Our Reference: P1104

OCS Study BOEM 2013-0116

FINAL TASK 2 REPORT

Updates to Fault Tree for Oil Spill Occurrence Estimators UPDATE OF GOM AND PAC OCS STATISTICS TO 2012

BOEM Contract Number M11PC00013

July 2013

By

BERCHA GROUP

Bercha International Inc.

Calgary, Alberta, Canada

BOEM Bureau of Ocean Energy Management

U.S. Department of the Interior

Alaska Outer Continental Shelf Region

Environmental Sciences Management

OCS Study BOEM 2013-0116

FINAL TASK 2 REPORT

Updates to Fault Tree for Oil Spill Occurrence Estimators UPDATE OF GOM AND PAC OCS STATISTICS TO 2012

BOEM Contract Number M11PC00013

July 2013

Principal Investigator: Dr. Frank G. Bercha, P.Eng.

Bercha International Inc.
2926 Parkdale Boulevard N.W.
Calgary, Alberta, T2N 3S9, Canada
Email: berchaf@berchagroup.com

Study concept, oversight, and funding were provided by the U.S. Department of Interior, Bureau of Ocean Energy Management, Environmental Studies Program, Washington, DC under Contract Number: M11PC00013.

EXECUTIVE SUMMARY

A. Introduction

Historical data and their statistical analyses are used as a starting point for fault tree application to oil spill indicator quantification for the Alaska Arctic Outer Continental Shelf (OCS). In the initial fault tree analysis [1][*], data from the Gulf of Mexico (GOM) OCS were analyzed for the period from 1972 to 1999. In 2008, a more refined publication of the data characteristics by MMS (now BOEM) has made it possible to conduct a more thorough statistical analysis as well as an update of the GOM data and its analysis to 2006 [2]. The current report generally discusses and gives data summaries as well as detailed statistical results from the re-analysis of the data, including an update of the GOM and Pacific (PAC) OCS data for platform and pipeline hydrocarbon (crude oil, diesel oil, condensate and refined petroleum products) spills, and an update of blowout and well release spill frequencies to 2012 [6, 7]. The work is covered by BOEM contract number M11PC00013, and it is the first update under Task 2.

B. Pipeline Spills

The pipeline spill statistics generated in this update are basic spill statistics. First, the number of spills by size occurring for each causal category is given. Next, spill causes by two principal spill size categories are given, and transformed to spill frequencies per kilometer-year by dividing the number of kilometer-years exposure. And finally, the spill frequency distribution for spills of different size categories, by pipe diameter is determined. Table 1 summarizes the spill occurrences by size for each of the principal causes. Both the exact spill size in barrels and the spill size distribution by each of the spill size categories are given in Table 1.

Table 2 gives the pipeline hydrocarbon spill statistics by cause. These statistics are given as the probability of occurrence per kilometer-year of operating pipeline. Thus, for example, approximately 13.59 spills per 100,000 km-yrs in the small and medium size category are likely to occur. Of these, it is expected that approximately 6.7% can be attributed to pipe corrosion.

Finally, Table 3 summarizes the pipeline hydrocarbon spill statistics by spill size and two pipe diameter ranges.

[*] Numbers in square brackets refer to publications listed in “References” section of this report.

Table 1
GOM and PAC OCS Pipeline Hydrocarbon Spill Summary by Spill Size (1972-2010)

CAUSE CLASSIFICATION	NUMBER OF SPILLS	SPILL SIZE (BBL)													NUMBER OF SPILLS					
		1	2	3	4	5	6	7	8	9	10	11	12	13	S	M	L	H	SM	LH
CORROSION	4														1	2	1		3	1
External	1	80													1				1	
Internal	3	100	5000	414												2	1		2	1
THIRD PARTY IMPACT	20														2	7	8	3	9	11
Anchor Impact	13	19833	65	50	300	900	323	15576	2000	800	1211	2240	870	1500	2	5	4	2	7	6
Jackup Rig or Spud Barge	2	200	3200													1	1		1	1
Trawl/Fishing Net	5	4000	100	14423	4569	4533										1	3	1	1	4
OPERATION IMPACT	4														3		1		3	1
Rig Anchoring	1	50													1				1	
Work Boat Anchoring	3	50	5100	50											2		1		2	1
MECHANICAL	3															3			3	
Connection Failure	2	135	150													2			2	
Material Failure	1	210														12			1	
NATURAL HAZARD	28														9	15	4		24	4
Mud Slide	3	250	80	8212											1	1	1		2	1
Storm/ Hurricane	25	3500	1720	671	126	200	250	260	95	123	960	50	55	132	8	14	3		22	3
		50	75	100	862	67	108	69	108	56	1316	209	268							
UNKNOWN	3	119	190	188												3			3	
TOTALS	62														15	30	14	3	45	17

Table 2
GOM and PAC Pipeline Hydrocarbon Spill Statistics by Cause (1972-2010)

CAUSE CLASSIFICATION	Small and Medium Spills 50-999 bbl				Large and Huge Spills >= 1000 bbl			
	HISTORICAL DISTRIBUTION %	NUMBER OF SPILLS	EXPOSURE (km-years)	FREQUENCY spill per 10^5 km-year	HISTORICAL DISTRIBUTION %	NUMBER OF SPILLS	EXPOSURE (km-years)	FREQUENCY spill per 10^5 km-year
CORROSION	6.67	3		0.896	5.88	1		0.299
External	2.22	1		0.299				
Internal	4.44	2		0.597	5.88	1		0.299
THIRD PARTY IMPACT	20.00	9		2.688	64.71	11		3.286
Anchor Impact	15.56	7		2.091	35.29	6		1.792
Jackup Rig or Spud Barge	2.22	1		0.299	5.88	1		0.299
Trawl/Fishing Net	2.22	1		0.030	23.53	4		1.195
OPERATION IMPACT	6.67	3		0.896	5.88	1		0.299
Rig Anchoring	2.22	1		0.299				
Work Boat Anchoring	4.44	2	334,764	0.597	5.88	1	334,764	0.299
MECHANICAL	6.67	3		0.896				
Connection Failure	4.44	2		0.597				
Material Failure	2.22	1		0.299				
NATURAL HAZARD	53.33	24		7.169	23.53	4		1.195
Mud Slide	4.44	2		0.597	5.88	1		0.299
Storm/ Hurricane	48.89	22		6.572	17.65	3		0.896
UNKNOWN	6.67	3		0.896				
TOTALS	100.0	45		13.442	100.0	17		5.078

Table 3
GOM and PAC Pipeline Hydrocarbon Spill Statistics by Spill Size and Pipeline Diameter (1972-2010)

GOM and PAC Pipeline Spills, Categorized 1972-2010			Spill Statistics (Number of Spills)	Exposure (km-yrs)	Frequency (spills per 10^5 km-yrs)
By Pipe Diameter		<= 10"	38	222,716	17.062
		> 10"	24	112,047	21.420
By Spill Size		Small 50 - 99 bbl	15	334,764	4.481
		Medium 100 - 999 bbl	30	334,764	8.962
		Large 1000 - 9999 bbl	14	334,764	4.182
		Huge >=10000 bbl	3	334,764	0.896
By Pipe Diameter, By Spill Size	<= 10"	Small 50 - 99 bbl	11	222,716	4.939
		Medium 100 - 999 bbl	19	222,716	8.531
		Large 1000 - 9999 bbl	7	222,716	3.143
		Huge >=10000 bbl	1	222,716	0.449
	> 10"	Small 50 - 99 bbl	4	112,047	3.570
		Medium 100 - 999 bbl	11	112,047	9.817
		Large 1000 - 9999 bbl	7	112,047	6.247
		Huge >=10000 bbl	2	112,047	1.785

C. Platform Spills

The primary platform hydrocarbon spill statistical information required is the spill frequency distribution by different causes and spill sizes, and the spill rate per well year. Table 4 summarizes the spill size distribution among the principal reported causes. As can be seen, the major cause attributable to over 50% of the spills – at 70 out of 135 spills – is hurricanes. The largest single spill, however, is the Macondo blowout which caused a spill of nearly 5 million barrels.

The spill frequency data, given per production well-year, is shown in Table 5, again, by causal distribution as well as two broad spill size categories of small and medium spills and large and huge spills. Here, it becomes immediately evident that the largest spill potential in terms of frequency is attributable to hurricanes, which are responsible for roughly 50% of the large and huge spills, and 52% of the small and medium spills.

D. Well Release and Blowout Spills

As a comparative study of well release and blowout spills is currently underway by Bercha for BOEM, only preliminary and cursory results are given in this update report.

Table 4
Summary of GOM and PAC OCS Platform Hydrocarbon Spills by Size and Cause

CAUSE CLASSIFICATION	NUMBER OF SPILLS	SPILL SIZE (bbl)															NUMBER OF SPILLS					
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	S	M	L	H	SM	LH
EQUIPMENT FAILURE	41	9,935	130	50	300	77	104	321	60	95	83	118	210	50	64	228	23	17	1		40	1
		600	77	320	200	77	50	107	50	643	50	58	52	60	50	55						
		400	55	280	50	75	435	62	125	127	50	62										
HUMAN ERROR	15	95	120	286	58	400	100	60	64	100	100	600	170	200	60	264	5	10			15	
COLLISION	1	119																1			1	
WEATHER	7	7,000	239	100	1,500	80	214	100									1	4	2		5	2
HURRICANE	70	75	200	1,456	66	350	497	741	52	55	264	106	66	510	141	242	28	38	4		66	4
		204	195	325	380	130	110	195	307	71	159	94	51	101	51	50						
		51	97	614	1,572	77	2,000	181	188	101	1,494	67	659	166	53	51						
		63	528	59	133	51	54	685	103	62	205	52	513	200	550	140						
		50	127	70	194	170	196	72	58	54	62											
UNKNOWN	1	4,900,000																		1		1
TOTALS	135																57	70	7	1	127	8

Table 5
GOM and PAC OCS Platform Hydrocarbon Spill Statistics (1972-2010)

CAUSE CLASSIFICATION	Small and Medium Spills 50-999 bbl				Large and Huge Spills >=1000 bbl			
	Historical Distribution %	Number of Spills	Exposure (well-years)	Frequency (spill per 10^4 well-year)	Historical Distribution %	Number of Spills	Exposure (well-years)	Frequency (spill per 10^4 well-year)
EQUIPMENT FAILURE	31.50	40	245,486	1.629	12.50	1	245,486	0.041
HUMAN ERROR	11.81	15		0.611				
COLLISION	0.79	1		0.041				
WEATHER	3.94	5		0.204	25.00	2		0.081
HURRICANE	51.97	66		2.689	50.00	4		0.163
UNKNOWN					12.50	1		0.041
TOTALS	100.00	127		5.173	100.00	8		0.326

ACKNOWLEDGEMENTS

Grateful acknowledgement for funding and direction is made to BOEM, Alaska OCS Region. In particular, the following BOEM and BSEE personnel are acknowledged together with their roles:

- Caryn Smith, Contracting Officer's Representative
- Dr. Heather Crowley, Advisor
- Warren Williamson, Petroleum Engineer, IT Advisor
- Lisa Algarin, Contracting Officer
- Joanne Murphy, Contract Administrator

This work was carried out by Bercha International Inc. Key Bercha personnel on the project team were as follows:

- Dr Frank G Bercha, Project Manager and Principal Engineer
- Milan Cerovšek, Reliability Engineering Specialist
- Wesley Abel, Offshore Engineering Specialist
- Susan Bercha, Editorial and Word Processing Manager

TABLE OF CONTENTS

LIST OF TABLES AND FIGURES

TABLE **PAGE**

FIGURE **PAGE**

GLOSSARY OF TERMS AND ACRONYMS

bbl	Barrel
Blowout	A blowout is an incident where formation fluid flows out of the well or between formation layers after all the predefined technical well barriers or the activation of the same have failed.
BOEM	**B**ureau of **O**cean **E**nergy **M**anagement, Department of the Interior
BSEE	**B**ureau of **S**afety and **E**nvironmental **E**nforcement, Department of the Interior
Consequence	The direct effect of an accidental event.
GOM	**G**ulf **o**f **M**exico
Hazard	A condition with a potential to create risks such as accidental leakage of hydrocarbons from a pressurized vessel.
LOWC	**L**oss **o**f **W**ell **C**ontrol
MMbbl	Million Barrels
MMS	**M**inerals **M**anagement **S**ervice. On October 1, 2011, the Bureau of Ocean Energy Management, Regulation and Enforcement (BOEMRE), formerly the Minerals Management Service (MMS), was replaced by the Bureau of Ocean Energy Management (BOEM) and the Bureau of Safety and Environmental Enforcement (BSEE) as part of a major reorganization
NPS	**N**ominal **P**ipe **S**ize or diameter
OCS	**O**uter **C**ontinental **S**helf
PAC	**P**acific
Risk	A compound measure of the probability and magnitude of adverse effect.
SINTEF	The Foundation of Scientific and Industrial Research at the Norwegian Institute of Technology
Spill Frequency	The number of spills of a given spill size range per year. Usually expressed as spills per 1,000 years (and so indicated).
Spill Frequency per Barrel Produced	The number of spills of a given spill size range per barrel produced. Usually expressed as spills per billion barrels produced (and so indicated).
Spill Occurrence	Characterization of an oil spill as an annual frequency and associated spill size or spill size range.

Spill Occurrence Indicator	Any of the oil spill occurrence characteristics; namely, spill frequency, spill frequency per barrel produced, or spill index (defined above).
Spill Sizes	Small (S): 50 - 99 bbl Medium (M): 100 - 999 bbl Large (L): 1,000 - 9,999 bbl Huge (H): >=10,000 bbl Significant (SG): >=1,000 bbl
TIMS	**T**echnical **I**nformation **M**anagement **S**ystem (of BSEE)
Well release	The reported incident is a well release if oil or gas flowed from the well from some point where flow was not intended and the flow was stopped by use of the barrier system that was available on the well at the time the incident started.

SECTION 1

INTRODUCTION

1.1 General Introduction

Historical data and their statistical analyses are used as a starting point for fault tree application to oil spill indicator quantification for the Alaska Arctic Outer Continental Shelf (OCS). In the initial fault tree analysis [1]*, data from the Gulf of Mexico (GOM) OCS were analyzed for the period from 1972 to 1999. In 2008, a more refined publication of the data characteristics by MMS (now BOEM) has made it possible to conduct a more thorough statistical analysis as well as an update of the GOM data and its analysis to 2006 [2]. The current report generally discusses and gives data summaries as well as detailed statistical results from the re-analysis of the data, including an update of the GOM and Pacific (PAC) OCS data for platform and pipeline hydrocarbon (crude oil, diesel oil, condensate and refined petroleum products) spills (1972-2010), and an update of blowout and well release frequencies to 2012 [6, 7]. The work is covered by BOEM contract number M11PC00013, and it is the first update under Task 2.

1.2 Data Sources

The bulk of the pipeline and platform data was obtained from the BOEMRE (now BSEE) website [3] and BSEE Technical Information Management System (TIMS) through BOEM communications [8], and was generally collated and analyzed in a format similar to that of the earlier data analysis and update by Bercha [2].

In addition to the data obtained directly from the BOEM website, numerous clarifications and supplemental TIMS data were acquired through a series of email discussions between Bercha investigators and BOEM staff, between October 1 and March 31, 2012 [8]. Additionally, under a separate BOEM contract (# MI2PC00004), Bercha has obtained access to the 2012 SINTEF blowout database [7] and related reports [6], so that a preliminary update of blowout and well release data is also included here.

1.3 Outline of Report

Following this brief introduction, Section 2 deals with the pipeline spill data and its analysis, while Section 3 deals with the platform spill data and its analysis, and Section 4 deals with blowout and well release data.

* Numbers in square brackets refer to publications listed in "References" section of this report.

SECTION 2

PIPELINE SPILLS

2.1 Introduction on GOM and PAC OCS Pipeline Spills

Subsea crude oil and gas condensate pipelines in the Gulf of Mexico (GOM) Outer Continental Shelf (OCS) which totaled roughly 15,500 kilometers (km) or 9,000 miles in 2010, represent an exposure of nearly 334,764 km-years between 1972 and 2010.

BSEE requires that all OCS oil spills greater than or equal to 1 barrel be reported to the Bureau. This analysis focuses on spills greater than or equal to 50 barrels since 1972. Although in the subsequent variability analysis to be reported elsewhere, continuous spill volume distributions will be utilized, spill size characterization is reported in this update according to the following spill size categories:

- Small (S): 50 - 99 bbl
- Medium (M): 100 - 999 bbl
- Large (L): 1,000 - 9,999 bbl
- Huge (H): >= 10,000 bbl
- Significant (SG): >=1,000 bbl

In the balance of this section, all reported pipeline spills in the GOM and PAC OCS are summarized; those containing hydrocarbons (crude oil, condensate) are extracted from these, and analyzed both by causal distribution and frequency distribution.

2.2 Pipeline Exposure

Table 2.1 summarizes the total length of GOM and PAC OCS subsea crude oil and gas condensate pipelines in operation between 1972 and 2010. In addition, it gives the total mile-years and kilometer-years and their distribution for pipelines of different nominal pipe diameter (NPS) in inches. Appendix A gives the exposure data for GOM in Table A.1 and PAC in Table A.2. Only the GOM pipelines include gas condensate; there are no gas condensate pipelines in the Pacific region.

2.3 All Pipeline Spills

Table 2.2 gives a summary of all pipeline liquid spills and associated causal information. As can be seen, most of these are crude oil or condensate; some are other liquid chemicals.

Table 2.1
GOM and PAC OCS Pipeline Exposure Data (1972-2010)

Miles of GOM and PAC Oil Pipeline Segments by Year and Size 1972-2010											
Year	<=10"	>10"	Total	2"	3"	4"	5 - 6"	7 - 8"	9 - 10"	11 - 19"	20 - 36"
1972	1,303	447	1,750	59	84	289	469	277	126	447	0
1973	1,420	522	1,942	60	88	299	500	321	153	518	4
1974	1,516	543	2,059	66	90	304	508	396	153	539	4
1975	1,592	618	2,210	67	94	310	525	444	153	614	4
1976	1,702	759	2,461	73	98	317	534	522	159	647	112
1977	1,786	787	2,573	74	101	345	557	551	159	654	133
1978	1,965	863	2,828	74	109	361	621	593	208	730	133
1979	2,106	875	2,980	74	112	389	640	650	241	742	133
1980	2,238	913	3,150	76	119	406	659	711	267	780	133
1981	2,421	959	3,380	79	120	450	756	749	267	826	133
1982	2,552	996	3,548	79	124	468	839	770	272	863	133
1983	2,702	1,041	3,743	79	142	483	931	795	272	908	133
1984	2,907	1,060	3,967	79	155	555	996	826	296	927	133
1985	3,043	1,062	4,105	79	175	585	1,038	865	301	929	133
1986	3,118	1,172	4,290	79	184	600	1,074	880	301	1,032	140
1987	3,234	1,174	4,409	79	192	634	1,093	900	336	1,034	140
1988	3,300	1,214	4,515	85	217	666	1,090	901	341	1,074	140
1989	3,363	1,262	4,626	86	241	689	1,094	912	341	1,122	140
1990	3,537	1,263	4,801	93	243	751	1,163	935	352	1,123	140
1991	3,648	1,251	4,900	94	267	790	1,180	957	360	1,111	140
1992	3,788	1,269	5,058	94	280	809	1,212	1,032	361	1,117	152
1993	3,831	1,276	5,107	88	290	829	1,229	1,034	361	1,124	152
1994	3,968	1,396	5,364	81	300	858	1,287	1,079	363	1,244	152
1995	4,083	1,530	5,613	82	306	886	1,327	1,113	369	1,305	225
1996	4,242	1,983	6,225	81	318	912	1,427	1,135	369	1,450	533
1997	4,362	2,148	6,510	80	320	950	1,465	1,149	398	1,607	541
1998	4,494	2,336	6,830	80	308	992	1,540	1,169	405	1,759	577
1999	4,646	2,427	7,073	80	307	1,008	1,587	1,235	429	1,850	577
2000	4,755	2,567	7,322	71	306	1,032	1,608	1,268	470	1,991	576
2001	4,922	2,625	7,547	70	300	1,079	1,687	1,306	480	2,030	595
2002	5,018	2,714	7,732	67	297	1,076	1,704	1,395	479	2,119	595
2003	4,996	2,927	7,923	64	270	1,035	1,749	1,403	475	2,296	631
2004	5,036	3,561	8,597	57	272	1,027	1,762	1,423	495	2,544	1,017
2005	4,944	3,506	8,450	57	257	1,013	1,729	1,407	481	2,489	1,017
2006	4,940	3,506	8,446	57	257	1,013	1,729	1,404	480	2,489	1,017
2007	5,215	3,609	8,824	58	268	1,068	1,860	1,462	499	2,468	1,141
2008	5,237	3,784	9,021	56	267	1,050	1,860	1,478	526	2,588	1,196
2009	5,229	3,847	9,076	54	251	1,020	1,880	1,470	554	2,652	1,195
2010	5,222	3,835	9,057	59	236	971	1,837	1,563	556	2,640	1,195
TOTAL mile-yrs	138,390	69,623	208,012	2,870	8,365	28,319	46,732	38,484	13,620	54,377	15,246
TOTAL km-yrs	222,716	112,047	334,764	4,619	13,462	45,575	75,208	61,934	21,919	87,511	24,536

Table 2.2
GOM and PAC OCS Pipeline All Spill Data Summary (1972-2010)

#	Year	Water Depth (feet)	NPS	Total Spilled	Product Spilled	Cause of Incident	Activity	Operation	ID
1	1972	140	12	100	crude oil	Equipment Failure	Development/ Production	Pipeline	0418
2	1973	168	16	5,000	crude oil	Equipment Failure	Development/ Production	Pipeline	0594
3	1974	240	14	19,833	crude oil	External Forces, Equipment Failure	Development/ Production	Pipeline	0729
4	1974	246	12	65	crude oil	Weather, External Forces, Equipment Failure	Development/ Production	Pipeline/Barge	0737
5	1974	141	8	3,500	crude oil	Weather, External Forces, Hurricane Carmen	Development/ Production	Hurricane	0760
6	1976	160	18	414	crude oil	External Forces, Equipment Failure	Development/ Production	Pipeline	0916
7	1976	210	10	4,000	crude oil	External Forces, Equipment Failure	Development/ Production	Pipeline	0979
8	1977	105	13	250	crude oil	External Forces, Equipment Failure	Development/ Production	Pipeline	1005
9	1977	247	14	50	crude oil	External Forces, Equipment Failure	Development/ Production	Pipeline/Barge	1014
10	1977	210	8	300	crude oil	External Forces, Equipment Failure	Development/ Production	Pipeline	1053
11	1978	177	9	135	crude oil	Equipment Failure	Development/ Production	Pipeline	1094
12	1978	103	9	900	crude oil	External Forces, Equipment Failure	Development/ Production	Pipeline	1128
13	1979	300	8	50	crude oil	External Forces, Equipment Failure	Development/ Production	Pipeline/Motor Vessel	1228
14	1980	137	8	100	condensate	External Forces, Equipment Failure	Development/ Production	Pipeline	1295
15	1981	54	4	80	crude oil	Equipment Failure	Development/ Production	Pipeline	1393
16	1981	190	8	5,100	crude oil	External Forces, Equipment Failure	Development/ Production	Pipeline/Motor Vessel	1427
17	1983	184	8	80	crude oil	Weather, External Forces, Equipment Failure	Development/ Production	Pipeline	1515
18	1985	162	13	323	crude oil	External Forces, Equipment Failure	Development/ Production	Pipeline	1688
19	1985	17	12	200	crude oil	External Forces, Equipment Failure	Development/ Production	Pipeline/Barge	1755
20	1986	27	6	119	crude oil	Equipment Failure	Development/ Production	Pipeline	1773
21	1986	300	8	210	crude oil	External Forces, Equipment Failure	Development/ Production	Pipeline	1819
22	1988	75	14	15,576	crude oil	Weather, Human Error, External Forces, Equipment Failure	Development/ Production	Pipeline/Motor Vessel	1868
23	1990	197	4	14,423	condensate	External Forces, Equipment Failure	Development/ Production	Pipeline	1934
24	1990	230	8	4,569	crude oil	External Forces, Equipment Failure	Development/ Production	Pipeline	1950
25	1991	90	11	50	crude oil	Weather, External Forces, Equipment Failure	Development/ Production	Pipeline/Motor Vessel	1989
26	1992	90	12	190	crude oil	Equipment Failure	Development/ Production	Pipeline	2022
27	1992	30	20	2,000	crude oil	Weather, External Forces, Equipment Failure, Human Error, Hurricane Andrew	Development/ Production	Hurricane	2046
28	1993	116	4	50	crude oil	External Forces, Equipment Failure	Development/ Production	Pipeline/Motor Vessel	2059
29	1994	197	4	4,533	condensate	External Forces, Equipment Failure	Development/ Production	Pipeline	2105
30	1996	1075	20	150	crude oil	Equipment Failure, Human Error	Development/ Production	Pipeline	2160
31	1997	5292	3	71	methanol	Equipment Failure	Development/ Production	Pipeline	2242
32	1998	150	14	800	crude oil	External Forces, Equipment Failure	Development/ Production	Pipeline	2253
33	1998	264	16	1,211	condensate	Human Error, External Forces, Equipment Failure	Development/ Production	Pipeline/Motor Vessel	2255
34	1998	5292	1	85	Chemical	Equipment Failure	Development/ Production	Pipeline	2276
35	1998	108	10	8,212	crude oil	Weather, External Forces, Human Error, Equipment Failure, Hurricane Georges	Development/ Production	Hurricane	2300
36	1999	133	12	3,200	crude oil	External Forces, Human Error	Development/ Production	Pipeline	2346
37	2000	435	24	2,240	crude oil	External Forces, Human Error, Equipment Failure	Development/ Production	Pipeline	2379
38	2003	479	4	83	Chemical	Human Error	Development/ Production	Pipeline	2632
39	2004	479	6	1,720	crude oil	Weather, External Forces, Hurricane Ivan	Development/ Production	Hurricane	2704
40	2004	200	18	671	crude oil	Weather, External Forces, Hurricane Ivan	Development/ Production	Hurricane	2667
41	2004	305	6	126	crude oil	Weather, External Forces, Hurricane Ivan	Development/ Production	Hurricane	2696
42	2004	244	8	200	crude oil	Weather, External Forces, Hurricane Ivan	Development/ Production	Hurricane	2698
43	2004	255	6	250	crude oil	Weather, External Forces, Hurricane Ivan	Development/ Production	Hurricane	2701
44	2004	255	8	260	crude oil	Weather, External Forces, Hurricane Ivan	Development/ Production	Hurricane	2700
45	2004	185	8	95	crude oil	Weather, External Forces, Hurricane Ivan	Development/ Production	Hurricane	2709
46	2004	300	10	123	crude oil	Weather, External Forces, Hurricane Ivan	Development/ Production	Hurricane	2710
47	2004	1475	2	4,834	Chemical	Weather, External Forces, Hurricane Ivan	Development/ Production	Hurricane	2723
48	2005	1100	8	960	crude oil	Weather, External Forces, Hurricane Katrina	Development/ Production	Hurricane	2835
49	2005	340	8	50	crude oil	Weather, External Forces, Hurricane Katrina	Development/ Production	Hurricane	2789
50	2005	240	10	55	crude oil	Weather, External Forces, Hurricane Katrina	Development/ Production	Hurricane	2794
51	2005	216	10	132	crude oil	Weather, External Forces, Hurricane Katrina	Development/ Production	Hurricane	2787
52	2005	48	8	50	condensate	Weather, External Forces, Hurricane Katrina	Development/ Production	Hurricane	2802
53	2005	180	4	75	crude oil	Weather, External Forces, Hurricane Rita	Development/ Production	Hurricane	2880
54	2005	17	14	100	condensate	Weather, External Forces, Hurricane Rita	Development/ Production	Hurricane	2845
55	2005	141	8	862	crude oil	Weather, External Forces, Hurricane Rita	Development/ Production	Hurricane	2894
56	2005	152	12	67	crude oil	Weather, External Forces, Hurricane Rita	Development/ Production	Hurricane	2897
57	2005	210	6	108	crude oil	Weather, External Forces, Hurricane Rita	Development/ Production	Hurricane	2900
58	2006	126	14	870	crude oil	External Forces, Human Error, Equipment Failure	Development/ Production	Pipeline	2976
59	2007	420	4	188	crude oil	Human Error	Development/ Production	Pipeline	3034
60	2008	46	8	69	crude oil	Weather, External Forces, Hurricane Ike	Development/ Production	Hurricane	3231
61	2008	50	6	108	condensate	Weather, External Forces, Hurricane Ike	Development/ Production	Hurricane	3232
62	2008	105	6	56	crude oil	Weather, External Forces, Hurricane Ike	Development/ Production	Hurricane	3260
63	2008	150	42	1,316	condensate	Weather, External Forces, Hurricane Ike	Development/ Production	Hurricane	3255
64	2008	324	4	209	crude oil	Weather, External Forces, Hurricane Ike	Development/ Production	Hurricane	3237
65	2008	324	8	268	condensate	Weather, External Forces, Hurricane Ike	Development/ Production	Hurricane	3236
66	2009	50	20	1,500	crude oil	Equipment Failure	Development/ Production		3387

2.4 Pipeline Hydrocarbon Spills

Table 2.3 gives the same basic data as Table 2.2, but only for hydrocarbon spills; that is, for crude oil and condensate spills from GOM and PAC OCS pipelines. Two PAC OCS spills are included. The previous number of 66 spills, has now been reduced by 4 to 62 spills, showing a relatively insignificant contribution of the non-hydrocarbon spills. Table 2.3 is used as a basis of statistical analysis subsequently, and in the scenario simulations to be carried out in future studies. As can be seen, for each spill and year of occurrence, Table 2.3 also provides the following:

- Water depth at which subsea spill occurred
- Pipeline diameter or NPS
- Spill volume
- Product spilled
- Cause of the spill

Table 2.3a gives summaries of spills by pipeline diameter or NPS categories.

2.5 Pipeline Spill Statistics

The pipeline GOM and PAC OCS spill statistics generated in this update are spill statistics in a form needed for the fault tree studies [1]. Two spills (150 bbl total) from the PAC were included in the statistical calculations. First, the number of spills by size occurring for each causal category is given in Table 2.4. Next, spill causes for two principal spill size categories are given, and transformed to spill frequencies per kilometer-year by dividing the number of kilometer-years exposure, as shown in Table 2.5. And finally, in Table 2.6, the spill frequency distribution for spills of different size categories, by pipeline diameter, is determined.

To summarize:

- Table 2.4 summarizes the spill occurrences by size for each of the principal causes. These causes are those that are reported in the BSEE TIMS database [3] and addenda thereto [8]. Both the exact spill size in barrels and the spill size distribution by each of the spill size categories are given in this table.
- Table 2.5 gives the pipeline hydrocarbon spill statistics by cause. These statistics are given as the frequency of occurrence of a spill per kilometer-year of operating pipeline. Thus, for example, approximately 13.44 spills per 100,000 km-yrs in the small and medium size category are likely to occur. Of these, it is expected that approximately 6.7% can be attributed to pipe corrosion.
- Table 2.6 summarizes the pipeline hydrocarbon spill statistics by spill size and pipeline diameter.

Table 2.3
GOM and PAC OCS Pipeline Hydrocarbon Spill Data Summary (1972-2010)

#	Year	Water Depth (ft)	NPS (in)	Spill Volume (bbl)	Product Spilled	Detailed Cause of Spill
1	1972	140	12	100	crude oil	Internal Corrosion
2	1973	168	16	5,000	crude oil	Internal Corrosion
3	1974	240	14	19,833	crude oil	Anchor Impact
4	1974	246	12	65	crude oil	Anchor Impact
5	1974	141	8	3,500	crude oil	Hurricane
6	1976	160	18	414	crude oil	Internal Corrosion
7	1976	210	10	4,000	crude oil	Shrimp Trawl
8	1977	105	13	250	crude oil	Mud Slide
9	1977	247	14	50	crude oil	Anchor Impact
10	1977	210	8	300	crude oil	Anchor Impact
11	1978	177	9	135	crude oil	Pipeline Clamp - Connection
12	1978	103	9	900	crude oil	Anchor Impact
13	1979	300	8	50	crude oil	Work Boat Anchor
14	1980	137	8	100	condensate	Trawler Net
15	1981	54	4	80	crude oil	External Corrosion
16	1981	190	8	5,100	crude oil	Work Boat Anchor
17	1983	184	8	80	crude oil	Storm and mud slide
18	1985	162	13	323	crude oil	Anchor Impact
19	1985	17	12	200	crude oil	Spud barge Anchor
20	1986	27	6	119	crude oil	Leak - Unknown
21	1986	300	8	210	crude oil	Material Fatigue
22	1988	75	14	15,576	crude oil	Anchor Impact
23	1990	197	4	14,423	condensate	Fish Net or Anchor tie-in
24	1990	230	8	4,569	crude oil	Trawl Net - Pipeline Valve
25 P	1991	90	11	50	crude oil	Rig Anchoring
26	1992	90	12	190	crude oil	Leak - Unknown
27	1992	30	20	2,000	crude oil	Anchor Impact
28	1993	116	4	50	crude oil	Work Boat Anchor
29	1994	197	4	4,533	condensate	Trawler Net
30	1996	1075	20	150	crude oil	Connection Failure
31 P	1998	150	14	800	crude oil	Anchor Impact
32	1998	264	16	1,211	condensate	Anchor Impact
33	1998	108	10	8,212	crude oil	Mud Slide
34	1999	133	12	3,200	crude oil	Jack-up Barge
35	2000	435	24	2,240	crude oil	Anchor Impact
36	2004	479	6	1,720	crude oil	Hurricane Ivan
37	2004	200	18	671	crude oil	Hurricane Ivan
38	2004	305	6	126	crude oil	Hurricane Ivan
39	2004	244	8	200	crude oil	Hurricane Ivan
40	2004	255	6	250	crude oil	Hurricane Ivan
41	2004	255	8	260	crude oil	Hurricane Ivan
42	2004	185	8	95	crude oil	Hurricane Ivan
43	2004	300	10	123	crude oil	Hurricane Ivan
44	2005	1100	8	960	crude oil	Hurricane Katrina
45	2005	340	8	50	crude oil	Hurricane Katrina
46	2005	240	10	55	crude oil	Hurricane Katrina
47	2005	216	10	132	crude oil	Hurricane Katrina
48	2005	48	8	50	condensate	Hurricane Katrina
49	2005	180	4	75	crude oil	Hurricane Rita
50	2005	17	14	100	condensate	Hurricane Rita
51	2005	141	8	862	crude oil	Hurricane Rita
52	2005	152	12	67	crude oil	Hurricane Rita
53	2005	210	6	108	crude oil	Hurricane Rita
54	2006	126	14	870	crude oil	Anchor Impact
55	2007	420	4	188	crude oil	Unknown
56	2008	46	8	69	crude oil	Hurricane Ike
57	2008	50	6	108	condensate	Hurricane Ike
58	2008	105	6	56	crude oil	Hurricane Ike
59	2008	150	42	1,316	condensate	Hurricane Ike
60	2008	324	4	209	crude oil	Hurricane Ike
61	2008	324	8	268	condensate	Hurricane Ike
62	2009	50	20	1,500	crude oil	Third party Impact

- P means PAC

Table 2.3a
Summary of Spills in Table 2.3 by Nominal Pipeline Size Categories (1972-2010)

Spill Size Category	Spill Size (bbl)	Number of Spills		
		All NPS	NPS <=10	NPS >10
Small	50 - 99	15	11	4
Medium	100 - 999	30	19	11
Large	1000 – 9,999	14	7	7
Huge	>= 10,000	3	1	2
TOTAL		62	38	24

Table 2.4
Pipeline Hydrocarbon Spill Summary by Spill Size (1972-2010)

CAUSE CLASSIFICATION	NUMBER OF SPILLS	SPILL SIZE (BBL)													NUMBER OF SPILLS					
		1	2	3	4	5	6	7	8	9	10	11	12	13	S	M	L	H	SM	LH
CORROSION	4														1	2	1		3	1
External	1	80													1				1	
Internal	3	100	5000	414												2	1		2	1
THIRD PARTY IMPACT	20														2	7	8	3	9	11
Anchor Impact	13	19833	65	50	300	900	323	15576	2000	800	1211	2240	870	1500	2	5	4	2	7	6
Jackup Rig or Spud Barge	2	200	3200													1	1		1	1
Trawl/Fishing Net	5	4000	100	14423	4569	4533										1	3	1	1	4
OPERATION IMPACT	4														3		1		3	1
Rig Anchoring	1	50													1				1	
Work Boat Anchoring	3	50	5100	50											2		1		2	1
MECHANICAL	3															3			3	
Connection Failure	2	135	150													2			2	
Material Failure	1	210														12			1	
NATURAL HAZARD	28														9	15	4		24	4
Mud Slide	3	250	80	8212											1	1	1		2	1
Storm/ Hurricane	25	3500	1720	671	126	200	250	260	95	123	960	50	55	132	8	14	3		22	3
		50	75	100	862	67	108	69	108	56	1316	209	268							
UNKNOWN	3	119	190	188												3			3	
TOTALS	62														15	30	14	3	45	17

Table 2.5
GOM and PAC Pipeline Hydrocarbon Spill Statistics by Cause (1972-2010)

CAUSE CLASSIFICATION	Small and Medium Spills 50-999 bbl				Large and Huge Spills >= 1000 bbl			
	HISTORICAL DISTRIBUTION %	NUMBER OF SPILLS	EXPOSURE (km-years)	FREQUENCY spill per 10^5 km-year	HISTORICAL DISTRIBUTION %	NUMBER OF SPILLS	EXPOSURE (km-years)	FREQUENCY spill per 10^5 km-year
CORROSION	6.67	3		0.896	5.88	1		0.299
External	2.22	1		0.299				
Internal	4.44	2		0.597	5.88	1		0.299
THIRD PARTY IMPACT	20.00	9		2.688	64.71	11		3.286
Anchor Impact	15.56	7		2.091	35.29	6		1.792
Jackup Rig or Spud Barge	2.22	1		0.299	5.88	1		0.299
Trawl/Fishing Net	2.22	1		0.030	23.53	4		1.195
OPERATION IMPACT	6.67	3		0.896	5.88	1		0.299
Rig Anchoring	2.22	1		0.299				
Work Boat Anchoring	4.44	2	334,764	0.597	5.88	1	334,764	0.299
MECHANICAL	6.67	3		0.896				
Connection Failure	4.44	2		0.597				
Material Failure	2.22	1		0.299				
NATURAL HAZARD	53.33	24		7.169	23.53	4		1.195
Mud Slide	4.44	2		0.597	5.88	1		0.299
Storm/ Hurricane	48.89	22		6.572	17.65	3		0.896
UNKNOWN	6.67	3		0.896				
TOTALS	100.0	45		13.442	100.0	17		5.078

Table 2.6
GOM and PAC Pipeline Hydrocarbon Spill Statistics
by Spill Size and Pipeline Diameter (1972-2010)

GOM and PAC Pipeline Spills, Categorized 1972-2010			Spill Statistics (Number of Spills)	Exposure (km-yrs)	Frequency (spills per 10^5 km-yrs)
By Pipe Diameter		<= 10"	38	222,716	17.062
		> 10"	24	112,047	21.420
By Spill Size		Small 50 - 99 bbl	15	334,764	4.481
		Medium 100 - 999 bbl	30	334,764	8.962
		Large 1000 - 9999 bbl	14	334,764	4.182
		Huge >=10000 bbl	3	334,764	0.896
By Pipe Diameter, By Spill Size	<= 10"	Small 50 - 99 bbl	11	222,716	4.939
		Medium 100 - 999 bbl	19	222,716	8.531
		Large 1000 - 9999 bbl	7	222,716	3.143
		Huge >=10000 bbl	1	222,716	0.449
	> 10"	Small 50 - 99 bbl	4	112,047	3.570
		Medium 100 - 999 bbl	11	112,047	9.817
		Large 1000 - 9999 bbl	7	112,047	6.247
		Huge >=10000 bbl	2	112,047	1.785

SECTION 3

PLATFORM SPILLS

3.1 Introduction on GOM and PAC Platform Spills

Generally, platform spills greater than or equal to 50 barrels in the GOM and PAC OCS have been reported to occur due to equipment failure, human error, tank failure, ship collisions, and weather, primarily hurricanes. In the period from 1972 to 2010, 135 platform spills of hydrocarbons have been reported. Hydrocarbons include crude oil, diesel, condensate and refined petroleum products.

In the statistical analysis, the exposure factor utilized in the platform spill frequency computation is the number of active producing wells in any given time period. In the balance of this section, following a discussion of the exposure, all platform spills are summarized, followed by the platform hydrocarbon spill summaries, and the spill statistical analysis by both causal distribution and active well year.

3.2 Platform Exposure

The exposure factor utilized for the platforms is the number of active producing wells in any given time period in the region. The definition of the number of active producing wells is "*the number of OCS wells producing oil and/or condensate which reported production greater than 0 barrels in each year (or the relevant time period)*".

Table 3.1 summarizes the number of these active producing wells for each year between 1972 and 2010 for the Gulf of Mexico (GOM) and Pacific (PAC) OCS. The bar chart in Figure 3.1 illustrates these numbers of producing wells for the GOM, while Figure 3.2 illustrates these for the PAC. In the GOM, a peak of roughly 7,000 producing wells in 1985 is followed by a gradual decline to a number of approximately 4,500 producing wells in 2010. In the PAC, the peak occurred in 1997 with 470 wells, reducing to 414 in 2010.

3.3 All GOM and PAC OCS Platform Spills

All hydrocarbon spills greater than or equal to 50 barrels reported from GOM and PAC OCS platforms between 1973 (none reported in 1972) and 2010 are summarized in Table 3.2. As can be seen in the table, following the spill itemization number data, given are the year of occurrence, the water depth, the primary cause, the operation underway, LOWC, spill volume and its components, and by BSEE ID and OCS region. Loss of Well Control (LOWC) hydrocarbon spills were identified for potential further consideration.

Table 3.3 gives a summary of the number of hydrocarbon spills in each spill size category. Table 3.4 gives a summary of the number of hydrocarbon spills for each primary cause.

Table 3.1
Annual Number of Active Producing Wells in GOM and PAC OCS (1972-2010)

Active Producing Oil Wells			
Year	GOM	PAC	Total
1972-2010	231,520	13,966	245,486
2010	4,490	414	4,904
2009	4,520	417	4,937
2008	5,074	419	5,493
2007	5,251	408	5,659
2006	4,824	401	5,225
2005	5,536	411	5,947
2004	5,926	412	6,338
2003	6,004	412	6,416
2002	6,174	414	6,588
2001	6,409	407	6,816
2000	6,288	403	6,691
1999	6,313	433	6,746
1998	6,442	459	6,901
1997	6,636	470	7,106
1996	6,681	457	7,138
1995	6,615	445	7,060
1994	6,721	447	7,168
1993	6,725	434	7,159
1992	6,789	427	7,216
1991	6,932	437	7,369
1990	6,927	406	7,333
1989	6,900	406	7,306
1988	6,904	396	7,300
1987	6,902	408	7,310
1986	6,934	385	7,319
1985	6,988	378	7,366
1984	6,724	367	7,091
1983	6,459	349	6,808
1982	6,326	317	6,643
1981	5,969	277	6,246
1980	5,715	225	5,940
1979	5,510	208	5,718
1978	5,228	204	5,432
1977	4,981	195	5,176
1976	4,763	179	4,942
1975	4,604	179	4,783
1974	4,546	182	4,728
1973	4,512	187	4,699
1972	4,278	191	4,469

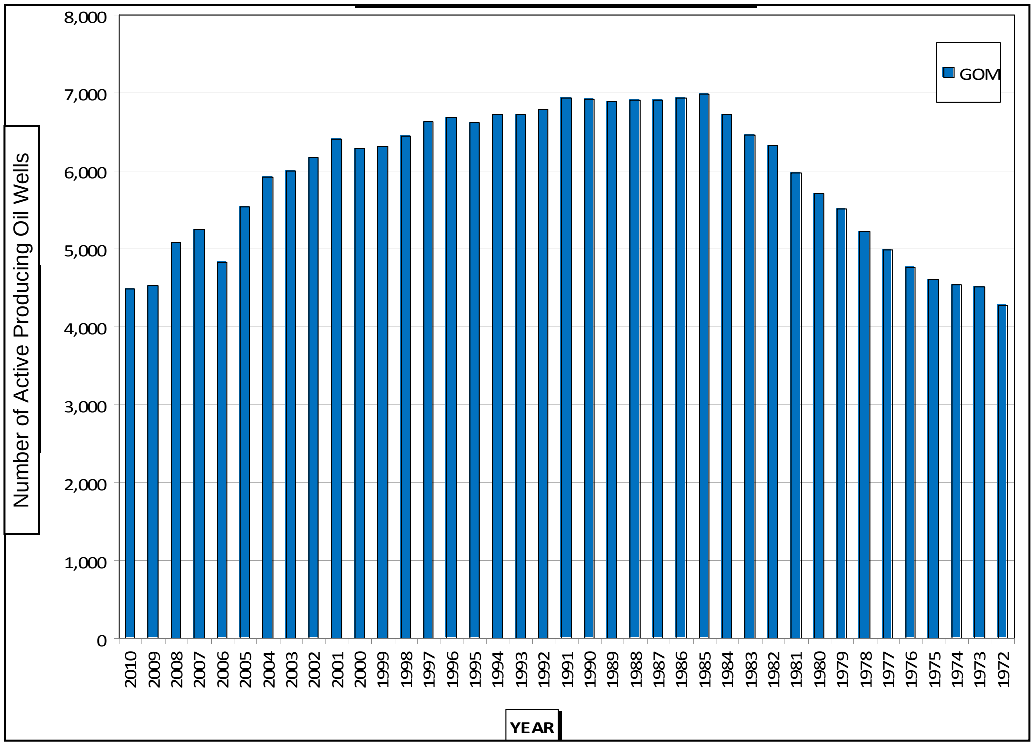

Figure 3.1
Annual Number of Active Producing Crude Oil and Condensate Wells in GOM OCS (1972-2010)

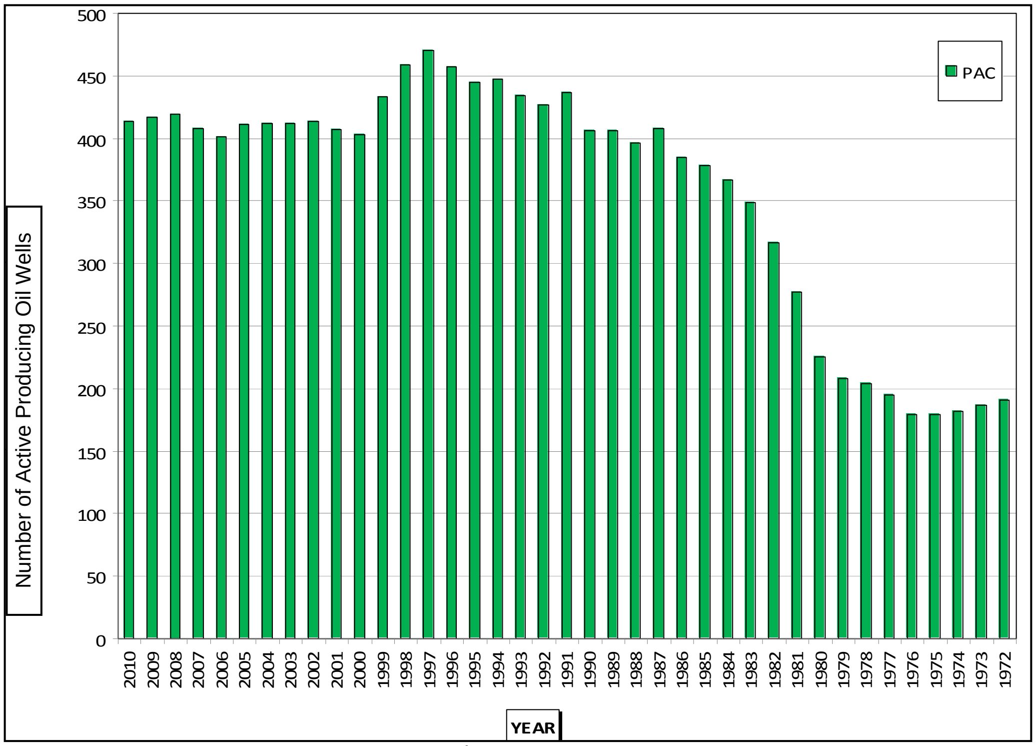

Figure 3.2
Annual Number of Active Producing Crude Oil Wells in PAC OCS (1972-2010)

Table 3.2
Summary of All GOM and PAC Greater than or Equal to 50 bbl OCS Platform Spills (1972-2010)

#	Year	Water Depth (ft)	Primary Cause of Incident	Operation	LOWC	Spill Total (bbl)	Crude and Condensate (bbl)	Refined Petroleum (bbl)	BSEE ID	Region
1	1973	110	Equipment Failure	Production		9,935	9,935	0	0521	GOM
2	1973	61	Weather	Production/Barge		7,000	7,000	0	0525	GOM
3	1973	300	Weather	Drilling/Motor Vessel		239	0	239	0615	GOM
4	1973	103	Human Error	Drilling/Motor Vessel		95	0	95	0693	GOM
5	1974	60	Equipment Failure	Production		130	130	0	0746	GOM
6	1974	29	Hurricane	Hurricane	YES	75	75	0	0757	GOM
7	1974	27	Equipment Failure	Production		50	50	0	0767	GOM
8	1974	140	Human Error	Production		120	120	0	0783	GOM
9	1974	30	Hurricane	Hurricane - Repair	YES	200	200	0	0787	GOM
10	1975	200	Weather	Drilling/Motor Vessel		100	0	100	0874	GOM
11	1976	127	Equipment Failure	Drilling/Motor Vessel		300	0	300	0963	GOM
12	1977	55	Equipment Failure	Drilling/Motor Vessel		77	0	77	1063	GOM
13	1978	105	Equipment Failure	Production		104	104	0	1102	GOM
14	1979	311	Equipment Failure	Drilling/Motor Vessel		321	0	321	1171	GOM
15	1979	210	Equipment Failure	Production		60	60	0	1197	GOM
16	1979	280	Weather	Drilling/Motor Vessel		1,500	0	1,500	1278	GOM
17	1980	156	Human Error	Drilling		286	0	286	1291	GOM
18	1980	140	Equipment Failure	Drilling		95	0	95	1307	GOM
19	1980	220	Weather	Drilling/Motor Vessel		80	0	80	1322	GOM
20	1980	187	Equipment Failure	Production		83	0	83	1339	GOM
21	1980	60	Hurricane	Hurricane		1,456	1,456	0	1344	GOM
22	1980	99	Equipment Failure	Drilling/Motor Vessel		118	0	118	1349	GOM
23	1981	54	Human Error	Production		58	58	0	1363	GOM
24	1981	49	Equipment Failure	Drilling		210	0	210	1368	GOM
25	1981	350	Equipment Failure	Drilling/Motor Vessel		50	0	50	1395	GOM
26	1981	340	Equipment Failure	Completion/Workover	YES	64	64	0	1422	GOM
27	1982	180	Human Error	Drilling/Motor Vessel		400	0	400	1434	GOM
28	1982	394	Equipment Failure	Drilling/Motor Vessel		228	0	228	1447	GOM
29	1982	60	Weather	Drilling/Motor Vessel		214	0	214	1474	GOM
30	1983	43	Equipment Failure	Drilling/Barge		600	0	600	1521	GOM
31	1983	48	Equipment Failure	Drilling/Motor Vessel		77	0	77	1530	GOM
32	1983	50	Equipment Failure	Drilling/Motor Vessel		320	0	320	1533	GOM
33	1983	65	Equipment Failure	Drilling/Motor Vessel		200	0	200	1536	GOM
34	1983	48	Equipment Failure	Drilling/Motor Vessel		77	0	77	1546	GOM
35	1983	105	Collision	Production/Motor Vessel		119	0	119	1581	GOM
36	1984	94	Equipment Failure	Production		50	50	0	1650	GOM
37	1984	307	Human Error	Drilling/Motor Vessel		100	0	100	1653	GOM
38	1985	130	Equipment Failure	Drilling/Fuel Transfer		107	0	107	1683	GOM
39	1985	50	Human Error	Deactivation		60	0	60	1684	GOM
40	1985	196	Equipment Failure	Production/Workover	YES	50	50	0	1689	GOM
41	1985	3115	Equipment Failure	Drilling/Motor Vessel		643	0	643	1711	GOM
42	1985	200	Equipment Failure	Drilling		50	0	50	1723	GOM
43	1985	55	Hurricane	Hurricane		66	66	0	1734	GOM
44	1985	103	Equipment Failure	Drilling/Motor Vessel		58	0	58	1739	GOM
45	1986	750	Equipment Failure	Construction		52	0	52	1816	GOM
46	1987	126	Equipment Failure	Drilling	YES	60	60	0	1828	GOM
47	1988	172	Equipment Failure	Production		50	50	0	1871	GOM
48	1988	200	Human Error	Drilling		64	0	64	1896	GOM
49	1988	140	Equipment Failure	Production		55	55	0	1897	GOM
50	1989	112	Equipment Failure	Production		400	400	0	1903	GOM
51	1989	206	Equipment Failure	Production		55	55	0	3351	GOM
52	1990	290	Human Error	Drilling		100	0	100	1951	PAC
53	1991	50	Equipment Failure	Production		280	280	0	2010	GOM
54	1992	187	Human Error	Drilling	YES	100	100	0	2053	GOM
55	1994	150	Equipment Failure	Production		50	50	0	2111	PAC
56	1995	50	Human Error	Drilling/Motor Vessel		600	600	0	2114	GOM
57	1995	116	Equipment Failure	Production		75	75	0	2133	GOM
58	1995	56	Equipment Failure	Production		435	435	0	2149	GOM
59	1996	705	Equipment Failure	Construction		62	0	62	2198	GOM
60	1997	40	Human Error	Production		170	170	0	2245	GOM
61	1998	700	Weather	Production		100	0	100	2263	GOM
62	1999	463	Equipment Failure	Workover	YES	125	125	0	2361	GOM
63	2000	2223	Human Error	Drilling	YES	200	200	0	2389	GOM
64	2000	172	Human Error	Production		60	60	0	2407	GOM
65	2001	243	Equipment Failure	Production		127	127	0	2446	GOM
66	2002	50	Hurricane	Hurricane	YES	350	350	0	2555	GOM
67	2002	37	Hurricane	Hurricane		497	0	497	2557	GOM
68	2002	94	Hurricane	Hurricane		741	0	741	2556	GOM
69	2002	165	Human Error	Motor Vessel		264	0	264	2605	GOM
70	2004	277	Hurricane	Hurricane		52	0	52	2707	GOM
71	2004	302	Hurricane	Hurricane		55	0	55	2668	GOM
72	2004	305	Hurricane	Hurricane		264	133	131	2695	GOM
73	2004	244	Hurricane	Hurricane		106	77	29	2697	GOM
74	2004	255	Hurricane	Hurricane		66	27	39	2699	GOM
75	2004	479	Hurricane	Hurricane		510	410	100	2703	GOM
76	2005	86	Hurricane	Hurricane		141	141	0	2771	GOM
77	2005	83	Hurricane	Hurricane		242	242	0	2770	GOM
78	2005	91	Hurricane	Hurricane		204	204	0	2772	GOM
79	2005	88	Hurricane	Hurricane		195	195	0	2773	GOM

Table 3.2: Summary of All GOM and PAC Greater than or Equal to 50 bbl OCS Platform Spills (1972-2010) ~ Continued ~

#	Year	Water Depth (ft)	Primary Cause of Incident	Operation	LOWC	Spill Total (bbl)	Crude and Condensate (bbl)	Refined Petroleum (bbl)	BSEE ID	Region
80	2005	1023	Hurricane	Hurricane		325	325	0	2775	GOM
81	2005	140	Hurricane	Hurricane		380	0	380	2781	GOM
82	2005	255	Hurricane	Hurricane		130	106	24	2782	GOM
83	2005	322	Hurricane	Hurricane		110	85	25	2793	GOM
84	2005	340	Hurricane	Hurricane		195	180	15	2788	GOM
85	2005	153	Hurricane	Hurricane		307	307	0	2819	GOM
86	2005	223	Hurricane	Hurricane		71	50	21	2821	GOM
87	2005	228	Hurricane	Hurricane		159	130	29	2830	GOM
88	2005	285	Hurricane	Hurricane		94	75	19	2832	GOM
89	2005	116	Hurricane	Hurricane		51	48	4	2805	GOM
90	2005	137	Hurricane	Hurricane		101	48	54	2808	GOM
91	2005	128	Hurricane	Hurricane		51	48	4	2809	GOM
92	2005	137	Hurricane	Hurricane		50	48	2	2810	GOM
93	2005	117	Hurricane	Hurricane		51	50	1	2813	GOM
94	2005	140	Hurricane	Hurricane		97	95	2	2816	GOM
95	2005	2107	Hurricane	Hurricane		614	536	78	2861	GOM
96	2005	182	Hurricane	Hurricane		1,572	0	1,572	2881	GOM
97	2005	204	Hurricane	Hurricane		77	44	33	2853	GOM
98	2005	230	Hurricane	Hurricane		2,000	2,000	0	2855	GOM
99	2005	254	Hurricane	Hurricane		181	150	31	2856	GOM
100	2005	231	Hurricane	Hurricane		188	150	38	2858	GOM
101	2005	472	Hurricane	Hurricane		101	101	0	2860	GOM
102	2005	238	Hurricane	Hurricane		1,494	0	1,494	2870	GOM
103	2005	182	Hurricane	Hurricane		67	0	67	2842	GOM
104	2005	230	Hurricane	Hurricane		659	582	77	2838	GOM
105	2005	230	Hurricane	Hurricane		166	166	0	3059	GOM
106	2005	230	Hurricane	Hurricane		53	53	0	3009	GOM
107	2006	230	Hurricane	Hurricane		51	51	0	3060	GOM
108	2006	240	Hurricane	Hurricane		63	63	0	3063	GOM
109	2006	240	Hurricane	Hurricane		528	528	0	3062	GOM
110	2006	88	Hurricane	Hurricane		59	59	0	2945	GOM
111	2006	240	Hurricane	Hurricane		133	133	0	2995	GOM
112	2006	230	Hurricane	Hurricane		51	51	0	3013	GOM
113	2008	88	Hurricane	Decommissioning		54	54	0	3121	GOM
114	2008	187	Hurricane	Hurricane		685	685	0	3219	GOM
115	2008	210	Hurricane	Hurricane		103	20	83	3251	GOM
116	2008	262	Hurricane	Hurricane		62	55	7	3226	GOM
117	2008	415	Hurricane	Hurricane		205	150	54	3249	GOM
118	2008	414	Hurricane	Hurricane		52	52	0	3227	GOM
119	2008	472	Hurricane	Hurricane		513	513	0	3250	GOM
120	2008	541	Hurricane	Hurricane		200	200	0	3209	GOM
121	2008	235	Hurricane	Hurricane		550	0	550	3252	GOM
122	2008	175	Hurricane	Hurricane		140	138	3	3270	GOM
123	2008	76	Hurricane			50	48	2	3266	GOM
124	2008	169	Hurricane	Hurricane		127	126	1	3271	GOM
125	2008	176	Hurricane	Hurricane		70	40	30	3269	GOM
126	2008	186	Hurricane	Hurricane		194	112	82	3225	GOM
127	2008	220	Hurricane			170	170	0	3275	GOM
128	2008	324	Hurricane	Hurricane		196	31	165	3238	GOM
129	2008	479	Hurricane	Hurricane		72	72	0	3177	GOM
130	2008	472	Hurricane			58	58	0	3331	GOM
131	2009	415	Hurricane			54	54	0	3322	GOM
132	2009	4420	Equipment Failure			50	50	0	3454	GOM
133	2009	6050	Equipment Failure	Plugging & Abandonment	YES	62	62	0	3435	GOM
134	2010	4992	Unknown	Drilling/T&A	YES	4,900,000	TBD	TBD	3496	GOM
135	2010	475	Hurricane			62	62	0	3509	GOM

Table 3.3
Platform Spill Size Distribution Summary

Number	Size	bbl
57	Small	50 - 99
70	Medium	100 - 999
7	Large	1000 - 9999
1	Huge	>= 10000
135	All	

Table 3.4
Platform Spill Cause Distribution Summary

Primary Cause of Incident	Number
Equipment Failure	41
Human Error	15
Collision	1
Weather	7
Hurricane	70
Unknown	1
Total	135

3.4 Platform Hydrocarbon Spill Statistics

The primary platform hydrocarbon spill statistical information required, is the spill frequency distribution by different causes and spill sizes, and the spill rate per well year. Table 3.5 summarizes the spill size distribution among the principal reported causes. As can be seen, the major cause attributable to over 50% of the spills – at 70 out of 135 spills – is hurricanes. The largest single OCS spill, of course, is the Macondo blowout (#134 in Table 3.2) which caused a spill of nearly 5 million barrels. McNutt et al [5] provide additional information on the Macondo oil spill.

Spills which were identified as associated with LOWC, except for #134 Macondo, are relatively small – ranging from 50 to 350 bbl. Such release volumes are generally not associated with blowouts, and are likely to be categorizable as temporary losses of well control, referred to as “well releases” rather than “blowouts”. The authors have adopted the following working definitions:

- **Well release:** The reported incident is a well release if oil or gas flowed from the well from some point where flow was not intended and the flow was stopped by use of the barrier system that was available on the well at the time the incident started.
- **Blowout:** A blowout is an incident where formation fluid flows out of the well or between formation layers after all the predefined technical well barriers or the activation of the same have failed.

Further attention will be addressed to this matter in the loss of well control study in progress cited in Section 1.2.

The spill frequency data, given per production well-year, is shown in Table 3.6, again, by causal distribution as well as two broad spill size categories of small and medium spills and large and huge spills. Here, it becomes immediately evident that the largest spill potential in terms of spill frequency is attributable to hurricanes, which are responsible for roughly 50% of the large and huge spills and 52% of the small and medium spills.

In regard to PAC oil spills, it is of interest to mention the 1969 Santa Barbara offshore oil blowout, which was estimated to have spilled 80,000 to 100,000 bbl of oil into the Santa Barbara Channel over its uncontrolled period of 10 days. Due to the catastrophic consequences of this spill, numerous articles of environmental protection legislation were subsequently promulgated, including an offshore drilling moratorium effected by the California Coastal Commission which has not granted any new leases for offshore drilling within its jurisdiction out to 3 nautical miles (6 km) from shore. In the data period (1972-2010), however, there were only two PAC platform spills as identified in Table 3.2.

Table 3.5
Summary of GOM and PAC OCS Platform Hydrocarbon Spills by Size and Cause

CAUSE CLASSIFICATION	NUMBER OF SPILLS	SPILL SIZE (bbl)															NUMBER OF SPILLS					
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	S	M	L	H	SM	LH
EQUIPMENT FAILURE	41	9,935	130	50	300	77	104	321	60	95	83	118	210	50	64	228	23	17	1		40	1
		600	77	320	200	77	50	107	50	643	50	58	52	60	50	55						
		400	55	280	50	75	435	62	125	127	50	62										
HUMAN ERROR	15	95	120	286	58	400	100	60	64	100	100	600	170	200	60	264	5	10			15	
COLLISION	1	119																1			1	
WEATHER	7	7,000	239	100	1,500	80	214	100									1	4	2		5	2
HURRICANE	70	75	200	1,456	66	350	497	741	52	55	264	106	66	510	141	242	28	38	4		66	4
		204	195	325	380	130	110	195	307	71	159	94	51	101	51	50						
		51	97	614	1,572	77	2,000	181	188	101	1,494	67	659	166	53	51						
		63	528	59	133	51	54	685	103	62	205	52	513	200	550	140						
		50	127	70	194	170	196	72	58	54	62											
UNKNOWN	1	4,900,000																		1		1
TOTALS	135																57	70	7	1	127	8

Table 3.6
GOM and PAC OCS Platform Hydrocarbon Spill Statistics (1972-2010)

CAUSE CLASSIFICATION	Small and Medium Spills 50-999 bbl				Large and Huge Spills >=1000 bbl			
	Historical Distribution %	Number of Spills	Exposure (well-years)	Frequency (spill per 10^4 well-year)	Historical Distribution %	Number of Spills	Exposure (well-years)	Frequency (spill per 10^4 well-year)
EQUIPMENT FAILURE	31.50	40	245,486	1.629	12.50	1	245,486	0.041
HUMAN ERROR	11.81	15		0.611				
COLLISION	0.79	1		0.041				
WEATHER	3.94	5		0.204	25.00	2		0.081
HURRICANE	51.97	66		2.689	50.00	4		0.163
UNKNOWN					12.50	1		0.041
TOTALS	100.00	127		5.173	100.00	8		0.326

SECTION 4

OIL WELL BLOWOUT AND WELL RELEASE DATA

4.1 Introduction

The development scenarios considered under this project include both the drilling of exploratory and development wells, and the operation of production wells including workovers. The principal data sources used in the update are the 2012 study by Scandpower giving oil blowout release frequencies [6], and the previously used book by Per Holand entitled “Offshore Blowouts”, which gives risk analysis data from the SINTEF worldwide offshore blowout database [4] 1980 to 1994. The most comprehensive historical information was found in the latter reference [4], which not only gives the results of database analyses for the North Sea and the Gulf of Mexico, but also provides confidence intervals calculated from these databases, but, of course, is somewhat dated.

4.2 Blowout Statistics

Table 4.1 gives a summary of the historical data analysis by Per Holand [4] for production wells and the drilling of exploratory and development wells. The combination of these statistics together with the cumulative distribution function for oil blowout release volumes given in [2], permits the blowout spill volume frequency distribution as summarized in Table 4.2. Finally, combining the population parameters of oil well blowouts from Table 4.1 with the size distribution factors – which can be derived from Table 4.2 – one arrives at the historical oil spill blowout distribution characteristics by spill size and well type, summarized in Table 4.3.

4.3 Ongoing Work

As a much more comprehensive and current investigation of Loss of Well Control Occurrence and Size Estimators for the Alaska OCS (under BOEM Contract M12PC00004)* by Bercha is currently underway, this Section is only provided as a preliminary introduction on blowouts, and should be updated as results become available from the above Loss of Well Control Occurrence and Size Estimators for the Alaska OCS study.

* The URL for the description of the study is located at: http://www.boem.gov/uploadedFiles/BOEM/Environmental_Stewardship/Environmental_Studies/Alaska/Fates_and_Effects/AK-11-12.pdf

Table 4.1
Summary of North Sea and Gulf of Mexico Blowout Rates [4]

Well Type	Unit	Low 90% CI	Average	High 90% CI
Production Well	Spills per 10^4 well-year	0.86	1.91	2.95
Exploration Well Drilling	Spills per 10^4 wells	11.00	25.05	51.00
Development Well Drilling	Spills per 10^4 wells	4.00	9.15	16.10

Table 4.2
Well Blowout Historical Spill Size Distribution [2]

EVENT	FREQUENCY UNIT	Small and Medium Spills 50-999 bbl	Large Spills 1000-9999 bbl	Small, Medium, and Large Spills 50-9999 bbl	Spills 10000-149999 bbl	Spills >=150000 bbl	All spills
		HISTORICAL FREQUENCY					
Production Well	Spills per 10^4 well-year	0.15	1.03	1.18	0.44	0.29	1.91
Exploration Well Drilling	Spills per 10^4 wells	1.97	13.75	15.72	5.91	3.42	25.05
Development Well Drilling	Spills per 10^4 wells	0.65	4.57	5.22	1.96	1.96	9.15

Table 4.3
Well Blowout Historical Spill Probability and Size Variability [2]

EVENT	FREQUENCY UNIT	Low Factor	High Factor	Frequencies: Historical	Low	Mode	High
				Small and Medium Spills 50-999 bbl			
PRODUCTION WELL	Spills per 10^4 well-year	0.448	1.545	0.147	0.066	0.148	0.227
EXPLORATION WELL DRILLING	Spills per 10^4 wells	0.439	2.036	1.966	0.863	1.032	4.002
DEVELOPMENT WELL DRILLING	Spills per 10^4 wells	0.437	1.760	0.654	0.286	0.526	1.151
				Large Spills 1000-9999 bbl			
PRODUCTION WELL	Spills per 10^4 well-year	0.448	1.545	1.028	0.460	1.037	1.588
EXPLORATION WELL DRILLING	Spills per 10^4 wells	0.439	2.036	13.754	6.039	7.220	28.001
DEVELOPMENT WELL DRILLING	Spills per 10^4 wells	0.437	1.760	4.570	1.998	3.671	8.041
				Small, Medium and Large Spills 50-9999 bbl			
PRODUCTION WELL	Spills per 10^4 well-year	0.448	1.545	1.175	0.526	1.185	1.815
EXPLORATION WELL DRILLING	Spills per 10^4 wells	0.439	2.036	15.719	6.903	8.252	32.003
DEVELOPMENT WELL DRILLING	Spills per 10^4 wells	0.437	1.760	5.224	2.284	4.197	9.192
				Spill 10000-149999 bbl			
PRODUCTION WELL	Spills per 10^4 well-year	0.448	1.545	0.441	0.197	0.444	0.681
EXPLORATION WELL DRILLING	Spills per 10^4 wells	0.439	2.036	5.909	2.595	3.102	12.031
DEVELOPMENT WELL DRILLING	Spills per 10^4 wells	0.437	1.760	1.963	0.858	1.577	3.454
				Spill >=150000 bbl			
PRODUCTION WELL	Spills per 10^4 well-year	0.448	1.545	0.294	0.132	0.296	0.454
EXPLORATION WELL DRILLING	Spills per 10^4 wells	0.439	2.036	3.421	1.502	1.796	6.965
DEVELOPMENT WELL DRILLING	Spills per 10^4 wells	0.437	1.760	1.963	0.858	1.577	3.454

REFERENCES

1. Bercha International Inc., "Alternative Oil Spill Occurrence Estimators for the Beaufort and Chukchi Seas – Fault Tree Method", Volume II, Appendix A – Historical Data, OCS Study MMS 2002-047, Final Report to US Department of the Interior, Minerals Management Service, Alaska Outer Continental Shelf Region, August 2002.
   http://www.boem.gov/BOEM-Newsroom/Library/Publications/2002/2002-047-1.aspx
2. Bercha International Inc. "Alternative Oil Spill Occurrence Estimators and their Variability for the Alaskan OCS – Fault Tree Method, Update of GOM OCS Statistics to 2006. OCS Study MMS 2008-025, MMS Contract Number 1435-01-05-CT-39348, to US Department of the Interior, Minerals Management Service, Alaska Outer Continental Shelf Region. March 2008.
   http://www.boem.gov/BOEM-Newsroom/Library./Publications/2008/2008-025.aspx
3. BSEE Website, www.bsee.gov
   - Spill Summaries OCS Spills >= 50 Barrels CY 1964 – 2012. http://www.bsee.gov/Inspection-and-Enforcement/Accidents-and-Incidents/Spills----Statistics-and-Summaries-1996-2012.aspx. Accessed December 2012.
4. Holand, Per. "Offshore Blowouts, Causes and Control. Comprehensive risk analysis data from the SINTEF Offshore Blowout Database". Gulf Publishing Company, Houston, Texas, USA. 1997.
5. McNutt, M., R. Camilli, G. Guthrie, P. Hsieh, V. Labson, B. Hehr, D. Maclay, A. Ratzel, and M. Sogge. "Assessment of Flow Rate Estimates for the Deepwater Horizon / Macondo Well Oil Spill". National Incident Command, Interagency Solutions Group, Flow Rate Technical Group, 2011.
6. Scandpower, "Blowout and Well Release Frequencies Based on SINTEF Offshore Blowout Database 2012," Proprietary (Confidential) Report No. 19.101.001-8/2013/R3. April 3, 2013.
7. SINTEF, "Offshore Blowout Database 2012," Proprietary (Confidential) Database. March 2012.
8. Smith, C. Email Communications and Update CDs, 2012-2013.

APPENDIX A

MILES OF GOM AND PAC OIL PIPELINE SEGMENTS BY YEAR AND SIZE (1972-2010)

Table A.1
GOM OCS Pipeline Exposure Data (1972-2010)

Miles of GOM Oil Pipeline Segments by Year and Size 1972-2010											
Year	<=10"	>10"	Total	2"	3"	4"	5 - 6"	7 - 8"	9 - 10"	11 - 19"	20 - 36"
1972	1,301	439	1,740	59	84	289	468	276	125	439	0
1973	1,418	514	1,932	60	88	299	499	320	152	510	4
1974	1,514	535	2,049	66	90	304	507	395	152	531	4
1975	1,590	610	2,200	67	94	310	524	443	152	606	4
1976	1,700	751	2,451	73	98	317	533	521	158	639	112
1977	1,784	779	2,563	74	101	345	556	550	158	646	133
1978	1,963	855	2,818	74	109	361	620	592	207	722	133
1979	2,089	867	2,956	74	112	389	639	647	228	734	133
1980	2,221	899	3,120	76	119	406	658	708	254	766	133
1981	2,404	939	3,343	79	120	450	755	746	254	806	133
1982	2,535	976	3,511	79	124	468	838	767	259	843	133
1983	2,684	1,019	3,703	79	142	483	929	792	259	886	133
1984	2,889	1,036	3,925	79	155	555	994	823	283	903	133
1985	3,025	1,038	4,063	79	175	585	1,036	862	288	905	133
1986	3,100	1,138	4,238	79	184	600	1,072	877	288	1,005	133
1987	3,210	1,135	4,345	79	192	634	1,091	891	323	1,002	133
1988	3,276	1,175	4,451	85	217	666	1,088	892	328	1,042	133
1989	3,339	1,223	4,562	86	241	689	1,092	903	328	1,090	133
1990	3,513	1,224	4,737	93	243	751	1,161	926	339	1,091	133
1991	3,624	1,212	4,836	94	267	790	1,178	948	347	1,079	133
1992	3,764	1,215	4,979	94	280	809	1,210	1,023	348	1,082	133
1993	3,807	1,223	5,030	88	290	829	1,227	1,025	348	1,090	133
1994	3,944	1,343	5,287	81	300	858	1,285	1,070	350	1,210	133
1995	4,059	1,477	5,536	82	306	886	1,325	1,104	356	1,271	206
1996	4,218	1,930	6,148	81	318	912	1,425	1,126	356	1,416	514
1997	4,338	2,095	6,433	80	320	950	1,463	1,140	385	1,573	522
1998	4,470	2,283	6,753	80	308	992	1,538	1,160	392	1,725	558
1999	4,622	2,374	6,996	80	307	1,008	1,585	1,226	416	1,816	558
2000	4,731	2,516	7,247	71	306	1,032	1,606	1,259	457	1,959	557
2001	4,892	2,574	7,466	70	300	1,079	1,685	1,291	467	1,998	576
2002	4,988	2,663	7,651	67	297	1,076	1,702	1,380	466	2,087	576
2003	4,966	2,876	7,842	64	270	1,035	1,747	1,388	462	2,264	612
2004	5,006	3,510	8,516	57	272	1,027	1,760	1,408	482	2,512	998
2005	4,914	3,455	8,369	57	257	1,013	1,727	1,392	468	2,457	998
2006	4,910	3,455	8,365	57	257	1,013	1,727	1,389	467	2,457	998
2007	5,185	3,558	8,743	58	268	1,068	1,858	1,447	486	2,436	1,122
2008	5,207	3,733	8,940	56	267	1,050	1,858	1,463	513	2,556	1,177
2009	5,199	3,796	8,995	54	251	1,020	1,878	1,455	541	2,620	1,176
2010	5,192	3,784	8,976	59	236	971	1,835	1,548	543	2,608	1,176
TOTAL mile-yrs	137,591	68,224	205,815	2,870	8,365	28,319	46,679	38,173	13,185	53,382	14,842
TOTAL km-yrs	221,431	109,796	331,227	4,619	13,462	45,575	75,123	61,433	21,219	85,910	23,886

Table A.2
PAC OCS Pipeline Exposure Data (1972-2010)

Miles of Pacific Oil Pipeline Segments by Year and Size 1972-2010											
Year	<=10"	>10"	Total	2"	3"	4"	5 - 6"	7 - 8"	9 - 10"	11 - 19"	20 - 36"
1972	2	8	10	0	0	0	1	1	1	8	0
1973	2	8	10	0	0	0	1	1	1	8	0
1974	2	8	10	0	0	0	1	1	1	8	0
1975	2	8	10	0	0	0	1	1	1	8	0
1976	2	8	10	0	0	0	1	1	1	8	0
1977	2	8	10	0	0	0	1	1	1	8	0
1978	2	8	10	0	0	0	1	1	1	8	0
1979	17	8	24	0	0	0	1	3	13	8	0
1980	17	14	30	0	0	0	1	3	13	14	0
1981	17	20	37	0	0	0	1	3	13	20	0
1982	17	20	37	0	0	0	1	3	13	20	0
1983	18	22	40	0	0	0	2	3	13	22	0
1984	18	24	42	0	0	0	2	3	13	24	0
1985	18	24	42	0	0	0	2	3	13	24	0
1986	18	34	52	0	0	0	2	3	13	27	7
1987	24	39	64	0	0	0	2	9	13	32	7
1988	24	39	64	0	0	0	2	9	13	32	7
1989	24	39	64	0	0	0	2	9	13	32	7
1990	24	39	64	0	0	0	2	9	13	32	7
1991	24	39	64	0	0	0	2	9	13	32	7
1992	24	54	79	0	0	0	2	9	13	35	19
1993	24	53	77	0	0	0	2	9	13	34	19
1994	24	53	77	0	0	0	2	9	13	34	19
1995	24	53	77	0	0	0	2	9	13	34	19
1996	24	53	77	0	0	0	2	9	13	34	19
1997	24	53	77	0	0	0	2	9	13	34	19
1998	24	53	77	0	0	0	2	9	13	34	19
1999	24	53	77	0	0	0	2	9	13	34	19
2000	24	51	75	0	0	0	2	9	13	32	19
2001	30	51	81	0	0	0	2	15	13	32	19
2002	30	51	81	0	0	0	2	15	13	32	19
2003	30	51	81	0	0	0	2	15	13	32	19
2004	30	51	81	0	0	0	2	15	13	32	19
2005	30	51	81	0	0	0	2	15	13	32	19
2006	30	51	81	0	0	0	2	15	13	32	19
2007	30	51	81	0	0	0	2	15	13	32	19
2008	30	51	81	0	0	0	2	15	13	32	19
2009	30	51	81	0	0	0	2	15	13	32	19
2010	30	51	81	0	0	0	2	15	13	32	19
TOTAL mile-yrs	799	1,399	2,197	0	0	0	53	311	435	995	404
TOTAL km-yrs	1,285	2,251	3,536	0	0	0	85	500	700	1,601	650

STUDY TITLE: Updates to the Fault Tree for Oil-Spill Occurrence Estimators Needed Under the Forthcoming BOEM 2012-2017, 5-Year Program

REPORT TITLE: Updates to Fault Tree for Oil Spill Occurrence Estimators UPDATE OF GOM AND PAC OCS STATISTICS TO 2012

CONTRACT NUMBER: M11PC00013

SPONSORING OCS REGION: Alaska

APPLICABLE PLANNING AREA: Beaufort Sea, Chukchi Sea

FISCAL YEARS OF PROJECT FUNDING: FY 2011-2016

COMPLETION DATE OF REPORT: July 2013

COSTS BY FY: FY 2012: $10,280.00
FY 2013: $64,400.00
FY 2014: $72,050.00
FY 2016: $60,450.00

CUMULATIVE PROJECT COST: $229,840 (Fixed price: $204,440.00)

PROJECT MANAGER: Dr. Frank G. Bercha

AFFILIATION: Bercha International Inc.

ADDRESS: 2926 Parkdale Blvd. NW, Calgary, Alberta, Canada, T2N 3S9

PRINCIPAL INVESTIGATOR(S)*: Dr. Frank G. Bercha

KEY WORDS: Oil spill occurrence, Beaufort Sea, Chukchi Sea, Gulf of Mexico, Pacific OCS, statistics, fault tree analysis

BACKGROUND: The Bureau of Ocean Energy Management Alaska Outer Continental Shelf (OCS) Region uses estimates of oil spill occurrences for the development of environmental impact statements for hypothetical offshore development scenarios resulting from the sale of leases for the US Beaufort and Chukchi Sea OCS. Since 2000, a series of studies and peer reviewed papers (summarized below under "STUDY PRODUCTS") carried out by Bercha International Inc. (Bercha) directed at the development of a realistic method of projecting oil spill occurrences, including source, size distribution, location, and timing for hypothetical development scenarios associated with offshore OCS lease sales.

OBJECTIVES: The main objective of this portion of the work was to update oil spill statistics for use in the fault tree analysis. Key objectives of the work may be summarized as follows:

- Assimilation of the most current data for oil spills in the US **Gulf of Mexico (**GOM) and Pacific (PAC) OCS regions from pipelines, platforms, and wells.
- Analysis of the data to provide statistics of the oil spills.

DESCRIPTION: Historical data and their statistical analyses are used as a starting point for fault tree application to oil spill indicator quantification for the Alaska Arctic OCS. In the initial fault tree analysis, data from the GOM OCS were analyzed for the period from 1972 to 1999. In 2008, a more refined publication of the data characteristics by MMS (now BOEM) has made it possible to conduct a more thorough statistical analysis as well as an update of the GOM data and its analysis to 2006. The current

* P.I.'s affiliation may be different than that listed for Project Manager(s).

report generally discusses and gives data summaries as well as detailed statistical results from the re-analysis of the data, including an update of the GOM and PAC OCS data for platform and pipeline hydrocarbon (crude oil, diesel oil, condensate and refined petroleum products) spills, and an update of blowout and well release spill frequencies to 2012. The work is covered by BOEM contract number M11PC00013, and it is the first update under Task 2.

SIGNIFICANT CONCLUSIONS: General conclusions from the work may be summarized as follows:

- Statistics for oil spills in the US GOM and PAC OCS from 1972 to 2012 have been generated.

STUDY RESULTS: Historical data and their statistical analyses are used as a starting point for fault tree application to oil spill indicator quantification for the Alaska Arctic OCS. In the initial fault tree analysis, data from the GOM OCS were analyzed for the period from 1972 to 2006. In this study, a more refined publication of the data characteristics by BOEMRE made it possible to conduct a more thorough statistical analysis, as well as an update of the data and its analysis to 2012. Additionally, the work generated data summaries and typical statistical results for the re-analysis of the data, including an update of the GOM and PAC OCS data for platform and pipeline spills. In addition, a summary of worldwide blowout statistical data was compiled.

STUDY PRODUCTS:

Bercha International Inc., *Alternative Oil Spill Occurrence Estimators for the Beaufort and Chukchi Seas – Fault Tree Method*, (OCS Study BOEMRE 2011-030), Summary Final Report to U.S. Department of the Interior, Bureau of Ocean Energy Management, Regulation and Enforcement, Alaska Outer Continental Shelf Region, March 2011.

Bercha International Inc., *Alternative Oil Spill Occurrence Estimators and their Variability for the Alaskan OCS – Fault Tree Method – Update of GOM OCS Statistics to 2006*, (OCS Study MMS 2008-025), Final Task 3.1 Report to U.S. Department of the Interior, Minerals Management Service, Alaska Outer Continental Shelf Region, March 2008.

Bercha International Inc., *Alternative Oil Spill Occurrence Estimators and their Variability for the Beaufort Sea – Fault Tree Method*, (OCS Study MMS 2008-035), Final Task 4A.1 Report to U.S. Department of the Interior, Minerals Management Service, Alaska Outer Continental Shelf Region, Vols. 1 and 2, March 2008.

Bercha International Inc., *Alternative Oil Spill Occurrence Estimators and their Variability for the Chukchi Sea – Fault Tree Method*, (OCS Study MMS 2008-036), Final Task 4A.2 Report to U.S. Department of the Interior, Minerals Management Service, Alaska Outer Continental Shelf Region, Vols. 1 and 2, March 2008.

Bercha, F.G., Prentki, R.T., and Smith, C. *Prediction of Oil Spill Occurrence Probabilities in the Alaskan Beaufort and Chukchi Seas OCS*. Paper No. ICETECH08-118-RF in Proceedings of the 8th International Conference and Exhibition on Performance of Ships and Structures in Ice (ICETECH 2008). Banff, Alberta, Canada. 20-23 July 2008.

Bercha, F. G. *Updates to the Fault Tree Approach to Oil Spill Occurrence Estimators for the Beaufort and Chukchi Sea.* Proceedings Alaska OCS Region 11th Information Transfer Meeting, held October 28-30, 2008, Anchorage AK, Anchorage AK: Prepared by BGES, Inc for MMS Alaska OCS Region, OCS Study MMS 2009-005, 2009.

Bercha, F.G. *Arctic and Northern Offshore Oil Spill Probabilities*. Paper No. ICETECH10-187-RF in Proceedings of the 9th International Conference and Exhibition on Performance of Ships and Structures in Ice (ICETECH 2010). Anchorage, AK, USA. 20-23 September 2010.

Bercha, F.G, Prentki, R., and Smith, C. *Alaska OCS Oil Spill Occurrence Probabilities*. Paper No. ICETECH12-142-RF in Proceedings of the 10th International Conference and Exhibition on Performance of Ships and Structures in Ice (ICETECH 2012). Banff, Alberta, Canada. 17-20 September 2012.