ECONOMIC IMPACTS OF ACCIDENTS ON THE MARINE INDUSTRY

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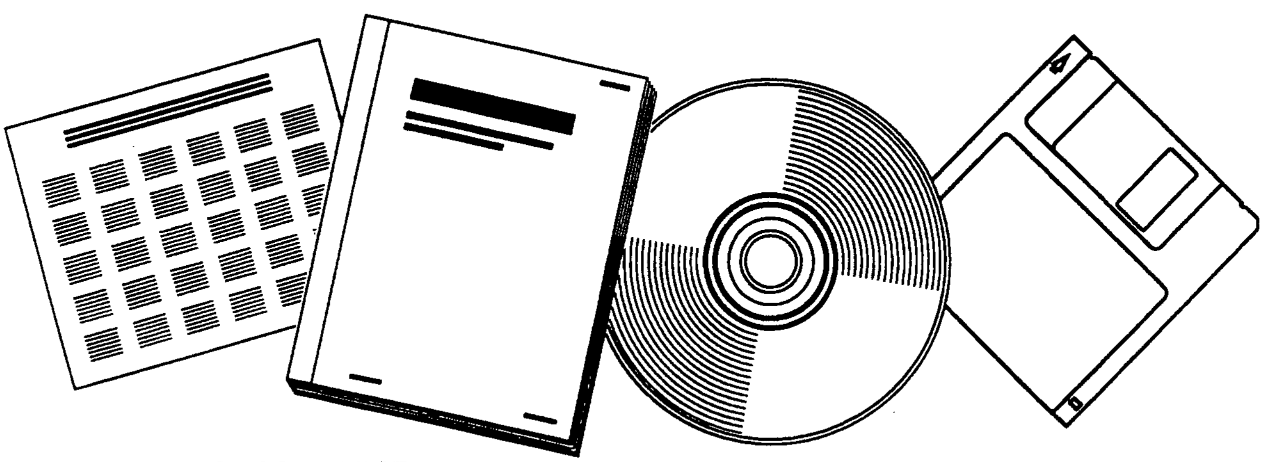

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APRIL 1997

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U.S. Coast Guard
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16. Abstract
This research provides information pertaining to the costs of marine accidents and estimates the share of those costs that might be avoided (i.e., benefits gained) through implementation of proactive accident prevention programs by companies involved in maritime operations.

The study places quantitative values on costs falling into one of two categories - direct costs and indirect costs. In general, direct costs are those costs that are easily attributable to an accident in terms of the impact on a company's bottom line. Common examples of such costs include property and equipment damage, workers' compensation payments resulting from injuries, cleanup costs, lost income resulting from operating delays or interruptions, etc. On the other hand, indirect costs, although real costs, are more difficult to measure. Indirect costs include productivity losses, costs of management and clerical time to investigate accidents and process information, absenteeism, impacts on public image and employee morale, etc. Actual cost savings due to effective accident prevention efforts is also discussed.

Four major maritime industries were analyized in this report: Barge/Tow/Tug, Fishing, Passenger, and Tanker. Statistics were also compiled for onshore and offshore facilities.

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SUMMARY OF ANALYSIS AND FINDINGS

The ultimate goal of this research effort was to gather information on the costs of marine accidents and to estimate the share of those costs that might be avoided (i.e., benefits gained) through implementation of proactive accident prevention programs by companies involved in maritime operations. Such costs generally fall into two categories - direct costs and indirect costs. In general, direct costs are those costs that are easily attributable to an accident in terms of the impact on a company's bottom line. Common examples of such costs include property and equipment damage, workers' compensation payments resulting from injuries, cleanup costs, lost income resulting from operating delays or interruptions, etc. On the other hand, indirect costs, although real costs, are more difficult to measure. Indirect costs include productivity losses, costs of management and clerical time to investigate accidents and process information, absenteeism, impacts on public image and employee morale, etc.

Accident prevention programs often have multiple components. Generally speaking, these components can be divided roughly into those that address technological considerations (e.g., double hulls on tank vessels) and those that address human factors (e.g., improved training). Human error is believed to be responsible for up to 80 percent of marine accidents. Because Prevention Through People (PTP) principles pertain to the human element of accident prevention, wherever possible the report focuses on cost savings that can be attributed to people-oriented improvements. Given the difficulty associated with assigning potential benefits to one particular aspect of an accident prevention program versus another, the ability to measure the potential benefits of such programs is limited. However, cost savings can be significant as demonstrated in the report.

Members of the maritime industry are familiar with the consequences of large-scale accidents. Well-known marine incidents such as the Exxon Valdez grounding, the Texas City disaster, and the Ixtoc well blowout provide a persuasive argument to risk averse owners and operators to adopt accident prevention programs. However, for those who argue that their operations are unlikely to result in a large-scale incident of this nature, the argument must take a different angle. The report was designed to show that even small-scale incidents that are common to maritime operations result in significant costs. The report provides reasonable estimates of the magnitude of such costs and how such costs might be reduced through the adoption of proactive accident prevention programs.

For purposes of this report, the terms "accident" and "marine industry" are broadly defined. An accident is an undesired event that results in physical harm to a person or damage to property.[1] Accidents downgrade the efficiency of a business operation. The term "marine industry" can be assumed to include tank ships, tugs/towboats/barges, fishing boats, passenger vessels, and other vessels (e.g., freight ships, offshore supply vessels, industrial vessels, etc.), offshore facilities (platforms, mobile drilling units), and onshore facilities. Recreational vessels were not considered in this study. Where possible, the focus of the analysis was on the actual costs to the company as a result of accidents versus overall costs to society.

In investigating the costs of marine accidents, ICF conducted a three-pronged approach, including a review of literature for information on the direct and indirect costs of accidents, analysis of industry-wide data on accidents and associated costs, and data-gathering efforts aimed at actual companies with maritime operations.

[1] Bird, Frank E., "Management Guide to Loss Control," Institute Press, Atlanta, GA, 1975, p. 15.

Obviously, accident scenarios differ tremendously both within and across sectors. Where data allow, the report breaks down cost estimates by sector to provide a more detailed understanding of how costs and associated savings differ from sector to sector. Because the main focus of the report was to investigate accident costs on a per incident basis, the analysis looks at typical or average accident scenarios that result in consequences under various cost categories. An appreciation for large-scale accident costs is also provided. Finally, the report provides the reader with industry-wide cost estimates for accidents.

The following major categories of costs are presented along with a discussion of individual cost components:

Oil Spill Costs. Responding to an oil spill, whether small or large, can be expensive. Even a relatively small spill has the potential to escalate into a complicated operation requiring significant response resources. Marine accidents which result in spilled oil can result in a variety of costs, including: emergency response and cleanup costs, natural resource damages, third-party damages, fines/penalties, loss of cargo, litigation expenses, and other costs.

Property Damage Costs. Marine accidents often result in damage or loss of property or equipment. Collisions and groundings, fires and explosions, and other events can cause varying levels of damage to vessels or facilities, ranging from minor losses to total construction losses.

Costs Associated with Injuries and Deaths. The major components of costs associated with injury or death are medical expenses and compensation for lost time (wage loss). Medical expenses include doctor fees, hospital charges, the cost of medicines, future medical costs, and emergency medical services. Wage and productivity losses include the total of wages and fringe benefits together with an estimate of the replacement-cost value of services.

Indirect Costs. There are additional costs that may be borne by a company in the wake of an accident or by a company with a poor environmental, health, and safety record. These costs can be attributed to a single event, a combination of events, or a company's safety culture in general. Such costs include decreased productivity, production slowdowns, training of replacement workers, time spent investigating and reporting injuries, weak relationships with contractors, low employee interest in company performance, reduced worker morale, increased absenteeism, strained labor/management relations, and poor understanding by employees of how to prevent future accidents. For estimation purposes, these costs are most often linked to direct costs associated with workplace deaths and injuries (i.e., medical and workers' compensation costs). An indirect cost multiplier of 2.7 times was used to estimate indirect costs from direct costs. This multiplier is believed to be conservative.

Other Costs. In addition to indirect costs that can be attributed to accidents, there are other hidden costs or opportunities for savings that can be influenced by accident prevention efforts. These areas include insurance, financing rates, costs of public notoriety, permitting, marketing, port fees, and stock price.

Table ES-1 provides estimates of such costs on a per incident basis. The body of the report provides more detailed information on how each of the various costs estimates was derived along with a discussion of appropriate limitations.

Table ES-1

Summary of Cost Category Estimates for Typical Marine Accident (by incident)

Cost Category		Vessel					Facility	
		Barge/Tow/Tug	Fishing	Passenger	Tanker	Other	Onshore	Offshore
Spills[a]	Emergency Response and Cleanup[b]	22,548	10,142	3,964	22,291	6,744	12,098	824
	Natural Resource Damage (NRD)[c]	110	49	19	108	33	59	4
	Fines and Penalties[d]	1,541	900	1,428	1,703	1,918	1,121	1,121
	Lost Cargo or Lost Stored Oil[e]	250	112	44	247	75	134	9
	Litigation Expenses[fg]	2,991	NA	NA	1,673	NA	3,916	1,964
	Total[h]	27,440	11,203	5,455	26,022	8,770	17,327	3,922
Property Damage[a]	Total[h]	69,674	90,478	55,015	292,009	246,130	212,810	170,000
Injuries[al]	Wage and Productivity Losses[j]	14,932	15,222	19,571	15,512	15,657	28,124	15,367
	Medical Expenses	4,794	4,887	6,284	4,980	5,027	9,030	4,934
	Administrative Expenses	6,367	6,491	8,345	6,615	6,676	11,993	6,553
	Indirect Cost[k]	53,260	54,295	69,807	55,329	55,846	100,316	54,812
	Total[h]	79,354	80,895	104,007	82,435	83,206	149,462	81,665
Deaths[al]	Wage and Productivity Losses	429,473	507,187	449,924	642,164	478,555	511,277	409,022
	Medical Expenses	137,891	162,843	144,457	206,180	153,650	164,156	131,325
	Administrative Expenses	183,136	216,275	191,857	273,832	204,066	218,019	174,416
	Indirect Cost[k]	1,531,882	1,809,079	1,604,829	2,290,528	1,706,954	1,823,669	1,458,935
	Total[h]	2,282,382	2,695,384	2,391,087	3,412,704	2,543,225	2,717,121	2,173,697

NA = Not available.

[a] Analysis of 1993 and 1994 Marine Safety Information System (MSIS) data.

[b] Data from the American Petroleum Institute Fourth Annual Petroleum Industry Environmental (PIEP) Report on industry expenditures from oil spill response and cleanup were used to determine an average cleanup cost of $51.48 per gallon.

[c] Based on a spill unit value of $0.25 per gallon.

[d] Analysis of 1991 - 1995 Marine Safety Information System (MSIS) data.

[e] Based on a market value of $0.57 per gallon.

[f] Analysis of 1991 - 1995 Oil Spill Intelligence Report Statistics for U.S. spills of more than 10,000 gallons. Adjusted to reflect an expected per incident value for all spills through the use of a 3 percent multiplier (i.e., approximate percentage of all spills that are more than 10,000 gallons).

[g] Based on a Minerals Management Service Outer Continental Shelf legal cost estimate of $1.39 per gallon spilled (inflated to 1997 dollars).

[h] Total may not add exactly due to rounding.

[i] Based on a National Safety Council estimate of $28,000 per disabling injury.

[j] Breakdown of injury and death costs (wage and productivity losses, medical expenses, administrative expenses) based on National Safety Council estimates.

[k] Indirect costs were calculated using a multiplier of 2.7 applied against the sum of wage and productivity losses and medical expenses.

[l] Based on a National Safety Council estimate of $790,000 per death.

As discussed previously, the approach used in the report was to look at the costs associated with a typical or average accident for each sector. It is, however, difficult to define a theoretical accident scenario that is considered "typical." Most accidents are minor in nature as are the associated costs. In fact, certain types of costs are likely not realized for most minor accidents. For example, a minor oil spill is not likely to result in third party damage costs. These minor accidents are often countered by a lesser number of large-scale accidents with much greater cost consequences. Thus, the costs for certain categories appear unusually low and only represent an average or typical cost by virtue of the fact that they were derived by taking industry-wide cost totals divided by the number of accidents.

The reader is cautioned against adding the per incident totals for the various cost categories within a particular sector. As discussed previously, very few accidents result in all of the types of costs presented in the exhibit, although for large scale accidents some combination of costs from various categories may often result. When looking at industry-wide estimates (derived by multiplying unit costs per category by the number of incidents resulting in a particular consequence), however, it is possible to aggregate the data to provide perspective on the approximate magnitude of accident costs in the marine industry.

Table ES-2 presents total annual cost estimates (by category and combined) for vessels, marine facilities, and a summary for the entire marine industry.

Table ES-2 Total Annual Costs for Marine Accidents

Cost Category	Vessels	Facilities	Total
Spills	$35,272,845	$23,823,291	$59,096,136
Property Damage	$113,291,444	$11,661,740	$124,953,184
Injuries	$122,609,423	$4,121,768	$126,731,191
Deaths	$259,626,347	$14,129,030	$273,755,377
Total	**$530,800,059**	**$53,735,829**	**$584,535,888**

Table ES-2 shows the estimated cost of all marine accidents is approximately $635,000,000 on an annual basis, with the majority of these costs (i.e., approximately 92 percent) attributable to vessel operations. The estimates provide perspective on the magnitude of potential cost savings that could result through the successful implementation of comprehensive accident prevention programs. These summary costs figures should be viewed as conservative estimates of the annual costs of marine accidents.

Through an analysis of time-series data at the industry and company level, ICF was able to identify downward trends in the occurrence of accidents as a result of accident prevention programs that embrace PTP principles. Taken over time, these trends can result in significant benefits (i.e., cost savings) for individual companies and for the marine industry overall. By applying estimates of the number of accidents that could be prevented against the cost figures shown above, the report provides the reader with an appreciation for the potential magnitude of costs savings that could result.

A review of estimates from data sources charting improvements in several of the major accident cost categories (i.e., injury rates, release prevention) over time indicated reductions in the number of incidents ranging from roughly 30 percent to 50 percent. Assuming a comparable program aimed at accident prevention in the marine industry that experiences similar levels of effectiveness over time, annual cost savings to the marine industry could range from $190.5 million to $317.5 million per year with a midpoint of $254 million per year. At the company level, gains would be expected to be greatest in the early years of the program and then taper off as the number of accidents prevented each year begins to decline. This is an inevitable result as the law of diminishing returns will eventually make prevention of the marginal accident prohibitive in terms of cost. Furthermore, despite improvements in human-related factors, accidents will continue to occur at a certain rate.

Findings

Presented below is a summary of key findings gleaned from data gathering efforts associated with the development of this report. These findings may help focus future efforts to track and investigate the cost of marine accidents.

- Information on the true costs of accidents in the marine industry is incomplete. Aggregate data sources provided some useful information, although the data are not necessarily comprehensive and may reflect some societal costs versus costs to the companies experiencing accidents. Most companies contacted do not track costs in a manner that allows for relatively straightforward reporting.

- Data on direct costs are more prevalent than data on indirect costs. Indirect costs are the largest component of accident costs and are the least understood.

- Data on the numbers of incidents resulting in a particular consequence are generally well tracked, especially where injuries to workers, property damage, or oil spills are involved. This is largely due to the fact that certain federal or state requirements address the need to track and report such information (e.g., Occupational Safety and Health Administration (OSHA) reporting requirements for workplace injuries and fatalities).

- Where insurance is involved, true costs to companies are difficult to identify. To a certain degree, insurance has played an important role in blinding managers to the extent and expense of accidents. Although it is true that insurance arrangements play a key role in limiting costs to a company as a result of a particular accident, rising claim values will always be matched by higher premiums or deductibles. To a certain extent, these costs are shared by others in the insurance pool as well. Because insurance markets can be significantly affected by the number and magnitude of losses, all companies in the industry (even loss-free ones) can experience premium increases and more restrictive coverage. Conversely, improved accident records can result in fewer deductible payments and savings on premiums on a company-specific and industry-wide basis.

- Although the report does not address the costs of accident prevention programs, returns on investing in accident prevention can be significant (under one study, 3.2 times the cost to implement the program).[2] In a recent presentation to the U.S. Coast Guard (USCG) and American Petroleum Institute (API), Det Norske Veritas (DNV) acknowledged that the effort spent in developing and maintaining a SMS "pays for itself many times over, however, it is very difficult to show a 'non-cost' for an accident which does not occur" and therefore, demonstrate the potential savings to a company. DNV added that to see the true benefits, senior managers

[2] The Business Roundtable, "Improving Construction Safety Performance," Report A-3, 1992.

must view the overall picture, not just the quarterly profit and loss statement as it may take a year or longer before companies begin to accrue benefits from an accident prevention program.

CHAPTER 1
INTRODUCTION

The USCG's PTP Quality Action Team (QAT) report identifies human error as the root cause of more than 80 percent of maritime casualties. However, a review of historical approaches to accident prevention in the maritime industry reveals that both private standards organizations and government regulatory regimes focus on eliminating accidents by reducing material failures and technical systems problems. This historical approach has led to accident prevention practices in the maritime community that promote engineering and technical solutions with little regard for human error as a predominant factor. Even if the maritime community wanted to begin today to integrate human factors into accident prevention, the PTP QAT report indicates that there would be problems which feed and compound each other.

For example, because spill and casualty investigations are directed at identifying physical sources and responsible parties rather than root causes, there are few data or analyses describing how human error contributes to accidents. It is difficult at best to find, implement, and explore preventive measures related to human factors. Further, because the maritime community uses accident and pollution frequency rates to assess safety performance, it does not get the type of data that are useful in identifying high-risk operations and associated subordinate processes. Consequently, the data do not exist to help develop appropriate preventive actions which incorporate human factors. In turn, because of the lack of data to determine how human factors may contribute to an accident, it is difficult for maritime interest groups to study and understand the human element in safety performance.

The PTP QAT report proposed a strategy articulating specific elements that should lead to a comprehensive and balanced systems approach to prevent human error, thereby reducing maritime injuries, deaths, and accidents. An important precursor to implementing this strategy was to enlist the support of various industry maritime sectors with the highest incidences of injuries, fatalities, and pollution resulting from human error. Part of the strategy to induce participation in programs that embrace PTP principles is to persuade industry that implementing such programs reduces accidents and their consequences (i.e., injuries, deaths, damage to property and the environment, etc.). Reducing accidents can in turn lead to substantial cost savings in the form of reduced costs associated with deaths and injuries, oil spill response, property damage, time out of service, insurance costs, and other direct and indirect costs.

The ultimate goal of this research effort was to gather information on the various costs associated with marine accidents and to estimate the share of those costs that might be avoided (i.e., benefits gained) through implementation of a proactive accident prevention program by companies involved in maritime operations. Such costs generally fall into two categories – direct costs and indirect costs. Although interpretations of these categorizations may vary, in general, direct costs are those costs that are easily attributable to an accident in terms of the impact on a company's bottom line. Common examples of such costs include property and equipment damage, workers' compensation payments resulting from injuries, cleanup costs, lost income resulting from operating delays or interruptions, etc. On the other hand, indirect costs, although real costs, are more difficult to measure. Indirect costs include productivity losses, costs of management and clerical time to investigate accidents and process information, absenteeism, impacts on public image, employee morale, etc.

Costs associated with accidents can be reduced in several ways. One is through reduction in the number of accidents that result in such costs. A second is through a reduction in the severity of accidents.

Because the main focus of PTP principles is on accident prevention, the potential benefits to be gained through a reduction in the severity of accidents are not addressed in this report.

Accident prevention programs often have multiple components. Generally speaking, these components can be divided roughly into those that address technological considerations (e.g., double hulls on tank vessels) and those that address human factors (e.g., management commitment, employee involvement, improved training). As mentioned previously, human error is believed to be responsible for up to 80 percent of marine accidents. Because the PTP initiative focuses on the human element of accident prevention, wherever possible this report will focus on cost savings that can be attributed to people-oriented fixes. Given the difficulty associated with measuring the true costs of accidents and the difficulty associated with assigning potential benefits to one particular aspect of a program versus another, the ability to measure the potential benefits of programs that embrace the principles of PTP is limited. However, as will be demonstrated in this report, such cost-savings can be significant.

The concept of cost reduction through accident prevention is certainly not a new one, especially to successful business ventures where the adoption of such measures is necessary to ensure adequate levels of profitability. In other words, few will disagree with the premise that having an effective accident prevention program makes good business sense. This conclusion is clearly evident when one considers large-scale accidents in the maritime industry where equipment and human resource expenditures can easily run into the tens of millions of dollars or more. Well-known marine incidents such as the Exxon Valdez incident, the Texas City disaster, and the Ixtoc well blowout provide a persuasive argument to risk averse owners and operators. However, for those who argue that their operations are unlikely to result in a large-scale incident of this nature, the argument must take on a different nature. This report will show that even smaller scale incidents that are common to maritime operations result in significant costs. The report attempts to provide reasonable estimates of the magnitude of such costs and how such costs might be reduced through the adoption of accident prevention programs.

The remainder of the report is structured as follows. Chapter 2 presents the methodology used to analyze the cost of marine accidents. Chapter 3 presents a qualitative discussion of various costs categories and, where data were available, presents quantitative estimates of such costs. Finally, Chapter 4 discusses the potential benefits (i.e., cost savings) that might result from successful accident prevention programs.

CHAPTER 2
METHODOLOGY

The purpose of this report is to discuss qualitatively and quantitatively the costs associated with marine accidents and demonstrate cost savings that can result through implementation of programs that embrace PTP principles. For vessel and facility owners and operators who are not persuaded by the safety incentives alone, demonstrable cost savings may serve as an incentive to implement such programs. The costs represented in this report are estimates of the direct and indirect costs of marine accidents to the extent that such estimates are possible given the limited availability of data.

To place the subject matter addressed by this report in context, it is useful to understand up front what is meant by the terms "accident" or "incident" especially as they apply to the marine industry. An incident is an undesired event that could (or does) downgrade the efficiency of a business operation. An accident is an undesired event that results in physical harm to a person or damage to property.[3] In this context, an accident is a type of incident. For purposes of this report, although the terms are often used somewhat interchangeably, the focus is on looking at the cost of accidents in the marine sector. Accidents resulting in injury to personnel, spilled oil, or damage to property are considered in this report. Obviously, some large-scale accidents have all of these impacts, but most of the time this is not the case. As such, data on these results are often reported and tracked separately. Accidents and their resulting impacts can vary tremendously in their scope from small mishaps resulting in a few gallons of oil spilled to the release of millions of gallons of oil from a vessel at sea, or from a worker's strained back to an explosion resulting in multiple injuries and/or deaths. As discussed previously, this report will attempt to provide information on common or typical accident scenarios in the marine sector as well as on large-scale accidents.

The term "marine industry" is defined broadly for purposes of this report and can be assumed to include tank ships, tugs/towboats/barges, passenger vessels, fishing boats, offshore facilities (platforms, mobile drilling units), onshore facilities, and other vessels (e.g., freight ships, offshore supply vessels, industrial vessels, etc.). Obviously, accident scenarios differ tremendously among these various sectors. Where data allow, the report attempts to break down cost estimates by these sectors to allow for a more detailed understanding of how costs and associated savings differ from sector to sector.

Where possible, the focus of the analysis was on the actual costs to the company as a result of accidents versus overall costs to society. Much of the prior work on this subject that was identified through literature reviews focused more on societal costs resulting from accidents, many of which are not borne by the company itself. An effort was made to adjust societal cost values to more accurately reflect costs to the company. However, this is not a straightforward proposition for several reasons. First, externalities associated with oil spills and other environmental impacts remain common, and although efforts at ensuring the polluter pays the full cost of accidents are improving, cost recovery mechanisms remain far from perfect — especially when litigation is involved. A second complicating factor involves insurance coverage. Many of the costs associated with accidents are covered by various forms of insurance. Accurate and comprehensive information on claims, deductibles, premiums, self-insurance, etc., remains difficult to obtain due to the complex and often confidential nature of insurance arrangements. However, despite these limitations, the estimates provided in this report are believed to provide a realistic indication of the magnitude of the cost of marine accidents.

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[3] Bird, Frank E., "Management Guide to Loss Control," Institute Press, Atlanta, GA, 1974, p. 15.

Approach

In investigating the costs of marine accidents, ICF conducted a three-pronged approach, including a review of literature for information on the direct and indirect costs of accidents, analysis of industry-wide data on accidents and associated costs, and data-gathering efforts aimed at actual companies with maritime operations.

A comprehensive review of literature on the subject of the costs of accidents yielded a significant amount of information on the subject matter. Although much of the information obtained from previous studies was not directed at the marine industry, many of the concepts and certain data on costs were useful for this report.

Industry-wide data were obtained from a variety of sources, including trade associations and government data bases. Chapter 3 presents details on the specific analyses conducted using such information sources. A summary of key industry-wide data sources used in the analysis is provided below:

- The USCG's Marine Safety Information System (MSIS), which contains data on marine casualties and pollution incidents, was used to obtain information on the number and volume of spill incidents, number of deaths and injuries resulting from marine casualties, property damage estimates, and penalties.[4]

- API's fourth annual Petroleum Industry Environmental Performance (PIEP) report was used to obtain information on number and volumes of spill incidents and on expenditures for cleanup of oil spills.

- OSHA's Voluntary Protection Program (VPP) database was used to obtain data on trends in accidents avoided over time by companies that have implemented proactive accident prevention programs.

- National Safety Council studies were used to provide estimates of the approximate costs associated with workplace injuries and deaths.

Throughout the course of the study, ICF met and/or spoke with numerous groups to discuss approaches to investigate the costs of marine accidents and to obtain data. These groups included:

- American Petroleum Institute
- Chemical Manufacturers Association
- Voluntary Protection Programs Participants Association
- North Pacific Fishing Vessel Owners Association
- Det Norske Veritas
- Independent Council of Cruise Lines

[4] To ensure greater accuracy for the analysis, records with the same case number were removed to avoid double-counting, unrelated entries (e.g., spill incidents other than oil) were deleted, and data entry errors minimized. MSIS data from 1993 and 1994 were combined in a single master file to provide a greater sample size of marine incidents and to calculate weighted averages. Vessel and facility data were grouped into the appropriate sector based on their service or category, respectively. Vessels classified as "recreational" were excluded.

- Marine Index Bureau
- The American Waterways Operators
- Chemical Carriers Association
- National Offshore Safety Advisory Council

In addition to gathering data at the trade association level, ICF attempted to obtain data directly from companies in the various sectors described above. Companies targeted for this effort were generally those that had already embraced the concept that proactive accident prevention programs make good business sense and had already begun to implement such programs. The procedure generally involved a preliminary phone call followed by delivery of a data collection survey designed to elicit both qualitative and quantitative information on the cost of marine accidents and on accident prevention efforts.

Efforts at obtaining company-specific information yielded mixed results. More often than not, data were not tracked in a manner which allowed the companies to easily provide useful cost (cost savings) estimates. Therefore, only limited company-specific information is contained in this report. Where available, this information is used throughout the report to confirm or support the accuracy of the findings obtained through analysis of aggregate and industry-wide information. The names of the actual companies are not used in this report due to the confidential nature of certain information presented.

CHAPTER 3
THE COSTS OF MARINE ACCIDENTS

This chapter presents a description and an analysis of the various costs of marine accidents. Both direct and indirect costs are discussed. The report is organized in cost categories by four main sections:

- Oil spill costs;
- Property damage costs;
- Costs associated with injuries and deaths; and
- Other direct and indirect costs.

Within these major sections, a discussion of various cost categories is presented. The discussion of each category begins with a qualitative description of the nature of the cost followed by a review of the methodology used to obtain quantitative estimates, as appropriate. For certain cost categories, ICF was unable to obtain reliable estimates and only qualitative descriptions are presented. As discussed previously, ICF relied on a variety of approaches to obtain cost estimates including a review of available literature, analysis of industry-wide data, and use of company-specific estimates. Where possible, estimates from multiple sources are presented to provide perspective on the relative clustering of the estimates obtained.

Where possible within each cost category, the report presents a breakdown of costs for the following major marine industry sectors:

- Barge/Towboat/Tugboat
- Fishing Vessels
- Passenger Vessels
- Tank Ships
- Other Vessels[5]
- Onshore Facilities
- Offshore Facilities

For several costs categories, however, data were not available to allow for such a breakdown and only aggregate industry-wide estimates are presented. Also, in certain cases, estimates for a particular cost category are derived by applying multipliers (obtained from literature) to values obtained from other costs categories. These multipliers are described in greater detail later in this chapter.

The last part of this chapter presents a series of summary exhibits that display estimates for the various cost categories to provide perspective on the overall value of expenditures relating to marine accidents. Despite certain limitations, the summary estimates shown at the end of this chapter represent reasoned order of magnitude indicators of the level of such costs. These cost estimates form the basis for analyses in Chapter 4 that are designed to demonstrate the potential benefits (i.e., cost savings) that can result through the adoption of proactive accident prevention programs.

[5] Other vessels includes vessels categorized in MSIS as follows: commercial, freight ship, industrial vessel, oil recovery, OSV, public freight, public vessel (unc.), research vessel, school ship, and unclassified vess.

A. OIL SPILL COSTS[6]

Responding to an oil spill, whether small or large, can be expensive. Even a relatively small spill has the potential to escalate into a complicated operation requiring significant response resources. Marine accidents which result in spilled oil can result in a variety of costs, including: emergency response and cleanup costs, Natural Resource Damage (NRD) compensations, third-party damage, loss of cargo, litigation expenses, fines and penalties, and other costs (e.g., damaged company reputation, etc.)

Emergency Response and Cleanup

For the purposes of this report, emergency response and cleanup refers to the activities immediately following a spill event which are designed to contain and control the spill, such as the mobilization of response equipment and personnel. Companies assume responsibility for internal response costs and for external expenses, such as response contractors and equipment, government expenditures[7], and other operations. Emergency response and cleanup costs do not include long-term remediation of the affected environment.

Cleanup costs were estimated in the following manner. First, average spill quantities for various sectors of the marine industry are determined through an analysis of spill statistics obtained through MSIS. Second, a spill unit value for cleanup of a gallon of spilled oil is derived through an analysis of industry-wide expenditures and corresponding spill data. Finally, unit spill values are multiplied by average spill sizes for each sector to provide an estimate of cleanup expenditures for a typical spill. A discussion of cleanup costs associated with large-scale spills is also provided.

Statistics on spill incidents are recorded in the USCG's MSIS database. Using the total number of incidents and the total quantity of the oil spilled into water over a two year period (1993-1994), ICF estimated the average quantity of oil spilled per spill incident for each industry sector. A summary of the findings by sector for vessels and facilities is presented in Table 3-1 below.

[6] Because of a lack of reliable data, this report does not consider costs associated with hazardous substance spills. It is important to note, however, that such costs can be considerable.

[7] The Federal government often becomes involved in the initial stages of oil spill response operations. Costs borne by the government for such operations are usually drawn from the Oil Spill Liability Trust Fund. However, these costs are ultimately paid by the responsible party following cost recovery by the government.

Table 3-1 Average Spill Quantities for Spill Incidents in MSIS 1993, 1994

	Number of Spill Incidents	Total Quantity (gallons)	Average Quantity (gallons)	Median Quantity
Barge/Tow/Tug	1,234[a]	540,065	438	5
Fishing	1,311	258,284	197	5
Passenger	278	21,330	77	5
Tanker	301	130,445	433	5
Other	1,437	187,640	131	5
Vessels (total)	**4,561**	**1,137,764**	**249**	**5**
Onshore	2,197	515,334	235	3
Offshore	2,438	39,142	16[b]	1
Facilities (total)	**4,635**	**554,476**	**120**	1

a Data set does not include the Morris J. Berman incident.

b Offshore facilities typically employ vigorous reporting standards, resulting in a proportionately larger number of small spills reported, and therefore, a much lower average spill quantity.

Related studies show these estimates to be reasonable indicators of typical spill sizes. An analysis of USCG data shows over 90 percent of all crude oil spills from tankers in U.S. waters from 1985 to 1995 were between 1 and 500 gallons.[8] In addition, API analyzes MSIS data and publishes its findings in its annual PIEP Report. The total number of incidents and the total quantity of oil spilled over a five year period (1990-1994) for vessels and facilities in API's PIEP report support the approximate magnitude of ICF's estimates in Table 3-1 above. A summary of the API findings are presented in Table 3-2.

Table 3-2 Average Spill Quantities for Spill Incidents from API's Fourth Annual PIEP Report

	Number of Spill Incidents	Total Quantity (gallons)	Average Quantity (gallons)
Vessels[a]	24,314	11,014,000	453
Facilities	20,839	7,049,000	338

a Vessels consist of tankers and tank barges only.

Spill unit values for emergency response and cleanup were used to derive a cost estimate for the average spill quantities. For purposes of this analysis, ICF used a unit spill value of approximately $50 per gallon of oil spilled (derived from the PIEP Report) to estimate company cleanup expenditures. Although this number is likely to vary somewhat depending upon the size and location of the spill (smaller spills generally have higher per gallon cleanup costs), the estimate provides a reasonable approximation of cleanup costs that can be expected to result from a typical spill.

API's PIEP Report provided estimates of expenditures for cleanup of oil spills (excluding long-term remediation costs) for the five-year period 1990–1994 for a sample of companies within the petroleum sector. Expenditure estimates were obtained through an annual survey of some 800 companies; approximately 200 companies returned responses each year the survey was conducted.

8 As modified by National Academy of Science National Research Council.

Estimates from the sample were extrapolated to industry-wide levels using methodology suggested by API in its PIEP report. Industry-wide estimates for annual spill cleanup expenditures for each sector were aggregated and the total was divided by annual spill volume estimates provided in the same report to yield an estimate of the cost of cleanup per gallon spilled of $51.48 or approximately $50 per gallon over the five-year period.

The unit value of $51.48 for cleanup of a gallon of spilled oil can then be used to monetize the average spill sizes as shown in Table 3-3.

Table 3-3 Estimated Emergency Response and Cleanup Costs for Typical Spill Incidents

	Average Quantity (gallons)	Spill Unit Value ($ per gallon)	Average Cleanup Cost ($)
Barge/Tow/Tug	438	51.48	22,548
Fishing	197	51.48	10,142
Passenger	77	51.48	3,964
Tanker	433	51.48	22,291
Other	131	51.48	6,744
Vessels (total)	**249**	**51.48**	**12,819**
Onshore	235	51.48	12,098
Offshore	16	51.48	824
Facilities (total)	**120**	**51.48**	**6,178**

It is recognized that this method somewhat oversimplifies the calculation of overall cleanup costs as spill unit values can vary widely depending on numerous factors (e.g., spill size, oil type, impacted environment, etc.). However, the estimates above provide a reasonable indicator of the range of costs ($824 - $22,291) that can be expected for emergency response and cleanup of a typical or average incident. Obviously, the actual cost to clean up larger spills can often be much higher. To demonstrate the potential price tag for cleanup of larger spills, ICF examined the following spill sizes from the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) at 40 CFR 300.5:

- A minor discharge is a discharge to the inland waters of less than 1,000 gallons of oil or a discharge to the coastal waters of less than 10,000 gallons of oil.
- A medium discharge is a discharge of 1,000 to 10,000 gallons of oil to the inland waters or a discharge of 10,000 to 100,000 gallons of oil to the coastal waters.
- A major discharge is a discharge of more than 10,000 gallons of oil to the inland waters or more than 100,000 gallons of oil to the coastal waters.

Using a spill unit value of approximately $50 per gallon spilled, cleanup costs for medium coastal discharges can equal or exceed $500,000 per spill incident. Similarly, cleanup cost for a major spill could easily run into the millions of dollars (e.g., $50/gallon * 100,000 gallons = $5,000,000). The following case study examples provide some perspective on the financial ramifications of large incidents.

- In a collision involving the Berge Banker on February 5, 1995, the cost to clean up a 37,000 gallon spill was approximately $500,000.[9]

- In a February 7, 1990 grounding of British Petroleum's American Trader tanker, almost $35,000,000 was spent to clean up a 400,000 gallon spill.[10]

- In the November 17, 1995 collision involving the Honam Sapphire tanker off the coast of South Korea, 294,000 gallons spilled resulted in cleanup claims totaling $8,300,000.[11]

- In the July 22, 1991 collision of the Tenyo Maru with a Chinese freighter, a 173,000 gallon spill cost approximately $9,000,000 to clean up.[12]

Natural Resource Damage Costs

Historically, the financial liability of responsible parties in an oil spill to water has been based on direct liability costs, such as costs for spill response, mitigation, and cleanup. The growing trend has been to expand spiller liability to include consequential costs of a spill. A broad category of consequential spill costs is associated with NRDs resulting from an oil spill. Approaches for monetizing such NRD costs remain a developing science and, therefore, are highly contentious. In many countries, a standard framework for claiming NRD costs from responsible parties still is evolving.

<u>Framework for NRD Compensation in the United States</u>

In the United States, spillers are liable for NRDs resulting from oil spills into navigable waters and hazardous substance spills to coastal and marine environments. Federal regulations for assessing NRD claims were published recently; one set of regulations revised an existing assessment regime, and the other created a new regime.

On May 7, 1996, the Department of Interior (DOI) revised its existing procedure, called the Type A procedure, for assessing NRD resulting from Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) hazardous substances releases to coastal and marine environments. (61 FR 20560.) DOI issued its original Type A procedures in 1987 (52 FR 9041, March 20, 1987), and Federally designated trustees (including state and tribal officials) could use the original DOI regulations to assess NRD for oil discharges into navigable water under the CWA *and* for CERCLA hazardous substances. However, by the time DOI published its 1996 revised Type A procedure, Congress passed the Oil Pollution Act of 1990 (OPA 90), authorizing the National Oceanic and Atmospheric Administration (NOAA) to develop new natural resource damage assessment regulations for assessing NRD resulting from discharges, or threats of discharges of oil into navigable water. NOAA published its final rule on January 5, 1996 (61 FR 439), and DOI acknowledged that NOAA's final rule supersedes the Type A procedure for assessing NRD under OPA 90 (see 61 FR 20560-61). ICF has used the 1996 Type A regime for estimating the value of NRD for reasons explained in the following discussion.

<u>The DOI regime</u>. Under the Type A regime for assessing NRD, federally-designated trustees may evaluate (1) the costs of restoring, rehabilitating, replacing, and/or acquiring the equivalent of the injured

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[9] Oil Spill Intelligence Report, *International Oil Spill Statistics: 1995*, p. 27.
[10] Oil And Gas Journal, Volume 93, Number 7, February 13, 1995, p. 32.
[11] Oil Spill Intelligence Report, *International Oil Spill Statistics: 1995*, p. 46.
[12] Oil Spill Intelligence Report, *The Financial Cost of Oil Spills, 1994*, p. 221.

natural resources; (2) the economic value lost by the public pending recovery of the resources (compensable value); and (3) reasonable costs of assessing NRD, as defined at 43 CFR 11.14. The Type A procedures let trustees arrive at a number representing spiller liability for the value of lost or damaged natural resources, capturing:

- Fisheries consumptive use values (commercial, recreational, and subsistence),
- Wildlife consumptive use values (e.g., hunting),
- Wildlife nonconsumptive use values (e.g., wildlife viewing),
- Recreational use values (e.g., beach use and boating),
- Restocking cost, and
- Direct restoration costs of affected habitats.

The NOAA regime. Under the NOAA regime, federal trustees evaluate NRD in terms of the necessary actions to assess, develop, and implement a restoration plan to: (1) return the damaged natural resources to pristine conditions; and (2) compensate for interim losses to natural resources until restoration occurs. In addition, federal trustees evaluate the reasonable costs of assessing NRD.[13]

Contrasting the DOI and NOAA regimes. The fundamental difference between the DOI and NOAA regimes is the way the agencies address restoration costs. Under the NOAA regime, trustees may charge the spiller with the responsibility for implementing NRD restoration actions, rather than simply demanding financial costs for NRD associated with the oil spill. In the alternative, NOAA trustees may monetize the costs for the government's implementing the NRD restoration actions, and assess those costs against the spiller. Under the DOI regime, a spiller would be charged up front for NRD costs, which may not necessarily be attributed to particular restoration actions.

For example, a spiller may arrange to compensate NOAA for NOAA's costs to conduct and oversee the necessary restoration actions; or a spiller may implement the restoration plan through arrangements with private contractors, obviating the need to monetize and pay the associated costs to NOAA. DOI's NRD assessment costs may not be associated with particular restoration activities of a spiller.

For purposes of this analysis, the DOI Type A approach was used for estimating NRD costs, because the Type A regime provides a convenient tool for understanding the potential magnitude of NRD costs in relation to spill size. The NOAA approach monetizes NRD costs based on specific restoration actions selected for a given incident, and thus, is not amenable to a generalized analysis.

However, for oil spills into navigable waters, a spiller should be aware that the NOAA approach for assessing NRD takes precedence over the Type A procedures, so that NRD costs may differ from those presented in this analysis.

While the NOAA and DOI rules provide a framework for assessing spiller liability for NRD, it is important to note that natural resource trustees (e.g., NOAA and DOI) are not required to apply either regulatory scheme in assessing NRD claims against the spiller but instead may apply other methodologies that, in their judgment, are appropriate. However, in using the above regulations, trustees benefit by a

[13] The NOAA rules apply a more expansive interpretation of "reasonable costs" than the DOI regime. This interpretation is currently being challenged by industry in a suit against NOAA. GE et al v. NOAA, No. 96-1096 (D.C. Cir) filed February 21, 1997.

statutory rebuttable presumption clause. In the event of litigation over NRD costs, this presumption basically places the burden of proving the inaccuracy of the NRD cost figures on spillers.

Because state and local officials are federally-designated as NRD trustees under both CERCLA and OPA 90, spillers also may be liable for NRD costs under relevant state or tribal rules. Under OPA 90, however, in a scenario involving multiple claims for NRD, federally designated trustees are prohibited from double recovery against a responsible party. (OPA 90, §1006(d)(3), 33 USC 2706.) For smaller spills, federal compensation formulas are usually unnecessary because state NRD schemes are applied.

State NRD compensation schemes vary, reflecting differences in regulatory approaches as well as coastal resources at risk among the states. For example, the Washington state compensation formula differentiates between regional zones and seasons in calculating spiller costs, while the Florida compensation formula does not. A representative of NOAA's Damage Assessment Center generalized that spills impacting West Coast resources can translate into higher NRD costs against spillers (than East or Gulf Coast spills) because of characteristically vast sensitive coastal resources along the West Coast, including many designated sanctuaries and parks, and stringent state NRD compensation rules already in place.

Estimated NRD Costs Based on the DOI Type A Procedure

To estimate NRD costs for average oil spill volumes, ICF used the DOI Type A procedure which has been incorporated into two computer models, one of which, the Natural Resource Damage Assessment Model (NRDAM) for Coastal and Marine Environments (CME), is relevant to this discussion. The NRDAM for CME covers aquatic systems along the coast of the contiguous United States, including territories and possessions, Alaska, and associated connecting channels (e.g., bays, estuaries, and river mouths). The model covers both U.S. and Canada; however, in this estimate, damages are quantified only for U.S. resources.

ICF used the NRDAM for CME computer model to estimate spill-related NRD costs as a function of spill volume. ICF examined the relationship between natural resource damages and spill volumes using the following methodology:

- Analyzed spill data obtained from the USCG[14] and reviewed by the National Academy of Sciences (NAS) to support National Research Council (NRC) research.

- For each incident, estimated NRD costs using the NRDAM for CME. The analysis examined those spills between 1,000 and 100,000 gallons, which are within the model's tolerances.

- Using the estimated NRDs, developed a clean up cost function.

- Calculated unit spill values, represented by the average NRD cost per gallon of oil spilled, for various spill size tiers. Spill unit values were calculated by dividing the estimated total damages by the total gallons spilled at various points along the NRD cost function shown below.

  $$\log(\text{total NRD costs (\$)}) = 1397.72*[\log(\text{spill volume (gal)})]^{[-17.66/(\text{spill volume (gal)})]}.$$

[14] Oil Spill Data 1975-1996, the USCG, edited by the National Academy of Science, National Research Council for NRC research.

Following this convention, the spill unit values in Table 3-4 were estimated for NRDs resulting from marine oil spills, ranging in size from 1,000 to 100,000 gallons.

Table 3-4 Spill Unit Values

Spill Tier (gallons)	Unit Cost ($/gallon)		
	Minimum	**Midpoint**	**Maximum**
1K to 5K	$0.06	$0.16	$0.25
>5K to 10K	$0.25	$0.34	$0.42
>10K to 15K	$0.42	$0.48	$0.54
>15K to 20K	$0.54	$0.57	$0.61
>20K to 30K	$0.61	$0.64	$0.67
>30K to 40K	$0.67	$0.67	$0.67
>40K to 50K	$0.64	$0.66	$0.67
>50K to 60K	$0.60	$0.62	$0.64
>60K to 70K	$0.55	$0.58	$0.60
>70K to 80K	$0.51	$0.53	$0.55
>80K to 90K	$0.47	$0.49	$0.51
>90K to 100K	$0.43	$0.45	$0.47

The maximum NRD spill unit values for the appropriate spill tier were then applied to our estimates of average spill sizes by sector to provide an indicator of the NRD costs of a typical spill, as shown in Table 3-5.

Table 3-5 Estimated NRD Costs for Typical Spill Incidents

	Average Quantity (gallons)	Spill Unit Value ($ per gallon)	Average NRD Cost ($)
Barge/Tow/Tug	438	0.25	109.50
Fishing	197	0.25	49.25
Passenger	77	0.25	19.25
Tanker	433	0.25	108.25
Other	131	0.25	32.75
[redacted]	**249**	**0.25**	**62.25**
Onshore	235	0.25	58.75
Offshore	16	0.25	4.00
[redacted]	**120**	**0.25**	**30.00**

In reality, it is unlikely that NRD costs would be calculated and assessed for such relatively small spill quantities; instead, NRD costs are more likely to be assessed for medium or major spills. The estimated NRD costs for a 10,000 (medium) spill and 100,000 (major) spill are presented in Table 3-6 below.

Table 3-6 Estimated NRD Costs for Medium and Major Spill Incidents

Spill Size	Quantity (gallons)	Spill Unit Value ($ per gallon)	Estimated NRD Cost ($)
Medium	10,000	0.54	5,400
Major	100,000	0.47	47,000

There are some limitations in cost estimates derived using the DOI Type A model. First, because the DOI NRDAM for CME is intended to represent average expectation or best estimate for a spill in coastal and estuarine marine environments, the geographic, environmental, biological, physical-chemical, and toxicological data and algorithms have been simplified and generalized to be applied in this format. The compensable value and restoration cost information also is generalized. Second, assumptions used in the model to value potential losses from NRD are based on available data and professional judgment where data were unavailable. In some cases, the use values used in the Type A model are inferred from studies that did not directly involve coastal or marine resources. Although the generalization of data can limit the ability of the model to accurately estimate the damages associated with a specific incident, such an approach was appropriate and necessary for estimating the damages associated with a large number of spills on a national scale.

Finally, there are a number of potential losses or damages that are not quantified by the DOI model. The model does not address all potential uses of the resources that are lost or reduced in value by the NRD. The Type A model also does not address lost non-use values of the resources. Non-use values are not addressed because of the lack of adequate empirical research to support the estimation of lost non-use values in a Type A modeling format.

ICF contacted NRD experts at DOI and NOAA for feedback on using the NRDAM for CME to estimate spiller costs for NRD resulting from a release. Contacts in both agencies noted that while the Type A model provides a convenient approach for understanding some NRD costs for which a spiller *may* be held liable, settlements against spillers ultimately involve a balance between protecting and restoring the environment and economic reality.[15] NOAA Damage Assessment experts cautioned further that spiller expenses associated with NRD claims settled under the new NOAA regime, in practice, would not be estimated using NRDAM for CME. NOAA has developed its own restoration guidance documents for assessing NRD costs against spillers based on the historical cost for various restoration actions in various habitats (e.g., costs to seed oysters or plant seagrass in damaged areas). Contacts in both agencies conceded that, at present, no better tool exists for generalizing potential NRD costs against responsible parties for a spill.

Review of Past NRD Claims and Settlements

A review of past NRD claims and settlements shows high variability in NRD costs charged against spillers:

[15] In the United States, federal and state funds are used when a spiller cannot pay for settlements.

- Tenyo Maru. A Chinese freighter, Tuo Hai, and a Japanese fishing vessel, Tenyo Maru, collided approximately 25 miles northwest of Cape Flattery, Washington. The Tenyo Maru sank with 354,800 gallons of intermediate fuel oil and 97,800 gallons of diesel. Under a settlement, the responsible parties paid $340,028 for NRD assessment costs and $5,159,972 plus interest for NRD actions in claims by the United States, Washington State, and the Makah Indian tribe.

- Exxon Valdez. An oil tanker grounded on Bligh Reef, Alaska, spilling 10.8 million gallons of crude. Under a settlement, Exxon will pay up to $1 billion in NRD costs for restoration actions implemented through the year 2001.

- Exxon Bayway Refinery. An underwater pipeline ruptured and spilled 56,700 gallons of No. 2 heating oil into Arthur Kill waterway, New York. Exxon paid $9,500,000 for NRD costs.

- Shell Oil Complex. A Shell Oil complex at Martinez, California, released 365,400 gallons of crude oil into Peyton Slough, Suisun Bay, Carquinez Strait, and Shell marsh. Shell was charged approximately $11 million for NRD-related damages.

- World Prodigy. A Greek tanker ran hard aground on Brenton Reef near Narrangansett Bay, Rhode Island, spilling 288,666 gallons of No. 2 heating oil. At the time of the incident, Rhode Island did not have NRD statutes in place and federal trustees did not claim NRD expenses. Under a settlement, the responsible party paid approximately $500,000 for damages to natural resources.

These spill incidents illustrate that there are no "typical" NRD costs against a spiller because the nature of spills are not "typical." At the same time, the data clearly show that spillers can face enormous NRD costs depending on a number of factors, including:

- Type and extent of damages to natural resources, which vary with spill size as well as fate and effects (e.g., spill location, substance characteristics, prevailing weather);

- Level of public interest; and

- Provisions of existing regulations concerning spiller financial liability.

Third Party Costs

Oil spills not only impact the environment, but often also have serious adverse economic effects on local recreation and tourism, industry, fisheries, and other third parties. Section 1002(b)(2)(E) of OPA 90 makes each responsible party liable for "...damages equal to the loss of profits or impairment of earning capacity due to the injury, destruction, or loss of real property, personal property, or natural resources, which shall be recoverable by any claimant."

Prior to OPA 90, the legal trend in judgments against spillers for third party claims was against compensation for economic losses unless the plaintiff suffered direct physical harm. Thus, the majority of third party claims against a spiller for economic losses resulting from a release were dismissed since they do not involve direct physical harm to the third party. Claims for economic losses suffered by commercial fishing[16], however, were often exempt from this interpretation. In the case of Exxon

[16] *Union Oil Co. v. Oppen*, 501 F.2d 558, 1974.

Valdez, for example, the Ninth Circuit Court of Appeals dismissed claims against Exxon from third parties (e.g., seafood wholesalers, processors, and cannery workers) other than commercial fisherman. The post-OPA 90 picture is much less clear at this point, because the courts are still in the process of applying the statute in cases involving third party costs.

As such, sufficient data on third party claims against spillers under the OPA 90 regime were not available to support a statistical analysis. However, two incidents provide examples of the potential magnitude of third party claims for a medium and major discharge.

- In a collision incident on August 3, 1995 off the coast of South Korea, a 12,000 gallon spill resulted in fishery-related claims of $25,400,000 and other loss of income claims of $3,950,000.[17]

- In a grounding involving the Sea Prince off the coast of South Korea on July 25, 1995, a 220,000 gallon spill resulted in fishery related-claims of $280,000,000, farming-related claims of $400,000, and tourism-related claims of $5,400,000.[18]

Data on resulting payments by responsible parties were not available. In addition, such claims are generally covered under insurance policies that shippers and cargo owners maintain. Direct costs to companies responsible for causing such spills thus usually take the form of premiums, deductible payments, and other insurance-related expenses. See the discussion of marine insurance later in this chapter for more information on these costs.

Value of Lost Cargo

Another potentially significant cost to companies for marine operations associated with oil spills is the loss of petroleum carried as cargo or fuel or oil stored in shoreside tanks. Such quantities can be significant. For example, tankers serving the U.S. can range in size from 20,000 DWT to 500,000 DWT and consequently, the potential product loss can vary substantially from accident to accident.

The value of lost petroleum cargo, fuel, or stored oil can be estimated based on the aggregate wholesale cost of the spilled commodity. For example, the value of spilled oil could be estimated by multiplying the spill volume by the current wholesale price for oil. For the average spill volumes estimated for the different sectors, assuming market prices for crude ($0.57 per gallon)[19], the value of lost oil per spill incident is modest:

[17] Oil Spill Intelligence Report, *International Oil Spill Statistics: 1995*, p. 39

[18] Oil Spill Intelligence Report, *International Oil Spill Statistics: 1995*, p. 38.

[19] Energy Information Association U.S. market price for January 1, 1997.

Table 3-7 Estimated Value of Lost Cargo/Fuel or Production Volume for Typical Spill Incidents

	Average Quantity (gallons)	Spill Unit Value ($ per gallon)	Average Value of Lost Cargo/Fuel ($)
Barge/Tow/Tug	438	0.57	250
Fishing[a]	197	0.57	112
Passenger[a]	77	0.57	44
Tanker	433	0.57	247
Other[a]	131	0.57	75
Vessels (total)	**249**	**0.57**	**142**
Onshore	235	0.57	134
Offshore	16	0.57	9
Facilities (total)	**120**	**0.57**	**68**

a For fishing, passenger, and other vessels, fuel oil not cargo is lost as a result of spill-related incidents. For purposes of consistency with calculations for "cargo" (i.e., in this case crude oil) loss, a value of $0.57 per gallon spilled was used for these vessel categories.

In contrast, the value of lost cargo alone for a medium (10,000 gallons) spill could exceed $5,000, and a large (100,000 gallons) spill could be greater than $50,000. The value of lost cargo for catastrophic events, such as the *Exxon Valdez* spill, can climb into the tens of millions. Again, cargo insurance arrangements are the major determinant of the actual cost to the company.

Fines and Penalties for Oil Spills

Companies found to be responsible for an oil spill and that fail to comply with oil spill regulations are subject to fines and penalties. Spillers who violate the U.S. Federal Water Pollution Control Act (FWPCA) and CERCLA are subject to civil penalties. The USCG enforces the FWPCA violations broadly, processing over 3,000 violations annually. CERCLA violations account for only a few cases each year.

OPA 90 provided the USCG with greater judicial and administrative means to pursue higher monetary penalties against responsible parties. The USCG currently adjudicates violations under pre-OPA 90 or "Class I" procedures or under post-OPA 90 "Class II" or "Judicial Civil Penalties," depending on the severity of the violation. Class I civil penalties can be assessed on any owner, operator, or person in charge of a vessel, onshore facility, or offshore facility, who fails to notify the appropriate authorities of a discharge of oil or who fails to comply with regulations implementing the National Response System. The maximum civil penalty for Class I violations is $10,000 per violation, but not more than $25,000. For more flagrant violations, the USCG may impose Class II penalties, which may not exceed $10,000 per day for each day of the violation up to a maximum of $125,000.

The Federal government may also, in lieu of USCG penalties, assess larger civil penalties by action in the US district court. These penalties can be up to $25,000 per day of violation or up to $1,000 per barrel of oil spilled. In addition to Federal and civil penalties imposed by OPA 90, responsible parties are also separately subject to state penalties and fines in many situations.[20]

[20] Oil Spill Intelligence Report, *Financial Cost of Oil Spills, 1994*, p. 112.

To estimate the actual value of fines levied and collected by the USCG, ICF used data on violations contained in the USCG's MSIS database. Several different fine and penalty amounts are tracked, such as the initial violation amount, settled amount, and paid amount. To best represent the cost to a company, ICF used data from the paid amount field.

Using the total number of violation incidents with a paid amount and the amount of these violations over a five year period (1991–1995), ICF estimated the average penalty for violation for each industry sector. A summary of the findings by sector for vessels and facilities is presented in Table 3-8 below.

Table 3-8 Average Violations for Violation Incidents

	Number of Paid Violation Incidents[a]	Total Penalties[a] ($)	Average Penalty ($)
Barge/Tow/Tug	1,753	2,701,454	1,541
Fishing	1,454	1,308,102	900
Passenger	298	425,413	1,428
Tanker	435	741,018	1,703
Other	1,410	2,703,870	1,918
Vessels (total)	**5,350**	**7,879,856**	**1,473**
Facilities (total)	**6,700**	**7,511,391**	**1,121**

[a] Based on MSIS data for 1991 - 1995. Total for five year period is shown here.

Litigation Expenses for Oil Spills

In this analysis, the legal cost element refers to costs a spiller incurs for spill-related legal transactions *beyond* any monetary or other compensation the spiller pays in settlements. Spill-related legal costs may include:

- Attorney's fees,
- Expert witness testimony,
- Professional consultant time, and
- Other overhead expenses (e.g., technical and administrative support).

The availability of data concerning specific legal costs associated with litigating a spill-related lawsuit is limited.[21] Damage settlements often require non-disclosure of the procedure. Many key spill-related cases are ongoing, with undetermined legal costs. Information concerning cases and fees are confidential and proprietary in nature. Information that is available publicly for spill-related lawsuits does not provide information on fees and costs for transacting the case.

For this analysis, legal costs related to spills are based on an analysis by the Minerals Management Service (MMS) for spill-related litigation for Offshore Continental Shelf (OCS) installations. The MMS analysis estimated legal costs for spill-related transactions in terms of barrels of

[21] U.S. Department of the Interior, Minerals Management Service, *Economic Analysis for the OCS 5-Year Program 1997-2002*, Chapter 14, Washington, D.C., 1990.

oil spilled. MMS projected costs for private legal transactions using data on government attorney hours. Due to inherent difficulties, identified above, in obtaining primary litigation data, the MMS analysis relied on secondary sources for data related to litigation costs and issues: literature review (e.g., *Environmental Reporter - Cases*), review of OCS program-related cases for NRD litigation resulting from oil spills, and data provided by the U.S. Department of Justice's (DOJ) General Litigation Division and Environment and Natural Resources Division.

In the analysis, MMS estimated private legal costs associated with a spill incident using data from four oil spill litigation cases (Ashland Oil, Shell Martinez, *World Prodigy*, and Total Petroleum) and the approach described below:

- Public (government) attorney fees were calculated based on DOJ data for OCS spill-related litigation. Cumulative attorney hours spent on OCS four cases between 1985 and 1990, were multiplied by typical hourly costs for a public attorney. The attorney fee was estimated based on interviews with the professional legal community, relevant lawsuits, and the federal General Schedule (GS) pay system.

- Additional government litigation costs, including costs for consultants, expert witness testimony, and overhead and operating expenses (e.g., travel and research), were estimated using a multiplier. A multiplier of 2.0 was incorporated, based on interviews with professionals within the legal community. It reflects the nature and potential complexity of spill-related litigation.

- Private attorney fees were calculated based on a ratio of private to public attorney effort. A ratio of 1:1 was estimated based on interviews with professionals within the legal community.

- Additional private litigation costs, including costs for consultants, expert witness testimony, and overhead and operating expenses (e.g., travel and research), were estimated using a multiplier. A multiplier of 5 was incorporated, based on interviews with professionals within the legal community. It reflects the extensive use of scientific and economic support involved in natural resource related litigation.

- Finally, the legal cost per barrel of oil spilled was calculated by dividing the aggregate cost for all public and private legal transactions related to the four spill events over the six-year period by the aggregate barrels spilled in these events. Based on the four spill events for which DOJ data was provided, the spill-related litigation cost was estimated at $1.39 per gallon (inflated to 1997 dollars) for private attorney expenses.

Legal data for the four spill cases used in the MMS analysis tentatively suggest that, in general, a larger spill would involve more hours of litigation. By the above convention, a larger spill also would involve higher legal costs. At the same time, a large spill that dissipates quickly and does not affect ecologically sensitive areas may result in lower legal costs for the responsible parties than a smaller spill that lingers and causes damage.

Given that legal fees are typically only incurred for major spills, the number and quantity of spills greater than 10,000 gallons in U.S. waters[22] were used to determine the average quantity spilled per major spill incident. From these average quantities for major spills, the estimated legal costs were determined for various sectors as shown in Table 3-9.

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[22] Oil Spill Intelligence Report, *International Oil Spill Statistics: 1995*, p. 21.

Table 3-9 Estimated Legal Costs for Spill Incidents

	Spill Incidents > 10,000 gallons[a]	Total Quantity (gallons)	Average Quantity per Spill Incident (gallons)	Average Legal Cost per Spill Incident ($)[b]
Barge/Tow/Tug	33	2,367,000	71,727	99,701
Tanker	12	481,500	40,125	55,774
Vessels (total)	69	3,437,700	49,822	69,253
Onshore	330[c]	30,988,000	93,903	130,525
Offshore	17	800,700	47,100	65,469
Facilities (total)	347	31,788,700	91,610	127,338

a Analysis of 1991–1995 Oil Spill Intelligence Reporter statistics for U.S. spills of more than 10,000 gallons. Total for five year period is shown here.

b Based on a MMS OCS attorney fee estimate of $1.39 per gallon spilled.

c Includes spills over 10,000 gallons for both coastal and inland onshore facilities.

B. PROPERTY DAMAGE COSTS

Marine accidents often result in damage or loss of property or equipment. Collisions and groundings, fires and explosions, and other events can cause varying levels of damage to vessels or facilities, ranging from minor losses to total construction losses.

Property damage information is estimated during USCG accident investigations and these estimates are maintained in MSIS. Although the values in MSIS are estimates, a significant sample size (over 2,000 vessel and facility incidents during the 1993–1994 period) increases the reliability of this data as a reasonable indicator of the cost of damage to a vessel, facility, or other property from a typical marine accident. The total number of incidents in MSIS in which the cost of property damage was estimated and the total estimated cost of this damage over a two year period (1993–1994) for each industry sector was determined to estimate the average cost of property damage per incident. A summary of the findings for vessels and facilities by sector is presented in Table 3-10 below.

Table 3-10 Estimated Property Damage Costs for Property Damage Incidents[a]

	Number of Damage Incidents	Total Damage ($)	Average Damage ($)	Median Damage ($)
Barge/Tow/Tug	794[b]	55,321,205	69,674	15,250
Fishing	505	45,691,260	90,478	15,000
Passenger	239	13,148,568	55,015	9,500
Tanker	76	22,192,658	292,009	49,000
Other	366	90,083,462	246,130	30,000
Vessels (total)	**1,980**	**226,437,153**	**114,362**	**18,000**
Onshore	108	22,983,444	212,810	55,000
Offshore	2	340,000	170,000	c
Facilities (total)	**110**	**23,323,444**	**212,031**	**60,000**

a Based on MSIS data for 1993 and 1994.
b Data set does not include the Morris J. Berman incident.
c Because there are only two property damage incidents with cost figures for offshore facilities, a median value cannot be determined.

Large or catastrophic property damage can result in much greater property damage costs. Marsh and McLennan Protection Consultants (M & M) documents large property damage losses in the hydrocarbon and chemical industries, including incidents at refineries, terminals, and vessels. M & M has documented more than 170 large property damage losses over the past 30 years, ranging in cost from $10,800,000 to $715,000,000. A selection of marine accidents includes:[23]

- Port Arthur, Texas. On January 12, 1991, an initial fire occurred because of a seal failure on a pump for the crude unit atmospheric tower. Before the pump could be shut down and isolated, a second product release occurred, spreading the fire. Approximately $27,500,000 of property damage occurred.

- Naples, Italy. On December 21, 1985, twenty-four of the 32 tanks at a large government-owned marine petroleum products terminal were destroyed by fire which began with a tank overfill. A large spill developed followed by a vapor cloud which was ignited by an unknown source. Almost immediately, 20 of the tanks were involved in a massive fire covering 3.7 acres. The devastating explosion caused complete destruction of the terminal buildings and extensive damage to nearby industrial and residential structures. Property damage for the accident approached $50,000,000.

- Bantry Bay, Ireland. On January 1, 1979, an 11-year-old 121,000 DWT tanker had completed unloading its first parcel of Arabian heavy crude at a deep-water port. No transfer operations were in process when a small fire was noticed on deck. About 10 minutes later, the fire spread aft along the length of the ship and was observed at sea at both sides of the ship. After a half-hour, a massive explosion occurred. Property damage was estimated at $34,600,000.

[23] Marsh & McLennan, *Large Property Damage Losses in the Hydrocarbon-Chemical Industries A Thirty-year Review*, Fifteenth Edition, p. 10.

These high-end figures do not include the cost of business interruption, extra expenses, fines and penalties, employee injuries, or liability claims. Therefore, the economic cost of these losses is even greater than indicated.

Again, like many of the other costs discussed in this report, property damage costs are often covered by insurance. The direct financial impact associated with the incident usually takes the form of a deductible payment which can be substantial. The discussion of insurance costs in this report provides greater perspective on this issue.

C. INJURY AND DEATH COSTS

A variety of information sources were reviewed to obtain data and information on the costs of injuries or deaths resulting from accidents in the marine industry. The major components of costs associated with injury and death are medical expenses and compensation for lost time (wage loss). Obviously insurance plays a major role in who incurs these costs and at what level. A quick overview of the structure of insurance coverage for injuries and deaths is useful to provide the reader with additional perspective on costs in this area.

Each of the 50 states, as well as the territories, have workers' compensation laws. These laws hold that industrial employers should assume costs of occupational disabilities without regard to any fault involved. Resulting economic losses are considered costs of production – chargeable, to the extent possible, as a price factor. Virtually all industrial employment is covered by workers compensation, including many activities related to the maritime sector. There are, however, several separate authorities that address maritime workers. The Longshore and Harbor Workers' Compensation Act provides for private and public employees in nationwide maritime work. Crew members aboard U.S. flag vessels are not governed by either state workers' compensation laws or by the Longshore and Harbor Workers' Compensation Act, but may seek damages under the Federal Employers Liability Act or Jones Act.

Most jurisdictions require employers to obtain insurance and prove financial ability to carry their own risk. In some cases (i.e., 32 states and the Longshore Act), self-insurance is permitted. Insurance for Jones Act crewmen is usually covered as part of Protection and Indemnity (P & I) Club policies.

The encouragement of safety is one of the basic objectives of workers' compensation. The effort to reduce the frequency and severity of work-related injuries is accomplished in at least two ways. First, the workers' compensation program provides employers with preventative services, including safety engineering. Second, the insurance premium structure provides a monetary incentive to employers to improve their safety records.[24]

Premium rates for workers' compensation are compiled scientifically. First, overall rates based on accident experience data throughout American business are established. Once these overall rates are established, they are applied under a uniform classification system that groups employers by hazard of employment. In addition, the uniform experience rating plan provides a price adjustment for each employer based on the actuarially predicted value of its own claims history. All but the smallest employers are subject to this experience rating, which furnishes direct monetary incentive for safety programs. Most jurisdictions also permit other forms of pricing adjustments such as retrospective rating, deductible plans, discounts, and loss sensitive dividend plans. Discussions with establishments offering

[24] U.S. Chamber of Commerce, *1995 Analysis of Workers' Compensation Laws*, p. 2.

P&I policies to employers of Jones Act crewmen indicate a roughly similar system of establishing and adjusting rates.

Benefits provided through such policies include cash benefits for impairment and wage loss, medical benefits, and rehabilitation benefits. Most cases involve temporary, not total, disability. That is, the employee – although totally disabled during the period when benefits are payable – is expected to recover and return to employment. In most cases, only medical benefits are provided since substantial impairment or wage loss is not involved.

Given this brief overview of the complicated insurance picture for injuries and deaths resulting from workplace accidents, it is evident that the ability to estimate the cost of workplace injuries and deaths to a particular company or industry is not a straightforward proposition. As such, the following information is presented to provide a general perspective on such costs.

In 1993, the Social Security Administration estimated that employers (including marine-and non-marine-related employers) spent over $57.3 billion to insure or self-insure their work-injury risks. The average cost per $100 in payroll was $2.30 for 1993. Total workers' compensation payments for 1993 were $42.9 billion. Medical costs totaled $17.5 billion in 1993, while compensation payments amounted to $25.4 billion or about 60 percent of all workers compensation payments.

The National Safety Council provides estimates of the approximate economic loss per death and per disabling injury.[25]

Type	Death	Disabling Injury[26]
Work Injuries without employer costs	$780,000	$25,000
Work injuries with employer costs	$790,000	$28,000

These estimates include costs for wage and productivity losses, medical expenses, employer costs, and administrative expenses, but do not include any estimate of property damage or non-disabling injury costs.

- **Wage and productivity losses** include the total of wages and fringe benefits together with an estimate of the replacement-cost value of services.
- **Medical expenses** include doctor fees, hospital charges, the cost of medicines, future medical costs, and emergency medical services.
- **Administrative expenses** include the administrative cost of public and private insurance and legal costs. Claims paid out by insurance companies are not identified separately, as every claim is compensation for losses such as wages, medical expenses, property damage, etc.
- **Employer costs** are an estimate of the uninsured costs incurred by employers and represent the money value of time lost by uninjured workers. It includes time spent investigating and reporting injuries, production slowdowns, training of replacement workers, and extra cost of overtime for uninjured workers. Employer costs in this context are indirect costs.

[25] National Safety Council, "Estimating the Cost of Unintentional Injuries, 1995," September, 1996, p. 3 of 4.

[26] A disabling injury is defined as one that results in death or some degree of permanent impairment, or renders the injured person unable to effectively perform his or her regular duties for a full day beyond the day of injury.

Several other sources confirm the use of the National Safety Council value ($28,000) as a reasonable estimate of the cost of a disabling injury. In a 1995 economic analysis to support the final rule on risk management regulations for chemical accident release prevention, the U.S. Environmental Protection Agency (EPA) used a value of $19,000 per injury.[27] From company-level data, ICF learned that cost savings for injuries are computed by some companies using the "industry" index of $10,000 direct cost per injury and $27,000 indirect cost per injury, totaling $37,000 per injury. Although the exact source of this figure is unavailable, it is a value that is accepted by several companies in the marine industry. The National Safety Council figure falls between these two estimates, and is therefore used for subsequent analyses in this report.

Incidents involving injuries are recorded in the USCG's MSIS database. Using the total number of incidents in which injuries occurred and the total number of injuries for these incidents over a two-year period (1993–1994), ICF estimated the average number of injuries per incident for each industry sector. Using the National Safety Council estimate of $28,000 for a disabling injury, it is possible to estimate the costs (i.e., direct and certain indirect costs) for a typical incident involving injuries. A summary of the findings by sector for vessels and facilities is presented in Table 3-11 below.

Table 3-11 Average Number of Injuries for Injury Incidents[a] and Average Cost per Incident[b]

	Number of Injury Incidents	Number of Injuries	Average Number of Injuries per Incident	Average Cost per Incident ($)
Barge/Tow/Tug	691	712	1.03	28,840
Fishing	769	808	1.05	29,400
Passenger	409	552	1.35	37,800
Tanker	210	224	1.07	29,960
Other	818	883	1.08	30,240
Vessels (total)	**2,897**	**3,179**	**1.10**	**30,800**
Onshore	18	35	1.94	54,320
Offshore	68	72	1.06	29,680
Facilities (total)	**86**	**107**	**1.24**	**34,720**

a Based on MSIS data for 1993 and 1994.
b Based on National Safety Council estimate of $28,000 per disabling injury.

MSIS contains similar statistics for incidents involving deaths. Using the total number of incidents in which deaths occurred and the total number of deaths for these incidents over a two-year period (1993–1994), ICF estimated the average number of deaths per incident for each industry sector. Using the National Safety Council estimate of $790,000 for a death, it is possible to estimate the direct costs for an average fatality incident. A summary of the findings by sector for vessels and facilities is presented in Table 3-12 below.

[27] Ted Miller, Charles Calhoun, and W. Brian Arthur, "Utility-Adjusted Impairment Years: A Low-Cost Approach to Morbidity Valuation," in "Estimating and Valuing Morbidity in a Policy Context" (June, 1989).

Table 3-12 Average Number of Deaths for Death Incidents[a] and Average Cost per Death Incident[b]

	Number of Death Incidents	Number of Deaths	Average Number of Deaths per Death Incident	Average Cost per Death Incident ($)
Barge/Tow/Tug	43	45	1.05	829,500
Fishing	76	94	1.24	979,600
Passenger	5	5	1.00	869,000
Tanker	7	11	1.57	1,240,300
Other	64	75	1.17	924,300
Vessels (total)	**195**	**230**	**1.17**	**1,023,600**
Onshore	4	5	1.25	987,500
Offshore	7	7	1.00	790,000
Facilities (total)	**11**	**12**	**1.09**	**861,100**

a Based on MSIS data for 1993 and 1994. The number of deaths associated with vessels categorized as "Fishing Boats" in 1993 and 1994 MSIS data declined significantly upon removal of duplicate case numbers from the master database. Total numbers of marine-related deaths and injuries for 1993 and 1994 are roughly consistent with other available estimates.

b Based on National Safety Council estimate of $790,000 per death.

The National Safety Council also provides estimates on the breakdown of costs for unintentional injuries and deaths in the workplace[28], as shown in Table 3-13 below.

Table 3-13 Approximate Costs of Unintentional Workplace Injuries/Deaths[a]

Cost Component	**Dollar Value (billions)[a]**	**Percent of Total**
Wage and Productivity Losses	59.8	51.8
Medical Expenses	19.2	16.6
Administrative Expenses	25.5	22.1
Employer Cost	11.0	9.5
Total	115.5	NA

a National Safety Council 1995 data.

The percentages above provide insight into the distribution of costs (i.e., direct and certain indirect costs) borne by companies as a result of injury or fatality incidents. By applying the percentages above to the costs in Table 3-11 and 3-12, it is possible to estimate the distribution of expenditures for injury and death incidents.

[28] The National Safety Council "Estimating the Cost of Unintentional Injuries, 1995" provides costs for motor-vehicle accidents, home injuries, public nonmotor-vehicle injuries, and work injuries. Data for work injuries were used for purposes of this analysis.

Table 3-14 Breakdown of Injury and Death Costs Based on National Safety Council Distribution

Cost Component	Vessels (total)		Facilities (total)	
	Average Cost per Injury Incident	Average Cost per Death Incident	Average Cost per Injury Incident	Average Cost per Death Incident
Wage and Productivity Losses	15,947	478,555	17,976	445,834
Medical Expenses	5,120	153,650	5,772	143,144
Administrative Expenses	6,800	204,066	7,665	190,113
Employer Cost	2,933	88,029	3,307	82,010
Total[a]	30,800	924,300	34,720	861,100

a Totals may not add exactly due to rounding.

D. OTHER COSTS

To this point, the report has presented data and information on major direct costs and certain indirect costs associated with accidents in the marine sector, including costs associated with oil spills, property damages, and workplace deaths and injuries. There are, however, additional direct and indirect costs that may be borne by a company in the wake of an accident or by a company with a poor environmental, health, and safety record. These costs can be attributed to a single event, a combination of events, or a company's safety culture in general.

Accidents can result in indirect costs to a company that are difficult to quantify. Such costs include reduced worker morale, increased absenteeism, strained labor or management relations, decreased productivity, weak relationships with contractors, low employee interest in company performance, and poor understanding by employees of how to prevent future accidents. Such indirect costs can be reduced dramatically through the implementation of vigorous accident prevention programs. Chapter 4 discusses the effectiveness and potential benefits of such programs.

For estimation purposes, these costs are most often linked to direct costs associated with workplace deaths and injuries costs (i.e., medical and workers' compensation costs). Rough estimates for certain of these indirect costs were shown above as "employer costs" which included time spent investigating and reporting injuries, giving first aid, production slowdowns, training of replacement workers, and extra cost of overtime for uninjured workers. Other studies indicate that the net impact of all indirect costs can be significantly greater than is demonstrated through the case of the "employer cost" estimates shown above. A study by Frank E. Bird[29], found that for every $1 spent for medical or insurance compensation costs (i.e., direct costs), an additional $1-$3 will be spent on indirect costs such as investigation time, lost-time wages, hiring and training replacements, and decreased productivity of worker on return (i.e., indirect costs). (Bird considered costs associated with property damage and production delays or interruptions separately). Bird's findings are supported by independent injury cost figures used by some companies with maritime operations. ICF learned that costs for injuries are computed by some companies using the "industry" index of $10,000 direct cost per injury and $27,000 indirect cost per injury, totaling $37,000 per injury. This index reveals a ratio of 2.7 to 1, which is within the range suggested by Bird.

[29] Bird, Frank E., "Management Guide to Loss Control," Institute Press, Atlanta, GA, 1974, p. 15.

To more fully account for these indirect costs, the analysis described previously was altered to reflect a different method to calculate such costs. In Table 3-15 below, the "employer cost" estimates have been removed and replaced with a more complete estimate of indirect costs using a 2.7 multiplier applied to certain direct costs (i.e., the sum of medical expenses and compensation costs).

Table 3-15 Breakdown of Injury and Death Costs Including Certain Additional Indirect Costs

Cost Component	**Vessels (total)**		**Facilities (total)**	
	Average Cost per Injury Incident	Average Cost per Death Incident	Average Cost per Injury Incident	Average Cost per Death Incident
Wage and Productivity Losses	15,947	478,555	17,976	445,834
Medical Expenses	5,120	153,650	5,772	143,144
Administrative Expenses	6,800	204,066	7,665	190,113
Indirect Costs	56,880	1,706,954	64,119	1,590,239
Total[a]	**84,747**	**2,543,225**	**95,533**	**2,369,330**

a Totals may not add exactly due to rounding.

In addition to indirect costs (such as those shown in Table 3-15 above) that can be attributed to accidents, there are other hidden costs or opportunities for savings that can be influenced by accident prevention efforts. These costs include opportunity costs associated with diversion of resources from intended or normal business operations. A brief description of these costs is provided below.

Insurance

Insurance arrangements play a key role in limiting costs to a company as a result of an accident. Policies can be obtained to address nearly all of the cost categories described in this report, including cargo loss, injuries, property damage (including third party and company property), and pollution. Protection against exposure to risk, however, is not free. That is, the costs associated with insuring risks in the marine industry can be extremely high. In general, these costs take the form of insurance premiums and deductibles or other forms of co-payment. Although little information was available on the size of deductibles that must be paid out for various types of claims, data from a major tank vessel operator indicated deductibles ranging from $45,000 to $250,000 for hull and machinery claims over the last five years. In addition, a poor claims record can lead to higher premiums. Although the economic cost of a large loss is mainly borne by the company experiencing the loss, it can also be felt throughout the entire industry. Because insurance markets can be significantly affected by the number and magnitude of losses, all companies in the industry (even loss-free ones) can experience premium increases and more restrictive coverage.

Conversely, improved accident records can result in fewer deductible payments and savings on premiums on a company-specific and industry-wide basis. For example, a major insurer of tug and barge operations on inland waterways has established a program by which premium reductions of 15 percent or more are offered for companies that obtain certification under the American Waterways Operators' (AWO) Responsible Carrier Program. Given the $100 million worth of premiums paid by tug and barge operators on inland rivers, up to $15 million or more worth of cost savings actually are possible on an industry-wide basis for inland tug and barge operations.

P & I clubs are the dominant institution in the marine insurance market. These are not-for-profit groups of ship owners and charterers who mutually indemnify one another. A 1992 analysis of claims by the UK P&I Club provides some perspective on the value and breakdown of major claims. The analysis reports that there were 1,444 major claims (>$100,000) totaling $784 million over the five-year period 1987–1991 for an average claim value of approximately $543,000. Table 3-16 below provides a breakdown by type of claim.

Table 3-16 Analysis of Major Claims

Type	Number	Percent of Total (%)	Value (million $)	Percent of Total (%)
Cargo	602	42	235	30
Injury	420	29	145	18
Property Damage	156	11	160	20
Pollution	79	6	105	13
Collision	123	9	79	10

The analysis indicates that human error was the main cause of the majority of major claims ranging from 50 percent of cargo and pollution claims to 90 percent of collision claims. Obviously, programs aimed at addressing human-related causes could have a significant impact on reducing these types of claims and the resulting costs. Chapter 4 addresses potential cost savings in more detail.

A study by DNV, the Norwegian classification society, sheds additional light on shipping industry claims. The study reports that across five types of incidents (cargo, pollution, personal injuries, collision/grounding, and property damage), company managers reported that their companies saw on average no more than 17 incidents per year which resulted in $10 million of claims. Again, these are not $10 million worth of costs to the companies but $10 million worth of costs per company shared across the industry. DNV correctly points out that insurance has played an important role in blinding managers to the extent and expense of accidents adding that rising payouts will always be matched by higher premiums or deductibles.

Interruptions in Operations

Interruptions in operations or service as a result of an accident can be costly to a company or organization. These types of delays often involve downtime for capital equipment and result in financial losses from reduced production or operations (i.e., an opportunity cost of not using corporate resources in the intended manner to generate returns). For example, accidents involving the collision or grounding of an oil tanker result not only in the property damage costs discussed previously in this report but also in opportunity costs for the time that the tanker is out of service. In such an instance, these costs can be estimated by subtracting the daily operating cost and crew costs from the daily timecharter rate. For example, a 100,000 DWT tanker with operating costs of $7,000 per day, crew costs of $8,000 per day, and time charter rates of $50,000 per day would lose approximately $35,000 in revenues for each day the tanker was out of service. [30]

[30] ICF Kaiser, *Regulatory Assessment of Supplemental Notice of Proposed Rulemaking on Structural Measures for Existing Single-Hull Tankers*, July, 1995, pp. 5–12.

Financing Rates

The risk associated with an increase in the number or severity of marine accidents may restrict the availability of capital to a company or make capital very expensive (i.e., higher financing rates). Companies with weak environmental, health, and safety records may experience increases in the time and money-consuming process of conducting environmental and risk assessments and also may turn away potential investors.

Costs of Public Notoriety

Dealing with the consequences of marine accidents diverts the company's focus from innovation and growth to crisis-type activities such as defending company actions, engaging in lawsuits, responding to the public and media attention, and combating lost market share.

Permitting

A poor accident record may weaken the company's relationship with the surrounding community and government regulators, and consequently, slow the permitting process. This, in turn, can result in delays or lengthy postponements in the initiation of operations and the realization of revenues.

Marketing

Companies with poor environmental, health, and safety records are at a marketing disadvantage to companies with more successful track records. Accidents can affect commercial relationships with suppliers, contract manufacturers, distributors, brokers, customers, and others.

Port Fees

Port fees can be a substantial component of operating expenses for a shipping company. In some cases, demonstration of an improved safety record by a shipping company can lead to a reduction in such fees. For example, the Rotterdam Municipal Port Management has developed the Green Award Certification scheme to improve the safety and environmental standards on board seagoing ships. The Green Award promotes safe and environmentally friendly ship and crew management, with the ultimate goal of ports accepting, recognizing, and providing reduced port fees to ships with Green Award Certificates. Although this recognition has yet to reach the U.S., the Rotterdam Port rewards ships with a Green Award Certificate a reduction in port fees of 6 percent. Other ports, including the Dirkzwager Coastal and Deepsea Pilotage B.V., Portnet South Africa, and State Ports of Spain, offer similar reductions on published tariffs for vessels with a Green Award Certificate.

Stock Price

Studies have shown that large-scale accidents and/or indications of a poor safety or environmental record can affect (at least temporarily) the stock value of publicly traded corporations. This impact can be measured by charting changes in the overall value of the firm before and immediately after an incident. Other things being equal, if the stock price of a company owning and operating a tanker fleet or marine facility decreases immediately after an accident, and there are no other nearly simultaneous confounding events, then the decrease in aggregate share value is the imputed cost to the firm's owners resulting from the accident. In a 1992 API study[31], the effects of thirteen severe accidents (i.e., those with either multiple fatalities or five or more hospitalizations) on common stockholders at U.S. refineries were examined. The study determined that the cumulative effect on stock valuation was between two and five billion dollars. Using the conservative estimate of two billion dollars, the average effect for a severe incident was on the order of $150 million.

A recent analysis by ICF suggests that improvements in a firm's environmental management system and environmental performance, including a vigorous environmental accident prevention program, might lead to a substantial reduction in the perceived risk of a firm, with an accompanying increase in a public company's stock price - of perhaps five percent.[32]

E. SUMMARY OF COSTS

Presented below are several summary exhibits that display estimates for the various cost categories to provide perspective on the overall magnitude of expenditures relating to marine accidents. Estimates are broken down by the major cost categories discussed in this report, i.e., spill costs, property damage costs, and the costs associated with injuries and deaths, including both direct and indirect costs. Where appropriate, these major cost categories are further subdivided by specific types of costs. Data are shown for each of the industry sectors discussed in this report, and, where appropriate, total estimates for the entire marine industry are also presented.

There are several caveats to consider in interpreting the data presented in this section. The uncertainty in estimating each of the cost categories presented is compounded when such estimates are combined to yield a summary or overall estimate. Uncertainty was introduced through the difficulty associated with appropriately defining both the types of events that are considered accidents and the resulting consequences. Also, while the majority of marine-related industries are represented in this report, it is unlikely that the costs of all marine-related accidents are addressed. Incomplete reporting and the difficulty in obtaining data for marine accidents are among the key reasons why the estimates are likely to understate the true cost of marine accidents. In addition, a conservative multiplier of 2.7 was used to account for indirect costs associated with accidents.

There is a significant amount of variation in the range of accidents and associated costs both within a particular sector and across sectors. The approach used in this report was to look at the costs associated with a typical or average accident for each sector. However, given the variation mentioned above, it is difficult to define a theoretical accident scenario that is considered "typical." Most accidents and associated costs are minor in nature. In fact, certain types of costs are likely not realized for most minor accidents. For example, a minor oil spill is not likely to result in third party damage costs. These minor accidents are often countered by a lesser number of large-scale accidents with much greater cost consequences. Thus, the costs for certain categories appear unusually low and represent only an average or typical cost, because they were derived by dividing industry-wide totals by the number of accidents.

Wherever possible throughout the analysis, attempts have been made to use current data. For the most part, data used are from the last ten years. Given the nature of the estimation process, dollar values

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[31] Rusin, Michael H., "Economic Aspects of Workplace Safety Regulation with Application to the U.S. Petroleum Industry," Research Study #066, September, 1992, American Petroleum Institute.

[32] Feldman, Stanley J., Peter Soyka, and Paul Ameer, "Does Improving a Firm's Environmental Management System and Environmental Performance Result in a Higher Stock Price?" November, 1996, ICF Kaiser International, summary page.

are not inflated to current year dollars except where estimates were considered dated to the point where they might significantly influence the results. Wherever possible, however, the average of data from multiple years was used to increase the reliability of an estimate, as large-scale accidents in a given year can skew the results. Despite these limitations, the estimates provided below represent reasonable - albeit conservative - indicators of the magnitude of the cost of marine accidents; and do provide the reader with an appreciation for the savings potential that can result from improved accident prevention efforts.

Cost Summary By Incident

Table 3-17 presents a summary of cost estimates for a typical or average incident (i.e., per incident costs) for various sectors of the marine industry. For the most part, these data are taken directly from tables presented earlier in the analysis. In the case of the litigation cost category, however, the typical cost for a litigation incident is first adjusted so it can be applied as an expected value for a typical spill to the total number of accidents for the appropriate sector.

In interpreting the data in Table 3-17 (as well as 3-18 and 3-19), estimates should be viewed as approximations and not as exact figures.[33] Note that Table 3-17 shows cost estimates for a particular cost category for a typical accident where that consequence occurs. For example, the estimate of $2.7 million in costs relating to deaths involving fishing vessel operations are for a typical fishing incident in which a death occurred. The reader is cautioned against drawing conclusions by adding the totals for the various cost categories within a particular sector. Very few accidents result in all of the types of costs presented in the exhibit, although for large scale accidents some combination of costs from various categories may often result.

As shown in Table 3-17, the largest total cost figures are for the death-related cost category. The magnitude of these estimates is largely driven by the 2.7 multiplier that is applied to the sum of wage and productivity losses and medical expenses (i.e., approximately $540,000 per death derived from the National Safety Council estimate of $790,000 total cost per death). Although the same multiplier is applied to the sum of wage and productivity losses and medical expenses associated with injuries, the effect is less dramatic because the direct costs are much lower (i.e., approximately $19,000 per injury derived from the National Safety Council estimate of $28,000 total cost per injury). Property damage incidents can also result in sizable costs especially where large vessels are involved. For example, as shown in Table 3-17, typical property damage costs for a tanker incident are approximately $300,000. Typical oil spill costs are shown to range from about $4,000 for offshore facilities to about $27,000 for a typical spill from a tank barge. These moderate cost estimates reflect the fact that in a large number of oil spill incidents, a small amount of oil is spilled.

Cost Summary By Sector

Table 3-18 shows total annual cost estimates by cost category for each industry sector (i.e., for all incidents occurring in a one year period). In contrast to the per-incident costs shown in Table 3-17, when looking at total annual costs by sector, it is possible to combine totals for each cost category to yield a total cost of all accident consequences in each sector. In this case, the total number of incidents involving spills, property damage, injuries, and deaths are multiplied by the typical costs of these respective

[33] In "Estimating the Cost of Unintentional Injuries, 1995," the National Safety Council recommends that if the estimate is less than $3,000,000, round to the nearest $100,000; if $3,000,000 to $10,000,000, round to nearest $500,000; if $10,000,000 to $30,000,000, round to nearest $1,000,000; and if more than $30,000,000, round to nearest $5,000,000.

incident types. Total costs for spills, property damage, injuries, and deaths can then be combined to yield total annual cost estimates (all cost categories) for each sector, irrespective of the fact that certain incidents may contribute to more than one cost category.

Table 3-17

Summary of Cost Category Estimates for Typical Marine Accident (by incident)

Cost Category		Vessel					Facility	
		Barge/Tow/Tug	Fishing	Passenger	Tanker	Other	Onshore	Offshore
Spills[a]	Emergency Response and Cleanup[b]	22,548	10,142	3,964	22,291	6,744	12,098	824
	Natural Resource Damage (NRD)[c]	110	49	19	108	33	59	4
	Fines and Penalties[d]	1,541	900	1,428	1,703	1,918	1,121	1,121
	Lost Cargo or Lost Stored Oil[e]	250	112	44	247	75	134	9
	Litigation Expenses[fg]	2,991	NA	NA	1,673	NA	3,916	1,964
	Total[h]	27,440	11,203	5,455	26,022	8,770	17,327	3,922
Property Damage[a]	Total[h]	69,674	90,478	55,015	292,009	246,130	212,810	170,000
Injuries[al]	Wage and Productivity Losses[j]	14,932	15,222	19,571	15,512	15,657	28,124	15,367
	Medical Expenses	4,794	4,887	6,284	4,980	5,027	9,030	4,934
	Administrative Expenses	6,367	6,491	8,345	6,615	6,676	11,993	6,553
	Indirect Cost[k]	53,260	54,295	69,807	55,329	55,846	100,316	54,812
	Total[h]	79,354	80,895	104,007	82,435	83,206	149,462	81,665
Deaths[al]	Wage and Productivity Losses	429,473	507,187	449,924	642,164	478,555	511,277	409,022
	Medical Expenses	137,891	162,843	144,457	206,180	153,650	164,156	131,325
	Administrative Expenses	183,136	216,275	191,857	273,832	204,066	218,019	174,416
	Indirect Cost[k]	1,531,882	1,809,079	1,604,829	2,290,528	1,706,954	1,823,669	1,458,935
	Total[h]	2,282,382	2,695,384	2,391,067	3,412,704	2,543,225	2,717,121	2,173,697

NA = Not available.

[a] Analysis of 1993 and 1994 Marine Safety Information System (MSIS) data.

[b] Data from the American Petroleum Institute Fourth Annual Petroleum Industry Environmental (PIEP) Report on industry expenditures from oil spill response and cleanup were used to determine an average cleanup cost of $51.48 per gallon.

[c] Based on a spill unit value of $0.25 per gallon.

[d] Analysis of 1991 - 1995 Marine Safety Information System (MSIS) data.

[e] Based on a market value of $0.57 per gallon.

[f] Analysis of 1991 - 1995 Oil Spill Intelligence Report Statistics for U.S. spills of more than 10,000 gallons. Adjusted to reflect an expected per incident value for all spills through the use of a 3 percent multiplier (i.e., approximate percentage of all spills that are more than 10,000 gallons).

[g] Based on a Minerals Management Service Outer Continental Shelf legal cost estimate of $1.39 per gallon spilled (inflated to 1997 dollars).

[h] Total may not add exactly due to rounding.

[i] Based on a National Safety Council estimate of $28,000 per disabling injury.

[j] Breakdown of injury and death costs (wage and productivity losses, medical expenses, administrative expenses) based on National Safety Council estimates.

[k] Indirect costs were calculated using a multiplier of 2.7 applied against the sum of wage and productivity losses and medical expenses.

[l] Based on a National Safety Council estimate of $790,000 per death.

Table 3-18

Summary of Annual Marine Accident Costs by Sector

Cost Category		Vessel					Facility	
		Barge/Tow/Tug	**Fishing**	**Passenger**	**Tanker**	**Other**	**Onshore**	**Offshore**
Spills	Number of Spill Incidents[a]	617	656	139	151	719	1,099	1,219
	Cost per Spill Incident	27,440	11,203	5,455	26,022	8,770	17,327	3,922
	Total Cost	16,930,480	7,349,168	758,245	3,929,322	6,305,630	19,042,373	4,780,918
Property Damage	Number of Damage Incidents[a]	397	253	120	38	183	54	1
	Cost per Damage Incident	69,674	90,478	55,015	292,009	246,130	212,810	170,000
	Total Cost	27,660,578	22,890,934	6,601,800	11,096,342	45,041,790	11,491,740	170,000
Injuries	Number of Injury Incidents[a]	346	385	205	105	409	9	34
	Cost per Injury Incident	79,354	80,895	104,007	82,435	83,206	149,462	81,665
	Total Cost	27,456,484	31,144,575	21,321,435	8,655,675	34,031,254	1,345,158	2,776,610
Deaths	Number of Death Incidents[ab]	22	38	26	4	32	2	4
	Cost per Death Incident	2,282,382	2,695,384	2,391,067	3,412,704	2,543,225	2,717,121	2,173,697
	Total Cost	50,212,404	102,424,592	62,167,742	13,650,816	81,383,200	5,434,242	8,694,788
Total		**122,259,946**	**163,809,269**	**90,849,222**	**37,332,155**	**166,761,874**	**37,313,513**	**16,422,316**

[a] Approximate number of annual incidents based on MSIS data for 1993 and 1994.

[b] The number of deaths associated with vessels categorized as "Fishing Boats" in 1993 and 1994 MSIS data declined significantly upon removal of duplicate case numbers from the master database. Total numbers of marine-related deaths and injuries for 1993 and 1994 are roughly consistent with other available estimates.

Table 3-18 shows that the relative magnitude of the total costs for each sector is primarily driven by the cost associated with deaths and injuries. The range of costs among the various categories, however, is somewhat less than is the case for per-incident costs because there are a much greater number of spill incidents and property damage incidents than there are incidents involving deaths. For example, the approximate total annual cost for fishing vessel accidents of $165 million is much greater than the $35 million cost for tanker accidents because the number of deaths and injuries on an annual basis is much higher in the fishing industry. Thus, changes to the number of deaths that occur on an annual basis and/or to the unit cost per death (e.g., adjusting the conservative multiplier of 2.7 for indirect costs) could affect the total cost figure for each sector dramatically. Oil spill costs make up a relatively small component of total costs for most sectors as shown in Table 3-18.

Other sources of data on unit costs for oil spills report different and often higher values than those used in this report. By doubling the spill unit value and thus roughly doubling the total cost figure for spill-related-costs, the total cost figure for all accident related costs increases as does the percentage contribution of spill costs. The increases in the ratio of spill costs to total costs range from 1 - 2 percent for passenger vessels to 51 - 68 percent for onshore facilities. Doubling the annual total for spill unit volumes would result in similar changes to the estimates. Except for facilities, the contribution of spill cost to total costs is below 15 percent for all other sectors. In most cases, the total cost estimates are not highly sensitive to changes in variables used to estimate spill related costs.

Finally, for purposes of illustration total annual costs for each sector can be combined to yield total cost figures for each cost category and for all cost categories combined. Table 3-19 presents total annual cost estimates (by category and combined) for vessels, marine facilities, and a summary for the entire marine industry.

Table 3-19 Total Annual Industry Costs for Marine Accidents

Cost Category	**Vessels**	**Facilities**	**Total**
Spills	35,272,845	23,823,291	59,096,136
Property Damage	113,291,444	11,661,740	124,953,184
Injuries	122,609,423	4,121,768	126,731,191
Deaths	259,626,347	14,129,030	$273,755,377
Total	**530,800,059**	53,735,829	**$584,535,888**

Table 3-19 shows that the estimated industry costs resulting from marine accidents is approximately $584,000,000 annually, with the majority of these costs (i.e., approximately 92 percent) attributable to vessel operations. Again, these summary costs figures should be viewed as conservative estimates of the annual costs of marine accidents given the limitations described previously. The estimates provide perspective on the magnitude of potential cost savings that could result through the successful implementation of comprehensive accident prevention programs.

CHAPTER 4
BENEFITS OF PROACTIVE ACCIDENT PREVENTION PROGRAMS

This chapter presents a discussion of the effectiveness of proactive accident prevention programs in reducing the occurrence of accidents and the costs associated with those accidents. Through an analysis of time-series data at the industry and company level, ICF was able to identify downward trends in the occurrence of marine-related accidents. Taken over time, these trends can result in significant benefits (i.e., cost savings) for individual companies and for the marine industry overall. The chapter presents a series of examples of how such programs have resulted in a reduction in the number of accidents or incidents over time. Examples were obtained through a review of trade association data, company-level data, and related studies from the literature. Following these examples, the report discusses the magnitude of accident reduction gains that could realistically be applied to the marine industry through widespread adoption of programs that embrace PTP principles.

The analysis and resulting estimates have certain limitations. First, the baseline level of costs against which potential benefits can be applied is difficult to estimate. The marine industry in general, and the specific sectors identified for purposes of this report, are difficult to define as are the events that are considered and counted as accidents. Moreover, this report has already addressed the limitations associated with estimating the variety of costs stemming from marine accidents. The estimates shown at the end of Chapter 3 are believed to be reasonable indicators of the magnitude of such costs. The figures presented in this report are likely to underestimate the true value of the overall cost of marine accidents to private concerns and should be viewed as conservative.

A second major limitation of the analysis involves estimating an appropriate effectiveness factor associated with adopting and implementing an accident prevention program to apply to our cost estimates. There are numerous factors that complicate the process of estimating and applying such an estimate. For example, not all accidents can be prevented by the adoption of such programs. Even for the 80 percent of accidents believed to be caused by human error, it is, for all practical purposes, impossible that all such accidents could be prevented through the adoption of such programs by all companies with maritime operations. Also, in many cases, accident prevention benefits are the result of factors that already have and will continue to contribute to accident prevention, such as programs in place based on Federal and State environmental, heath, and safety rules. In fact, safety and accident prevention programs are not new to the marine industry. Many programs stem from regulations or from good business sense. The various sectors described in this report are made up a of a variety of companies at different stages in the process of addressing accident prevention concerns. The remainder of this chapter should be viewed from the perspective of an average or typical marine facility or vessel owner or operator, possessing an average accident prevention record, and an average program in place to promote workplace safety and accident reduction. In this context, the benefits of adopting accident prevention programs on both a company-specific and industry-wide basis can be appreciated.

A. BENEFITS OF ANALOGOUS PROGRAMS

Det Norske Veritas Safety and Environmental Protection Rules

The Norwegian classification society DNV has been a leader in the study of the human element in ship operations since the mid 1970s. For the past five years, DNV has certified shipping companies' management systems for compliance with DNV's Safety and Environmental Protection (SEP) Rules. Some of the core concepts of the SEP Rules were derived from the DNV International Loss Control Institute (ILCI). ILCI has been using the International Safety Rating System (ISRS) for the past twentyfive years to assess the improvement in performance of marine companies' safety management systems. DNV's experience with SEP and ISRS certified companies provide insight into the effectiveness of accident prevention programs.

DNV has identified a broad range of benefits that can be attributed to the adoption of a comprehensive safety and environmental protection program. DNV has analyzed the progress of member companies in implementing aspects of the SEP program and has begun to chart the results. According to DNV, over the past four years of SEP, member companies have achieved approximate reductions of:

- 25 - 35% in loss of man-hours
- 15 - 25% in hospital hours
- 35 - 45% in sick-leave
- 30 - 40% in environmental pollution fines
- 50 - 90% in cargo damage
- 10 - 15% in comprehensive premiums
- 6 - 10% in P&I premiums.

In addition, personal injury pay-outs dropped by about 70 percent in the three-year period after the introduction of SEP. Individual examples of savings in this area vary between 60 percent and 90 percent. Other benefits resulting from SEP have included reduced port fees for companies with SEP/ISM certification under the Port of Rotterdam's Green Award, and a higher incidence of approval during vetting inspections by charterers. None of the 95 vessels certified according to SEP Rules or ISM Code have failed a charterer's vetting inspection. DNV estimates that for the shipping industry as a whole, with a conservative estimate of $500 million to a $1 billion in savings due to accident reduction, individual companies could save approximately $200,000 per year.

In a recent presentation to the USCG and API, DNV acknowledged that the effort spent in developing and maintaining a safety management system "pays for itself many times over. However, it is very difficult to show a "non-cost" for an accident which does not occur" and therefore, demonstrate the potential savings to a company. DNV added that to see the true benefits, senior managers must view the overall picture, not just the quarterly profit and loss statement, as it may take a year or longer before companies begin to accrue benefits from an accident prevention program. The following examples demonstrate the potential benefits of an DNV's accident prevention program:

- A major U.S. bulk shipping company, certified according to DNV's SEP Rules, noted several positive trends over the past five years. The lost time injury rate among the vessels of their fleet decreased steadily, with disabling injury and total injury rates (both per 200,000 hours) decreasing by 50 percent or more over a three year period. These reductions resulted in an estimated cost-savings (direct and indirect) for the fleet of over $1 million in 1994 (an increase of almost ten-fold since 1990).

- Another SEP certified client, a container shipping company, realized improvements in hull & machinery loss ratios (i.e., ratio of the value of company claims to premiums paid out by the company). The ratio dropped from approximately 180 percent in 1990, to 7 percent in 1993, and to zero in 1994. The company confirmed a savings of several millions of dollars and a sizable reduction to both the self insured amount and to the total premium paid. In addition, loss due to unplanned vessel non-availability and voyage maintenance and replacement part costs have declined. The company publicly stated that "the investment has been returned many times over in increased safety, efficiency, and economy."

- A ship management SEP client also attributed a list of improvements to its safety management system. Such improvements included an easier rotation of crews between vessels because of standardized training and procedures and an almost complete elimination of problems with oil company vettings.

- A land-based major petrochemical company experienced positive results after implementing a safety rating system aimed at reducing the human element in accidents. Benefits included an appreciation by personnel of increased recognition, greater personnel participation in creating solutions, more control and exposure for operating and middle managers, a drop in the unlicensed crew turnover rate (from 37 percent to 32 percent) within the first six months, a more competitive atmosphere and heightened interest in fleet performance, and an improved attitude towards wearing protective equipment.

Chemical Manufacturers Association Responsible Care Program[34]

In 1988, the Chemical Manufacturers Association (CMA) launched Responsible Care to respond to public concerns about the manufacture and use of chemicals. Since then, Responsible Care has become the chemical industry's health, safety, and environmental framework and has resulted in significant performance improvement within the chemical manufacturing industry. Six primary codes are the core of Responsible Care activities and focus on management practices in specific areas of chemical manufacturing, transportation, and handling.

- The Community Awareness and Emergency Response (CAER) Code emphasizes communication and cooperative emergency planning between the chemical industry and local communities.

- The Process Safety Code is designed to prevent fires, explosions, ands accidental chemical releases.

- The Pollution Prevention Code focuses on reducing waste generation and pollutant emissions.

- The Distribution Code is aimed at reducing the risk that transportation and storage of chemicals poses to the public, carriers, customers, contractors, employees, and to the environment.

- The Employee Health and Safety Code protects and promotes the health and safety of people working at, or visiting, CMA member sites.

- The Product Stewardship Code is designed to incorporate health, safety, and design into designing, manufacturing, distributing, using, recycling, and disposing of chemical products.

CMA either has or is in the process of establishing measures of performance for each of the six codes. The Product Stewardship, CAER, and Process Safety Codes are still evolving and their initial success is documented only by relatively few examples, although more definitive measures are expected in the near future. On the other, the effectiveness of Employee Health and Safety, Pollution Prevention, and Distribution codes have been tracked quantitatively.

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[34] Chemical Manufacturers Association, 10 Elements of Responsible Care, 1994-95 Responsible Care Progress Report.

Employee Health and Safety. Responsible Care members submit Occupational Injury and Illness Reports (OIIR) semi-annually to CMA. The OIIR data are the same recordable occupational injury and illness cases that companies are required to document under the OSHA Recordkeeping Standard. Table 4-1 shows the total number of reportable cases (per 200,000 exposure hours) for CMA members from 1990 to 1995.

Table 4-1 Total Number of Reportable Cases of Injury and Illness for CMA Members, 1990 - 1995

Year	1990	1991	1992	1993	1994	1995
Reportable Cases[a]	3.6[b]	3.2[b]	3.15	2.97	2.85	2.5

[a] Total Reportable Cases per 200,000 exposure hours
[b] Approximation based on a bar chart on page 24 of the CMA 1994-95 Responsible Care Progress Report

As shown in the table over the six-year period, CMA members have reduced the number of recordable incidents by approximately 30 percent. From 1990 to 1995, the injury and illness rate declined from 3.6 to 2.5 per 200,000 hours. Using the National Safety Council estimate of $28,000 per disabling injury, this decline represents a cost reduction of $30,800 per 200,000 hours worked[35]. In addition, in 1995 alone, CMA members improved their performance by 12 percent from 1994, reducing the number of incidents to 2.5 per 200,000 hours. By comparison, the 1995 rate for the chemical and allied products industry (SIC Code 2800) was 5.5 per 200,000 hours and the rate for all manufacturing was 11.6.

Pollution Prevention. EPA's Toxics Release Inventory (TRI) program, established in 1987, tracks releases of listed toxic chemicals to the air, water, and land. CMA collects TRI data submitted by Responsible Care member companies to understand the effectiveness of pollution prevention efforts. Data from 1993 show that CMA member companies have reduced toxic releases by 49 percent since TRI started. This represents the seventh straight year of reductions, while production increased over the same time period by 18 percent. During the same year, member companies showed reductions of 16 percent for toxic chemical releases, 14 percent for underground injection, and 21 percent for transfers.

Distribution. In 1995, CMA adopted the Department of Transportation (DOT) hazardous materials transportation incident database to measure the performance of CMA's Distribution Code. Performance measure reporting is being phased in by mode, beginning with bulk rail incidents. For the period of 1992 to 1994, the number of bulk rail incidents involving CMA members decreased by 21 percent, as shown in Table 4-2.

Table 4-2 Number of Bulk Rail Incidents for CMA Members and Entire Industry, 1992 - 1994.

Year	1992	1993	1994
CMA Member Incidents	378	292	262
Total Industry Incidents	1,010	1,013	1,019

Much of the improvements in these indicators can be traced to the success of the Responsible Care Initiative in changing the safety and accident prevention culture at member companies. It is not

[35] The estimated savings would be even higher if a multiplier were applied to account for certain additional indirect costs not included in the National Safety Council Estimate.

difficult to see how similar gains could be made by members of the maritime industry through the adoption of proactive accident prevention programs.

American Petroleum Institute STEP Program

In 1990, API and its member companies (currently, over 300 oil and natural gas companies) created STEP -- Strategies for Today's Environmental Partnership. STEP is the framework the industry uses to improve its environmental, health, and safety performance, measure progress, and report the results. Through STEP, member companies are working to prevent pollution, promote safe operating practices, conserve resources, promote product stewardship, maintain crisis readiness, and address community concerns. STEP combines and represents many ongoing initiatives. For example, there is the Safety and Environmental Management Program[36] (SEMP) for offshore facilities developed in association with the MMS and USCG being undertaken by individual member companies. STEP enables API members and others to share the lessons learned from the collective experiences of petroleum companies that have achieved environmental, health, and safety improvements through the use of cost-effective management practices.

STEP's progress has been measured using statistics from the USCG, EPA, the Bureau of Labor Statistics (BLS), and surveys conducted by API. Performance data is published annually in the PIEP report. In this report, API tracks the chemical releases, oil spills, workplace safety, and other indicators of the effectiveness of STEP.

Chemical Release. This performance measure is based on the EPA's annual TRI. Since 1988, total releases of TRI chemicals have declined by 24 percent, releases of TRI carcinogens have declined by 22 percent, and releases and transfers of chemicals included in EPA's 33/50 program (a voluntary effort to reduce releases of certain chemicals) have declined by 35 percent.

Oil Spills. API uses USCG data to analyze the frequency and volume of spills from different sources (vessels, facilities, pipelines, etc.). Data on the number and volume of industry-wide spills should be viewed with caution, as spill data can vary significantly from year to year. The annual volume of oil spilled can be significantly affected by a few large spills, whereas the total number of spills reported (versus the number that actually occurred) is affected by reporting practices and is largely shaped by the number of small spills, sometimes a gallon or less. Nonetheless, the number of spills is a more reliable measure of progress than is spill volume. Since reaching a high of 9,600 spills in 1991, the number of spills has declined to 7,800 in 1994, a 20 percent reduction.

Workplace Safety. The BLS publication, "Occupational Injuries and Illnesses: Counts, Rates, and Characteristics" provides information on workplace safety to allow API to compare the rate of job-related injuries and illnesses for the petroleum sector to more general indicators. BLS data provides a statistical profile of OSHA-required data. Since 1990, the rate of job-related injuries and illnesses in the petroleum industry has dropped by 20 percent - in contrast to the U.S. private sector as a whole, where

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[36] SEMP is an emerging Outer Continental Shelf (OCS) operating concept that was conceived by the MMS nearly four years ago. In practice, SEMP is a plan for designing, managing, and conducting OCS operations in ways that emphasize the importance of human behavior in offshore safety and pollution prevention. SEMP guidelines are contained in API's Recommended Practices for Development of a Safety and Environmental Management Plan for OCS Operations and Facilities (RP75). RP75 is the result of a cooperative effort among API, the Offshore Operator's Committee, MMS, and others to apply the SEMP concept to oil and gas production facilities. Performance measures for SEMP do not yet exist.

the rates have remained about the same. The exploration and production sector of the petroleum industry has experienced a 32 percent decline in their job-related injuries and illnesses rate (from 8.0 per 200,000 hours in 1990 to 5.4 per 200,000 hours in 1994). Using the National Safety Council estimate of $28,000 per disabling injury, this decline represents a cost reduction of approximately $72,800 per 200,000 hours worked. The estimated savings would be even higher if a multiplier were applied to account for certain additional indirect costs not included in the National Safety Council estimate.

OSHA Voluntary Protection Program

A significant amount of information on the potential benefits of adopting proactive workplace safety and accident prevention programs is available through a review of materials related to OSHA's VPP. In summary, VPP (established by OSHA back in the early 1980s) is designed to recognize and promote effective safety and health management in the workplace. VPP sites are by their very nature "de facto" supporters of PTP principles. Under VPP, management, labor, and OSHA establish a cooperative relationship as follows:

- Management agrees to operate an effective program that meets an established set of criteria
- Employees agree to participate in the program and work with management
- OSHA verifies that the program meets the VPP criteria and periodically reassesses program status.

VPP criteria go beyond compliance with OSHA standards. Star participants meet all VPP criteria. Merit participants have demonstrated the potential and willingness to achieve Star program status, and are implementing planned steps to fully meet all Star requirements. Today there are over 265 facilities that participate in VPP as either Star, Merit, or Demonstration facilities. There has been an extensive amount of data collected and analyzed on the VPP program over the years.

OSHA maintains comprehensive data on VPP sites, including data comparing the safety record of VPP sites to industry standards. An analysis of 1995 VPP participant data indicated that for all VPP sites (216 in 1995):

- 3,728 lost workday injuries (LWDI) were avoided[37] for an average of 17.2 LWDI avoided per site per year; and
- 7,877 recordable injuries were avoided for an average of 36 recordable injuries avoided per site per year.

It is not difficult to see how significant costs savings can result from such reductions in the number of injuries. For example, by applying our National Safety Council estimate of $28,000 per disabling injury to a figure of 17.2 LWDI, nearly $500,000 in costs are avoided without consideration of insurance coverage. The estimate could be even higher if multipliers that account for additional indirect costs were applied.

[37] Figures were obtained by comparing expected industry rates based on SIC code averages obtained from BLS to reported injury rates for VPP participant sites. The difference represents the number of injuries assumed to be avoided as a result of VPP participation.

Data on reductions in workers' compensation payments for VPP participants tell a similar story. The VPP Participants Association (VPPPA), a non-profit trade association whose members are sites which are either participating in or have applied to participate in VPP, conducts a periodic survey of its membership to help quantify the benefits of VPP participation. The results of VPPPA's latest survey completed in mid-1996 by approximately 50 respondents revealed that the average per-company workers' compensation costs (for those companies that provided responses in that field) decreased by approximately 30 percent over the five-year period 1991-1995 (from $231,401 to $160,321).

In percentages, lost workday injury rates and recordable injury rates for VPP participants as reported by OSHA were approximately 50 percent below the industry averages reported by BLS. Some companies experience more success than others, and rates of improvement vary depending on the exact phase of program implementation. However, the data send a clear message -- VPP participation has lead to significant reductions in rates of workplace injuries and associated costs. Participation in the program is also reported to yield other benefits such as decreased absenteeism and increased worker productivity.

The Construction Industry: A Case Study in the Cost of Accidents

Companion studies on safety in the industrial, utility, and commercial sectors of the construction industry — conducted under the auspices of The Business Roundtable — show that the cost of accidents: (1) can represent a significant portion of direct costs to industry; and (2) are controllable through improved safety performance. The findings underscore the economic incentive for companies to reduce the number of work-related accidents by implementing an effective safety program.

The study found that, in 1979, the aggregate cost of accidents to the industrial, utility, and commercial sectors of the construction industry was $8.9 billion annually, or 6.5 percent of the $137 billion per year industry. The cost of workers' compensation insurance (WCI) was $2.74 billion annually, constituting 65 percent in accident costs and 35 percent in administrative costs to the insurance industry. Thus, the construction industry paid $1.78 billion in direct costs for accidents in 1979. The study estimated an additional $7.12 billion was paid in indirect costs, using a conservative cost multiplier of 4.0.

In 1989, accident costs for these sectors rose to $17.1 billion per year of a $245 billion per year industry, while WCI costs reached $5.26 billion. Due to changes in workers' compensation laws, broadened regulatory protection of occupational health, soaring medical costs, and widespread abuse of benefits, the study projects that WCI costs will continue to rapidly increase and impact the competitiveness of firms.

The study examined three categories of costs associated with safety in construction:

- Direct costs of accidents and insurance. Direct costs include medical and other insurance costs for: workers' compensation, liability, and property damage. Among these, the study identified WCI as most costly to the construction industry (e.g., 7 percent of direct labor payroll, in contrast to liability costs at 1 percent). Significantly, the study showed how a company's improved safety performance factors into the basic formula for calculating workers' compensation (WCI = EMR x MR x Payroll Units), driving down the cost of WCI to industry. In particular, the EMR, or Experience Modification Rating, is a function of the past injury experience of the individual policy holder and varies by company. The MR, or Manual Rate, is a function of the past injury experience of all contractors doing similar work in a specific state, although it does not vary by company. A lower EMR reflects an individual company's ability to prevent accidents through safety programs, while a lower MR reflects a collective ability to prevent accidents.

- Indirect costs of accidents. Indirect costs comprise the bulk of total accident costs and include: loss of productivity, disrupted schedules, administrative time for investigations and reports, training of replacement personnel, wages paid to injured and other workers for time not worked, cleanup and repair, adverse publicity, third-party liability claims against the owner, and equipment damage. For the 49 construction accidents analyzed, the study reported a ratio of indirect to direct costs varying from 1.1 to 5.1, with a mean indirect cost for accidents involving no lost time of $1,450 and $7,700 for those involving lost time. The ratios are believed to be conservatively low since, for example, none of the accidents included costs for third-party or punitive damages. The study noted further that this ratio depends on so many variables (e.g., diligence of an investigation, severity of an accident, type of project) that it was not possible to calculate a single factor for all industry accidents.

- Costs of safety program. Data collected from a separate sample of construction sites in 1980 indicate that the cost of administering a construction safety and health program was approximately 2.5 percent of direct labor costs, or a nominal investment with respect to the high cost of accidents avoided.

If, for example, 45 percent of WCI costs were paid per year for accidents rather than 65 percent, the direct costs of accidents to the industrial, utility, and commercial sectors of the construction industry in 1979 would fall to $1.23 billion (1979 dollars) and indirect costs to $4.92 billion. This decrease, $2.75 billion annually, represents eight percent of the direct labor payroll for an estimated $3.20 in accident costs avoided per $1 spent to administer a safety and health program.

Individual Company Examples

There are numerous individual company examples that could be used to demonstrate the potential for success that could result through the widespread adoption of programs that embrace PTP principles throughout the various sectors of the maritime industry. The gains tracked by VPP sponsors (DNV, CMA, and API) that are described above are made up of numerous individual company success stories. Presented below are several short examples that highlight success stories of individual companies that were willing to provide information to use for this study with the understanding that their names would not be used.

Case A. The owner and operator of a fish processing barge that operates in the waters near Dillingham, Alaska was approved as a Merit facility in the OSHA VPP in 1994. The barge is engaged in packaging and freezing crab, herring, and salmon. The products are delivered by catcher vessels and off-loaded to other vessels or for land transport. Potential hazards at the facility include: electrical, machinery, ergonomic risks, and slips-and-falls due to multiple levels of wet walking surfaces.

Largely as a result of the company's efforts to implement and embrace accident prevention efforts based on VPP criteria, the three-year average illness and injury rate (IIR) for the period 1994 through 1996 was 6.26, or 60 percent below the 1994 industry average, while the corresponding LWDI was 1.87, or 77 percent below the 1994 industry average. These rates are a dramatic improvement over the previous three-year period when the average IIR was 16 percent below the industry average and LWDI exceeded the industry average by 13 percent.[38]

Applying our estimated cost per injury of $28,000 under one measure to the average LWDI figure (1.87) yields over $150,000 in accident-related costs avoided for the barge over the last three years. The estimated savings could be even greater if a multiplier to account for certain additional indirect costs were used. Based on the dramatic improvements achieved by its safety and health program, the facility has recently been recommended by an OSHA review team for participation in VPP at the Star level.

Case B. A major energy and chemical company, primarily involved in oil and gas exploration and production, coal mining, and production of industrial chemicals provided information on its recent efforts to improve the safety record at its facilities. One component of the company's efforts directed at offshore operations is based on API's SEMP discussed previously. The company is several years into a five-year program to fully implement SEMP and is already beginning to demonstrate marked improvements under several measures. A review of trends in accident and cost data for the company's marine facilities shows a 59 percent decline in the number of worker injuries over the period 1991 through 1995 and a decline of 71 percent in accident-related equipment repair and replacement costs for the same interval.

Table 4-3 Case B Trends in Worker Injuries and Equipment Repair/Replacement Due to Accidents

Category	1991	1992	1993	1994	1995
Number Worker Injuries	17	6	9	5	7
Equipment Repair/ Replacement Due to Accidents	$85,000	$427,112	$140,983	$31,872	$24,987

These data demonstrate the potential for significant cost savings through a commitment to a comprehensive accident prevention program. The data, however, also indicated continued room for improvement in payouts for medical costs, workers' compensation, and third party damages.

Case C. A major diversified bulk shipping company, operating both in U.S. and international waters, provided information on accident prevention successes realized through adoption of a safety awareness program following DNV's SEP rules. The company operates a fleet of 36 vessels, with an aggregate capacity of approximately 3 million DWT;[39] and also engages in other maritime activities, such as lightering of crude carriers in the Gulf of Mexico, workboat supply services, and ship management for the U.S. Ready Reserve Fleet.

[38] These numbers are significant in that incidence rates for the company are calculated based on the hours worked although the numbers reflect injuries for the full 24 hours workers are on board. This means a floating processor is at a disadvantage to a shoreside processors from which the industry average rates have been primarily derived. In addition, the majority (110) of the 125 employees in the Case A example are seasonal employees, many of whom do not have prior experience on the vessel.

[39] As of November, 1996.

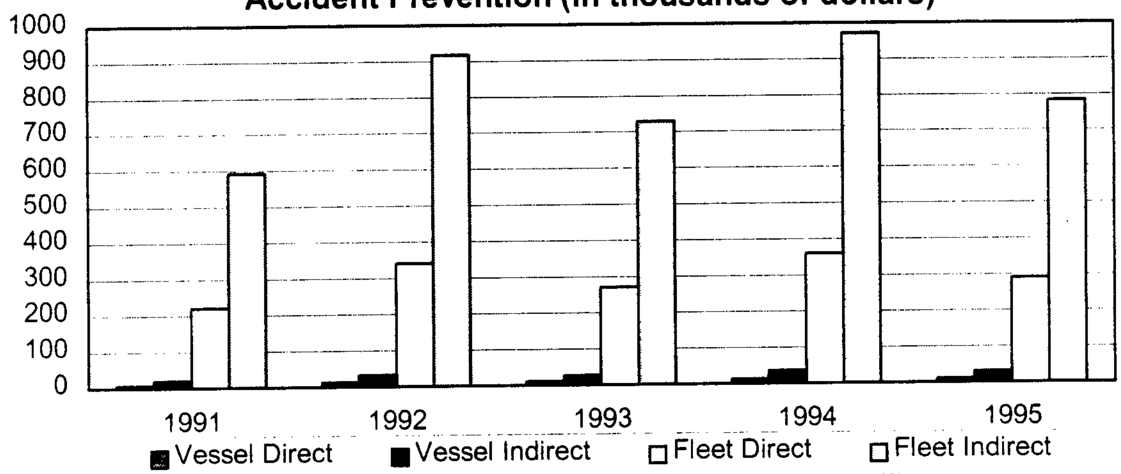
A review of the number of company incident files opened during the period 1993 through 1996 shows that the frequency of incident files related to the following categories of incidents have decreased over this three-year period:[40]

- Personal injury and illness (17 percent)
- Environmental (50 percent)
- Hull and machinery (54 percent)
- Fixed and floating objects (42 percent); and
- Violations and stowaways (74 percent).

Despite an increase in the number of cargo incidents over this period, the company achieved an overall decrease in incident files by almost 24 percent over the four-year period.

As a result of its Safety Awareness Program, the company estimates that relative to 1990 as a baseline, it has achieved the following aggregate savings in direct and indirect fleet and vessel costs for the years 1991 through 1995:

Estimated Direct/Indirect Savings from Lost Time Accident Prevention (in thousands of dollars)



These estimates are based on data for incidents involving lost time, and reflect the industry index of $10,000 of direct cost per injury and $27,000 of indirect cost per injury. These data demonstrate that substantial cost savings are achievable through implementation of effective safety and health programs

The company's recent claims history corroborates this trend in improved safety performance. For the period 1991 through 1996, the company filed 70 percent fewer insurance claims. The total value of such claims has also fallen.

Case D. A major tank ship operator which follows the guidelines established by the International Safety Management code provided accident and cost data for the years 1992 through 1996. During this time, the company experienced a slight reduction in fleet size, from 13 vessels in 1992 to 10 vessels in

[40] The calendar year of the incident may differ from the calendar year in which the case file is opened, because notification of claims is not always received in a timely manner.

1996, with a corresponding decrease of about 24 percent in aggregate crew size (290 persons in 1992 to 220 in 1996).

Despite relatively few serious injuries among crewmembers between 1992 and 1996, the data show a trend toward fewer serious injuries to crewmembers, accompanied by a corresponding reduction in costs paid for medical and workers' compensation. The company also has operated without crew fatalities since 1993. One incident resulting in one crew fatality in 1992, accounts for 87 percent of accident-related costs reported by the company for that year. Also, the costs incurred for vessel repair declined 72 percent over the period 1992 to 1996, perhaps reflecting a decrease in both the number and severity of accidents resulting in vessel damage.

Overall, the company achieved a 75 percent reduction in accident-related costs between 1992 and 1996. Total direct and indirect accident-related costs dropped from an estimated $690,000 in 1992 to $174,000 in 1996. With respect to the annual volume of product transported, the company achieved a 71 percent reduction in accident-related dollars lost per gallon of product transported per year.

Case E. A major inland tug and barge operator participating in AWO's Responsible Carrier Program provided its accident and cost data for the years 1992 through 1996. During this time, the company showed a significant increase in the number of vessels it operates and in crew size required to work those vessels.

Despite this increase in its fleet and crew size, the company has operated without any crewmember fatalities, crewmember serious injuries, or medium or major spills for the past five years. The company does report two incidents involving vessel casualties (one in 1994 and the other in 1996), for a cumulative cost of $202,250 in accident-related costs[41] for the years 1992 through 1996. This accident record is significantly better than would be expected for a typical operator of this size. It is reasonable to assume that a major factor allowing the company to achieve such a safety record was the adoption and continued implementation of a proactive accident prevention program modeled after the Responsible Carrier Program.

B. POTENTIAL BENEFITS OF ACCIDENT PREVENTION PROGRAM IMPLEMENTATION

This final section provides a brief discussion of the magnitude of cost savings that might result from the widespread implementation of comprehensive accident prevention programs aimed at the human element of maritime operations. The percentage reductions discussed earlier this chapter reveal that the effectiveness of accident prevention programs can vary. These programs are all targeted at different sectors. In addition, individual companies within each sector are at different stages of evolution of their safety culture (i.e., evasion culture, compliance culture, beyond compliance safety culture). For purposes of this analysis, the more companies contained in a data set, the better the data set as average conditions are more likely to be reflected. Also, data sets that reflect several years worth of data and that coincide with the advent of a new initiative aimed at going beyond compliance provide better information for trend analysis.

The CMA Responsible Care, API STEP, and OSHA VPP data sets appear to provide the most reliable information for identifying a reasonable effectiveness factor to apply to our estimate described at the end of Chapter 3 for the cost of marine accidents. A review of estimates from these data sources

[41] Vessel repair and replacement costs, fines and penalties, and third party damage claims.

charting improvements in several of the major accident cost categories (i.e., injury rates, release prevention) over time indicated effectiveness values ranging from roughly 30 percent to 50 percent. Assuming a comparable program aimed at accident prevention in the marine industry that produces similar levels of success over time, annual cost savings to the marine industry could range from $190.5 million to $317.5 million per year with a midpoint of $254 million per year. For individual companies, gains may be greatest in the early years of the program and taper off as the number of accidents prevented each year declines. This decline is an inevitable and welcome end result as the law of diminishing returns will eventually make prevention of the marginal accident cost prohibitive. Furthermore, despite improvements in human-related factors, accidents will continue to occur at a certain rate.

Despite certain limitations in the analysis, the data suggest that significant costs savings -- resulting from accident reduction levels on the order of 30 to 50 percent -- can accrue to companies with marine-related operations. Individual company experiences can differ significantly from these levels with certain companies realizing greater benefits and others less. This variation has been documented through the presentation of various case study examples contained in this report. Furthermore, the cost estimates presented in this report are conservative, providing further incentive for managers not to overlook the costs of marine accidents, many of which are effectively hidden from the balance sheet. Ultimately, proactive accident prevention efforts not only save lives, reduce injuries, and improve environmental protection but can also form an integral part of a company's cost reduction strategy in today's cost competitive marketplace.

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