JACK-UP ACCIDENT STATISTICS – YET ANOTHER UPDATE

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ABSTRACT

This paper analyses the accident trends from another 8.5 years of operations since the paper "Jack-Up Statistics: A Further Update!" was presented at the 14th Jack-Up Platform Conference in September 2013.

The paper shows the economic impact and the number of fatalities during jack-up operations since the start in 1956.

It also looks again into the relevant frequencies and consequences of the main causes of these accidents and how overall in this time both fatalities and economic loss per operating rig year have each reduced by almost 4% (compounded) each year.

It also makes suggestions as to how progress can be made in further reducing these accidents.

It also compares these accidents to those for smaller liftboats.

KEY WORDS: Jack-up, Accidents, Fatalities, Risk, Liftboats

INTRODUCTION

We cannot manage or reduce risk until we understand it, and, as Lord Kelvin said, we cannot understand anything until we can measure it.

This paper analyses the accident trends from another eight and a half years of operations since the paper "Jack-Up Statistics: A Further Update!" was presented at the 14th Jack-Up Platform Conference in September 2013. This in turn updated a similar paper "Jack-Up Statistics: Lots to Learn!" at the 11th Conference in 2007, which in turn updated a similar paper "The Facts Behind Jack-Up Accident Statistics" from the 8th conference in 2001.

This 2021 paper illustrates the patterns of incidents for jack-ups (predominantly drilling but including those adapted for accommodation or maintenance). It summarises the results of an analysis of accident statistics from DNV's offshore accident database "WREC" which has data from a wide variety of sources including the insurance industry. It shows the trends over time for total losses, severe accidents, and fatalities, and it further delineates those trends in terms of major causes.

In this analysis, jack-up accidents leading to total loss or severe damage over the last 66.5 years were reviewed (13 in the last eight and a half years). Helicopter accidents were excluded as they are generally not structure-specific. Similarly, construction units, lift boats and small work-over rigs were excluded in the main analysis, as were incidents that occurred during construction or repair ashore unless they helped to show a significant pattern.

Additionally, a comparison has been made between the accident rates of jack-ups as defined above and smaller liftboats which have loss rates and fatality rates appreciably higher than for jack-ups.

Appendix A lists the incidents that occurred from the beginning of 2013 to the middle of 2021 which were considered in this analysis to have major economic impact. It also includes an accident from 2012 which was classified as a total loss in 2019. The results of these incidents are summarised in Table 1 according to the phase of operation in which they occurred and the initiating hazard. Note that Table 1 also includes fatalities from other accidents that had little or no other economic impact.

Table 1: Summary of jack-up total losses and severe accidents between 2013 and June 2021 inclusive

Phase of Operation	Initiating Hazard	Total Loss or CTL	Severe Damage	Fatalities
Under tow	Flooding	1		
Moving on or off location	Punch-through	3	5.5	6
	Jacking system failure		1.5	
On location	Blow-out /well control		2	
	Lifting operation			1
	Fire			1
	Falling or moving object			2
All	Total	4	9	10

Key: **CTL** = Constructive Total Loss (Cost of repair exceeds insured value)

The primary problem with any incident analysis is that many accidents are not reported. This is particularly troublesome in areas with lax health and safety requirements. In the comparatively close-knit offshore oil industry, however, almost all major losses and severe accidents soon become common knowledge, even if the exact causes are not fully understood. For this reason, we are reasonably confident that at least 95 percent of all total losses worldwide, and probably more than 50 percent of all severe accidents and multiple fatalities, have been identified in the database. This under-reporting should not significantly affect trends or ratios of the different types of incident frequency since this type of quantified risk assessment is accurate only to within an order of magnitude at best.

Economic impact of jack-up accidents 1955 to mid-2021

To remove the effects of inflation, cost estimates were obtained by assuming (in 2001) the value for the total loss of an average jack-up to be US$50 million and the value for an average case of severe damage to be US$5 million. While these assumptions are far from precise, they should present the resulting losses appropriately in relative terms.

Figure 1 shows the trend of economic impact of jack-up accidents (estimated as the sum of the frequency of each type of accident multiplied by its consequence, expressed in US dollars) over the past 66.5 years. A five-year rolling mean has been used to smooth out the "spikes" caused by the comparatively small working population, especially notable in the early years. It shows the total cost impact divided into five causes in the following order, starting at the bottom:

1. Towage incidents
2. On location structural, foundation, and jacking system failures (excluding hurricanes)
3. Blowouts and fires
4. Other (such as slips, falls, lifting, and collision incidents) – generally with more impact on fatalities than cost.
5. Hurricane damage when elevated.

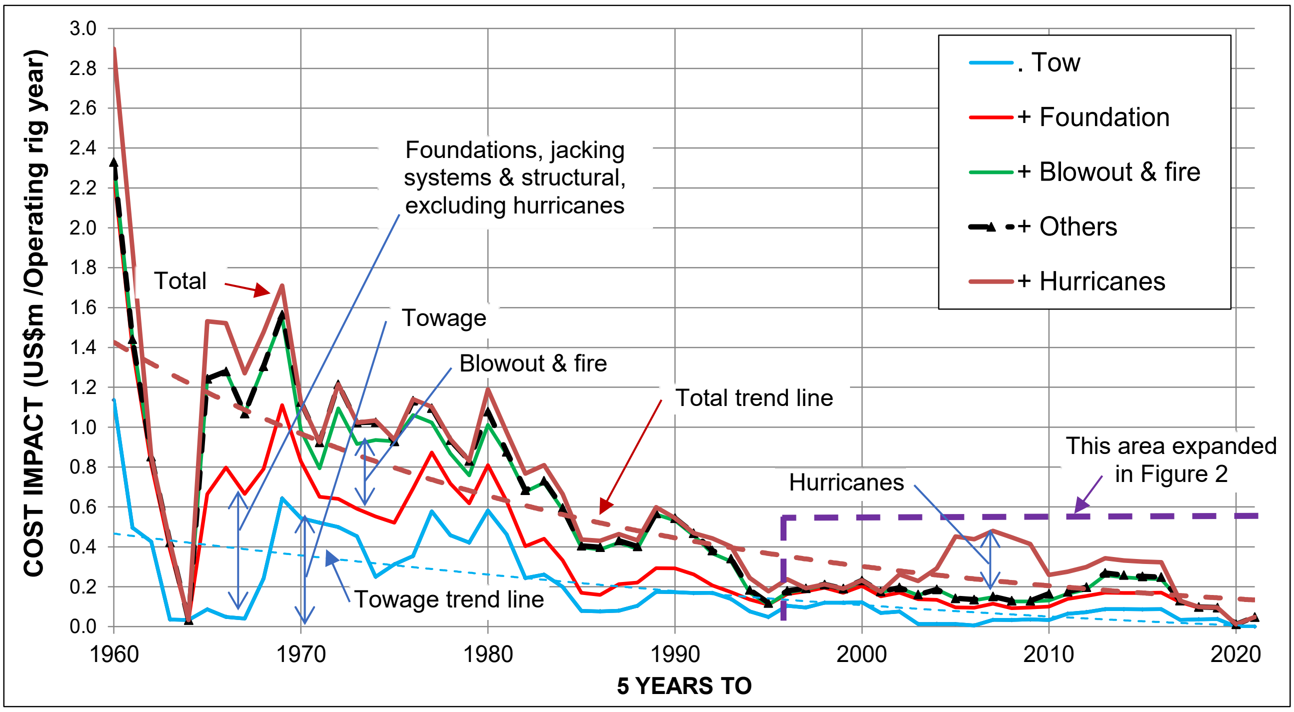

Figure 1: Jack-up cost impact over 61.5 years (5-year rolling means & trend lines)

Figure 2 expands the last 26.5 years of Figure 1.

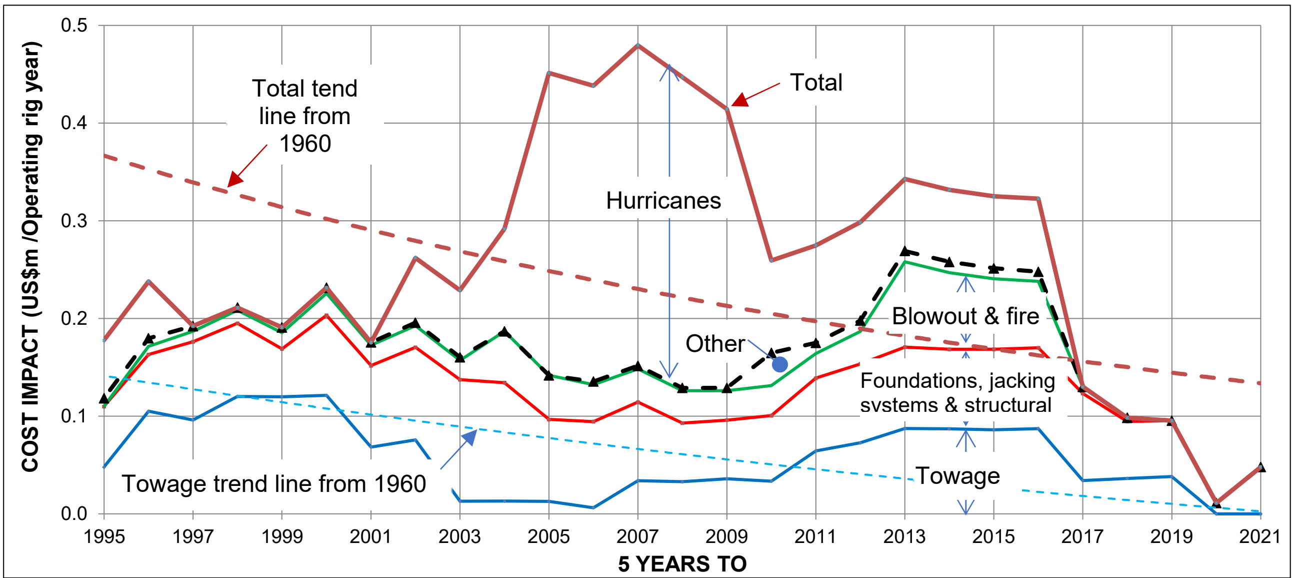

Figure 2 Jack-up cost impact over 26.5 years (5-year rolling means & overall trend lines)

Figure 2 shows clearly the significant effect of Gulf of Mexico hurricanes in 2002-2008 and the increase in other risks between 2010 and 2013. The lag caused by using 5-year rolling tends to obscure the exact events. After the loss of the "Rigmar 152" under tow in February 2015, almost all major accidents have been foundation or jacking system failures.

Overall improvement in overall loss rate

Figure 1 shows that the total trend line at the end of 1960 had a cost of $1.4M per operating rig year. Table 2 show what the (exponential) trend line would have predicted as the loss rate at the end of 2021 using data for the cut-off dates for this and some of the previous papers.

Table 2: Improvement in predicted overall loss rate with time.

Predicted at	Predicted loss rate at end of 2021 ($M /op rig year)	Annual reduction in loss rate
End 2001	0.11	4.1%
End 2006	0.14	3.8%
End 2012	0.18	3.3%
End 2021	0.14	3.8%

The right-hand column shows that the average annual loss rate was reduced by a factor of 10 over 61 years from $1.4M to $0.14M per operating rig year between 1960 and 2021. This corresponds to 3.8% reduction per year compound. The total annual rate reduction deteriorated from 4.1% to 3.8% between 2001 and 2007 and again to 3.3% by the end of 2012, for the reasons given in the 2007 and 2013 papers. The last 8.5 years have shown an improvement to a 3.8% annual reduction rate though the relatively short time spans means that these changes are probably not statistically significant.

Hurricane risks

In the Gulf of Mexico "best practice" has been to batten down and evacuate all jack-ups, semi-submersibles, and most fixed platforms well in advance of a hurricane's approach, and this practice has been highly effective in protecting the people who work on these units. For jack-ups, implicit in this approach was acceptance that the asset might suffer damage or loss, especially if a strong hurricane passed just to the west of the rig's location. However, because the wind and wave intensities decrease rapidly the farther one is from the eye of the storm, jack-ups historically tended to survive all but a direct hit from a hurricane, provided they had sufficient air gap to avoid wave impact with the hull. Unfortunately, that was not the case in 2005 when there was a significant number of incidents and losses.

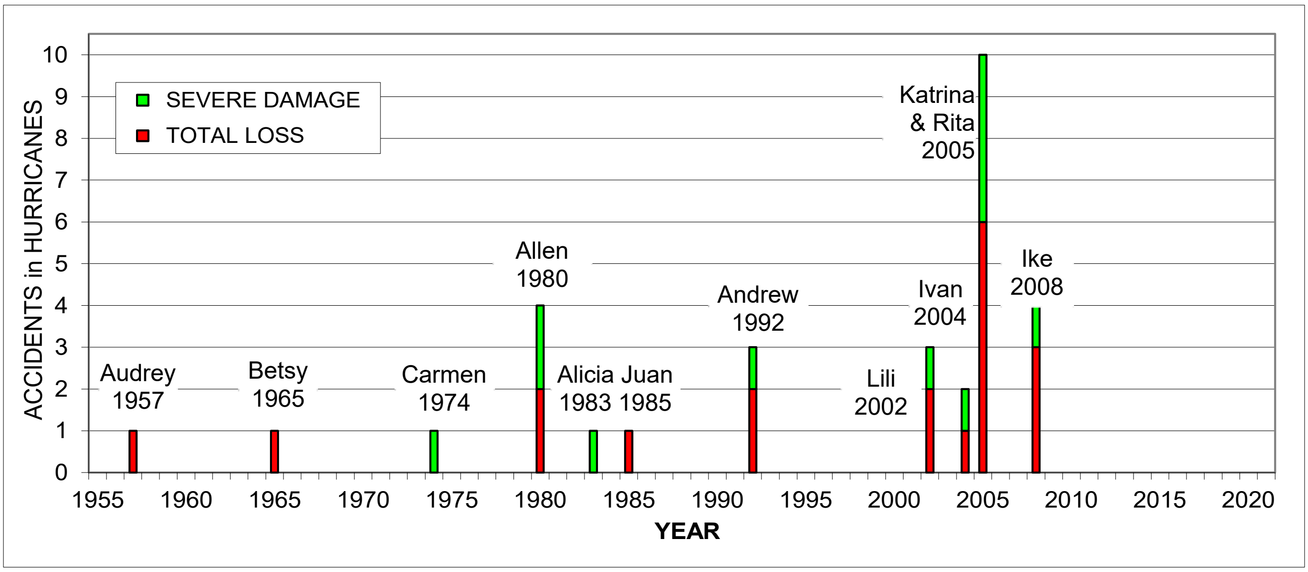

Figure 3: Jack-up total losses or severe damage in Gulf of Mexico hurricanes

Figure 3 shows the number of jack-ups in the Gulf of Mexico in any one year that were total losses or had severe damage (over US$1 million) due to hurricanes. This figure shows the random nature of hurricane damage, due to the randomness and very localised paths of the hurricanes themselves. The increasing number of accidents seems to be mainly a function of the increasing number of jack-ups at risk in vulnerable areas of the Gulf of Mexico, but the 2004-2008 hurricane seasons have also demonstrated a definite trend of increasing storm intensity due to global warming. Of course, with more jack-ups exposed to more severe weather, there is also increased risk of a collision between a "runaway" rig and a drilling or production unit that would otherwise survive, which has caused growing concern amongst operators and regulators.

In response to the learnings from these losses, air gaps were increased and the US Gulf of Mexico Annex to ISO 19905-1 (first published in 2012) includes minimum airgap requirements and "sudden" hurricane metocean data for both a 48-hour sudden hurricane assessment case that could be reached whilst just still manned at the end of the normal storm preparation and evacuation window and a 72-hour contingency case to ensure survivability should the evacuation take longer than expected. A "sudden" hurricane is one that forms near the site and that can affect the jack-up within a few days, potentially in less time than the time required by the emergency evacuation plan. ISO 19905-1 also includes a requirement to address the unmanned post-evacuation case using criteria agreed upon between the jack-up owner and the operator.

In the forthcoming 3rd edition of ISO 19905-1 the required hurricane metocean data for will be referenced from API RP 2MET, thus adopting the results of the most recent re-evaluation and the post-evacuation survivability requirements will be based on the 2,500 year return period full-population hurricane.

Insitu structural, foundation and jacking system risks

Figure 4 shows the breakdown of the cost impact due to structural, foundation, and jacking system incidents (excluding hurricanes), and the trends since 1995 are shown in Figure 5. There is significant interaction between the four risk categories, especially for foundation failures when moving onto a location. For example, structural failure may be due to a punch-through or a leg sliding into a previous footprint combined with inadequate reserve leg strength.

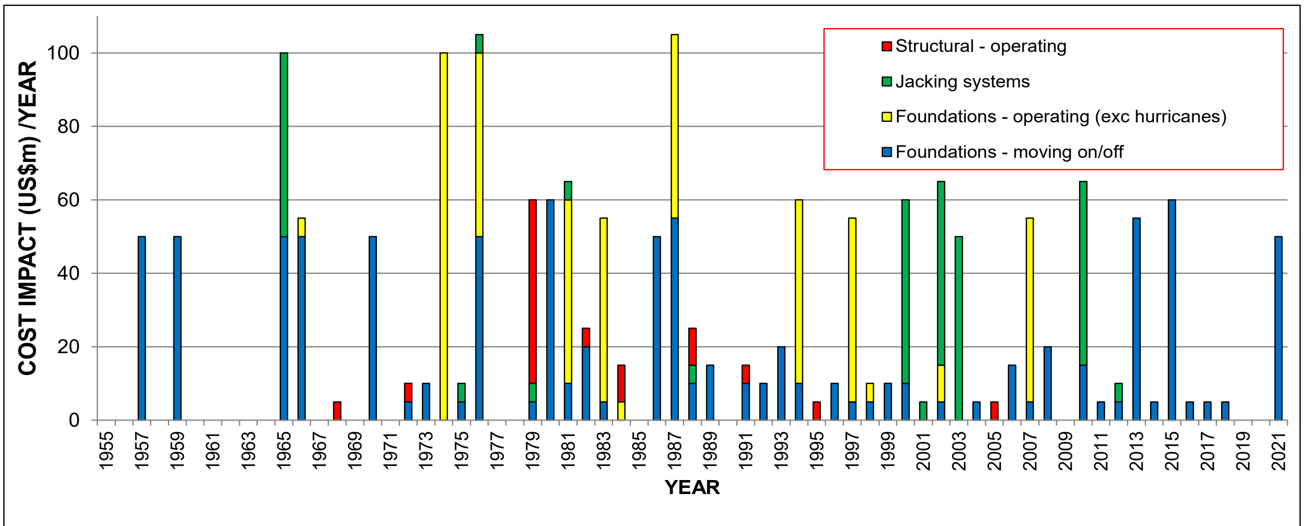

Figure 4: Jack-up cost impact for structural, foundation and jacking system risks (excluding hurricanes)

Foundation failures when moving on and off location are discussed further below. An obvious mitigation measure, to the hazards associated with performing preload operations, is to reduce the target preload. This option should be treated with considerable caution, because of the associated reduction in the rig's foundation capacity when at full working airgap. Such a reduction in foundation capacity may only be appropriate for less severe metocean conditions (benign weather locations or restricted seasons in harsh environments). There may also be some restrictions placed on the amount of variable load that the rig can carry. Whilst this is often a feasible option, it does place additional demands on the logistic operations such as supply vessel capacity and attendance frequency.

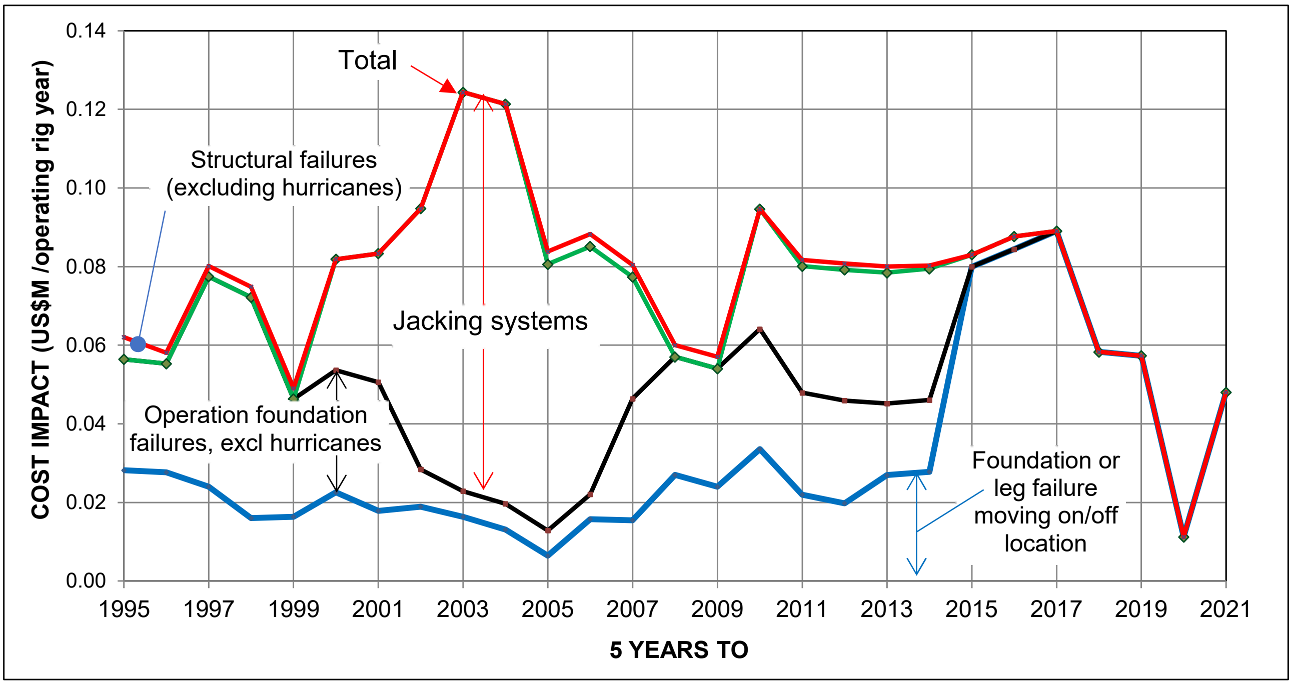

Figure 5: Jack-up cost impact for structural, foundation and jacking system risks, excluding hurricanes (5-year rolling mean)

Jacking Systems

Our 2013 paper looked at the many significant accidents and fatalities caused by jacking failures between 2000 and 2012. Since then, a Joint Industry Project (JIP) led by DNV has investigated the problems and provided recommendations on avoiding jacking failures. The DNV publication in late 2014 (Inspection & Maintenance of Jacking Systems DNVGL-RP-0075) addressed several issues including; competency levels, critical component design assumptions and the collection of essential field data. Since 2012 there have been no major losses in the public domain and only one definite and one possible serious accident due to this cause which has been encouraging. However it is understood that the maintenance alert issued by one manufacturer in 2019 was precipitated by an incident that indicated that a major jacking failure had gone undetected for some considerable time. This suggests that there is scope for the existing inspection regimes, driven by OEM specification or other parties, to be enhanced so there is clearer guidance on when purely visual inspection may be insufficient.

Foundation failures when moving on/off location

Figures 4 and 5 also indicate a disappointing pattern in the cost impact due to foundation failures (mainly punch-throughs or sliding into footprints) both when operating and when moving onto location. Having reduced significantly up to 2005, the rate of failure moving on and off location has increased significantly since then and has recently become the main cause of losses. It is often unclear if the rig move team were "ambushed" by the seabed soils (bathymetry, soil strength etc) or were aware and subsequently found that the planned mitigation measures (metocean conditions, airgap or draft, preload amount or sequence) were insufficient or impractical. The use of a minimum airgap is often used as a key mitigation against rapid leg penetration, but may be difficult to achieve when there is a large tidal range or a lot of swell at the location.

There are several other possible causes for this increase; for example many of the newer jack-up designs with comparatively less robust legs and are being stretched to operate in greater water depths. These legs work well under normal operating and survival conditions (with fixation systems engaged) but have less reserve strength to resist the loads experienced during a punch-through. The need for some designs to use their fixation system (rack chocks) to briefly protect the climbing pinion capacity during preload places an additional burden on the rig move team.

There is also at least one new rig design where the Marine Operation Manual includes a section on Punch Through which states: "The Unit is not classed to be installed in PUNCH THROUGH SITE." This has several implications, not least the quality demanded from the leg penetration assessment and the techniques and the data used to develop it. These newer rigs may also have elevating systems that are more complex to operate, requiring more experienced personnel trained in the measurement and control of leg chord loading and leg brace loading. An estimate of leg brace loading may be achieved by the measurement of Rack Phase Difference (RPD).

There also seems to be a developing shortage of skilled rig movers, and many offshore rig move personnel do not have the skills to accurately monitor leg penetration and leg loading as the rig loses draft and then goes into pre-load operations. The combination of inadequate tools (e.g. stability programs, pinion load and RPD monitoring systems) and inadequate knowledge and experience tend to result in protracted conversations between the rig and shore base that can be confusing and non-productive.

A review of rig move reports can sometimes reveal a lack of understanding of key variables involved in a leg preloading operation, or at least an unwillingness to track and document these variables. For a three-leg unit, several of the variables are dependent which makes it easier to track the data and ensure data quality. For example, spudcan penetration, water depth, airgap (or hull draft) and leg mark for one leg are all related to the other legs by trim and heel angle. Incomplete or inconsistent data that is only discovered after the rig move can introduce a loss of confidence in the rig move report.

The rig move procedure developed in advance of the rig move should clarify what data the rig move team will be using; for example:

- Changes in tidal elevation above LAT predicted for duration of rig move
- Water depth at location (LAT)
- Hull draft
- Individual leg loads at the elevation of the climbing pinions/ rack chocks will be extracted from the rig stability software and/or calculated manually based on the rig stability booklet (supplemented by tank soundings), before, during and after preloading.
- Pinion alarm settings and alarm activations will be tracked alongside the pinion loads output from the above
- Hull trim & heel angles
- Guide clearances
- Rack phase values and the subsequent Rack Phase Differences
- Individual leg loads at the spudcan will be extracted from the rig stability software (supplemented by tank soundings), before, during and after preloading. These will be tracked against the leg-load versus leg-penetration curve developed prior to the rig move.

Prior to the rig move, it should be clear what hull levelling options are available as the preloading operation matures. For example, at 80% preload, hull elevating to correct a loss of trim may not be possible, so hull lowering may be the only option prior to dumping preload. Similarly, the maximum loss of hull trim or heel, past which corrective jacking will not be attempted, should be documented.

Blow-outs

Figure 1 shows how the cost impact of blow-outs reduced dramatically from a peak five-year average of $0.28M per operating rig year in 1983 to zero in 1995 (due apparently to the learning curve of the drilling crews as discussed in the 2001 paper). Figure 2, however, shows a gradual, consistent increase from then through $0.05M per operating rig year in 2004 to $0.06M in 2012. There do not seem to be any obvious reasons for this increase; though it may be the drilling of more High Pressure, High Temperature (HPHT) wells, more complex well design or less rigorous checks during well construction. Since 2013 there have been no serious blow-outs on jack-ups reported.

Jack-up population and ages

The variation of the age profile over time for the entire drilling jack-up fleet is shown in Figure 6, and for those with a rated water depth of 350 feet or more in Figure 7.

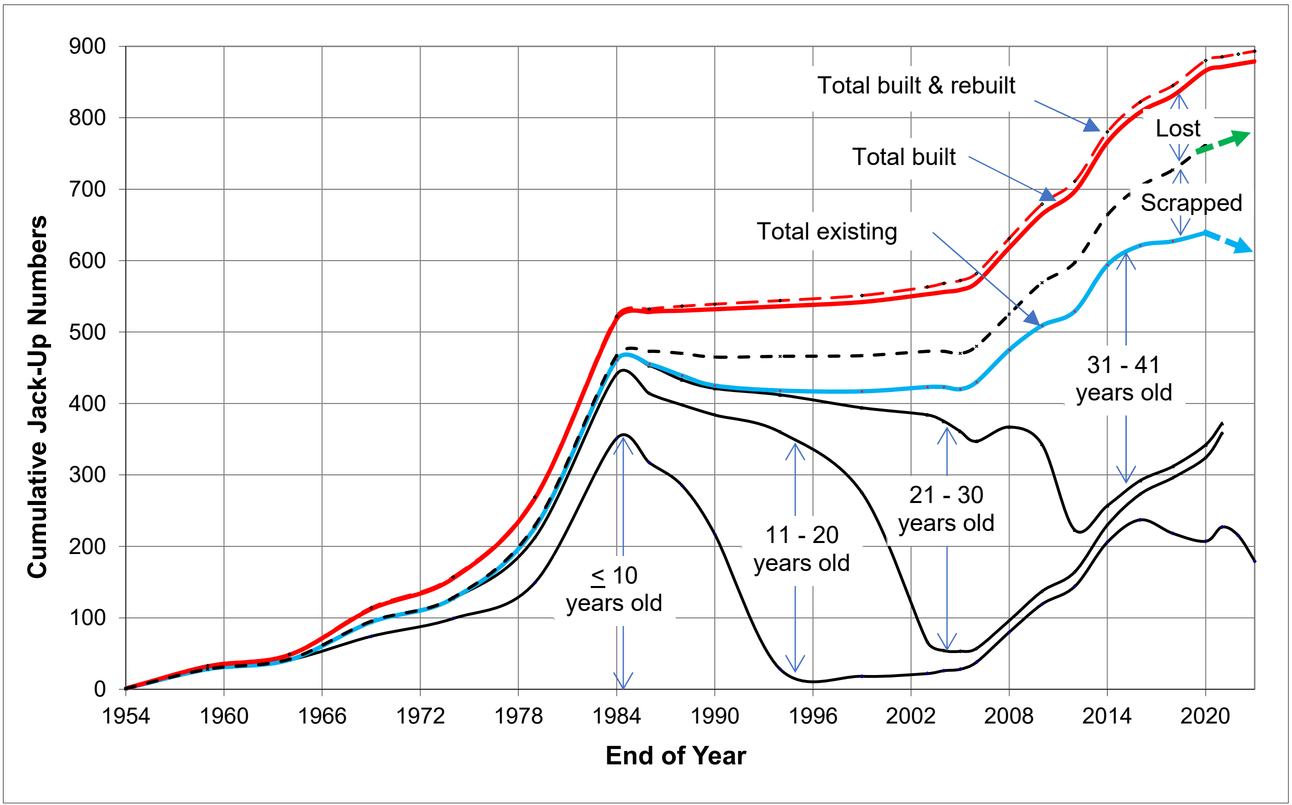

Figure 6: Age of jack-up fleet (all rigs)

Figure 6 shows the effect of the building boom in the late 1970s with the sudden slow down after the price of oil dropped in the early 1980s. A new surge in new construction started with deliveries in 2006 when 86% of the jack-up fleet was more than 20 years old. New orders slowed dramatically in about 2010 when the oil price dropped to $50 /barrel. As the oil price dropped further, delivery dates for new rigs were delayed or orders cancelled. The rate of rig scrapping increased, especially but not only of the older ones, from about 2015 when the oil price dropped to $20 or less.

The 2013 paper showed little correlation between the ages of units and their accident rates, with the exception of towage losses where there was an increased risk with age and foundation and jacking system failures where newer and higher specification units were most at risk.

The last 8.5 years has not changed these conclusions. The only total loss under tow was 59 years old. The two total losses from foundation and jacking system failures were 4 and 6 years old, and of the serious accidents 5 of the 8 were less than 6 years old.

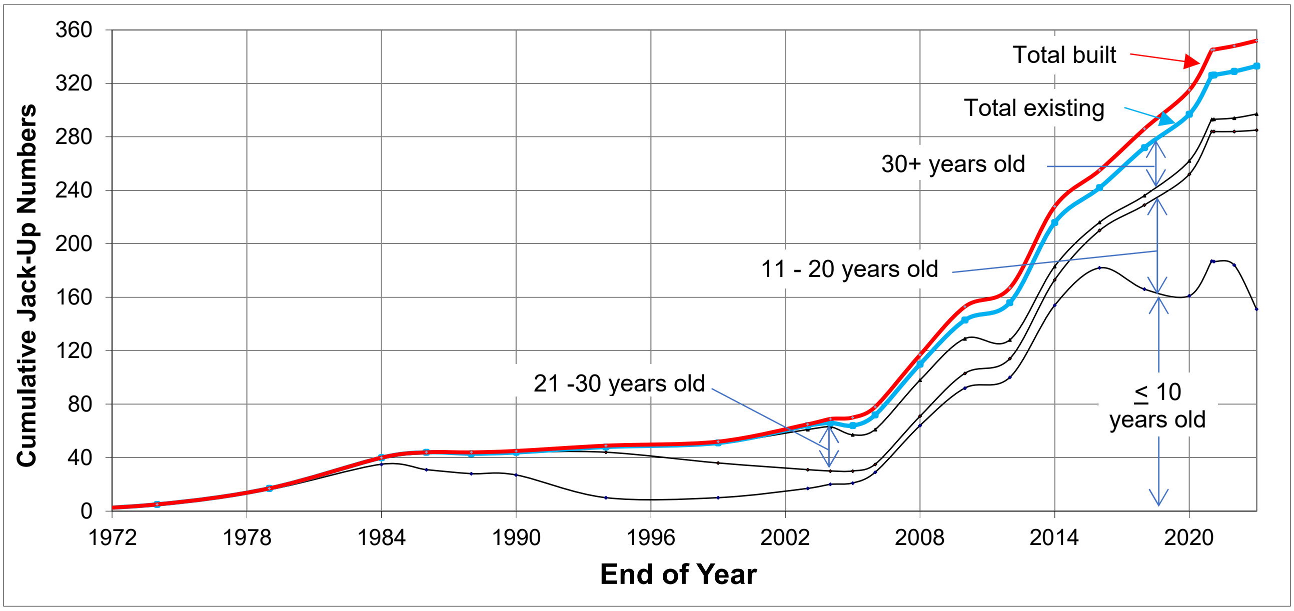

Figure 7: Age of jack-up fleet with rated water depth of 350 feet or more

This figure shows how units with rated water depths of 350 or more feet is expected to increase from 68 units in 2005 (16% of the fleet) to about 325 units at the end of 2021 (about 50% of the fleet depending on scrappages before then). There are about 40 of these deeper-water units forecast to be built at present.

FATALITIES

Figure 8 shows the individual fatalities by cause over the last 26.5 years. This figure shows that the 3 most serious fatal accidents (5 or more deaths) have been due to towage or foundation /jacking system failures and show little pattern.

These accidents were:

2000 5 deaths when AL MARIYAH dropped 60 feet (jack brake failures plus leg weld failures) when skidding cantilever

2007 22 deaths when "Usumacinta" had a foundation failure in a storm two days after jacking up next to a small platform. The rig mat slid towards the platform and the extended cantilever (which may have contributed to the slide) sliced open the two wells, one of which had a subsea shut-off valve that did not hold. This led to a gas leak and evacuation via lifeboats and rafts (during which the fatalities occurred).

2011 53 crew (of 67) died when the "Kolskaya" was caught under tow by bad weather after the end of the normal operating season and after deviating from the planned route.

Since 2012 there have been 3 accidents involving foundation or jacking system failures which led to a total of 6 deaths. There has also been 1 fire leading to a death and 3 fatalities from falls.

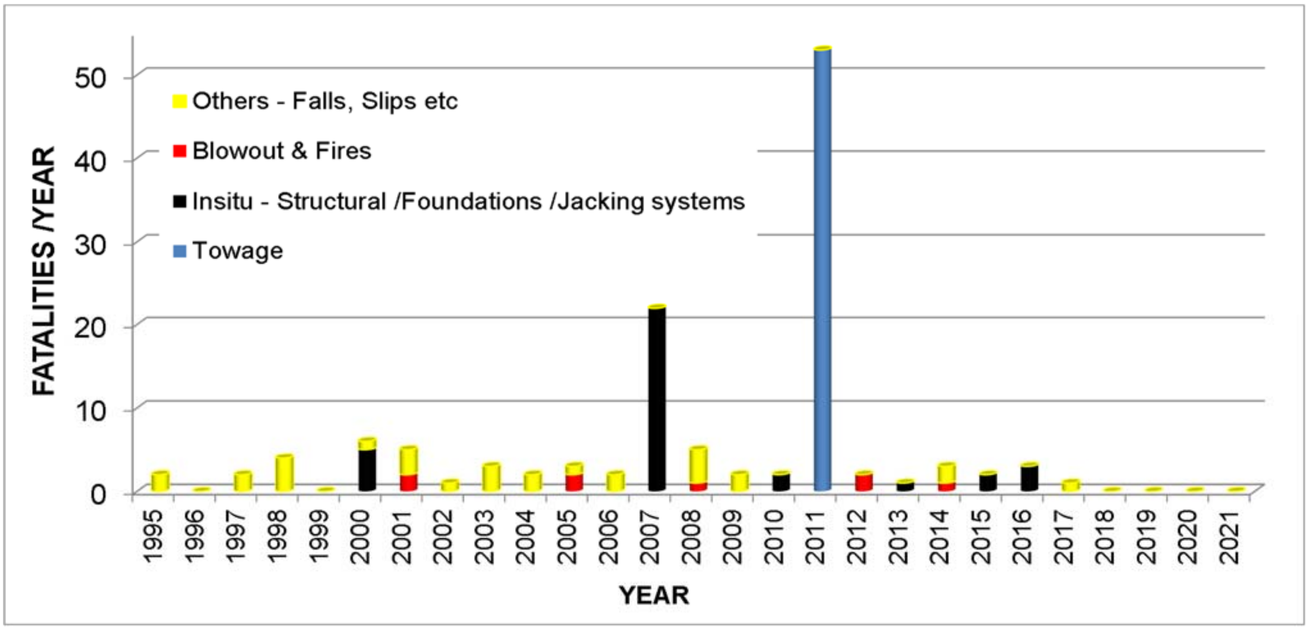

Figure 8: Causes of fatalities on jack-ups over the last 26.5 Years

The following Figure 9 shows the 5-year rolling mean fatality rate from 1960 to mid-2021. Figure 10 expands the same data from 1995.

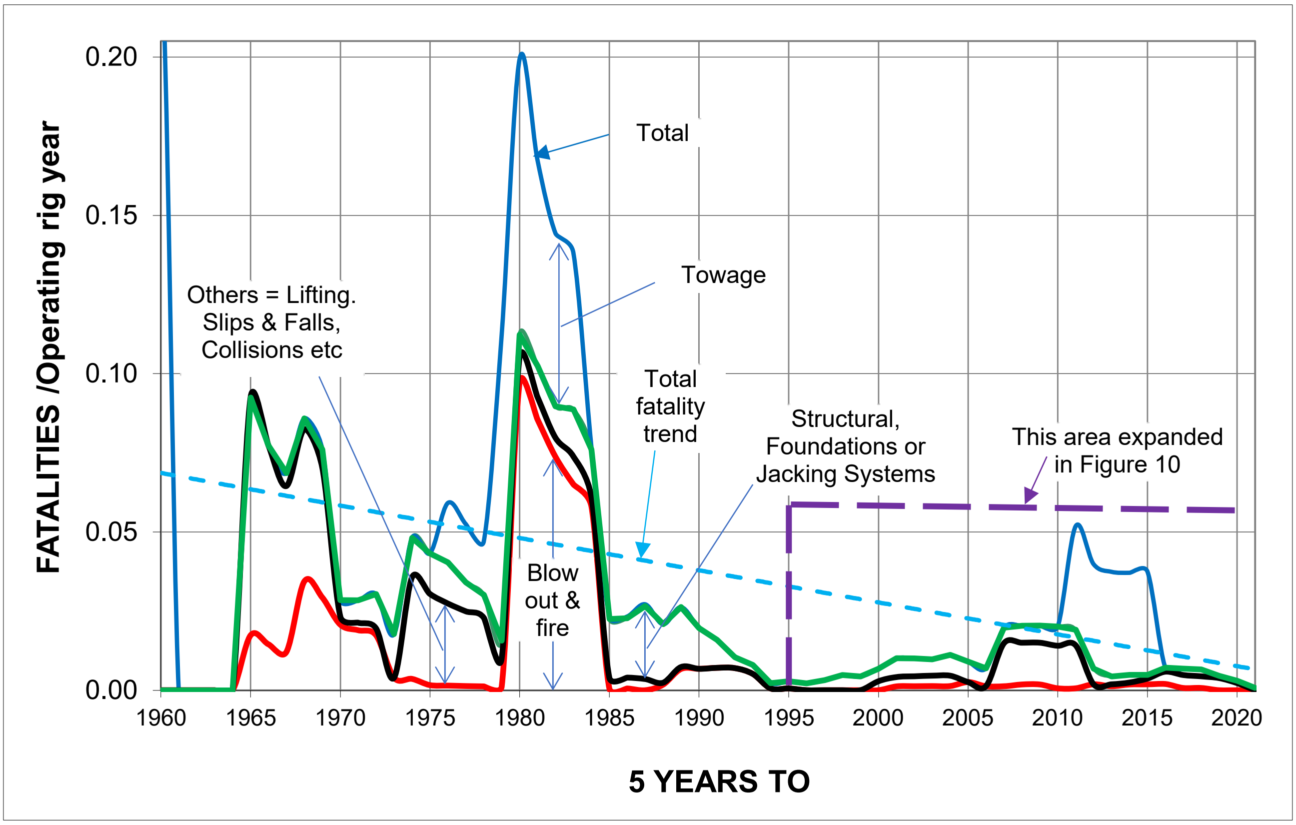

Figure 9: Jack-up fatality rate over 61.5 years (5-year rolling mean)

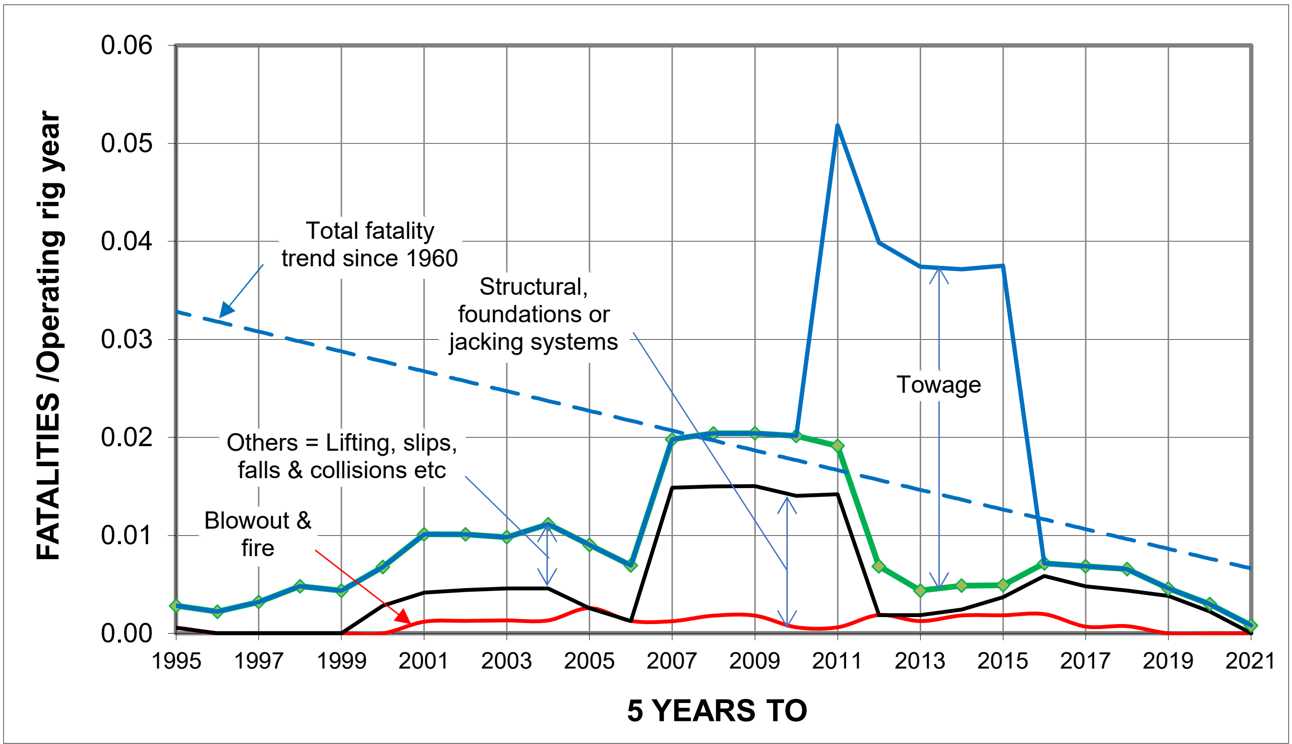

Figure 10: Jack-up fatality rate over the last 26.5 years (5-year rolling mean)

The total trend line from 1960 in these figures show an encouraging improvement over time. Unfortunately, this is only indicative since an exponential trend line could not be fitted to this data and the logarithmic trend (as shown) and polynomial trend both become negative when projected, which is not reasonable. Even so it shows a reduction by a factor of about 10 (from 0.07 to 0.007 fatalities /operating rig year) over the 61 years which is virtually the same as the reduction in economic risk.

Comparison with lift boats

A lift boat is a self-propelled, self-elevating vessel used in support of various offshore mineral exploration and production or offshore construction activities. They are commonly used to perform maintenance on oil and gas well platforms. Until recently most were much smaller than those used for drilling and had crew numbers less than 10% of drilling jack-ups. Most operate in the Gulf of Mexico outside the hurricane season or in benign areas. Many are not designed to be afloat in more than 1 to 2 m high seas and are expected to go for shelter before a storm arrives. The first was designed in 1955 and the numbers built are probably about half those of the jack-up fleet shown in Figure 6. It is difficult to be sure since most are not classed by classification societies and most liftboat registers are very incomplete.

The following Figure 11 show the number of units lost each year, totalling 90. 4 have capsized or sunk twice and one 3 times. 7 were a result of hurricane JUAN in 1985. Figure 12 shows the number of fatalities each year, totalling 56.

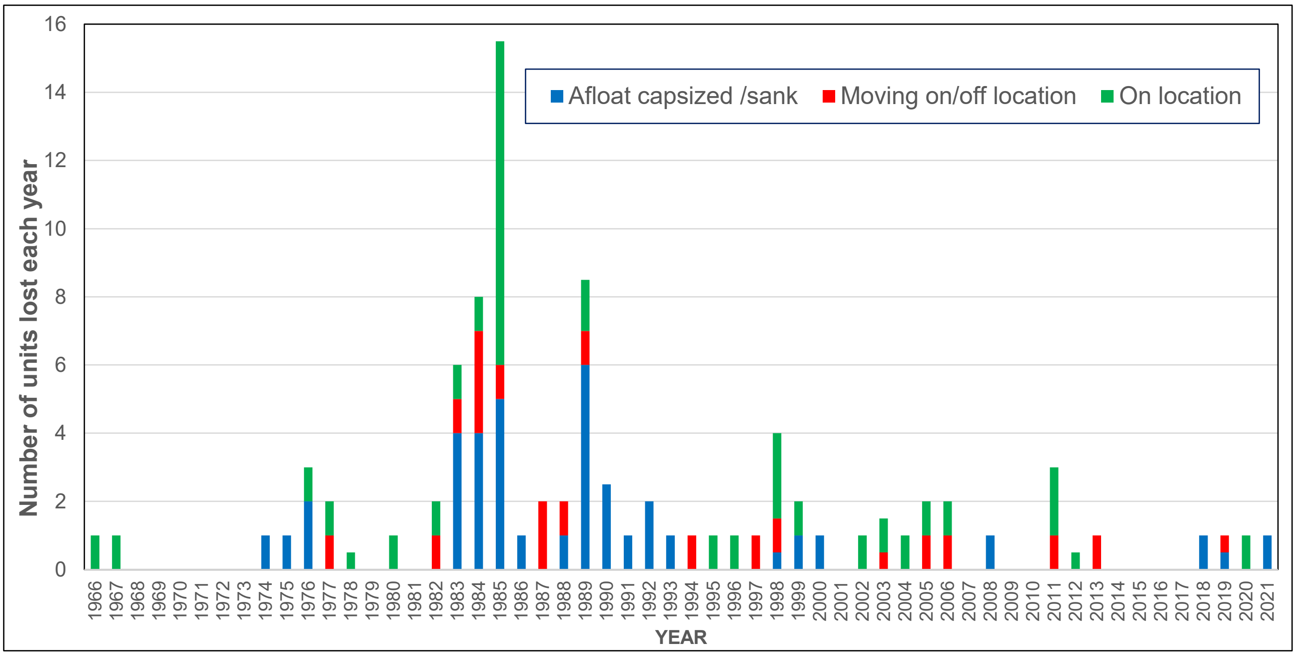

Figure 11: Losses of liftboats each year

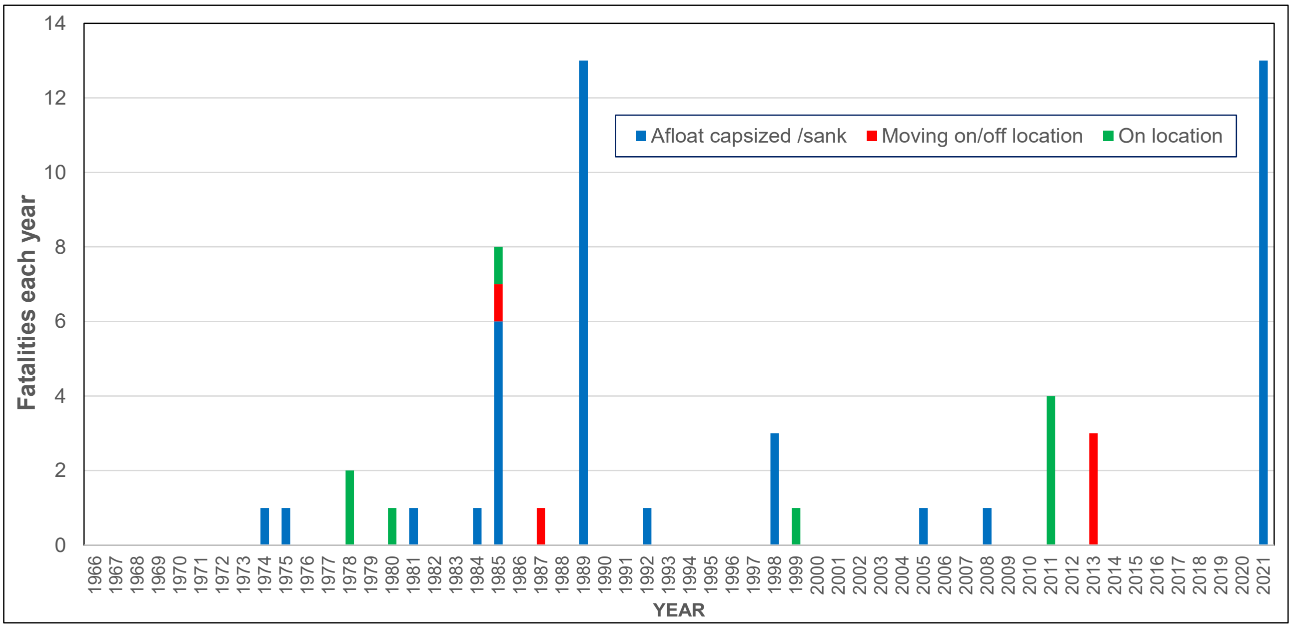

Figure 12: Fatalities each year on liftboats

The historical loss rate for liftboats is between 2 and 3 times that for drilling jack-ups while the overall probability of a liftboat crew member dying at work has also been between 2 and 3 times that for the crew of a drilling jack-up.

The worst fatalities were in 2021 when 12 crew died when "Seacor Power" capsized in a sudden storm with 7-8 ft seas, and in 1989 when 10 died when "Avco 5" capsized in 12 ft seas, when seeking shelter from hurricane CHANTAL

Appendix A: Summary of worst accidents for jack-ups, or declared total loss, since 2012

Year	Name	Age	Location	Details	Fatal ities	Total loss	Primary Cause
	UNDER TOW						
2012	HERCULES 2502	31	Gulf of Mexico	Mat badly damaged due poor cribbing alignment on barge for dry tow - rig retired - **declared total loss in 2019**		1	S
2015	RIGMAR 152	59	S Atlantic	Sank under tow from Brazil to Gabon		1	K
	MOVING ON /OFF LOCATION						
2013	PERRO NEGRO 6	4	Angola	Capsized after punch through with 103 on board in Congo R mouth in 40m water depth	1	1	B
2013	TRIDENT 15	31	Thailand	Port leg punch-through giving 7˚ list at Moragot 19. Many braces damaged			B
2014	AQUAMARINE DRILLER	5	Sarawak	Serious punch-through off Miri (plus possible heavy weather damage under tow)			B
2015	COSLGIFT	2	SE Asia	Serious punch-through			B
2015	TROLL SOLUTION	5	Gulf of Mexico	Probable punch-through & tilt when positioning to do maintenance on Caan Alf well	2	1	B
2015	RUMAILAH	1	Qatar	Punch-through at Al Shaheen field. 3 legs broken			B
2016	SAR 201	34	Saudi Arabia	Punch-through (or BMC jack failure) on port leg causing deck at port stern to drop to nearly sea level (& minor damage to adjacent Safaniya Platform). Evacuated. 3 expats missing.	3		B /M
2017	WEST TITANIA	3	Gulf of Mexico	Jacking system failure at Manick 100-1A caused c5˚ trim by stern and slight list caused flooding of starboard stern main deck.			M
2018	KS JAVA STAR	37	Indonesia	Rapid penetration of starboard leg when preloading next to Camar Seagull jacket. Gas well fire on adjacent platform SE of Bawean Island			M
2021	VELESTO NAGA 7	6	Sarawak	Punch-through at Salam-3 well off Sarawak. Fully submerged,		1	B
	ON LOCATION						
2013	HERCULES 265	31	Gulf of Mexico	Gas B/O at S Timbalier 220 A-3. Fire in derrick Beams supporting derrick & rig floor collapsed.			O
2014	ROWAN LOUISIANA	39	Gulf of Mexico	Well control problem at Verm 366 A7 during wiper trip. All non-essential crew evacuated			O
2014	MENADRILL 1	4	Gulf of Mexico	Fire in shale shakers /motor generator room at Akal field.	1		F
2014	ENSCO 104	12	Malaysia	2 crew killed when lifeboat fell 150 ft to sea during maintenance	2		N
2017	MAERSK INTERCEPTOR	3	Norway	2 drilling staff injured at Tambar after braided sling lifting pump broke. 1 subsequently Man Over Board & recovered by stand-by vessel but died.	1		L
	Key to Primary Cause: **B**=Punch-through, **F**=Fire, **K**=Flooding, **L**=Lifting, **M**=Jacking system, **N**=Falling object, **O**=Blowout, **S**=Structural.			Totals	10	4	