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Research Paper

Evolution of the deep-sea fleet that supports Canada's international trade

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The Evolution of the Deep-sea Fleet that Supports Canada's International Trade

Introduction:

The oceans are truly global highways. Port states may control navigation in territorial waters, but not in the oceans beyond. In 1999, 46,002 cargo ships from 152 flag-states carried the world's trade[1]. There were 173 ship registers as some states had more than one.

Canada's trade depends on foreign-registered ships. In 1999, ships registered by 68 foreign states carried 80% of the international cargo handled by Canadian ports. This dependence may carry risk if those ships are substandard. The shipping industry's practice of 'flagging-out' or registering ships in countries other than the shipowner's nation of residence has been a cause for concern. Some high-profile shipping accidents[2] that have resulted in severe pollution have focussed international attention on "flags-of-convenience".

This paper identifies the flag-related trends of fleets used in Canada's international sea-borne trade relative to the world fleet over a 15-year time frame (1985 to 1999). The goal is to see if there is any indication that fleets that served Canada were any less safe in 1999 than 1985.

The idea a ship's flag may predict its condition is not new. Canada and other states use the flag as one variable for targeting port state control (PSC) inspections[*]. An interesting

[*] PSC is a ship inspection program. Foreign ships entering a state's waters are boarded and inspected to ensure compliance with major international maritime conventions.

paradox is arising from these efforts. Canadian PSC inspection statistics show that the share of ships with deficiencies hovered around 50% with detentions of 11% for the past 6 years[3]. However, accident rates for foreign ships in Canadian waters declined 51% from 1991 to 2000[4].

Data Sources and Limitations

Statistics Canada's Marine International Origin-Destination (MIOD) Database (1985-1999) is the data source on the fleet used in Canada's international trade. This database is derived from a Canada Customs A6 General Declaration that all ships must file upon entering Canada. The A6 records the vessel name, registration number, flag, Gross Registered Tonnage (GRT) and last or next port of call.

The Lloyd's Register (LR) annual publications *World Fleet Statistics* (1992-1999) and *Statistical Tables* (1985-1991) are the sources for world fleet by registration. The data include self-propelled sea-going merchant ships of not less than 100 Gross Tons (GT), both cargo and non-cargo ships (e.g., ferries, fishing vessels). This differs from the MIOD data, which have non-self-propelled barges and no thresholds.

The Lloyd's Register annual publications *Casualty Statistics* (1994-2000) and *Casualty Returns* (1985-1993), are the sources for casualty data. The casualties are "total losses" which LR defines as ships "which as a result of a marine casualty, have ceased to exist, either by virtue of the fact that the ships are irrecoverable or have subsequently been broken up. Ships which have been declared constructive total losses but which are undergoing or have undergone repairs are not included"[5]. Accidents resulting in loss of life, environmental or economic losses are included only if there is a "total loss" of a self-propelled ship of at least 100 GT.

LR publications include tables of revised data for the previous five years that are significantly higher than those initially reported. For example, world fleet casualties for 1996 were reported as 179 ships and 891,351 GT in the 1996 Casualty Statistics and revised to 255 ships and 1,163,090 GT in the 2000 edition. The revised data are used in this study. These tables list the casualties for 37 flag states and a residual "other countries" that accounted for 28% of the ships and 16% of the GT for 1985 to 1999[6]. The tables cover 19 of the top 20 fleets by GT for 1999.

The Choice of Vessel Registers

The concept of vessel registration is simple but its application raises questions about the true nature of ship registers. In its simplest form, registration binds a ship to the flag-state and the merchant ship is an extension of the flag-state's territory and subjected to its laws[7].

Ship registers themselves have become a business as some flag-states compete for vessel registration with zero tax regimes, relaxed labor legislation, and even discounted registration fees. One state registers ships, sight unseen, over the internet. Some flag-states have contracted out their registers to private commercial enterprises.

These registers have developed in response to shipping industry demands. International shipping was among the first industries to engage in transnational production as shipowners sought the most attractive combinations of factors-of-production. For many years, ships have been built and financed in countries that offered subsidies, they have been crewed from low-income developing countries and managed from countries that offered expertise in effective ship management.

There are 2 fundamental types of registers: closed and open registers. Closed registers require the shipowner to be a national of the flag-state. Open registers are available to any shipowner regardless of nationality who meets the condition of the register. There are 2 types of open registers, Open National Registers and Open International Registers. Ships under Open National Registers are subjected to the economic regulations that apply to all businesses in the flag-state, including labour and tax regulations. Coastwise shipping is often reserved for National Registers (open or closed) under cabotage laws.

Open International Registers offer shipowners competitive terms for international shipping operations. These terms may include tax exemptions on earnings, few restrictions on crewing ships with non-nationals, the easing of the legal requirements of corporate governance and liberal enforcement of safety standards[8]. Lax crewing regulations and safety standards appears to be the reason why some of these registers are described as "flags-of-convenience" or FOC.

The International Transportation Workers Federation (ITF) defines a FOC as a registry where there is no “genuine link” between the nationality of the shipowner and the flag of the ship. The ITF’s Fair Practices Committee currently lists 30 FOCs based on six criteria[9]. The term FOC has negative connotations, however, it was once synonymous with 'flag-of-necessity'[10] at a time when such registers were needed to compete in an industry under constant price pressures.

To the shipowner, choosing a flag is akin to deciding where to incorporate. Entrepreneurs form companies to avail themselves of corporate tax laws and to limit personal liability. Shipowners select a flag for similar reasons. An 'economically-efficient' flag allows the shipowner to compete for cargo and earn profits. Shipowners must consider: costs; ownership restrictions; taxation; financing; insurance; Port State Control (PSC); law enforcement; safety standards; charterers’ flag preferences;

union and political actions (e.g., blockades, regional trade sanctions)[11]. While a FOC may have cost advantages, it may be constrained in terms of routes and markets.

Many charterers are increasingly selective in the flag of the ships they use. Vessel and cargo insurance may be prohibitively expensive for FOC ships. Some flags are targeted for frequent PSC inspections or for industrial actions by trade unions within the ports. Delays in port can add significantly to the shipowner's and charterer's costs.
In addition to these factors, characteristics of the ship itself affect the decision to use a national register or flag-out. An empirical study of U.K. tanker and general cargo shipowners by Bergantino and Marlow found a tendency to flag-out older and larger ships engaged in deep-sea trade routes[12]. Some registers (e.g., the Norwegian International Ship register (NIS)[13]) will not register ships over a certain age.

This paper uses 4 standard categories of ship registers to analyze the world fleet, casualty returns and Canadian marine statistics:

1. **Traditional Maritime Nations (TMN)** - the national and international open registers (excluding FOCs) of 15 nations that account for 90% of the GT registered in OECD countries.
2. **Flags-of-convenience (FOC)** include 23 flags listed by the ITF. OECD shipowners were the primary users of these registers
3. **Flags of newly industrialized states (NIC).** The 1980's saw the rise of both shipowners and registries in developing countries as these countries played a larger role in a world economy[14].
4. The remaining registers or the **Rest of the World (ROW).** †

Evolution of the World Fleet 1985-1999

In 1999, the world fleet consisted of 86,817 ships with 543.6 million Gross Tons (mGT). From 1985 to 1999 the fleet expanded by 13.6% for ships and 30.6% for GT. However, the distribution of the fleet by registers changed dramatically over this period.

The TMN fleet declined by 19.5% in ships and 23.3% in GT over the 15 years. In contrast, the FOC fleet expanded with 90.7% more ships and 135.9% more GT. While the TMNs had more ships over the period than the FOCs, their dominance in terms of GT was lost to the FOCs by 1988. This seems to

† TMNs: Australia, Canada, Denmark, France, Germany, Greece, Italy, Japan, Netherlands, Norway, Spain, Sweden, Turkey, United Kingdom and the United States of America; FOC: Antigua and Barbuda, Bahamas, Barbados, Belize, Bermuda (UK), Bolivia, Myanmar, Cayman Islands (UK), Cyprus, Gibraltar (UK), Honduras, Lebanon, Liberia, Luxembourg, Malta, Marshall Islands (USA), Mauritius, Netherlands Antilles, Panama, Sri Lanka, St. Vincent, Tuvalu, Vanuatu. NICs: Brazil, Hong Kong, India, Indonesia, Malaysia, Mexico, Philippines, Peoples Republic of China, Poland, Russia, Singapore, South Korea, Taiwan.

support Bergantino and Marlow's finding that shipowners are more likely to flag out their larger ships.

All TMN national fleets experienced declines in ships except Turkey. While the national fleets of Norway and Denmark declined, their overall fleets increased due to their international registers. In 1985, Japan had the largest TMN register in ships and GT. By 1999, Japan had the most ships of the TMN registers but had fallen to 3rd place in GT after Greece and the combined Norwegian registers.

Table 1:	**World Fleet by Flag Group**			
	1985		1999	
	Ships	Million GT	Ships	Million GT
World Fleet	76,395	416.3	86,817	543.6
Share:				
TMN	49%	41%	35%	24%
FOC	13%	28%	22%	51%
NIC	14%	15%	24%	18%
ROW	24%	16%	20%	7%
Source: Lloyd's Register Statistical Tables(1985) and World Fleet Statistics (1999)				

Liberia was the largest FOC in 1985 but declined over the reference period, perhaps due to its civil unrest through most of the 1990s. In contrast the GT of the Panamanian-flagged fleet increased by 159% to become the world's largest fleet in GT by 1999. Nineteen of the 23 FOC registers saw increases in the GT of their registered fleets.

The NIC fleet also grew from 1985 to 1999 while the ROW fleet declined. These trends are partly explained by the breakup of the former Soviet Union resulting in a new Russian fleet in 1992. The fleets of Singapore and Malaysia experienced the most rapid growth with a threefold expansion in GT. The South Korean fleet's GT declined by 20%, possibly reflecting the

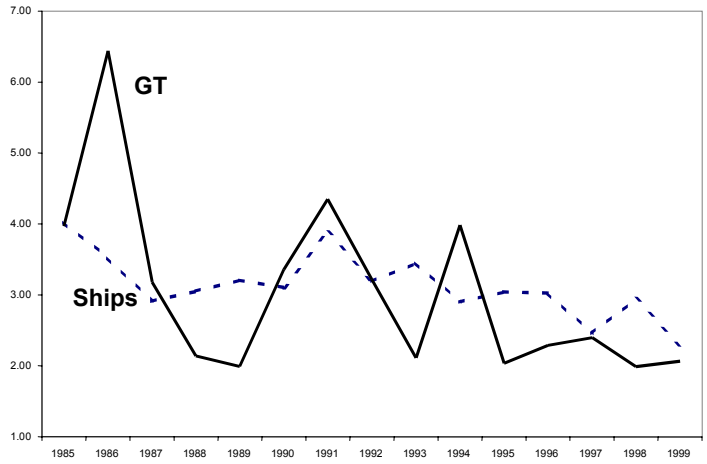
impact that improvements in wages and working conditions in shore-based occupations has had on the supply of South Korean sailors[15].

Casualty Rates

The casualty rate for the world fleet improved from 1985 to 1999, with declines in total losses of ships and their gross tonnage. In 1985, the world fleet lost 307 ships and 1.7 mGT for casualty rates of 4.0 ships per 1000 ships and 4.0 GT per 1000 GT. In 1999 the world fleet lost 199 ships and 1.1 mGT or 2.3 ships per 1000 ships and 2.1 GT per 1000 GT. However, there was much volatility over the period.

Figure 1:

World Fleet Casualty Rates per 1000 GT and per 1000 Ships



(Source*: Lloyd's Register Casualty Statistics and Casualty Returns*)

The calculation of casualty rates by category is complicated by the suppression or lack of data for some flag states particularly in the FOC category where the casualties are reported for only 7 of the 23 flag states. Including the combined fleets of all 23 FOC in the denominator of the casualty rate results in an underestimate of the FOC casualty rates and an overestimate of the ROW rates. Fortunately the 7 FOC covered by the casualty statistics account for more than 80% of the FOC ships and 90% of the total FOC GT.

From 1985 to 1999, the TMN casualty rates have generally been the lowest and can therefore be used to benchmark the rates for the FOC, NIC and ROW fleets. The casualty rates for the NIC registers are closest to the TMN rates over the 15-year term and show the least volatility relative to TMNs. The average FOC casualty rates over the same period have been double the TMN rates for ship casualty and triple the rate for GT casualties. The ROW registers have on average lost 1.5 times the number of ships and 3.6 times the GT of the TMN registers.

There are significant differences among the casualty rates for the fleets within the flag categories. Over the 15 year reference period, 3 TMN fleets have average casualty rates much higher than the TMN benchmarks: Turkey (2.2 times (x) the average TMN ship casualty rate; 5.9 times the average TMN GT rate), Spain (1.7x; 3.1x) and Greece (1.6x; 1.7x). Among the NICs, South Korea (1.9x; 3.5x), the Philippines (1.6x; 2.9x) and Taiwan (2.2x; 1.6x) have the worst rates.

Among the FOC the worst casualty rates compared to the TMN rates are for Malta (4.9x; 7.1x), Honduras (4.8x; 14.3x), St. Vincent (4.8x; 9.4x), Cyprus (3.2x; 7.2x), Panama (2.3x; 2.7x), and Bahamas (1.4x; 1.7x)[‡]. Liberia, the world's second largest

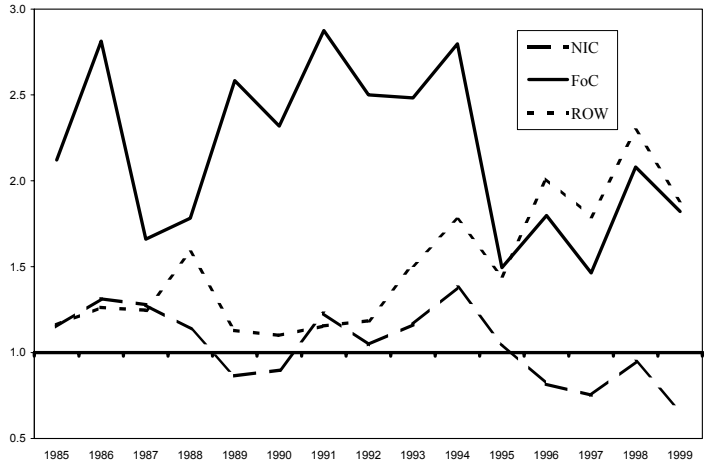
[‡] The rates for Bahamas, Honduras and Saint Vincent are based on 11 years of available casualty data.

register, has the same casualty rate as the TMN registers for ships, but a GT casualty rate 2.7 times the TMN rate due to the larger average ship size in the Liberian-flagged fleet.

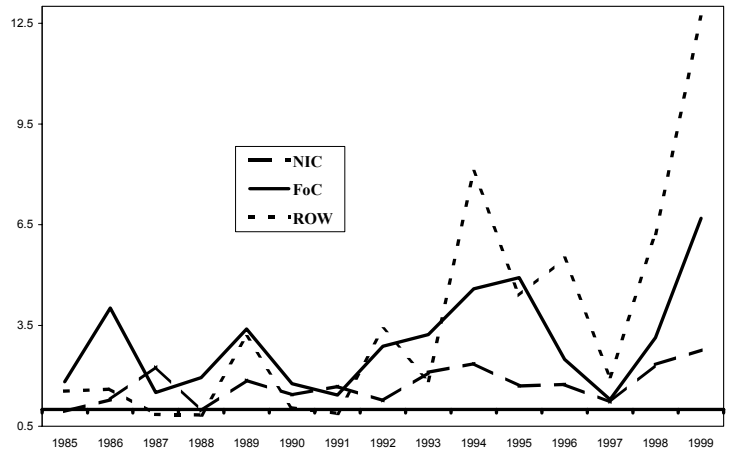
There are significant differences in the magnitude of the casualty rates among fleets. However, it is interesting to note there is a significant positive correlation in the annual casualty rates of the TMN, FOC, NIC and ROW fleets. This suggests that all fleets are affected by extreme conditions but not to the same degree.

Figures 2 and 3

FOC, NIC and ROW Ship Casualty Rates versus TMN



FOC, NIC and ROW GT Casualty Rates versus TMN



The Fleets that Served Canada 1985 to 1999

While the world fleet's ships increased by 13.6% from 1985 to 1999, the number of ships arriving and departing Canadian ports with international origins and destinations declined by 1.9%. However, the gross registered tonnage (GRT) of those ships increased by 50.4% compared to the 30.6% growth in the GT of the world fleet[§].

Table 2. **Ships Arriving and Departing Canada by Flag Group**

	1985		1999	
	Ships	Million GRT	Ships	Million GRT
Total	52,993	515.1	51,982	774.8
Share:				
TMN	74%	49%	65%	39%
FOC	15%	29%	28%	48%
NIC	6%	19%	5%	9%
ROW	5%	8%	3%	4%

Note: a ship is counted when it arrives and when it departs and may be counted more than once if it makes repeat voyages.
Source: Statistics Canada Marine International Origin-Destination Database

The fleet serving Canada evolved similarly to the world fleet as the TMN share of Canadian international traffic declined while the FOC share increased. However, the TMN held a larger share of Canada's international traffic than their share of the world fleet from 1985 to 1999. Conversely, the NIC and ROW fleets' shares of Canada's traffic were considerably less than their shares of the world fleet.

[§] The IMO's "International Convention on Tonnage Measurement of Ships" may have affected the GT and GRT reported during this period it entered into force in 1982, but not fully adopted until July 1994.

TMN ship arrivals and departures declined by 13.8% from 1985 to 1999 while the GRT of those ships increased by 18.7%. The GRT increase was due to the fleets of the United States, Norway and Canada. However, over 98% of the activity for the Canadian and U.S. fleets was transborder traffic. Again this is consistent with Begantino and Marlow's findings that it is the deep-sea fleet that is more likely to be flagged-out. Canadian and U.S. shipowners engaged in transborder trade may prefer their national register to avail of cabotage laws. The gains of the Norwegian fleet were entirely offset by decreased traffic by the Japanese fleet.

FOC ship arrivals and departures increased by 80.3% from 1985 to 1999 while the GRT of those ships increased by 148.6%. Almost all FOC fleet traffic increased particularly for ships registered in the Bahamas, Panama and Cyprus. Liberian ship traffic declined even though the GRT of those ships increased. The average GRT of the FOC ships increased 37.8% from 1985 to 1999 which was more than the 23.6% increase in the GT of FOC ships in the world fleet. In 1999, the FOC ships calling Canadian ports averaged 26,966 GRT while the FOC ships in the world fleet averaged 14,598 GT.

The NIC and ROW fleets declined in importance to Canada's seaborne trade in both numbers of ships and GRT. The one exception was the Singaporean flag, which increased in vessel traffic and GRT.

The increase in average vessel sizes appears to be supported by the international cargo statistics. International cargo loaded and unloaded at Canadian ports increased by 37.8% from 1985 to 1999 from 204.1 Million tonnes (Mt.) to 281.2 Mt.. TMN ships carried the largest share of this cargo over the 15-years, but their share has been declining relative to the share for FOC ships particularly since 1997. Cargo loaded and unloaded by TMN ships increased just 6.0% from 106.4 Mt. in 1985 to 112.8

Mt. in 1999, while cargo loaded and unloaded by FOC ships increased 104.6% from 62.1 Mt. to 127.0 Mt.

Two commodities, coal and crude petroleum, particularly illustrate the flag-related changes in the fleets serving Canada. Coal was the leading international commodity handled by the ports in 1999. Outbound coal rose by 24.2% from 26.0 Mt in 1985 to 32.2 Mt. in 1999. In 1985, 66.7% of the coal was destined for Japan and Japanese-flagged ships carried 51.7% of the total outbound coal, while Panamanian ships carried just 4.4%. By 1999, 46.2% of the coal was bound for Japan and Japanese-flagged ships carried just 12.9% while Panamanian-flagged ships carried 44.6% of outbound coal. The flagging-out of some Japanese ships was evident from the detailed data. However it was not possible to follow all such changes over the reference period due to revisions in vessel registration numbers.[**]

Coal imports have centered mainly on the Great Lakes with the US being the source of 99.8% of the 15.2 Mt that were unloaded by Canadian ports in 1985 and 91.1% of the 20.4 Mt unloaded in 1999. Canadian-flagged ships carried 96.3% of the inbound coal in 1985 and 81.1% in 1999 as coal remained a staple of the Great Lakes fleet.

Crude petroleum has been one of the largest imports through much of the reference period as feedstock for petroleum products, particularly at East Coast refineries. The crude petroleum unloaded at the ports increased almost threefold from 9.7 Mt. in 1985 to 28.5 Mt in 1999. Europe, particularly the North Sea, was the major source of this crude throughout much of the reference period (43.1% in 1985, 52.9% in 1999)

[**] In 1996, the International Maritime Organization (IMO) adopted the Lloyd's number as the official registration number for all vessels in international trade. The advantage of this number is that it can be used to track vessels over time even as the ships name and flag of registry changes.

followed by the Middle East/Africa (28.1% in 1985, 35.7% in 1999) and South and Central America (26.9% in 1985, 11.3% in 1999). Several fleets were prominent in the carriage of this product, particularly the Liberian-flagged fleet, which carried 36.4% of the cargo over the 15-year term. However, the Liberian-flag fleet's share of the cargo has ranged from a high of 50.1% in 1996 to a low of 15.1% in 1999. These changes in share seem related to changes in Greek shipping policy over the years as the peaks in Liberian cargo appear related to valleys in Greek cargo and vice versa.

Outbound shipments of crude petroleum rose from 695 kilotonnes in 1985 to 9.3 Mt. in 1999. Two factors explain this increase: 1) double-hull regulations of the 1990 U.S. Oil Pollution Prevention Act that led to the 1994 start-up of a transshipment facility at Port Hawkebury, N.S. for North Sea crude bound for the U.S.; and 2) Newfoundland's offshore oil production started in 1989. In 1985, the fleets of Liberia, Greece, Panama and Norway handled 88.5% of outbound crude petroleum shipments. These fleets carried 2.6 times as much outbound crude in 1999, but their share of the total dropped to just 16.2%. By 1999, Singaporean and Canadian flagged ships dominated outbound crude shipments with 47.9% and 31.6% of the tonnage, respectively.

A Flag Related Risk Index

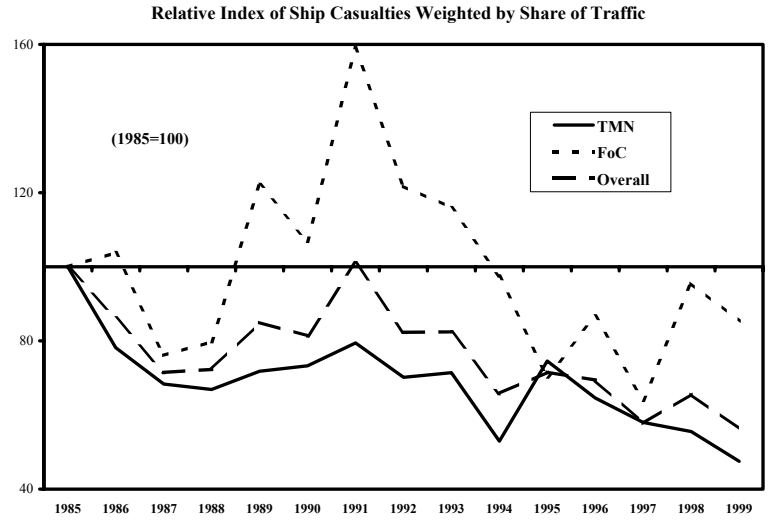
Risk is a composite measure of the probability and severity of an adverse occurrence.[16] The data presented above are not sufficient to calculate the risk of a marine casualty in Canada but can provide insight into the trends of the probability of casualties based on the flag-state criterion alone. An index (1985=100) was constructed based on the sum of the annual casualty rate for each flag group weighted by that group's proportion of the total ship arrivals and departures at Canadian ports in that year.

This index suggests that despite Canada's increasing dependence on FOC ships, the overall probability of a vessel casualty has declined. Indeed, the index remained under 100 for the entire reference period except for 1991 when it rose to 101. By 1999, the index had fallen to 56, due almost entirely to the decline in overall casualty rates.

Some interesting observations arose in the calculation of this index:

1. The FOC posted the worst casualty rates over the reference period averaging 2.2 times the TMN rates, but TMN ships have averaged 3.5 times as many arrivals and departures as FOC ships suggesting that TMN ships could be more likely to have casualties in Canadian waters.
2. The weighted index for all flag groups except the FOC had fallen below 50 by 1999 due to the declines in both casualty rates and traffic for these fleets.
3. While FOC casualty rates had declined by almost 54% over the reference period, the impact of this decline was limited by the 80.3% increase in FOC ship arrivals and departures resulting in a 15% improvement in the weighted index (i.e., 1999 = 85). For 6 of the 15-years the weighted index for FOC ships was above 100.
4. While the average ship size (GT) for casualties increased for the world fleet 5.0% from 1985 to 1999, the average ship size for the FOC fleet increased by 32.4%. The average FOC casualty over the reference period was 1.9 times the GT of the average world fleet casualty. This suggests that if a casualty had happened, the size of the ship involved would likely have been larger in 1999 than 1985, particularly if the casualty were an FOC ship.

Figure 4:



This weighted index was compared to the number of marine accidents to foreign ships in Canadian waters reported by the Transportation Safety Board (TSB) of Canada for 1989 to 1999. The 2 data series are significantly different as the TSB data do not include Canadian-flagged ships and include all accidents as opposed to just casualties. A positive correlation of ρ=0.75 was found suggesting that despite the differences the two data series are very similar. The TSB data and the index developed here appear to validate one another.

Conclusions and Recommendations

Canada has become significantly more dependent on 'flag-of-convenience' ships for its cargo international trade. Yet the fleet that called at the country's ports in 1999 seemed to be significantly safer than the one in 1985, as world shipping had in general become safer.

This improvement may appear to be in conflict with stable rate of deficiencies and detentions resulting from Port State Control inspections. Yet the improvement may be due in part to the effective targeting of PSC inspections that has resulted in these stable rates. It may also be due to the impact of regulations and legislation implemented by port states arising from accidents such as the Exxon Valdez and Erika.

Some cautions and concerns need to be stated with these findings. The first concern is with respect to the publicly released casualty data. There is a need for more complete accident data rather than just those that have resulted in casualties. There is also a need for more publicly available data on the causes and consequences of accidents and variables relating to the characteristics of the ships involved.

The suggestion that the overall fleet may be safer does not imply that there are no substandard ships calling at Canadian ports, nor does it imply that all coasts and ports share the same level of risk. The finding does not mitigate the need for effective PSC inspections but suggests that the vigilance of Port States acting in concert has positively impacted the overall safety of the seas.

Flag is one of a number of characteristics that could indicate the casualty potential of the fleets that support Canada's international trade. The average age of the fleet, nationality and certification standards of officers and crew, classification society and frequency of changes in flag, ownership and class offer other avenues for further study.

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[1] Lloyd's Register (1999). *World Fleet Statistics*. Table 1A.

[2] For example – On December 12th, 1999, the 25-year old Maltese-flag tanker ERIKA, broke in two spilling 14,000 tonnes of fuel oil onto the beaches of northwestern France. The European Union responded by stepping up port state control inspections, more closely monitoring the performance of classification societies, speeding up the elimination of single-hulled tankers and improving the liability and compensation

regimes for pollution damage. See *Erika Oil Spill Prompts Maritime Safety Action by EU*. Harbour and Shipping, January 2002, p.16-17.

[3] Transport Canada, Marine Safety Port State Control 2000 Annual Report, TP13595.

[4] Transportation Safety Board, *Annual Report to Parliament 2000-2001*. P.12

[5] Lloyd's Register. Casualty Returns, 2000. P 4.

[6] Lloyd's Register. Casualty Returns, 2000

[7] Cullinane, K and Robertshaw, M (1996) *The influence of qualitative factors in the Isle of Man ship registration decisions.* Maritime Policy and Management Vol 23, No 4.p. 321-326.

[8] Stopford, Martin (1988). *Maritime Economics* p. 161 Unwin Hyman Ltd. London, England.

[9] http://www.itf.org.uk/sections/mar/foceng.html . 1. Non citizens are allowed to own and control vessels; 2. Access to and from the register is easy; 3. Taxes upon shipping income are low or non-existent; 4. The country of registration does not need the shipping tonnage for its own purposes but is keen to earn the tonnage fees; 5. Manning by non-nationals is freely permitted; 6. The country lacks the power (or willingness) to impose national or international regulations on shipowners.

[10] Brodie, P (1994). *Dictionary of Shipping Terms, 2nd Edition.* Lloyd's of London Press Ltd. London

[11] Mathews, Steve (2001), *Choosing the Right Flag*. Lloyds Ship Manager (LSM), June 2001, p. 39-41.

[12] Bergantino, A and Marlow, P. (1998). *Factors influencing the choice of flag: empirical evidence.* Maritime Policy and Management. V25, No. 2, p.157-174.

[13] http://www.nis-nor.no/announce.htm

[14] Thanopoulou, H.A. (1995) *The growth of fleets registered in newly-emerging maritime countries and maritime crises.* Maritime Policy and Management Vol 22, No 1.p. 51-62.

[15] Lee, T.-W. (1996). *Flagging options for the future: A turning point in Korean shipping policy?* Maritime Policy and Management. V23, No. 2, p.177-186.

[16] Transport Canada (1994). *Guide to Benefit-Cost Analysis in Transport Canada*. TP 1187E.