OCS Study
BOEM 2018-006

US Outer Continental Shelf Oil Spill Statistics

US Department of the Interior
Bureau of Ocean Energy Management
Alaska OCS Region

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US Outer Continental Shelf
Oil Spill Statistics

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Disclaimer

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Report Availability

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Abbreviations and Acronyms

ABSG	ABS Group
API	American Petroleum Institute
bbl	Barrel (42 US gallons, 0.159 kiloliters, 0.159 m^3, or 0.136 metric tonnes)
BOEM	Bureau of Ocean Energy Management
BSEE	Bureau of Safety and Environmental Enforcement
DOI	US Department of Interior
ESPIS	Environmental Studies Program Information System
GOM	Gulf of Mexico
LOWC	Loss of Well Control
MISLE	Marine Information for Safety and Law Enforcement
NPS	Nominal Pipeline Size
NRC	National Response Center
OCS	Outer Continental Shelf
O&G	Oil and Gas
PAC	Pacific Ocean
PHMSA	Pipeline and Hazardous Material Safety Administration
TIMS	Technical Information Management System
USCG	US Coast Guard

1 Introduction

On 26 September 2017, the Bureau of Ocean Energy Management (BOEM) contracted ABSG Consulting, Inc.(ABSG) in an Indefinite Delivery/Indefinite Quantity contract to perform fault tree analysis to develop oil-spill occurrence frequencies for size ranges of crude oil, condensate, and refined petroleum spills for use in environmental analyses related to proposed oil and gas leasing, exploration, development, and production activities in the Alaska Outer Continental Shelf (OCS) Arctic Planning Areas. Task 1 of the first task order in the contract involves estimation of spill occurrence frequencies. This analysis includes:

- Collation of historical data from the Gulf of Mexico (GOM) and Pacific (PAC) OCS oil spills
- Calculation of spill exposure metrics
- Review of spill causal factors
- Calculation of spill occurrence frequencies
- Estimation of uncertainty metrics such as confidence intervals

This report documents the approach and statistical results to be used in subsequent fault tree analyses. Spill occurrence frequencies are calculated for an array of spill categories. The results are reported in a format compatible with prior oil-spill occurrence analyses, in particular the 2013 report produced by Bercha International, Inc.

1.1 Analysis Scope

The data analysis and calculations presented in this report are designed to provide oil-spill frequency estimates for different spill sizes, fluids, and facility types associated with OCS oil and gas (O&G) operations. Table 1 summarizes the scope of the analysis.

Table 1. Scope of the report

	Scope	Categories (bbl)	Specific Exclusions
Spill Volumes	≥50 barrels (bbls)	50 to <100; 100 to <1,000 1,000 to <10,000; ≥10,000	NA
Fluids	Petroleum	Crude oil, condensate, refined petroleum	Synthetic/vegetable oil-based drilling fluids
Facilities	Offshore O&G exploration, development, and production	Pipelines, platforms	Workboats
Geography	US OCS	GOM and PAC	State waters

The analysis is limited to spill volumes greater than or equal to 50 bbls. Spills of this size have been consistently reported and documented throughout the historical period of data collected.

The results from this analysis are intended to support oil-spill occurrence estimates associated with offshore exploration or development and production plans for individual facilities. To make the output relevant, oil-spill occurrence frequencies are considered relative to exposure metrics for pipelines and platforms. Other entities, such as dive support vessels, geological survey vessels, workboats, and supply boats are not permanent facilities and so are not considered a persistent risk in the same way as platforms (including drilling platforms) and pipelines.

Finally, the analysis is confined to spills occurring on the US OCS for two reasons. First, OCS spill rates are relevant for estimating future oil-spill occurrence frequencies on the US OCS. Second, the US Government has long maintained consistent data describing these kinds of incidents as well as exposure.

1.2 Causal Factors

BOEM's most recent oil spill analysis study estimates statistics for spill occurrence for a broad scope of spill volumes as well as additional facility types (ABSG Consulting Inc., 2016). This report narrows the focus to petroleum spills of 50 bbls or more, which typically have more documentation, allowing for more detailed review of the causes of oil spills. This additional information enables the users to break down the overall spill frequency into component estimates, split by causal factor category. These component estimates will then directly support the fault tree analysis for developing Arctic-specific spill frequencies, extrapolating spill information from GOM and PAC experience.

1.3 Data Sources

This report estimates spill occurrence frequencies based on historical incident data from 1972 to 2017. Spill frequencies decreased substantially after 1973 (ABSG Consulting Inc., 2016), making prior years less relevant for calculating future expected occurrence. The frequencies are calculated as counts of incidents divided by metrics for spill exposure.

ABSG collated spill data from the following sources to develop incident counts:

- Historical incident tables (1972 to 2010) provided in a prior BOEM report by Bercha (Bercha International Inc., 2013)
- Data collected by ABSG (1964 to 2015) for prior spill study for BOEM and Bureau of Safety and Environmental Enforcement (BSEE) (ABSG Consulting Inc., 2016)
- Spill-related documents (2010 to 2017) provided by BOEM (Crowley, 2017)
- Spill tables (1972 to 2012) provided by BOEM (BSEE, 2013)

The ABSG spill study (ABSG Consulting Inc., 2016), conducted for BOEM/BSEE, screened thousands of spills from various sources including multiple spill tables compiled by BSEE from Anderson, Mayes, and LaBelle (2012) and many others cited in that report. In addition, data extracted from the BOEM/BSEE Technical Information Management System (TIMS) database, public Pipeline and Hazardous Material Safety Administration (PHMSA) pipeline spill data, public USCG National Response Center (NRC) data, and US Coast Guard (USCG) data from the Marine Information for Safety and Law Enforcement (MISLE) database were used (ABSG Consulting Inc., 2016).

For exposure, ABSG queried data found on the BSEE website:

- O&G Operations Reports (BSEE, 2017a; BSEE, 2017b)
- Pipeline Masters (BSEE, 2017c; BSEE, 2017d)

Appendices A and C describe the methodology used to query these sources, respectively, to develop the data used in this report’s analysis.

2 OCS Platform Spills

In this report, platform spills include petroleum spills of 50 bbls or more occurring from rig and platform facilities performing exploration and development operations, including production, on the GOM and PAC OCS. From 1972 to 2017, ABSG has identified 149 spills of crude oil, condensate, or refined petroleum, equal to or greater than 50 bbls.

2.1 OCS Platform Exposure

Platforms can take many shapes, ranging from a simple caisson platform in shallow water to a deep water tension-leg facility with dozens of well bays and permanent drilling equipment. The variation in size for platforms makes a simple count of platforms a poor exposure variable for estimating future spill occurrence in the US Arctic OCS.

Instead, this analysis uses counts of active well-years (the mean number of wells that are active for each year of the analysis). This metric fairly accommodates the variety of OCS platform types by assuming that large facilities with potentially higher chances of spill will have large numbers of wells while a small platform may have only one. Furthermore, it is consistent with prior works upon which this analysis is based.

A well is deemed active if it has produced crude or condensate within a given year. Publicly available data does not include well production information back to 1972. To estimate exposure over the entire period, this report combines the historical estimates for active well counts through 2010 (Bercha International Inc., 2013) with estimates based on the publicly available data for the remaining period (2011 to 2017) (BSEE, 2017a; BSEE, 2017b). Table 2 summarizes these results. Appendix A provides a summary of the logic used to compile the publicly available data.

Table 2. Annual count of active wells in GOM and PAC OCS (1972 to 2017)

Year	GOM	PAC	Total
1972 to 2017	**258,054**	**16,714**	**274,768**
1972	4,278	191	4,469
1973	4,512	187	4,699
1974	4,546	182	4,728
1975	4,604	179	4,783
1976	4,763	179	4,942
1977	4,981	195	5,176
1978	5,228	204	5,432
1979	5,510	208	5,718
1980	5,715	225	5,940
1981	5,969	277	6,246
1982	6,326	317	6,643
1983	6,459	349	6,808
1984	6,724	367	7,091
1985	6,988	378	7,366
1986	6,934	385	7,319
1987	6,902	408	7,310
1988	6,904	396	7,300
1989	6,900	406	7,306
1990	6,927	406	7,333
1991	6,932	437	7,369
1992	6,789	427	7,216
1993	6,725	434	7,159
1994	6,721	447	7,168
1995	6,615	445	7,060
1996	6,681	457	7,138
1997	6,636	470	7,106
1998	6,442	459	6,901
1999	6,313	433	6,746
2000	6,288	403	6,691
2001	6,409	407	6,816
2002	6,174	414	6,588
2003	6,004	412	6,416
2004	5,926	412	6,338
2005	5,536	411	5,947
2006	4,824	401	5,225
2007	5,251	408	5,659
2008	5,074	419	5,493
2009	4,520	417	4,937
2010	4,490	414	4,904
2011	4,350	418	4,768
2012	4,093	432	4,525
2013	3,905	428	4,333
2014	3,810	430	4,240
2015	3,659	438	4,097
2016	3,459	305	3,764
2017	3,258	297	3,555

2.2 Platform Spills

This report considers 149 platform spill events that were determined to be within the scope of the project. Table 15 in Appendix B summarizes these spills. It focuses on features of the context of the incident, including causal factors. The “Primary Cause of Incident” column includes the original cause identified in the data. The table expands on the spill list developed in the most recent update of this analysis (Bercha International Inc., 2013).

After a thorough, line-by-line review of the prior list and other available data, several updates were made:

- Bercha spill number 69 from (from Table 3.2 of Bercha International Inc., 2013) was removed because it was associated with a maritime vessel rather than a platform or rig.
- Spill numbers 147 and 148 were added from data provided by BOEM for the years 2010 to 2017 (BSEE, 2013; Crowley, 2017).
- Spills numbers 55, 64, 68, 69, 73, 111, 118, 119, 120, 142, 143, and 149 were added after collating the existing data with previous ABSG results (ABSG Consulting Inc., 2016)

Figure 1 provides a visual summary of the platform spills. The *Deepwater Horizon* spill (included in the “Unknown” category) is not shown proportionally to the other spills.

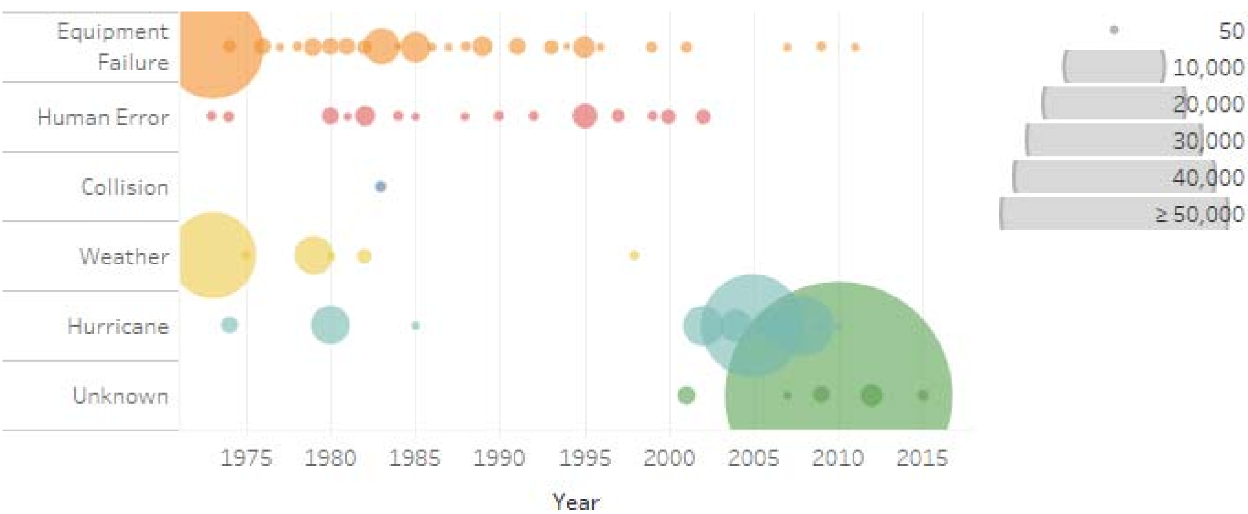

Figure 1. Platform spills ≥ 50 bbl of petroleum

Table 3 and Table 4 summarize counts of spills by spill size, by causal factor, and by both factors simultaneously, respectively.

Table 3. Platform spill size distribution summary

Size (bbls)		Spill Count
Small	50 to <100	62
Medium	100 to <1,000	79
Large	1,000 to <10,000	7
Huge	≥10,000	1
Total		**149**

Table 4. Platform spill summary by spill size (1972 to 2017)

Cause Classification	Detailed Size Category (bbls)				Summary Categories (bbls)		Total
	Small	Medium	Large	Huge	50 to <1,000	≥1,000	
Equipment Failure	25	18	1	0	43	1	44
Human Error	6	10	0	0	16	0	16
Collision	0	1	0	0	1	0	1
Weather	1	4	2	0	5	2	7
Hurricane	29	40	4	0	69	4	73
Unknown	1	6	0	1	7	1	8
TOTAL	**62**	**79**	**7**	**1**	**141**	**8**	**149**

2.3 OCS Platform Spill Statistics

Combining the spill count results with well-year exposure,

Table 5 presents spill frequency estimates for platform spills. Hurricanes are the biggest causal factor. Next, equipment failure accounts for many small and medium spills. And, then, weather (other than hurricanes) is the next most common causal factor of large and huge spills.

The *Deepwater Horizon* spill is shown in Table 6 below as the one spill larger than 1,000 barrels and is included as an "Unknown" cause. This category has been selected to allow individual analysis of this important spill. The environmental and safety impact of this one spill drastically outweighs the other spills shown, despite its relatively low occurrence rate (0.04 spills per 10,000 well years). The investigation conducted by DOI identified critical equipment failure and human error factors that contributed to the spill (DOI, 2011).

Table 5. GOM and PAC OCS platform hydrocarbon spill statistics (1972 to 2017)

Cause Classification	50 to 999 bbl				≥ 1,000 bbl			
	Historical Distribution %	Number of Spills	Exposure (well-years)	Frequency (spill per 10^4 well-years)	Historical Distribution %	Number of Spills	Exposure (well-years)	Frequency (spill per 10^4 well-years)
Equipment Failure	30.5	43	274,768	1.56	12.5	1	274,768	0.04
Human Error	11.3	16		0.58	0.0	0		0.00
Collision	0.7	1		0.04	0.0	0		0.00
Weather	3.5	5		0.18	25.0	2		0.07
Hurricane	48.9	69		2.51	50.0	4		0.15
Unknown	5.0%	7		0.25	12.5%	1		0.04
Total	**100.0%**	**141**		**5.13**	**100.0%**	**8**		**0.29**

2.4 Loss of Well Control Spills

Many spills have a maximum plausible spill size based on quantities of petroleum stored or processed at a facility. Loss of well control (LOWC) spills are of particular interest because a freely flowing well has the potential for much higher spill volumes. Table 6 summarizes the subset of spills in the data for which a LOWC was reported.

Table 6. LOWC Spill Summary

Size (bbls)		Spill Count	Exposure (well-years)	Frequency (spill per 10^4 well-years)
Small	50 to <100	5	274,768	0.18
Medium	100 to <1,000	6		0.22
Large	1,000 to <10,000	0		0.00
Huge	≥10,000	1		0.04
Total		**12**		**0.44**

3 OCS Pipeline Spills

O&G operations in the GOM and PAC OCS often rely on pipelines to transfer oil and gas to market onshore. In 2017, there were over 9,000 miles of active oil pipeline in the GOM OCS waters. These pipelines are the source of 70 spills since 1972 identified as greater than 50 barrels. External factors such as hurricanes and third-party vessels operating in the domain are particularly important threats to pipeline integrity.

The pipeline facility category encompasses many pipeline types ranging from smaller subsea well riser segments to large-diameter transport pipelines. In addition, pipelines can carry a variety of fluids. This analysis considers only pipelines carrying crude, condensate, or refined petroleum. Pipelines for refined petroleum, such as diesel fuel, appeared very rarely.

3.1 OCS Pipeline Exposure

The frequency of pipeline spills is a function of a variety of factors including the pipeline's water depth, diameter, and distance from shore. These features affect the likelihood of a spill as well as the probable spill volume.

This report uses pipeline mile-years (the mean of the total length of pipeline in use for each year) as the exposure metric for pipelines, which is consistent with prior analyses (ABSG Consulting Inc., 2016; Bercha International Inc., 2013). This exposure metric is justified because of the pipeline hazards that are typical in the OCS. Many common causes for pipeline spills are external forces, such as third-party vessels, anchor drags, and trawl nets. For these types of causal factors, a long pipeline suggests a greater chance of accidental contact and spill.

The pipeline spill frequency estimates in this report distinguish spills from different pipeline diameters. To support this calculation, Table 17 in Appendix C presents annual exposure estimates for an array of nominal pipeline size (NPS) categories.

3.2 OCS Pipeline Spills

The 70 pipeline spills in this report are consolidated from the data sources described in Section 1.3 (after filtering them based on the established scope). This section summarizes features of the context of the incident, including causal factors. Table 17 in Appendix D lists all of the pipeline spills.

This table expands on the spill list developed in the most recent study (Bercha International Inc., 2013). After a thorough line-by-line review of the prior list and other available data, several updates were made:

- Bercha spill numbers 31,34, 38, and 47 (from Table 2.2 of the Bercha International Inc., 2013 report) were removed since they were chemical rather than petroleum spills
- Spill numbers 25, 35, 56, 66, 67, and 68 were added after collating the existing data with ABS Consulting results (ABSG Consulting Inc., 2016)
- Spill numbers 69 and 70 were added based on spills recently reported on by public news outlets (Knodel, 2016; Grant, 2017)

Figure 2 summarizes these spills in a timeline format, emphasizing the spill cause and spill size. Importantly, this visual does not adjust for exposure differences year to year. However, it does seem to reveal an interesting trend: most spills since the turn of the century have been hurricane-related spills. In addition, spill sizes appear to be getting smaller. Adjusting for exposure, the data reveal a very weak statistical trend over this period for spills ≥50 bbls but a strong trend when looking at the total number of reported pipeline spills (including very small spills) (ABSG Consulting Inc., 2016).

Removing hurricane-related spills further emphasizes this trend, suggesting that the operations-related spill rate has been decreasing. For the purposes of this report, this finding suggests that our estimated rates, calculated using data since 1972, may be substantially conservative.

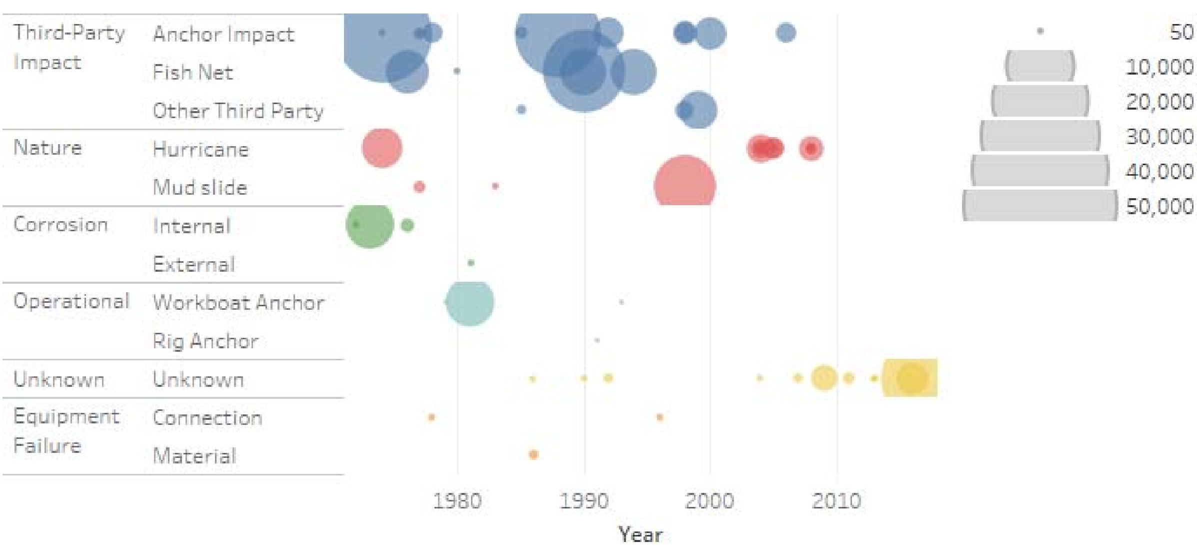

Figure 2. Pipeline Spills ≥ 50 bbl of petroleum

Table 7 and Table 8 provide basic summaries of spill counts by pipeline diameter measured in NPS and by causal factor categories.

Table 7. Count of pipeline spills by NPS categories (1972 to 2017)

Category	Spill Size (bbl)	All NPS	NPS ≤10	NPS >10	Unknown. NPS
Small	50-99	16	12	4	0
Medium	100-999	35	21	11	3
Large	1,000-9,999	15	7	7	1
Huge	≥10,000	4	1	2	1
Total		70	41	24	5

Table 8. Count of pipeline spills by causal factors (1972 to 2017)

Cause Classification	Detailed Size Category (bbls)				Summary Categories (bbls)		Total
	Small	Medium	Large	Huge	50 to <1,000	≥1,000	
Corrosion	1	2	1	0	3	1	4
External	1	0	0	0	1	0	1
Internal	0	2	1	0	2	1	3
Third-Party Impact	2	8	7	3	10	10	20
Anchor Impact	2	5	3	2	7	5	12
Jackup Rig or Spud Barge	0	2	1	0	2	1	3
Trawl/Fishing Net	0	1	3	1	1	4	5
Operation Impact	3	0	1	0	3	1	4
Rig Anchoring	1	0	0	0	1	0	1
Workboat Anchoring	2	0	1	0	2	1	3
Mechanical	0	3	0	0	3	0	3
Connection Failure	0	2	0	0	2	0	2
Material Failure	0	1	0	0	1	0	1
Natural Hazard	9	15	4	0	24	4	28
Mud Slide	1	1	1	0	2	1	3
Hurricane	8	14	3	0	22	3	25
Unknown	1	7	2	1	8	3	11
Total	16	35	15	4	51	19	70

3.3 Pipeline Spill Statistics

The estimates of spill frequency presented in this section provide frequencies broken down by cause classification category to support future fault tree rates assumptions of specific spill rate causal factors or pipeline diameters, or spill size. Table 9 and Table 10 summarize these estimates.

Table 9. GOM and PAC pipeline hydrocarbon spill statistics by cause (1972 to 2017)

Cause Classification	50 to <1,000				≥1000			
	Historical Distribution %	Number of Spills	Exposure (km-year)	Frequency Spills per 10^5 km-year	Historical Distribution %	Number of Spills	Exposure (km-years)	Frequency Spill Per 10^5 km-year
Corrosion	5.9%	3	444,901	0.674	5.3%	1	444,901	0.225
External	2.0%	1		0.225	0.0%	0		0.000
Internal	3.9%	2		0.450	5.3%	1		0.225
Third-Party Impact	19.6%	10		2.248	52.6%	10		2.248
Anchor Impact	13.7%	7		1.573	26.3%	5		1.124
Jackup Rig or Spud Barge	3.9%	2		0.450	5.3%	1		0.225
Trawl/Fishing Net	2.0%	1		0.225	21.1%	4		0.899
Operation Impact	5.9%	3		0.674	5.3%	1		0.225
Rig Anchoring	2.0%	1		0.225	0.0%	0		0.000
Workboat Anchoring	3.9%	2		0.450	5.3%	1		0.225
Mechanical	5.9%	3		0.674	0.0%	0		0.000
Connection Failure	3.9%	2		0.450	0.0%	0		0.000
Material Failure	2.0%	1		0.225	0.0%	0		0.000
Natural Hazard	47.1%	24		5.394	21.1%	4		0.899
Mud Slide	3.9%	2		0.450	5.3%	1		0.225
Hurricane	43.1%	22		4.945	15.8%	3		0.674
Unknown	15.7%	8		1.798	15.8%	3		0.674
Total	**100.0%**	**51**		**11.463**	**100.0%**	**19**		**4.271**

The two largest causal categories are natural hazards and third-party impacts; these two categories combined make up about two thirds of the known causal factors shown, suggesting that the pipeline technology is not typically at fault.

Table 10. GOM and PAC pipeline hydrocarbon spill statistics by spill size and pipeline diameter (1972 to 2017)

GOM and PAC Pipeline Spills, Categorized 1972 to 2017			Number of Spills	Exposure (km-years)	Frequency (spills per 10^5 km-years)
By Pipe Diameter	≤10"		41	292,206	14.031
	>10"		24	152,695	15.718
	Unk.		5	444,901	1.124
By Spill Size	Small		16	444,901	3.596
	Medium		35	444,901	7.867
	Large		15	444,901	3.372
	Huge		4	444,901	0.899
By Pipe Diameter, By Spill Size	≤10"	Small	12	292,206	4.107
		Medium	21	292,206	7.187
		Large	7	292,206	2.396
		Huge	1	292,206	0.342
	>10"	Small	4	152,695	2.620
		Medium	11	152,695	7.204
		Large	7	152,695	4.584
		Huge	2	152,695	1.310
	Unk.	Small	0	444,901	0.000
		Medium	3	444,901	0.674
		Large	1	444,901	0.225
		Huge	1	444,901	0.225

Pipeline size appears to have a slight correlation with spill frequency. Overall, larger pipelines have a slightly higher spill frequency. Furthermore, larger pipelines have higher spill rates in the medium, large, and huge spill size categories while smaller pipelines have the higher rate in the small spills category.

4 Confidence Intervals

To estimate confidence intervals, ABSG assumes that spill occurrences are a Poisson process. The Poisson distribution models the number of events to take place in a specified time interval when the events occur independently of each other and at a given rate. This is the ideal distribution for modeling independent spill events.

The Poisson process is defined by the parameter λ. When estimating λ using historical data, it can be assumed without loss of generality that the historically observed events all occur in a single time interval. In this simple case, the best estimate of λ is equal to the number of events observed, *x*. Confidence intervals for λ can then be computed using a variety of statistical estimates. Two of these estimates were used to calculate the 90% confidence intervals used in this report, based on recommendations found in *Comparison of Confidence Intervals for the Poisson Mean* (Patil & Kulkarni, 2012):

Equation 1

$$\left(\chi^2_{(2x,0.05)} \big/ 2, \chi^2_{(2(x+1),0.95)} \big/ 2 \right)$$

Equation 2

$$\left((x - 0.5) + Z_{0.05}\sqrt{(x - 0.5)}, (x + 0.5) + Z_{0.05}\sqrt{(x + 0.5)} \right)$$

Equation 1 is an ideal estimate when *x* equals 4 or more, and Equation 2 is ideal when *x* equals 2 or less. Equation 1 was used in the *x* equals 3 case. When *x* equals 0, the lower bound of the interval in Equation 2 cannot be evaluated. Of course, the lower bound should be 0 in this case. After computing the confidence interval for λ, the results were then converted to spill rate confidence intervals by dividing by the exposure.

These results include a minor caveat related to the effect of hurricanes. Hurricanes tend to cause multiple oil spills at once as multiple platforms or pipelines are damaged simultaneously, which violates an assumption of the Poisson distribution that spill occurrences are independent events. A more thorough analysis of the covariance of hurricane spills is beyond the scope of this analysis. In addition, the number of spill occurrences during a hurricane can be hard to estimate. Multiplicative spill reports and unreported spills are can be difficult to track following a devastating storm. As such, hurricane spill rates and their confidence intervals may not account for some data uncertainty, though they have been painstakingly analyzed.

Table 11, Table 12, Table 13, and Table 14 summarize the confidence intervals for all of the spill rates presented in the report.

Table 11. Confidence intervals for GOM and PAC OCS platform hydrocarbon spill statistics (1972 to 2017)

Cause Classification	50 to <1,000 bbls			≥1,000 bbls		
	Frequency (spills per 10^4 well-year)	Lower	Upper	Frequency (spills per 10^4 well-year)	Lower	Upper
Equipment Failure	1.56	1.3	2.28	0.04	0	0.12
Human Error	0.58	0.41	1.02	0	0	0.04
Collision	0.04	0	0.12	0	0	0.04
Weather	0.18	0.04	0.45	0.07	0	0.2
Hurricane	2.51	2.24	3.46	0.15	0.04	0.41
Unknown	0.25	0.12	0.57	0.04	0	0.12
Total	**5.13**	**4.97**	**6.64**	**0.29**	**0.12**	**0.61**

Table 12. LOWC Spill Summary

Size (bbls)		Frequency (spills per 10^4 well-year)	Lower	Upper
Small	50 to <100	0.18	0.04	0.40
Medium	100 to <1,000	0.22	0.07	0.44
Large	1,000 to <10,000	0.00	0.00	0.04
Huge	≥10,000	0.04	0.00	0.20
Total		**0.44**	**0.22**	**0.73**

Table 13. Confidence intervals for GOM and PAC pipeline hydrocarbon spill statistics by cause (1972 to 2017)

Cause Classification	50 to <1,000 bbls			≥1,000 bbls		
	Frequency (spills per 10^5 km-year)	Lower	Upper	Frequency (spills per 10^5 km-year)	Lower	Upper
Corrosion	**0.67**	**0.00**	**1.80**	**0.23**	**0.00**	**0.68**
External	0.23	0.00	0.68	0.00	0.00	0.23
Internal	0.45	0.00	1.13	0.23	0.00	0.68
Third-Party Impact	**2.25**	**1.12**	**3.82**	**2.25**	**1.12**	**3.82**
Anchor Impact	1.57	0.67	3.15	1.12	0.22	2.47
Jackup Rig or Spud Barge	0.45	0.00	1.13	0.23	0.00	0.68
Trawl/Fishing Net	0.23	0.00	0.68	0.90	0.22	2.25
Operation Impact	**0.67**	**0.00**	**1.80**	**0.23**	**0.00**	**0.68**
Rig Anchoring	0.23	0.00	0.68	0.00	0.00	0.23
Work Boat Anchoring	0.45	0.00	1.58	0.23	0.00	0.68
Mechanical	**0.67**	**0.00**	**1.80**	**0.00**	**0.00**	**0.23**
Connection Failure	0.45	0.00	1.13	0.00	0.00	0.23
Material Failure	0.23	0.00	0.68	0.00	0.00	0.23
Natural Hazard	**5.39**	**3.60**	**7.64**	**0.90**	**0.22**	**2.25**
Mud Slide	0.45	0.00	1.13	0.23	0.00	0.68
Storm/ Hurricane	4.95	3.15	7.19	0.67	0.00	1.80
Unknown	**1.80**	**0.67**	**3.37**	**0.67**	**0.00**	**1.80**
Total	**11.46**	**8.77**	**14.61**	**4.27**	**2.70**	**6.29**

Table 14. Confidence intervals for GOM and PAC pipeline hydrocarbon spill statistics by spill size and pipeline diameter (1972 to 2017)

			Frequency (spills per 10^5 km-year)	Lower	Upper
By Pipe Diameter		**≤10"**	14.03	10.61	18.48
		>10"	15.72	10.48	22.27
		Unknown	1.12	0.22	2.47
By Spill Size		**Small**	3.60	2.25	5.62
		Medium	7.87	5.62	10.56
		Large	3.37	2.02	5.39
		Huge	0.90	0.22	2.25
By Pipe Diameter, By Spill Size	**≤ 10"**	**Small**	4.11	2.05	6.84
		Medium	7.19	4.79	10.61
		Large	2.40	1.03	4.79
		Huge	0.34	0.00	1.03
	> 10"	**Small**	2.62	0.65	6.55
		Medium	7.20	3.93	12.44
		Large	4.58	1.96	9.17
		Huge	1.31	0.00	3.27
	Unk.	**Small**	0.00	0.00	0.22
		Medium	0.67	0.00	1.80
		Large	0.22	0.00	0.67
		Huge	0.22	0.00	0.67

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Appendix A: OCS Platform Exposure

The platform exposure metric is the number of active wells each year. The approach was determined to replicate the metric used in prior analyses (Bercha International Inc., 2013). It was calculated using data that is publicly available on BSEE's website (BSEE, 2017a).

The metric estimates the number of active wells as the number of unique American Petroleum Institute (API) well ID numbers associated with non-zero oil production volumes. The pseudo-SQL code below documents this logic. The output variable "Well_Count" is the exposure metric. This logic is for the GOM region. Similar data and logic were used for the PAC region.

```
Select Year, Count(*) AS Well_Count
From
    (Select *
    From
        (Select *, 2017 as YEAR From ogora2017 UNION ALL
        Select *, 2016 as YEAR From ogora2016 UNION ALL
        Etc…)
    Where MON_O_PROD_VOL <> 0
    Group by Year, API_WELL_NUMBER)
Group by Year
```

Appendix B: OCS Platform Spills

Table 15. GOM and PAC OCS Platform Spills ≥ 50 bbls (1972 to 2017)

Spill # *	Bercha Spill #	Year	Water Depth (ft)	Primary Cause of Incident **	Operation	LOWC	Spill Total (bbl)	Crude & Cond. (bbl)	Refined Oil (bbl)	BSEE Spill ID	Region
1	1	1973	110	Equipment Failure	Production		9935	9935	0	0521	GOM
2	2	1973	61	Weather	Production/Barge		7000	7000	0	0525	GOM
3	3	1973	300	Weather	Drilling/Vessel		239	0	239	0615	GOM
4	4	1973	103	Human Error	Drilling/Vessel		95	0	95	0693	GOM
5	5	1974	60	Equipment Failure	Production		130	130	0	0746	GOM
6	6	1974	29	Hurricane	Hurricane	YES	75	75	0	0757	GOM
7	7	1974	27	Equipment Failure	Production		50	50	0	0767	GOM
8	8	1974	140	Human Error	Production		120	120	0	0783	GOM
9	9	1974	30	Hurricane	Hurricane - Repair	YES	200	200	0	0787	GOM
10	10	1975	200	Weather	Drilling/Vessel		100	0	100	0874	GOM
11	11	1976	127	Equipment Failure	Drilling/Vessel		300	0	300	0963	GOM
12	12	1977	55	Equipment Failure	Drilling/Vessel		77	0	77	1063	GOM
13	13	1978	105	Equipment Failure	Production		104	104	0	1102	GOM
14	14	1979	311	Equipment Failure	Drilling/Vessel		321	0	321	1171	GOM
15	15	1979	210	Equipment Failure	Production		60	60	0	1197	GOM
16	16	1979	280	Weather	Drilling/Vessel		1500	0	1500	1278	GOM
17	17	1980	156	Human Error	Drilling		286	0	286	1291	GOM
18	18	1980	140	Equipment Failure	Drilling		95	0	95	1307	GOM
19	19	1980	220	Weather	Drilling/Vessel		80	0	80	1322	GOM
20	20	1980	187	Equipment Failure	Production		83	0	83	1339	GOM
21	21	1980	60	Hurricane	Hurricane		1456	1456	0	1344	GOM
22	22	1980	99	Equipment Failure	Drilling/Vessel		118	0	118	1349	GOM
23	23	1981	54	Human Error	Production		58	58	0	1363	GOM
24	24	1981	49	Equipment Failure	Drilling		210	0	210	1368	GOM
25	25	1981	350	Equipment Failure	Drilling/Vessel		50	0	50	1395	GOM
26	26	1981	340	Equipment Failure	Completion/Workover	YES	64	64	0	1422	GOM

Spill # *	Bercha Spill #	Year	Water Depth (ft)	Primary Cause of Incident **	Operation	LOWC	Spill Total (bbl)	Crude & Cond. (bbl)	Refined Oil (bbl)	BSEE Spill ID	Region
27	27	1982	180	Human Error	Drilling/Vessel		400	0	400	1434	GOM
28	28	1982	394	Equipment Failure	Drilling/Vessel		228	0	228	1447	GOM
29	29	1982	60	Weather	Drilling/Vessel		214	0	214	1474	GOM
30	30	1983	43	Equipment Failure	Drilling/Barge		600	0	600	1521	GOM
31	31	1983	48	Equipment Failure	Drilling/Vessel		77	0	77	1530	GOM
32	32	1983	50	Equipment Failure	Drilling/Vessel		320	0	320	1533	GOM
33	33	1983	65	Equipment Failure	Drilling/Vessel		200	0	200	1536	GOM
34	34	1983	48	Equipment Failure	Drilling/Vessel		77	0	77	1546	GOM
35	35	1983	105	Collision	Production/Vessel		119	0	119	1581	GOM
36	36	1984	94	Equipment Failure	Production		50	50	0	1650	GOM
37	37	1984	307	Human Error	Drilling/Vessel		100	0	100	1653	GOM
38	38	1985	130	Equipment Failure	Drilling/Fuel Transfer		107	0	107	1683	GOM
39	39	1985	50	Human Error	Deactivation		60	0	60	1684	GOM
40	40	1985	196	Equipment Failure	Production/Workover	YES	50	50	0	1689	GOM
41	41	1985	3115	Equipment Failure	Drilling/Vessel		643	0	643	1711	GOM
42	42	1985	200	Equipment Failure	Drilling		50	0	50	1723	GOM
43	43	1985	55	Hurricane	Hurricane		66	66	0	1734	GOM
44	44	1985	103	Equipment Failure	Drilling/Vessel		58	0	58	1739	GOM
45	45	1986	750	Equipment Failure	Construction		52	0	52	1816	GOM
46	46	1987	126	Equipment Failure	Drilling	YES	60	60	0	1828	GOM
47	47	1988	172	Equipment Failure	Production		50	50	0	1871	GOM
48	48	1988	200	Human Error	Drilling		64	0	64	1896	GOM
49	49	1988	140	Equipment Failure	Production		55	55	0	1897	GOM
50	50	1989	112	Equipment Failure	Production		400	400	0	1903	GOM
51	51	1989	206	Equipment Failure	Production		55	55	0	3351	GOM
52	52	1990	290	Human Error	Drilling		100	0	100	1951	PAC
53	53	1991	50	Equipment Failure	Production		280	280	0	2010	GOM
54	54	1992	187	Human Error	Drilling	YES	100	100	0	2053	GOM
55	-	1993	8	Equipment Failure	Unknown	YES	250	250	0	3360	GOM

Spill # *	Bercha Spill #	Year	Water Depth (ft)	Primary Cause of Incident **	Operation	LOWC	Spill Total (bbl)	Crude & Cond. (bbl)	Refined Oil (bbl)	BSEE Spill ID	Region
56	55	1994	150	Equipment Failure	Production		50	50	0	2111	PAC
57	56	1995	50	Human Error	Drilling/Vessel		600	600	0	2114	GOM
58	57	1995	116	Equipment Failure	Production		75	75	0	2133	GOM
59	58	1995	56	Equipment Failure	Production		435	435	0	2149	GOM
60	59	1996	705	Equipment Failure	Construction		62	0	62	2198	GOM
61	60	1997	40	Human Error	Production		170	170	0	2245	GOM
62	61	1998	700	Weather	Production		100	0	100	2259	GOM
63	62	1999	463	Equipment Failure	Workover	YES	125	125	0	2361	GOM
64	-	1999	150	Human error	Unknown		83	0	83	2363	GOM
65	63	2000	2223	Human Error	Drilling	YES	200	200	0	2389	GOM
66	64	2000	172	Human Error	Production		60	60	0	2407	GOM
67	65	2001	243	Equipment Failure	Production		127	127	0	2446	GOM
68	-	2001	Unk.	Unknown	Unknown		225	225	0	NA	GOM
69	-	2001	Unk.	Unknown	Unknown		100	100	0	NA	PAC
70	66	2002	50	Hurricane	Hurricane	YES	350	350	0	2555	GOM
71	67	2002	37	Hurricane	Hurricane		497	0	497	2557	GOM
72	68	2002	94	Hurricane	Hurricane		741	0	741	2556	GOM
73	-	2002	Unk.	Human Error	Completion/Workover		230	0	230	NA	GOM
74	70	2004	277	Hurricane	Hurricane		52	0	52	2707	GOM
75	71	2004	302	Hurricane	Hurricane		55	0	55	2668	GOM
76	72	2004	305	Hurricane	Hurricane		264	133	131	2695	GOM
77	73	2004	244	Hurricane	Hurricane		106	77	29	2697	GOM
78	74	2004	255	Hurricane	Hurricane		66	27	39	2699	GOM
79	75	2004	479	Hurricane	Hurricane		510	410	100	2703	GOM
80	76	2005	86	Hurricane	Hurricane		141	141	0	2771	GOM
81	77	2005	83	Hurricane	Hurricane		242	242	0	2770	GOM
82	78	2005	91	Hurricane	Hurricane		204	204	0	2772	GOM
83	79	2005	88	Hurricane	Hurricane		195	195	0	2773	GOM
84	80	2005	1023	Hurricane	Hurricane		325	325	0	2775	GOM

Spill # *	Bercha Spill #	Year	Water Depth (ft)	Primary Cause of Incident **	Operation	LOWC	Spill Total (bbl)	Crude & Cond. (bbl)	Refined Oil (bbl)	BSEE Spill ID	Region
85	81	2005	140	Hurricane	Hurricane		380	0	380	2781	GOM
86	82	2005	255	Hurricane	Hurricane		130	106	24	2782	GOM
87	83	2005	322	Hurricane	Hurricane		110	85	25	2793	GOM
88	84	2005	340	Hurricane	Hurricane		195	180	15	2788	GOM
89	85	2005	153	Hurricane	Hurricane		307	307	0	2819	GOM
90	86	2005	223	Hurricane	Hurricane		71	50	21	2821	GOM
91	87	2005	228	Hurricane	Hurricane		159	130	29	2830	GOM
92	88	2005	285	Hurricane	Hurricane		94	75	19	2832	GOM
93	89	2005	116	Hurricane	Hurricane		51	48	4	2805	GOM
94	90	2005	137	Hurricane	Hurricane		101	48	54	2808	GOM
95	91	2005	128	Hurricane	Hurricane		51	48	4	2809	GOM
96	92	2005	137	Hurricane	Hurricane		50	48	2	2810	GOM
97	93	2005	117	Hurricane	Hurricane		51	50	1	2813	GOM
98	94	2005	140	Hurricane	Hurricane		97	95	2	2816	GOM
99	95	2005	2107	Hurricane	Hurricane		614	536	78	2861	GOM
100	96	2005	182	Hurricane	Hurricane		1572	0	1572	2881	GOM
101	97	2005	204	Hurricane	Hurricane		77	44	33	2853	GOM
102	98	2005	230	Hurricane	Hurricane		2000	2000	0	2855	GOM
103	99	2005	254	Hurricane	Hurricane		181	150	31	2856	GOM
104	100	2005	231	Hurricane	Hurricane		188	150	38	2858	GOM
105	101	2005	472	Hurricane	Hurricane		101	101	0	2860	GOM
106	102	2005	238	Hurricane	Hurricane		1494	0	1494	2870	GOM
107	103	2005	182	Hurricane	Hurricane		67	0	67	2842	GOM
108	104	2005	230	Hurricane	Hurricane		659	582	77	2838	GOM
109	105	2005	230	Hurricane	Hurricane		166	166	0	3059	GOM
110	106	2005	230	Hurricane	Hurricane		53	53	0	3009	GOM
111	-	2005	Unk.	Hurricane	Completion/Workover		119	119	0	3769	GOM
112	107	2006	230	Hurricane	Hurricane		51	51	0	3060	GOM
113	108	2006	240	Hurricane	Hurricane		63	63	0	3063	GOM

Spill # *	Bercha Spill #	Year	Water Depth (ft)	Primary Cause of Incident **	Operation	LOWC	Spill Total (bbl)	Crude & Cond. (bbl)	Refined Oil (bbl)	BSEE Spill ID	Region
114	109	2006	240	Hurricane	Hurricane		528	528	0	3062	GOM
115	110	2006	88	Hurricane	Hurricane		59	59	0	2945	GOM
116	111	2006	240	Hurricane	Hurricane		133	133	0	2995	GOM
117	112	2006	230	Hurricane	Hurricane		51	51	0	3013	GOM
118	-	2006	240	Hurricane	Hurricane		120	120	0	2933	GOM
119	-	2007	Unk.	Unknown	Unknown		71	71	0	Unknown	GOM
120	-	2007	Unk.	Equipment Failure	Unknown		70	0	70	NA	GOM
121	113	2008	88	Hurricane	Decommissioning		54	54	0	3121	GOM
122	114	2008	187	Hurricane	Hurricane		685	685	0	3219	GOM
123	115	2008	210	Hurricane	Hurricane		103	20	83	3251	GOM
124	116	2008	262	Hurricane	Hurricane		62	55	7	3226	GOM
125	117	2008	415	Hurricane	Hurricane		205	150	54	3249	GOM
126	118	2008	414	Hurricane	Hurricane		52	52	0	3227	GOM
127	119	2008	472	Hurricane	Hurricane		513	513	0	3250	GOM
128	120	2008	541	Hurricane	Hurricane		200	200	0	3209	GOM
129	121	2008	235	Hurricane	Hurricane		550	0	550	3252	GOM
130	122	2008	175	Hurricane	Hurricane		140	138	3	3270	GOM
131	123	2008	76	Hurricane	Hurricane		50	48	2	3266	GOM
132	124	2008	169	Hurricane	Hurricane		127	126	1	3271	GOM
133	125	2008	176	Hurricane	Hurricane		70	40	30	3269	GOM
134	126	2008	186	Hurricane	Hurricane		194	112	82	3225	GOM
135	127	2008	220	Hurricane	Hurricane		170	170	0	3275	GOM
136	128	2008	324	Hurricane	Hurricane		196	31	165	3238	GOM
137	129	2008	479	Hurricane	Hurricane		72	72	0	3177	GOM
138	130	2008	472	Hurricane	Hurricane		58	58	0	3331	GOM
139	131	2009	415	Hurricane	Hurricane		54	54	0	3322	GOM
140	132	2009	4420	Equipment Failure	Drilling		50	50	0	3454	GOM
141	133	2009	6050	Equipment Failure	Abandonment	YES	62	62	0	3435	GOM
142	-	2009	254	Hurricane	Hurricane		70	70	0	3319	GOM

Spill # *	Bercha Spill #	Year	Water Depth (ft)	Primary Cause of Incident **	Operation	LOWC	Spill Total (bbl)	Crude & Cond. (bbl)	Refined Oil (bbl)	BSEE Spill ID	Region
143	-	2009	340	Unknown	Unknown		186	186	0	3409	GOM
144	-	2009	Unk.	Unknown	Unknown		100	100	0	NA	GOM
145	134	2010	4992	Unknown	Drilling/Abandonment	YES	4900000	4900000	0	3496	GOM
146	135	2010	475	Hurricane	Hurricane		62	62	0	3509	GOM
147	-	2011	541	Equipment Failure	Drilling		67	67	0	Unknown	GOM
148	-	2012	63	Unknown	Production		480	480	0	Unknown	GOM
149	-	2015	125	Unknown	Unknown		125	0	125	NA	GOM

* This list only includes spills within the scope of the analysis described within this report. Spills from facility types, volume categories, fluid types, and geographic areas outside of this scope are excluded. Some years do not include any spills within the scope criteria.

** "Hurricane" is listed under both cause and operation for spills associated with named hurricanes. The cause "Weather" identifies spills caused by all other weather events, such as strong tides, rough seas, and waves.

Appendix C: OCS Pipeline Exposure

Pipeline exposure was estimated using the pipeline data available on BSEE's website (BSEE, 2017c; BSEE, 2017d). Pipeline lengths were queried in miles and converted to kilometers for the calculation of frequencies. Table 16 provides the pipeline exposure results. Values have been rounded.

The metric estimates the number of miles of oil-bearing pipeline in Federal waters in each year which have been installed or approved and have not yet been abandoned. This pseudo-SQL code describes the logic.

Note that the Field "Product" is defined as:

```
IIf(InStr([PROD_CODE],"O")<>0 AND [PROD_CODE]<>"H2O","Oil",IIf([PROD_CODE] In
    ("BLKG","GAS","BLGH","FLG","G/C","GASH")," Gas","OTHER")) AS Product
```

```
Select
        m.YEAR_NUM,
        size.Size,
        Count(*) AS Segments,
        Sum([SEG_LENGTH])/5280 AS Miles,
        Product
From PPL_MASTERS AS pm, MONTHS AS m, PipelineSizeRanges AS [size]
Where
        (((pm.PPL_SIZE_CODE)>[size].[minsize] AND
        (pm.PPL_SIZE_CODE)<[size].[maxsize]) AND
        ((m.YEAR_NUM)<Year(Date())) AND
        ((pm.SEGMENT_NUM)<500000) AND
        ((pm.STATUS_CODE) Not In ("PROP","CNCL","COMB")) AND
        ((m.MONTH_NUM)=12) AND
        ((IIf(IsNull([INIT_HS_DT])=False,[INIT_HS_DT],IIf(IsNull([APPROVED_DATE])=
            False,[APPROVED_DATE],#1/1/1964#)))<=[m].[end_date]) AND
        ((IIf(IsNull([ABAN_APRV_DT])=False,[ABAN_APRV_DT],[ABAN_DATE])) Is Null
            OR (IIf(IsNull([ABAN_APRV_DT])=False,
            [ABAN_APRV_DT],[ABAN_DATE]))>=[m].[end_date]))
```

```
Group By
	m.YEAR_NUM,
	size.Size,
	Product
Having [Product]="Oil"
```

Table 16. Miles of GOM and PAC oil pipeline segments by year and size (1972 to 2017)

Year	Summary NPS Categories			Detailed NPS Categories (inches)							
	≤10’’	>10’’	Total	2	3	4	5-6	7-8	9-10	11-19	20+
1972	1,439	373	1,812	68	95	378	467	314	117	320	53
1973	1,553	447	2,000	69	99	388	497	359	142	391	56
1974	1,643	461	2,104	76	99	392	499	435	142	405	56
1975	1,732	534	2,266	76	104	399	516	448	189	478	56
1976	1,814	702	2,516	82	108	406	524	499	195	537	165
1977	1,868	706	2,574	83	110	431	541	508	195	541	165
1978	2,031	773	2,804	83	118	445	601	550	234	609	165
1979	2,163	792	2,955	83	123	472	632	598	255	627	165
1980	2,257	815	3,073	85	126	499	655	635	257	651	165
1981	2,454	855	3,310	88	128	539	768	673	258	688	168
1982	2,556	893	3,449	88	131	559	822	694	261	725	168
1983	2,686	936	3,622	88	151	580	911	695	261	768	168
1984	2,871	943	3,814	88	169	632	970	727	285	775	168
1985	3,012	948	3,960	86	197	669	1,013	756	292	777	172
1986	3,111	1,016	4,126	86	200	687	1,083	763	292	838	178
1987	3,227	1,044	4,271	86	208	721	1,108	777	327	866	178
1988	3,322	1,085	4,407	92	231	753	1,119	796	332	907	178
1989	3,379	1,133	4,512	93	257	772	1,119	806	332	955	178
1990	3,538	1,134	4,672	93	264	827	1,183	823	347	956	178
1991	3,634	1,133	4,767	95	293	868	1,194	829	354	956	178
1992	3,834	1,147	4,981	95	313	896	1,247	903	380	969	178
1993	3,871	1,153	5,024	89	321	922	1,256	904	380	976	178
1994	3,998	1,209	5,206	83	334	952	1,299	949	379	1,031	178
1995	4,122	1,281	5,403	84	346	985	1,343	979	385	1,031	251
1996	4,293	1,663	5,957	83	352	1,014	1,456	1,002	386	1,176	487
1997	4,402	1,866	6,268	82	354	1,035	1,508	1,021	402	1,371	495
1998	4,527	1,927	6,453	82	344	1,058	1,582	1,048	412	1,432	495
1999	4,745	2,142	6,887	82	339	1,085	1,674	1,127	438	1,611	531
2000	4,865	2,375	7,240	75	343	1,115	1,717	1,156	459	1,755	621

Year	Summary NPS Categories			Detailed NPS Categories (inches)							
	≤10’’	>10’’	Total	2	3	4	5-6	7-8	9-10	11-19	20+
2001	4,983	2,435	7,418	74	337	1,160	1,763	1,177	472	1,796	640
2002	5,137	2,523	7,660	72	340	1,188	1,803	1,265	471	1,883	640
2003	5,087	2,804	7,890	69	323	1,164	1,791	1,273	467	2,128	676
2004	5,160	3,371	8,531	68	321	1,164	1,820	1,305	482	2,309	1,062
2005	5,270	3,491	8,761	67	304	1,163	1,877	1,351	507	2,383	1,108
2006	5,427	3,661	9,088	68	306	1,175	1,926	1,429	524	2,473	1,188
2007	5,415	3,711	9,126	68	304	1,242	1,912	1,369	520	2,479	1,232
2008	5,529	3,885	9,414	64	303	1,228	1,933	1,438	562	2,598	1,287
2009	5,519	3,967	9,485	62	297	1,178	1,943	1,453	586	2,680	1,287
2010	5,520	3,916	9,436	67	267	1,170	1,945	1,487	583	2,629	1,287
2011	5,618	4,001	9,619	65	279	1,226	1,990	1,475	582	2,714	1,287
2012	5,673	3,924	9,597	65	261	1,218	2,042	1,497	590	2,637	1,287
2013	5,650	4,006	9,656	59	234	1,195	2,067	1,502	593	2,681	1,325
2014	5,729	4,364	10,093	59	225	1,156	2,149	1,524	616	2,903	1,461
2015	5,782	4,395	10,177	58	225	1,122	2,143	1,595	639	2,898	1,497
2016	5,663	4,447	10,110	58	221	971	2,073	1,652	687	2,920	1,527
2017	5,459	4,491	9,951	58	217	972	1,875	1,658	679	2,894	1,597
TOTAL mile-yrs	**181,569**	**94,881**	**276,449**	**3,547**	**11,021**	**40,172**	**62,355**	**46,224**	**18,250**	**68,127**	**26,754**
TOTAL km-yrs	**292,206**	**152,695**	**444,901**	**5,708**	**17,737**	**64,651**	**100,350**	**74,390**	**29,370**	**109,639**	**43,056**

Appendix D: OCS Pipeline Spills

Table 17. GOM and PAC OCS pipeline spills ≥ 50 bbls (1972 to 2017)

# *	Bercha Spill #	Year	Water Depth (feet)	NPS	Total Spilled (bbls)	Product Spilled	Cause of Incident	Detailed Cause	Operation	BSEE Spill ID
1	1	1972	140	12	100	Crude Oil	Equipment Failure	Internal Corrosion	Pipeline	0418
2	2	1973	168	16	5000	Crude Oil	Equipment Failure	Internal Corrosion	Pipeline	0594
3	3	1974	240	14	19833	Crude Oil	External Forces, Equipment Failure	Anchor Impact	Pipeline	0729
4	4	1974	246	12	65	Crude Oil	Weather, External Forces, Equipment Failure	Anchor Impact	Pipeline/Barge	0737
5	5	1974	141	8	3500	Crude Oil	Weather, External Forces, Hurricane Carmen	Hurricane	Hurricane	0760
6	6	1976	160	18	414	Crude Oil	External Forces, Equipment Failure	Internal Corrosion	Pipeline	0916
7	7	1976	210	10	4000	Crude Oil	External Forces, Equipment Failure	Fish Net	Pipeline	0979
8	8	1977	105	13	250	Crude Oil	External Forces, Equipment Failure	Mud slide	Pipeline	1005
9	9	1977	247	14	50	Crude Oil	External Forces, Equipment Failure	Anchor Impact	Pipeline/Barge	1014
10	10	1977	210	8	300	Crude Oil	External Forces, Equipment Failure	Anchor Impact	Pipeline	1053
11	11	1978	177	9	135	Crude Oil	Equipment Failure	Connection	Pipeline	1094
12	12	1978	103	9	900	Crude Oil	External Forces, Equipment Failure	Anchor Impact	Pipeline	1128
13	13	1979	300	8	50	Crude Oil	External Forces, Equipment Failure	Workboat Anchor	Pipeline/Vessel	1228
14	14	1980	137	8	100	Condensate	External Forces, Equipment Failure	Fish Net	Pipeline	1295
15	15	1981	54	4	80	Crude Oil	Equipment Failure	External Corrosion	Pipeline	1393
16	16	1981	190	8	5100	Crude Oil	External Forces, Equipment Failure	Workboat Anchor	Pipeline/Vessel	1427
17	17	1983	184	8	80	Crude Oil	Weather, External Forces, Equipment Failure	Mud Slide	Pipeline	1515
18	18	1985	162	13	323	Crude Oil	External Forces, Equipment Failure	Anchor Impact	Pipeline	1688
19	19	1985	17	12	200	Crude Oil	External Forces, Equipment Failure	Third Party Spud Barge	Pipeline/Barge	1755
20	20	1986	27	6	119	Crude Oil	Equipment Failure	Unknown	Pipeline	1773
21	21	1986	300	8	210	Crude Oil	External Forces, Equipment Failure	Material	Pipeline	1819
22	22	1988	75	14	15576	Crude Oil	Weather, Human Error, External Forces, Equipment Failure	Anchor Impact	Pipeline/Vessel	1868
23	23	1990	197	4	14423	Condensate	External Forces, Equipment Failure	Fish Net	Pipeline	1934
24	24	1990	230	8	4569	Crude Oil	External Forces, Equipment Failure	Fish Net	Pipeline	1950
25	-	1990	Unk.	Unk.	100	Crude Oil	Unknown	Unknown	Pipeline	NA
26	25	1991	90	11	50	Crude Oil	Weather, External Forces, Equipment Failure	Rig Anchor	Pipeline/Vessel	1989
27	26	1992	90	12	190	Crude Oil	Equipment Failure	Unknown	Pipeline	2022

# *	Bercha Spill #	Year	Water Depth (feet)	NPS	Total Spilled (bbls)	Product Spilled	Cause of Incident	Detailed Cause	Operation	BSEE Spill ID
28	27	1992	30	20	2000	Crude Oil	Weather, External Forces, Equipment Failure, Human Error, Hurricane Andrew	Anchor Impact	Hurricane	2046
29	28	1993	116	4	50	Crude Oil	External Forces, Equipment Failure	Workboat Anchor	Pipeline/Vessel	2059
30	29	1994	197	4	4533	Condensate	External Forces, Equipment Failure	Fish Net	Pipeline	2105
31	30	1996	1075	20	150	Crude Oil	Equipment Failure, Human Error	Connection	Pipeline	2160
32	32	1998	150	14	800	Crude Oil	External Forces, Equipment Failure	Anchor Impact	Pipeline	2253
33	33	1998	264	16	1211	Condensate	Human Error, External Forces, Equipment Failure	Anchor Impact	Pipeline/Vessel	2255
34	35	1998	108	10	8212	Crude Oil	Weather, External Forces, Human Error, Equipment Failure, Hurricane Georges	Mud slide	Hurricane	2300
35	-	1998	170	8	738	Crude Oil	Equipment Failure, External Forces	Third Party Vessel	Pipeline	NA
36	36	1999	133	12	3200	Crude Oil	External Forces, Human Error	Third Party Jackup	Pipeline	2346
37	37	2000	435	24	2240	Crude Oil	External Forces, Human Error, Equipment Failure	Anchor Impact	Pipeline	2379
38	39	2004	479	6	1720	Crude Oil	Weather, External Forces, Hurricane Ivan	Hurricane	Hurricane	2704
39	40	2004	200	18	671	Crude Oil	Weather, External Forces, Hurricane Ivan	Hurricane	Hurricane	2667
40	41	2004	305	6	126	Crude Oil	Weather, External Forces, Hurricane Ivan	Hurricane	Hurricane	2696
41	42	2004	244	8	200	Crude Oil	Weather, External Forces, Hurricane Ivan	Hurricane	Hurricane	2698
42	43	2004	255	6	250	Crude Oil	Weather, External Forces, Hurricane Ivan	Hurricane	Hurricane	2701
43	44	2004	255	8	260	Crude Oil	Weather, External Forces, Hurricane Ivan	Hurricane	Hurricane	2700
44	45	2004	185	8	95	Crude Oil	Weather, External Forces, Hurricane Ivan	Unknown	Hurricane	2709
45	46	2004	300	10	123	Crude Oil	Weather, External Forces, Hurricane Ivan	Hurricane	Hurricane	2710
46	48	2005	1100	8	960	Crude Oil	Weather, External Forces, Hurricane Katrina	Hurricane	Hurricane	2835
47	49	2005	340	8	50	Crude Oil	Weather, External Forces, Hurricane Katrina	Hurricane	Hurricane	2789
48	50	2005	240	10	55	Crude Oil	Weather, External Forces, Hurricane Katrina	Hurricane	Hurricane	2794
49	51	2005	216	10	132	Crude Oil	Weather, External Forces, Hurricane Katrina	Hurricane	Hurricane	2787
50	52	2005	48	8	50	Condensate	Weather, External Forces, Hurricane Katrina	Hurricane	Hurricane	2802
51	53	2005	180	4	75	Crude Oil	Weather, External Forces, Hurricane Rita	Hurricane	Hurricane	2880
52	54	2005	17	14	100	Condensate	Weather, External Forces, Hurricane Rita	Hurricane	Hurricane	2845
53	55	2005	141	8	862	Crude Oil	Weather, External Forces, Hurricane Rita	Hurricane	Hurricane	2894
54	56	2005	152	12	67	Crude Oil	Weather, External Forces, Hurricane Rita	Hurricane	Hurricane	2897
55	57	2005	210	6	108	Crude Oil	Weather, External Forces, Hurricane Rita	Hurricane	Hurricane	2900
56	-	2005	322	8	99	Crude Oil	Weather, External Forces, Hurricane Katrina	Hurricane	Pipeline	NA

# *	Bercha Spill #	Year	Water Depth (feet)	NPS	Total Spilled (bbls)	Product Spilled	Cause of Incident	Detailed Cause	Operation	BSEE Spill ID
57	58	2006	126	14	870	Crude Oil	External Forces, Human Error, Equipment Failure	Anchor Impact	Pipeline	2976
58	59	2007	420	4	188	Crude Oil	Human Error	Unknown	Pipeline	3034
59	60	2008	46	8	69	Crude Oil	Weather, External Forces, Hurricane Ike	Hurricane	Hurricane	3231
60	61	2008	50	6	108	Condensate	Weather, External Forces, Hurricane Ike	Hurricane	Hurricane	3232
61	62	2008	105	6	56	Crude Oil	Weather, External Forces, Hurricane Ike	Hurricane	Hurricane	3260
62	63	2008	150	42	1316	Condensate	Weather, External Forces, Hurricane Ike	Hurricane	Hurricane	3255
63	64	2008	324	4	209	Crude Oil	Weather, External Forces, Hurricane Ike	Hurricane	Hurricane	3237
64	65	2008	324	8	268	Condensate	Weather, External Forces, Hurricane Ike	Hurricane	Hurricane	3236
65	66	2009	50	20	1500	Crude Oil	Equipment Failure	Unknown	Pipeline	3387
66	-	2011	Unk.	Unk.	400	Diesel	Equipment Failure	Unknown	Pipeline	NA
67	-	2013	Unk.	10	113	Crude Oil	Equipment Failure	Unknown	Pipeline	NA
68	-	2013	Unk.	Unk.	102	Crude Oil	Equipment Failure	Unknown	Pipeline	NA
69	-	2016	2900	Unk.	2100	Crude Oil	Unknown	Unknown	Pipeline	NA
70	-	2017	4463	Unk.	16152	Crude Oil	Unknown	Unknown	Pipeline	NA

* This list only includes spills within the scope of the analysis described within this report. Spills from facility types, volume categories, fluid types, and geographic areas outside of this scope are excluded. Some years do not include any spills within the scope criteria.

Appendix E: Additional Spill Documents

BOEM provided the following spill reports as part of their data transfer for the development of this report (Crowley, 2017).

20100123-ZnBr2-6bbl_100123-pdf
20100126-SBM-4bbl_100126-pdf
20100306-SBM-21bbl_100306-pdf
20100312-SBM-48bbl_100312-pdf
20100407-SBM-125bbl_100407-pdf
20100514-Oil-14bbl_100514-pdf
20100521-Crude-LT30bbl_100521-pdf
20100729-LiqHC-ukn_100729-pdf
20100914-Oil-LT5bbl_100914-pdf
20100929-OilCond-7bbl_100929-pdf
20101201-SBM-98bbl_101201-pdf
20110106-Oil-12gal_exxonmobil-wd-73a-06-january-2011
20110722-SBM-79bbl_110722-pdf
20110730-Oil-LT231gal_110730
20110917-Cond-1gal_110917-pdf
20111216-SBM-319bbl_12-18-11-shell-mc-348
20120204-SBM-100bbl_sanitized-chevron-wr-29-4-feb-2012
20120210-SBM-44bbl_sanitized-chevron-gc-205-a-10-feb-2012
20120219-CompletionFluid-849bbl_sanitized-anadarko-eb-602-19-feb-2012
20120515-Diesel-5gal_sanitized-mariner-hi-a-7-15-may2012
20120622-Crude-35bbl_houchinreport6-22-2012
20120708-Oil-16bbl_ankor-ss-229-a-7-jul-2012
20120817-unk-unk_ew-921-eni-17-august-2012
20120904-Cond-LT1gal_wd-70-gom-shelf-4-september-2012
20120926-Oil-69gal_ss-233-b-w-t-offshore-26-sep-2012
20120927-Oil-9gal_hi-a443-black-elk-27-sep-2012
20121124-SBM-14bbl_kc-875-anadarko-24-november-2012
20121208-SBM-31bbl_gb-386-hess-8-december-2012-1
20130117-SBM-91bbl_hi-a-119-bp-17-jan-2013
20130303-Oil-13gal_vk-817-flextrend-03-mar-2013
20130403-CaBrZnBr-938bbl_gc-683-anadarko-03-april-2013
20130419-SBM-50bbl_kc-93-bp-19-apr-2013
20130516-SBM-21bbl_mc-762-shell-16-may-2013
20130518-Oil-3bbl_sp-60f-ankor-energy-18-may-2013
20130603-Oil-LT1gal_mc-243-w-t-offshore-03-jun-2013
20130707-HC-unk_ss-225b-energy-resource-tech-07-jul-2013
20130720-SBM-66bbl_mc-778-bp-20-jul-2013
20131213-AviatFuel-390gal_gb-189-a-chevron-usa-inc-13-dec-2013
20140211-Mud-144bbl_ac-857a-shell-offshore-11-feb-2014
20140212-SBM-128bbl_mc-29-stone-energy-12-feb-2014
20140325-SBM-42bbl_mc-503-llog-25-mar-2014
20140523-SBM-61bbl_gb-213-apache-deepwater-23-may-2014
20140830-SBM-12bbl_kc-829-chevron-30-aug-2014
20140924-SBM-150bbl_gc-155-marubeni-oil-and-gas-24-sep-2014
20141016-SBM-150bbl_gc-237-ert-16-oct-2014

20141113-ZnBr-66bbl_vr-342-arena-offshore-13-nov-2014
20141203-Cond-LT1bbl_sm-27-sea-robin-pipeline-5-dec-2014
20141211-SBM-142bbl_wr-508-shell-11-dec-2014
20150213-SBM-260bbl_mc-726-hess-13-feb-2015
20150216-Methanol-438bbl_mc-941a-bennu-oil-and-gas-16-feb-2015-sanitized
20150323-SBM-2200bbl_gb-958-cobalt-rowan-reliance-23-mar-2015
20150401-SBM-unk_kc-147-bp-01-apr-2015
20150619-Oil-LT1gal_vr-279a-w-and-t-offshore-19-jun-2015
20150620-SBM-12bbl_mc-772-eni-20-jun-2015
20150702-SBM-368_mc-126-freeport-mcmoran-02-jul-2015
20150808-SBM-6bblTotal_wr51-anadarko-08aug2015
20150921-MethanolHW525-41bbl_eb-643-anadarko-21-sep-2015
20151016-Oil-25bbl_gc-338a-murphy-exploration-and-production-16-oct-2015
20160217-ZnBr2-22bbl_gb_216_hess_corporation_17_feb_2016
20160303-BaseOil-10bbl_mc_778_bp_exploration_03_mar_2016
20160527-Methanol-46bbl_ac_857_shell_offshore_25_may_2016
20160921-Oil-8bbl_wd-32-energy-xxi-21-sep-2016
20161106-SBM-12bbl_mc-778-bp-exploration-06-nov-2016
20170607-SBM-94bbl_gb-427-shell-offshore-7-jun-2017
20170627-SBM-29bbl_wr-778-chevron-27-jun-2017
20170913-SBM-71bbl_gc-782-bp-exploration-13-sep-2017

Department of the Interior (DOI)
The Department of the Interior protects and manages the Nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors the Nation's trust responsibilities or special commitments to American Indians, Alaska Natives, and affiliated island communities.

Bureau of Ocean Energy Management (BOEM)
The mission of the Bureau of Ocean Energy Management is to manage development of U.S. Outer Continental Shelf energy and mineral resources in an environmentally and economically responsible way.

BOEM Environmental Studies Program
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