Loss of well control occurrences in offshore operations, 2000 – 2015

Based on BSEE study TAP 765

https://www.bsee.gov/sites/bsee.gov/files/tap-technical-assessment-program/765aa.pdf

Per Holand, ExproSoft

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 – 2015

Area		Dev. drilling	Expl. Drilling	Unk. Drilling	Compl-etion	Work-over	Production		Wire-line	Aband-oned well	Un-known	Total
							External cause*	No ext. cause*				
US GOM OCS		16	24		3	21	5	7	3	3		82
		19.5 %	29.3 %		3.7 %	25.6 %	6.1 %	8.5 %	3.7 %	3.7 %		
Regu-lated areas	UK & Norwegian waters	4	3		5	5		3	4	1	1	26
		15.4 %	11.5 %		19.2 %	19.2 %		11.5 %	15.4 %	3.8 %	3.8 %	
	Netherlands, Canada East Coast, Australia, US Pacific OCS, Denmark, Brazil	2	3			3					1	9
		22.2 %	33.3 %			33.3 %					11.1 %	
Rest of the world		9	5	4	2	4	7	4		2	2	39
		23.1 %	12.8 %	10.3 %	5.1 %	10.3 %	17.9 %	10.3 %		5.1 %	5.1 %	
Total		**31**	**35**	**4**	**10**	**33**	**12**	**14**	**7**	**6**	**4**	**156**
		19.9 %	22.4 %	2.6 %	6.4 %	21.2 %	7.7 %	9.0 %	4.5 %	3.8 %	2.6 %	

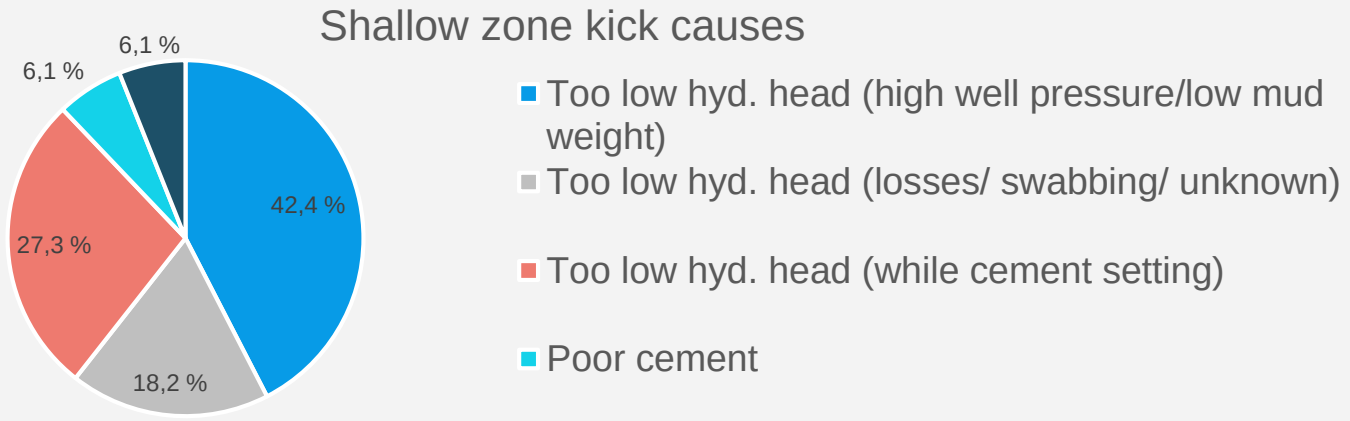
* *External causes are typical; storm, military activity, ship collision, fire and earthquake.*

LOWC categories in US GoM OCS and “Regulated area”

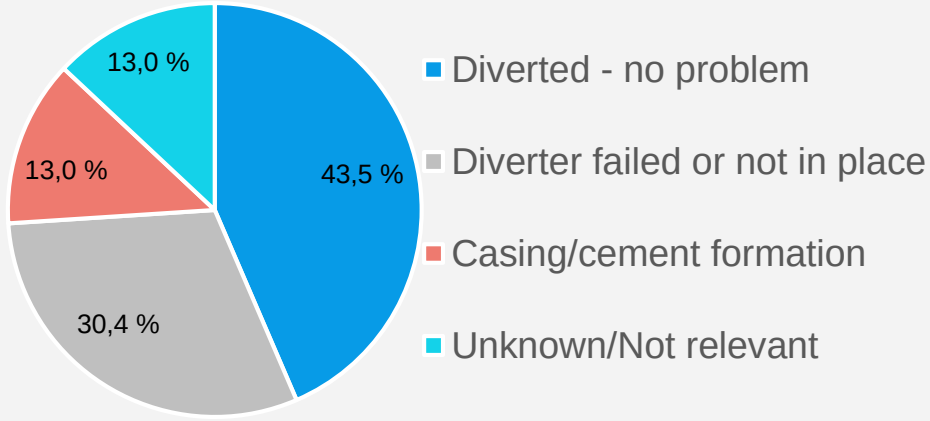
Main category	Deep zone LOWCs			Shallow zone LOWCs			Total
	Regulated area	US GoM OCS	Total	Regulated area	US GoM OCS	Total	
Blowout (surface flow)	8	30	38	4	12	16	**54**
Blowout (underground flow)	1	3	4				**4**
Diverted well release		2	2	2	8	10	**12**
Well release	20	25	45		2	2	**47**
Total	**29**	**60**	**89**	**6**	**22**	**28**	**117**

Regulated areas:
UK, Norway, Netherlands, Canada East Coast, Australia, US Pacific OCS, Denmark, Brazil

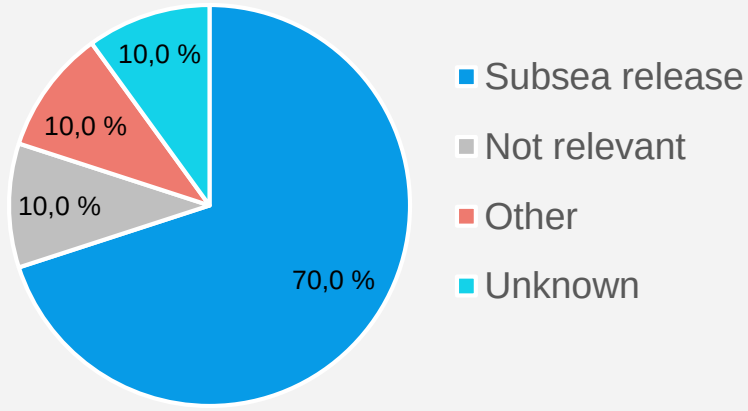
LOWC causes, shallow drilling (before landing BOP)



Shallow zone flow handling, Drilling with riser (**bottom fixed installation**)

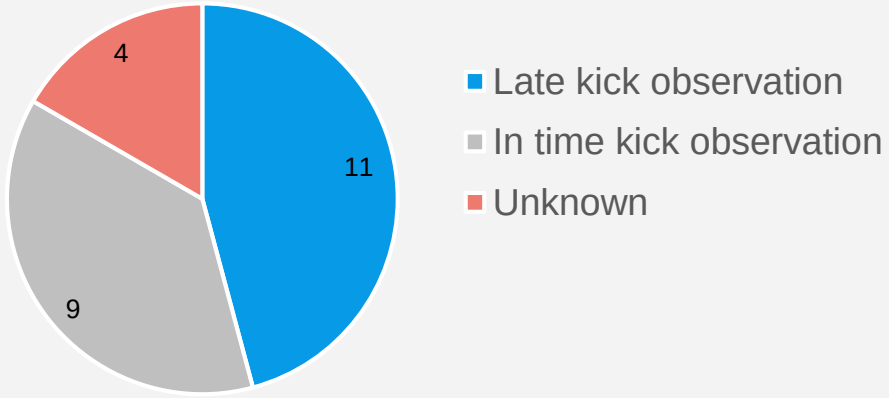


Shallow zone flow handling, Drilling without riser (**floating drilling**)

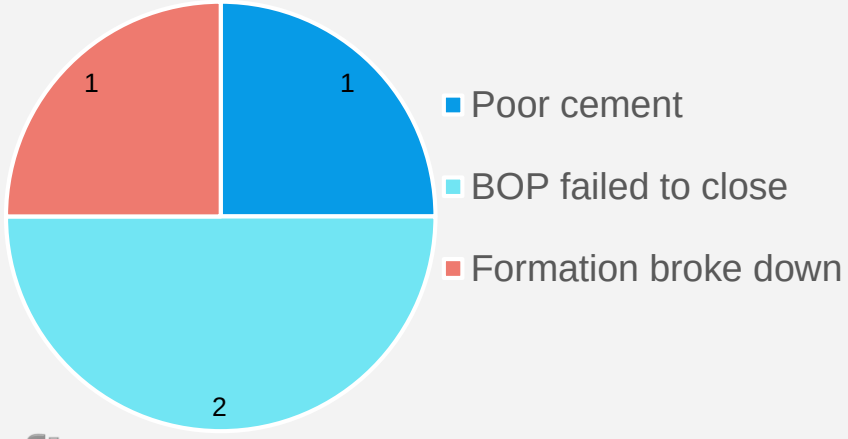


LOWC causes, deep drilling (after BOP landed)

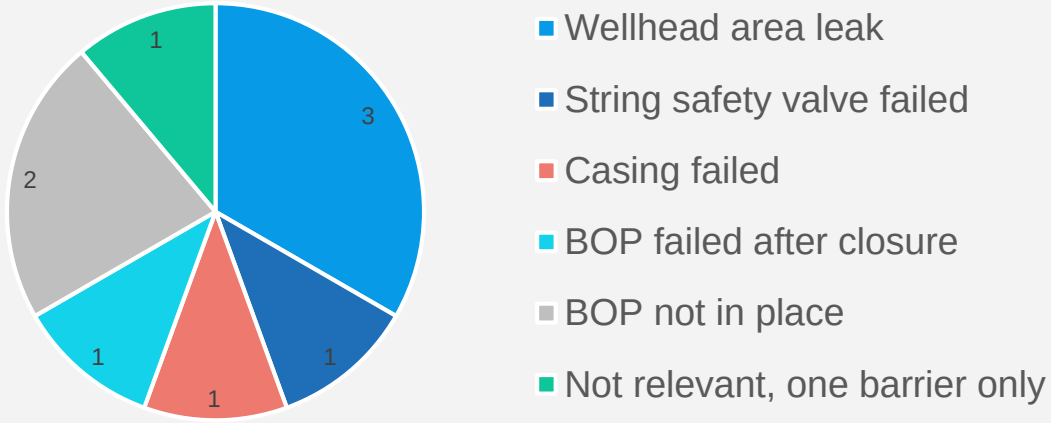
Kick observation, deep zone **all drilling**
LOWCs



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

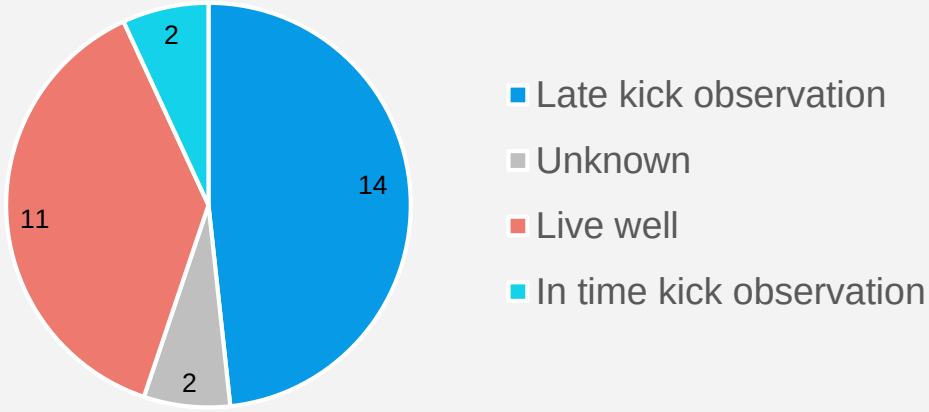


Bottom fixed installation, secondary barrier failure in deep drilling ***Blowout (surface flow)***

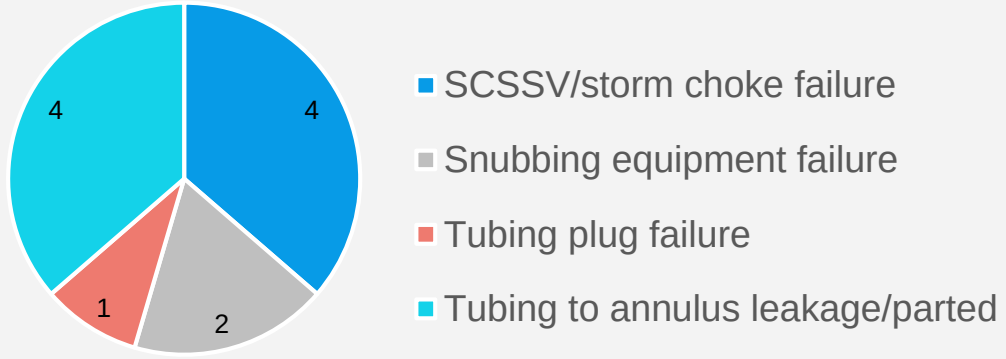


LOWC causes, workovers

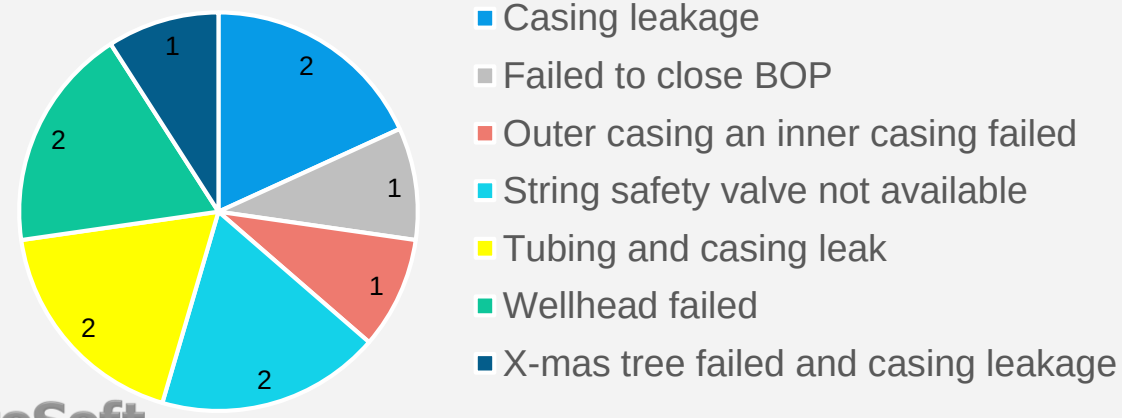
Workover LOWC observation



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



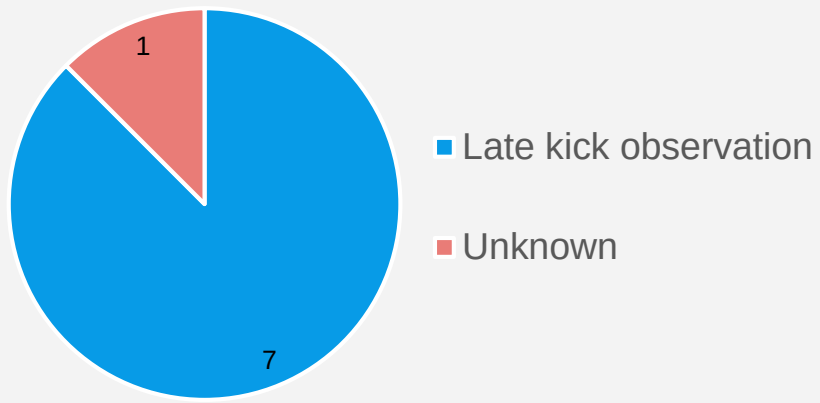
Loss of secondary barriers in workover ***Blowout (surface flow)***



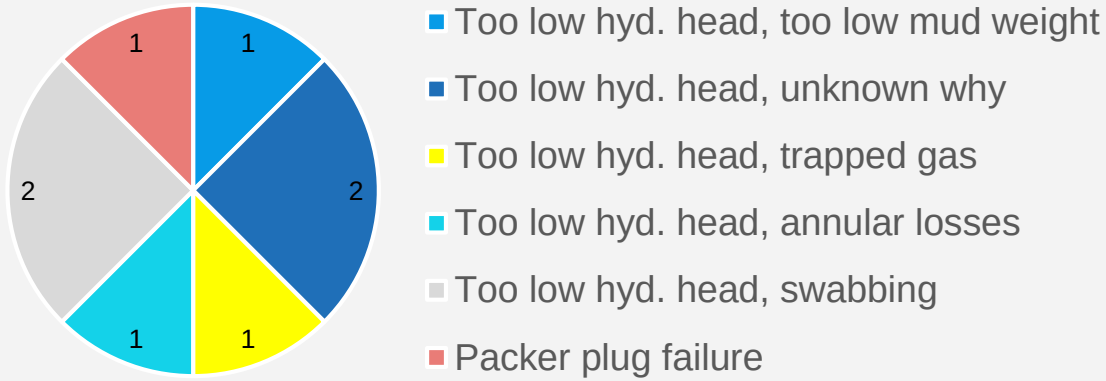
4 of the 11 *blowout (surface flow)* and 4 of the *well releases* were in wells that should be permanently abandoned. Many of them had been suspended/closed in for many years

LOWC causes, completions

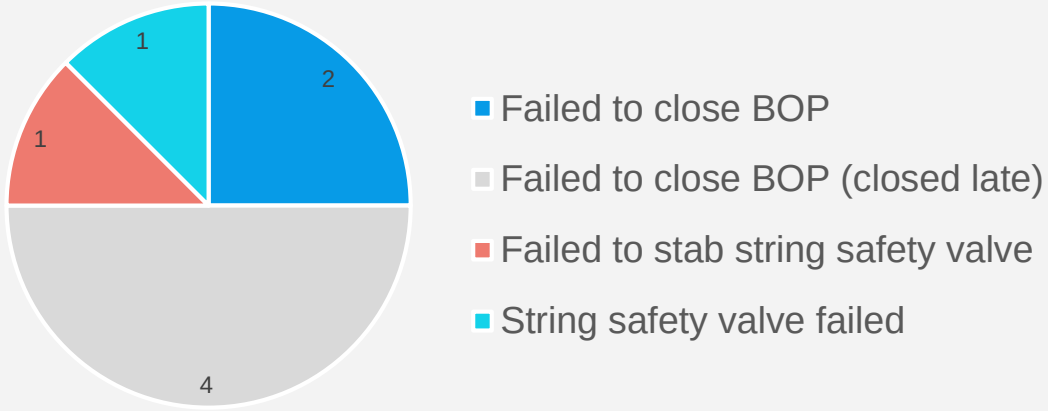
Completion LOWC observation



Loss of primary barrier for completion LOWCs



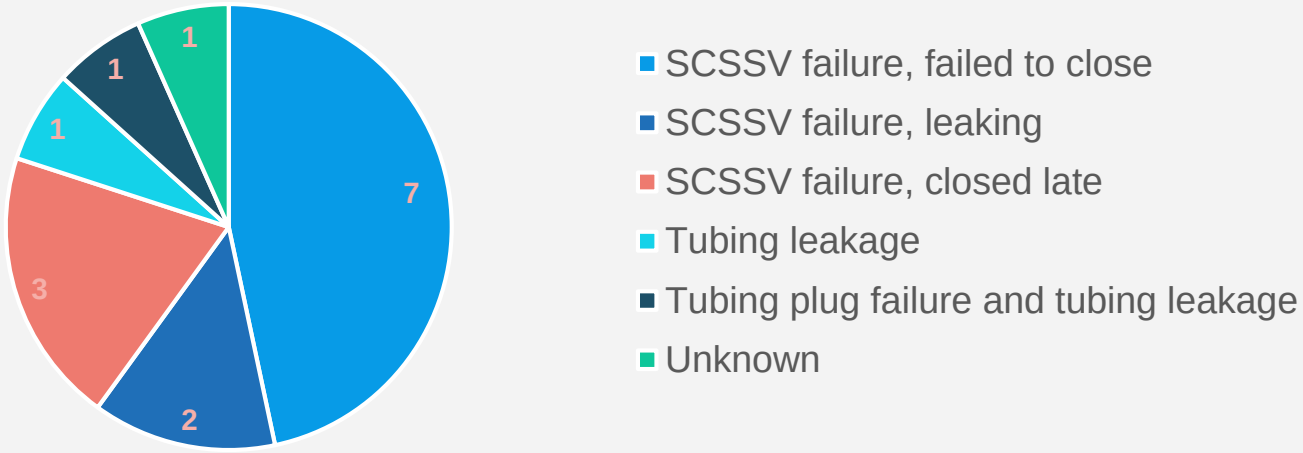
Loss of secondary barrier for completion LOWCs



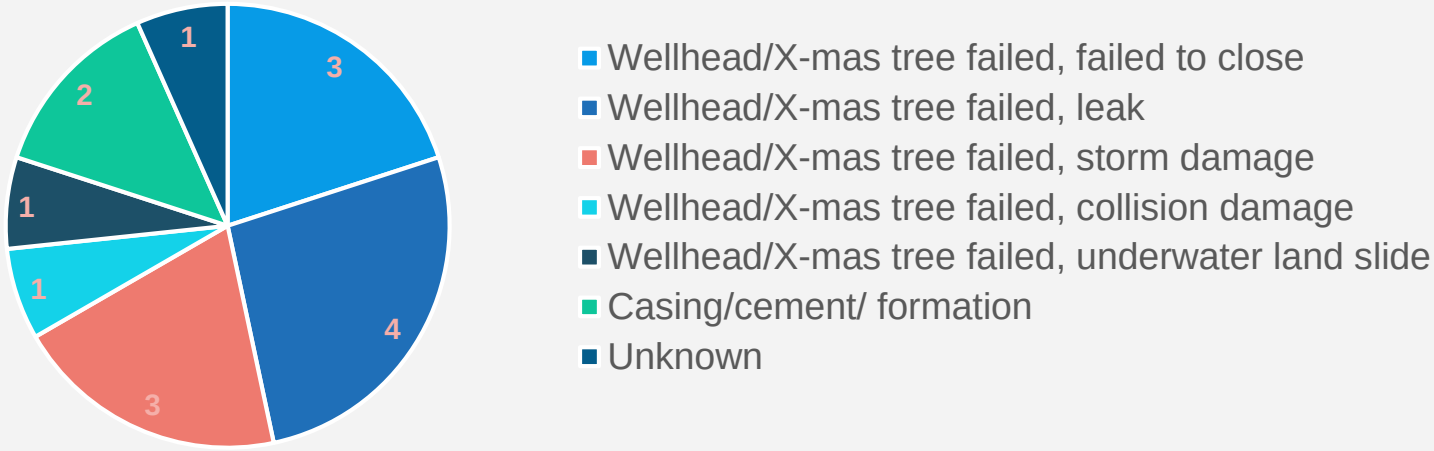
For the two *Blowout (surface blowout)* LOWCs the BOP failed to close

LOWC causes, production

Loss of primary barrier for production LOWCs



Loss of secondary barrier for production LOWCs



Kick statistics

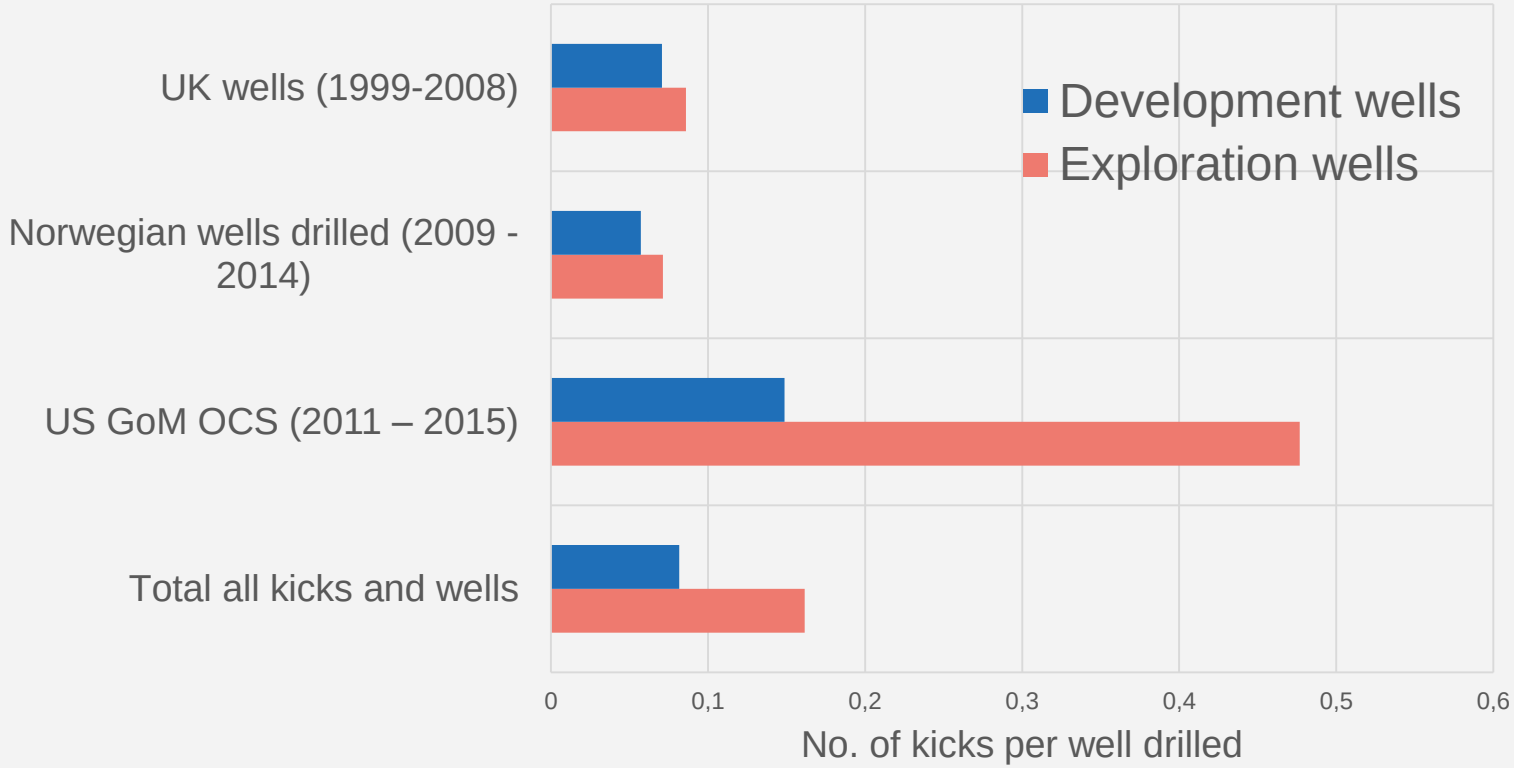
«Old» kick data

DATASET			No. of kicks	No. of wells	Kick freq. per well drilled	Shallow kicks incl.
Canadian East Coast (1970 - 1993), Expl. wells			55	273	0.201	Yes
US GoM OCS deep-water	Exploration wells	Well drilled 1997 - 1998	39	58	0.672	No
		Wells drilled 2007 – 2009	74	206	0.359	
		Total	113	264	0.428	
	Development wells	Well drilled 1997 – 1998	9	25	0.360	
		Wells drilled 2007 – 2009	7	53	0.132	
		Total	16	78	0.205	
Norwegian wells drilled 1984 - 1997	Exploration, Appraisal wells	Normal (Well depth < 4000m TVD)	15	121	0.124	No
		Deep (Well depth > 4000m TVD, not incl. HPHT)	7	24	0.292	
		HPHT wells	4	5	0.800	
		Total	26	150	0.173	
	Exploration, Wildcats	Normal (Well depth < 4000m TVD)	24	295	0.081	
		Deep (Well depth > 4000m TVD, not incl. HPHT)	29	87	0.333	
		HPHT wells	64	44	1.455	
		Total	117	426	0.275	
	TOTAL exploration		143	576	0.248	
	Development wells		272	1,478	0.184	
Canadian Beaufort wells deep (1973 - 1991), Exploration wells			42	86	0.488	No

«Recent» kick data

DATASET			No. of kicks	No. of wells	Kick freq. per well drilled	Shallow kicks incl.
UK wells (1999-2008)		Exploration wells	74	862	0.086	Yes
		Development wells	218	3,082	0.071	
Norwegian wells drilled 2009 - 2014	Exploration, Appraisal	Normal (Well depth < 4000m TVD)	1	94	0.011	No
	Exploration, Wildcat	Normal (Well depth < 4000m TVD)	10	182	0.055	
		Deep (Well depth > 4000m TVD, not incl. HPHT)	7	41	0.171	
		HPHT wells	5	6	0.833	
		Total	22	229	0.096	
	TOTAL exploration		23	323	0.071	
	Development wells		50	875	0.057	
US GoM OCS (2011 – 2015)	Exploration wells	Normal (Well depth < 4000m TVD)	32	85	0.376	Yes
		Deep (Well depth > 4000m TVD	111	215	0.516	
		Total	143	300	0.477	
	Development wells	Normal (Well depth < 4000m TVD)	78	664	0.117	
		Deep (Well depth > 4000m TVD	44	157	0.280	
		Total	122	821	0.149	

Recent 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, 2000–2015

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	3 998	1.00	14	3 971	3.53	3.5
Shallow	2		0.50	10		2.52	5.0
Total	6		1.50	24		6.04	4.0
Development drilling							
Deep	2	8 156	0.25	4	6 288	0.64	2.6
Shallow	3		0.37	12		1.91	5.2
Total	5		0.61	16		2.54	4.2

LOWC Frequencies comparison, 2000–2015

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	47 683	1.05	21	77 843	2.70	2,4

Comple-tion	UK & Norwegian waters			US GoM OCS			US GoM OCS vs. Norway and UK
	No. of LOWCs	Number of well completions	Frequency per 1 1 000 wells completed	No. of LOWCs	Number of well completions	Frequency per 1 000 wells completed	
Total	5	5 305	0.94	3	5 004	0.60	0,6

Fatalities in LOWC events, worldwide 2000 - 2015

Country	Sum of Fatalities in LOWCs				
	Development drilling	Exploration drilling	Work-over	Prod-uction	Total
Azerbaijan				32	32
Mexico				23	23
Nigeria		2			2
Saudi Arabia				3	3
US GoM State water	1				1
US GoM OCS		12	1		13
Total	1	14	1	58	74

- In the US GoM OCS one LOWC event caused 11 fatalities (Deepwater Horizon) and two LOWC events caused one fatality.
- A LOWC in Azerbaijan caused 32 fatalities in 2015. A LOWC in Mexico in 2007 caused 23 fatalities. Both these events occurred in the production phase, and the personnel died during evacuation.

Pollution from LOWC Events, US GoM and “regulated” areas, 2000 - 2015

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.

Storm related Production wells

- A storm created an underwater landslide that toppled a US GoM OCS platform in 2004. Wells are still leaking, total volume since 2004 is 6,000 – 25,000 barrels

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.

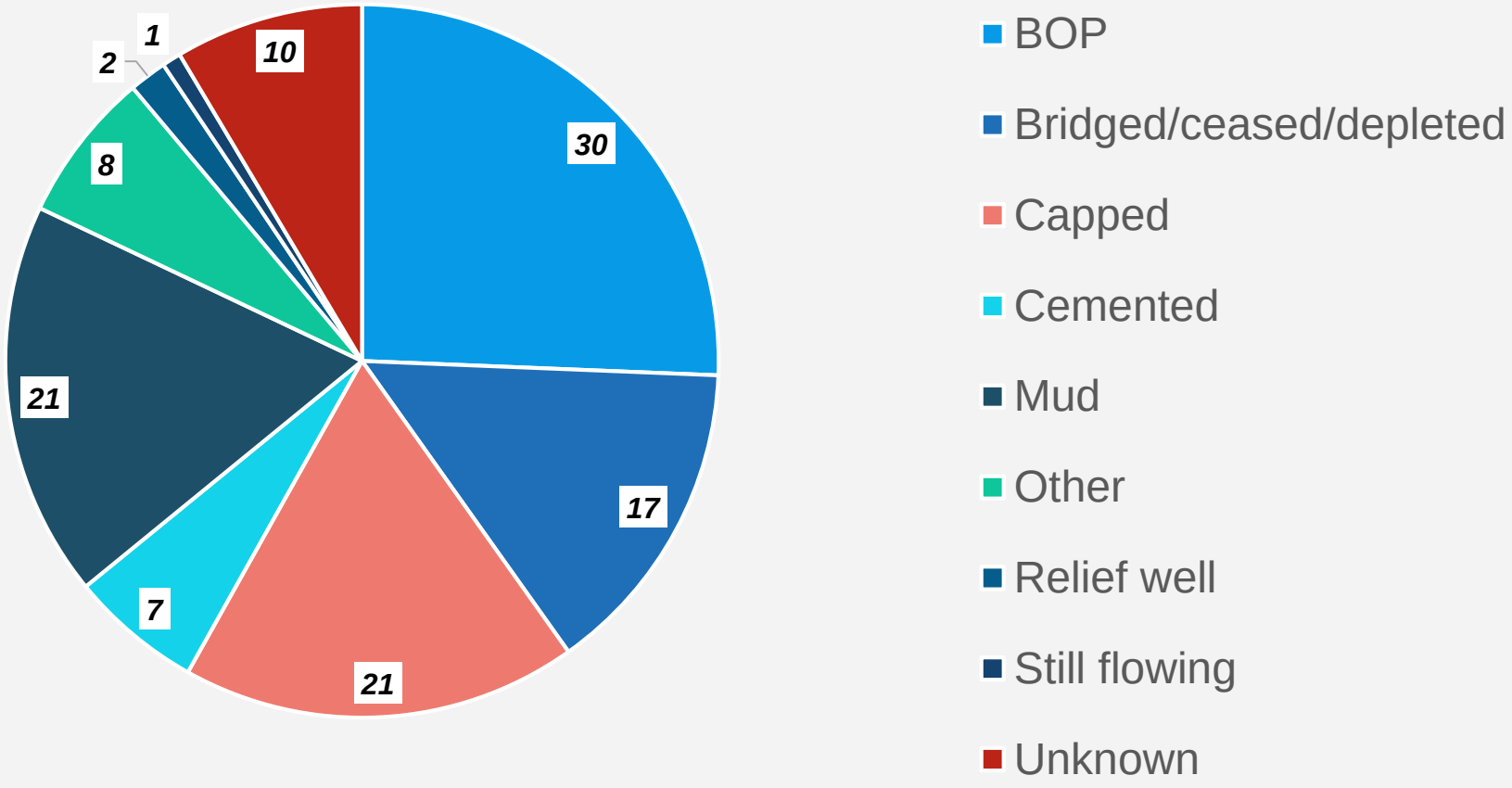
Ignition of LOWCs, US GoM and “regulated” areas, 2000 - 2015

Main category	Ignition time grouped	Dev. drilling	Expl. drilling	Compl-etion	Work-over	Prod-uctio n	Wire-line	Abando-ned well	Un-known	Total	Distri-bution %
Blowout (surface flow)	Immediate ignition		2			1		1		4	7.4 %
	Delayed ignition	3		1						4	7.4 %
	No ignition	10	14	1	11	7	1	1	1	46	85.2 %
	Total	13	16	2	11	8	1	2	1	54	100.0 %
Blowout (undergro-und flow)	No ignition	1	3							4	100.0 %
	Total	1	3							4	100.0 %
Diverted well release	No ignition	6	5	1						12	100.0 %
	Total	6	5	1						12	100.0 %
Well release	Immediate ignition		1		1					2	4.3 %
	No ignition	2	5	5	17	7	6	2	1	45	95.7 %
	Total	2	6	5	18	7	6	2	1	47	100.0 %
Total all		22	30	8	29	15	7	4	2	117	

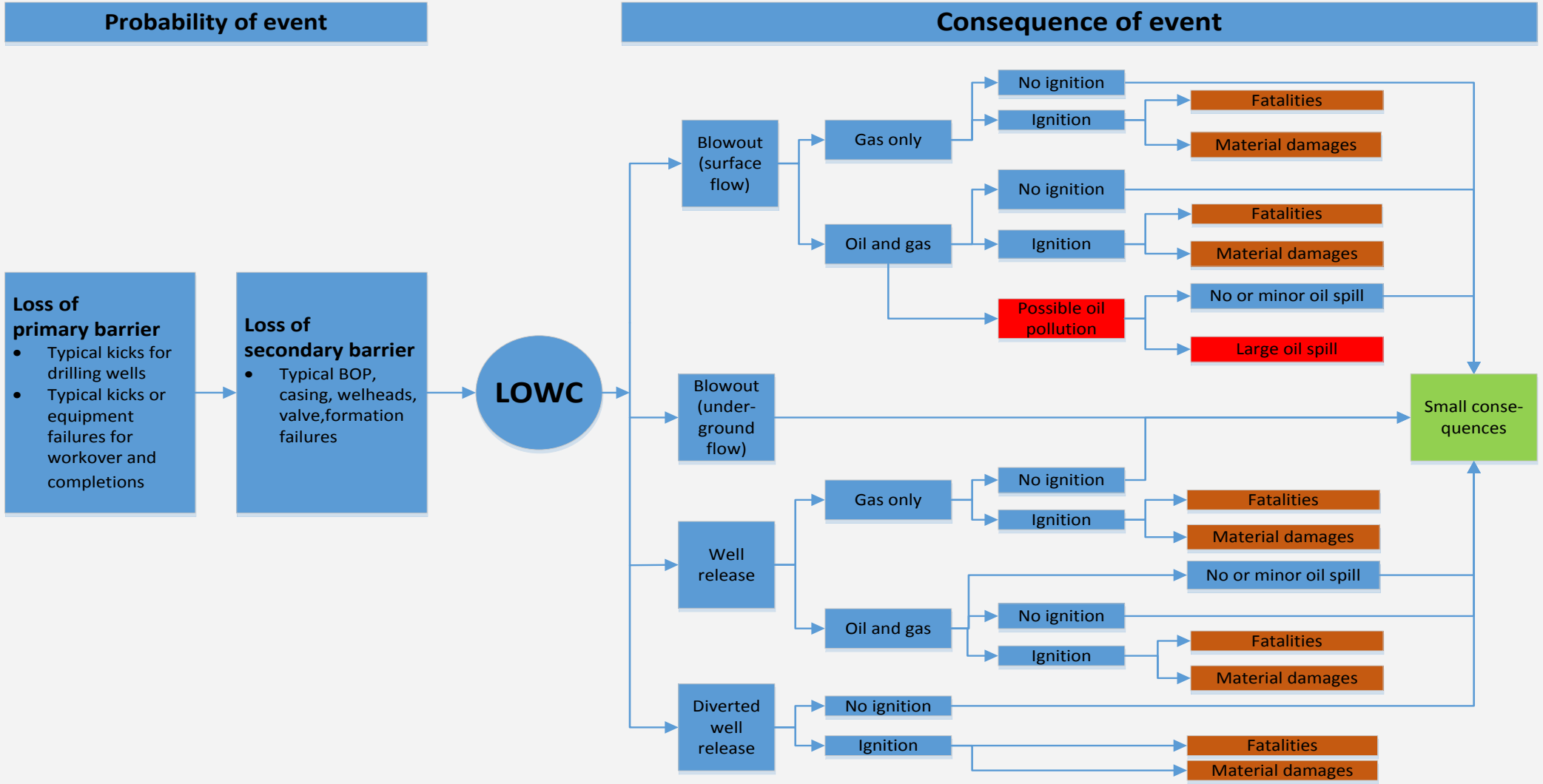
- Ten (8.5%) of the 91 LOWC events ignited

Control of LOWCs

How flow from LOWCs were stopped, “regulated” areas incl US GoM OCS 2000-2015



Risk model, future risk



Predicted 5-year risk level US GoM OCS, based on 2015 activity level

Activity type	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	0.149	0.014	0.021	0.0071	0.0035	0.0053	0.1330	0.0052
Exploration drilling from floating vessel	3.018	0.275	0.361	0.1118	0.0815	0.1095	2.7156	0.0734
Development drilling floating or bottom fixed installation	1.376	0.118	0.174	0.0574	0.0305	0.0449	1.2436	0.0140
Workover	4.559	0.401	0.490	0.1447	0.1278	0.1640	4.1227	0.0352
Completion	0.264	0.017	0.021	0.0065	0.0051	0.0068	0.2454	0.0040
Production	2.605	0.294	0.404	0.1287	0.0828	0.1150	2.2788	0.0521
Wireline	0.651	0.028	0.014	0.0000	0.0139	0.0139	0.6236	0.0000
Total all	12.62	1.15	1.49	0.46	0.34	0.46	11.36	0.18

* A large spill includes spills with a total release above from 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