Washington Oil Spill Advisory Council

Causal Analysis of Vessel-Related Incidents and Oil Spills in the State of Washington Occurring Between November 1993 – December 2006

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I. EXECUTIVE SUMMARY

At the direction of the Washington Oil Spill Advisory Council, this study was conducted to identify and rank the primary and secondary causes of vessel-related incidents and spills that occurred within Washington waters. Reports identifying the contributing (or causal) factors for vessel related spills and incidents were received from the Washington State Department of Ecology (Ecology) for 94 vessel-related incident investigations between November 1993 and December 2006. Of note, Ecology initially provided investigation reports for 106 incidents involving vessels. However, in 12 of the incident investigation reports, contributing factors were not identified because too little information was available to Ecology's investigating field staff, leaving 94 incidents total that this study could effectively evaluate. Of these 94 reports, 50 resulted in spills. Actions possibly might have been taken during the course of an incident that prevented additional oil spills from occurring. In addition, more spills probably occurred during this period of time for which we have no investigative reports. The investigation reports primarily involved incidents on cargo, fishing and tank vessels. Only a couple of tugs, dredges, ferries and passenger vessels were involved in incident investigations. Therefore, the study focuses primarily on cargo, fishing and tank vessels. The report uses the lexicon of the Pacific States/British Columbia Oil Spill Task Force Spill and Incident Data Collection Dictionary (Data Dictionary) (1997) to define and categorize causal factors because it is the standard reference used in the Ecology investigative reports.

Vessel incidents analyzed in this report involved cargo ships, tank ships, tank barges, tugs, dredges, bulk carriers, ferries and passenger ships. The incident investigation reports detailed incidents and spills associated with the loss of steering, loss of propulsion, fire/explosions, equipment and structural failures, navigation errors, seaworthiness issues, and errors related to the transfer of oil (bunkering, internal transfers, and loading and discharging cargo). This report categorizes causal factors into five classes: equipment failure, organizational/management failure, external conditions, human error and unknown. Additional subcategories of more specific causal factors are further broken down within each of these broad classes.

The following is a summary of the most significant findings in this report:

Findings for All Spills and Incidents

FINDING #1: The principal root cause for mishaps is the organizational/management failure related to policies or procedures (OMF-Procedure/Policy).

FINDING #2: The principal root cause (OMF-Procedure/Policy) contributed to eight of the nine types of mishaps.

FINDING #3: The majority of procedural/policy root causes result in oil transfer mishaps.

FINDING #4: The most common secondary causes of all mishaps are human errors involving communication, judgment, inattention and procedural error.

FINDING #5: The dominant secondary causal factors are associated with mishaps such as oil transfers, navigation/ship handling, and equipment failure.

FINDING # 6:

a. OMF-Procedure/Policy and Maintenance failures contribute to approximately 70% of all cargo vessel mishaps.

b. OMF-Procedure/Policy failures contribute to more than half of all mishaps on fishing and tank vessels.

FINDING #7:

a. For cargo vessels, losses of propulsion mishaps are the most common, followed by errors in oil transfers and equipment failure.

b. For fishing and tank vessels, oil transfer mishaps are the most common, followed by equipment failure.

FINDING #8: For cargo vessels, oil transfer mishaps are primarily caused by OMF-Procedure/Policy failures, while losses of propulsion mishaps are primarily caused by OMF-Maintenance failures.

FINDING #9: For fishing and tank vessels, OMF-Procedure/Policy failures are the primary cause of errors in oil transfer mishaps.

Findings for Investigated Spills

FINDING #10: The principal root cause of investigated spills is OMF-Policy/Procedure.

FINDING #11: OMF-Procedure/Policy failures are the primary cause of errors in oil transfers for investigated spills.

FINDING #12: OMF-Procedure/Policy failures play a prominent role in investigated spills for fishing, tank and cargo vessels.

FINDING #13: Investigated spills involving fishing, tank and cargo vessels were most commonly caused by errors in oil transfers.

FINDING #14:

a. For cargo vessels, the majority of investigated spills occurred while bunkering.

b. For fishing vessels, the majority of investigated spills occurred while bunkering or conducting transfers.

c. For tank vessels, the majority of investigated spills occurred while loading and discharging cargo.

FINDING #15: OMF-Personnel and OMF-Equipment are the two most dominant secondary causes associated with the investigated spills.

II. BACKGROUND AND PURPOSE OF THE REPORT

In 2006, the Washington Oil Spill Advisory Council's Subcommittee on Lessons Learned conducted an initial evaluation of information from the Washington State Department of Ecology (Ecology), the United States Coast Guard (USCG) and others to identify underlying causes of vessel-related incidents and spills, including both primary and secondary causes. This study is a continuation of the Subcommittee's memorandum regarding a Review of Lessons-Learned Reports Pertaining to Prevention. More specifically, this study provides a framework for understanding how primary and secondary causes are involved in vessel related incidents with a more detailed analysis of the causal factors associated with vessel incidents and spills that have been identified in available incident investigation reports. For purposes of clarity, this study does not purport to identify or assess the risks associated with activities or vessels.

This study analyzes Type 2 and Type 3 investigative reports prepared by Ecology. Type 2 and Type 3 incident investigation reports primarily involve vessels greater than 300 gross tons. All available Ecology reports were requested for vessel-related incidents that occurred in the State of Washington, including the outer coast and the Columbia River, from 1990 to the present. However, the only reports available during this time period were from November 1993 to December 2006.

III. METHODOLOGY

A. Document Review – Information Sources

Through this study, we sought to review and analyze investigative reports for incidents in Washington waters from January 1, 1990 to present. For this report, "Washington waters" means the area from the Columbia River to the Strait of Juan de Fuca, including the outer coast. As the primary agencies charged with protecting the waters of the United States and Washington, USCG and Ecology were contacted to acquire reports within this study's scope. Staff from the agencies and three classification societies (American Bureau of Shipping, Det Norske Veritas, and Lloyds' Register) were interviewed at length regarding their expertise and insight into the investigative process, identification of root causes and other causal analysis, lessons learned from past incidents, personal experiences and other relevant information.

The analyses presented in this report are primarily based on the investigations and findings in reports prepared by Ecology. Ecology provided reports for 106 incident investigations that occurred between 1993 and 2006. Available reports from the National Transportation and Safety Board (NTSB) were also searched; however, no reports were available within the designated time or geographic search criteria.

In addition, USCG causal data was obtained for vessel incidents in Washington waters. However, due to the different methodologies used by the USCG in determining causal factors, the lack of detailed case specific incident information in the USCG database and the relative

absence of common data in the two agency databases, we were not able to conduct a meaningful analysis of the USCG information to either correlate and/or validate the analysis conducted in this report (see Section V).

The Ecology incident investigation reports used for this study are based on a standard and consistent investigation process that analyzes incidents to better understand ways to protect the environment by improving oil spill prevention efforts and increasing maritime safety in Washington. Since Ecology's incident reports were so important to this study, a detailed description of the agency's investigation process is discussed below.

B. Department of Ecology's Investigation Process

Ecology has established standard operating procedures (SOPs) to investigate incidents and oil spills. Ecology's initial decision to investigate an incident is based on a number of considerations, which include:

- Whether oil entered waters of the state; or if there is a substantial spill threat;
- Actual or potential amount of oil spilled;
- Complexity and significance of incident; and
- Compliance history of the responsible party.

Under agency guidelines, investigations are divided into three classes: Types 1, 2 and 3.

Ecology typically conducts Type 1 investigations for incidents involving relatively small vessels and incidents. These investigations are handled by field staff from Ecology's regional and headquarter offices and generally begin and end at this level. No follow-up is required beyond the initial information collected by lead field staff. Causal factors are noted in the field reports completed by field staff, but no investigative report is prepared. As a result, no causal analysis is available for Type 1 investigations.

Type 2 investigations are more significant and involve the designation of a lead investigator who is responsible for conducting and completing an investigation once the on-scene work by field staff is finished. There is usually some follow-up investigative work to further document the case. An incident investigation summary is completed that includes the identification of causal factors. Typically, oil spills greater than 25 gallons fall into this category. These investigations may take a few days to a few weeks to complete.

Type 3 investigations are even more complex than Type 2 investigations. Field staff and a lead investigator are involved and the appropriate program management team members are consulted. There is extensive investigation and documentation of the incident. Both a summary of the incident and a detailed narrative analysis of findings are completed. These incidents may take several weeks to many months to completely investigate.

Both Type 2 and Type 3 investigations result in the documentation of relevant causal factors contributing to the incident. Ecology makes no decision as to an incident's definitive causal factors until the investigation is complete. Once the investigation is finished, Ecology may send prevention recommendations based on the investigative findings to the responsible party, USCG and others. Ecology documents information from incident investigations in the form of investigative reports, prevention bulletins and safety advisory bulletins. Some of these reports are posted on Ecology's website for access by the general public.

C. Identification of the Causes of Incidents

For this study, incident investigation reports from Ecology were reviewed to determine the immediate cause and contributing factors associated with each vessel incident. The immediate cause of an incident is defined as the action or inaction that immediately preceded and led to the spill and/or event or near miss. Contributing factors are defined as those factors that contributed or led to the incident's immediate cause. Many of the incidents reviewed in this study had immediate causes that resulted from multiple simultaneous or sequential contributing factors. As described in Section D below, this study further classified contributing factors as primary and secondary causes to incidents. A root or primary cause is defined as the contributing factor that ultimately caused the incident. Secondary causes are those contributing factors not identified as the root cause but that contributed to the incident's occurrence.

Contributing factors for each incident were taken directly from the underlying Ecology investigative reports. The Ecology investigation reports defined contributing factors associated with each incident. These contributing factors were identified by investigators who interviewed witnesses, examined detailed data, inspected ships, took oil samples, and did other hands-on investigative work. This analysis has deferred to the determinations made by the expert investigators who conducted and oversaw the investigations, taking contributing factors directly from the reports.

In conducting incident investigations reviewed in this study, Ecology employed terminology consistent with the *Spill and Incident Reporting Data Collection Dictionary* (Data Dictionary) (1997) created by the Pacific States/British Columbia Oil Spill Task Force. The Data Dictionary is included with this report as Appendix A. The Data Dictionary was developed as an important tool to help investigators consistently collect, report, categorize and analyze spill and incident information. It includes definitions for items such as incident type, source, activity, and contributing causal factors by class and category. The Dictionary was used as the standard reference for common terminology and definitions for contributing factors and other information throughout this report.

The Data Dictionary categorizes contributing factors into five major classes:

1. External Conditions (EC)
2. Equipment Failure (EF)
3. Human Error (HE)
4. Organizational/Management Failure (OMF)
5. Unknown (O)

Each contributing factor is subdivided into specific categories. For example, equipment failure is separated into the different types of equipment (electrical, mechanical, structural and electronic). Similarly, Organizational/Management Failure is separated into different types of failure that relate to procedures/policy, personnel, equipment or maintenance issues. See Appendix A for a complete breakdown of contributing factors by class and category from the Data Dictionary.

The Ecology incident investigation reports identify the immediate, but not the primary cause of an incident. For example, the immediate cause of an oil spill may have been grounding of the vessel, but contributing factors such as human fatigue, equipment failures, procedural problems or weather related issues may have played crucial roles as well. One of these contributing factors was likely more important than the others in causing the incident, and that factor is defined as the primary or root cause. Because the Ecology reports do not identify an incident's primary cause, for this study EI conducted an independent evaluation of primary causes. Professional judgment was used to identify the primary cause based on a case-by-case review of each incident's facts and circumstances. After reviewing all available information in the reports, a detailed qualitative analysis ranked the importance of each factor in incident causation. Where possible, the series of events that gave rise to the incident was mapped out to help identify the underlying primary cause or root of the incident. In addition, a "what-if" analysis was conducted to identify the most substantial factor contributing to the incident, with all other contributing factors categorized as secondary. Interrelationships among contributing factors were also analyzed.

D. Analysis of Causal Factors

All of the data were evaluated to identify and rank the specific contributing factors most critical in incident causation. Due to the small sample sizes when examining the incident investigations by category, it was not possible to test for statistical significance or correlations in the data. Instead, this study ranks the causal factors by prevalence and qualitatively describes the data.

As a first step in characterizing the information, similar categories of contributing factors (e.g. lack of procedure, inadequate procedure) were combined to facilitate presenting a large amount of like data in a more understandable way. For example, contributing factors for organizational/management failures consist of the following sub-groups:

- OMF: Policy/Procedure –
    - Lack of Procedure/Policy
    - Inadequate Procedure/Policy
    - Inadequate Implementation of Procedure/Policy
- OMF: Maintenance –
    - Lack of Planned Maintenance Program
    - Inadequate Planned Maintenance Program
    - Inadequate Implementation of Planned Maintenance Program
- OMF: Equipment –
    - Equipment design
    - Manufacture/construction
    - Installation
- OMF: Personnel –
    - Lack of supervision
    - Poor oversight
    - Insufficient personnel
- OMF: Training – Inadequate training

In addition to ranking causal factors by incident investigation, an evaluation was conducted to show root and secondary causes by mishap or activity type (e.g. loss of propulsion or transfer spill). The Data Dictionary was used to define the mishaps by category. Because the Data Dictionary does not include a spill within the definition of an "incident," a new term is being introduced for this study's purposes. This study uses the term "mishap" to encompass a specific event or occurrence that triggered the incident investigation. The term mishap applies to all incidents regardless of whether or not there is a spill. Although allisions, collisions, and groundings are included within the Data Dictionary's definition of an incident, they are excluded from the definition of a mishap, as they result from the events categorized under mishaps. Upon

review of the investigative reports, nine types of mishaps were identified. The types of mishaps include:

1. Equipment Failure
2. Fire/Explosion
3. Loss of Power
4. Loss of Propulsion
5. Loss of Steering
6. Navigation/Ship Handling
7. Seaworthiness/Fitness of Service
8. Structural Failure
9. Oil transfers

These types of mishaps were selected on two bases. First, the study relied on the Data Dictionary and the criteria it uses to categorize incidents. Second, the study identified occurrences in the Ecology investigative reports that did not fall within the criteria identified in the Data Dictionary; they can most easily be described as loss of power and oil transfers. As a result, these categories were added to the list found in the Data Dictionary.

Vessels involved in the incidents have also been grouped by class. The primary classes of vessels are cargo vessels, dredges, fishing vessels, tank vessels and tugs. For this report, the term "cargo vessel" includes all cargo ships, bulk carriers and the various types of container ships. The term "tank vessels" includes tank ships and tank barges.

The terms "root cause" and "primary cause" are used synonymously in this report to identify each incident's principal contributing factor. Other contributing factors are shown in the raw data and several analyses and charts to illustrate which factors are important to consider as secondary causes. Using this information, an analysis was conducted with a goal of ranking root and secondary causes in the order of which would, if prevented, have the greatest potential to effectively reduce the risk of mishaps. This ranking was based on several factors, which include:

- The determination of primary or root cause
- The determination of other contributing factors or secondary causes
- An analysis of the importance of each contributing factor in causing the incident
- Any commonalties within categories of contributing factors that could be easily grouped together to identify a single issue or related cause within the overall category (e.g. policy/procedure)
- Grouping types of vessels, mishaps and other activities to identify any causal trends within each category of activity or association between activities

E. General Description of the Data

Ecology provided investigation reports for 106 incidents involving vessels. Information was documented for each incident to the maximum extent possible, including date and time, incident type, vessel class, activity, weather, causal factors and other data. In 12 of the incident investigation reports, contributing factors were not identified because too little information was available to the investigating field staff, leaving a total of 94 incidents that could be effectively evaluated in this study. Therefore, the remainder of this report only addresses the characteristics of the 94 incidents that were analyzed in more depth. Summary statistics of the reports are briefly presented below and in Appendix B to provide a more detailed understanding of the incident investigation reports available for this study. Appendix C provides a list of the reports reviewed for this study.

The majority of the reports analyzed were from incidents occurring between 1997 and 2002 (Figure Appendix B-1). The number of contributing factors for each incident ranged from one to six, with an average of three contributing factors per incident (Figure Appendix B-2). The mishaps associated with the incidents primarily involved oil transfer problems (37%), loss of propulsion (18%) and general equipment failure (16%) (Figure Appendix B-3). More than half of the incidents involved a spill of some degree (50 spills). The vessels involved in the incidents included bulk carriers, cargo ships, dredges, ferries, fishing vessels, tank barges, passenger ships, tank ships and tugs (Figure Appendix B-4). The majority of the vessels involved in the incidents were cargo vessels (42%), tank vessels (29%), and fishing vessels (24%).

IV. CAUSAL ANALYSIS AND FINDINGS

The following section analyzes contributing factors and ranks both primary (or "root") and secondary causes for all incidents and ranks primary causes for incidents involving spills. The analysis further ranks casual factors by mishaps and vessel class. Additionally, an analysis of primary causes is presented based on the timing of spills.

A. Analysis of Causal Factors of All Incidents

1. <u>Root Causes</u>

a) Overall

At the most basic level, the most significant advances in oil spill prevention can be accomplished by addressing the most common (or "dominant") root causes of incidents. In analyzing the root causes of all 94 incident investigations relied upon for this study, more than 80% of all incidents was associated with an organizational or management failure (OMF). See Figure IV.A-1. About ten percent of root causes involved human error (HE). Very few incidents had root causes associated with equipment failure (EF) or external conditions (EC). The line in Figure IV.A-1 provides a cumulative total of the percentages of the classes from left to right.

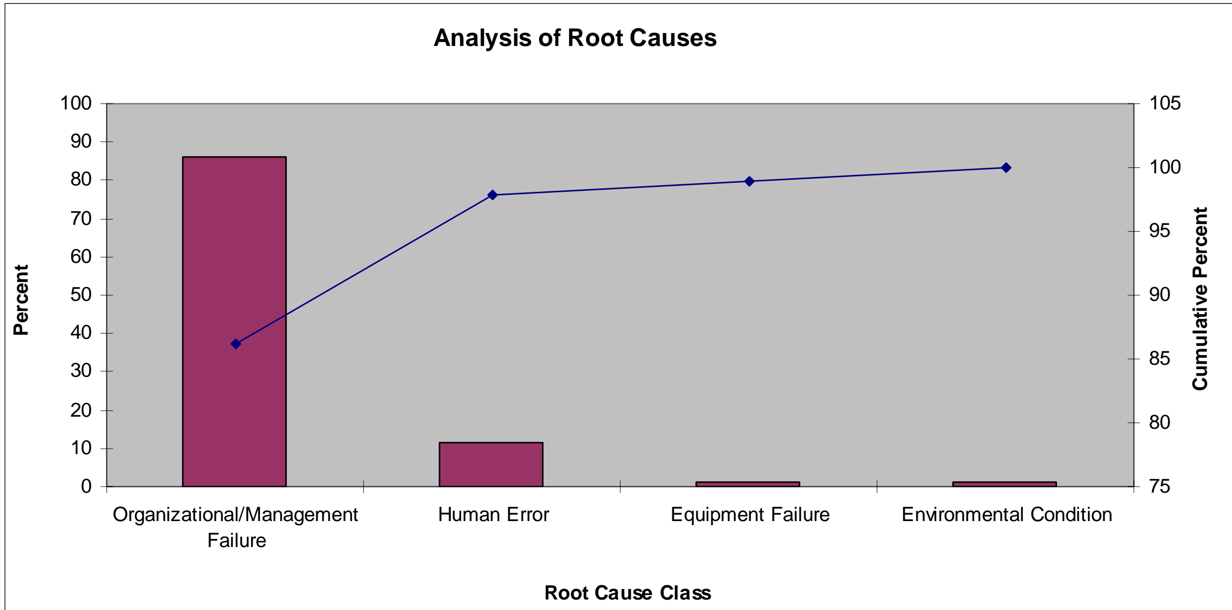

Figure IV.A-1: Analysis of Root Causes by Class

When root causes were examined at the next lower level or category, problems with policies and procedures were the principal root cause of more than 40% of the incidents analyzed. See Figure IV.A-2. Another 40% of mishaps were caused by organizational/management failures associated with maintenance, equipment, personnel, and training inadequacies. The remainder of the root cause analysis will focus on these organizational and management failures, as they were the underlying reason for the majority of mishaps.

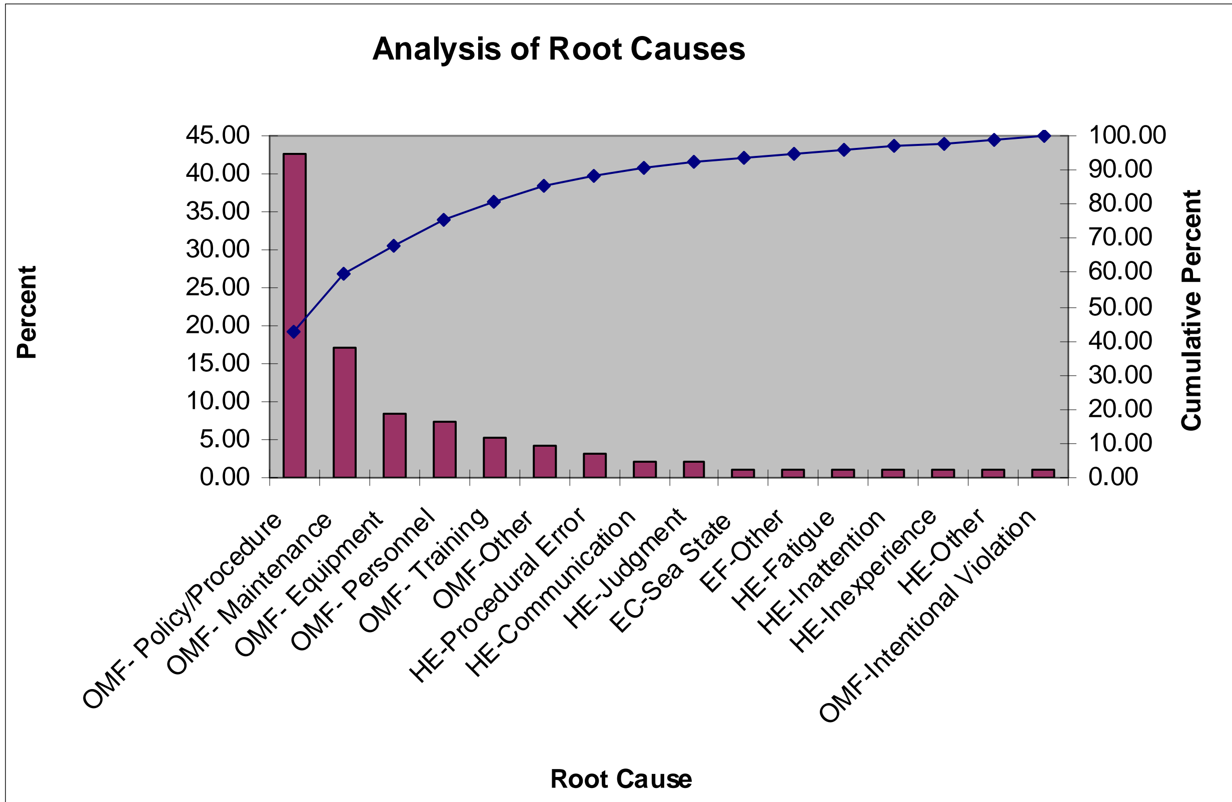

Figure IV.A-2: Analysis of Root Causes by Category

FINDING #1: The principal root causes for mishaps analyzed in this study are organizational or management failures related to policies or procedures.

Identification of the dominant root causes of incidents is helpful; however, it is only the first step in understanding the root causes of incidents. The next issue to address is what types of mishaps result from the dominant root causes. The following section examines the relationship between mishaps and the dominant root causes.

b) Mishaps

As described above, this section presents an analysis of the dominant root causes associated with mishaps. Of the 94 investigative reports examined, 76 were associated with one of the dominant organizational/management failures. Mishaps related to oil transfers, loss of propulsion and equipment failure constitute more than 50% of the events associated with dominant root causes. See Table IV.A-1. Examination of the data further shows that more than half of the organizational/management failures involved procedure/policy failures. See Table IV.A-2. With the exception of Seaworthiness/Fitness for Service issues, each type of mishap was caused by at least one procedure or policy failure. Loss of propulsion and seaworthiness/fitness for service were the only mishaps where policy/procedure failures were not the most prevalent root cause.

Mishap	Number of Incidents
Oil Transfer	29
Loss of Propulsion	15
Equipment Failure	12
Fire/Explosion	4
Loss of Power	4
Loss of Steering	4
Navigation/Ship Handling	4
Structural Failure	3
Seaworthiness/Fitness for Service	1
Total	76

Table IV.A-1: Mishaps from Investigative Reports Associated with the Dominant Root Causes

Ranking dominant root causes by mishap suggests that mishaps related to oil transfers, equipment failure, and loss of propulsion most commonly involve a failure of a policy or procedure. Combined, oil transfers, loss of propulsion and equipment failure mishaps that were caused by procedure/policy failures comprised 41% of the incident investigations shown in the table below.

Mishap	OMF-Procedure/Policy	OMF-Maintenance	OMF-Equipment	OMF-Personnel	OMF-Inadequate Training	Total
Oil Transfers	19	3	2	3	2	29
Loss of Propulsion	4	6	2	1	2	15
Equipment Failure	8	3	1			12
Fire/Explosion	1	1	1	1		4
Loss of Power	1	1		1	1	4
Loss of Steering	1	1	1	1		4
Navigation/Ship Handling	4					4
Structural Failure	2		1			3
Seaworthiness/Fitness for Service		1				1
Total	40	16	8	7	5	76

Table IV-A-2: Mishaps Associated with the Dominant Root Causes

FINDING #2: The principal root cause (OMF-Procedure/Policy) contributed to eight of the nine types of mishaps.

FINDING #3: The majority of policy/procedural root causes result in oil transfer mishaps.

2. Secondary Causes

a) Overall

In addition to ranking the primary causal factors associated with vessel-related mishaps, this study seeks to rank secondary causal factors. As previously defined, secondary causal factors are those contributing factors involved in an incident that are not primary or root causes. A contributing factor, therefore, may be a primary or secondary cause depending on the facts of a particular case. Because of this nuance, an initial analysis of secondary causal factors resulted in a pattern of dominant secondary causal factors similar to that seen in the primary causal analysis. Presentation of the information in this manner is redundant because the dominant root causal factors have already been identified as areas of further investigation to improve oil spill prevention.

Therefore, for purposes of the analysis of secondary causes, contributing factors associated with the dominant primary causes have been removed from the data set of secondary causal factors. All 268 contributing factors for the 94 incidents were screened. Contributing factors that fell within the dominant primary causes were removed resulting in a data set of 134 contributing factors associated with factors other than policy/procedure, maintenance, personnel, or training. See Table IV.A-3. The analysis shows that, unlike the primary causal analysis where one factor was overwhelmingly prevalent, several contributing factors occur at a similar frequency. See Figure IV.A-3.

Secondary Causal Factors	Total
O/MF-Other	18
HE-Communications	17
HE-Judgment	15
HE-Inattention	14
EC	14
HE-Procedural Error	12
HE-Inexperience	8
O/MF-Sabotage/ Intentional Violation	7
HE-Improper equipment use	5
HE-Other	5
EF-Mechanical Failure	4
EF-Other	4
HE-Fatigue	4
EF-Structural	3
EF-Electrical	2
HE-Language	1
HE-Inaccurate computation	1
Total	134

Table IV.A-3: Secondary Causal Factors

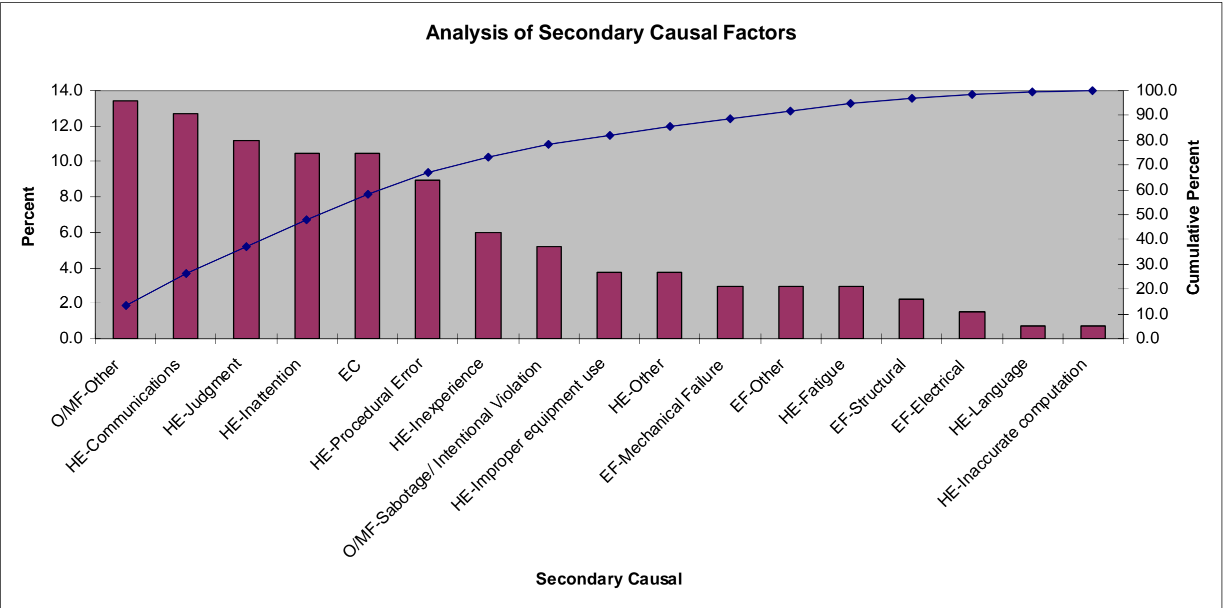

Figure IV.A-3: Analysis of Secondary Causal Factors

The first secondary causal factor presented in Figure IV.A-3 is OMF-Other. This is a catchall category for organizational or management failures that did not fit within the Data Dictionary definitions. For instance, a ship that had a wooden frame, which was allowable, contributed to a fire on the vessel. There is no common theme associated with these errors, except that they are related to issues within organizational or management control. Because these do not fall within a neat category that provides for the ability to address a specific issue and because in some instances the causes in the O/MF-Other category may be addressed indirectly in the course of addressing the dominant primary causes, this category will not be discussed further in this analysis.

The dominant secondary causal factors are human error associated with communication, judgment, inattention, and procedural errors. External conditions also account for just over ten percent of secondary factors. The distinction between human error factors is too subtle to identify an overall principal secondary cause, as they are involved with mishaps at similar frequencies. Therefore, a more detailed examination of the dominant secondary causal factors in the context of mishaps is necessary.

FINDING #4: The most common secondary causes of all mishaps are human errors involving communication, judgment, inattention and procedural error.

b) Mishaps

The dominant secondary causal factors identified above most commonly trigger mishaps involving oil transfers, navigation/ship handling and equipment failure. See Table IV.A-4. A detailed analysis of the dominant secondary causes shows that mishaps related to oil transfers were never caused by external conditions. See Table IV.A-5. The four human errors of communications, judgment, inattention and procedural error contributed equally to oil transfer mishaps.

Mishap	Total
Oil Transfer	34
Navigation/Ship Handling	13
Equipment Failure	12
Loss of Propulsion	7
Structural Failure	4
Loss of Power	1
Seaworthiness/ Fitness for Service	1
Total	72

Table IV.A-4: Secondary Causal Factors by Mishap

The distinctions between the dominant secondary causal factors associated with the other mishap types are too subtle to draw definite conclusions; however, the data suggest that there may be an association between external conditions and mishaps involving equipment failure, navigation/ship handling, and loss of propulsion. There also may be an association between communication problems and navigation/ship handling and between judgment and equipment failure.

Mishap	HE-Communications	HE-Judgment	HE-Inattention	EC	HE-Procedural Error	Total
Oil Transfer	8	8	9		9	34
Navigation/Ship Handling	4	1	2	4	2	13
Loss of Propulsion	2	1		4		7
Equipment Failure	1	4	2	4	1	12
Structural Failure	1		1	2		4
Loss of Power	1					1
Seaworthiness/ Fitness for Service		1		0		1
Total	17	15	14	14	12	72

Table IV.A-5: Mishaps Associated with the Dominant Secondary Causes

FINDING #5: The dominant secondary causal factors are associated with mishaps such as oil transfers, navigation/ship handling, and equipment failure.

B. Analysis of Root Causes by Vessel Class

The incident investigation reports provided by Ecology primarily involve cargo, fishing and tank vessels. Because vessels in other classes comprise a minor portion of the investigative reports included in this study (approximately 5%), only the three major classes of vessels will be addressed here. Section A above presented an analysis of the primary and secondary causal factors overall and in relation to the different types of mishaps. The next step in ranking the priority of causal factors is to inquire further into the association among vessels, causal factors, and mishaps. The following sections examine the interrelationships between vessel classes and primary causes.

The analysis of root causes above identified that failures associated with procedures and policies are most commonly responsible for mishaps. Further, the most common type of mishap (involving errors in oil transfers) was most frequently associated with procedural and policy failures. In exploring and analyzing how these findings apply to the different vessel classes, we ranked root causes by vessel class. For each of the three vessel classes, OMF-Procedure/Policy accounts for close to or more than half of the events associated with the dominant root causes. OMF-Maintenance failures also contributed to a large percentage of cargo vessel mishaps. See Table IV.B-1.

Vessel Class	OMF-Procedure/Policy	OMF-Maintenance	OMF-Equipment	OMF-Personnel	OMF-Inadequate Training	Total
Cargo Vessels	14	9	2	3	3	31
Fishing Vessels	13	3	3	2	1	22
Tank Vessels	10	4	3		1	18
Total	37	16	8	5	5	71

Table IV.B-1: Dominant Root Causes by Vessel Class

FINDING # 6:

a. OMF-Procedure/Policy and Maintenance failures contribute to approximately 70% of all cargo vessel mishaps.

b. OMF-Procedure/Policy failures contribute to more than half of all mishaps for fishing and tank vessels.

When examined from the perspective of mishaps there was less of a similarity between the vessel classes. 42% of cargo vessel mishaps involved the loss of power, and 93% of the loss of propulsion mishaps investigated were associated with cargo vessels. See Table IV.B-2. In contrast, 68% of fishing vessel mishaps and 39% of tank vessel mishaps involved errors in oil transfers. 54% of all of the mishaps involving oil transfers occurred on fishing vessels.

Although errors associated with oil transfers only comprise 19% of the mishaps associated with cargo vessels, the fact that cargo vessels had six oil-related mishaps is important. Similarly, each of the vessel classes had four mishaps associated with equipment failure.

Vessel Class	Oil Transfer	Loss of Propulsion	Equipment Failure	Fire/ Explosion	Loss of Steering	Structural Failure	Navigation/ Ship Handling	Loss of Power	Seaworthiness/ Fitness for Service	Total
Cargo Vessel	6	13	4	1	1	1	2	2	1	31
Fishing Vessel	15		4	2			1			22
Tank Vessels	7	1	4	1	3	2				18
Total	28	14	12	4	4	3	3	2	1	71

Table IV.B-2: Mishaps associated with Vessel Class (Dominant Root Causes)

FINDING #7:

a. **For cargo vessels, loss of propulsion mishaps are the most common, followed by errors in oil transfers and equipment failure.**

b. **For fishing and tank vessels, oil transfer mishaps are the most common, followed by equipment failure.**

As Finding #6 showed, cargo vessel mishaps are most commonly due to failures of procedures and policies and maintenance. Also, the majority of cargo vessel mishaps are related to the loss of propulsion and oil transfer errors. There appears to be a connection between these findings. Loss of propulsion was caused by all five dominant root causes, with OMF-Maintenance responsible for 46% and OMF-Procedure/Policy responsible for 23% of these mishaps respectively. See Table IV.B-3. OMF-Procedure/Policy failures accounted for 67% of oil transfer mishaps, while none of these mishaps were as a result of maintenance failures.

Root Cause	Loss of Propulsion	Oil Transfer	Equipment Failure	Navigation/ Ship Handling	Loss of Power	Loss of Steering	Seaworthiness/ Fitness for Service	Fire/ Explosion	Structural Failure	Total
OMF- Procedure/Policy	3	4	3	2				1	1	14
OMF-Maintenance	6		1		1		1			9
OMF- Personnel	1	1				1				3
OMF-Inadequate Training	2				1					3
OMF-Equipment	1	1								2
Total	13	6	4	2	2	1	1	1	1	31

Table IV.B-3: Dominant Root Causes Associated with Cargo Vessels

FINDING #8: For cargo vessels, oil transfer mishaps are caused primarily by OMF-Procedure/Policy failures, while loss of propulsion mishaps are caused primarily by OMF-Maintenance failures.

As one would expect, based on Findings 7 and 8, OMF-Procedure/Policy failures are the greatest cause of mishaps associated with oil transfers for both fishing vessels (67%) and tank vessels (71%). See Tables IV.B-4 and IV.B-5.

Dominant Root Cause	Oil Transfer	Equipment Failure	Fire/ Explosion	Navigation/ Ship Handling	Total
OMF- Procedure/Policy	10	2		1	13
OMF-Maintenance	2	1			3
OMF-Equipment	1	1	1		3
OMF- Personnel	1		1		2
OMF-Inadequate Training	1				1
Total	15	4	2	1	22

Table IV.B-4: Dominant Root Causes Associated with Fishing Vessels

Dominant Root Cause	Oil Transfer	Equipment Failure	Loss of Steering	Structural Failure	Fire/ Explosion	Loss of Propulsion	Total
OMF- Procedure/Policy	5	3	1	1			10
OMF-Maintenance	1	1	1		1		4
OMF-Equipment			1	1		1	3
OMF-Inadequate Training	1						1
Total	7	4	3	2	1	1	18

Table IV.B-5: Dominant Root Causes Associated with Tank Vessels

FINDING #9: For fishing and tank vessels, OMF-Procedure/Policy failures are the primary cause of errors in oil transfer mishaps.

C. Analysis of Incident Investigations Involving Spills

The following section provides an analysis of contributing factors in relation to investigated spill incidents. The prior sections provided a framework for ranking contributing factors for all incidents. That analysis is helpful, as any one mishap could result in a large-scale spill. However, it is also useful to analyze and prioritize causal factors associated with actual spills. Because this study's intent is not to make risk determinations, this analysis is based on the occurrence of oil spills and not upon the size of the spills.

Ranking causal factors in association with mishaps that specifically result in spills is a helpful step toward improving spill prevention. Before presenting the rankings, it is important to understand the subset of incident investigations involving spills. Of the 94 incident investigations relied upon for this study, 50 involved spills. Of course, undoubtedly more spills occurred during this period for which no investigative reports were available. Also, possible actions taken during the course of an incident might have prevented the situation from becoming worse, resulting in an oil spill.

Ninety-six percent of the spills investigated involved fishing, tank, and cargo vessels. See Figure IV.C-1.

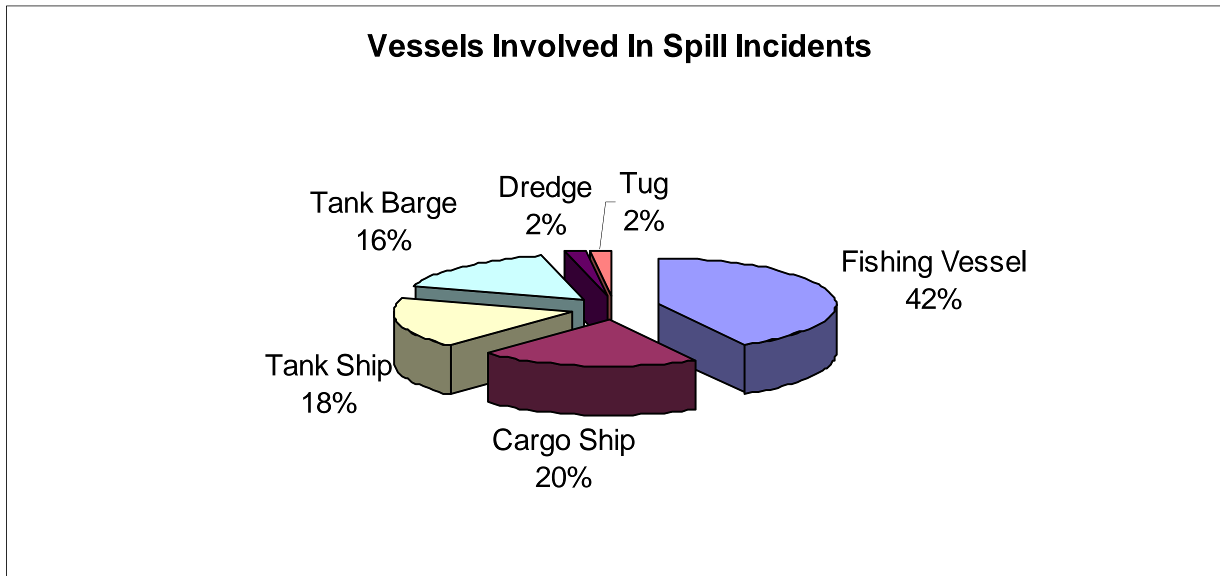

Figure IV.C-1: Percentage of Vessels Involved in Incidents

As Figure IV.C-2 shows, fishing vessels were responsible for 21 spills (44%); tank vessels were responsible for 18 (37%); and cargo vessels were responsible for nine of the spills (19%). Of the fishing vessel spills, 80% were less than 250 gallons in volume. Tank vessels were the only class of vessels that had spills greater than 1,000 gallons.

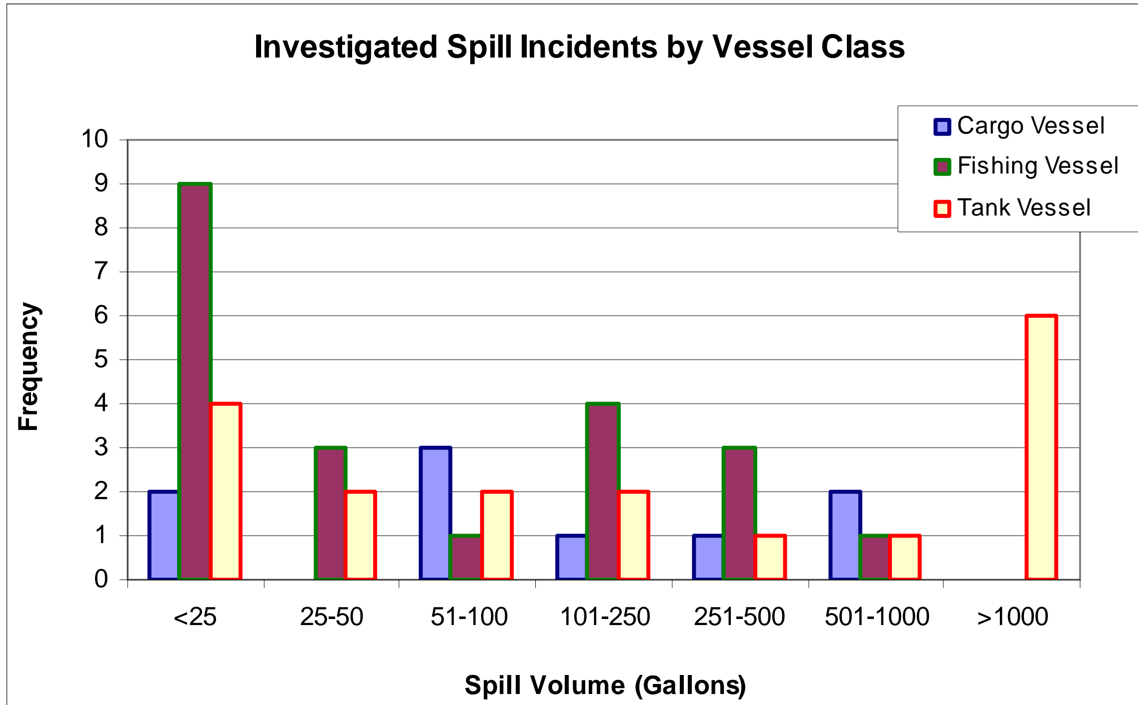

Figure IV.C-2: Investigated Spills by Vessel Class

The majority of the spills occurred while vessels were stationary. Only four of the spills (8%) occurred while vessels were underway. In Figure IV.C-3, three of these spills are categorized under the activity heading of "underway" as this was the primary activity at the time of the spill. The spills were associated with a collision, an allision and a grounding resulting from navigational mishaps. The fourth spill that occurred underway involved an internal transfer, and is therefore presented in this table as an "internal transfer". Each of the spills occurring while the vessels were underway was greater than 500 gallons. The majority of spills happened while vessels were stationary and bunkering, conducting transfers, or loading or discharging cargo.

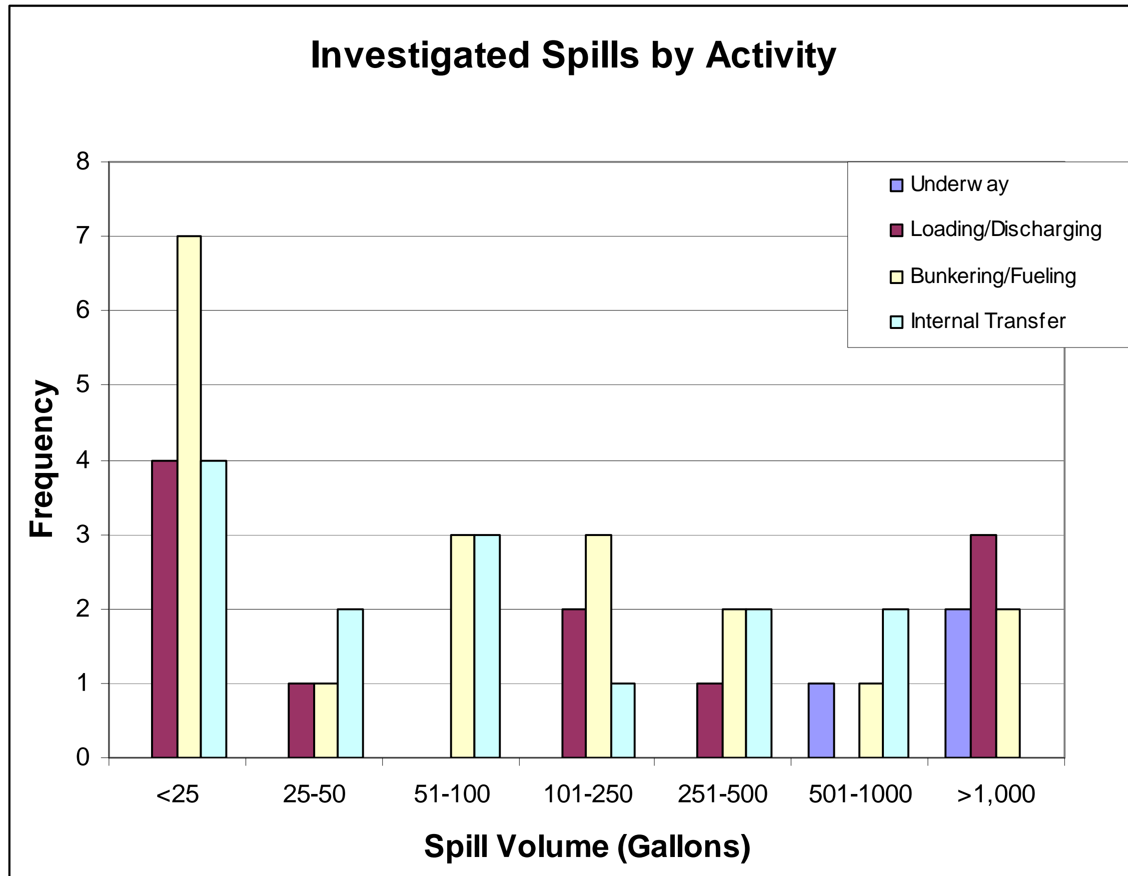

Figure IV.C-3: Investigated Spills by Activity

1. Root Causal Analysis of Investigated Spills

Following the analytical process set out in the prior sections, the analysis of Ecology investigations into spills begins with the overall ranking of primary causes. Ranking the primary or root causes by frequency of occurrence, the principal root cause of spills is the same as the principal root cause of all investigated incidents: organizational or management failure involving a policy or procedure (OMF-Policy/Procedure). See Figure IV.C-4. Policy or procedural failures are the primary cause of 52% of the spills investigated by Ecology. OMF-Maintenance is the second most common root cause, contributing to an additional 12% of spills.

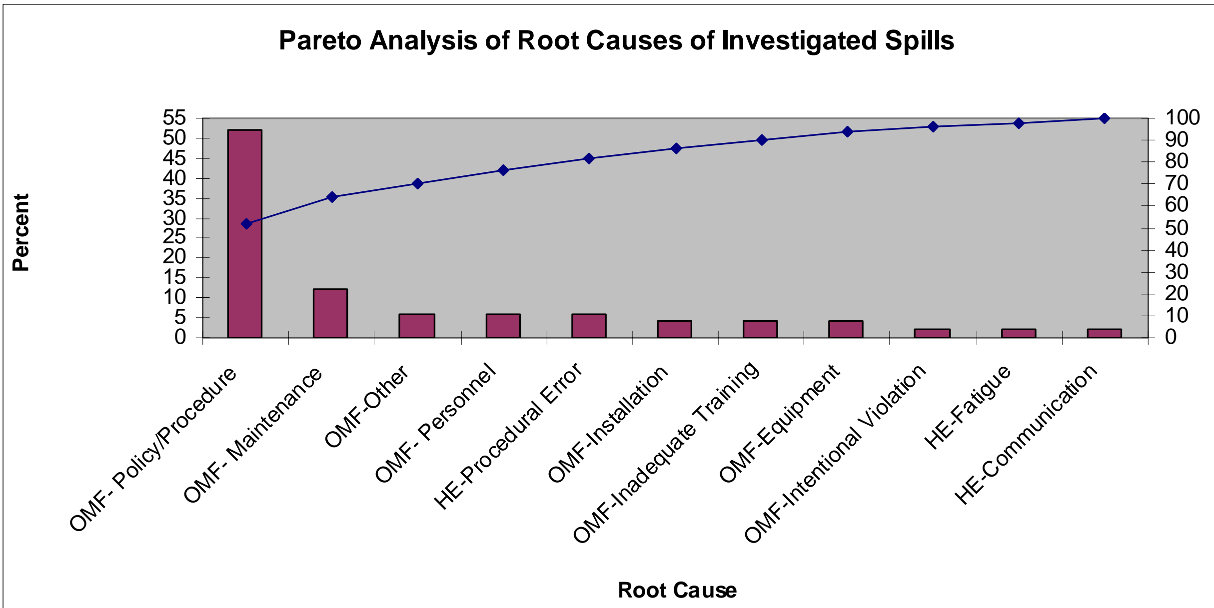

Figure IV.C-4: Analysis of Root Causes of Investigated Spills

FINDING #10: The principal root cause of investigated spills is OMF-Policy/ Procedure

As observed in Table IV.C-1, oil transfer mishaps are primarily associated with OMF-Procedure/Policy failures, and vice versa.

Mishap	Dominant Root Cause		Total
	OMF-Procedure/ Policy	OMF-Maintenance Program	
Oil Transfer	19	3	22
Equipment Failure	5	2	7
Seaworthiness/Fitness for Service		1	1
Structural Failure	1		1
Total	25	6	31

Table IV.C-1: Dominant Root Causes for Spills by Mishap

FINDING #11: OMF-Procedure/Policy failures are the primary cause of errors in oil transfers for investigated spills.

After observing that the majority of spills are caused by procedural and policy failures and that the majority of mishaps associated with errors in oil transfers are caused by procedural/policy failures, the next question is to examine the association between the principal root cause and vessel class. Approximately half of the procedure/policy failures gave rise to spills on fishing vessels. Conversely, the majority of spills on fishing vessels are caused by OMF-Procedure/Policy failures.

Vessel Type	Dominant Root Cause		Total
	OMF-Procedure/ Policy	OMF-Maintenance	
Fishing Vessel	12	3	15
Tank Vessel	8	2	10
Cargo Ship	5	1	6
Total	25	6	31

Table IV.C-2: Dominant Root CausesSpills by Vessel Class

FINDING #12: OMF-Procedure/Policy failures play a prominent role in investigated spills for fishing, tank and cargo vessels.

As would be expected, the majority (68%) of investigated spills were associated with oil transfer mishaps. See Table IV.C-3. Within this category of mishap, fishing vessels contributed to 48% of spills, while tank vessels and cargo vessels contributed to 27% and 24% respectively. Beyond the oil transfer mishaps, another 18% of investigated spills were associated with equipment failure, and the remaining 14% of spills involved navigation/ship handling, structural failure and seaworthiness/fitness for service.

Vessel Class	Oil Transfer	Equipment Failure	Navigation/ Ship Handling	Structural Failure	Seaworthiness/ Fitness for Service	Total
Fishing Vessel	16	4	1			21
Tank Vessels	9	4	1	3		17
Cargo Vessel	8	1			1	10
Total	33	9	2	3	1	48

Table IV.C-3: Vessels by Mishap for Investigated Spills

FINDING #13: Investigated spills involving fishing, tank and cargo vessels most commonly involved errors in oil transfers.

Further analysis shows that the majority of spills on cargo and fishing vessels are due to mishaps associated with the activity of bunkering. See Table IV.C-4. Tank vessels, however, have a larger percentage of spills occurring while loading/discharging cargo.

	Cargo Ship			Fishing Vessel			Tank Vessel			
Mishap	Bunkering/ Fueling	Internal Transfer	Loading/ Discharging	Bunkering/ Fueling	Internal Transfer	Drydocking	Loading/ Discharging	Internal Transfer	Bunkering/ Fueling	Stationary
Oil Transfer	7		1	10	5	1	4	2	2	1
Equipment Failure		1		1	3		3	1		
Total	7	1	1	11	8	1	7	3	2	1

Table IV.C-4: Most Fequent Mishaps Resulting in Investigated Spills for Each Vessel Class by Activity

FINDING #14:

a. For cargo vessels, the majority of investigated spills occurred while bunkering.

b. For fishing vessels, the majority of investigated spills occurred while bunkering or conducting transfers.

c. For tank vessels, the majority of investigated spills occurred while loading and discharging cargo.

The most dominant secondary causal factors are organizational and management failures associated with personnel and equipment. See Figure IV.C-5. In addition, human errors associated with inattention, judgment, procedural errors and communication were also commonly associated with investigated spill incidents.

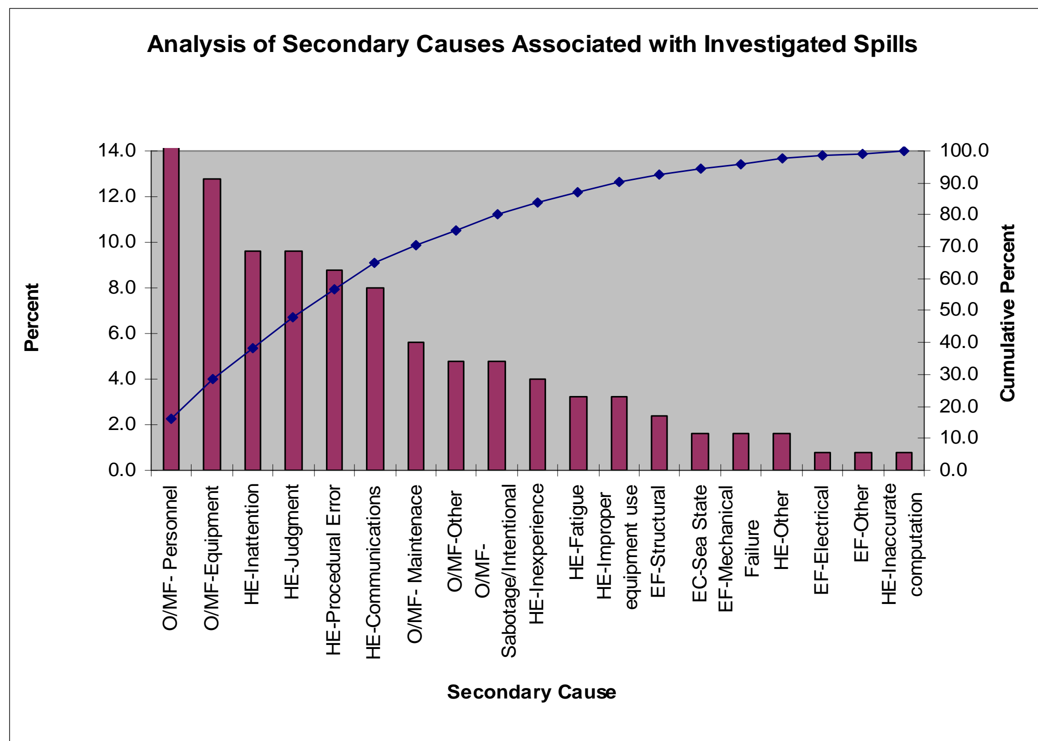

Figure IV.C-5: Analysis of Secondary Causes Associated with Investigated Spills

When examined in further detail, 74% of the secondary causal factors contributed to errors in oil transfers. There is too little data to make any observations regarding secondary causes for the remaining eight categories of mishaps.

FINDING #15: OMF-Personnel and OMF-Equipment are the two most dominant secondary causes associated with the investigated spills.

2. Analysis of Investigated Spills by Time

An additional examination of spill events was conducted to determine if certain mishaps or causes occurred more frequently with the time of day. When grouped into 2-hour increments, the majority of incidents appear to occur during two periods in the day. See Figure IV.C-6. Between the 0400 and 1400 hours, 66% of the spills occurred. Another 18% of spills occurred between 2200 and 0200.

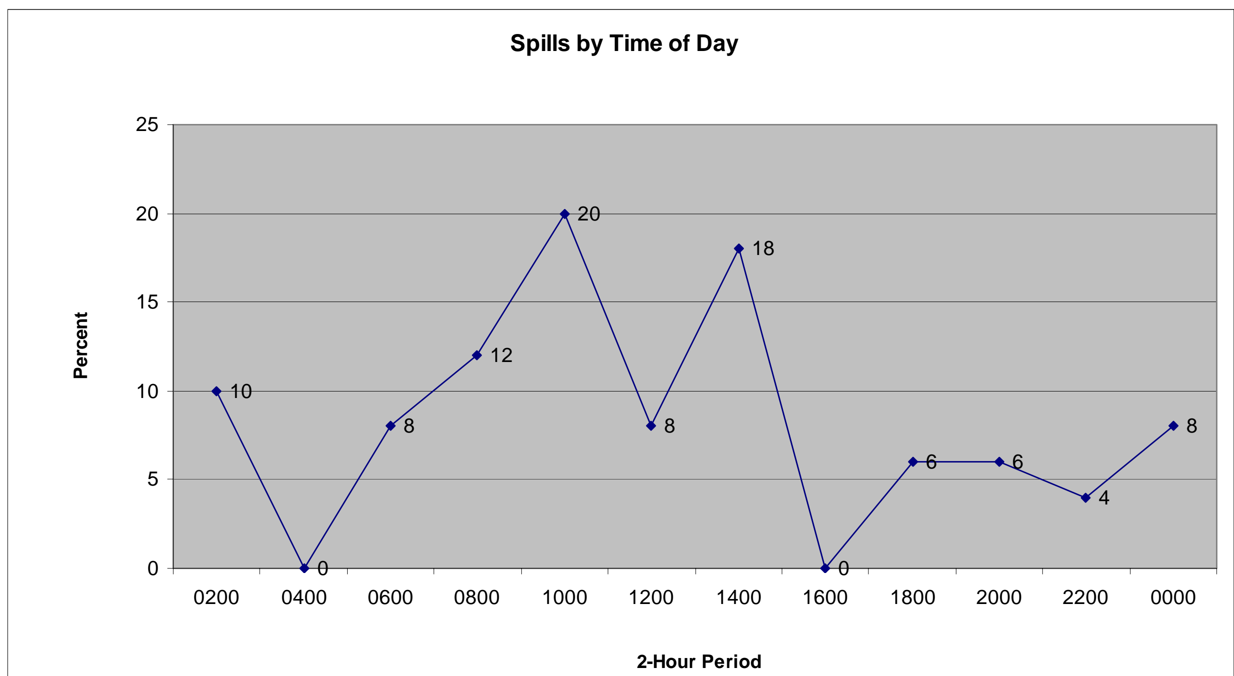

Figure IV.C-6: Investigated Spill Incidents by Time*

*(Numbers on line represent actual numbers of incidents)

A further analysis of the data shows that during these peaks fishing vessels are bunkering and conducting transfers; tank vessels are loading and discharging cargo; and cargo vessels are bunkering. See Table IV.C-5. As detailed in Finding #13, these spills are primarily caused by policy and procedure failures.

Vessel Class	Bunkering/ Fueling	Internal Transfer	Loading/ Discharging	Underway	Drydocking	Stationary	Total
Fishing Vessel	9	7		1	1		18
Tank Vessels	2	3	7	1		1	14
Cargo Vessel	6	1	1				8
Total	17	11	8	2	1	1	40

Table IV.C-5: Investigated Spills During Peak Periods - Activity and Vessel Class

V. USCG INCIDENT DATA CAUSAL ANALYSIS

Analysis of USCG data

EI staff contacted the USCG to obtain causal data and other information on vessel incidents for Washington waters. The USCG provided us with a causal database that contained a complete list of causes for all casualties in the U.S. investigated by the Coast Guard for vessels from 1996-2007. The USCG records casual factors for "significant" marine casualties as defined by agency policy so the database only covers about 10-15% of vessel incidents. Significant marine casualties are those that meet certain criteria involving deaths, injuries, property damage, vessel loss, collisions, flooding/fire, and other issues. We combined this causal database with additional USCG data for vessel casualties published to the public through the National Technical Information Service (NTIS). In addition, the USCG provided us with a website that provided limited investigative information. Although the USCG did provide causal information for some incidents, not enough incident specific detailed information was available to allow meaningful analysis.

Once we obtained the NTIS database and USCG causal information, we screened it to further identify Washington specific incidents. We communicated with the USCG several times during the analysis of their data to better understand their principles of causal analysis, scope of the data, investigative process, incident details, etc. The screening process resulted in 2079 records covering 511 individual vessel incidents from 2000-2007.

After reviewing USCG incident causal data, we found that there were significant challenges in using the information in this analysis due to the following issues.

1. <u>The USCG and Ecology use two different methodologies for their causal analyses.</u>
   The USCG uses a process that was adopted from the International Maritime Organization (IMO) code which integrates human errors across the spectrum of causal factors. Under this process, all maritime operations are considered part of an overall marine transportation system. Maritime operations are considered part of a production system that transports commodities (including people) by sea. Many different factors are integrated to produce a safe fuel transfer, transit, or waterways use. These include, for example, aids to navigation, vessel traffic systems, laws and regulations, and safety inspections.

The marine transportation production system is described in terms of five basic categories or elements – organizations, workplace, production, defenses, and preconditions. Each of these categories is established in the context of the role they play within the marine transportation production model. For example:

- the "organization" element is where goals are set and the means to achieve them are established (e.g. procedures, training)
- "workplace" is considered where and how production occurs (e.g. schedules, communications),
- "production" is the actual operations of the system (e.g. fuel transfers),
- the "precondition" element addresses the conditions that affect people's ability to work (e.g. work gear, fatigue), and
- "defenses" are the safeguards that protect people and equipment from injury or damage (e.g. warning systems, regulations).

These five elements are then further divided into more than 120 detailed factors that describe organizational, human error, equipment failures, and other factors. Some of these factors are common to one or more of the five major elements. In addition, the USCG process uses a very detailed analysis of the role human error plays in causing incidents.

This approach differs greatly from Ecology's way of conducting a causal analysis, which is based on the States/B.C. Oil Spills Task Force data dictionary. The data dictionary establishes four primary categories of causal factors--organizational failures, equipment failures, external conditions, and human error. In the USCG methodology, these four causal categories are broadly integrated into all five of the production system elements. As a result, a causal analysis using these two methodologies cannot be directly related to one another.

2. <u>The USCG database does not contain detailed case-specific investigative information on vessel incidents.</u>
   The USCG database shows causal factors that have been identified for each vessel incident. However, it does not provide any detailed case-specific investigation information. That information may be contained in each incident's individual electronic or paper files. However, we did not have access to that material, and all indications are that obtaining such data would not be possible. While each incident shown in the database may have several causal factors, it does not identify primary causal factors. Without detailed background investigative information, it is not possible to determine root or secondary causes and correlate the USCG data with our analysis of Ecology's data.

3. <u>Lack of common incident data in the USCG and Ecology databases.</u>
   When we compared Ecology's data to the USCG's data, we found only two incidents that were common to both databases. This may be due to the differences in how the two agencies determine their investigation priorities, an informal sharing of their investigative responsibilities to more efficiently manage workload, or other factors.

Conclusions

Due to the different methodologies used by Ecology and the USCG for determining causal factors, the lack of detailed case specific incident information available and the inconsistencies between the two databases, we were not able to use the USCG information to either correlate and/or validate the analysis conducted in this report using Ecology's data. However, based on our understanding of the USCG's analytical process, we note that issues related to organizational failures and human error seemed to appear as consistent themes in their causal conclusions.

VI. APPENDIX A: STATES/BRITISH COLUMBIA OIL SPILL TASK FORCE SPILL & INCIDENT REPORTING DATA COLLECTION DICTIONARY (1997)

Appendix A
STATES/BRITISH COLUMBIA OIL SPILL TASK FORCE
SPILL & INCIDENT REPORTING DATA COLLECTION DICTIONARY

Reported By	The source of the information (the caller [individual, organization, other agency, etc.]).
Phone/Fax	The above persons' phone and/or fax number.
Responsible Party	The source of the spill and/or event (name and/or identification number of involved vessel, vehicle, or facility).
Point of Contact	The name of the person designated by the owner or operator of the source to handle inquiries about the spill and/or event.
Phone/Fax	The above person's phone and/or fax number.
Investigator(s)	The name(s) of the person(s) investigating (making the official report, filling out the information, etc.).
Phone/Fax	The above persons' phone and fax number.
Date/Time of the Report	Date and time the report was received (mm/dd/yy - 00:00 on 24 hour clock).
Date/Time of the Incident	Date and time the incident occurred (mm/dd/yy - 00:00 on 24 hour clock).
Location	
Land	Spill/Incident that impacts the land and/or ground water, but not surface water.
Marine	Spill/Incident that impacts surface water or wetlands under jurisdiction of the U.S. or Canadian Coast Guard as the Federal On-Scene Coordinator.
Fresh Water	Spill/Incident that impacts surface water or wetlands under the jurisdiction of the U.S. Environmental Protection Agency or Environment Canada as Federal On-Scene Coordinator.
Location Name	Where the incident occurred.
County (US)/ District (CANADA)	County/Regional District where the incident occurred.
City/Town	City or town nearest to where the incident occurred.
Water Body	Affected water body (river, stream, bay, strait, etc.) (latitude/longitude if in ocean.)
Type of Incident	
Spill and Incident	Oil spill plus related incident affecting a vessel, vehicle, facility, and/or pipeline.

Incident (no spill) See *Incident Definitions* below.

Vessel	Grounding, collision, allision, flooding, fire/explosion, loss of propulsion, loss of steering, and/or an occurrence affecting the vessel's seaworthiness or fitness for service.
Facility/ Pipeline	Significant ground/dock/structural movement or failure, significant equipment failure, or fire/explosion.
Vehicle	Applies to tank trucks (as information is available) and trains only; collision or other accident, fire or explosion, train derailment and/or an occurrence affecting the vehicle's fitness for service.

Near Miss (no spill)

Vessel	An incident in which the pilot, master, or other person in charge of navigating a vessel successfully takes action of a non-routine nature to avoid a collision, allision, grounding of the vessel, or an oil spill.
Facility/ Pipeline	An incident in which the person in charge of an oil facility or pipeline operation successfully takes action of a non-routine nature to avoid an oil spill or a fire/explosion.
Vehicle	An incident in which the driver or operator of a train or tank truck successfully takes action of a non-routine nature to avoid a collision or other accident, an oil spill, a fire/explosion, or a train derailment.

Incident Definitions

Vessel

Grounding	Vessel striking the waterway bottom with enough force to damage the vessel or prevent the vessel from continuing its voyage.
Collision	Vessels striking each other.
Allision	Vessel striking a fixed or semi-fixed object such as a pier, bridge, or buoy.

Type of Incident (continued)

Incident Definitions(continued)

Vessel (continued)

Flooding	Water intrusion into areas on a vessel not intended to hold water.
Fire/Explosion	Uncontrolled ignition of gas or liquid

Loss of Propulsion	Self-explanatory; includes partial and temporary loss.
Loss of Steering	Self-explanatory; includes partial and temporary loss.
Seaworthiness/ Fitness for Service	Vessel unable to safely perform its function without repairs.

Facility/Pipeline

Ground/Dock/ Structural Move-ment or Failure	Structural movement/failure caused by earthquake, land slide, or material failure significant enough to stop or seriously curtail operations.
Equipment Failure	Major equipment failure including, but not limited to, oil transfer systems equipment, significant enough to stop or seriously curtail operations.
Fire/Explosion	Uncontrolled ignition of gas or liquid.

Vehicle (tank truck or train only)

Collision/Other Accident	Vehicles striking each other or a fixed object, or some other type of traffic accident.
Fire/Explosion	Uncontrolled ignition of gas or liquid.
Train Derailment	Self-explanatory.
Fitness for Service	Vehicle unable to safely perform its function without repairs.

Source

Vessel

Cargo Barge A non-self propelled vessel designed to transport break-bulk and/or containerized cargo.

Cargo Ship A self-propelled ship, other than a tank ship, 300 gross tons or more.

Ferry/ A vessel of 300 gross tons or more carrying passengers

Passenger Ship for compensation.

Fishing Vessel	A vessel (a) on which persons commercially engage in catching, taking or harvesting fish or preparing fish or fish products; or (b) which supplies, stores, refrigerates or transports fish, fish products or materials directly related to fishing or the preparation of fish.
Tank Barge	A non-self propelled vessel designed to transport oil or chemicals in bulk.
Tank Ship	A self-propelled ship designed to transport oil or chemicals in bulk, including combination carriers actually transporting oil.
Public Vessel	A vessel owned or chartered and operated by a government that is not engaged in commercial service and is not included in one of the above categories.
Pleasure Craft	A recreational vessel such as a yacht, sailboat, or motorboat.
Other	A vessel not included in one of the above categories, including tugs.

Facility

NOTE: A single facility may contain multiple functions from the following list of definitions. For the purpose of analyzing spills, a facility should be reported under the definition which is most consistent with the *source* of the spill. For example, a marine terminal and marina may be co-located at one facility. Should a spill occur at the oil dock during a transfer from a tank barge, the facility should be listed as "marine terminal" not "marina."

Marine Terminal:

A facility other than a vessel located in or adjacent to marine waters and used for transferring oil to or from tank vessels or barges. The term refers to all parts of the facility including structures, equipment, and appurtenances thereto capable of being used to transfer oil products.

Source, continued:

Refinery:

A facility which processes crude oil into usable fractions and refined products

Bulk Oil Facility:

A land based facility located in or adjacent to marine waters and major rivers which transfer crude oil or refined petroleum products to or from tank vessels and tank barges

Commercial/Industrial Facility:

An end use consumer of *bulk* petroleum products.

Marina:

A small harbor or boat basin typically providing dockage, supplies, marine fuels and other services for small pleasure craft.

Retail Petroleum Outlet:

Re tail distributors of petroleum fuels, primarily service stations.

Drilling Platform:

An off-shore crude oil drilling and production platform including gathering lines and associated crude oil storage tanks.

Oil Well:

On-shore crude oil drilling and production systems including gathering lines and associated crude oil storage tanks.

Other Facility:

A facility for which the source of the spill does not fit any of the above categories.

Transmission Pipeline

Transmission Pipeline:

An oil pipeline which transports oil as a common carrier (that is oil not owned by the pipeline company). Includes line pipe, valves, assemblies, controls and pump stations.

Other:

A transmission pipeline not included in one of the above categories.

Vehicle

Aircraft	Self-explanatory.
Tank Truck	Commercial motor vehicle used to transport oil.
Train	Self-explanatory.

Unknown Self-explanatory.

Type of Oil Spilled

For a technical definition see American Petroleum Institute or Environment Canada classifications.

Crude oil
Bunker C and other heavy fuel oils (Grade numbers 4-6 fuel oils)
Diesel fuel and home heating oil
Jet fuel and kerosene
Gasoline
Hydraulic Oil
Lubrication Oil
Waste Oil and Oily Water Mixtures (Report oil volume estimate only)
Other/ Unknown

Quantity Spilled (U.S. Gallons)

Total Spilled The total estimated amount of oil released/discharged.

Spilled to Water	The estimated amount of oil that reached surface water or wetlands.
Recovered	The estimated amount of oil that was recovered.

Activity at the Time of the Incident

Stationary	Vessel or vehicle stopped for a sustained period (includes anchored vessels), a facility/pipeline that is not operating, or no oil transfers in progress.
Bunkering/Fueling	An oil transfer operation to replenish fuel supply, used to propel a vessel or vehicle.
Construction	The process of building or assembling.
Maintenance/ Testing	An action which involves repairing, replacing or working on equipment associated with a vessel/vehicle/facility/pipeline, including electrical, mechanical, and structural systems.
Underway	Planned and controlled movement/maneuvering of a vessel or vehicle.

Activity at the Time of the Incident, continued:

Loading/ Discharging	The movement of oil between a vessel or vehicle and a facility (dock, terminal etc.) or other vessel/vehicle.
Start-up	The act of opening valves, starting pumps or otherwise causing oil to flow between vessels, vehicles, and/or facilities/pipelines. Start-up ends when the desired constant transfer pressure is reached.
Steady-state	Period of time when an oil transfer is taking place at a constant pressure.
Shut-down	The act of closing valves, stopping pumps or otherwise causing oil to stop flowing between vessels, vehicles, and/or facilities/pipelines.
Internal Transfer	The movement oil from one tank to another within a vessel/vehicle/facility.
Vessel-Specific	
Ballasting/ Deballasting	Taking on/discharging sea water or fresh water to/from vessel tanks.
Bilge Pumping	The pumping of water and other materials, including waste oil, which has collected in a vessel's bilge.
Oil Transfer	Taking on or discharging lubrication, hydraulic, or other oil not used as fuel.
Other	Activity not listed above.
Unknown	Self-explanatory.

Immediate Cause	Action or inaction that immediately preceded and led to the spill and/or event or near-miss.
Contributing Factors	Factors that contributed or led to the immediate cause. The principal contributing factor is sometimes called the 'root cause'.

Choose only one Immediate Cause and as many Contributing Factors as relevant from list below.

Equipment Failure	
Electrical	Failure of circuitry, or power generation equipment
Mechanical Failure	Failure of a mechanical device.

Cause/Contributing Factor, continued:

Structural	Breach of structural integrity of a tank or pipeline.

Electronic	Failure of electronic navigation or vessel control equipment, including computer hardware and/or software
Other	Equipment failure not included above.

Organizational/Management Failure

Lack of Procedure/Policy	Failure to have company procedures or policies.
Inadequate Procedure/Policy	Procedures or polices that are conflicting, ineffective, inaccurate, out-of-date, or insufficient.
Inadequate Implementation of Procedure/Policy	Failure to ensure procedures or policies are followed.
Lack of Supervision	The absence of proper situational guidance, direction, information or instruction to operating personnel.
Poor Oversight	Failure of management to effectively oversee subordinates; lack of involvement, inspection, communication, etc.
Insufficient Personnel	Failure to ensure that all required tasks can be done with adequate personnel of the proper skill level, physical ability, mental ability, experience, or certification.
Equipment Design	Failure of equipment design (within the control of the responsible party) to provide for safe operations under normal operating conditions.
Manufacture/ Construction	Failure caused by faulty manufacture or construction (within the control of the responsible party) when operating under normal conditions.
Installation	Failure caused by faulty equipment installation, when operating under normal conditions.
Lack of Planned Maintenance Program	Failure to have company planned maintenance program.
Inadequate Planned Maintenance Program	Planned maintenance policies and procedures that are conflicting, ineffective, inaccurate, out-of-date, or insufficient.

Cause/Contributing Factor, continued:

Inadequate Implementation of Planned Maintenance Program	Failure to ensure planned maintenance program is followed.

Inadequate Training	Inadequate technical knowledge due to insufficient training.
Sabotage/ Intentional violation	Destruction of property or obstruction of normal operations; treacherous action to defeat or hinder; purposeful deviation from procedure.
Other	Organizational/management failure not listed above.

External Condition (exceeding reasonably expected design and operating conditions)

Fog	Self-explanatory, may limit visibility.
Earthquake	Movements in the earth's surface caused by strains along geologic faults or volcanic activity.
Ice	Self-explanatory, may cause loss of control.
Lightning	Self-explanatory.
Rain	Self-explanatory, may limit visibility.
Snow	Self-explanatory, may cause loss of control or limit visibility.
Tidal Conditions	A periodic variation in the level of the earth's waters that may affect vessel maneuverability (including currents).
Wind	Rapid air movement caused by weather systems.
Sea state	Storms, high waves, shoaling, severe eddies or strong currents that may affect vessel maneuverability.
Land Slide	The dislodging and fall of a mass of earth or rock.
Temperature	Self-explanatory.
Other	External condition not listed above.

Human Error (Individual Level)

Communications	Difficulties in the transfer of information (not language related); failure to understand or comply.
Language	Difficulties in the transfer of information due to language barriers.

Drugs/Alcohol	Any form or level of diminished ability (physical or mental) due to the use of drugs or alcohol.
Inexperience	Inadequate technical knowledge due to a properly trained person not having enough experience to properly perform the task at hand.
Improper Equipment Use	Using equipment to accomplish tasks other than those for which the equipment was specifically designed
Inaccurate Computation	Mathematical error
Inattention	Loss of attention, not paying attention; the failure to detect, attend to, or be aware of critical or significant information.
Procedural Error	Unintentional deviation from, or failure to follow an established procedure.
Fatigue	Weariness or exhaustion from work, other exertion, or sleep disorder that leads to diminished ability (physical or mental).
Illness	Sickness which causes decrease in physical or mental abilities.
Judgment	Incorrect assessment, estimation, interpretation or opinion.
Other	Individual human error not listed above.
Unknown	Self-explanatory.

Narrative

General description of spill and/or incident. Provide supplemental information on “Other” and “Unknown” data fields. Describe links between Incident Type, Source, Activity, Immediate Cause, and Contributing Factors. The narrative should provide a significant level of detail. For example, if there was a valve failure at a transmission pipeline pump station, the investigator must specify basic information on the valve design and operation such as the size, type, manufacturer, material, packing, installation date, maintenance and inspection schedule, and operating environment. Describe any conclusions by technical consultants if available. Make sure references are adequate to allow follow-up contact with principle investigators and request any technical reports which are available.

VII. APPENDIX B: SUPPLEMENTAL FIGURES

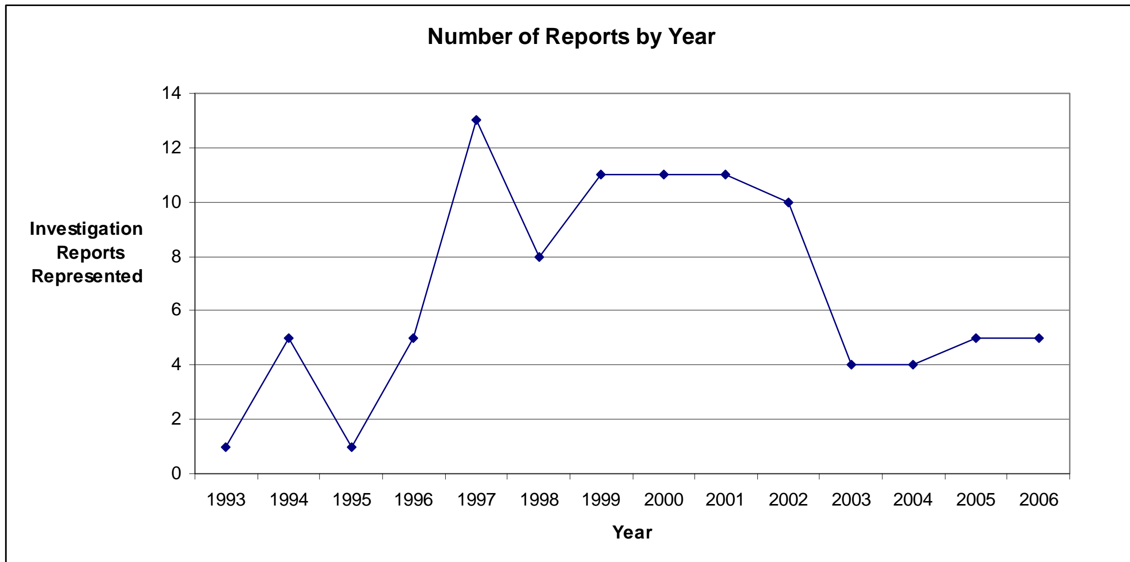

Figure Appendix B-1: Number of Incident Investigation Reports by Year

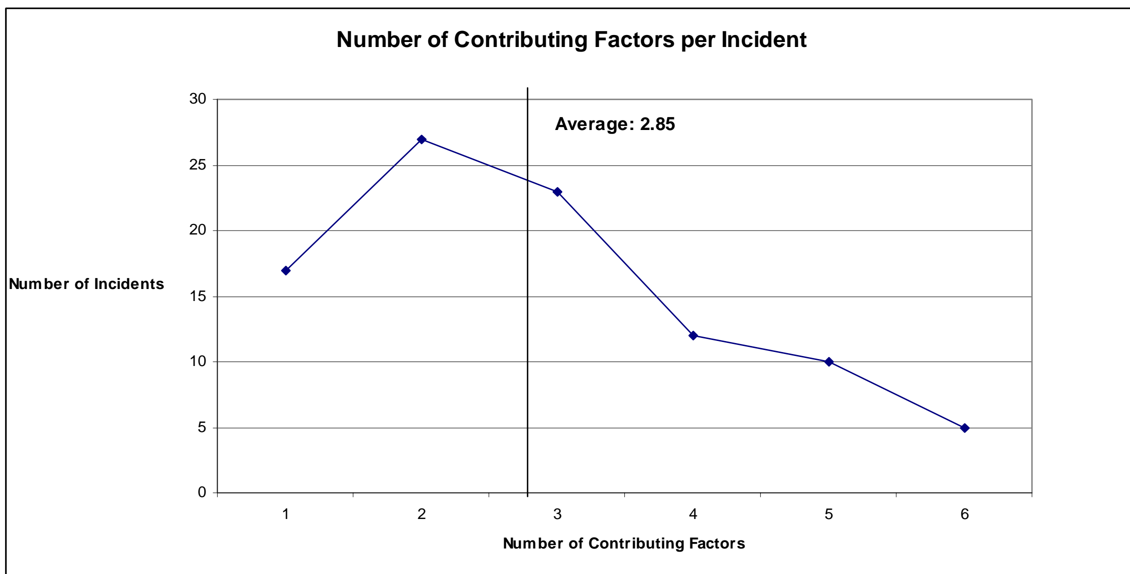

Figure Appendix B-2: Number of Contributing Factors per Incident

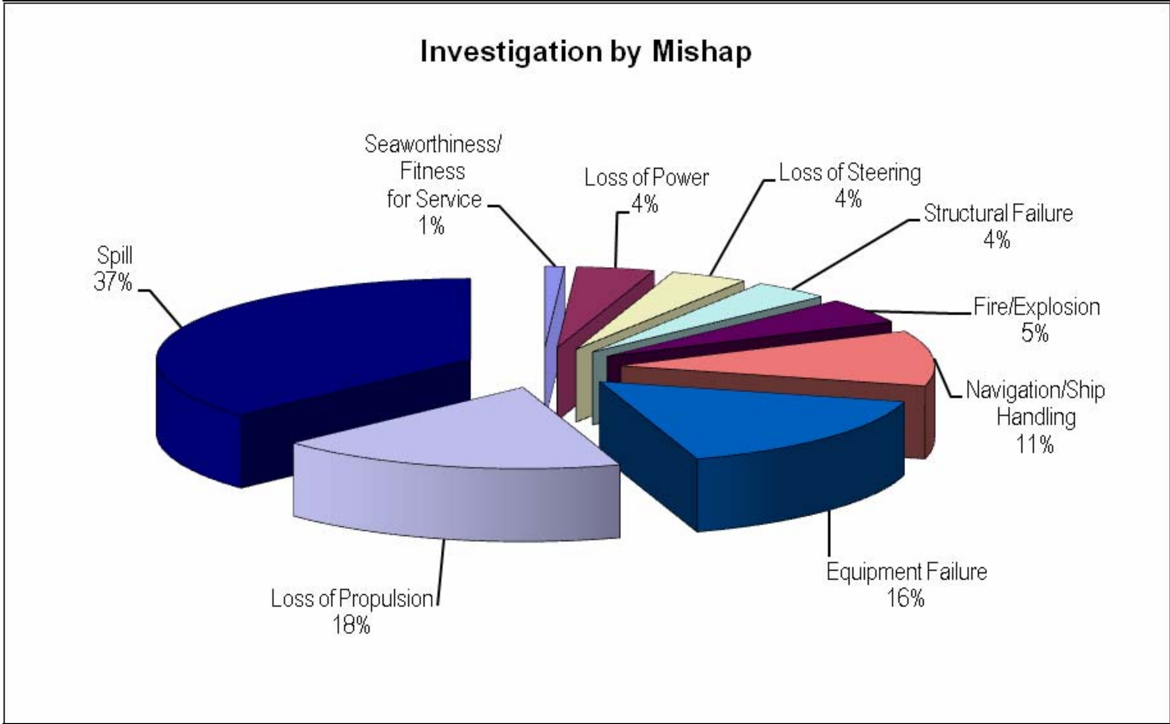

Figure Appendix B-3: Number of Investigations by Mishap

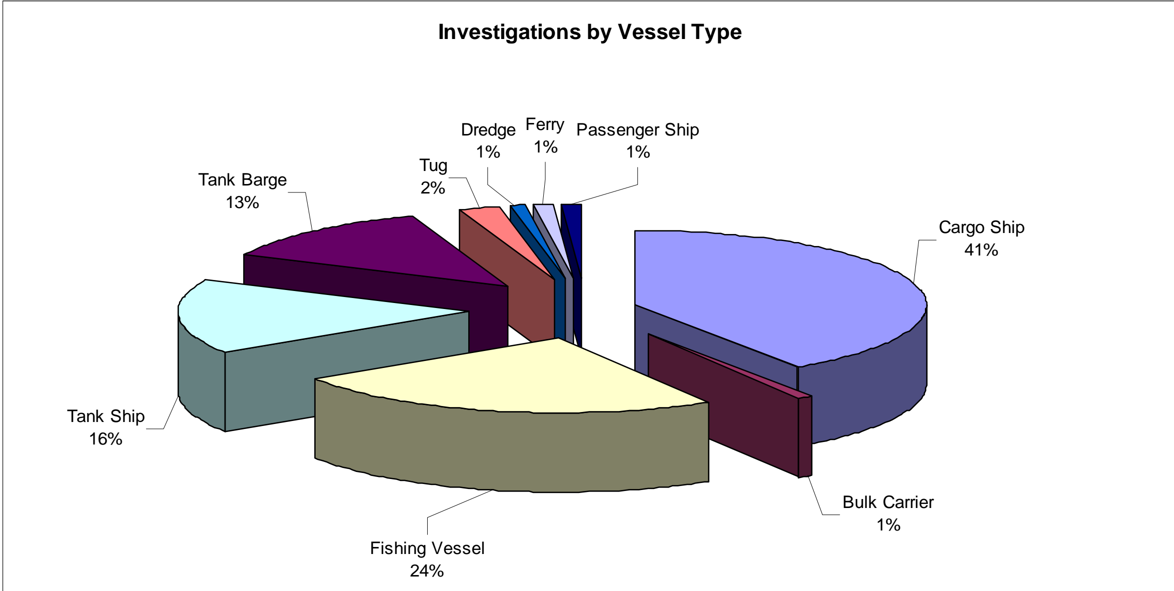

Figure Appendix B-4: Number of Investigations by Vessel Type.

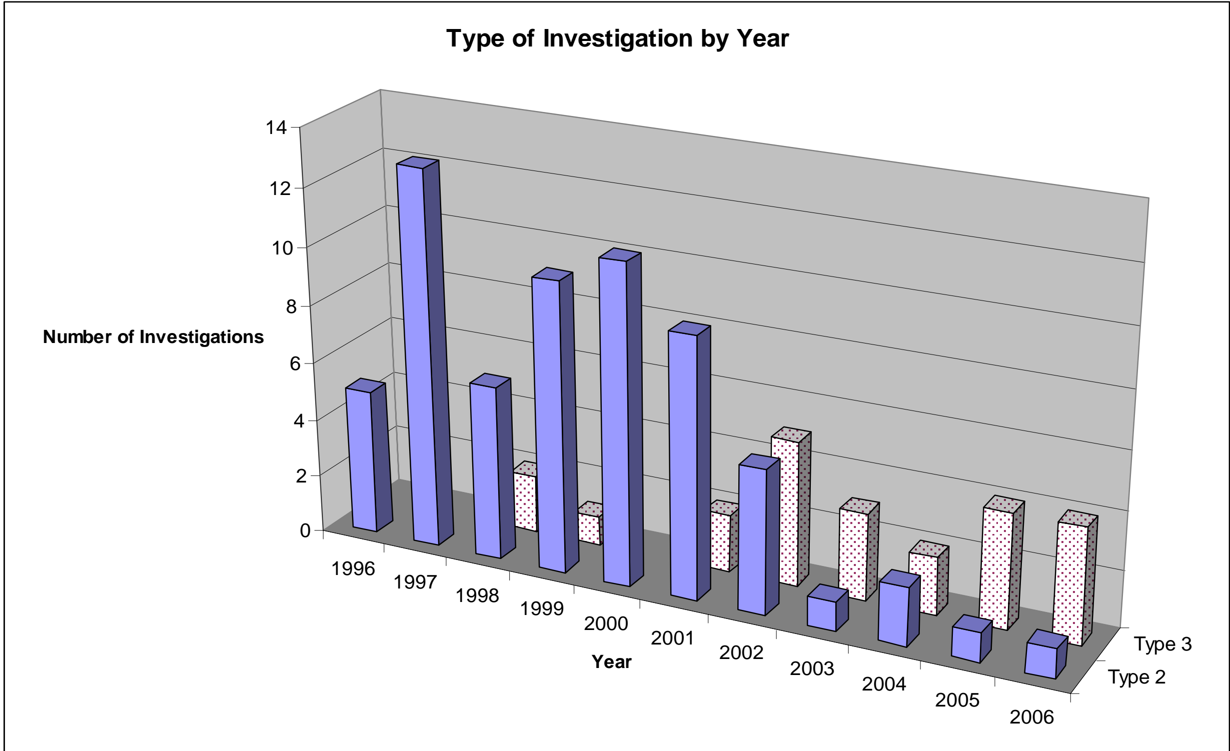

Figure Appendix B-5: Number of Type 2 and Type 3 Ecology Investigations by Year

VIII. APPENDIX C: REPORTS REVIEWED

1993.IGS Explosion on the SeaRiver Philadelphia November 29, 1993.

IMS.Code for the Investigation of Marine Casualties and Incidents. Resolution A.849(20) adopted on 27 November 1997.

IMS.1999.Amendment to the Code for the Investigation of Marine Casualties and Incidents (Resolution A.849.20). Resolution A.884(21) adopted on 25 November 1999.

Pacific States/British Columbia Oil Spill Task Force.1997.States/British Columbia Oil Spill Task Force Spill & Incident Reporting Data Collection Dictionary.

USCG.2007.USCG Causal Factors Excel spreadsheet.

U.S. Department of Commerce, National Technical Information Service (NTIS). 2007. Marine Casualty and Pollution Database, August 9, 2007.

WA DOE.1994.Incident Investigation Report: WNTRH2O

WA DOE.1995.Findings/Analysis Summary of the Investigation of the Grounding of the M/V Westward Cleo on the Columbia River, Washington, December 13, 1995.

WA DOE.1996.Incident Investigation Summary Form: ARC1096.

WA DOE.1996.Incident Investigation Summary Form: GOL0796.

WA DOE.1996.Incident.Investigation Summary Form: WES0996.

WA DOE.1997.Incident Investigation Summary Form: ANA0198.

WA DOE.1997.Incident Investigation Summary Form: BOR0797.

WA DOE.1997.Incident Investigation Summary Form: CAS1098.

WA DOE.1997.Incident Investigation Summary Form: CENO497.

WA DOE.1997.Incident Investigation Summary Form: CHR1097.

WA DOE.1997.Incident Investigation Summary Form: CON0799.

WA DOE.1997.Incident Investigation Summary Form: FNT1297.

WA DOE.1997.Incident Investigation Summary Form: HES0697.

WA DOE.1997.Incident Investigation Summary Form: KOM0997.

WA DOE.1997.Incident Investigation Summary Form: MAN0897.

WA DOE.1997.Incident Investigation Summary Form: NOL0397.

WA DOE.1997.Incident Investigation Summary Form: SKA0397.

WA DOE.1997.Oil Spills in Washington State: A Historical Analysis.97-252.

WA DOE.1997.Spill Management Program Prevention and Response Activities.1996 Annual Report.97-251.

WA DOE.1998.Findings of the Investigation of the Fuel Oil Spill During Bunkering Operations Involving the M/V Anadyr at the Blair Waterway, Tacoma, Washington, May 13, 1989.

WA DOE.1998.Findings of the Investigation of the Fuel Oil Spill During Bunkering Operations Involving the M/V Anadyr at the Sitcum Waterway, Tacoma, Washington, January 1, 1998.

WA DOE.1998.Findings of the Investigation of the Powered Grounding Involving the M/V Monchegorsk at Amsterdam Bay, Anderson Island, Washington, September 5, 1998.

WA DOE.1998.Findings of the Investigations of the Collision Involving the F/V Northern Victor and the F/V Lady Valerie in the Western Strait of Juan de Fuca, Washington, November 22, 1998.

WA DOE.1998.Incident Investigation Summary Form: ANA0598.

WA DOE.1998.Incident Investigation Summary Form: ARI1198.

WA DOE.1998.Incident Investigation Summary Form: COL1198.

WA DOE.1998.Incident Investigation Summary Form: HYU0898.

WA DOE.1998.Incident Investigation Summary Form: MON0998.

WA DOE.1998.Incident Investigation Summary Form: NOR1198.

WA DOE.1998.Incident Investigation Summary Form: POL0198.

WA DOE.1998.Incident Investigation Summary Form: Ton1098.

WA DOE.1998.Prevention Bulletin 98-01.

WA DOE.1998.Prevention Bulletin.98-01.

WA DOE.1998.Safety Advisory Bulletin.98-01.

WA DOE.1999.Findings of the Investigation of the Oil Spill Involving the M/V Super Rubin in the Upper Vancouver Anchorage on the Columbia River June 30, 1999.

WA DOE.1999.Findings of the Investigation of the Spill Involving the F/V Alaskan Command in Elliot Bay, Seattle, Washington July 7, 1999.

WA DOE.1999.Findings of the Investigation of the Spill Involving the T/V Arco Texas at the Tosco Refinery Terminal, Ferndale, Washington June 27, 1999.

WA DOE.1999.Incident Investigation Summary Form: ALA0799.

WA DOE.1999.Incident Investigation Summary Form: APL0299.

WA DOE.1999.Incident Investigation Summary Form: ARC0699.

WA DOE.1999.Incident Investigation Summary Form: BOU0399.

WA DOE.1999.Incident Investigation Summary Form: CAP0199.

WA DOE.1999.Incident Investigation Summary Form: CRO0599.

WA DOE.1999.Incident Investigation Summary Form: FRE0699.

WA DOE.1999.Incident Investigation Summary Form: IRE0199.

WA DOE.1999.Incident Investigation Summary Form: ITB1299.

WA DOE.1999.Incident Investigation Summary Form: MAX1099.

WA DOE.1999.Incident Investigation Summary Form: NOR0199.

WA DOE.1999.Incident Investigation Summary Form: PHO0799.

WA DOE.1999.Incident Investigation Summary Form: SUP0699.

WA DOE.1999.Prevention Bulletin.99-01.

WA DOE.1999.Prevention Bulletin.99-02.

WA DOE.1999.Safety Advisory Bulletin.99-01.

WA DOE.1999.Safety Advisory Bulletin.99-02.

WA DOE.2000.Findings of the Investigation of the Oil Spill Involving the F/V Western Queen at the Lake Washington Ship Canal, Seattle, Washington, November 21, 2000.

WA DOE.2000.Findings of the Investigation of the Spill Involving the F/V Alaskan Command in Middle Waterway, Tacoma, Washington June 19, 2000.

WA DOE.2000.Findings of the Investigation of the Spill Involving the F/V Pathfinder in Salmon Bay, Seattle, Washington July 24, 2000.

WA DOE.2000.Findings of the Investigation of the Spill Involving the M/V Rubin Pearl in Blair Waterway, Tacoma, Washington, December 20, 2000.

WA DOE.2000.Incident Investigation Summary Form: ALA0600.

WA DOE.2000.Incident Investigation Summary Form: FRA0900.

WA DOE.2000.Incident Investigation Summary Form: KAL0100.

WA DOE.2000.Incident Investigation Summary Form: MAR0800.

WA DOE.2000.Incident Investigation Summary Form: NOR0200.

WA DOE.2000.Incident Investigation Summary Form: OVE0500.

WA DOE.2000.Incident Investigation Summary Form: OVE0600.

WA DOE.2000.Incident Investigation Summary Form: PAT0700.

WA DOE.2000.Incident Investigation Summary Form: RUB1200.

WA DOE.2000.Incident Investigation Summary Form: SEL0900.

WA DOE.2000.Incident Investigation Summary Form: VIR0600.

WA DOE.2000.Incident Investigation Summary Form: WES1100.

WA DOE.2000.Investigations.Certified Coatings Barge Listing.

WA DOE.2000.Safety Advisory Bulletin.00-01.

WA DOE.2000.Spill Scene.1999 Annual Report.V4,Num2.00-08-014.

WA DOE.2001.Findings of the Investigation of the "Kalama Mystery Spill" Kalama, Washington March 4, 2001.

WA DOE.2001.Findings of the Investigation of the Oil Spill Involving the (ATA) Coastal Merchant at the Lake Washington Ship Canal, Seattle, Washington, January 3, 2001.

WA DOE.2001.Findings of the Investigation of the Oil Spill Involving the F/V Blue Dutch at the Lake Washington Ship Canal, Seattle, Washington, January 3, 2001.

WA DOE.2001.Findings of the Investigation of the Oil Spill Involving the F/V Stormy Sea at Anacortes, Washington, April 11, 2001.

WA DOE.2001.Findings of the Investigation of the Oil Spill Involving the M/T Oversees Boston and Tosco Refining Company at Ferndale, Washington June 13, 2001.

WA DOE.2001.Findings of the Investigation of the Oil Spill Involving the S/T Overseas Chicago and U.S. Oil & Refining Company at the Blair Waterway, Tacoma, Washington, June 18, 2001.

WA DOE.2001.Findings of the Investigation of the Oil Spill Involving the S/T Prince William Sound at the Port Angeles Anchorage, Port Angeles, Washington, January 29, 2001.

WA DOE.2001.Findings of the Oil Spill Involving the ITB Baltimore at the BP Refinery Dock, Cherry Point, Ferndale, Washington August 28, 2001.

WA DOE.2001.Incident Investigation Summary Form: ARA0101.

WA DOE.2001.Incident Investigation Summary Form: BLU0101.

WA DOE.2001.Incident Investigation Summary Form: COA0101.

WA DOE.2001.Incident Investigation Summary Form: COL0401.

WA DOE.2001.Incident Investigation Summary Form: CSX0601.

WA DOE.2001.Incident Investigation Summary Form: HYU0601.

WA DOE.2001.Incident Investigation Summary Form: ITB0801.

WA DOE.2001.Incident Investigation Summary Form: KAL0301.

WA DOE.2001.Incident Investigation Summary Form: OSC0601.

WA DOE.2001.Incident Investigation Summary Form: OVE1201.

WA DOE.2001.Incident Investigation Summary Form: PAD0701.

WA DOE.2001.Incident Investigation Summary Form: PRI0101.

WA DOE.2001.Incident Investigation Summary Form: STE0401.

WA DOE.2001.Incident Investigation Summary Form: STO0401.

WA DOE.2001.Incident Investigation Summary Form: TOS0601.

WA DOE.2001.Prevention Bulletin.01-01.

WA DOE.2001.Prevention Bulletin.01-02.

WA DOE.2001.Spill Scene.2000 Annual Report.V5,Num2.01-08-003.

WA DOE.2002.Findings of the Investigation of the Oil Spill Involving the F/V Pathfinder at Salmon Bay, Seattle, Washington May 22, 2002.

WA DOE.2002.Findings of the Investigation of the Oil Spill Involving the M/T Gaz Diamond Port Angeles, Washington May 19, 2002.

WA DOE.2002.Findings of the Investigation of the Oil Spill Involving the M/V Pendrecht at the Longview Anchorage, Columbia River Longview, Washington January 24, 2002.

WA DOE.2002.Incident Investigation Summary Form: ATL1202.

WA DOE.2002.Incident Investigation Summary Form: CRI1002.

WA DOE.2002.Incident Investigation Summary Form: GAZ0502.

WA DOE.2002.Incident Investigation Summary Form: GRE1002.

WA DOE.2002.Incident Investigation Summary Form: HAY0302.

WA DOE.2002.Incident Investigation Summary Form: KAE1002.

WA DOE.2002.Incident Investigation Summary Form: PAC1202.

WA DOE.2002.Incident Investigation Summary Form: PAT0502.

WA DOE.2002.Incident Investigation Summary Form: PEN0102.

WA DOE.2002.Incident Investigation Summary Form: SCT1202.

WA DOE.2002.Incident Investigation Summary Form: TAI1202.

WA DOE.2002.Spill Scene. 2001 Annual Report.V6,Num1.02-08-005.

WA DOE.2002.Spill Scene. Summer 2002.V6,Num2.02-08-006.

WA DOE.2002.Washington Investigations of Marine Incidents Cover a Range of Vessel Types. Available at: http://www.ecy.wa.gov/programs/spills/prevention/measures/Washington%20Investigations%20Web%203.htm.

WA DOE.2002.Washington Investigations of Marine Incidents Support '80 Percent Rule' of Principal Cause.Available at: http://www.ecy.wa.gov/programs/spills/prevention/measures/Washington%20Investigations%20WEB%201.htm.

WA DOE.2003.Findings of the Investigation of the Oil Spill Involving the F/V Excellence at Elliott Bay, Seattle, Washington August 21, 2003.

WA DOE.2003.Findings of the Investigation of the Oil Spill Involving the M/T Rosa Tomasos at the Hayden Island Anchorage, Near Vancouver, Washington, August 30, 2003.

WA DOE.2003.Findings of the Investigation of the Oil Spill Involving the Tank Barge Foss 248-P2 at the Chevron Products Company Richmond Beach Asphalt Plant Point Wells, Washington December 30, 2003.

WA DOE.2003.Incident Investigation Summary Form: BUX0103.

WA DOE.2003.Incident Investigation Summary Form: EXE0803.

WA DOE.2003.Incident Investigation Summary Form: FOS1203.

WA DOE.2003.Incident Investigation Summary Form: ROS0803.

WA DOE.2003.Incident Investigation Summary Form: SEA0103.

WA DOE.2003.Prevention Bulletin.03-01.

WA DOE.2004.Findings of the Investigation of the Oil Spill Involving the F/V Diomedes at Salmon Bay, Seattle, Washington August 13, 2004.

WA DOE.2004.Findings of the Investigation of the Oil Spill Involving the Frontier Mariner, IMO 8907163, at Marco Shipyard Seattle, Washington March 26, 2004.

WA DOE.2004.Findings of the Investigation of the Oil Spill Involving the Veteran Severa, IMO 7814565, at Ballard Oil Seattle, Washington July 14, 2004.

WA DOE.2004.Incident Investigation Summary Form: DIO0804.

WA DOE.2004.Incident Investigation Summary Form: FRO0304.

WA DOE.2004.Incident Investigation Summary Form: SEA0504.

WA DOE.2004.Incident Investigation Summary Form: VET0704.

WA DOE.2004.Lessons Learned Report.Foss Maritime Barge 248-P2 Spill Point Wells Facility Shoreline, Washington December 30,2003.

WA DOE.2004.Preliminary Findings of the Investigation of the "Dalco Passage Mystery Spill" Off Vashon and Maury Islands, Washington October 13, 2004.

WA DOE.2004.Spill Scene.2003 Annual Report.V8,Num1.04-08-001.

WA DOE.2004.Spill Scene.2004 Fall/Winter.V8,Num2.04-08-004.

WA DOE.2005.Findings of the Investigation of the Oil Spill Involving Tank Barge Noho Hele at the Conocophillips Refinery, Ferndale, Washington January 18, 2005.

WA DOE.2005.Findings of the Investigation of the Oil Spill Involving the M/T Allegiance Vancouver, Washington November 16, 2005.

WA DOE.2005.Findings of the Investigation of the Oil Spill Involving the M/V Pacific Explorer at the Blair Waterway Tacoma, Washington April 15, 2005.

WA DOE.2005.Findings of the Investigation of the Oil Spill Involving the Tank Barge PB-20 at the Conocophillips Marine Terminal, Ferndale, Washington February 14, 2005.

WA DOE.2005.Incident Investigation Summary Form: ALL0105.

WA DOE.2005.Incident Investigation Summary Form: NOH0105.

WA DOE.2005.Incident Investigation Summary Form: PAC0405.

WA DOE.2005.Incident Investigation Summary Form: PB20205.

WA DOE.2005.Incident Investigation Summary Form: SEA1205.

WA DOE.2005.Prevention Bulletin.05-01.

WA DOE.2005.Spill Scene.2004 Annual Report.V9,Num1.05-08-002.

WA DOE.2006.Fact Sheet.

WA DOE.2006.Findings of the Investigation of the Oil Spill Involving the F/V Coastal Navigator Seattle, Washington May 19, 2002.

WA DOE.2006.Findings of the Investigation of the Oil Spill Involving the F/V Defender, Seattle, Washington March 29, 2006.

WA DOE.2006.Findings of the Investigation of the Oil Spill Involving the Tugboat Catherine Quigg Seattle, Washington September 4, 2006.

WA DOE.2006.Incident Investigation Summary Form: CAT0906.

WA DOE.2006.Incident Investigation Summary Form: COA0506.

WA DOE.2006.Incident Investigation Summary Form: DEF0306.

WA DOE.2006.Incident Investigation Summary Form: JAM1206.

WA DOE.2006.Investigations.Lake Union Oil Spill.Press Release.

WA DOE.2006.Prevention Bulletin.06-01.

WA DOE.2006.Prevention Bulletin.06-02.

WA DOE.2006.Safety Advisory Bulletin.06-02.

WA DOE.2007.Neah Bay Rescue Tug Summaries of Responses Since 1999.

WA DOE.2007.Spill Scene.Spill Prevention, Preparedness, and Response Program.2006 Annual Report.V10,Num1.07-08-002.

WA DOE.Ecology Prevention Recommendations on Bulk Oil Transfer Operations 1998-2005.Available at: http://www.ecy.wa.gov/programs/spills/prevention/measures/BulkOilRecommend98-05.html.

WA DOE.Ecology Prevention Recommendations on Loss of Propulsion Incidents 1998-2005.Available at: http://www.ecy.wa.gov/programs/spills/prevention/measures/LossofProp120605.html.

WA DOE.Ecology Prevention Recommendations on Loss of Steering Incidents 1998-2005.Available at: http://www.ecy.wa.gov/programs/spills/prevention/measures/LossofSteer123105.html.

WA DOE.Ecology Prevention Recommendations on Ship Bunkering (Fueling) Operations 1998-Present.Available at: http://www.ecy.wa.gov/PROGRAMS/spills/prevention/measures/BunkeringRecommend072106.html.

WA DOE.Investigations.Collision Results in Point Wells Grounding.Available at: http://www.ecy.wa.gov/programs/spills/incidents/wellspoint/wellspointbase.htm.

WA DOE.Investigations.Ediz Hook Oil Spill.Available at: http://www.ecy.wa.gov/programs/spills/incidents/pwsound/pwsoundbase.htm.

WA DOE.Investigations.Foss Maritime Barge Spill at Point Wells.Available at: http://www.ecy.wa.gov/programs/spills/incidents/fosspointwells/fosspointwellsbase.htm.

WA DOE.Investigations.M/V Padre Island-Diesel Fuel Spill.Available at: http://www.ecy.wa.gov/programs/spills/incidents/padreisland/padreislandbase.htm.

WA DOE.Investigations.Polar Texas-Conoco Phillips Spill.Available at: http://www.ecy.wa.gov/programs/spills/incidents/dalco/dalcobase.htm.

WA DOE.Investigations.Songa Hua Elliott Bay Oil Spill.Press Release.Available at:

WA DOE.Investigations.Sunken Vessel "Columbia".Available at: http://www.ecy.wa.gov/programs/spills/incidents/fishngboat55/fishboat55.htm.

WA DOE.Investigations.Swiftsure Prince-Lost Barge Incident.Available at: http://www.ecy.wa.gov/programs/spills/incidents/swiftsure_prince/lostbargebase.htm.

WA DOE.Investigations.Thrasyvoulos V-Cargo Ship Incident.Available at: http://www.ecy.wa.gov/programs/spills/incidents/t5/t5base.htm.

WA DOE.Investigations.Tosco Ferndale-Overseas Boston Spill.Available at: http://www.ecy.wa.gov/programs/spills/incidents/tosco/toscobase.htm.

WA DOE.Washington Investigations of Marine Incidents Indicate Different Cause Distribution from Self-reported Incidents.

WA OMS.1994.Investigation Report Barge 101 December 30, 1994..

WA OMS.1994.Investigation Report on the M/V Verbier Incident August 3, 1994.

WA OMS.1996.Incident Investigation Summary Form: OSS0896.

WA OMS.1996.Incident Investigation Summary Form: PAC1096.

WA OMS.1997.Incident Investigation Summary Form: ARC0397.

WA OMS.1997.Incident Investigation Summary Form: BAN0597.

WA OMS.1997.Incident Investigation Summary Form: HUA0197.

WA OMS.2000.Prevention Bulletin 95-01.

WA OMS.2000.Prevention Bulletin 95-02.

WA OMS.2000.Prevention Bulletin 96-01.

WA OMS.2000.Prevention Bulletin 96-02.

WA OMS.2000.Prevention Bulletin.95-01.

WA OMS.2000.Prevention Bulletin.95-02.

WA OMS.2000.Prevention Bulletin.96-01.

WA OMS.2000.Prevention Bulletin.96-02.

WA OMS.2000.Safety Advisory Bulletin.94-01.

WA OMS.2000.Safety Advisory Bulletin.94-02.

WA OMS.2000.Safety Advisory Bulletin.94-03.

WA OMS.2000.Safety Advisory Bulletin.96-01.

WA OMS.2000.Safety Advisory Bulletin.97-01.