WHEN TRUST MATTERS

Risk Assessment of Manned Underwater Operations

Bergen International Diving Seminar 2021

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Agenda

Brief presentation of:

- Background
- Methodology
- Data sources
- Deliverable

Results

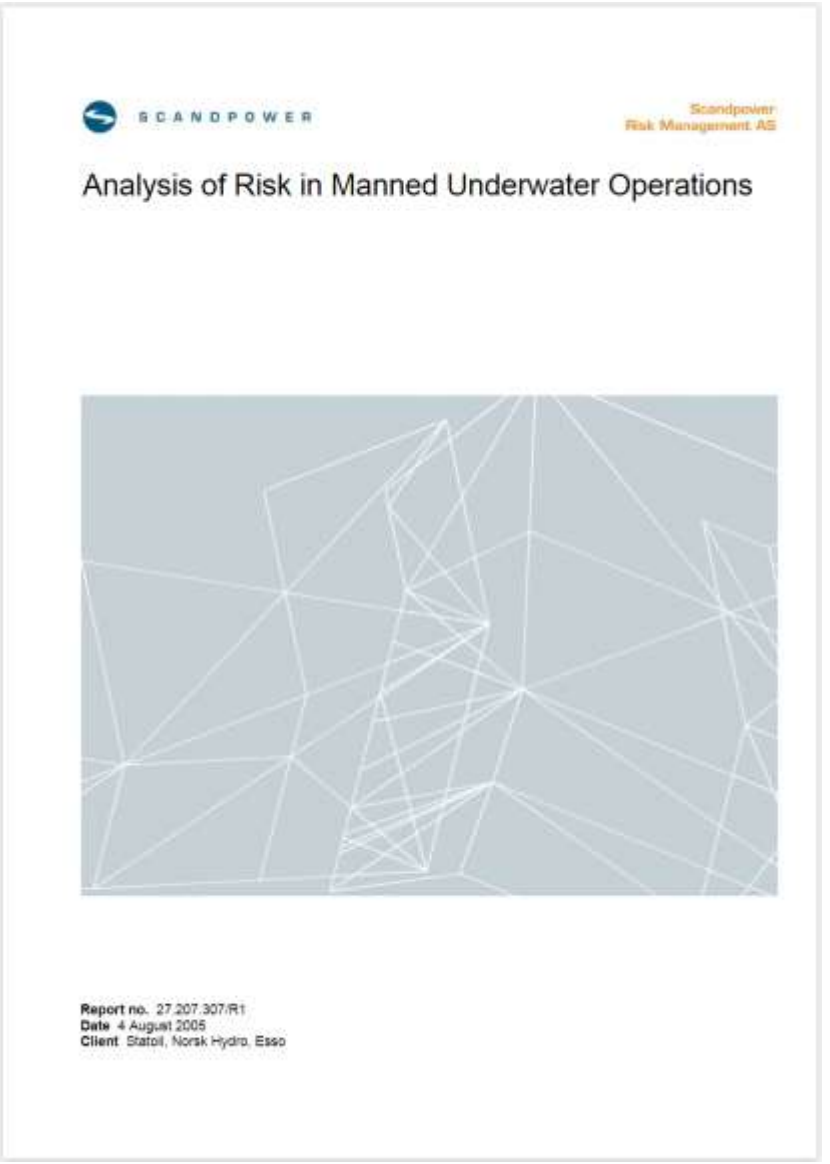
- Risk model/Barrier map
- Recommended FAR value for petroleum-related diving in Norway/North Sea
- Other findings:
  - Technical development
  - Organisational development

Brief presentation of the project

Background

- 4. August 2005 Scandpower issued “Analysis of Risk in Manned Underwater Operations” as the result of a common industry project, based on data primarily from 1990 to 2003.

- Objective of resent project:
  - Establish/recommend updated FAR value
  - Identify and describe changes over the past decades and effect on the level of safety
  - Describe hazards and barriers in "barrier maps"



Methodology

- Desk top studies, workshops, interviews and external hearing;
- Collection of data:
  - Exposure - manhours in saturation/water/compression
  - Reported incidents, diving related injuries, work related illnesses, and fatalities
- Estimation of fatality risk
- Incident analysis
- Cause analysis
- Technical and organisational development
- Risk model

Data sources

- Basis
  - Publicly available accident/incident statistics (DSYS and UK HSE)
  - Synergi-reports and activity reports (Equinor and contractors)
  - Interviews
  - Feedback from external hearing
- Focus:
  - Petroleum related diving
  - North Sea – Norwegian and UK sectors
  - 2004 – 2019

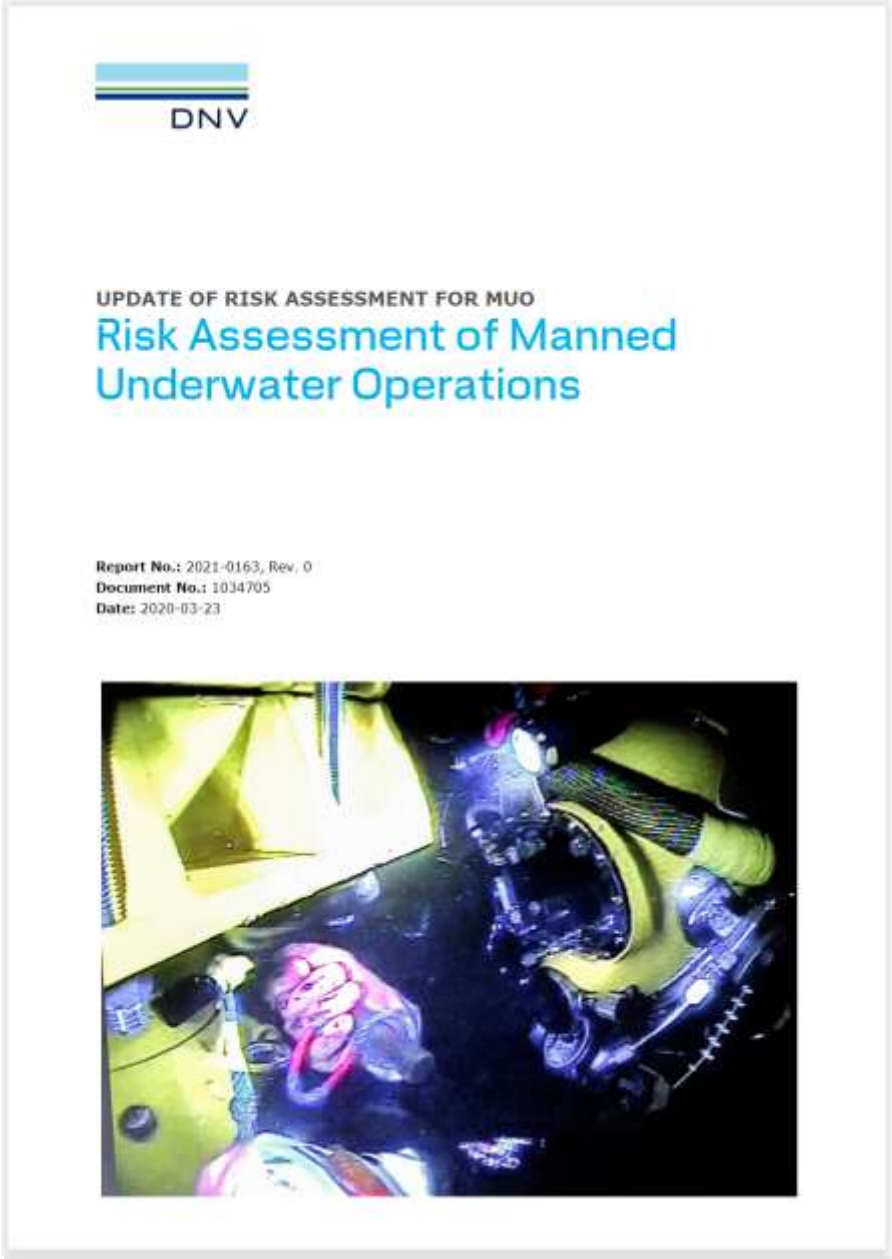
Deliverable

- DNV Report no. 2021-0163, Rev. 0 issued 30.04.2021
- Downloadable from:

https://www.dnv.com

https://www.dnv.com/cases/risk-assessment-of-manned-underwater-operations-200837

https://www.dnv.com/Publications/risk-assessment-of-manned-underwater-operations-200846



Presentation of results

HAZID-log / Barriers

9 “guide words”:
Pressure
Breahting gas
Temperature
Loss of position
Contamination/chemical expo.
Fire/explosion
Incident on vessel/installation
Chronic health effects
Occupational accident d.diving
Acute illness

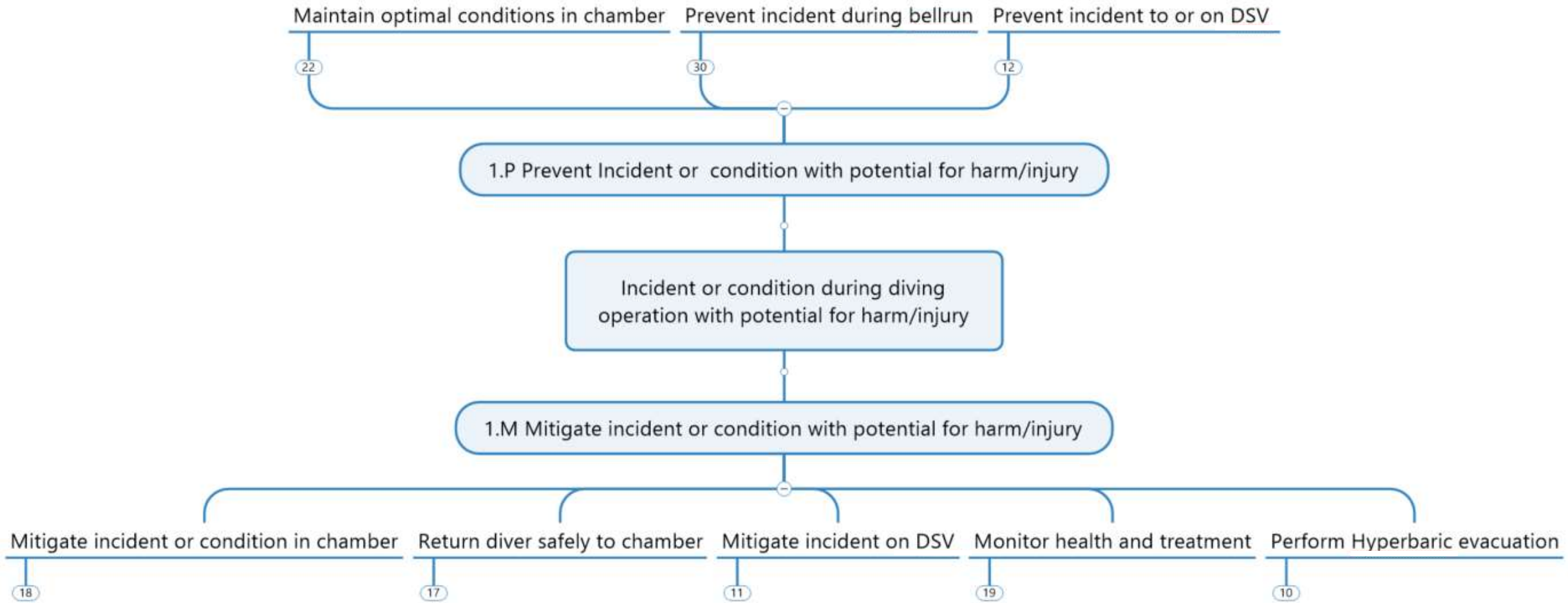
1 – 5 hazardous events for g.w.

1 – 4 causes for each hazardous event

Details in ch. 8 and App. E in the report

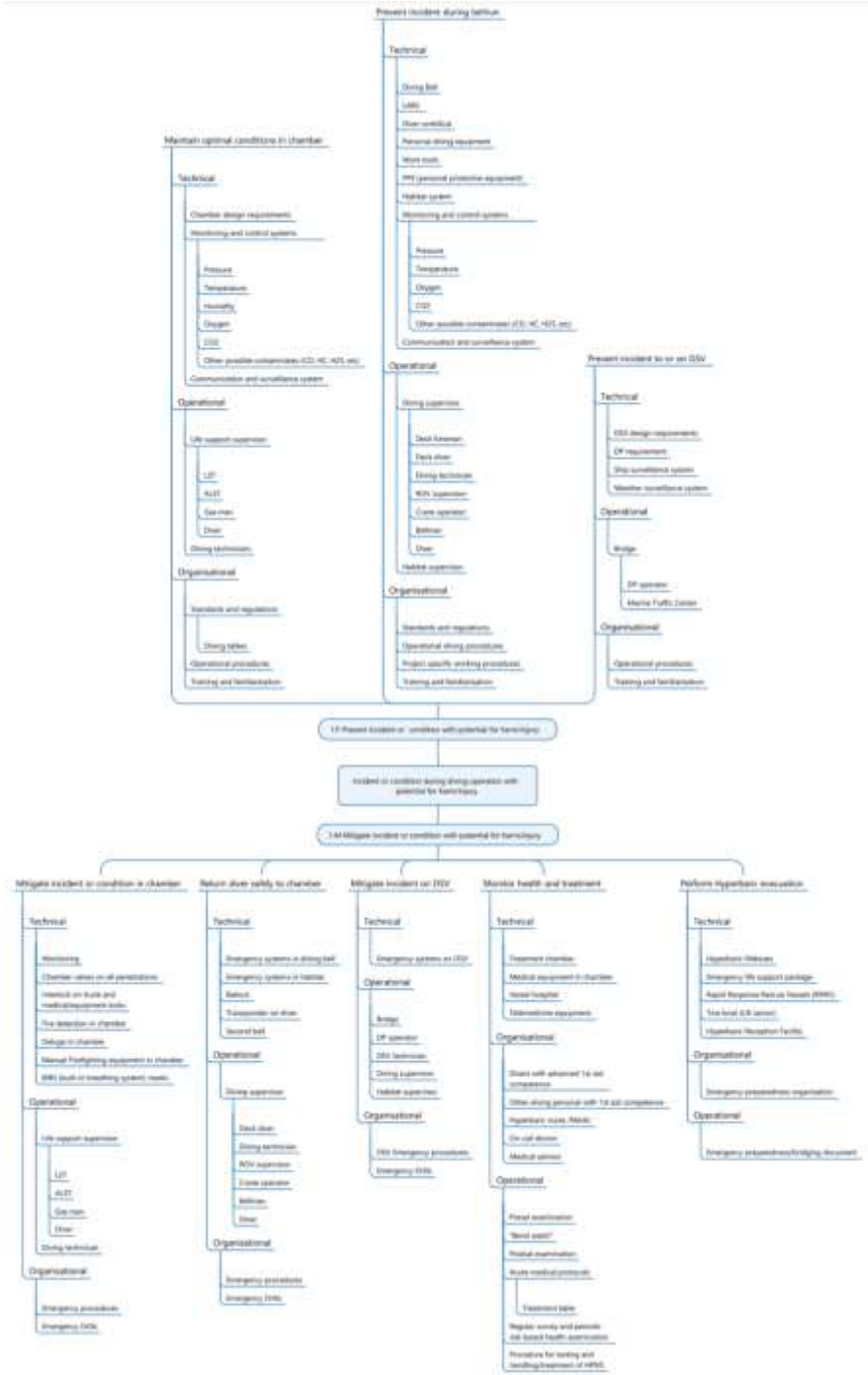
Guide word	ID	Hazardous event	Cause	Preventive barrier		Mitigating barrier		Consequence
				Barrier function	Barrier element	Barrier function	Barrier element	
Pressure	1,1	Uncontrolled decompression	Technical error leads to pressure loss in diving bell/chamber	Maintain pressure control	* Analogue/digital manometer as well as control panel	Mitigate loss of pressure control	* Its valves can be closed on all penetrations in the diving bell/chamber * Interlock on the trunk and medical/equipment locks	Decompression sickness
			ROV drags diver up	Position-monitoring of ROV	* Training of ROV operator * Communication with diving supervisor			
	1,2	Wrong decompression	Wrong decompression time	Maintain pressure control	Procedure for diving: * Diving tables (integrated in control system) * Limitation to bottom time * Diving-free-days for surface-supplied dives * Utilize correction factor for taxing surface-supplied dives	Monitor health and treatment	* "Bend watch" * On-call doctor * Treatment table * Treatment chamber * Telemedicine equipment in chamber for saturation diving	
			Blow-up, uncontrolled upwards movement of diver (with help of crane, lift bag)	Maintain correct depth	* Valves on diving suit (for surface-supplied dives) * Procedures diving tables * Diving supervisor monitors depth of diver * Umbilical management * Routing/planning * ROV monitoring of diver and umbilical	Monitor health and treatment	* "Bend watch" * On-call doctor * Treatment table * Treatment chamber * Telemedicine equipment in chamber for saturation diving	
						Mitigate loss of pressure control	* Procedure to breath out during upwards movement * Training on blow-up scenarios	
			Failure on lift bag/crane	Maintain correct depth	* Lift bag * Crane			
			Wrong operation of chamber valves	Maintain pressure control	* Procedures * Training			
	1,3	Uncontrolled compression	Technical error leads to pressure increase in diving bell/chamber Wrong opening of valves	Maintain pressure control	* Analogue/digital manometer as well as control panel * Procedures for opening of valves	Mitigate loss of pressure control	* Its valves can be closed on all penetrations in the diving bell/chamber * Interlock on the trunk and medical/equipment locks * Adjust living depth	Injury, hyperthermic situation
			ROV drags diver down	Maintain correct depth	* Umbilical management * Routing/planning	Mitigate loss of pressure control	* Adjust to living depth	
			ROV drags diver up	Maintain correct depth	* Umbilical management * Routing/planning	Mitigate loss of pressure control		
			ROV drags diver down	Position-monitoring of ROV	* Training of ROV operator * Communication with diving supervisor	Mitigate loss of pressure control	* Adjust to living depth	
Breathing gas	2,1	Mix of breathing gas not to standards	Breathing gas (quality) outside of predefined values/limits	Monitors gas quality	* Analyse breathing gas from supplier/vendor Continous monitoring of breathing gas * Analyse breathing gas from compressor	Maintain life support function	* Emergency breathing system * Quick return to diving bell * Standby-diver	Injury, death
	2,2	Contaminated breathing gas	Compressor failure introduces CO into breathing gas Exss enters breathing gas system	Monitors gas quality	* Analyse breathing gas from supplier/vendor * Continous monitoring of breathing gas * Analyse breathing gas from compressor	Maintain life support function	* Emergency breathing system * Quick return to diving bell * Standby-diver	
	2,3	Contaminated breathing gas in habitat	Welding	Monitors gas quality		Maintain life support function	* Emergency breathing system * Quick return to diving bell * Standby-diver	
	2,4	Loss of breathing gas	Loss of umbilical	Maintain life support function	* Umbilical management * Routing/planning	Maintain life support function	* Emergency breathing system * Quick return to diving bell * Standby-diver	
			Compressor failure introduces CO into breathing gas Exhaust enters breathing gas system	Maintain gas supply	* Procedures for valve operations * Training and competence	Maintain life support function	* Emergency breathing system * Quick return to diving bell * Standby-diver	
			Technical failure of main supply	Maintain gas supply	* Maintenance * Redundancy in gas supply	Maintain life support function	* Emergency breathing system * Quick return to diving bell * Standby-diver	

Barrier map


Maintain optimal conditions in chamber
Prevent incident during bellrun
Prevent incident to or on DSV
22
30
12
1.P Prevent Incident or condition with potential for harm/injury
Incident or condition during diving operation with potential for harm/injury
1.M Mitigate incident or condition with potential for harm/injury
Mitigate incident or condition in chamber
Return diver safely to chamber
Mitigate incident on DSV
Monitor health and treatment
Perform Hyperbaric evacuation
18
17
11
19
10

Barrier map

Figure 8.4,
Page 31 in the report



Recommended FAR value for petroleum-related diving in Norway/North Sea

FAR = 7

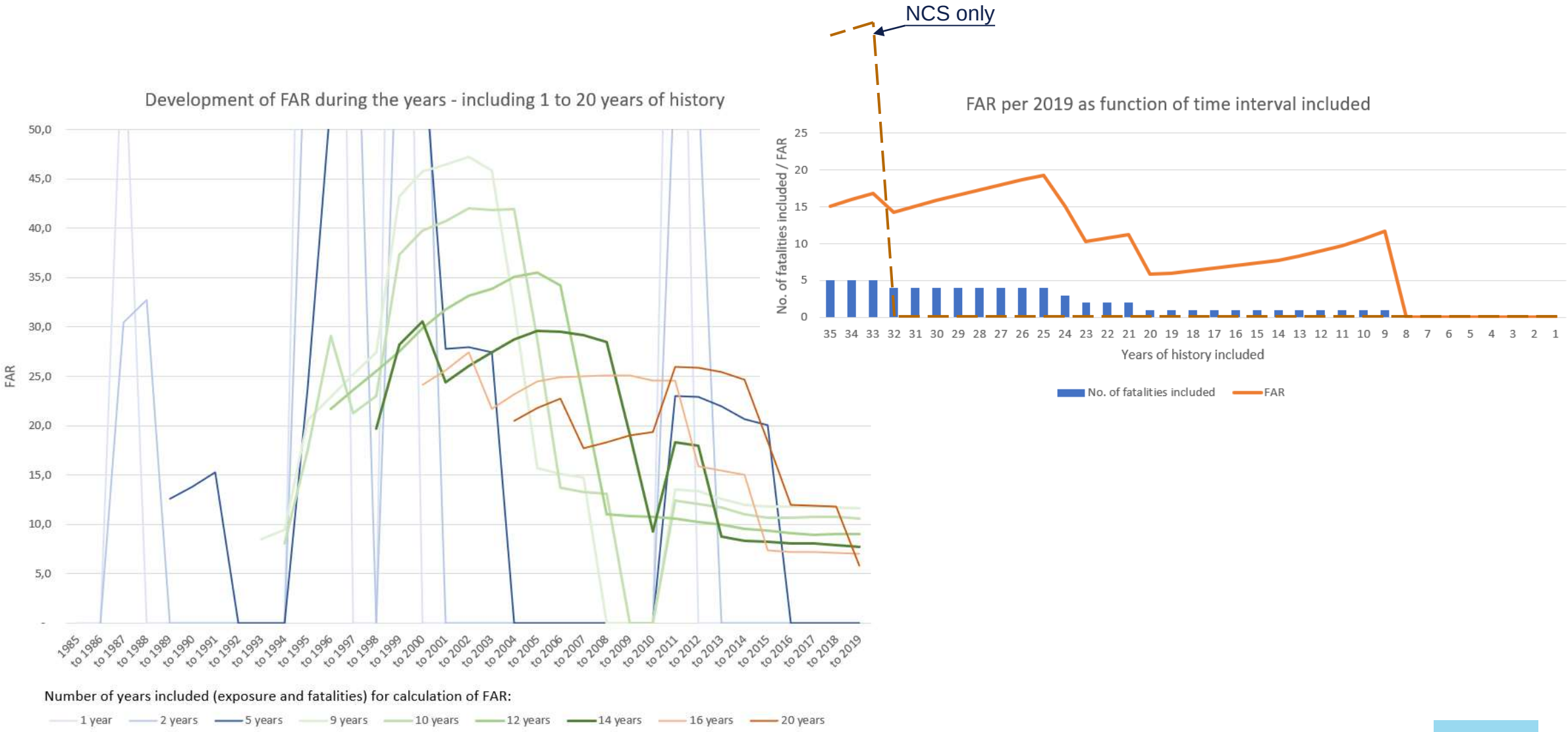
- One fatality in the UK sector in 2011, and a total of 14.3 million hours in saturation in the period 2004 - 2019:

$$FAR = 1/14250343*10^{8} = 7.0$$

Fatal accident rate (FAR) is defined as **the expected number of fatalities per 100 million exposed hours**.

DNV

FAR Value – Experienced development over time



Statistical uncertainty – prediction interval (95%)

Area	Time period	No. of hrs. in saturation	Fatalities	FAR		
				Lower limit	*Mean*	*Upper limit*
UKCS + NCS	2004 – 2019	14250343	1	0.4	7.0	33.3
UKCS + NCS	1990 – 2019	25190722	4	5.4	15.9	36.3
NCS	2004 – 2019	992343	0	-	-	302
NCS	1990 – 2019	2259053	0	-	-	133
UKCS + NCS	1990 – 2003*	10940379	3	7	27	71

Technology development

- Dedicated PLCs – continuous monitoring and automation
- Improvements to the hotwater supply and the bail out system
- Improved lay out and sizes of the chambers and bells
- Development of medical equipment that can be used inside the chambers
- Improved systems for hyperbaric evacuation and development of both stationary and mobile hyperbaric reception facilities

Organisational development

- Permanent employment perceived to give better conditions for openness and reporting. Looser contractual obligations between divers and diving contractors, and thus between divers and operating companies, may make it undesirable for divers and diving companies to report events. Thereby missing out on the opportunity for improvement and learning.
- Day rate contracts and reduced activity have reduced the perceived safety and sense of job security for some divers.
- Reduced MUO activity makes efforts to ensure a continuous preservation of the knowledge and competence important with regard to keeping safety risks under control. Relevant within the operator, engineering and contractor organisations and may be key to improve the safety and make it likely for future projects to consider diving as an option.

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