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7 July 2011

Mr. Jay Wright
AIRA Program Manager
National Fish and Wildlife Foundation
1133 15th Street, NW Suite 1100
Washington, D.C. 20005

Subject: Phase A – Aleutian Islands Risk Assessment Consequence Analysis Report and Task 5 Accident Scenario and Causality Study Report Deliverables

Dear Mr. Wright,

ERM-West, Inc. (ERM) and Det Norske Veritas (U.S.A.), Inc. (DNV) appreciate the opportunity to provide our consulting services for the Phase A – Aleutian Islands Risk Assessment (AIRA). This cover letter transmits the Consequence Analysis Report, which covers Task 3 - Characterizing Spills and Task 4 – Consequence Analysis; as well as the Task 5 – Accident Scenario and Causality Study Report of the Phase A Preliminary Risk Assessment (PRA).

The Phase A PRA consists of eight main tasks. However, it is imperative to recognize that each task is defined by the scope of work and is not a discrete unit of analysis. Rather, the work described in these reports and related tasks are inter-related with studies completed under other tasks and deliverables. Thus, the information provided in the Consequence Analysis Report and Accident Scenario and Causality Report are based on the volume of work completed to date and best understood in reference to previous reports.

Overview

The results of the Task 1 and 2 studies were used to develop the inputs for the Consequence Analysis Report. Additionally, two webinars were conducted (April 2010 and June 2010) to characterize the spills and develop the Risk Matrix during Task 3. Based on the risk matrix results from Task 3, 16 scenarios were developed with consensus from the Management Team and Advisory Panel members for evaluation of the Consequence Analysis (Task 4) and development of the Accident Scenario and Causality Study (Task 5). The enclosed reports incorporate revisions to address cumulative comments received from the Peer Review Panel and Management Team on the draft reports submitted on March 7, 2011.

Scope and Objectives

The studies completed by the risk analysis team were defined by the scope and objectives of the Phase A PRA Program as described in the Transportation Research Board Special Report 293 and more directly, the Phase A Request for Proposal. Thus, the analyses and information should be reviewed in context with the scope of the Phase A AIRA Program.

The objectives of these deliverables are to summarize the findings of the Conseqence Analysis and Accident Scenario and Causality Study and provide documentation of the studies completed for Tasks 3, 4, and 5 of the Phase A PRA.

In accordance with the scope of work, the studies focused on characterizing spills based on identify the hazardous substances, representative spill sizes, and locations of spills from the highest-risk accidents. This process led to the selection of 16 hypothetical high-risk spill scenarios associated with the Aleutian Islands study area, based on the unique combinations of vessel type, spill volumes, accident types, and spill material (Task 3). Once the scenarios were selected, a high-level spill trajectory and fate analysis for the selected spill scenarios was performed. The spill model outputs (surface oiling, shoreline impacts, subsurface concentrations, and sediment concentrations) were used to then perform a qualitative assessment of the potential resource damage and socioeconomic impact of these representative spills (Task 4). The intent was to gain an understanding of the relative environmental consequences associated with the scenarios and use the information as input into the accident scenario and causality analysis (Task 5) and to assess potential risk reduction measures (Tasks 6 and 7).

Consequence Analysis Report

The purpose of the consequence analysis is to gain an understanding of the relative impact of spill size, types of hazardous substance spilled, and spill location on environmental consequences. The analysis is a qualitative assessment of the potential resource damage and socioeconomic impact of selected high-risk spill scenarios and provides a high-level assessment of vulnerability of identified natural resource(s).

Since the goal of the spill scenario selection process was to identify the hazardous substances, representative spill sizes, and locations of spills associated with the highest-risk accidents, this resulted in selection of "reasonable worst case" spill scenarios. Thus, caution should be exercised if trying to make a leap to other spill events.

For each location, the analysis included evaluating a) the probability of the various environmental and socioeconomic resources/receptors coming into contact with a spill and b) the extent of impact (e.g., area or concentration level). The oil spill modeling output results and ecological and socioeconomic impacts for each of the 16 scenarios are summarized in Table 5.4 of the Consequence Analysis Report.

Based on the findings of the consequence analysis, the ecological receptors potentially at greatest risk include seabirds and marine mammals, while the socioeconomic resources at greatest risk are subsistence use areas and fisheries. Clearly, an oil spill of a notable amount has the potential to result in ecological and/or socioeconomic impacts depending on the relation to important receptors of the study area.

Even Scenario 4, characterized as a 25,000-barrel diesel fuel spill north of Unimak Pass (Location1), has the potential to result in impacts to marine mammal habitat if receptors are present during the winter season. Of additional note, scenarios associated with large spills (400,000 barrels) of persistent oil at high-release rates (e.g., Scenarios 3, 8, and 12) indicate the greatest potential of ecological and socioeconomic impacts.

This study represents a qualitative assessment of potential environmental and socioeconomic impacts associated with selected high-risk scenarios to receptor categories present within the Aleutian Islands. The scenarios, spill locations, and consequence analysis reflect best professional assessments based on experience, existing data, and modeling outputs. The spill scenarios, of course, are not exhaustive of all possible spills; however, they do provide a wide spectrum of high-risk scenarios with which to evaluate the relative impacts and potential consequences to the study area's resources should a spill occur. Notably, a potential spill event would likely have greater socioeconomic consequences than could be evaluated in this study because region-wide impacts were not evaluated due to the scope constraints.

Accident Scenario and Causality Study Report

The work performed under Task 5 is more directly linked to the work performed under Tasks 1, 2, and 3, and is not readily linked to Task 4. Task 4 seeks to more fully understand the consequence of spills, whereas Task 5 presents information on the causality of spills. The objective of Task 5 is to evaluate the major causes of the higher-risk scenarios and assign probabilities of occurrence.

The main purpose of the Accident Scenario and Causality Study Report is to provide a stronger narrative of how marine risks arise, to complement the mainly numerical results presented in the Task 2A Report. As documented in the enclosed report, the Task 5 risk results show that, for the hypothetical (referred to as representative) accident scenarios:

- The spill volumes are generally over estimated compared to what the event trees predict is most likely to happen.
- The collision and powered grounding accidents are predominantly attributed to human error.
- The drift grounding accidents are predominantly attributed to technical failures.

The comparison of the Representative Accident Scenarios with historical accidents shows that the Phase A Accident Scenarios are mostly pessimistic (larger spill volumes, more toxic spilled materials) compared to that observed historically, but in other ways are similar to historical accidents. It is concluded that the Representative Accident Scenarios are indeed, reasonable worst case scenarios, consistent with Phase A AIRA Program requirements. This conclusion should be considered when the results from Task 4 are interpreted.

The Risk Analysis Team appreciates the opportunity to work with the Management Team and other stakeholders as part of the AIRA Phase A Program. If you have questions or inquires concerning this submittal, please contact Laura Tesch at 425-214-0453 or laura.tesch@erm.com.

Sincerely,

Laura Tesch
AIRAProgram Director

Dr. Jack Colonell
Partner-in-Charge

Enclosure via email:
Consequence Analysis Report
Task 5 Accident Scenario and Causality Study Report

cc: David Pertuz, DNV
Leslie Pearson, Pearson Consulting

DET NORSKE VERITAS

&

ERM - WEST INC.

Aleutian Islands Risk Assessment Phase A - Preliminary Risk Assessment

TASK 5: Accident Scenario and Causality Study Report

Prepared For:

National Fish and Wildlife Foundation

United Stated Coast Guard

Alaska Department of Environmental Conservation

Report No./DNV ref No.: EP007543

July 1, 2011

Aleutian Islands Risk Assessment Phase A - Accident Scenario and Causality Study	**DET NORSKE VERITAS (U.S.A.), INC.** **1400 Ravello Dr** **Katy**, **TX 77449** Tel: **(281) 396-1000** Fax: **(281) 396-1900** http://www.dnv.com
For:	
NFWF, USCG, ADEC	
Account ref: Laura Tesch	

Date of issue:	July 1, 2011	Project no:	EP007543
Report No.:		Subject Group:	Marine Transport
Summary:	The Aleutian Island Risk Assessment (AIRA) program was created to produce a comprehensive evaluation of the risk of vessel accidents and spills in the Aleutian Islands (www.aleutiansriskassessment.com). The first of two distinctive phases for the assessment is Phase A- Preliminary Risk Assessment: Semi-quantitative Studies. This report fulfills Task 5 – Accident Scenario and Causality Study Report.		
Prepared by:	*Name and position* David Pertuz, Senior Consultant	*Signature*	
Verified by:	*Name and Position* Tim Fowler, Principal Consultant	*Signature*	
Approved by:	*Name and position* Cheryl Stahl, Head of Section	*Signature*	

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Rev No:	Reason for issue:	Prepared by:	Verified by:	Accepted by:
0	final submittal	David Pertuz	Dr. Tim Fowler	Cheryl Stahl

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Executive Summary

This document is the deliverable due under Task 5 of the "Phase A – Aleutian Islands Risk Assessment". Task 5 is the "Accident Scenario and Causality Study". The representative accident scenarios are determined from the dominant accident types identified under Task 3 in terms of vessel type, type of accident, spill size, and location. The objective of Task 5 is to evaluate the major causes of the higher risk scenarios and assign probabilities of occurrence.

The work performed in preceding tasks is briefly summarized as follows:

- A detailed traffic study was performed under Task 1 (Ref. /1/). This study identified trading routes and volumes through the study area and made predictions of future marine traffic trading patterns.
- Task 2 (Ref. /2/, /3/) performed a baseline spill study by combining the traffic study data with environmental and operational data and using this input dataset to generate semi-quantitative oil spill risk results via MARCS (Marine Accident Risk Calculation System) (Ref. /2/).
- Task 3 used the results from Task 2 to identify the higher risk accident scenarios in terms of accident location, spilt material, spill volume, accident type, and ship type and size. A total of 16 hypothetical, but assumed representative, accident scenarios, made up of different combinations of 6 spill locations, 3 spilled material types (including persistent and non-persistent oil), 3 accident types and 5 ship types, were selected for additional analysis.
- Task 4 performed a detailed consequence analysis of the oil spills from the 16 scenarios identified in Task 3 for each of the 6 spill locations.

It should be noted that the work performed under Task 5 is more directly linked to the work performed under Tasks 1, 2 and 3, and is not readily linked to Task 4. Task 4 seeks to more fully understand the consequence of spills whereas Task 5 presents information on the causality of spills. In risk construct terms, Task 4 explores further to the right of the event tree and Task 5 explores further to the left of the fault tree.

This report describes the bow-tie models that were used by MARCS to calculate the risk results shown in the Task 2A report (Ref. /2/). The main purpose of this report is to provide a stronger narrative of how marine risks arise, to complement the mainly numerical results presented in the Task 2A report (Ref. /2/).

This report documents the Task 5 risk results, which show that for the Representative Accident Scenarios:

- The spill volumes are generally over estimated compared to what the event trees predict is most likely to happen.
- The collision and powered grounding accidents are predominantly attributed to human error.
- The drift grounding accidents are predominantly attributed to technical failures.

The comparison of the Representative Accident Scenarios with historical accidents shows that the Representative Accident Scenarios are mostly pessimistic (larger spill volumes, more toxic spilled materials) compared to that observed historically, but in other ways are similar to historical

accidents. It is concluded that the Representative Accident Scenarios are, indeed, reasonable worst case scenarios, consistent with project requirements. This conclusion should be considered when the results from Tasks 3 and 4 are interpreted.

1 INTRODUCTION

Task 5 of Phase A of the AIRA program is the Accident Scenarios and Causality Study. The main objective of Task 5 is to describe in more detail the Representative Accident Scenarios selected in Tasks 2A (Ref. /2/) and 3, and analyzed in detail in Task 4. In particular, the representative scenarios previously identified were selected as "reasonable worst case spill scenarios". This means they are neither the most likely outcome of a given marine accident (this is normally no spill), nor are they always the worst case outcome (which would be all cargo and all bunker fuel oil carried by the ship is spilled into the marine environment).

This report describes the Representative Accident Scenarios in the following terms:

- A more detailed description of the accident scenarios and how they can be used.
- A quantitative description of the possible outcomes of each accident, including the representative spill scenario, from event tree analysis.
- A relative quantitative description of the dominant causes of each accident leading to each spill scenario, from fault tree analysis.
- A description of recent historical accidents in the Aleutian Islands, in order to provide a reality check on the results from the risk model.

This Task 5 report, therefore, provides a fuller narrative of the numerical marine accident risk modeling results, which were presented in quantitative terms in the Task 2A report.

2 DATA SOURCES AND ASSUMPTIONS

2.1 Data Sources

The risk modeling work using MARCS (Marine Accident Risk Calculation System) presented under Tasks 1 and 2 is based upon three main data sources. These are described here.

It should be noted that MARCS does not utilize near-miss, or incident, data as an *input* into the calculations. It does however calculate the frequency of critical situations (which some could argue to be near misses) as an intermediate result prior to calculating accident frequencies. Since DNV is unaware of a data source that systematically records a representative cross-section of near miss data there is limited value in presenting theoretical near miss frequencies.

2.1.1 Environmental and Operational Data

Environmental data, such as visibility, wind speed and wind direction, wave height (sea state), water depths and shore line characteristics are all site specific to the Aleutian Islands study area. This data is described in the Task 2A report (Ref. /2/).

Operational data, such as the presence of Vessel Traffic Services (VTS) (not defined in the Aleutians study area), Traffic Separation Schemes (TSS) (not defined in the Aleutians study area), the presence and capability of salvage tugs (none defined in the Aleutians study area), the effectiveness of ship anchors as a save mechanism for drift grounding (incapable in the Aleutians study area), and ship speed as a function of vessel type are all site specific to the Aleutian Islands study area. This data is described in the Task 2A report (Ref. /2/).

2.1.2 Accident Frequency and Probability Data

Other operational data mostly relates to the failure rates of people (human error / mistakes) and human failure (e.g. incapacitation due to illness) and of ships (e.g. breakdown frequencies). This data was mainly derived from the SAFECO (Safety of Shipping in Coastal Waters) research projects (Ref. /13/, /14/). The SAFECO projects involved about 20 partner organizations and were performed over a 3 year period. The Risk Analysis Team believes they remain the single largest coherent work program focused solely on marine risk assessment methods and validated marine risk input data performed anywhere in the world to date.

SAFECO mainly derived risk assessment parameters with reference to a database of marine accident in the North Sea in the years up to 1998. The shipping industry has a strong international character. Ships are often designed in one country, built in another and then operated worldwide. Similarly crews are educated in many countries but gain their experience in mixed-nationality crewed vessels internationally. It is for these reasons that the Risk Analysis Team believe that, in the absence of good site specific data on accident frequencies/ probabilities, it is acceptable to apply risk assessment parameters derived from the North Sea to other regions in the world.

It is acknowledged that human error is a significant contributor to accidents in the marine transport sector. These human error rates have been represented in the Phase A results by unmodified generic factors derived from North Sea historical data. It may be justified to attempt to refine this human performance data with site specific data for the Aleutian Islands for work to be performed under Phase B.

2.1.3 Accident Consequence Data

The accident consequence data used by MARCS are derived from an analysis of historical oil spills performed by the Risk Analysis Team based on data sourced from the Lloyds Maritime Information System (LMIS) between 1978 and 1998. This analysis was performed to support internal DNV research work on ship classification rules. It is not available in the public domain. While this analysis is not fully up-to-date the Risk Analysis Team believe that it remains valid for judging relative risks and DNV has not identified a better dataset to form the basis of the MARCS consequence models.

The LMIS classifies reported accidents as:

- Incidents. These are events reported to, and recorded by, Lloyds which do not meet the criteria for serious casualties or total loss.

- Serious casualties (accidents). These events include total losses and, broadly, any other accident that requires the ship to be repaired before it can continue to trade. A grounding on a soft shore line without spill or other consequence, or a collision that does not involve puncture of the hull plating are not serious casualties.
- Total loss. These include both actual total loss and constructive total loss. In a constructive total loss the ship is considered to be too badly damaged to be economically repaired, but it may not have spilled its entire cargo into the sea. The Exxon Valdez was a constructive total loss that spilled about half of its cargo.

MARCS calculates the frequency of serious casualties and groundings irrespective of if a spill occurs due to grounding. It then applies an oil outflow spill model (an event tree) that specifies probabilities of different consequences (no spill, through some spill to 100% spill) given a serious casualty that is dependent upon ship type, hull design, accident type and accident severity.

DNV's analysis of the LMIS data does not distinguish between actual total loss and constructive total loss, thus the oil outflow models in MARCS over predict the loss of oil into the water whenever the total loss is a constructive total loss. That is, the MARCS oil spill risk results are conservative in their absolute numbers. Nevertheless the Risk Analysis Team believe that the relative risk results between different accident types is sufficiently valid for Phase A of this work because it is only for structural failure/ foundering accidents that actual total loss is a high percentage of all total losses.

2.2 Assumptions

The MARCS model necessarily makes a number of assumptions and estimates in order to generate the results that provide the input to Task 3. These assumptions are described in the Task 2A report (Ref. /2/). All estimates are best estimates unless stated otherwise.

In the ship-ship collision model it is assumed that the one ship strikes the other struck ship. Only the struck ship is damaged with a probability of 50%. This assumption should have been stated in the Task 2A report but was omitted in error.

3 REPRESENTATIVE ACCIDENT SCENARIOS IDENTIFIED

3.1 Definition of Representative Accident Scenarios

The Representative Accident Scenarios identified by the work performed in Tasks 1, 2 and 3 are shown in Table 3-1 below.

The results in Tasks 3 and 4 are organized by where the spill originates (spill location). This is appropriate because in Tasks 3 and 4 the emphasis is on the consequence of the spill. In this report, however, the results are organized by scenario because it is necessary to discuss the accident type and possible causes of the accident that led to the spill.

Table 3-1 Representative Accident Scenarios

#	Location	Season	Casualty Type	Vessel Type	Product Spilled	Amount Spilled-bbl*
1	North side of Unimak Pass	Summer	Collision	Container Ship	Bunker Oil	3,000
2	North side of Unimak Pass	Summer	Collision	Bulk Carrier	Bunker Oil	15,000
3	North side of Unimak Pass	Summer	Collision	Crude Oil tanker	Crude Oil	400,000
4	North side of Unimak Pass	Winter	Collision	Product Tanker	Diesel	25,000
5	North side of Unimak Pass	Summer	Collision	Tank Barge	Diesel	40,000
6	Off Sanak Island	Summer	Drift Grounding	Container Ship	Bunker Oil	3,000
7	Off Sanak Island	Summer	Drift Grounding	Bulk Carrier	Bunker Oil	15,000
8	Off Sanak Island	Summer	Drift Grounding	Crude Oil tanker	Crude Oil	400,000
9	Off Sanak Island	Summer	Drift Grounding	Tank Barge	Diesel	40,000
10	Holtz Bay on Attui Island	Winter	Drift Grounding	Container Ship	Bunker Oil	25,000
11	Holtz Bay on Attui Island	Summer	Drift Grounding	Bulk Carrier	Bunker Oil	15,000
12	Holtz Bay on Attui Island	Spring	Drift Grounding	Crude Oil tanker	Crude Oil	400,000
13	Holtz Bay on Attui Island	Spring	Drift Grounding	Product Tanker	Diesel	50,000
14	North of Adak	Summer	Powered Grounding	Tank Barge	Diesel	40,000
15	South of Amlia Island	Summer	Drift Grounding	Container Ship	Bunker Oil	40,000
16	North of Urilia Bay	Spring	Drift Grounding	Bulk Carrier	Bunker Oil	15,000

*Note: bbl = barrels

3.1.1 Description of the Accident Scenarios

The Task 2A report (Ref. /2/) identified six example spill scenarios based upon the MARCS (risk model) results for the Base Year (2008/2009). Each spill scenario defined:

- The ship type and ship size that sustained the accident.
- The type of accident that occurred (e.g. collision).
- The type of material that was spilt and the total spill amount.
- The location of the spill.

Each of these parameters can be directly linked to the MARCS results. The spill scenarios also defined one or more release rates, the release duration and the season of the spill. These later parameters were required inputs to the detailed spill modeling. They were selected to be consistent with the reasonable worst case spill scenarios that were derived from MARCS.

The spill scenarios identified in Task 2A (Ref. /2/) were modified and augmented during work performed under Task 3 to develop the 16 Representative Accident Scenarios shown in Table 3-1.

3.1.2 Description of the Dominant Accident and Traffic Types

The Task 2A report (Ref. /2/) identified the dominant accident types in the Base Year (2008/2009) as shown in Table 3-2.

Table 3-2 Accident Types for the Base Year (2008/2009)

Accident Type	Percentage of Accident Frequency	Percentage of Bunker Fuel Oil Spill Risk	Percentage of Cargo Spill Risk
Powered grounding	53%	35%	45%
Drift grounding	43%	42%	41%
Collision	2%	11%	6%

It also identified the dominant traffic types for accident frequency as: Fishing Vessels (72%), Tugs (10%) and Tank Barges (4%). The corresponding dominant traffic types for bunker fuel oil spill risk are: Container Ships > 4500 Twenty Foot Equivalent Units (TEUs) (29%), Container Ships < 4500 TEUs (19%) and Fishing Vessels (15%). Finally, the corresponding dominant traffic types for cargo spill risk are: Tank Barge (72%), Container Ships > 4500 TEUs (12%) and Container Ships < 4500 TEUs (6%).

These results were considered during the selection of the 16 Representative Accident Scenarios shown in Table 3-1.

3.1.3 Description of the Accident Scenario Locations

The spill locations selected under Task 3 are described below.

Location 1 - North side of Unimak Pass

The selected spill location selected is at Longitude 166°714.18"W, Latitude 54°15'24.48"N or approximately 4.5 nautical miles northwest of Lava Point on Akutan Island (Ref. /4/). This location is approximately 8 nautical miles south of the Unimak Pass Safety fairway. NOAA Charts 16520 (Ref. /5/) and 16531 (Ref. /6/) cover this location.

Location 2 - Off Sanak Island on the south side of Unimak Pass

The selected spill location is at Longitude 162°39'27.43"W, Latitude 54°17'49.47"N or approximately 5 nautical miles south of Peterson Bay on Sanak Island. This location is approximately 8 nautical miles north of the Unimak Pass Safety fairway. Foul ground of numerous reefs, islands, islets, shoals, and covered and uncovered rocks extends almost 6 miles South (Ref. /4/) which include the spill location. NOAA Charts 16520 (Ref. /5/) and 16547 (Ref. /7/) cover this location.

Location 3 - Holtz Bay on Attu Island

The selected spill location is at Longitude 173°15'16.43"E, Latitude 52°56'59.93"N. Attu Island is part of the Near Islands which also include the Semichi Islands and Agattu Islands. Attu Island is the westernmost of the Aleutians. Holtz Bay is formed by rock and sand, west of Holtz Bay the north coast of Attu Island is precipitous and rugged. A number of reefs and rocks, all less than 0.3 miles from shore, are off this coast. Strong currents may be encountered along the north coast of Attu Island and, while variable, the consensus seems to be that they follow strong winds and are noticeably affected by the weather (Ref. /4/). It is assumed that most if not all traffic transiting the North Pacific Great Circle Route crosses the western end of the Aleutians through Amchitka Pass, which is approximately 270 miles east from Holtz Bay. NOAA Charts 16420 (Ref. /8/) and 16421 (Ref. /9/) cover this location.

Location 4 - North of Adak

The selected spill location is at Longitude 176°51'20.72"W, Latitude 52° 3'13.39"N, roughly 5 nautical miles off of Cape Moffett and northwest of Andre Bay and Cape Adagdak. Cape Adagdak is the northernmost point of Adak Island; from there the coast trends South West and then curves west to form Andrew Bay. A 20-foot-high rocky dike separates the head of the bay from freshwater Andrew Lake (Ref. /4/). NOAA Charts 16467 (Ref. /10/) and 16471 (Ref. /11/) cover this location.

Location 5 - South of Amlia Island

The selected spill location is at Longitude 173° 9'26.03"W, Latitude 52° 0'28.78"N and is the south shore of the small Sagigik Island, approximately 3.5 nautical miles from the south shore of Amlia Island. Sagigik Island is a small islet and presents a danger to navigation (Ref. /4/). AIS tracks show that some westbound transpacific and domestic vessel traffic transits relatively close to this area. NOAA Charts 16480 (Ref. /12/) covers this location.

Location 6 - North of the shores of Urilia Bay

The selected spill location is at Longitude 164°23'55.98"W, Latitude 54°56'59.05"N or approximately 1.5 nautical miles North of Cape Mordvinof on Unimak Island. This location is approximately 45 nautical miles northeast of the Unimak Pass Safety fairway. NOAA Chart 16520 (Ref. /5/) covers this location.

3.2 Purpose of the Representative Accident Scenarios

The MARCS results indicate that there are very low accident frequencies, each of which may have significant or severe spill outflows, at very large numbers of locations within the AIRA area. This result was entirely expected, but is not a practical starting point for the detailed spill trajectory modeling work and associated spill impact assessment work that was performed under Task 4. It was, therefore, necessary to select a smaller number of Representative Accident Scenarios to provide the input into Task 4. "Reasonable worst case" spill scenarios were selected because there is little point in performing detailed spill modeling of small spills which will have minor impacts.

The purpose of the Representative Accident Scenarios is, therefore, to provide an input into Task 4. They will also be used in this report as the starting point for the consequence and causality analysis. In addition, the Scenarios could be used to judge the effectiveness of risk reduction options identified under Task 7 and prioritized under Task 8.

3.3 Consequence and Causality Analysis

The MARCS marine risk model consists of multiple bow-tie models. A "bow-tie" is a risk analysis tool that links a fault tree and an event tree through a central accident. An example of a bow-tie model for a gas escape is shown in Figure 3-1. (Note, in Figure 3-1 the characteristic bow-tie shape of the bow-tie model is distorted by the need to displace the event tree downwards.)

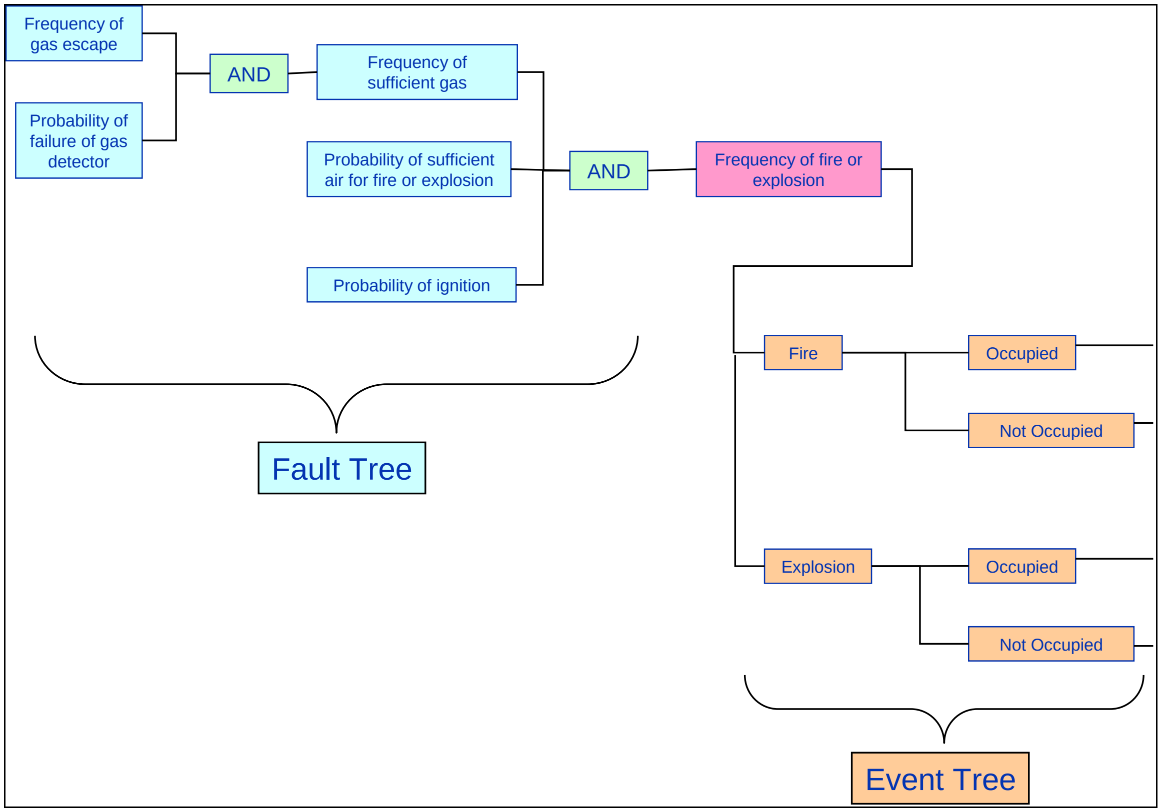

Figure 3-1 Example Bow-Tie Model

The event tree on the right side of the bow-tie shows how the outcome of an accident is distributed over multiple possible events, ranging from little or no consequence to the most severe consequence. The fault tree on the left side of the bow-tie shows the main logical conditions that must be true for the accident to occur. Thus, the consequence analysis, see Section 4, is based on the event trees in MARCS, and the causality analysis, shown in Section 5, is based on the fault tree analysis in MARCS.

4 CONSEQUENCES OF ACCIDENT SCENARIOS IDENTIFIED

The results in this section are presented first for spills of oil cargo (e.g. spills of cargo from crude oil tankers, tank barges, etc.) in Section 4.1. MARCS has different cargo spill models for each accident type (collision, powered grounding, etc.), so each scenario (accident type, ship type and size) is discussed separately. The results are then presented for spills of ship bunker fuel oil in Section 4.2. The worldwide spill data on bunker fuel oil spills is not sufficiently strong to justify differentiation by accident type, thus results for each accident type, ship type and size are presented together in the sub-sections of Section 4.2.

4.1 Spills of Cargo Oil

Eight of the 16 Representative Accident Scenarios involve spills of cargo oil. Each is discussed in turn. At the generic level, all the event trees discussed in this section have the same format as shown in Figure 4-1.

It should be noted that a cargo ship's deadweight is its maximum cargo carrying capacity. This means a 100,000 deadweight ton tanker could be carrying 660,000 barrels (100,000 tons[1]) of oil cargo, plus perhaps 33,000 barrels (5,000 tons) of bunker fuel oil. Total loss of the ship (e.g. the break-up of the ship following a grounding without lightering) could result in the release of all this oil into the environment.

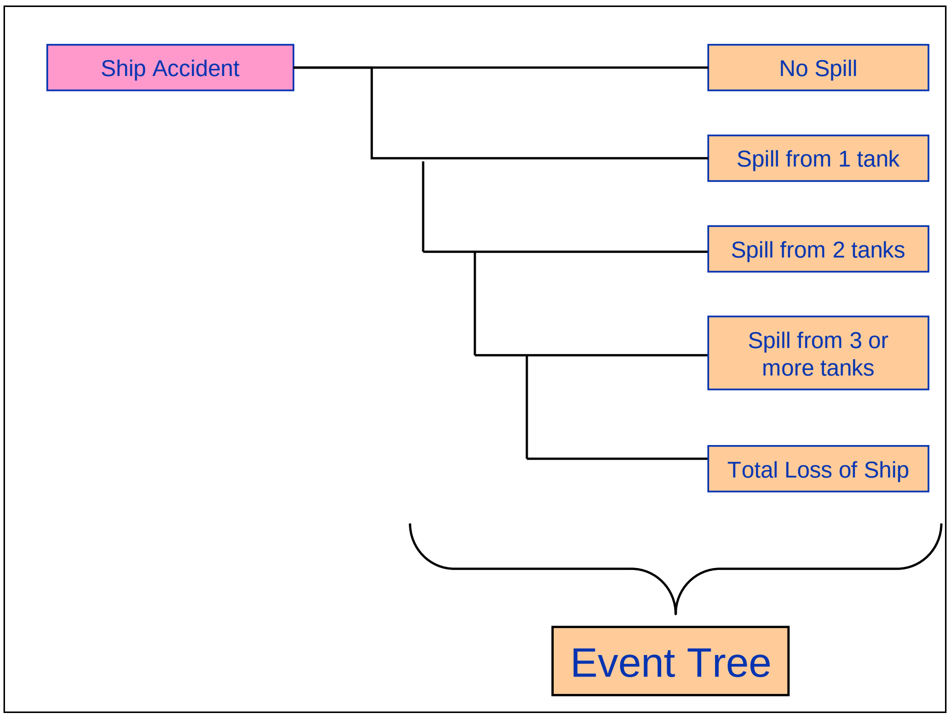

Figure 4-1 Generic Oil Outflow Event Tree

4.1.1 Spill of Cargo Oil from Accident Scenario 3

Accident Scenario 3 is a spill of 400,000 barrels (approximately 60,600 tons) of crude oil following a collision involving a crude oil tanker. The traffic study (Ref. /1/) indicates that the following types of crude oil tankers trade through the Aleutian Islands:

- Single and double hulled tankers in the range 30-50 thousand deadweight tons.
- Single and double hulled tankers in the range 90-130 thousand deadweight tons.

[1] Liquid density varies between oil types, and hence the volumes in bbl from tons can be different for different oil types. For this study, an average of fuel oils density is applied which corresponds to approximately 6.6 bbl per metric ton.

Thus, Accident Scenario 3 corresponds to either a total loss of all cargo from one of the smaller tankers or a severe accident (damage to about half of the tanks on the ship) from one of the larger tankers.

Based on worldwide data, the probability of a total loss due to collision is about 8%. Thus, Accident Scenario 3 will occur for only about 1 in 13 collisions. The remaining collisions are likely to result in either no-spill (40% probability for a double-hulled tanker) or damage to a single tank resulting in a spill size 10 to 20 times smaller than 400,000 barrels.

Thus, Accident Scenario 3 is close to a worst case accident.

4.1.2 Spill of Cargo Oil from Accident Scenario 4

Accident Scenario 4 is a spill of 25,000 barrels (approximately 3,800 tons) of diesel following a collision involving a product tanker. The traffic study (Ref. /1/) indicates that the following types of product tankers trade through the Aleutian Islands:

- Double hulled tankers in the range 6-14 thousand deadweight tons.
- Double hulled tankers in the range 14-30 thousand deadweight tons.
- Double hulled tankers in the range 30-50 thousand deadweight tons.

Thus, Accident Scenario 4 corresponds to the loss of perhaps two tanks from one of the smaller product tankers, or a single tank from one of the larger product tankers.

Based on worldwide data, the probability of damage to one or two tanks due to collision is about 25% and 20% respectively (given that a serious collision has occurred). Accident Scenario 4 is thus one of the most likely outcomes from a collision involving a product tanker.

4.1.3 Spill of Cargo Oil from Accident Scenario 5

Accident Scenario 5 is a spill of 40,000 barrels (approximately 6,060 tons) of diesel following a collision of a tank barge. The traffic study (Ref. /1/) indicates that the following types of tank barges trade through the Aleutian Islands:

- Single hulled barge in the range 0-2 thousand deadweight tons.
- Single hulled barge in the range 2-6 thousand deadweight tons.
- Single hulled barge in the range 6-14 thousand deadweight tons.
- Single hulled barge in the range 14-30 thousand deadweight tons.

Thus, Accident Scenario 5 corresponds to the total loss of a smaller tank barge or the loss of several to only one tank on one of the larger tank barges.

The loss of a single tank on a single hulled tank vessel upon collision is the most likely outcome from an accident with an estimated probability of 30% (given that a serious collision has occurred).

4.1.4 Spill of Cargo Oil from Accident Scenario 8

Accident Scenario 8 is a spill of 400,000 barrels (approximately 60,600 tons) of crude oil following a drift grounding of a crude oil tanker. The traffic study (Ref. /1/) indicates that the following types of crude oil tankers trade through the Aleutian Islands:

- Single and double hulled tankers in the range 30-50 thousand deadweight tons.
- Single and double hulled tankers in the range 90-130 thousand deadweight tons.

Thus, Accident Scenario 8 corresponds to either a total loss of all cargo from one of the smaller tankers or a severe accident (damage to about half of the tanks on the ship) from one of the larger tankers.

Based on worldwide data, the probability of a total loss due to drift grounding is about 10%. Thus, Accident Scenario 8 will occur for only about 1 in 10 drift groundings. The remaining drift groundings are likely to result in either no-spill (50% probability for a double-hulled tanker) or damage to a single tank.

Thus, Accident Scenario 8 is close to a worst case accident (like Accident Scenario 3).

4.1.5 Spill of Cargo Oil from Accident Scenario 9

Accident Scenario 9 is a spill of 40,000 barrels (approximately 6,060 tons) of diesel following the drift grounding of a tank barge. The traffic study (Ref. /1/) indicates that the following types of tank barges trade through the Aleutian Islands:

- Single hulled barge in the range 0-2 thousand deadweight tons.
- Single hulled barge in the range 2-6 thousand deadweight tons.
- Single hulled barge in the range 6-14 thousand deadweight tons.
- Single hulled barge in the range 14-30 thousand deadweight tons.

Thus, Accident Scenario 9 corresponds to the total loss of a smaller tank barge or the loss of several to only one tank on one of the larger tank barges.

The loss of a single tank on a single hulled tank vessel upon drift grounding is the most likely outcome from a serious accident with an estimated probability of 60%.

4.1.6 Spill of Cargo Oil from Accident Scenario 12

Accident Scenario 12 is a spill of 400,000 barrels (approximately 60,600 tons) of crude oil following a drift grounding of a crude oil tanker. The traffic study (Ref. /1/) indicates that the following types of crude oil tankers trade through the Aleutian Islands:

- Single and double hulled tankers in the range 30-50 thousand deadweight tons.
- Single and double hulled tankers in the range 90-130 thousand deadweight tons.

Thus Accident Scenario 12 corresponds to either a total loss of all cargo from one of the smaller tankers or a severe accident (damage to about half of the tanks on the ship) from one of the larger tankers.

Based on worldwide data, the probability of a total loss due to drift grounding is about 10%. Thus, Accident Scenario 12 will occur for only about 1 in 10 drift groundings. The remaining drift groundings are likely to result in either no-spill (50% probability for a double-hulled tanker) or damage to a single tank.

Thus, Accident Scenario 12 is close to a worst case accident (like Accident Scenarios 3 and 8).

4.1.7 Spill of Cargo Oil from Accident Scenario 13

Accident Scenario 13 is a spill of 50,000 barrels (approximately 7,600 tons) of diesel following a drift grounding of a product tanker. The traffic study (Ref. /1/) indicates that the following types of product tankers trade through the Aleutian Islands:

- Double hulled tankers in the range 6-14 thousand deadweight tons.
- Double hulled tankers in the range 14-30 thousand deadweight tons.
- Double hulled tankers in the range 30-50 thousand deadweight tons.

Thus, Accident Scenario 13 corresponds to the loss of perhaps two tanks from one of the smaller product tankers or a single tank from one of the larger product tankers.

Based on worldwide data, the probability of damage to one or two tanks due to drift grounding is about 20% and 10% respectively. For double hulled tankers the probability of no spill is 50%. Accident Scenario 13 is thus a reasonably likely outcome from a drift grounding involving a product tanker.

4.1.8 Spill of Cargo Oil from Accident Scenario 14

Accident Scenario 14 is a spill of 40,000 barrels (approximately 6,060 tons) of diesel following the powered grounding of a tank barge. The traffic study (Ref. /1/) indicates that the following types of tank barges trade through the Aleutian Islands:

- Single hulled barge in the range 0-2 thousand deadweight tons.
- Single hulled barge in the range 2-6 thousand deadweight tons.
- Single hulled barge in the range 6-14 thousand deadweight tons.
- Single hulled barge in the range 14-30 thousand deadweight tons.

Thus, Accident Scenario 14 corresponds to the total loss of a smaller tank barge or the loss of several to only one tank on one of the larger tank barges.

The loss of a single tank on a single hulled tank vessel upon powered grounding is the most likely outcome from an accident with an estimated probability of 60%.

4.2 Spills of Bunker Fuel Oil

Eight of the 16 Representative Accident Scenarios involve spills of bunker fuel oil. Each is discussed in turn, though the worldwide historical spill data for bunker fuel spills is not sufficiently detailed to support the derivation of bunker oil spill event trees as a function of accident type. The generic spill event tree shown in Figure 4-1 also applies to bunker spills, but it should be noted that some ships only have two bunker oil tanks.

4.2.1 Spill of Cargo Oil from Accident Scenarios 1, 6, 10 and 15

These scenarios involve the spill of bunker fuel oil from a container ship. The traffic study (Ref. /1/) indicates that container ships ranging from 14 thousand deadweight tons to 130 thousand deadweight tons trade through the Aleutian Islands.

Container ships tend to navigate at higher speeds (about 22 knots) because of the higher value of their cargos. This means they need larger fuel tanks compared to slower cargo ships. The traffic study (Ref. /1/) indicated average bunker oil tank capacities of 34,000 and 53,000 barrels for smaller and larger container ships in the Aleutians respectively. Normally there will be at least two bunker fuel oil tanks on a ship. In the base year, (2008/2009) bunker tanks are assumed to not be protected by double hulls.

Typically, bunker fuel oil tanks will not be full. In this study they are assumed to be 70% full, but they could be as little as 5% to 10% full at the end of a long voyage.

The most probable outcome of an accident where only bunker fuel oil may be spilled is no spill (90%). This is because most accidents will not result in damage to the bunker fuel oil tanks.

Thus, all accident scenarios which result in bunker oil spills are close to the worst case outcome for that accident.

Accident Scenarios 1, 6, 10 and 15 specify spills of 3,000, 3,000, 15,000 and 25,000 barrels respectively. The largest spill size is only likely to occur for a larger container ship with full fuel tanks, or in the event of a total loss to a container ship.

4.2.2 Spill of Cargo Oil from Accident Scenarios 2, 7, 11 and 16

These scenarios involve the spill of bunker fuel oil from a bulk carrier. The traffic study (Ref. /1/) indicates that bulk carriers ranging from 14 thousand deadweight tons to over 130 thousand deadweight tons trade through the Aleutian Islands.

The traffic study (Ref. /1/) indicated average bunker oil tank capacities of 11,500 and 18,500 barrels for smaller and larger bulk carriers in the Aleutians respectively. Normally there will be at least two bunker fuel oil tanks on a ship. In the base year (2008/2009) bunker tanks are assumed to not be protected by double hulls (Ref. /2/).

Typically, bunker fuel oil tanks will not be full. In this study they are assumed to be 70% full, but they could be as little as 5% to 10% full at the end of a long voyage.

The most probable outcome of an accident where only bunker fuel oil may be spilled is no spill (90%). This is because most accidents will not result in damage to the bunker fuel oil tanks.

Thus, all accident scenarios which result in bunker oil spills are close to the worst case outcome for that accident.

Accident Scenarios 2, 7, 11 and 16 each specify spills of 15,000 barrels. These spill sizes can clearly only occur for the larger bulk carriers and probably only occur in the event of total loss of the ship. Thus, these spill scenarios are very unlikely.

4.3 Sensitivities and Uncertainties

Section 8 of the Task 2A report (Ref. /1/) provided a detailed discussion of the sensitivities and uncertainties of the modeling results which are the foundation of all the information presented in this Task 5 report. This discussion is all relevant and is not repeated here.

Most of the results presented in this section are dependent on the analysis of worldwide historical spill data performed by DNV to support internal DNV work programs. The AIRA Risk Analysis Team believes that this data is the best data available to support the AIRA project. The key issues, and our response to these issues, are:

- Is worldwide data transferable to the Aleutians without modification? There is not sufficient spill data in the Aleutian Islands area alone to support the level of detail required by this risk assessment. If modification factors were applied, then these would need to be justified and could themselves be open to criticism.
- How representative is the data? Data for cargo spilling accidents from single hulled tankers is strong. Spill data from double hulled tankers is weaker and so is augmented by judgments. Spill data from bunker fuel oil spills is sparse and sometimes difficult to distinguish from cargo oil spill information.
- How precise is the data? Percentage figures quoted in this report are likely to be precise within 5 to 10% (that is, if the spill probability is quoted as 20%, the true value could be in the range 10% to 30%).

Overall, it is considered that the results presented in this Task 5 report are a sufficient basis for Phase A.

5 CAUSALITY OF ACCIDENT SCENARIOS IDENTIFIED

In MARCS the accident frequencies are calculated as the frequency of a critical situation, which is accident dependent, multiplied by the probability that an accident will occur given that the critical situation has occurred, see Figure 5-1. See the Task 2A report for a more detailed description of the MARCS accident models (Ref. /1/).

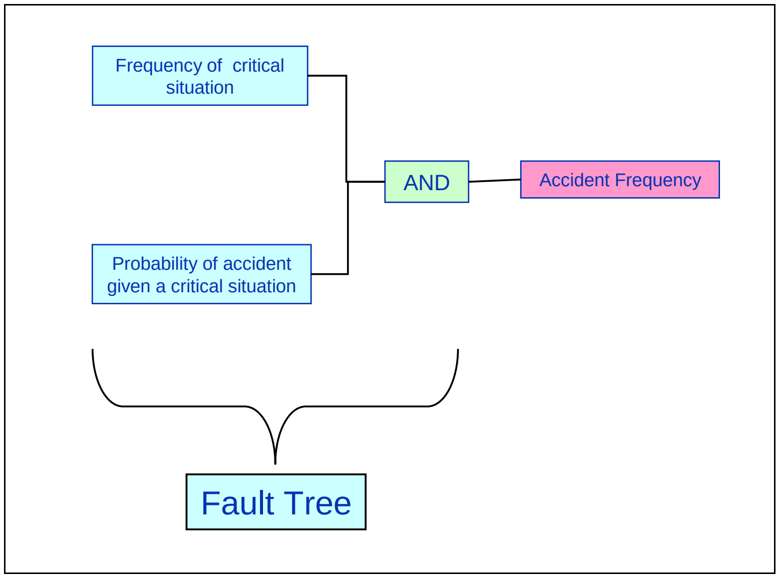

Figure 5-1 Generic Accident Frequency Fault Tree Used by MARCS

This section presents and discusses the major underlying causes of marine accidents as represented in MARCS.

5.1 Drift Grounding

For drift grounding the critical situation is the frequency of breakdown of the ship's main systems (propulsion and steering). Figure 5-2 shows a generic fault tree for the drift grounding accident type.

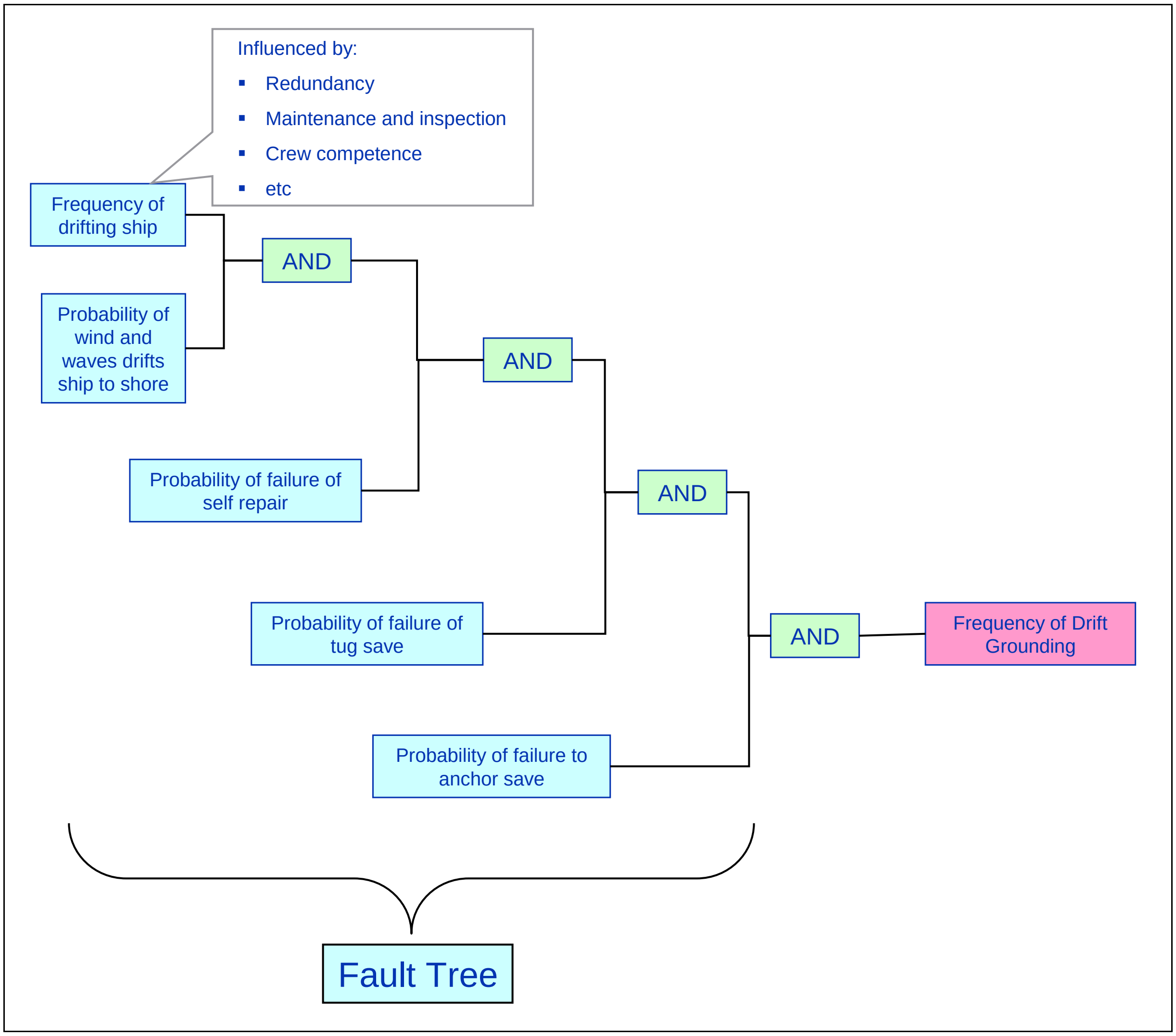

Figure 5-2 Drift Grounding Fault Tree

Accident scenarios 6 through 13, 15 and 16 are all drift grounding accidents. Each are the same for the purposes of this analysis.

The magnitude of the four generic probabilities shown in Figure 5-2 are, with the exception of the probability of failure of self-repair, all strongly dependent on the location of the ship breakdown. In MARCS, these location dependent factors are taken into full account, but these failures are neither technical nor operational; they mostly reflect good or bad luck, though the choice of a deep sea route, where a coastal route is equally feasible, represents good risk management.

The frequency of ship breakdowns (breakdowns per hour) mainly depends on the following factors:

- The level of redundancy of main systems on the ship. Most ships have only single engines and single rudders, but some ferries will have twin propulsion systems and some specialist ships (e.g. the Alaska Class tankers) have full propulsion and steering system redundancy. Where redundancy exists, the frequency of ship breakdown will be reduced.
- The quality of the ship's mechanical maintenance routines, including preventative maintenance and quality of the ship companies management system control of such issues.
- The level of competence of the crew (selection, training and motivation) and the degree to which the in-ship management supports good crew performance.

Similarly, the probability that the ship can self-repair within a given time is also likely to be enhanced by factors noted under bullet points 2 and 3 above.

DNV does not have an analysis which shows the relative importance of contributing factors to the frequency of ship breakdowns. Such failures, once they occur, are 100% technical failures at the immediate cause level, but a portion of these failures will be attributable to the strength of the management system applied in the ship and the shipping company at the basic cause level.

5.2 Powered Grounding

For powered grounding there are two critical situations:

- The frequency of critical course change points within 20 minutes navigation of a shore line.
- The frequency of navigation parallel to a shore line with wind and waves from the side and within 20 minutes navigation of the shore line.

See the Task 2A report (Ref. /2/) for a more detailed description of the MARCS accident models (Ref. /1/). Figure 5-3 shows the main parts of the fault tree used for powered grounding.

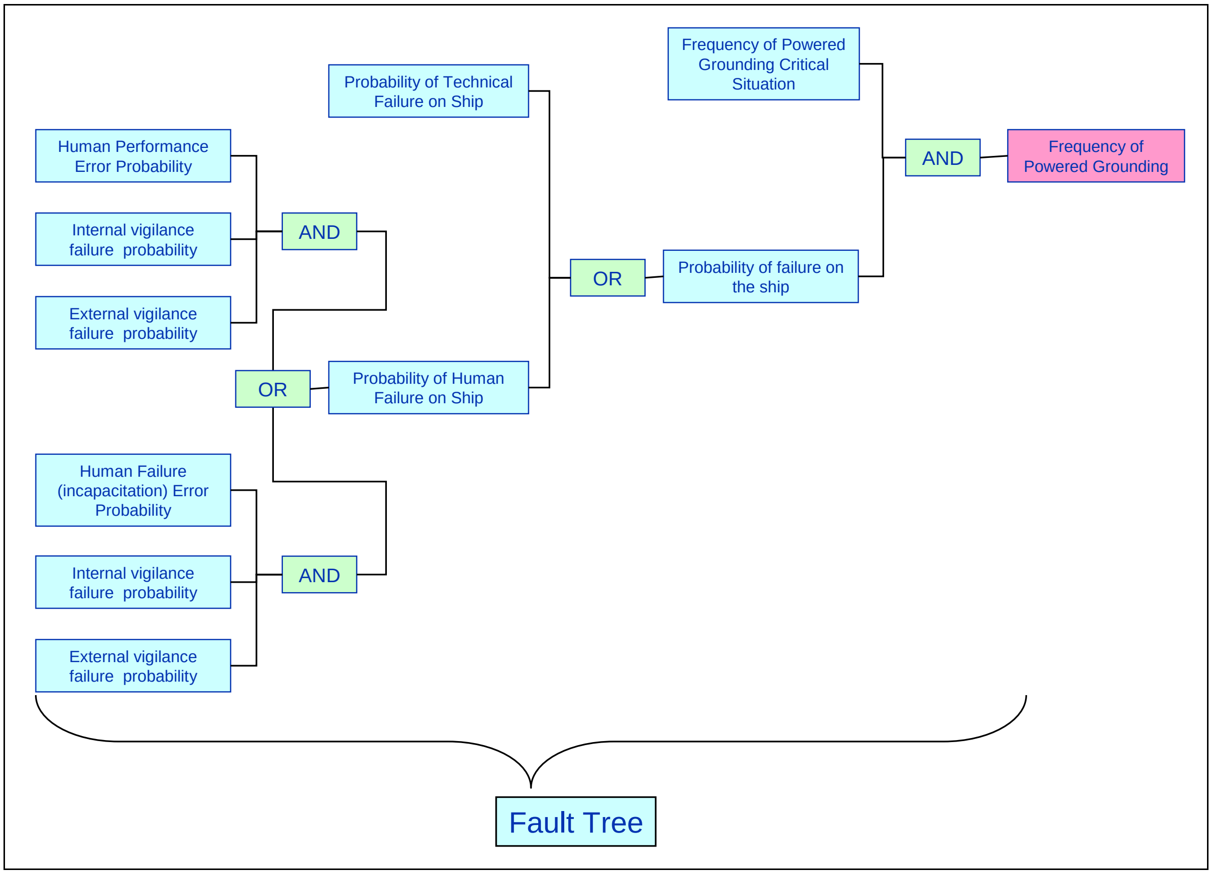

Figure 5-3 Powered Grounding Fault Tree

Table 5-1 defines the terms used in Figure 5-3.

Accident Scenario 14 is the only powered grounding accident in the list of 16 Representative Accident Scenarios.

Table 5-1 Definition of Terms Used in Powered Grounding Fault Tree

Term	Definition
Incapacitation	Officer on board is absent, absorbed, injured, asleep/sleepy or intoxicated.
Internal Vigilance with respect to Incapacitation	Failure of internal vigilance of the deck officer with respect to detection of incapacitation.
External Vigilance with respect to Incapacitation	Related to efforts by others to warn or divert a vessel on dangerous course.
Human Performance	Inadequate planning of voyage, substandard use of navigational equipment, lack of experience, poor judgment of conditions, etc.
Internal Vigilance with respect to Human Performance	Failure in internal vigilance of the navigating office on the ship with respect to detecting sub-standard human performance.
External Vigilance with respect to Human Performance	Related to efforts by others to warn or divert a vessel on dangerous course.

In Figure 5-3 the technical failure (e.g. radar failure and poor visibility) part of the tree contributes less than 5% of the total error probability. The remainder arises from human error (operational error) and about 90% of this error is contributed by human performance error. It should be noted that these ratios depend on conditions external to the ship (e.g. visibility or vessel traffic service area) and internal to the ship (e.g. presence of pilot).

Thus, the majority of powered grounding risk, for a given traffic pattern, is attributed to human performance error (operational error). This can be controlled by improved standards of training, improved enforcement of existing standards of training, improved motivation, and similar risk reduction measures. Alternatively, the traffic pattern could be amended to reduce the frequency of critical situations and so reduce powered grounding risk.

5.3 Collision

For collision the critical situation is when two ships navigate within 0.5NM of each other (an encounter). The collision fault tree is similar to the powered grounding fault tree but is more complex because of the need to assess the possibility of error on both ships involved in the encounter.

See Task 2A report (Ref. /1/) for a more detailed description of the MARCS accident models (Ref. /1/).

Accident Scenarios 1 through 5 are all collision accidents. Each accident analysis is the same for the purposes of this analysis.

The collision fault tree is similar to the powered grounding fault tree in that technical failures make a modest contribution to the overall collision probability. Next most important is the possibility of human incapacitation (asleep, heart attack, etc) and the most important contribution is again the human performance error.

Thus, the majority of collision risk is attributed to human performance error (operational error). This can be controlled by improved standards of training, improved enforcement of existing standards of training, improved motivation, and similar risk reduction measures. Alternatively, the traffic pattern could be amended to reduce the frequency of critical situations and so reduce collision risk.

5.4 Sensitivities and Uncertainties

Section 8 of the Task 2A report (Ref. /1/) provided a detailed discussion of the sensitivities and uncertainties of the modeling results which are the foundation of all the information presented in this report. This discussion is all relevant and is not repeated here.

The results presented in this section of this Task 5 report are dependent on the analysis of accident data mainly from the North Sea performed by DNV under the SAFECO projects (Ref. /13/, /14/). The AIRA Risk Analysis Team believes that this data is the best data available to support the AIRA project.

6 REVIEW OF HISTORICAL / NEAR SPILLS

This section first presents a summary of the most significant spills and near-spills that have occurred in the Aleutian Islands over the last 30 years. Section 6.2 discusses how these actual accidents relate to the Representative Accident Scenarios described in Sections 3, 4 and 5 of this report.

6.1 Historical Spills and Near-Spills in the Aleutians

Table 6-1 presents the historical spills and near-spills identified. There are 42 US gallons per barrel. Note that information on causes is not complete and thus the causes attributed should be considered to be indicative and not definitive.

Where brief accident descriptions are available they are quoted, along with the source of the description, below Table 6-1.

Table 6-1 Historical and Near Spills

Date	Vessel Name	Vessel Type	Location	Product Spilled	Amount Spilled (US Gallons)	Probable Cause
12/26/1988	Tank Barge 283	Tank Barge	East of Shumagin Islands	Diesel	2,041,662 (48,611 bbl)	Structural failure / Foundering
12/8/2004	M/V Selendang Ayu	Bulk Carrier	Unalaska Island, Skan Bay	IFO 380, Diesel	335,732 (7,993 bbl)	Mechanical failure / Structural Failure / Grounding
3/5/1981	M/V Dae Rim	General Cargo	Attu Island	Diesel	109,998 (2,619 bbl)	Structural failure / Collision
1/17/1989	T/B Foss 256	Tug-Barge	Amchitka Island	Diesel	83,958 (1,999 bbl)	Weather / Structural failure / Grounding
1/11/1989	M/V Chil Bo San	Fishing Vessel	Unalaska Island	Diesel	60,984 (1,452 bbl)	
11/26/1997	M/V Kuroshima	Reefer	Unalaska, Summer Bay	Bunker	38,976 (928 bbl)	Weather / Structural failure / Grounding
2/1/1988	F/V Alaska Star	Fishing Vessel	Nikolski	Diesel	35,952 (856 bbl)	Structural failure /Grounding
12/10/1988	M/V Aoyagi Maru	Reefer	Akun Island	Diesel	31,962 (761 bbl)	Human Error / Mechanical failure / Structural Failure / Grounding
2/27/1989	M/V Swallow	Reefer	Dutch Harbor	Diesel	29,988 (714 bbl)	Unknown / Grounding
2/17/1988	F/V Captain Billy	Fishing Vessel	Yunalaska Island	Diesel	16,002 (381 bbl)	Weather / Grounding
12/3/1988	F/V Opty	Fishing Vessel	Shemya Island	Diesel	16,002 (381 bbl)	Weather / Grounding
7/22/1995	F/V Northern Wind	Fishing Vessel	Seguam Island	Diesel	14,994 (357 bbl)	Structural Failure / Grounding
3/8/1987	F/V Birgit N	Fishing Vessel	Uluak Island	Diesel	12,012 (286 bbl)	Structural Failure / Grounding
11/3/1988	F/V City of Seattle	Fishing Vessel	Atka Island	Diesel	12,012 (286 bbl)	Structural Failure / Grounding
5/6/1987	F/V Tae Woong	Fishing Vessel	Uliaga Island	Diesel	10,500 (250 bbl)	Structural Failure / Grounding
7/23/ 2006	M/V Cougar Ace	Roll On/Roll off	South of Aleutians	No spill	Possible 180,000 (4,286 bbl)	Possible human failure.

Tank Barge 283

Shumagin Islands, Western Gulf of Alaska, 1988-Dec-28

On December 26, 1988, the U.S. Coast Guard Marine Safety Office, Anchorage, was notified that the tank barge 283, towed by the tug Marine Explorer, was sinking stern down in the western Gulf of Alaska. The tug and barge were en route to Dutch Harbor with approximately 2,000,000 gallons of diesel when they encountered extremely heavy weather. The void aft tanks were flooded, causing the barge to turn bow-up with approximately 80 feet of the barge above water and the remaining 200 feet below the surface. The salvage vessel arranged for by the T/B 283's owner, United Marine Tug and Barge, Inc., of Seattle, would take approximately eight days to arrive from its location in Astoria, Oregon. Meanwhile, the barge began leaking diesel as 50-60 knot winds and 20-25 foot seas racked this portion of Alaska. USCG district 17. (Ref. /15/)

M/V Selendang Ayu

On December 8, 2004, the 738 ft Malaysian-registered bulk carrier lost power and was adrift off Unalaska Island. Efforts to tow the vessel failed and it went aground and broke apart between Skan Bay and Spray Cape at approximately 6:00pm, December 8. Approximately 321,052 gallons of IFO and 380 and 14, 680 gallons of marine diesel and miscellaneous oils were released into the environment. Reported causal factors included main engine failure; crew unable to repair work and rescue operations; failure to notify authorities and seek assistance in a timely manner; lack of adequate emergency towing and anchoring gear; inadequate prior engine maintenance; lack of adequate rescue/towing vessel and equipment in the region. (Ref. /16/, /17/)

M/V Dae Rim

291’ 1500 ton Korean M/V Dae Rim wrecked ½ mile east of Cape Wrangell on the north side. The vessel had previously suffered a collision with a Soviet vessel, caught fire and been abandoned by its crew 90 miles west of Attu. Twenty-four of the crew of twenty-six died after abandoning ship. The Dae Rim, still afloat, was taken under tow by another Soviet vessel, the towline was subsequently lost or cut loose, and Dae Rim drifted ashore. A U.S. Navy EOD team, using the U.S.C.G. cutter Boutwell as a platform for operations, set high explosives on the wreck’s fuel tanks to vent them and burn off about 110,000 gallons of fuel oil. All but two tanks were ruptured and burned by the explosive charges, with the Boutwell firing its guns to vent the remaining two. (Ref. /18/, /19/)

T/B Foss 256

Amchitka, Island, Aleutian Island Chain, Alaska, 1989-Jan-18

At approximately 0800 on January 17, 1989, the Foss Company's tank barge 256 holed itself at Bird Cape, Amchitka Island during heavy weather. The vessel was transferring diesel fuel to the U.S. Navy facility at Bird Cape when approximately 70 knot winds pushed the barge and the tug DANIEL FOSS over rocks, ripping holes in several cargo tanks. The total capacity of the barge was approximately 1,800,000 gallons of diesel. The Daniel Foss, with the barge in tow, moved from Bird Cape to Chitka Cove. As the weather permitted, the fuel transfer was completed by January 25. The barge apparently lost approximately 84,000 gallons of diesel. U.S. Navy personnel surveyed the beach from Bird Cape to Chitka Cove and found no evidence of the spill on the beach. The case was closed on January 26. USCG district 17. (Ref. /15/, /17/)

M/V Kuroshima

Summary: The Japanese cargo vessel, M/V Kuroshima (Japanese-registered freighter, 367 ft in length), had been anchored outside Summer Bay near Dutch Harbor, Alaska for over 3 weeks waiting to take on fishery's cargo when a powerful storm hit on November 26.

Northerly winds built to 40 - 50 knots with gusts up to 90 knots and seas of 28 to 30 feet. After dragging both anchors, the captain decided to weigh anchor and move the ship. Residents reported seeing the vessel pitching severely in the water starting the morning of November 26: "...from the front beach in Unalaska, we could see her stern rise so sharply as to expose her props and rudder." (The Dutch Harbor Fisherman, December 18, 1997) The vessel broke anchor and ran aground near Second Priest Rock the afternoon of November 26.

During the grounding, there were two fatalities. The ship ran aground on the beach in Summer Bay just west of the outlet of Summer Bay Lake, with the port side to the beach. The huge storm waves caused a surge that propagated up the stream channel, under the bridge, carrying oil all the way into the south end of the lake.

The incident resulted in two fatalities, vessel damage, and 40,000 gallons of bunker fuel oil spilled impacting the beach and a fresh water lake. (Ref. /17/, /20/)

F/V Alaska Star

On February 20, 1988, the 153-foot fish processor, Alaska Star, grounded in heavy seas in Nikolski Bay on the northwest side of Umnak Island. The vessel carried an estimated 36,000 gallons of diesel aboard. All fifteen crewmen were rescued by another fishing boat. (Ref. /15/)

M/V Aoyagi Maru

On December 10, 1988, the Aoyagi Maru, a 288-foot Japanese fish refrigerant vessel, grounded at Lost Harbor on the west side of Akun Island, Alaska, when a line caught in its screw after the fish were loaded from another vessel. An estimated 32,000 gallons of diesel, 78,000 gallons of bunker C, and 3,250 gallons of lube oil were on board when the vessel was blown aground. Despite the extremely inclement weather, the U.S. Coast Guard Cutter RUSH was on the scene by December 11 to rescue the crew of 19. The Aoyagi Maru sustained holes in its engine room and two of its three holds. It was December 15 before weather permitted observers to reach the vessel. Reports indicated only a sheen around the vessel with minimal pollution, with the water coming in through the holes in the bottom of the hull hydraulically supporting the bunker C. (Ref. /15/)

M/V Swallow

On the morning of February 27, 1989, the SWALLOW, a 287-foot Japanese refrigerant fish cargo vessel, grounded just south of Ulakta Head, roughly 10 miles north of Unalaska. The vessel was carrying approximately 65,000 gallons of Bunker C; 30,000 gallons of diesel; l3,000 gallons of lube oil; and over 200 tons of frozen crab. Within a few days most of the diesel and some of the Bunker C had been lost. Because the vessel lost generating capability shortly after it grounded, the Bunker C fuel thickened, so that little fuel was actually lost. Booms were of little use in the surf zone where the vessel was grounded. (Ref. /15/)

F/V Captain Billy

On February 17, 1988, the fishing vessel, Captain Billy, grounded in heavy weather on Yunaska Island, one of the Islands of Four Mountains on the Aleutian Islands chain. The vessel was 83 feet long and had an estimated 16,000 gallons of diesel aboard. The six crewmen went ashore and were rescued by a Coast Guard helicopter. Oil was observed leaking from the vessel. (Ref. /15/)

F/V Opty

On December 3, 1988, the OPTY, a 139-foot vessel owned by Opty Fishing Corporation of Fairhaven, Massachusetts, grounded outside Alcan Harbor on the north-western side of Shemya Island, part of the Aleutian Island Alaska Maritime National Wildlife Refuge System. High winds and seas apparently contributed to the grounding of the vessel, which carried 16,000 gallons of diesel, 1,000 gallons of hydraulic oil, and 400 gallons of lube oil. None of the oil was observed to be leaking into the water. (Ref. /15/)

M/V Northern Wind

The M/V Northern Wind, a 178-foot fish processing vessel, ran aground on the north-eastern side of Seguam Island holing the #1 port and starboard fuel tanks containing approximately 60,000 gallons of diesel fuel. The vessel owner, Arctic Alaska Seafoods in Dutch Harbor, sent a spill response team with equipment to the grounding site by the F/T American Enterprise. Within 12 hours the vessel floated free from the rocks and anchored one-half mile from the grounding site. An estimated 20 to 25 thousand gallons of diesel were lost and the response vessel pumped another 20 to 25 thousand gallons from the two damaged tanks. An additional 75 thousand gallons of diesel remained in the undamaged stern tanks. The USCG Cutter Morgenthau was on-scene throughout the incident. USCG permission was granted to move the vessel 70 miles west to a sheltered bay on the east side of Atka Island for temporary repairs. Initially the winds were northwest to 20 knots but diminished to light and variable for the duration of the incident. The response lasted for approximately five days. (Ref. /15/)

F/V Birgit N

NOAA/OAD was notified of the incident at 0930 on March 9, 1987, by the U.S. Coast Guard Marine Safety Office, Anchorage, and asked to provide trajectory, resources-at-risk, and weather information. Consultation with the NWS in Anchorage indicated quite variable wind and weather conditions, thus making fuel trajectory forecasts difficult and unreliable. By March 12, the salvage crew, Underwater Construction, reported that the vessel had been abandoned, with the crew to arrive in Adak on March 13, and 70% of the 18,000 gallon fuel capacity had been lost. A U.S. Coast Guard overflight on March 13 reported that the vessel remained hard aground on a rocky ledge 100-200 yards off the beach with a 15 degree starboard list, and a light oil sheen up to 3/4 mile long observed. The U.S. Fish and Wildlife Service (USFWS) reported that, by mid-April, an estimated 500 sea otters and 7,000 birds (gulls, cormorants, and puffins) would be in the area. USFWS recommended three possible courses of action to remove the oil: 1) removing the fuel, 2) burning the fuel in place, or 3) during a favorable wind, blow the tanks and release all the fuel at once. (Ref. /15/)

F/V City of Seattle

At 0200 on November 3, 1988, the 100-foot fishing vessel, City of Seattle, grounded in heavy seas at Crescent Bay on the northwest end of Atka Island, spilling approximately 12,000 gallons of diesel. All of the crew aboard the vessel was rescued by another fishing boat. (Ref. /15/)

F/V Tae Woong

At about 0630 on May 6, 1987, the Tae Woong, a 210-foot, 1,500-ton Korean fishing vessel carrying approximately 105,000 gallons of diesel and some drums of lubricating oil, ran aground on the east side of Uliaga Island, part of the Aleutian Islands National Wildlife Refuge. One tank was ruptured upon grounding and was leaking at a rate of over 1,000 gallons per hour. The U.S. Coast Guard Cutter RUSH removed the 49-member crew. Because the vessel was hard aground on the rocks, salvage appeared not to be feasible. An extensive oil sheen was observed around the vessel extending for approximately 2 miles. (Ref. /15/)

M/V Cougar Ace

On July 23, 2006 the M/V Cougar Ace, a 654-foot car carrier homeported in Singapore, contacted the US Coast Guard and reported that their vessel was listing at 80 degrees and taking on water. The Alaska Air National Guard and Coast Guard aircraft crews rescued the 23 crewmembers on July 24. Estimates for amount of fuel onboard the Cougar Ace are 142,184 gal Intermediate Fuel Oil 380 (IFO 380) and 34,182 gal Marine Diesel (MDO). The vessel was able to be towed to Dutch Harbor for repairs; no pollution was reported. (Ref. /17/, /21/)

6.2 Comparison of Historical Spills with Representative Accident Scenarios

This section compares the spills that have actually occurred to those Representative Accident Scenarios identified and analyzed in Tasks 3, 4 and 5. The comparison is done by considering:

- Spill size
- Spill material
- Accident type
- Ship type

The three largest spills that have occurred historically are 48,600, 7,993 and 2,619 barrels, compared to 400,000 barrels (3 scenarios) in the Representative Accident Scenarios. The chosen Representative Accident Scenarios are more than 10 times larger and are, therefore, very conservative compared to historical experience and represent worst-case estimates.

For the historical spills, 13 out of 15 (87%) spills were diesel. For the Representative Accident Scenarios 5 out of 16 (31%) spills were diesel. Diesel is a non-persistent fuel and therefore this material causes less long term harm to the environment. Thus, the chosen Representative Accident Scenarios are conservative compared to historical experience.

The causes of the historical accidents are not clearly attributed in the historical records. Nevertheless, grounding is mentioned in 12 out of the 15 actual accidents, with one collision. This is broadly similar to the accident types in the set of Representative Accident Scenarios.

For the historical accidents, 8 were from fishing vessels, 3 from reefers, 2 from tank barges and 1 from a bulk carrier. For the Representative Accident Scenarios, 4 spills were from container ships and 4 from bulk carriers, 3 from tank barges, 2 from product tankers and 3 from crude oil tankers. Thus, fishing vessels are under-represented in the Representative Accident Scenarios and container ships, bulk carriers, product tankers and crude oil tankers are over-represented. The chosen Representative Accident Scenarios are, on balance, probably conservative compared to historical experience.

7 TASK 5 SUMMARY AND CONCLUSIONS

This report describes the bow-tie models that were used by MARCS to calculate the risk results shown in the Task 2A report (Ref. /1/). The main purpose of this report was to provide a stronger narrative of how marine risks arise and to complement the mainly numerical results presented in the Task 2A report (Ref. /1/).

The risk results show that for the Representative Accident Scenarios:

- The spill volumes are generally over estimated compared to what the event trees predict is most likely to happen.
- The collision and powered grounding accidents are predominantly attributed to human error.
- The drift grounding accidents are predominantly attributed to technical failures.

The comparison of the Representative Accident Scenarios with historical accidents shows that the Representative Accident Scenarios are mostly pessimistic (larger spill volumes, more toxic spilled materials) compared to that observed historically, but in other ways are similar to historical accidents. It is concluded that the Representative Accident Scenarios are, indeed, reasonable worst case scenarios, consistent with project requirements. This conclusion should be remembered when the results from Tasks 3 and 4 are interpreted.

8 REFERENCES

/1/ Aleutian Islands Risk Assessment: Phase A Preliminary Risk Assessment, Task 1 Semi-Quantitative Traffic Study Report, September 2010

/2/ Aleutian Islands Risk Assessment: Phase A Preliminary Risk Assessment, Task 2A Marine Spill Frequency and Size Report, September 2010

/3/ Aleutian Islands Risk Assessment: Phase A Preliminary Risk Assessment, Task 2B Baseline Spill Study Report, September 2010

/4/ United States Coast Pilot 9: Pacific and Arctic Coasts Alaska: Cape Spencer to Beaufort Sea. 2009 (27th)

/5/ NOAA Navigation Chart 16520 Unimak and Akutan Passes and approaches; Amak Island

/6/ NOAA Navigation Chart 16531 Krenitzan Islands

/7/ NOAA Navigation Chart 16547 Sanak Island and Sandman Reefs; Northeast Harbor; Peterson and Salmon Bays; Sanak Harbor

/8/ NOAA Navigation Chart 16420 Near Islands Buldir Island to Attu Island

/9/ NOAA Navigation Chart 16421 Ingenstrem Rocks to Attu Island

/10/ NOAA Navigation Chart 16467 Adak Island to Tanaga Island

/11/ NOAA Navigation Chart 16471 Atka Pass to Adak Strait; Three Arm Bay, Adak Island; Kanaga Bay, Kanaga Island; Chapel Roads and Chapel Cove, Adak Island

/12/ NOAA Navigation Chart 16480 Amkta Island to Igitkin Island; Finch Cove Seguam Island; Sviechnikof Harbor, Amlia Island

/13/ SAFECO I: "Safety of Shipping in Coastal Waters (SAFECO I) Summary Report", DNV 98-2038, 1998.

/14/ SAFECO II: "Safety of Shipping in Coast Waters (SAFECO II) Summary Report", DNV 99-2032, 1999.

/15/ NOAA Office of Response and Restoration Incident data base http://www.incidentnews.gov/

/16/ U.S. Coast Guard Office of Investigation and Analysis (CG-545), Notable Oil Spills in U.S. Waters, 1989-2009

/17/ Risk of Vessel Accidents and Spills in the Aleutian–Islands – Designing a Comprehensive Risk Assessment, Special Report 293, Transportation Research Board of the National Academies, 2008

/18/ Alaska Maritime National Wildlife Refuge, Shipwrecks on Alaska Maritime National Wildlife Refuge

/19/ U.S. Fish & Wildlife Service memorandum 6/2/81, Anchorage Daily News 3/26/84

/20/ NOAA Final Report for the M/V Kuroshima Response

/21/ Alaska Department of Environmental Conservation M/V Cougar Ace Unified Command Report

/22/ U.S. Coast Guard Marine Casualty and Pollution Data Base. December 2001 to June 2009.

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