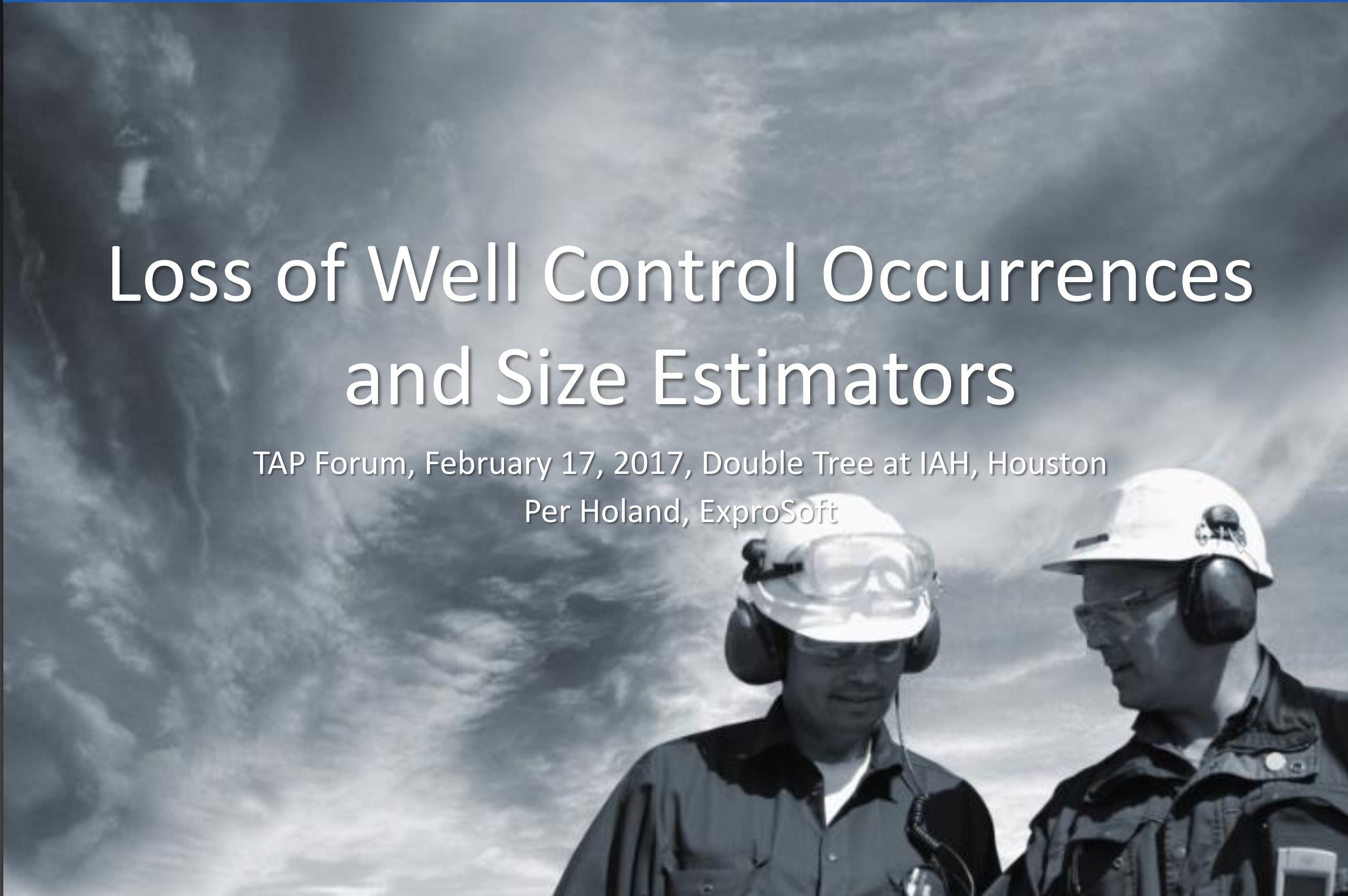


Loss of Well Control Occurrences and Size Estimators

TAP Forum, February 17, 2017, Double Tree at IAH, Houston

Per Holand, ExproSoft

LOWC definition

BSEE definition for *Loss of Well Control*:

- Uncontrolled flow of formation or other fluids. The flow may be to an exposed formation (an underground blowout) or at the surface (a surface blowout).
- Flow through a diverter
- Uncontrolled flow resulting from a failure of surface equipment or procedures

SINTEF Offshore Blowout Database LOWC Categories

Category	Sub category
Blowout (surface flow)	Totally uncontrolled flow, from a deep zone
	Totally uncontrolled flow, from a shallow zone
	Shallow gas “controlled” subsea release only
Blowout (underground flow)	Underground flow only
	Underground flow mainly, limited surface flow
Well release	Limited surface flow before the secondary barrier was activated
	Tubing blown out of well, then the secondary barrier is activated
Diverted well release	Shallow gas controlled flow (diverted)

LOWC overview

- *Loss of Well Control* (LOWC) events from 2000 – 2014

Area		Development drilling	Exploration drilling	Unknown drilling	Com-pletion	Work-over	Aband-oned well	Total
US GoM OCS		16	24		3	21	2	66
		24.2 %	36.4 %		4.5 %	31.8 %	3.0 %	
Regulated areas	UK, Norway	3	3		5	5	1	17
		17.6 %	17.6 %		29.4 %	29.4 %	5.9 %	
	Other “regulated areas” *)	2	3			3		8
		25.0 %	37.5 %			37.5 %		
Rest of the World		9	5	4	2	4	2	26
		34.6 %	19.2 %	15.4 %	7.7 %	15.4 %	7.7 %	
Total		30	35	4	10	33	5	117
		25.6 %	29.9 %	3.4 %	8.5 %	28.2 %	4.3 %	

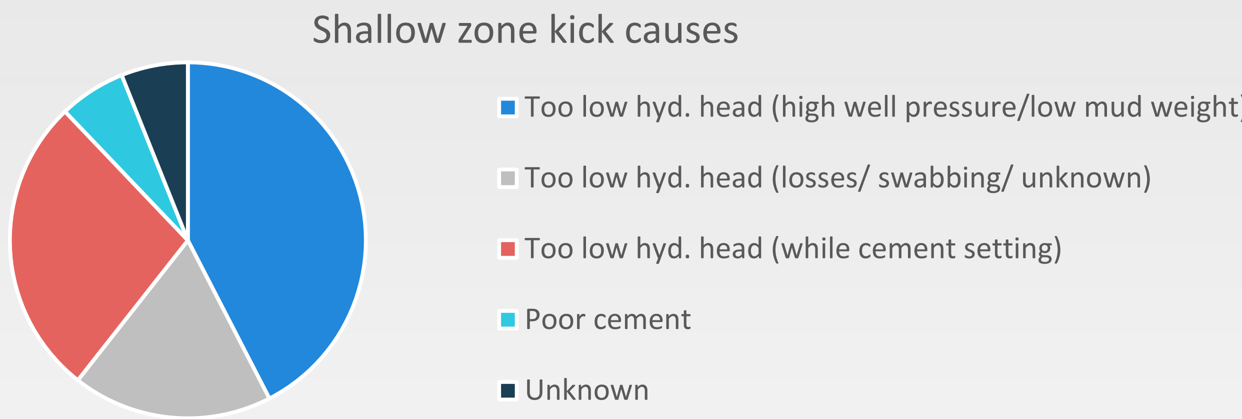
*)Netherlands, Canada East Coast, Australia, US Pacific OCS, Denmark, Brazil

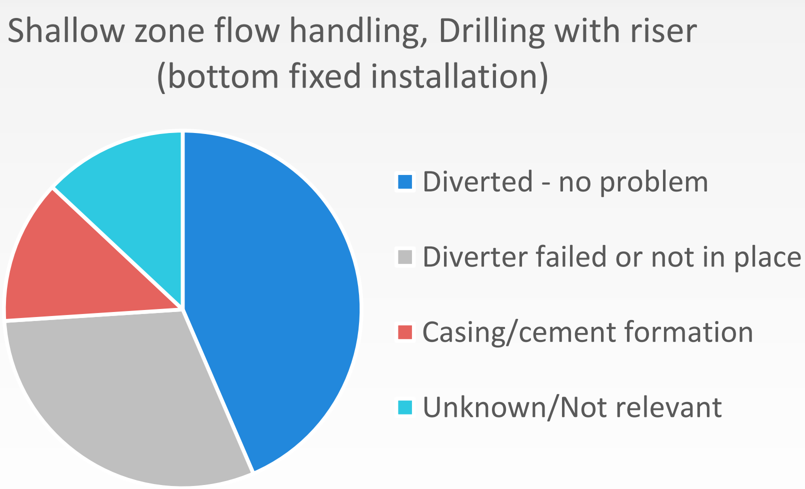
- Production and pure wireline operations not included

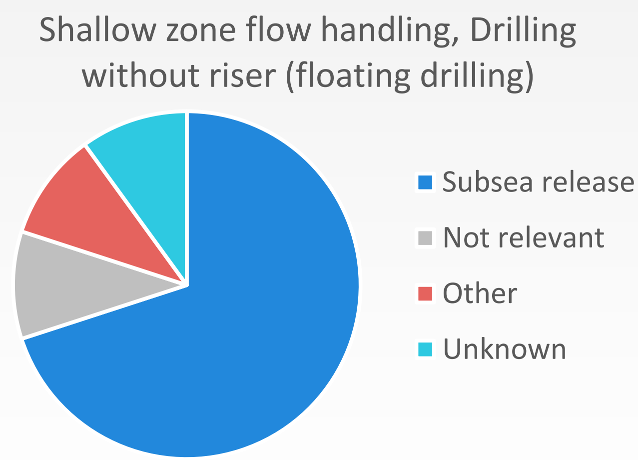
LOWC categories in US GoM OCS and “Regulated area”

Main category	Deep zone LOWCs			Shallow zone LOWCs			Total
	Regulated area	US GoM OCS	Total	Regulated area	US GoM OCS	Total	
Blowout (surface flow)	6	21	27	3	12	15	42
Blowout (underground flow)	1	3	4				4
Diverted well release		2	2	2	8	10	12
Well release	13	18	31		2	2	33
Total	20	44	64	5	22	27	91

LOWC causes, shallow drilling (before landing BOP)



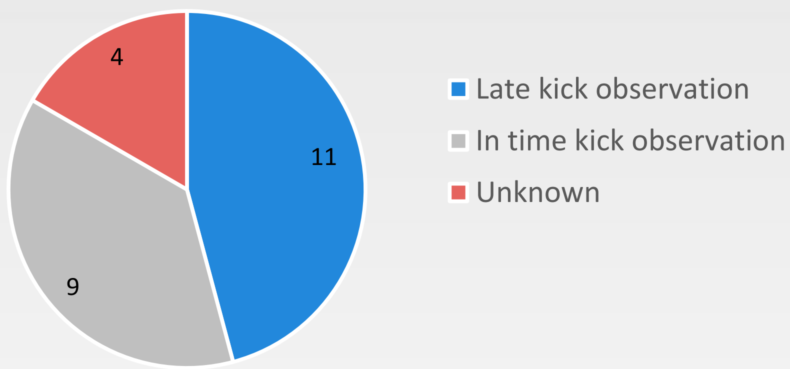




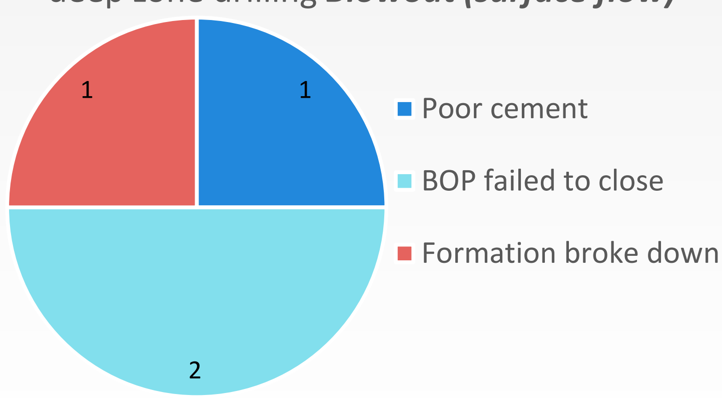
WELLMASTER
FOR INCREASED UPTIME

LOWC causes, deep drilling (after BOP landed)

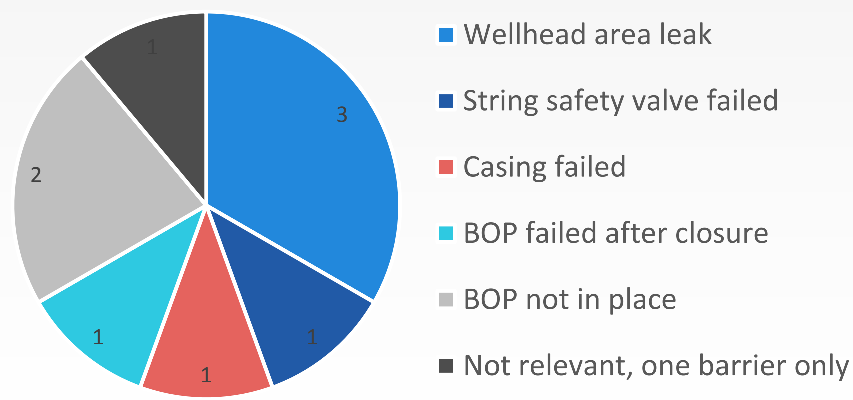
Kick observation, deep zone drilling LOWCs



Floating vessel, secondary barrier failure in deep zone drilling ***Blowout (surface flow)***

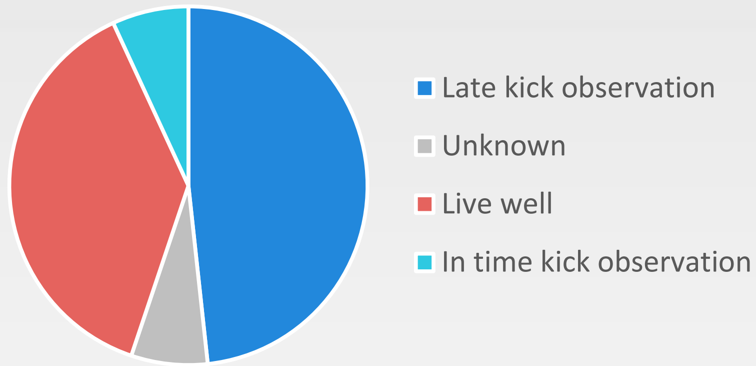


Bottom fixed installation, secondary barrier failure in deep drilling ***Blowout (surface flow)***

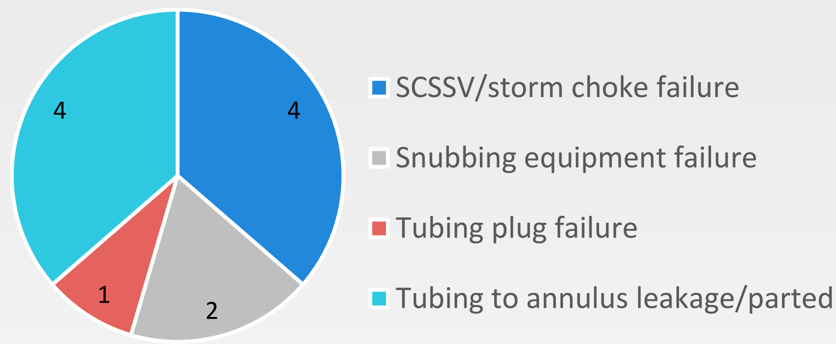


LOWC causes, workovers

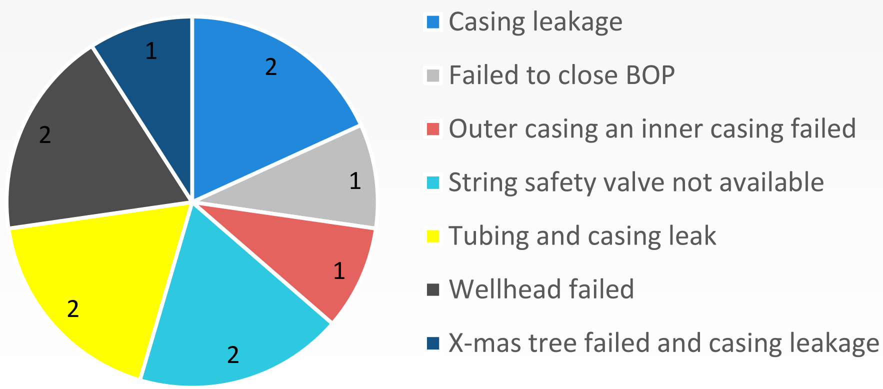
Workover LOWC observation



Loss of primary barrier for workover LOWCs in ***live wells***

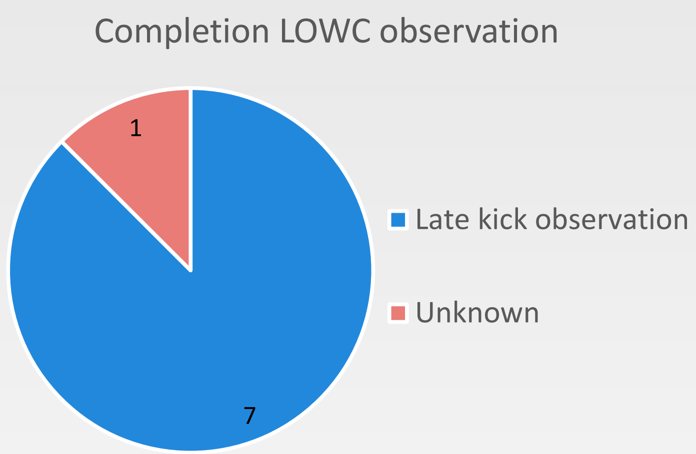


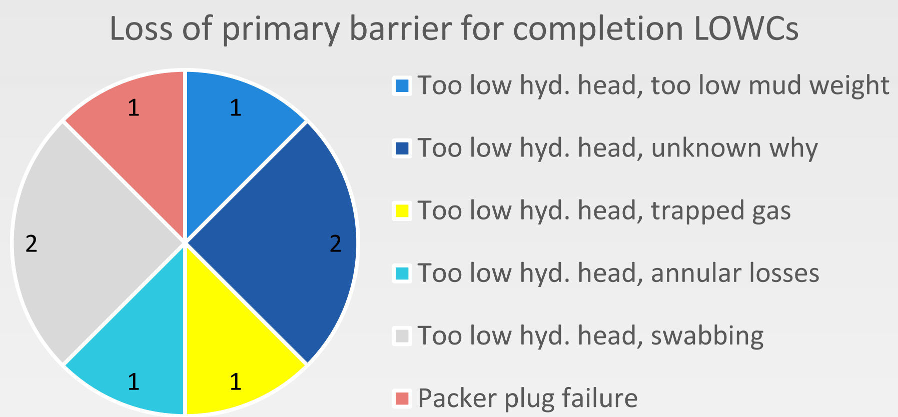
Loss of secondary barriers in workover ***Blowout (surface flow)***

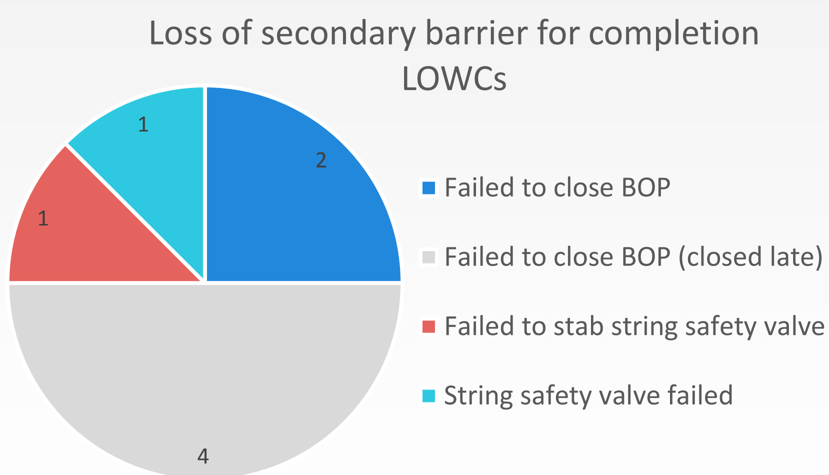


Four of the 11 *blowout (surface flow)* and four of the *well releases* were in wells that should be permanently abandoned. Many of them had been temporary abandoned or closed in for many years

LOWC causes, completions

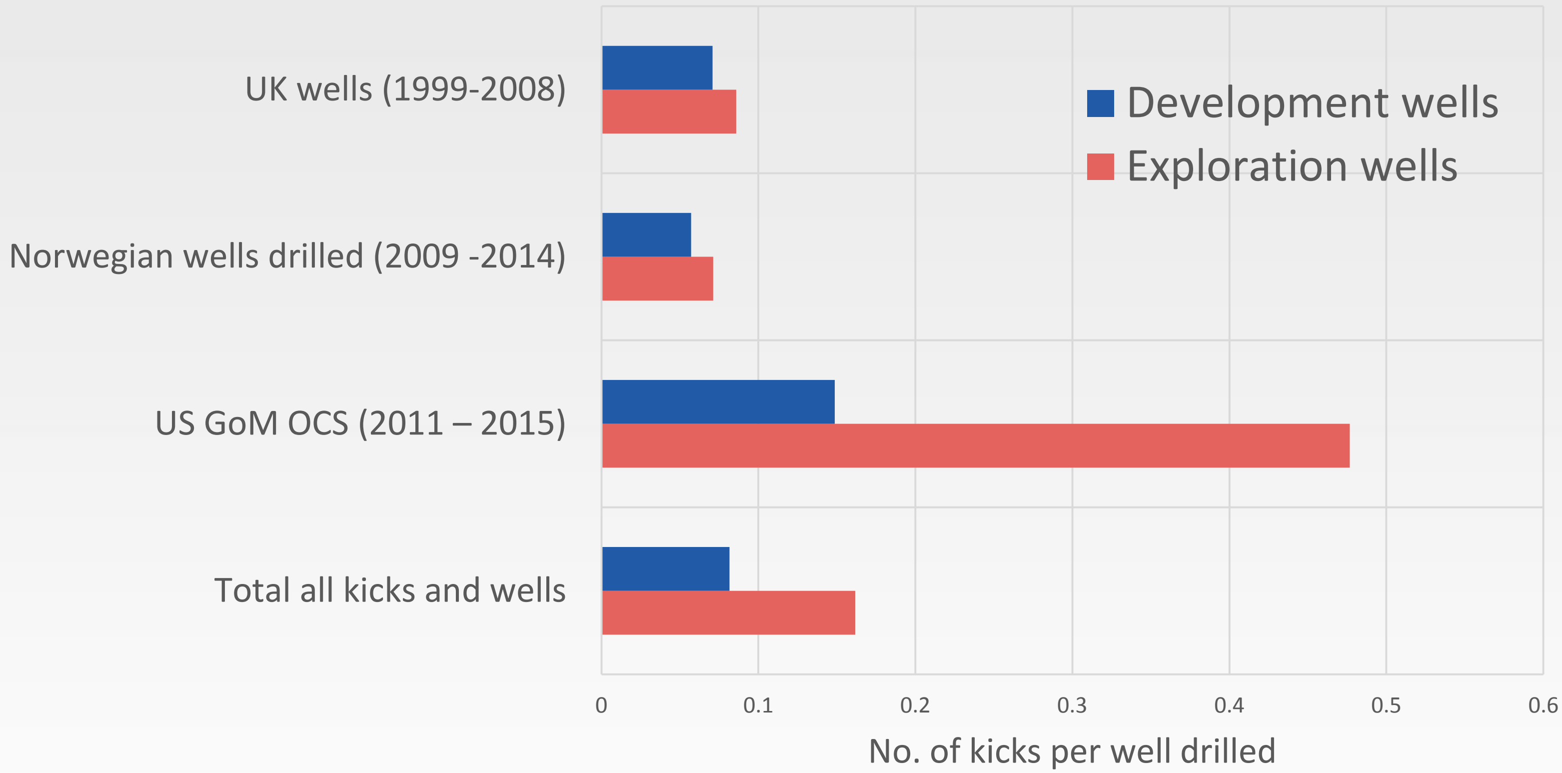






For the two *Blowout (surface blowout)* LOWCs the BOP failed to close

Kick frequencies



The US GoM OCS 2011–2015 kick frequency is significantly higher than the most recent statistics from Norway and the UK

LOWC Frequencies comparison, 2000–2014

Type of drilling	Regulated area			US GoM OCS			US GoM OCS vs. Regulated areas
	No. of LOWCs	No. of wells drilled	LOWC frequency per 1,000 wells drilled	No. of LOWCs	No. of wells drilled	LOWC frequency per 1,000 wells drilled	
Exploration drilling							
Deep	4	3,600	1.11	14	3,869	3.62	3,3
Shallow	2		0.56	10		2.58	4,7
Total	6		1.67	24		6.20	3,7
Development drilling							
Deep	2	7,796	0.26	4	6,180	0.65	2,5
Shallow	3		0.38	12		1.94	5,1
Total	5		0.64	16		2.59	4,0

LOWC Frequencies comparison, 2000–2014

Workover	UK & Norwegian waters			US GoM OCS			US GoM OCS vs. Norway and UK
	No. of LOWCs	Number of well years in service	LOWC frequency per 10,000 well years in service	No. of LOWCs	Number of well years in service	LOWC frequency per 10,000 well years in service	
Total	5	44,579	1.12	21	74,463	2.82	2,5

Completion	UK & Norwegian waters			US GoM OCS			US GoM OCS vs. Norway and UK
	No. of LOWCs	Number of well completions	Frequency per 1,000 wells completed	No. of LOWCs	Number of well completions	Frequency per 1,000 wells completed	
Total	5	4,985	1.00	3	4,916	0.61	0,6

Fatalities in LOWC events, worldwide 2000 - 2014

Country	Sum of Fatalities in LOWCs			
	Development drilling	Exploration drilling	Workover	Total
Nigeria		2		2
US GoM State water	1			1
US GoM OCS		12	1	13
Total	1	14	1	16

- In the US GoM OCS one LOWC event caused 11 fatalities (Deepwater Horizon) and two LOWC events caused one fatality.
- One incident in Nigeria caused two fatalities

(Note; Production incidents not included)

Pollution from LOWC Events, US GoM and "regulated" areas, 2000 - 2014

Major pollution incidents, all drilling

- 2009 – Australia, Montara: A total volume of **29,600 barrels**, or 400 barrels per day.
- 2010 – USA, Macondo: 50,000 barrels a day in 85 days, **4,250,000 barrels**
- 2011 – Brazil, Frade field: 600 barrels per day or **3,700 barrels** in total.

Other,

- One drilling LOWC event in 2000 caused a release of 150–200 barrels of crude oil
- One abandoned well spilled 62 barrels before being controlled in 2010.
- Some workover and completion LOWC events were listed with minor pollution.

- In the period 1980–1999, none of the LOWC events in the US GoM OCS, Norway, or UK caused a large pollution incident.

(Note; Production incidents not included)

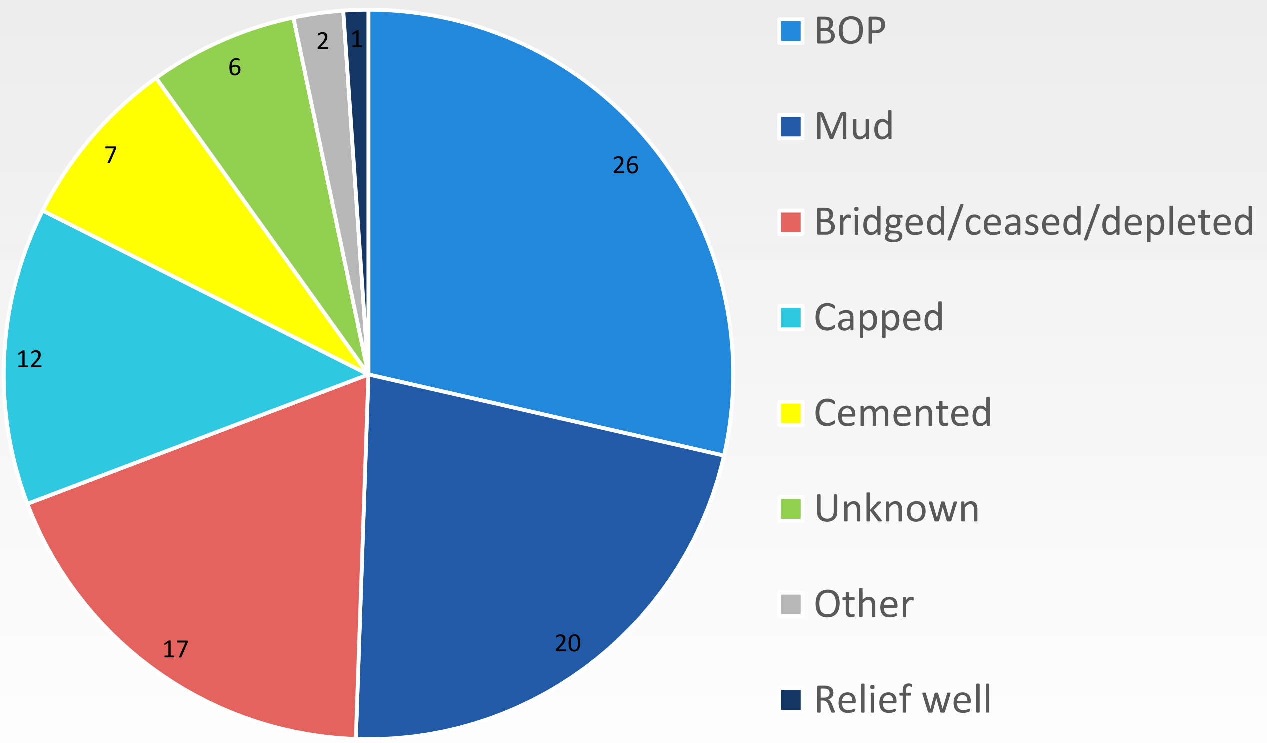
Ignition of LOWCs, US GoM and "regulated" areas, 2000 - 2014

Main category	Ignition time grouped	Dev. Drilling		Expl. drilling		Compl-etion	Work-over	Abando-ned well	Total	Distri-bution %
		Deep	Shallow	Deep	Shallow					
Blowout (surface flow)	Immediate ignition			2					2	4.8 %
	Delayed ignition	1	2			1			4	9.5 %
	No ignition	2	7	8	6	1	11	1	36	85.7 %
	Total	3	9	10	6	2	11	1	42	100.0 %
Blowout (underground flow)	No ignition	1		3					4	100.0 %
	Total	1		3					4	100.0 %
Diverted well release	No ignition		6	1	4	1			12	100.0 %
	Total		6	1	4	1			12	100.0 %
Well release	Immediate ignition			1			1		2	6.1 %
	No ignition	2		3	2	5	17	2	31	93.9 %
	Total	2		4	2	5	18	2	33	100.0 %
Total all		6	15	18	12	8	29	3	91	

- Eight (8.8%) of the 91 LOWC events ignited

Control of LOWCs

How flow from LOWCs were stopped, “regulated” areas
incl US GoM OCS 2000-2014



Predicted US GoM OCS 2017 - 2021, based on 2014 activity level

Activity type	Exposure data 5 year period	RISK RESULTS							
		No. of LOWCs to expect	No. of ignited events to expect	No. of fatalities to expect	Material damages				Large spill probability*
					Total Loss	Severe	Damage	Small/no	
Exploration drilling from bottom fixed installation	210 wells drilled	1.25	0.115	0.230	0.058	0.019	0.038	1.139	0.044
Exploration drilling from floating vessel	325 wells drilled	2.13	0.172	0.317	0.076	0.038	0.051	1.967	0.052
Development drilling floating or bottom fixed installation	1,115 wells drilled	2.89	0.239	0.469	0.116	0.044	0.077	2.651	0.029
Workover	18,080 well years in service	5.10	0.450	0.713	0.156	0.140	0.104	4.698	0.042
Completion	815 wells completed	0.50	0.031	0.052	0.012	0.009	0.008	0.469	0.007
Total all		11.87	1.007	1.782	0.418	0.251	0.278	10.923	0.173

* A large spill includes spills with a total release above 500 barrels.

Risk reduction

- **Reduce the kick frequency**, US GoM OCS kick frequency is high compared to UK and Norwegian kick frequencies
- **Improve kick detection**. For a large proportion of the serious LOWCs in drilling, completion, and workover operations the kick is not observed before the well is flowing to the surroundings
- Be prepared that the barrier situation in a well that shall be worked over may be different than expected