Risk Factor and Trend Analysis Capsizing and Foundering by Small Fishing Vessels - 2006

Prepared by

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Transport Canada does not endorse products or manufacturers. Trade or manufacturers' names appear in this report only because they are essential to its objectives.

Since the accepted measures in the marine industry are metric and imperial, both measures are used in this report where appropriate.

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Abstract

The aim of this study is to report on the risk factors and trends in capsizing and foundering occurrences by fishing vessels up to 24 metres in length or 150 gross tons. The findings in this report are intended to provide input to a broader study by BMT Fleet Technology.

A quantitative risk factor analysis was conducted comparing accident frequency per days at sea. Although significant risk factors and areas were identified, an overall decrease in accident frequency has occurred from 1990 to 2006. During this period there have been shifts in the predominant fisheries.

Accident trends:

- The average frequency of capsizing or foundering of fishing vessels in the Pacific and Atlantic regions is 1 per 20,000+ days at sea except for vessels of 15 to 30m in the Atlantic region which have a significantly lower frequency of over 1 per 150,000 days at sea.
- The number of fishing accidents per year is on the decline and the accident rate per day spent at sea is decreasing in the Atlantic region.
- The accident rate in the Pacific region is steady during this decade.

Risk factors:

- Occurrence rates are greater in the herring and capelin fishery on the Atlantic coast and in the herring and urchins fishery on the Pacific coast.
- Dive fishing is probably a risk factor on both coasts. Seiners are probably at a higher risk than other vessel types on the Pacific coast.
- 59% of capsizing and foundering occurrences investigated by TSB between 1990 and 2003 were caused by operator issues such as overloading, improper loading, free surface effects or closed scuppers.
- About 19% of capsizing or founderings had modifications to the vessel thought to impact stability.
- The Bay of Fundy, and Bonavista Bay in the Atlantic region and the Fraser River and Georgia Strait in the Pacific Region are areas of higher relative capsizing or foundering rates per days at sea.

Fishery trends:

- The use of bottom otter stern trawl is on the decline and pot fishing is on the rise in the Atlantic fishery.
- The Pacific fishery shows a shift from salmon gillnetting and trolling to trap fishing, bottom otter trawl and longlining.

Key words

Risk factors, fishing vessels, stability, capsizing, foundering, days at sea.

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1 INTRODUCTION

1.1 Background

Government of Canada Regulatory Policy requires that any government department, which intends to put regulations into place, must first establish that there is a problem, that the problem is related to its mandate and that the problem is well defined. Regulations are designed to reduce the problem or the impact of the problem.

Based on basic statistics from the Transportation Safety Board and Statistical Information Search and Rescue (SISAR), Transport Canada has determined that the Fishing Vessel Inspection Regulations do not adequately address the safety of fishing vessels. The Transportation Safety Board has been especially critical of the minimalist regulations pertaining to fishing vessels, especially in regard to stability, overloading, and downflooding issues.

Transport Canada is concerned that although the number of accidents has reduced over recent years, the rate of accidents may have actually remained the same. There may be fisheries or areas where fishing time has actually increased or decreased and the risk may have significantly changed.

1.2 Objective

To verify if the current widely held assumptions regarding the historical, and current and future risk factors in relation to fishing vessel operation in Canada are accurate. The study will summarize the relevant fishing vessel accident statistics (past and present) to identify statistically significant risk factors and provide a trend analysis.

1.3 Scope

Category and size of fishing vessels
The analysis is restricted to small fishing vessels of up to 150 tons (gross tonnage) or 24 metres in length.

Primary occurrence type of interest
This study is primarily interested in fishing vessel stability and the reduction of capsizing and foundering. Capsizing is to turn over and foundering is to fill from above the waterline and sink.

Information sources
Primary data sources include: a sample of Transportation Safety Board (TSB) MARSIS data for the period 1990-2006, TSB marine occurrence reports, and Fisheries and Oceans fishing effort data for the Pacific and Atlantic Regions. There has been no update by Fisheries and Oceans to the Statistical Information

Search and Rescue (SISAR) data previously analyzed in 2002. Workers compensation board data did not prove valuable because its access is restricted and its use by fishers is not universally mandatory. Neither Ontario nor Manitoba capture effort data, i.e., days at sea.

Study areas
Areas examined included the east and west coasts of Canada, the Great Lakes and the St. Lawrence River (the Arctic and other waterways were not within the scope of this analysis).

2 APPROACH

2.1 Overall approach

The overall approach to the project was to analyze historical fishing vessel effort and accident data to identify risk factors and trends from 1990 to 2005.

- In order to identify significant highest-risk vessels and low risk vessels, observed capsizing or foundering occurrences by fishery, vessel types/designs/gear types, and vessel length were compared to expected frequencies given fleet data obtained from Fisheries and Oceans Canada (the analysis method is described in further detail below).
- A data set was created from relevant marine occurrence reports from the Transportation Safety Board to permit the analysis of seaworthiness, vessel operations and equipment failure cause factors and to determine if these factors vary significantly by vessel design and if any factor can be considered the primary cause.
- A geospatial analysis of areas of operation was conducted to compare observed capsizing or foundering frequencies per days at sea in different areas. These areas were defined by Fisheries and Oceans Canada statistical areas.
- Current and historical risk rates of capsize, foundering, man overboard, fire and other risks for fishing vessels were presented.
- Current and historical changes in fisheries were presented.
- To assist with risk reduction and cost benefit analysis, possible risk mitigation strategies were proposed where appropriate.

2.2 Statistical analysis methods

To estimate an accident rate that provides a reasonable measure of relative risk, reliable and appropriate data must be obtained.

- Data collected by the Transportation Safety Board of Canada provides the most reliable and consistent source of accident counts. The data counts are more reliable for accidents that would not go unnoticed such as the loss of a vessel or a fatality. This data is collected across Canada. It is reasonable to assume that the counts of capsizing or founderings in Canada is a good measure of total counts of this type of marine occurrence.

- Data collected by Fisheries and Oceans Canada provides the most complete and consistent picture of fishing activity in terms of days at sea, gear (vessel) type, and fishery. It is essential to compare the number of accidents given the days at sea to provide a reasonable and comparable description of the accident frequency. Analyses that describe accidents per year or per fleet size miss the mark because a vessel may only spend two weeks at sea per year and not all vessels spend the same time at sea.

- Unfortunately, Fisheries and Oceans Canada does not collect effort data for the Great Lakes or Lake Winnipeg. Some fishing data is collected by the governments of Ontario and Manitoba; however, the effort data collected does not provide reasonable and comparable information on the exposure of fishers to risk, i.e., the days at sea. Fortunately, the total number of capsizing and founderings by fishing vessels in these provinces represented only 6 out of 231 across Canada or 2.6% over the period 1990 to 2006.

What is meant by a significant risk factor? In normal English, "significant" means important, while in statistics "significant" means probably true (not due to chance). The analysis method used to identify risk factors in this study is to test for statistical significance. Consider the following to understand if this is a reasonable approach:

- A risk factor is identified if its frequency of occurrence is greater or less than what would be expected. For example, if 22% days at sea were by trawl vessels, you would expect that 22% of the accidents would be by this group, everything else being equal. Therefore, if the total number of ***observed*** historical accidents by all vessels in a sample was 14, the ***expected*** number of accidents by trawl vessels would be 3 which is 22/100 x 14.

- It is possible to have some difference between observed and expected values based on chance, so a table is used to see if this difference is significant. If the difference is significant then probably a risk factor has been identified. The difference between observed O and expected E values is calculated using the formula $\frac{(O_i - E_i)^2}{E_i}$ for each category.

- This type of statistical analysis is called a Chi-square analysis. The sum of the measured statistic for each category is the Chi-square value. It is just a name, but the approach is as described above. It is a technique described by the highly respected Extra Master John F Kemp, PhD, Fellow of the Royal Institute of Navigation and faculty at the City of London Polytechnic. See Marine Statistics, Theory and Practice, Stanford Maritime London, pp.202-205.

- As it turns out, the *observed* number of accidents by trawlers in the Atlantic is very close to the *expected* number given the percentage of days at sea, so being a trawler is probably not a significant risk factor (Section 3.2).

The examination of trends in accident rates and fisheries used Excel bar charts and trend lines to depict change over time. No statistical analysis of significance was required for a reader to see the trends which were described.

Lastly, geospatial analysis was used to map the frequency of capsizing and founderings per days at sea for different geographic areas. A graphic called a "thematic map" was produced in a MapInfo geographic information system to make variations in accident rates immediately apparent. It is not a statistical analysis technique; however, it is a convincing way of depicting actual accident rates in different areas of operations, and it is better than anecdotal recollection of accident counts that may *seem* high without considering that the traffic, exposure or days at sea which may also be high.

3 RISK FACTORS

3.1 Is fishery a significant risk factor?

Is there a significant difference between the observed frequency of capsizing and foundering by fishery compared to the frequency expected given the distribution of days at sea in each fishery?

A Chi-Square goodness of fit test was used to analyze DFO data and TSB Marine Occurrence Report data (see Tables 1 and 2). For the Atlantic and Pacific regions[1], the total days at sea by fishery was compared to the frequency of small fishing vessel accidents resulting in a Marine Occurrence Report of a capsizing or foundering (a 33/258 or 13% sample of all capsizing or foundering occurrences between 1993 and 2002).

Table 1. Fishery risk factor – Atlantic region

	lobster	crab	shrimp	cod	hake, pollock	flounder	haddock	scallops	halibut	herring	mackerel	redfish	capelin	other	total
Fleet distribution - days at sea by fishery - 2004	413456	80826	52288	34008	27849	24574	20355	18563	18314	14743	13143	10873	927	79446	809365
Percent	51	10	6	4	3	3	3	2	2	**2**	2	1	**0**	10	100
Expected capsizing/founderings	7.15	1.40	0.90	0.59	0.48	0.43	0.35	0.32	0.32	0.26	0.23	0.19	0.02	1.37	14
Observed capsizing/founderings in MOR sample 93-02	6	0	0	1	0	1	0	1	0	2	0	1	1	1	14
Percent	43	0	0	7	0	7	0	7	0	**14**	0	7	**7**	7	100
$\frac{(O_i - E_i)^2}{E_i}$	0.19	1.40	0.90	0.29	0.48	0.78	0.35	1.44	0.32	11.94	0.23	3.51	60.39	0.10	
Chi-Square	**82.31**														

Note: The critical region of a Chi-Square distribution for 13 degrees of freedom at the 5% significance level is 22.36

Since the Chi-Square value of 82.31 exceeds 22.36, there is a significant difference between the observed and expected capsizing or foundering frequencies by fishery in the Atlantic region.

Conclusion: *Fishery is probably a risk factor for capsizing or foundering in the Atlantic region for vessels in the herring and capelin fishery as these groups have a disproportionately higher capsizing or foundering frequency than expected given the distribution of days at sea by fishery.*

[1] Unlike Fisheries and Oceans Canada, Manitoba and Ontario do not collect fishing days at sea information.

Table 2. Fishery risk factor – Pacific region

	rockfish	salmon	sole	shrimp	skate	crab	cod	prawns	halibut	tuna	urchins	herring	other	total
Fleet distribution - days at sea by fishery - 2004	201592	159465	51068	28299	27896	27859	27012	13673	3593	2324	735	374	138866	682757
Percent	30	23	7	4	4	4	4	2	1	**0**	**0**	**0**	20	100
Expected capsizing/founderings	3.25	2.57	0.82	0.46	0.45	0.45	0.44	0.22	0.06	0.04	0.01	0.01	2.24	11
Observed capsizing/founderings in MOR sample 93-02	0	3	0	0	0	0	0	2	1	1	2	2	0	11
Percent	0	27	0	0	0	0	0	18	9	**9**	**18**	**18**	0	100
$\frac{(O_i - E_i)^2}{E_i}$	3.25	0.07	0.82	0.46	0.45	0.45	0.44	14.38	15.33	24.75	333.85	659.42	2.24	

Chi-Square **1056**

Note: The critical region of a Chi-Square distribution for 12 degrees of freedom at the 5% significance level is 21.03

Since the Chi-Square value of 1056 exceeds 21.03, there is a significant difference between the observed and expected capsizing or foundering frequencies by fishery in the Pacific region.

Conclusion: *Fishery is probably a risk factor for capsizing or foundering in the Pacific region for vessels <u>in the herring and urchins fishery and possibly the tuna fishery</u> as these groups have a disproportionately higher capsizing or foundering frequency than expected given the distribution of days at sea by fishery. The rockfish fishery has the highest total days at sea and no recorded capsizings or founderings in the sample of Marine Occurrence Reports analyzed.*

3.2 *Is gear (vessel) type a significant risk factor?*

Is there a significant difference between the observed frequency of capsizing and foundering by vessel gear type compared to the frequency expected given the proportion of days at sea for each fishing vessel gear type in the fleet?[2]

A Chi-Square goodness of fit test was used to analyze DFO data and TSB Marine Occurrence Report data (see Tables 3 and 4). For the Atlantic and Pacific regions, the total days at sea by vessel gear types was compared to the frequency of small fishing vessel accidents resulting in a Marine Occurrence Report of a capsizing or foundering (a 33/258 or 13% sample of all capsizing or foundering occurrences between 1993 and 2002).

Table 3. Fishing vessel gear type risk factor – Atlantic region

	Trawls	**Traps**	**Seine**	**Gillnet**	**Longline**	**Hand tools, diving**	**Trolling, handline**	**Total**
Fleet distribution - days at sea by gear type 2004	147551	374438	21831	62866.5	62812.6	1113	10145.8	680758
Percent	22	55	3	9	9	**0**	1	100
Expected capsizing/founderings distribution	3.03	7.70	0.45	1.29	1.29	0.02	0.21	14
Observed capsizing/founderings in MOR sample 93-02	4	6	0	3	0	1	0	14
Percent	29	43	0	21	0	**7**	0	100
$\frac{(O_i - E_i)^2}{E_i}$	0.31	0.38	0.45	2.25	1.29	41.71	0.21	
Chi-Square	**46.6**							

Note: The critical region of a Chi-Square distribution for 6 degrees of freedom at the 5% significance level is 12.59

Since the Chi-Square value of 46.6 exceeds 12.59, there is a significant difference between the observed and expected capsizing or foundering frequencies by gear type in the Atlantic region.

Conclusion: *Fishing vessel gear type is a risk factor for capsizing or foundering in the Atlantic region for vessels engaged in diving operations such as fishing with hand tools as this group has a disproportionately higher capsizing or foundering frequency than expected given the distribution of days at sea by vessel gear type. Since no other gear type showed a significant variation in the number of accidents that would be expected given the distribution of days at sea, vessel designs that typically employ these other gear types are probably not a risk factor.*

[2] DFO does not capture data on vessel type; however, gear type is captured.

Table 4. Fishing vessel gear type risk factor – Pacific region

	Trawls	Traps	Seine	Gillnet	Longline	Hand tools, diving	Trolling	Total
Fleet distribution - days at sea by gear type 2004	290574	61210	8957	102156	123851.7	2196.93	99500	688446
Percent	42	9	**1**	15	18	**0**	14	100
Expected capsizing/founderings	5.49	1.16	0.17	1.93	2.34	0.04	1.88	13
Observed capsizing/founderings in MOR sample 93-02	5	2	3	1	1	1	0	13
Percent	38	15	**23**	8	8	**8**	0	100
	0.04	0.62	47.38	0.45	0.77	22.15	1.88	
Chi-Square	**73.28**							

Note: The critical region of a Chi-Square distribution for 6 degrees of freedom at the 5% significance level is 12.59

Since the Chi-Square value of 73.28 exceeds 12.59, there is a significant difference between the observed and expected capsizing or foundering frequencies by gear type in the Pacific region.

Conclusion: *Fishing vessel gear type is probably a risk factor for capsizing or foundering in the Pacific region for seiners and diving operations such as fishing with hand tools as these groups have a disproportionately higher capsizing or foundering frequency than expected given the distribution of days at sea by vessel gear type.*

3.3 Is vessel length a significant risk factor?

Is there a significant difference between the observed frequency of capsizing and foundering by vessel length compared to the frequency expected given the distribution of fishing vessel lengths in the fleet?

A Chi-Square goodness of fit test was used to analyze DFO and TSB data (see Table 5). Vessel length ranges approximate those provided by DFO.

Table 5. Fishing vessel length risk factor – Pacific and Atlantic regions

	Pacific Region		Atlantic Region		
	< 15m	**15m to 30m**	**< 15m**	**15m to 30m**	**Total**
Days at sea (average) 90-04	112,000	33,000	193,000	136,000	329,000
Percent	24	7	41	29	100
Expected capsizing/foundering distribution	55	16	94	**66**	231
Observed capsizing/foundering distribution 90-06	76	24	118	**13**	231
Percent	33	24	51	6	100
$\frac{(O_i - E_i)^2}{E_i}$	8.4	3.9	6.09	**42.83**	
Chi-Square	**61.23**				
Annual capsizing/foundering (average)	5	2	8	1	15
Vessel days between capsizing/foundering	22105	20625	24534	156923	30779

Note: The critical region of a Chi-Square distribution for 3 degree of freedom at the 5% significance level is 7.81

Since the Chi-Square value of 61.23 exceeds the critical region value, there is a significant difference between the observed and expected capsizing or foundering frequencies by vessel length.

Conclusions: *The significant difference length has on the frequency of capsizing or founderings is only apparent in the Atlantic region for vessels from 15 to 30 metres as this group has a disproportionately lower capsizing or foundering frequency than expected given the distribution of days at sea by vessel size. Otherwise, length is not factor.*

3.4 What is the primary cause factor of capsizing and foundering?

Is there a significant difference between the observed and expected frequency of causes for capsizing and foundering?

59% (19/32) of capsizing and foundering occurrences investigated by TSB between 1990 and 2003 were caused by operations issues such as overloading, improper loading, free surface effects or closed scuppers (see Table 6). 8/32 were attributed to seaworthiness, 3/32 equipment failure and 2/32 were of unknown cause. A total of 19% or 6/32 of the vessels were modified in some manner that contributed to the loss of stability. 13% or 4/32 of vessels had modifications which reduced freeboard; 6% or 2/32 of vessels had modifications that impacted transverse stability.

Table 6. Primary cause of capsizing and foundering – all regions

	Equipment failure	Operation	Seaworthiness primarily due to modifications	Total
Observed	3	19	8	30
Expected[3]	10	10	10	
	4.90	8.10	0.40	
Chi-square	**13.4**			

Note: The critical region of a Chi-Square distribution for 2 degrees of freedom at the 5% significance level is 5.99

Since the Chi-Square value of 13.4 exceeds 5.99, there is a significant difference between observed and expected primary cause factors.

Conclusion: *Critical error(s) in vessel operation at sea is the primary risk factor for capsizing or foundering as this cause factor has a disproportionately higher observed frequency than would be expected by chance.*

3.5 Do seaworthiness, vessel operations or equipment failure cause factors vary significantly by vessel design?

Is there a significant difference between the observed and expected frequency of primary causes for each vessel design?

A Chi-Square goodness of fit test was used to analyze TSB Marine Occurrence Report data (see Table 7). Since the Chi-Square value of 57.06 is less than 58.12, there is no significant difference between the observed and expected frequency of primary cause factor by vessel design.

Conclusion: *There is no relationship between fishing vessel design and the cause factors of equipment failure, operation or seaworthiness.*

[3] The observed total number of occurrences (30) is divided by three to estimate the expected occurrence of a cause factor if each cause factor had an equal chance.

Table 7. Fishing operation vs. seaworthiness risk factor – all regions

Vessel design		Equipment failure	Operation	Seaworthiness	Unknown	Total
Cape Island	Observed		2	1		3
	Expected	0.3	1.8	0.8	0.2	9%
		0.28	0.03	0.08	0.19	
Carvel	Observed			1		1
	Expected	0.1	0.6	0.3	0.1	3%
		0.09	0.59	2.25	0.06	
dive tender	Observed			1		1
	Expected	0.1	0.6	0.3	0.1	3%
		0.09	0.59	2.25	0.06	
dragger	Observed	2		1		3
	Expected	0.3	1.8	0.8	0.2	9%
		10.50	1.78	0.08	0.19	
fishing	Observed		7			7
	Expected	0.7	4.2	1.8	0.4	22%
		0.66	1.95	1.75	0.44	
gillnetter/longliner	Observed				1	1
	Expected	0.1	0.6	0.3	0.1	3%
		0.09	0.59	0.25	14.06	
groundfish	Observed		1			1
	Expected	0.1	0.6	0.3	0.1	3%
		0.09	0.28	0.25	0.06	
Lake Winnipeg Yawl	Observed		2			2
	Expected	0.2	1.2	0.5	0.1	6%
		0.19	0.56	0.50	0.13	
Northumberland	Observed			1		1
	Expected	0.1	0.6	0.3	0.1	3%
		0.09	0.59	2.25	0.06	
open boat	Observed		2			2
	Expected	0.2	1.2	0.5	0.1	6%
		0.19	0.56	0.50	0.13	
Packer	Observed		1	1		2
	Expected	0.2	1.2	0.5	0.1	6%
		0.19	0.03	0.50	0.13	
punt	Observed	1				1
	Expected	0.1	0.6	0.3	0.1	3%
		8.76	0.59	0.25	0.06	
seiner	Observed		2	1	1	4
	Expected	0.4	2.4	1.0	0.3	13%
		0.38	0.06	0.00	2.25	
trap	Observed		1	1		2
	Expected	0.2	1.2	0.5	0.1	6%
		0.19	0.03	0.50	0.13	
troller	Observed		1			1
	Expected	0.1	0.6	0.3	0.1	3%
		0.09	0.28	0.25	0.06	
Column total		3	19	8	2	32
		9%	59%	25%	6%	100%
		21.80	7.92	9.42	17.94	

Chi-Square **57.06**

Note: The critical region of a Chi-Square distribution for 42 degrees of freedom at the 5% significance level is 58.124

3.6 Is area of operations a risk factor?

In order to examine a spatial variation in risk, both fishing vessel capsizing/foundering occurrences and fishing activity data was obtained from the Transportation Safety Board, Fisheries and Oceans Canada and the Ontario Ministry of Natural Resources. Ratios of occurrences to days at sea were estimated for each unique fishing area where data was provided. Note that fatality data was not available from any workers compensation agency with the exception of Prince Edward Island; and appropriate fishing effort data was not available from the Province of Manitoba. Unfortunately, data received from Ontario was not readily useable for this analysis.

Average total days at sea from 1990 to 2004 were summarized for each distinct unit area in the boundaries forming Pacific and Atlantic regions of Fisheries and Oceans Canada as shown in Figures 1 to 4. The ratio of average annual small fishing vessel capsizings or founderings for average annual days at sea is graphed to show areas of high and low risk.

The average frequency of capsizing or foundering of fishing vessels in the Pacific and Atlantic regions is 1 per 20,000+ days at sea except for vessels of 15 to 30m in the Atlantic region which have a lower frequency of over 1 per 150,000 days at sea.

Pacific Region of Fisheries and Oceans Canada

In the Pacific region, the average frequency of capsizing or foundering of fishing vessels under 15m is 1 per 22000 days at sea[4] (Figure 1). The average frequency of capsizing or foundering of fishing vessels from 15 to 30m is 1 per 20,000 days at sea[5] (Figure 2). Figures 1 and 2 are described as follows:

- Areas with capsizing or founderings, but at the lowest frequency of occurrences per days at sea, are marked by green dots. Fishing vessels under 15m are at lower relative risk in Barkley Sound, Quatsino Sound and Chatham Sound. Fishing vessels from 15 to 30m are at a lower relative risk in Barkley Sound.
- Areas with the highest frequency of occurrences are marked by red dots. Fishing vessels under 15m are at higher relative risk in Portland Inlet and the Fraser River. Fishing vessels from 15 to 30m are at a higher relative risk in Georgia Strait.
- Red stars show actual positions of capsizing or founderings by fishing vessels.
- Unfortunately, the data provided by DFO did not include the offshore waters between Queen Charlotte Island and the mainland south to Vancouver Island.

[4] 76 capsizing/founderings by FVs <15m in apx 15 years per 112,000 average annual days at sea
[5] 24 capsizing/founderings by FVs 15-30m in apx 15 years per 33,000 average annual days at sea

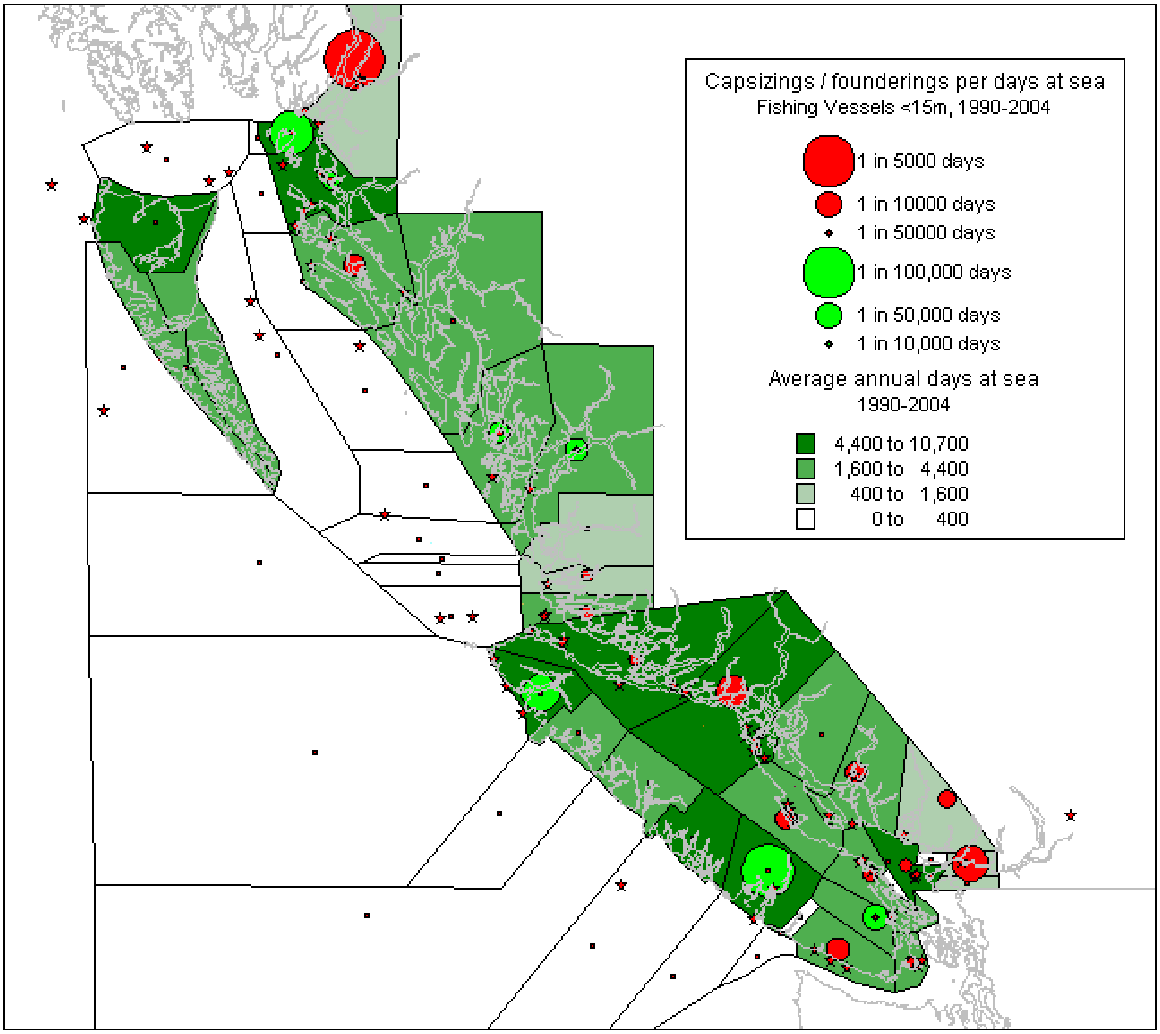

Figure 1. Spatial comparison of Capsizing/foundering risk for fishing vessels under 15m in the Pacific region

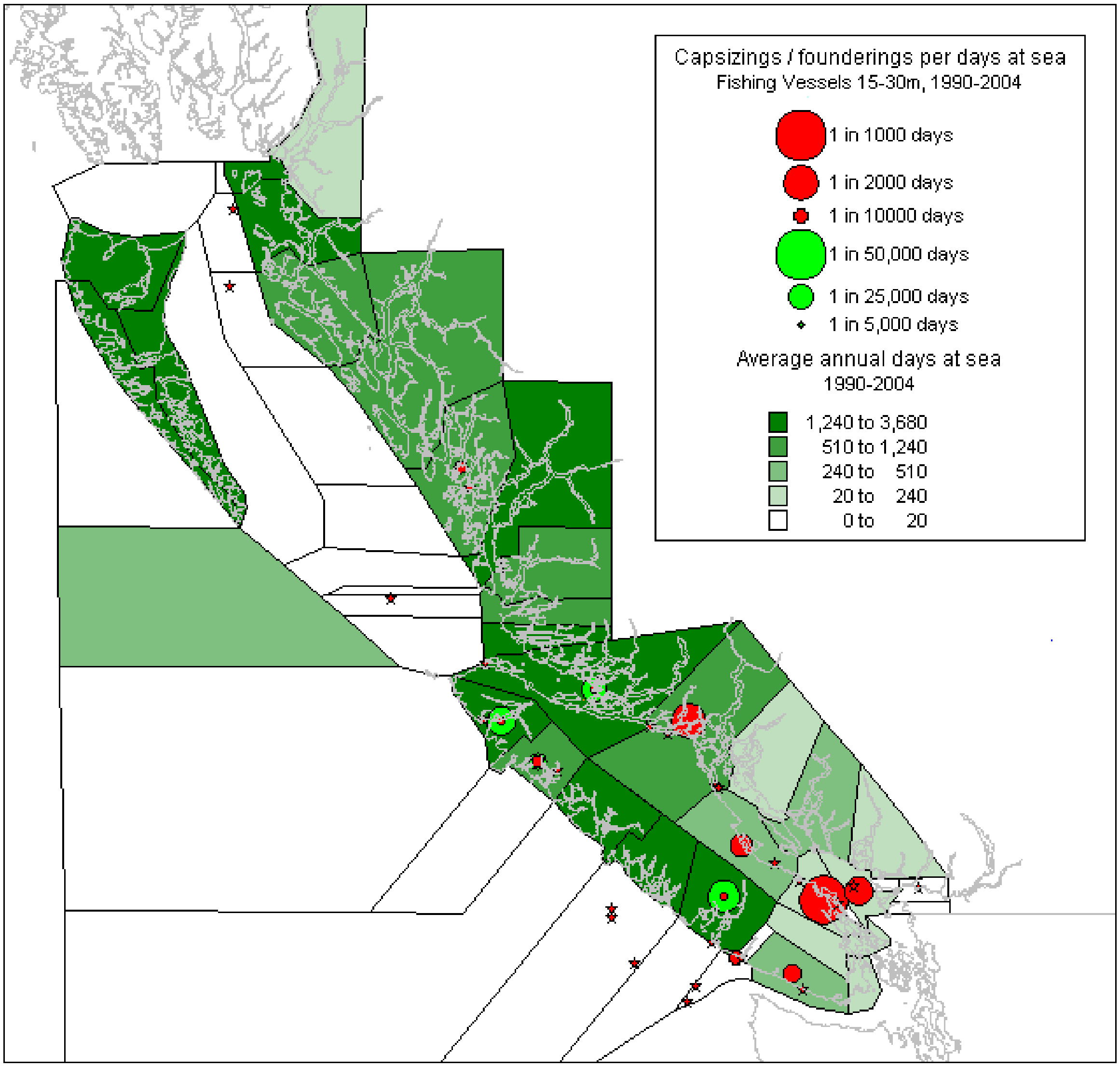

Figure 2. Spatial comparison of Capsizing/foundering risk for fishing vessels from 15 to 30m in the Pacific region

Atlantic Region of Fisheries and Oceans Canada

In the Atlantic region, the average frequency of capsizing or foundering of fishing vessels under 15m is 1 per 24000 days at sea[6] (Figure 3). The average frequency of capsizing or foundering of fishing vessels from 15 to 30m is 1 per 157,000 days at sea[7] (Figure 4). Figures 3 and 4 are described as follows:

- Dark green areas of the map show the highest level of fishing activity.
- Areas with capsizing or founderings, but at the lowest frequency of occurrences per days at sea, are marked by green dots. Fishing vessels under 15m are at lower relative risk in the Magdalen Islands, Prince Edward Island, and Nova Scotia's, south shore. Fishing vessels from 15 to 30m are at a lower relative risk in the Gulf of St. Lawrence, the Bay of Fundy and the Nova Scotia south shore.
- Areas with the highest frequency of occurrences are marked by red dots. Fishing vessels under 15m are at higher relative risk in the Bay of Fundy (south shore) and Bonavista Bay. Fishing vessels from 15 to 30m are not at a higher relative risk anywhere. The single large red dot represents an anomaly with very low total days at sea in the area.
- Red stars show actual positions of capsizing or founderings by fishing vessels.

[6] 118 capsizing/founderings by FVs <15m in apx 15 years per 193,000 average annual days at sea

[7] 13 capsizing/founderings by FVs 15-30m in apx 15 years per 136,000 average annual days at sea

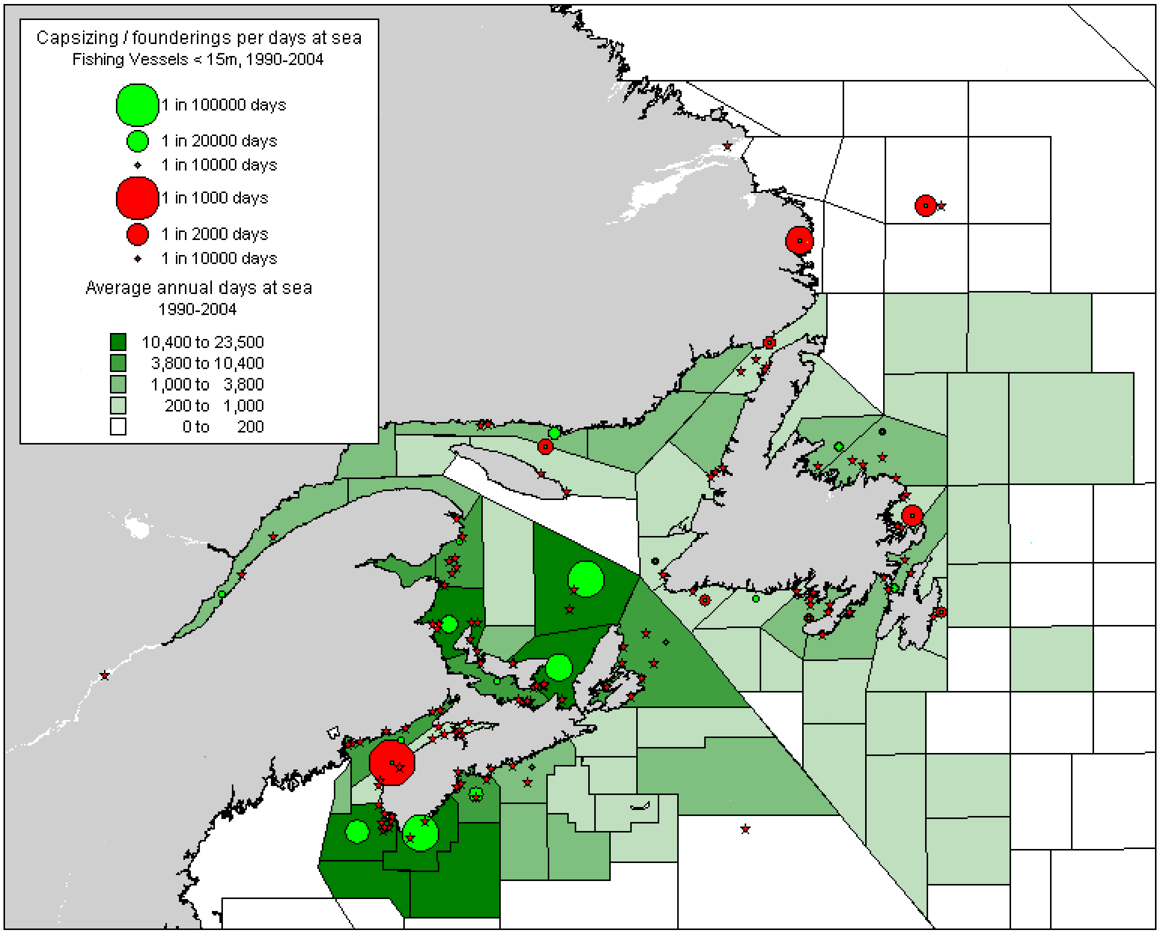

Figure 3. Spatial comparison of Capsizing/foundering risk for fishing vessels under 15m in the Atlantic region

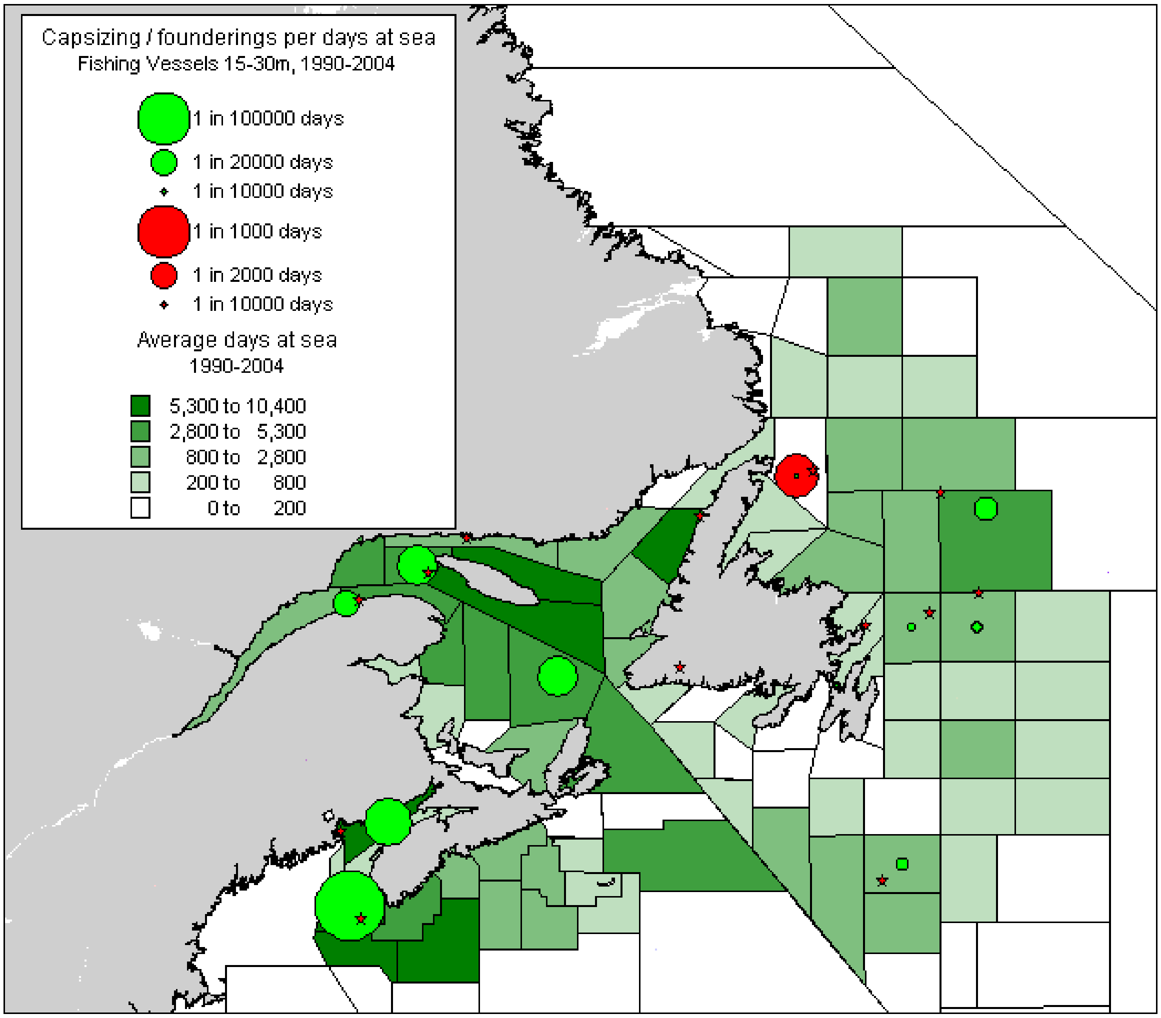

Figure 4. Spatial comparison of Capsizing/foundering risk for fishing vessels from 15 to 30m in the Atlantic region

Central Region

Unfortunately, Fisheries and Oceans Canada does not collect effort data for the Great Lakes or Lake Winnipeg. Some fishing data is collected by the governments of Ontario and Manitoba; however, the effort data collected does not provide reasonable and comparable information on the exposure of fishers to risk, i.e., the days at sea.

There were only six capsizing or foundering occurrences by fishing vessels in the Central region compared to 231 in the Atlantic and Pacific regions from 1990 to 2006. Four were in Lake Winnipeg and two in Lake Huron/Georgian Bay. Fortunately, the total number of capsizing and founderings by fishing vessels in these provinces represented only 6 out of 231 across Canada or 2.6% over the period 1990 to 2006.

4 TREND ANALYSIS

4.1 What is the trend in days spent at sea per year?

To understand the significance of any change in the number of marine occurrences over time, consider the number of days spent at sea by fishing vessels (Figures 5 and 6). A widely held assumption was that overall number of days fished has been going down. However, this is not the case. The Atlantic region shows a stable pattern since 1994 and a recent growth in activity. Therefore, one would expect accident rates to remain largely unchanged as well. The Pacific region shows a 35% decline from 1990 to 1999; however, days at sea has been steady since 1999. Therefore, one would expect accident rates to have declined in the 1990s and remain largely unchanged since 1999.

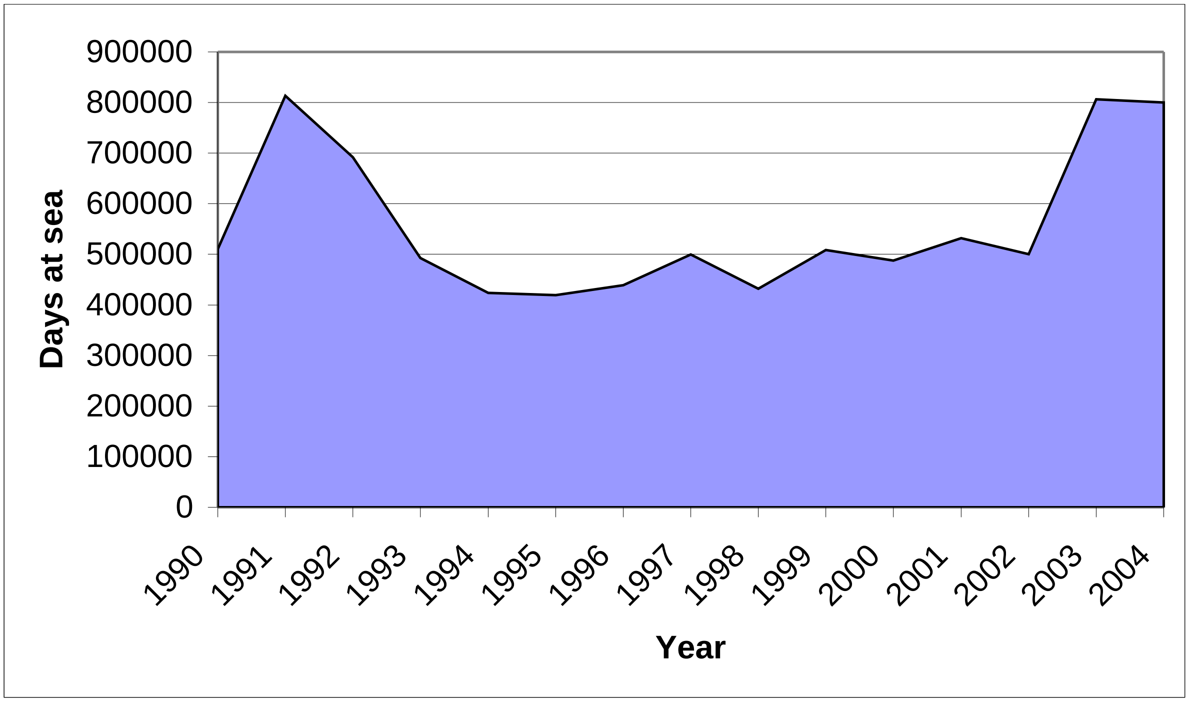

Figure 5. Days at sea - Atlantic region

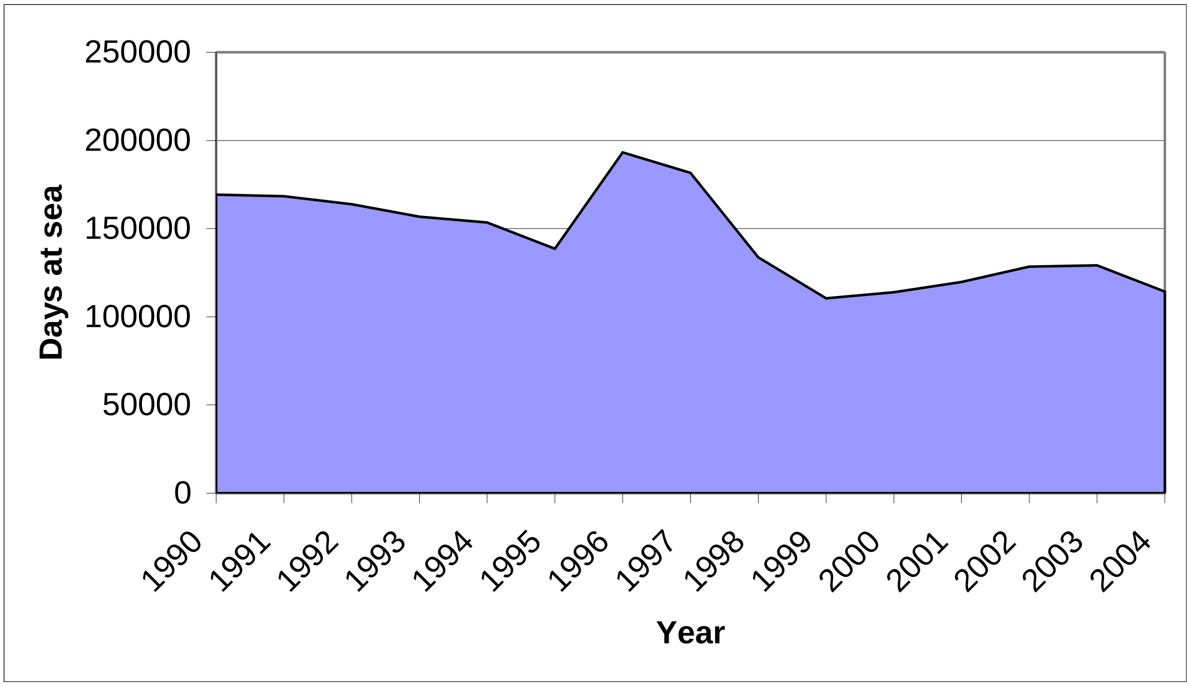

Figure 6. Days at sea – Pacific Region

4.2 What is the overall trend in marine occurrence rates?

Figures 7 to 9 show marine occurrence rates and total numbers are dropping—including those of capsizing and founderings which have dropped by 75% over the last 15 years. In the Pacific region, this trend began in the mid 1980s and is documented by the Transportation Safety Board (Figure 7)[8]. Figure 9 shows that total capsizing and founderings by fishing vessels has remained steady since 1998. Since days at sea since 1999 is steady on the Pacific coast and increasing on the Atlantic coast, accident rates are actually in decline on the Atlantic coast and steady on the Pacific coast.

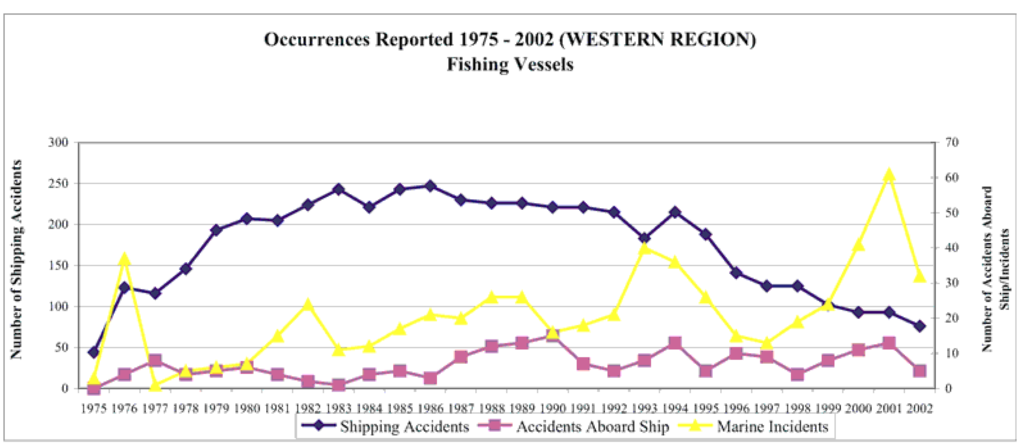

Figure 7. Marine occurrence trends – Historical

[8] Source: Marine Investigation Report Number M01W0253, Transportation Safety Board, 2001

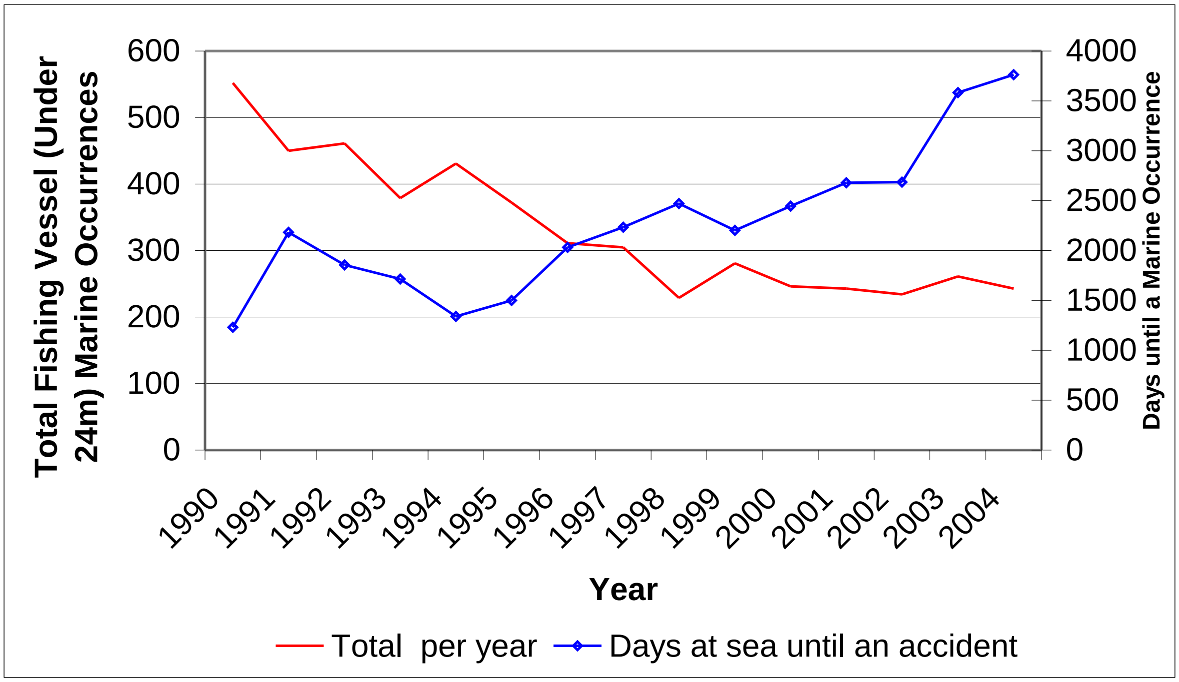

Figure 8. Marine occurrence trends – Pacific and Atlantic regions

4.3 What is the trend for capsizing or founderings?

Like the overall trend for marine occurrences, the trend for capsizing or foundering is also a steady decline (Figure 9).

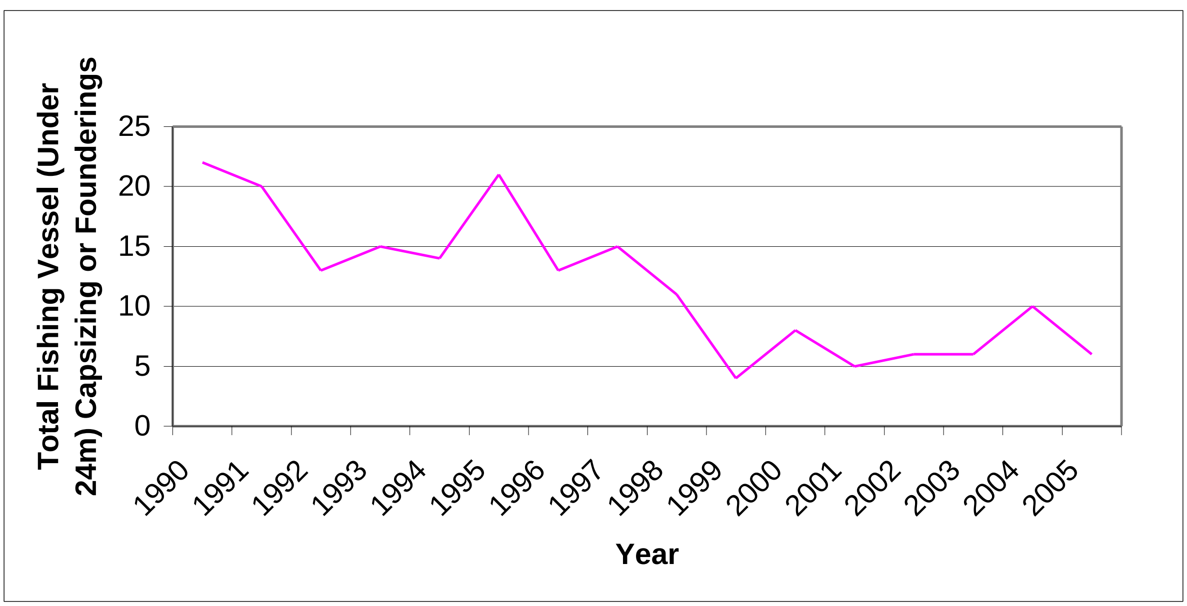

Figure 9. Capsizing or foundering trend – Pacific and Atlantic regions

4.4 What percentage of occurrences are capsizing or founderings?

Table 10 represents the classification of over 85 percent of all marine occurrences by fishing vessels[9]. Four percent of these occurrences are capsizing or founderings. This occurrence group is responsible for over 40 percent of fatalities—about six per year (Table 11).

Table 10. Marine occurrence types

Marine Occurrence Type	Total 1990-2005	Percent	Average per year
GROUNDING	1171	22	73
TAKING WATER	850	16	53
FIRE	293	6	18
FIRE IN ENGINE ROOM	285	5	18
SINKING, I.E. FROM INTAKE BELOW WATERLINE	269	5	17
COLLISION	261	5	16
ACCIDENT ABOARD SHIP - AT SEA/UNDERWAY	209	4	13
CAPSIZE	**134**	**3**	**8**
PROPELLER - SHAFT BROKEN	127	2	8
STRIKING	110	2	7
ICE DAMAGE	105	2	7
RUDDER - LOST	91	2	6
STRUCK BY ANOTHER VESSEL	86	2	5
GROUNDING AND TAKING WATER	84	2	5
RUDDER INOPERATIVE	74	1	5
PROPELLER - LOST	66	1	4
HEAVY WEATHER DAMAGE	63	1	4
SWAMPING	59	1	4
STRIKING ANOTHER VESSEL	58	1	4
FOUNDERING, I.E. FROM INTAKE ABOVE WATERLINE	**55**	**1**	**3**
OTHER	785	15	49
Total	**5235**	**100**	**327**

Table 11. Fatalities by marine occurrence type

Marine Occurrence Type	Total 1990-2005	Percent	Average per year
CAPSIZE	69	26	4
FOUNDERING, I.E. FROM INTAKE ABOVE WATERLINE	34	12	2
SWAMPING	20	7	1
Other	142	53	9
Total	**265**	**100**	**16**

[9] 15% of marine occurrences by fishing vessels belong to other categories. These were noted in Table 10 as 'other'.

4.5 What is the trend in gear used?

The Pacific fishery shows a shift from salmon gillnetting and trolling (yellow and pale blue) to trap fishing (burgundy), bottom otter trawl (black) and longlining (orange) over the 1990 to 2004 period (Figure 10). The Atlantic fishery shows a shift from bottom otter stern trawl (burgundy) to pot fishing (blue) in the Atlantic fishery over the same period (Figure 11).

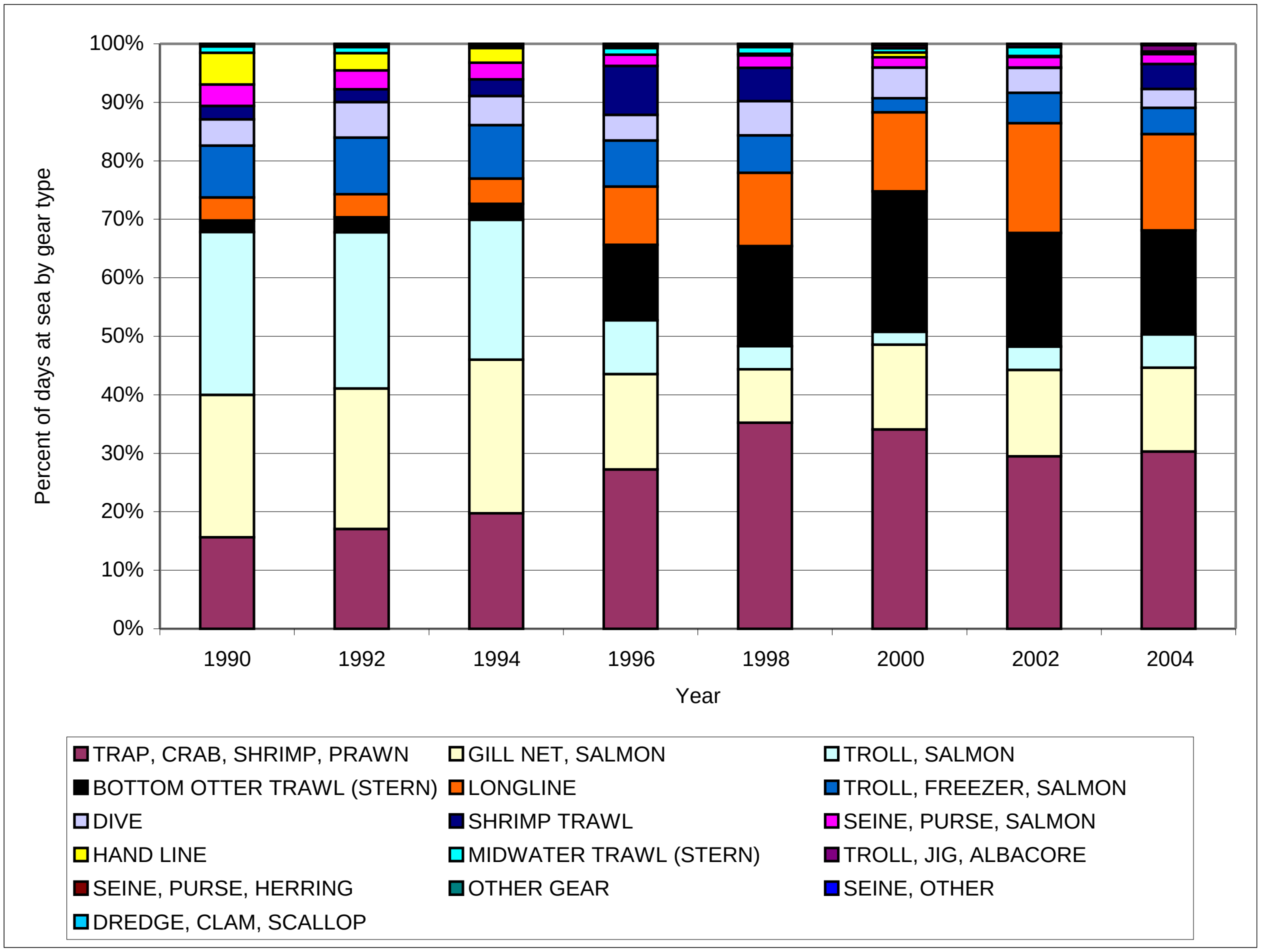

Figure 10. Gear used in the Pacific fishery, 1990 to 2004

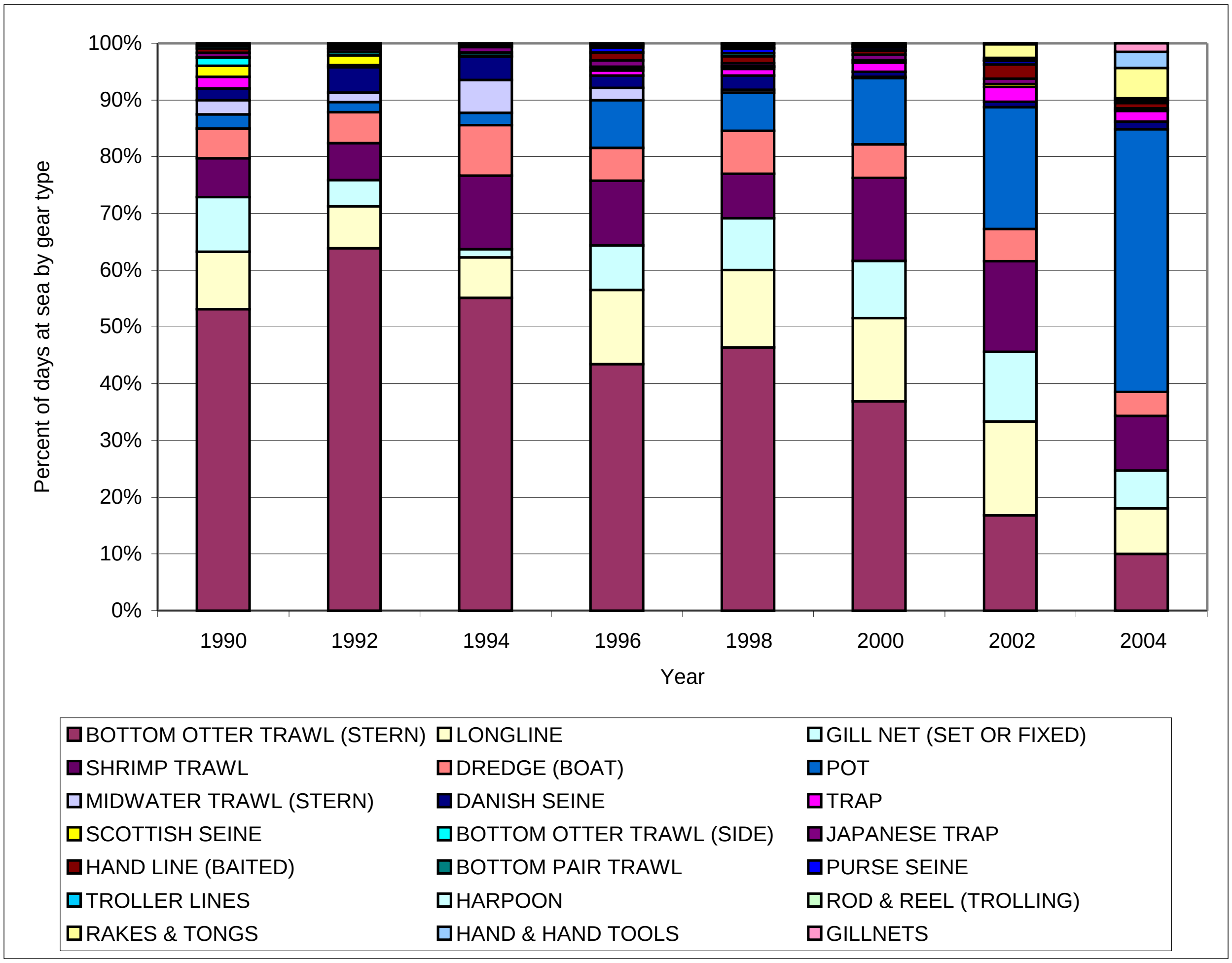

Figure 11. Gear used in the Atlantic fishery, 1990 to 2004

4.6 How do Canadian fishing vessel marine occurrence rates fair compared to other countries?

An examination of fatalities from fishing should provide a comparative measure. According to the Food and Agriculture Organization of the United Nations (FAO)[10], the fishing fatality rate compared to the national average occupational fatality rate is less in Canada compared to other countries (see Table 12). However, the data source for their report was an International Labour Organization study which showed only 8 fishing fatalities in Canada for the year 1997 whereas the Transportation Safety Board has a record of 14 fatalities for that year. Unfortunately, without a measure of confidence, this information does not provide insight into how Canadian fishing safety compares to other countries. A useful comparison should use appropriate and similar exposure data and vessel classifications such as days at sea and vessel design.

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[10] *Safety at Sea as an Integral Part of Fisheries Management*, FAO Fisheries Circular No. 966, Petursdottir, Hannibalsson and Turner, Food and Agriculture Organization of the United Nations, Rome, 2001

Table 12. Comparison of Canada to other countries
Fishing fatality rate – average occupational fatality rate multiplier

Country	Relation to the national average occupational fatality rate	Data year
Canada	3.5	1997
Spain	6	1997
Poland	9	1997
Estonia	11	1997
Lithuania	11	1997
Republic of Korea	15	1997
Australia	18	1982 to 1984
Italy	21	1997
Denmark	30	1989 to 1996
United States	40	1996

5 RISK REDUCTION

5.1 Are there reasonable opportunities to reduce the number of fishing vessel capsizing or foundering occurrences related to stability?

Four percent of fishing vessel marine occurrences are capsizing or foundering events (11 per year). On average, there were 7 fatalities per year associated with capsizing, foundering or swamping occurrences from 1990 to 2005. Since this is about 50% of the total fatalities from fishing vessels, addressing this impact might reduce the fatality rate. Addressing other casualty types, which represent 96% of occurrences, might also have other positive affects on the environment, the workforce and the economy as well as possible reductions in property losses.

5.2 Inspection or training

The analysis of marine occurrence reports suggests that more than half of the capsizing or founderings examined were caused by operational problems as opposed to a seaworthiness or equipment issue. Problems included overloading, improper loading, free surface effects or closed scuppers. While inspection might address some seaworthiness or equipment issues, it will not address a rare error in judgment unless of course, vessels are robust enough to survive. Certainly operators of larger fishing vessels have less accidents per time spent at sea and this might be attributed to many factors including vessel certification or training. It is reasonable to think that increased training and education might help; however, over 3500 fishing days go by between all marine occurrences with these fishers not having a problem.

5.3 Stability assessment or load lines

Would stability assessment or load lines help address this operational issue? Absolutely, a stability assessment would help with the education of the fishing vessel operator and would provide an operator with a calculated a weight and balance for each loaded condition. However, if the operator varied from proper loading techniques or over loaded, the book would only help the investigators with a forensic analysis of a capsized or foundered vessel. Would a stability assessment help prevent a modified vessel which has lost much of its stability from going to sea? Probably. This may be the single most effective tool to add to the education risk reduction measures that are already in place. About 19% of capsizing or founderings had modifications to the vessel; therefore, a reasonable reduction in accidents might be two per year if this measure was 100% effective.

Would load lines help? Possibly, but there were a number of events where water could not drain off of the deck because scuppers or freeing ports were purposely blocked with little freeboard left—in other words, the operator knew the vessel was overloaded. Would these load lines be seen as an excessive safety margin by the majority of fishers who do not have accidents?

5.4 Risk management

Risk management by fishers is inherent in their business. They assess the weather and seas, the route, the crew, the supplies, the load and quality of the catch, and the vessel condition. Risk outcomes can be positive and negative. With every potential positive reward from a decision there is a chance of a negative outcome. Of course the potential for negative outcomes cannot be eliminated—there is some random chance involved. If risk reduction measures were legislated such that the likelihood of capsizing or foundering was reduced (if operational behaviour remained the same), a few fishers might rebalance the risk spreadsheet and seize the opportunity to push marginal weather, for example, risking weather for potential rewards because of a perceived increased margin of safety. Thus it is reasonable to assume that the overall accident rate would remain the same.

However, marine occurrence rates and total numbers are dropping—including those of capsizing and groundings which have dropped by 75% over the last 15 years which is a trend that began in the mid 1980s. We should consider that many factors led to a substantial decline in the marine occurrence rates over the last 15 years and that a 4% reduction (if there were no capsizing or founderings) might not be significant in comparison. In other words, efforts to prevent groundings and collisions would have more impact on the safety of vessels just as efforts to increase survival given a capsizing or foundering would reduce the number of fatalities. Fishers should practice escape from an overturned enclosed vessel in darkness; enclosed vessels should be fitted with an illuminated circular bubble level showing which way is up; the location of exits should be illuminated and marked; the carriage of a float-free life raft should be required on larger vessels; and crew should wear anti-exposure work suits.[11]

5.5 A culture of safety

Over the years, the Transportation Safety Board has recommended educational programs to promote a safety culture, and Transport Canada has responded with safety bulletins, meetings with operators, safety manuals and regulatory review.

> Since 1990, the TSB has issued a number of safety communications addressing deficiencies related to stability awareness, unsafe on-board working practices, structural modifications, and loss of watertight integrity. To address these deficiencies, a number of measures have been instituted which include publications, ship safety bulletins, audio-visual aids, and training workshops. In spite of these efforts, accidents associated with those deficiencies continue to

[11] *Risk Assessment Study Group 3 Small Fishing Vessels*, GeoInfo Solutions Ltd. For Transport Canada, 2002

> occur. The Board, therefore, continues to be concerned with the lack of real progress[12].

The Transportation Safety Board is concerned with accident rates, awareness, safety practices and structural modifications and now recommends a code of best practice be developed—a reasonable suggestion; however, it would seem that the reduction in accidents and the lower accident rate since the mid 1980s would suggest that there has been real progress—the efforts of fishers, federal and provincial governments and agencies are working. The Transportation Safety Board is concerned that accidents related to stability continue to occur in spite of efforts by Transport Canada and others. Accidents will always continue to occur so an alternative recommendation would be keep up with the education and awareness efforts—the decline in accident rates suggest these risk reduction efforts are working—accident rates may even continue to decline.

[12] *Marine Investigation Report Number M02W0147*, Transportation Safety Board of Canada, 2002

6 FINDINGS & OBSERVATIONS

6.1 Summary of findings

Accident trends:

- The average frequency of capsizing or foundering of fishing vessels in the Pacific and Atlantic regions is 1 per 20,000+ days at sea except for vessels of 15 to 30m in the Atlantic region which have a significantly lower frequency of over 1 per 150,000 days at sea.
- The number of fishing accidents per year is on the decline and the accident rate per day spent at sea is decreasing in the Atlantic region.
- The accident rate in the Pacific region is steady during this decade.

Risk factors:

- Occurrence rates are greater in the herring and capelin fishery on the Atlantic coast and in the herring and urchins fishery on the Pacific coast.
- Dive fishing is probably a risk factor on both coasts. Seiners are probably at a higher risk than other vessel types on the Pacific coast.
- 59% of capsizing and foundering occurrences investigated by TSB between 1990 and 2003 were caused by operator issues such as overloading, improper loading, free surface effects or closed scuppers.
- About 19% of capsizing or founderings had modifications to the vessel thought to impact stability.
- The Bay of Fundy, and Bonavista Bay in the Atlantic region and the Fraser River and Georgia Strait in the Pacific Region are areas of higher relative capsizing or foundering rates per days at sea.

Fishery trends:

- The use of bottom otter stern trawl is on the decline and pot fishing is on the rise in the Atlantic fishery.
- The Pacific fishery shows a shift from salmon gillnetting and trolling to trap fishing, bottom otter trawl and longlining.

6.2 Observations

- Transport Canada should validate the results of this analysis with fishers in the context of the BMT Fleet Technology study.
- Transport Canada should continue with publications, ship safety bulletins, audio-visual aids, and training workshops to help fishers understand and comply with safety and stability best practice and regulations.
- Transport Canada should educate fishers and other federal partners and marine agencies about the improving safety trend.
- Fishers be encouraged to seek expert advice when modifying vessel construction or when intending to use the vessel in a different fishery. This may include the recommendation of a stability assessment on a case by case basis.

- Continue to focus efforts to increase survival to reduce the number of fatalities.
- Provide the means for a fishing vessel master to do a self-check of stability and assess loading.

ANNEX A – DATA CONSTRAINTS

Days or hours at sea information is not captured by the governments of Manitoba or Ontario. The government of Ontario captures the place and time at which a net is placed in the Great Lakes. Manitoba captures information on the fish catch only. Fisheries and Oceans Canada is able to capture days or hours at sea information with the aid of fisheries observers. Perhaps there is a way that this type of information could be captured by the provinces in convenient way. Without this information, any analysis of accident rates in Lake Winnipeg or the Great Lakes is limited to the 'accidents per year or accidents per registered vessel' type of analysis which does not address the uncertainty about which types of vessels spend more time on the water.

The workers compensation agencies on the Atlantic and Pacific coasts were not able to provide data on the location and date of a fatality. There were issues related to confidentiality, completeness of data (registration by fishers may not be mandatory), and access to data (paper records). Access to workers compensation data could have provided a secondary source of information on fishing fatalities to help validate the completeness of Transportation Safety Board records.