are in the total port state control inspection dataset. In reality, the presented figures might therefore be different but for the purpose of this study, the figures should merely give an overall indication on the costs associated with port state control.

Table 3: Total Estimated Port State Control Inspection Costs (USD)

# of Inspections		# Hours/Insp.		Rate	Total 4 years	Per Year	Per Insp.
zero def.	98,895	395,580	4	126	50,038,229	12,509,557	**506**
with def.	84,924	509,544	6	126	64,453,914	16,113,479	**759**
Total	**183,819**	**905,124**			**114,492,143**	**28,623,036**	**623**
			+20% Admin		**137,390,572**	**34,347,643**	**747**

Note: 1 hour surveyor = 72 British Pounds[12], 1 GBP = 0.5692 USD, Administrative Costs = +20%, compiled by author

The estimated inspection costs of a port state control inspection is USD 747 per inspection or a total of USD 34,3 million for all types of inspection. Inspections associated with zero deficiencies and without administrative costs are estimated to be at USD 12,5 million per year or USD 50 million for the total four year period. Looking at the total estimated costs

[10] The total amount of years for each regime was converted into month of inspections and then converted into total amount of years (291 total months/12 = 24.25 years/6 regimes = 4 years)
[11] as per information obtained from the Maritime and Coast Guard Agency, UK
[12] as per information obtaine from the Maritime and Coast Guard Agency, UK

per year per vessel and including shore based costs for ship owners and operators, the result can be seen in Table 4

Table 4: 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 data is a summary from several sources from the 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 all other ship types, it is estimated to be at 5 inspections.

Shore based costs include the costs for the inspections 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 costs per year per vessel associated with inspections vary from USD 47,000 for tankers to USD 17,500 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 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[13] 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 5.

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

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

type, size or ownership of the vessel. In addition, it varies considerably between hull and machinery (H&M) and other P&I club claims[14]. 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. It is difficult to compare the costs of inspections with the insurance claim costs but an overall comparison per ship type is given in Table 6. The result indicate that the total 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.

Table 5: 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[15], H&M = Hull and Machinery

Table 6: Average Inspection Costs versus Insurance Claims in USD (2000 to 2004)

In USD per vessel	Inspection Costs	Insurance Claims
GG & Container	17,464	41,804
Dry Bulk	24,280	57,316
Tanker	47,166	156,624
Passenger	17,464	141,961
Other	17,464	91,127
Average per Vessel/year	**24,768**	**97,766**

Compiled by author

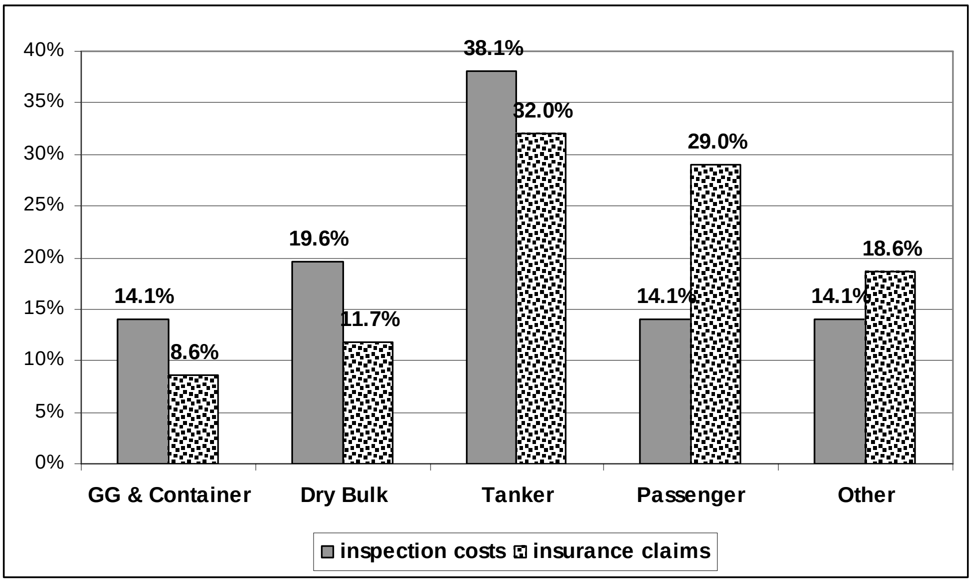
Figure 4 shows the split up of the inspection costs and insurance claims per ship type in order to see the relation between the two categories. One can easily see that the percentages are not in line for passenger vessels where the insurance claims are substantially higher than the inspection costs. For tankers on the other hand, the higher inspection costs seem to be in line with the insurance claims due to the high costs that are for instance involved if pollution is involved in a casualty. It is difficult to conclude if the inspection costs are in relation to the insurance claims and if the relative high frequency of inspections on oil and chemical tankers is justified since the costs of preventing accidents due to inspection are not known. In addition, the insurance claims costs are in reality higher than shown here and only based on two P&I Clubs. For the regression analysis on casualties and the effect of port

[14] 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.

[15] legal principal of maritme law according to which all parties in a sea venture proportionally share any losses resulting from a voluntary sacrifice of part of the ship or fleet to save the whole in an emergency (definition from: http://en.wikipedia.org/wiki/General_average)

state control in the probability of having a casualty, the insurance claim costs were not taken into consideration but are based on the seriousness of a casualty instead.

Figure 4: Inspection Costs versus Insurance Claims in % to Total

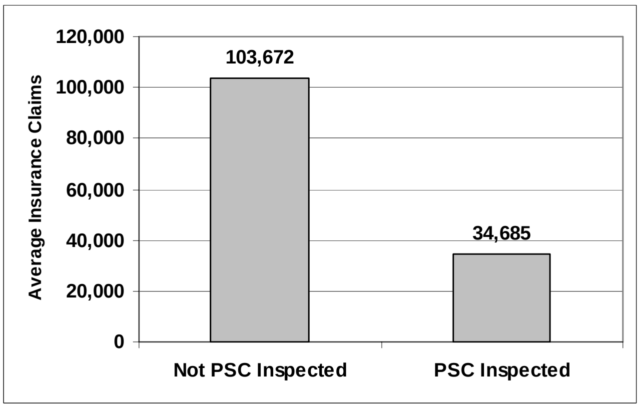


Compiled by author

In order to get an impression about the difference in insurance claims of vessel that were inspected with vessels that were not inspected, the following graphs should give an impression to see the difference based on claim costs. The graphs were produced the following way. The total casualty dataset was combined with the insurance claim costs listed in Table 5 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 by port state control. The figures do not match the figures presented in Table 6 since they are averages across all ship types and based on the total casualty dataset and not the claim information received from the P&I Clubs directly.

Figure 5 gives an overview of the total average claims of inspected vessels versus not inspected vessels.

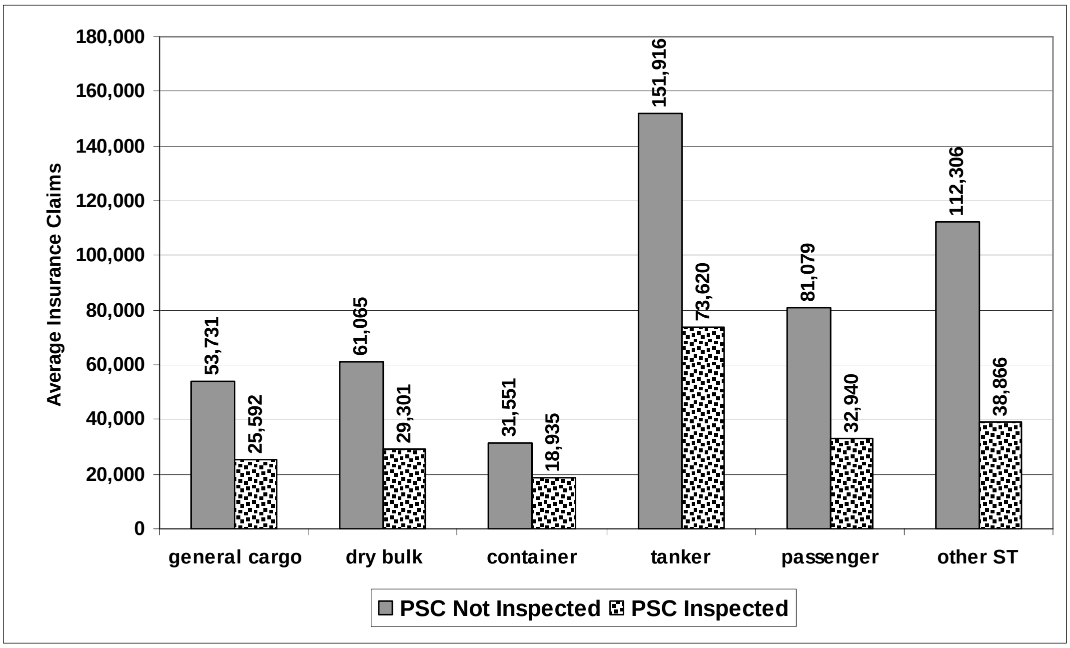
Figure 5: Average Claims of Inspected versus Non-Inspected Vessels



Based on inspections from 1999 to 2004

One can easily see that not inspected vessel have higher average claim costs than inspected vessels. The same applies for Figure 6 for the average claim costs per ship type based on the casualty dataset but using the average claims that were calculated and shown in Table 5.

Figure 6: Average Claims of Inspected versus Non-Inspected Vessels per Ship Type



Based on inspections from 1999 to 2004

One can see that the differences between inspected and not inspected vessels is greatest for tankers and other ship types which are easily explained with the frequency of inspections performed on oil tankers.

3. The Link between Inspections and Casualties.

The datasets used for this analysis comprises data on the world fleet received from Lloyd's Register Fairplay (43,817 vessels), a combined PSC inspection dataset from five regimes[16] of 183,819 inspections (26,020 ships), casualty data from three different sources[17] of approx. 11,701 cases (9,589 ships) and some industry vetting inspection data. The data was combined using the ship's IMO number as a link and the time frame is question is from 1999 to 2004 where some of the casualty data extends beyond this time frame.

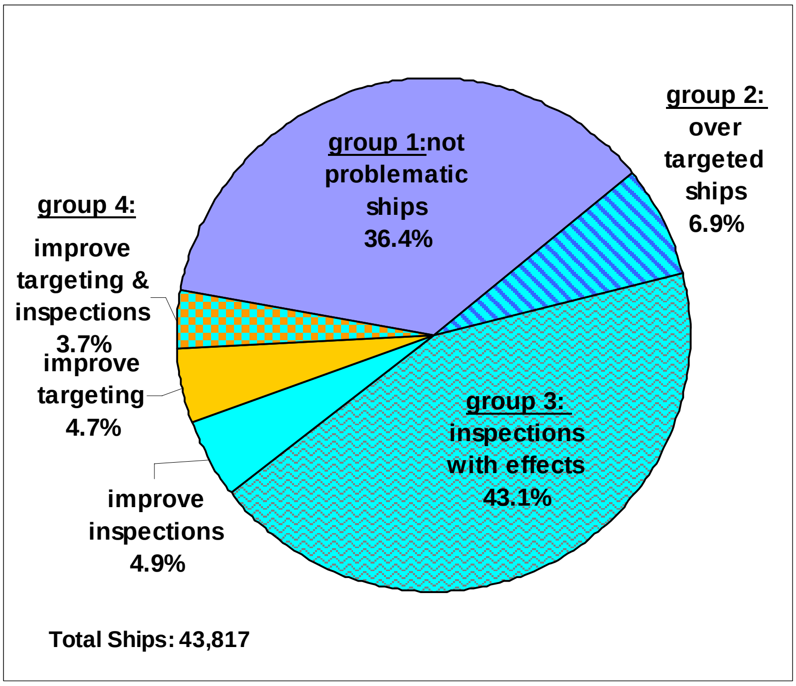
Figure 7 gives on overview of the magnitude of improvement possibilities for targeting vessels. In total, about 16% of all inspected vessels had zero deficiencies over the time period in question and these ships might have been ships which should not have been targeted (4,221 ships). On the other hand, looking at ships which have been inspected six months prior to a casualty (2,321 ships) where 52.3% of these vessels had zero deficiencies (1,215 ships) and the rest had deficiencies. This changes the 4,221 ships which should not have been targeted into 3,006 vessels or approx. 501 ships per year.

It is further worth noticing that out of the 1,106 vessels (2,321 – 1,215) with deficiencies, 14.6% were detained (162 vessels) and had a casualty. This portion could be understood as

[16] Paris MoU, Caribbean MoU, Viña del Mar Agreement on PSC, AMSA and the Indian Ocean MoU
[17] IMO, Lloyd's Register Fairplay and LMIU

ships that have been targeted correctly and identified as sub-standard vessels but for some reason, detention was not sufficient to increase the safety standard of the vessel to prevent a casualty. The remaining portion of the vessels which have been inspected and were deficiencies were found are the vessels where the effect of inspections decreased the probability of a casualty which is the partial effect of the regressions. In number of vessels, this amounts to approx. 18,874[18] vessels or 3,146 ships per year.

Figure 7: Improvement Areas for PSC eligible ships (1999-2004)



Note: Based on only PSC relevant ships and based on total time frame (1999-2004)

The figure is only based on ships that are relevant for port state control (excluding the fishing fleet > 400gt) and is a summary of the total time frame. The graph shows several groups out of which *group 1* of about 36% of the vessels eligible for inspections are identified not to have been problematic over the time period and have also not been targeted by the regimes in question. About 7% of the vessels eligible for port state control have been targeted over the time frame but did not have a casualty and also no deficiencies and therefore represent a group of over-inspected vessels *(group 2)*.

Group 3 of 43% of the vessels can be identified to belong to a group where inspections are effective in decreasing the probability of casualty where this effect can be measured for very serious casualties and estimated (depending on the basic ship risk profile) to be a 5% decrease per inspection. This category can also represent further room for improvement but shows that port state control is effective.

Group 4 is split into three portions. The first portion is 5.3% of PSC eligible vessels which are the amount of ships that have been targeted correctly but since they had a casualty within six month after the inspection, the enforcement could be improved. The second portion shows 4.7% of ships which had a casualty but were not inspected and where targeting could be improved. Finally, the last category shows a grey area. In this group, ships had a casualty but regardless of the time frame. Therefore, inspections and possibly

[18] 21,880 total inspected ships with no casualty minus 3,006 ships with no deficiencies

targeting could be improved. Most improvement to decrease the probability of a casualty can be achieved by concentrating on the categories in group 4 by shifting the emphasis from group 2 to group 4.

4. The Probability of Casualty per Frequency of Inspection

This section will provide the probability of casualty for either inspection or detention. Average probabilities are then calculated and presented per frequency of inspection or detention.

4.1. The Selection of Port State Control Relevant Casualties

Considerate care was given on the selection of casualties for the analysis. From the casualty dataset within the time period 1999 to 2004 of 9,851 cases, the following cases were eliminated.

1. Cases due to extreme weather conditions such as hurricanes, typhoons, gales and very heavy storms
2. Ships attacked by pirates or ships lost due to war
3. Ships involved in a collision with no identified fault[19]
4. Any other miscellaneous items not relevant to PSC such as drugs found, virus outbreaks of passengers or accidents which happened in dry docks
5. Not PSC relevant ships types such as ferries, the fishing fleet, tugs or government vessels. The fishing fleet cases were kept separate and a separate analysis was performed based only on the fishing fleet above 400gt.

The remaining 6291 cases concern 6,005 ships when aggregated by IMO number and were then reviewed and re-grouped into the three groups of seriousness as per IMO MSC Circular 953 of December 2000:[20]

1. ***Very serious casualties:*** casualties to ships which involve total loss of the ship, loss of life or severe pollution
2. ***Serious casualties*** are casualties to ships which do not qualify as "very serious casualties" and which involve fire, explosion, collision, grounding, contact, heavy weather damage, ice damage, hull cracking, or suspected hull defect, etc. resulting in: immobilization of main engines, extensive accommodation damage, severe structural damage, such as penetration of the hull under water, etc. rendering the ship unfit to proceed, or pollution (regardless of quantity); and/or a breakdown necessitation towage or shore assistance.
3. ***Less serious casualties*** are casualties to ships which do not qualify as "very serious casualties" or "serious casualties" and for the purpose of recording useful information also include "marine incidents" which themselves include "hazardous incidents" and "near misses".

4.2. Model Description

This model will provide the estimated probability (*P*) of a ship having a casualty. The dependent variable (*y*) in this case is "casualty" or "no casualty". In a binary regression, a

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[19] The identification of "no fault" in this case was not straight forward and some cases still included in the dataset might be ships with no fault and were not eliminated due to lack of exactness of data.
[20] as per IMO MSC Circular 953, 14th December 2000

latent variable y^* gets mapped onto a binominal variable y which can be 1 (casualty) or 0 (no casualty). When this latent variable exceeds a threshold, which is typically equal to 0, it gets mapped onto 1, other wise onto 0. The latent variable itself can be expressed as a standard linear regression model

$$y^*_i = x_i\beta + \varepsilon_i$$

where i denotes ship i. The x_i contains independent variables such as age, size, flag, classification society or owner, and β represents a column vector of unknown parameters (the coefficients). The binary regression model can be derived as follows:

$$P(y_i = 1 \mid x_i) = P(y^*_i > 0 \mid x_i) = P(x_i\beta + \varepsilon_i > 0 \mid x_i) = P(\varepsilon_i > -x_i\beta \mid x_i) = \mathrm{P}(\varepsilon_i \leq x_i\beta \mid x_i)$$

The last term is equal to the cumulative distribution function of ε_i evaluated in $x_i\beta$, or in short:

$$P(y_i = 1 \mid x_i) = \mathrm{F}(x_i\beta)$$

This function F can take many forms and for this study two were considered, namely the cumulative distribution function of the normal distribution (probit model) and the cumulative distribution function of the logistic function (logit model). The general model can therefore be written in the form of 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 7 for further reference.

Equation 1: Probability of Casualty

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

Equation 2: Definition of term $x_i\beta$ of Casualty Detailed Model

$$\begin{aligned}
x_\mathrm{i}\beta = {} & \beta_0 + \beta_1 \ln(\mathrm{AGE}_i) + \beta_2 \ln(\mathrm{SIZE}_i) + \sum_{k=1}^{n_3 - 1} \beta_{3,k}\, \mathrm{ST}_{k,i} + \beta_4\, \mathrm{STInd}_i \\
& + \sum_{k=1}^{n_5 - 1} \beta_{5,k}\, \mathrm{CL}_{k,i} + \beta_6\, \mathrm{CLInd}_i + \beta_7\, \mathrm{CLWdr}_i + \sum_{k=1}^{n_8 - 1} \beta_{8,k}\, \mathrm{FS}_{k,i} \\
& + \beta_9\, \mathrm{FSInd}_i + \sum_{k=1}^{n_{10} - 1} \beta_{10,k}\, \mathrm{OWN}_{k,i} + \beta_{11}\, \mathrm{OwnInd}_i + \beta_{12}\, \mathrm{LIOWN}_i \\
& + \beta_{13}\, \mathrm{LIFS}_i + \beta_{14}\, \mathrm{DH}_i + \sum_{k=1}^{n_{15} - 1} \beta_{15,k}\, \mathrm{RS}_{k,i} + \beta_{16}\, \mathrm{GR}_i + \beta_{17} \ln(\mathrm{TIME}_i) \\
& + \sum_{k=1}^{n_{18} - 1} \beta_{18,k}\, \mathrm{PSC}_{k,i} + \sum_{k=1}^{n_{19} - 1} \beta_{19,k}\, \mathrm{DETPS}_{k,i} + \sum_{k=1}^{n_{20}} \beta_{20,k}\, \mathrm{CODE}_{k,i}
\end{aligned}$$

The model produces probabilities on an individual ship level (i). The rest of the notation is 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. To estimate the coefficients, quasi-maximum likelihood (QML)[21] is used as method of estimation in order to give some allowance for a possible misspecification of the assumed underlying distribution function. For the final models, logit and probit models are compared to see if there are any significant differences and logit models are used for the visualization part.

The variables in the models are then further explained in Table 7. Within block 1, changes in any of the variables since the construction of the vessel and during the years of inspection history are identified (e.g. the ship type was converted, flag, class or ownership changed). This block also includes information on the number of legal instruments a certain flag or country of residence of an owner has rectified.

Table 7: Variables Used in the Twin Regressions

		Dependent Variable 1: Casualty: *This can be either per seriousness or by casualty first event*			**1/0**
		Independent Variables	**Number of Variable n_ℓ**	**Remark on Variable**	**Expected Sign**
	ℓ	***Block 1: Ship Particulars: included to account for target factors***			
Ln(Age)	1	Average age at Inspection	1	C	
Ln(SIZE)	2	Gross Tonnage	1	C	
ST	3	Ship Type at present	6	D	
STInd	4	Ship Type Changed	1	D	
CL	5	Classification Society at inspection	33	D	
CLInd	6	Classification Society changed	1	D	
CLWdr	7	Class Withdrawn	1	D	
FS	8	Flag State at inspection	81	D	
FSInd	9	Flag State Changed	1	D	
OWN	10	Owner of vessel	6	D	
OWNInd	11	Ownership changed	1	D	
LIOWN	12	Legal Instruments Rectified (Owner)	1	C	
LIFS	13	Legal Instruments Rectified (Flag)	1	C	
DH	14	Double Hull	1	D	
		Block 2: Inspection History: variables of interest			
RS	15	Rightship Inspected (5 Star Rating or indicator)	5	D	neg
GR	16	Greenaward Certified	1	D	neg
ln(TIME)	17	Time in between inspections (days)	1	C	neg
PSC	18	Inspections Frequency per Regime (Fractions)	6	D	neg
DETPS	19	Detention Frequency per Regime	6	D	neg
CODE	20	Deficiency main codes (also multiplied by ST)	26 (156)	C	und
		Total Variables*)	**181(311)**		

**) in brackets indicates number of multiplicative dummy variables*
C= Continuous, D= Dummy

Since the whole inspection and casualty history of a particular vessel is taken into consideration, average percentage fractions over all records of one particular vessel (aggregated by IMO number) are used in the regressions for the inspections and the detentions while the deficiencies are aggregated and represent a total sum.

[21] for further details on QML, refer to Greene H.W. (2000), *Econometric Analysis*, Fourth Edition, page 823ff

The models are based on inspected ships where one vessel had a casualty and one did not. From the vessels with casualty, corresponding twins were matched from the vessels without casualty and a time frame (six month) was incorporated into the model. The variables used for matching are the variables which are assumed not to have a direct impact on the seriousness of a casualty and are listed in Table 8 in order of importance given the fact that the difference of observations in the datasets is quiet large. In doing the match, the first three variables are the most important ones followed by the country the ship was constructed and the owner and then the remaining variables such as class, flag and hull details for tankers. Ship type is found to be the most important variable for determining the construction quality and operating environment of a ship.

Table 8: List of Variables used to Match Ships

1. Ship Type at the time of construction
2. Year Built (in 11 ranges)
3. Gross Tonnage (in 44 ranges)
4. Country of Owner at time of construction
5. Country where Ship was primarily built
6. Class at construction
7. Flag at construction
8. Double Hull

4.3. Model Evaluation and Final Results

The model for very serious casualty was tested for presence of heteroscedasticity using the LM test as described by Davidson and McKinnon (1993)[22]. Only the very serious casualty models were tested since the author felt that it was more important to investigate heteroscedasticity for the casualty models due to the sensitivity of the topic in question. The null hypothesis (h_o) assumes homoscedasticity and the alternative hypothesis assumes heteroscedasticity in the following form where γ is unknown and z are a number of variables which are assumed to be the cause of heteroscedasticity:

$$\text{Variance} = \exp(2z'\gamma)$$

The test was performed separately for two variables, namely tonnage and age where presence of heteroscedasticity was not found as can be seen in Table 9. Table 10 lists the key statistics of the final models.

Table 9: Test Statistics for LM-Test

Type of Model	**Variable Tested**	**LM-Statistic**	**p-value**
6m very serious	Age	4.261	0.0389 – *do not reject* h_o
	Tonnage	4.061	0.0438 – *do not reject* h_o

Note: 1% significance level used

[22] Davidson and McKinnon (1993), *Estimation and Inference in Econometrics*, New York: Oxford University Press, 1993, page 526ff

Table 10: Key Statistics of Final Models: Probability of Casualty

	6 months Time Frame					
Type I Models	**very serious**		**serious**		**less serious**	
# observations in final model	0 =	5665	0 =	44124	0 =	26551
	1 =	161	1 =	1362	1 =	860
	Total =	5826	Total =	45486	Total =	27411
# outliers (twins)	none		none		none	
Cut Off	0.0276		0.0299		0.0314	
	LOG	**PRO**	**LOG**	**PRO**	**LOG**	**PRO**
Mc Fadden R2	0.166	0.162	0.139	0.139	0.077	0.077
% Hit Rate y=0	73.93	72.22	70.00	68.28	66.95	66.00
% Hit Rate y=1	71.43	72.67	73.35	75.18	64.07	65.23
% Hit Rate Tot	73.86	72.23	70.10	68.49	66.86	65.97
HL-Stat. (df=8)	9.41	19.54	3.00	16.60	9.75	9.62
p-value	0.3088	0.0120	0.9343	0.0345	0.2832	0.2927
Remarks	w/o passenger vessels and Caribbean MoU		with passenger vessels but without Caribbean MoU			

In comparing logit with probit, not much difference can be seen in the results other than that the HL-statistic suggests a better fit for the logit model versus the probit model. The results are acceptable for the amount of data in each of the models. For visualization of the results in the next chapter, the probabilities based on the logit model were used.

4.4. Visualization of Results – Frequency of Inspections and Detention

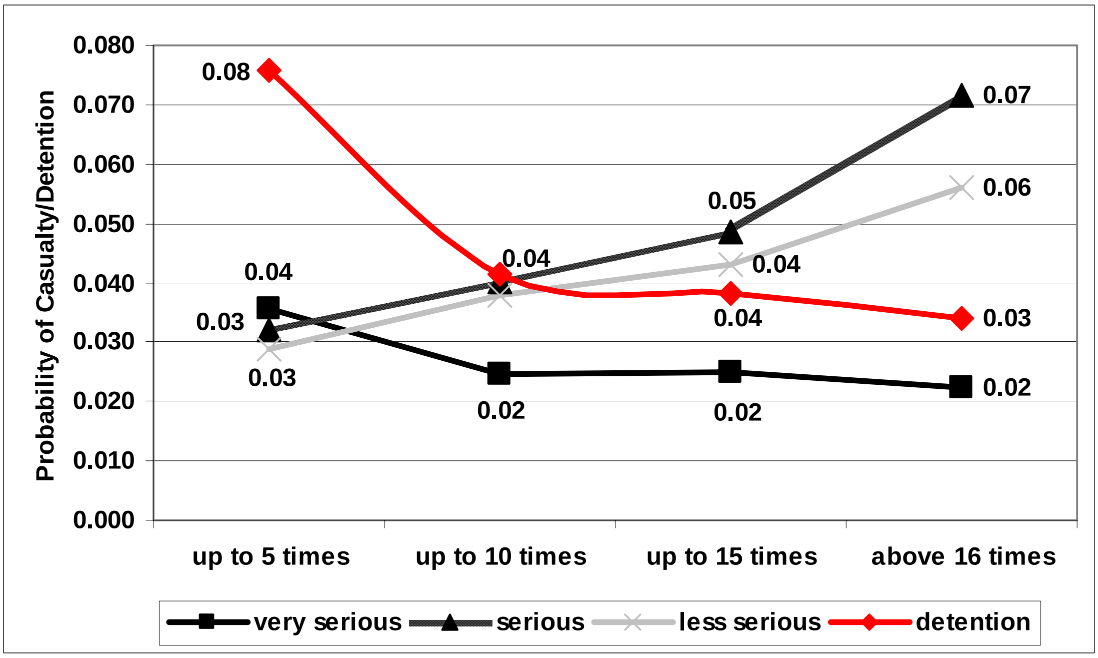
The next two graphs give an overview of the probability of casualty per frequency of inspection and detention given the ship has been inspected at least once within a six months time period. The probabilities are averages based on all inspected vessels or all detained vessels.

Figure 8 shows that the probability of detention decreases with the frequency of inspections while the probability of serious casualty increases from 3% to 7%. Less serious casualties increase by about 3% while very serious casualties decrease from 4% to 2% over time and with increased frequency of inspections. In essence, on could conclude that with increased amount of inspections, the probability of casualty does not necessarily decrease.

Figure 9 then shows the probability of casualty and how it changes with the frequency of detention versus not detained ships. The graph shows that for ships that are inspected and detained six months prior to a casualty, the probability decreases from an average of 2.8% to 1.8% for very serious casualties over a time period of six years while it increases for serious and less serious casualties. For less serious casualties, it then decreases again after the ship has been detained more than 3 times.

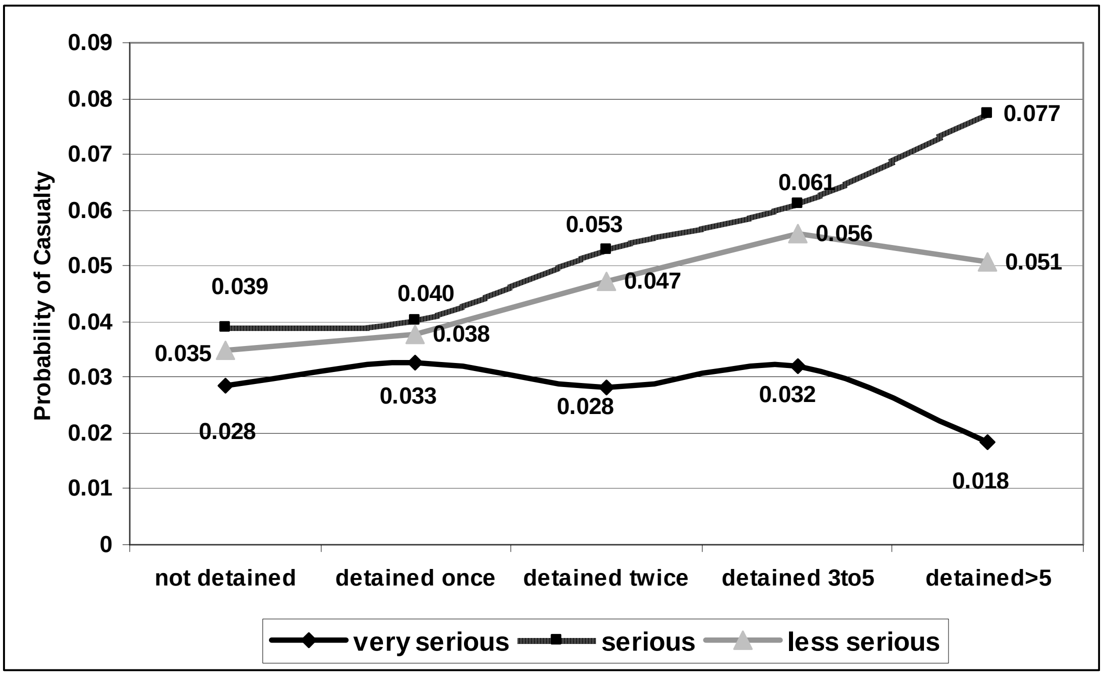
The fact that the probability of casualty for serious casualties and less serious casualties increases with either the frequency of inspection and detention could also indicate the involvement of a certain human factor associated with these casualties. It might be easier for port state control to identify very substandard vessels and therefore the effect of inspections and detentions are expected to be higher for very serious casualties while this is not the case for serious and less serious casualties. On the other hand, the increased probability of casualty for increased inspections and detentions also reflects to a certain extend that higher risk vessels are targeted for inspection. As third reflection, increased inspection or over inspection does not necessarily have a negative effect of the probability of detention.

Figure 8: Probability of Casualty per Frequency of Inspection (6 months prior)



Note: based on a time frame of six years or 4 complete inspection years and average probabilities of approx. 50,000 vessels

Figure 9: Probability of Casualty per Frequency of Detention (6 months prior)



Based on average probabilities of approx. 50,000 vessels

5. Conclusions on Safety Regimes: Are ships over inspected?

This article provided an overview of the overall complexity of the safety regimes. Many players are part of the safety systems consisting of a mandatory (statutory) part and a non mandatory part (industry driven). The mandatory part based on the legal framework and normally enforced by the flag states is nowadays more and more performed by recognized or authorized organizations (the classification societies) and as a last resource by the port states.

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) nowadays in the name of safety. The areas that are inspected in all of these inspections show a considerable amount of overlapping between statutory and industry driven inspections. In addition, the safety regimes do not accept port state control inspections that are performed in another regime. This leaves certain ship types to be exposed to a relatively large amount of inspections where the inspections are performed sometimes during critical port operations and take time away from the crew. With shortened time in ports, the inspections can increase the working hours of shipboard personnel considerable. None of the inspections takes this into account or actually looks closer into working and living conditions of the crew in particular the working and resting hours.

The lack of enforcement of the minimum international standards also shows the political sensitivity of this topic overall and further underlines the lack of trust and cooperation between the players and the various port state control regimes. 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 can be better used to eliminate substandard ships?

The estimated inspection costs of a port state control inspection is USD 747 per inspection or a total of USD 34,3 million for all types of inspection. Inspections associated with zero deficiencies and without administrative costs are estimated to be at USD 12,5 million per year or USD 50 million for the total four year period. Total inspection costs per vessel per year are estimated to vary from USD 47,000 for tankers to USD 17,500 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. Comparing average insurance claim costs of vessels that have been inspected with vessels that have not been inspected, one can clearly see that the average insurance claim costs are higher for non inspected vessels and the difference between the two categories is further highest for tankers.

On could argue that the inspections that are performed on ships with zero deficiencies which is about 54% of the total inspection dataset and its associated costs (USD 12,5 million per year) could be used for training and to further created the necessary framework to harmonize port state control activities by assisting emerging regimes where more substandard ships are to be found. During the last FSI (14) in June 2006, harmonization of port state control was considered and a working group established which should create the necessary framework in order to achieve harmonization.

Aggregated by IMO number, the 54% reduce to only 16%. About 36% of the vessels eligible for inspections are identified not to have been problematic over the time period in question and have also not been targeted by the regimes in question. About 7% of the vessels eligible for port state control have been targeted over the time frame but did not have a casualty and also no deficiencies and therefore represent a group of over-inspected vessels.

About 43% of the vessels can be identified to belong to a group where inspections are effective in decreasing the probability of casualty where this effect is strongest for very serious casualties and estimated (depending on the basic ship risk profile) to be a 5% decrease per inspection. This category can also represent further room for improvement but shows that port state control is effective. Finally, about 5.3% of PSC eligible vessels have been targeted correctly but since they had a casualty within six month after the inspection, the enforcement could be improved. Another portion of 4.7% of ships had a casualty but was not inspected. This is an area where targeting could be improved.

Based on the average probabilities, one can see that the probability of detention decreases with the frequency of inspections while the probability of serious casualty increases from 3% to 7%. Less serious casualties increase by about 3% while very serious casualties decrease from 4% to 2% over time and with increased frequency of inspections. In essence, on could conclude that with increased amount of inspections, the probability of casualty does not necessarily decrease.

With respect to the probability of casualty based on detained vessels, one can see that for ships that are inspected and detained six months prior to a casualty, the probability decreases from an average of 2.8% to 1.8% for very serious casualties over a time period of six years while it increases for serious and less serious casualties. For less serious casualties, it then decreases again after the ship has been detained more than 3 times.

The fact that the probability of casualty for serious casualties and less serious casualties increases with either the frequency of inspection and detention could also indicate the involvement of a certain human factor associated with these casualties. It might be easier for port state control to identify very substandard vessels and therefore the effect of inspections and detentions are expected to be higher for very serious casualties while this is not the case for serious and less serious casualties.

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PSC Inspection: Flag: Syria, Ship Type: General Cargo, Surveyor: Walter De Graeve, Antwerp, July 2004

PSC Inspection: Flag: Cyprus, Ship Type: General Cargo, Surveyor: Walter De Graeve, Antwerp, July 2004

PSC Expanded Inspection: Flag: Grand Caymans, Ship Type: Bulk Carrier, Surveyor: Aarnout Salwegter, Amsterdam, August 2005

PSC inspection/Detention: Flag: Ukraine, Ship Type: General Cargo, Inspector: J. P. Van Byten, Antwerp, October 2005.

PSC safety inspection: Flag: Hong Kong, Ship Type: Dry Bulk, Inspector in charge: Ralph Savercool, New York, March 2006

PSC security inspection: Flag: Liberia, Ship Type: Container, Inspector in charge: Diane R. Semmling, New York, March 2006

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Flag State Inspection: Flag: Malta, Ship Type: Container, Surveyor: Henk Engelsman, Rotterdam, August 2005

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Class Annual Survey: Flag: Norwegian International Register, Ship Type: Chemical Tanker, Surveyor: Yuri Sakurada, DNV, Rotterdam, May 2005

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Class Annual Survey: Flag: Barbados, Ship Type: General Cargo Ship, Surveyor: Pieter Andringa, Germanischer Lloyd, Rotterdam, October 2005.

Class Renewal Survey: Ship Name: Flag: Dutch, Ship Type: Chemical/Oil Product Tanker, Surveyor: Rob Pijper, Lloyd's Register, Rotterdam Damen Shipyard, August 2005

Class Follow Up: Flag: Cyprus, Ship Type: Bulk Carrier, Surveyor: Rob Pijper, Lloyd's Register, Rotterdam, September 2005

ISM Audit: Flag: Liberia, Ship Type: Juice Carrier, Surveyor: Rob Pijper, Lloyd's Register, Rotterdam, October 2005

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Vetting Inspection (SIRE, Kuwait Oil): Flag: Sweden, Ship Type: Oil Tanker, Inspector (OCIMF): Henk Engelsman, Rotterdam, September 2005

Vetting Inspection (SIRE, Eni Oil): Flag: Saudi Arabia, Ship Type: Chemical Tanker, Inspector (OCIMF): Henk Engelsman, Rotterdam, October 2005;

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Vetting Inspection (SIRE, Statoil): Flag: Liberia, Ship Type: Oil Tanker, Inspector (OCIMF): Henk Engelsman, Rotterdam, June 2006

Vetting Inspection (Rightship): Flag: Hong Kong, Ship Type: Dry Bulk Carrier, Inspector (Rightship): Dennis Barber, Ijmuiden, March 2006

P&I Club Inspection: Flag: Greece, Ship Type: Bulk Carrier, Inspector: Walter Vervloesem, Ghent, October 2005;

Marpol Inspection: Flag: Norway, Ship Type: Oil Tanker, Port Superindendent: Mr. Cees-Willem Koorneef, Rotterdam, August 2004

Marpol Inspection: Flag: Panama, Ship Type:OBO, Port Superindendent: Mr. Cees-Willem Koorneef, Rotterdam, August 2004

Ship Visit (VLCC): Flag: Bahamas, Ship Type: Oil Tanker, Class: ABS, Rotterdam, October 2005

Appendix

Appendix 1: Grouping of Countries of Ownership

The grouping of ownership of a vessel was made according to Alderton and Winchester (1999) and is as follows:

1. *Old Open Registries:* Antigua and Barbuda, Bahamas, Bermuda, Cyprus, Honduras, Liberia, Malta, Marshall Islands, Panama, St. Vincent & the Grenadines

2. *New Open Registries:* Barbados, Belize, Bolivia, Cambodia, Canary Islands, Cayman Islands, Cook Islands, Equatorial Guinea, Gibraltar, Lebanon, Luxembourg, Mauritius, Myanmar, Sri Lanka, Tuvalu and Vanuatu

3. *International Registries:* Anguila, British Virgin Islands, Channel Islands, DIS, Falklands, Faeroes, Hong Kong, Isle of Man, Kerguelen Islands, Macao, Madeira, NIS, Philippines, Sao Tome and Principe, Singapore, Turks and Caicos, Ukraine, Wallis and Fortuna, Netherlands Antilles

4. *Traditional Maritime Nations:* Argentina, Australia, Austria, Belgium, Brazil, Canada, Chile, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Japan, Mexico, Netherlands, New Zealand, Norway, Portugal, Russia, South Africa, Spain, Sweden, Switzerland, UK, Uruguay, USA, Venezuela.

5. *Emerging Maritime Nations:* Albania, Algeria, Angola, Azerbaijan, Bahrain, Bangladesh, Benin, Brunei, Bulgaria, Cameroon, Cape Verde, China, Colombia, Comoro, Congo, Costa Rica, Croatia, Cuba, Djibouti, Dominica, Dominican Republic, Egypt, El Salvador, Ecuador, Eritrea, Estonia, Ethiopia, Fiji, Gabon, Gambia, Georgia, Ghana, Grenada, Guatemala, Guinea, Guyana, Haiti, Hungary, India, Indonesia, Iran, Iraq, Israel, Jamaica, Jordan, Kazakhstan, Kenya, Kiribati, North Korea, South Korea, Kuwait, Laos, Latvia, Libya, Lithuania, Madagascar, Malaysia, Maldives, Mauritania, Micronesia, Morocco, Mozambique, Namibia, Nicaragua, Nigeria, Oman, Pakistan, Papua New Guinea, Paraguay, Peru, Poland, Qatar, Romania, St. Helena, St. Kitts & Nevis, Samoa, Saudi Arabia, Senegal, Seychelles, Sierra Leone, Slovakia, Slovenia, Solomon Islands, Somalia Republic, Sudan, Surinam, Syria, Taiwan, Tanzania, Thailand, Togo, Trinidad, Tunisia, Turkey, Turkmenistan, UAE, Vietnam, Yemen

6. *Other/Unknown:* Undefined by dataset, Unknown (Fairplay), Azores, Cameroon, Greenland, Monaco, Puerto Rico, Serbia & Montenegro, St. Pierre & Miquel