TEORI BLIR TIL TRYGG PRAKSIS

DECOM AV WESTERN ISLES FPSO

SEMAR

Who we are?

Lars Digerud

Structural Engineer

Western Isles FPSO decom:

Engineering lead pri / project engineer post (onboard the FPSO)

Øyvind Hopshaug

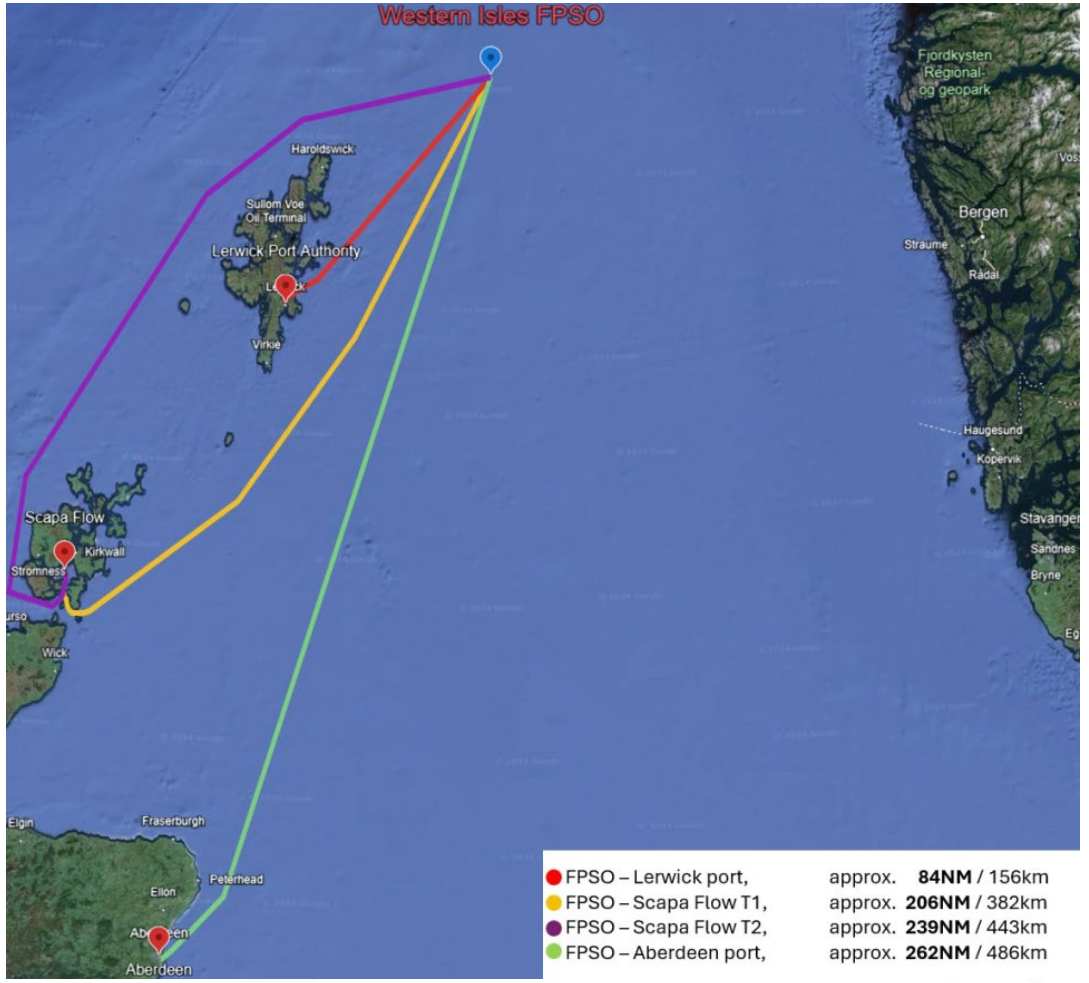
Senior Marine consultant/Master Mariner

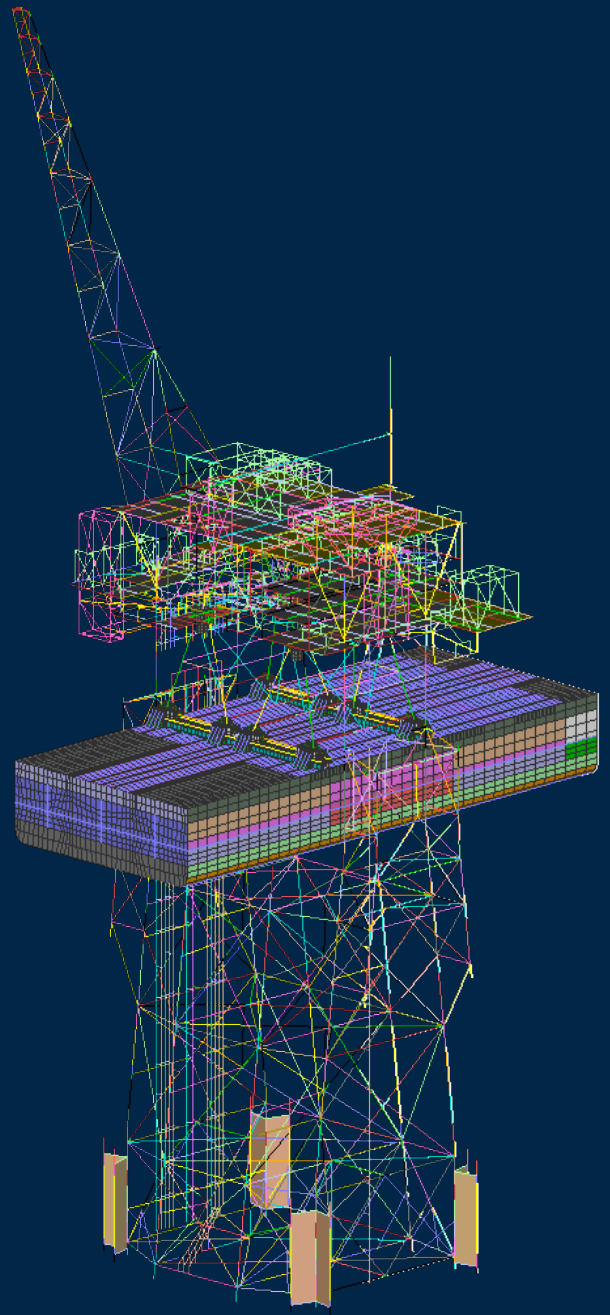
Western Isles FPSO decom :

Technical lead and Offshore manager

Agenda

- Semar
- Project Overview
- FPSO Preparation
- Station Keeping and Disconnection
- Tow To Scapa flow
- Inshore hook-up in Scapa Flow
- Mooring recovery of old mooring system



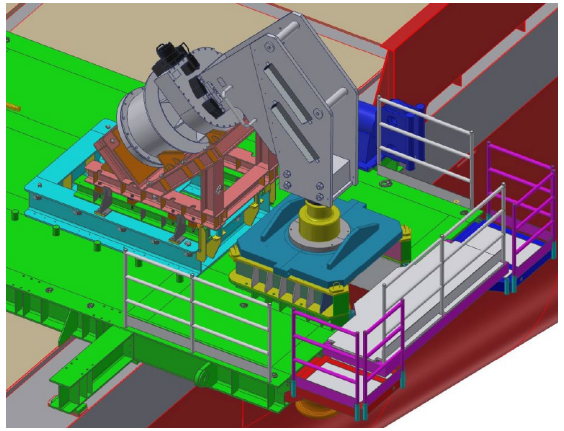


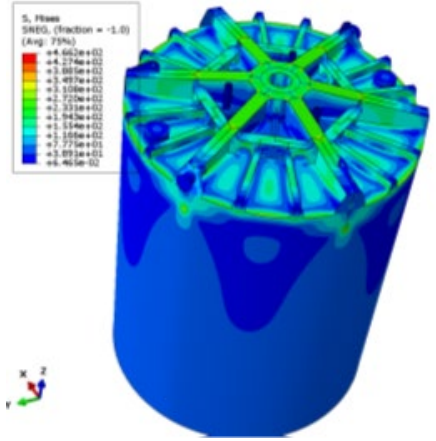
Semar at a glance

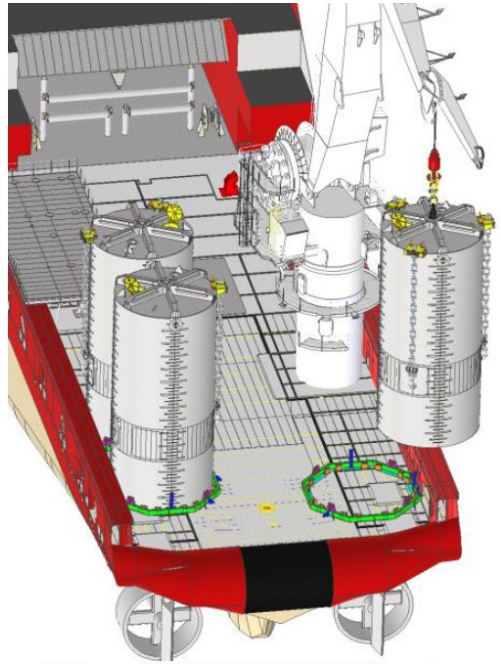
- Engineering and execution of marine operations (since 1980)
- 40+ years of experience in marine and offshore installation projects
- Have specialized and multidisciplinary competences
  - Marine hydrodynamics
  - Structural engineering
  - Marine design
  - Marine operations
- Offshore experience combined with efficient planning gives excellent execution
  - Tow & installation
  - Mooring design & installation
  - Grillage & sea fastening
  - Honeymooring
- We have engineered and executed marine operations in offshore wind since 2001:
  - Installation of world's largest floating wind park (Hywind Tampen, 2022/2023)
  - Studies/FEED for development of future wind parks

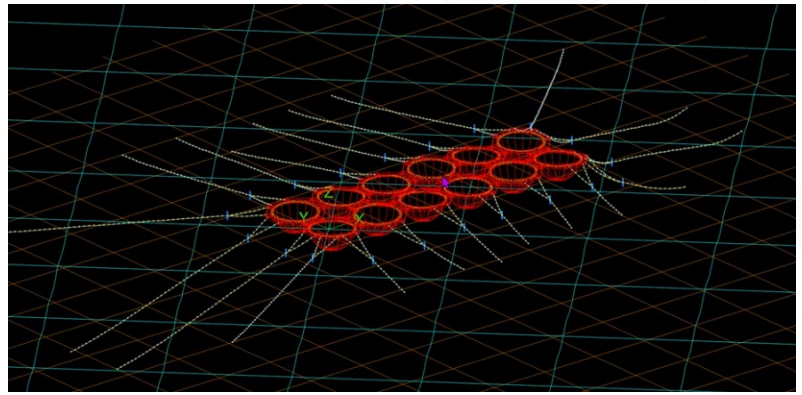
SEMAR

Semar at a glance









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Scope Overview

- **Engineering**
  - Tow and station-keeping analysis, task plans, procedures
  - Disconnection analysis, task plans, procedures
  - Rigging verifications and equipment procurement
  - Operational analysis
  - FPSO preparations
  - Development of tools for successful & safe marine operations.
- **Marine Operations**
  - Offshore station-keeping for disconnection of mooring system
  - Offshore tow from field to inshore (Scapa flow)
  - Hook-up to a pre-laid mooring system and tensioning
  - Removal of remaining offshore/field mooring system

Western Isles FPSO - Decom

- **Involved parties**
  - Dana Petroleum (operating company)
  - DOF Subsea (Project management, vessel provider, personnel provider, contract holder)
  - Semar (engineering, planning & conducting the operations)
- **FPSO details:**
  - Sevan 400 design, built in China in 2017
  - Dia. (main hull): 70.0m
  - Displacement: 69900 Te
    - Offshore draft: 16m
    - Inshore draft: 12m
    - 5 % tilt during tow
  - 12x mooring lines
    - Four clusters
    - 159mm Dia chain (top chain)
  - Four 300Te SWL Smit brakets

Project Overview Vessels

Skandi Hera – primary Installation Vessel (IV)
Odin of Scapa – inshore Tug

Skandi Mercury – tow #1

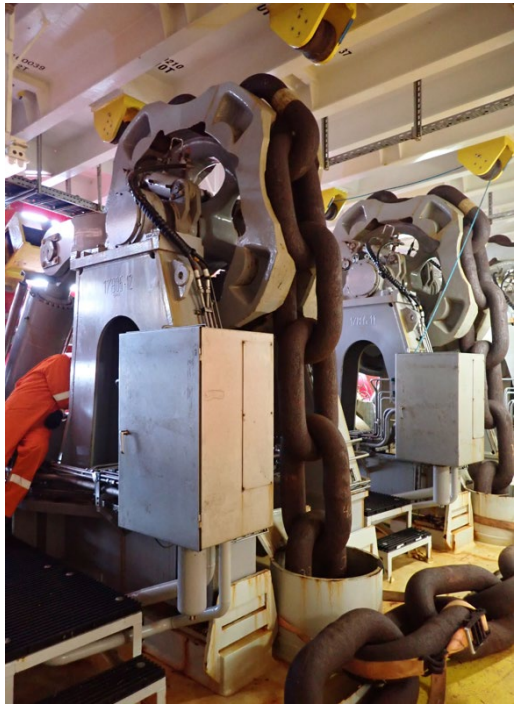
Skandi Jupiter – tow #2

Skandi Peregrino – station keeping

FPSO Preparation

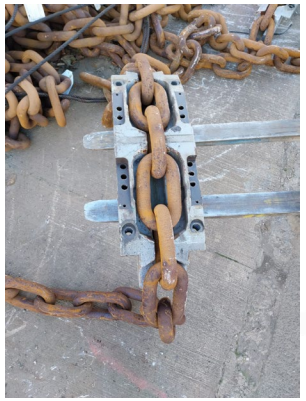
- Site visit (3 month ahead of operation)
  - COMPANY Responsibilities (after site visit)
    - Function testing of mooring interfaces
    - Rust removal, DNV certifications, tugger winch installations, etc.
    - Emergency towlines
  - Familiarizing of mooring interfaces
- Purchase and mobilization of equipment
- No securing of fairleads prior tow - agreement with COMPANY (ROV survey when at destination)

Trial fit connection between 159 to 84mm dia chain



Function testing of mooring winches

Function test inlays

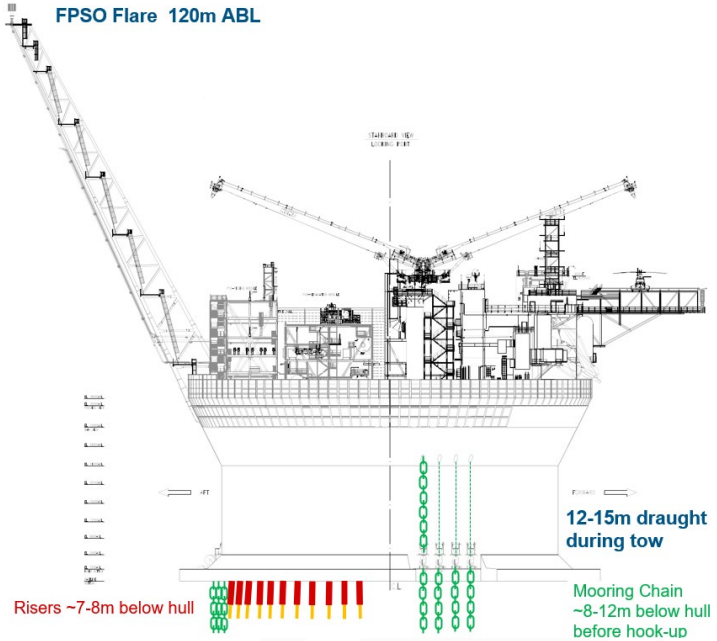


Trial fit 50mm chain to inlays

Corroded Smith Brackets. Function testing

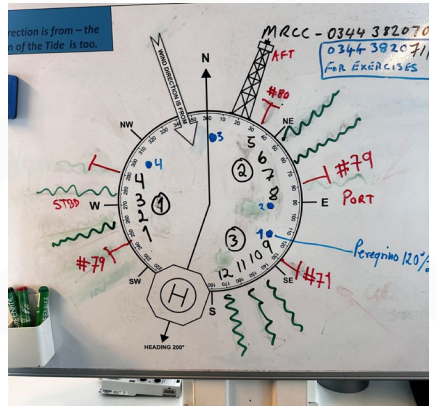
Offshore Station-keeping & Disconnection

- Station-keeping and tow analysis performed.
  - Verifying vessel capacities versus environmental requirements.
  - Verifying rigging (tow pennant rigging)
  - Protubing risers & chain below hull
    - 27 m extreme draft inshore (water depth: 30 – 40 m inshore LAT)
- 3 AHT vessels BP ranging from 187t to 284t available.
- 1 AHT for disconnection work
- Helicopter arrivals
  - Max. 2h notice Mon-Sun during all Helicopter operations
  - Vessels to be outside helicopter safety entrance zone 1 hour before helicopter arrival
    - Had to incorporate plans and tactics for maximizing operations for this (e.g. disconnections)



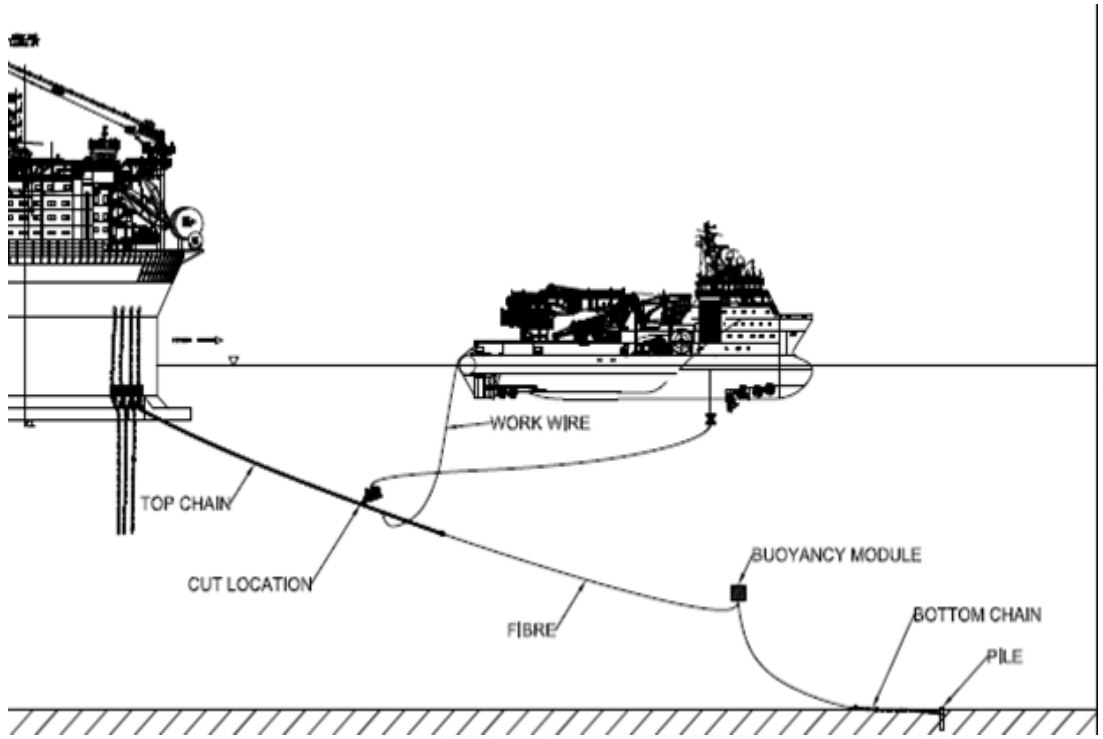
Environmental Citeria	Required bollard pull [t]
Weather restricted	259
Weather unrestricted	432

Combined estimated required BP pull during offshore station-keeping



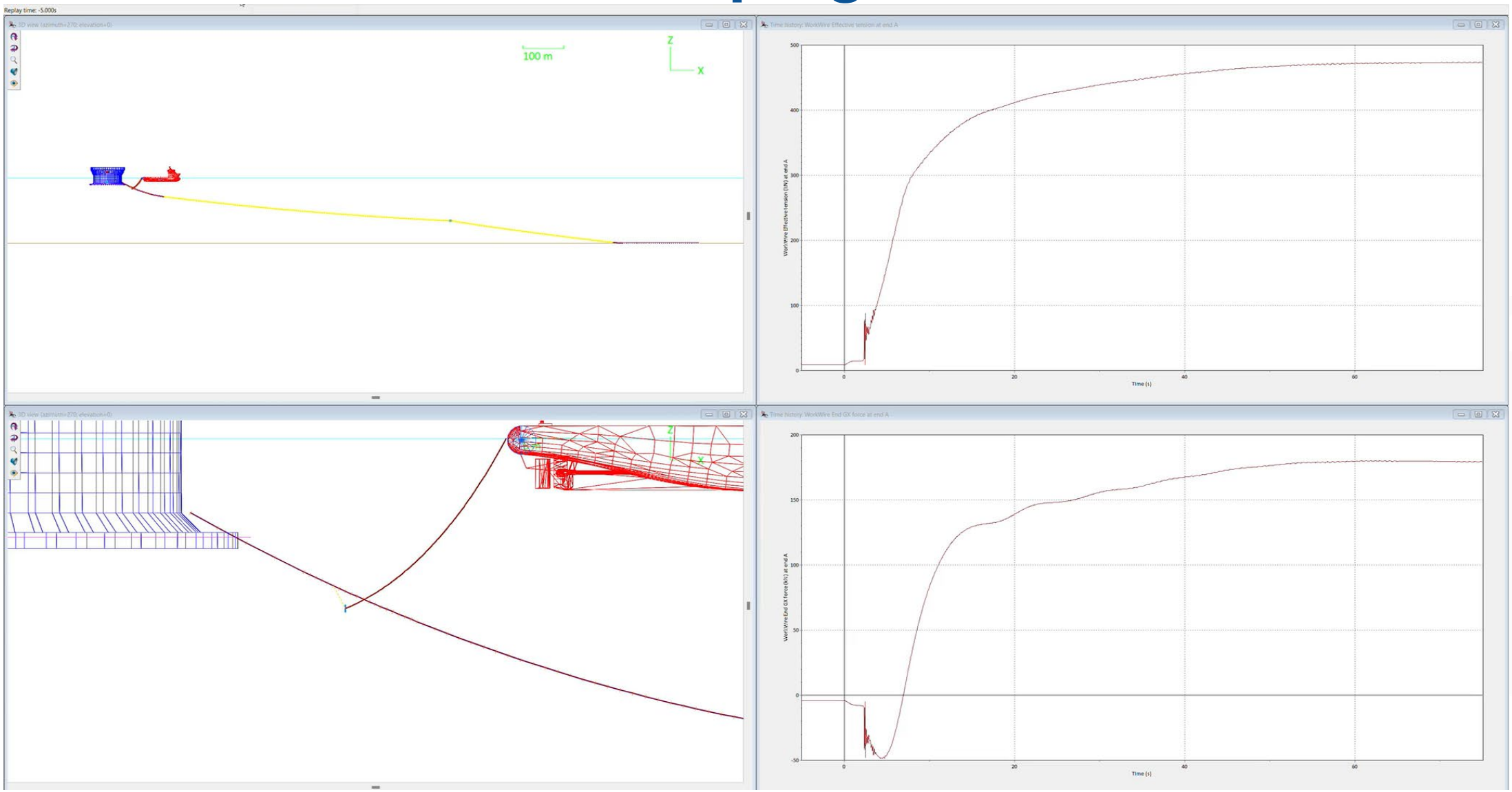
Offshore Station-keeping & Disconnection

- Before we started to disconnect the first 6 mooring lines the FPSO had slacked out all chain on these lines.
- When a line was disconnected it was laid down on the bottom with a ROV friendly pick-up system
- After 6 mooring lines was cut the Station keeping vessels connected the tow line to Smit brackets on the FPSO
- FPSO slacked out the remaining lines for disconnection. And the IV disconnected the last 6 lines.



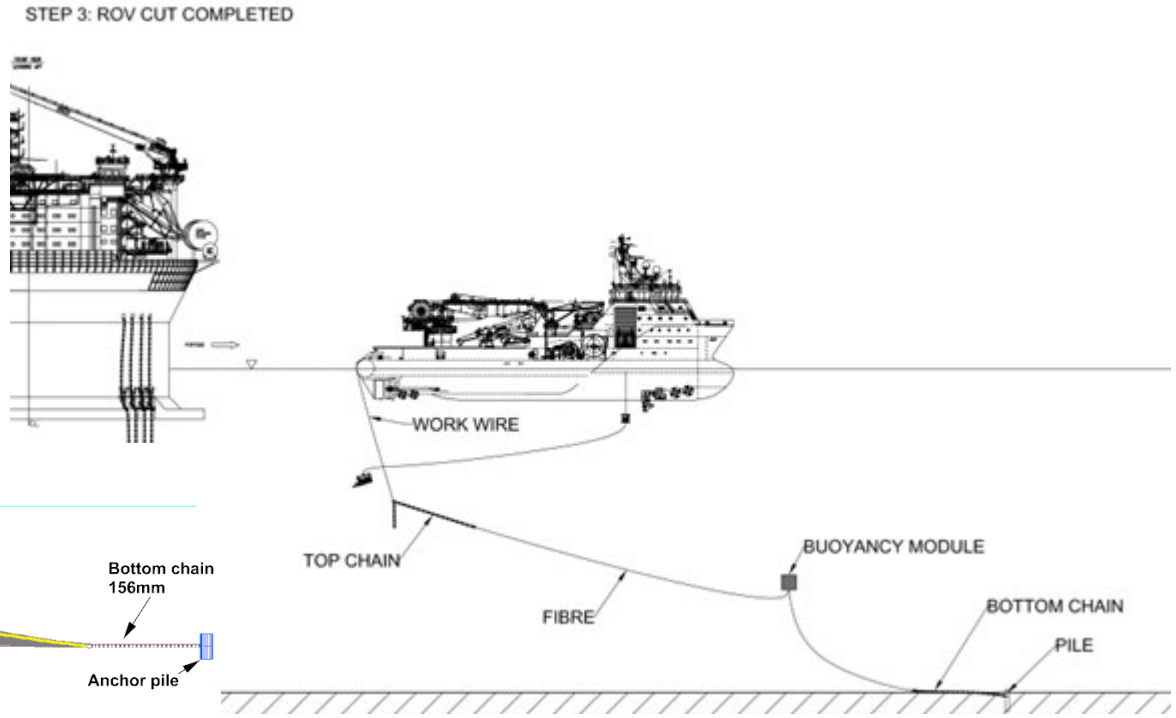
Water depth at offshore field: 150 – 165 m (LAT)

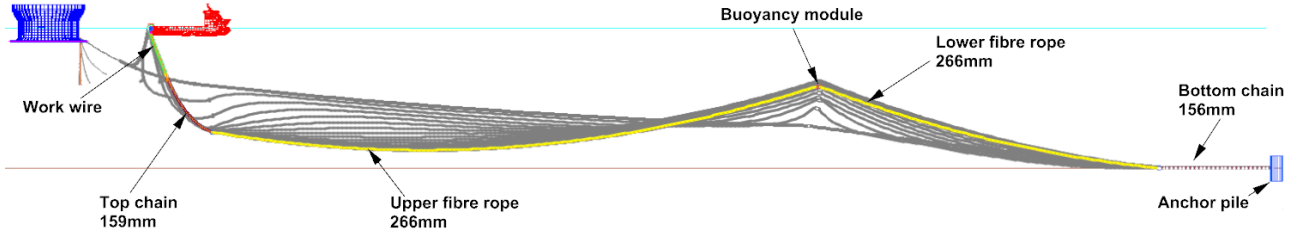
Offshore Station-keeping & Disconnection

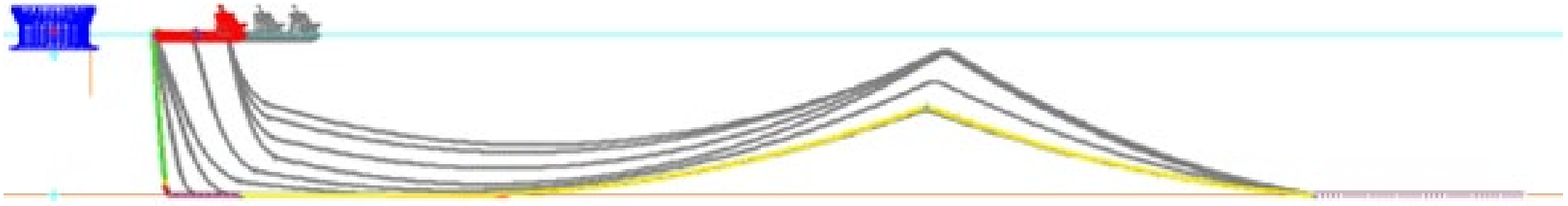


Offshore Station-keeping & Disconnection

- The analysis showed that the AHT should experience about 50t tension in work wire when the chain was cut.
- During the operation, the experienced load in work wire was just above 50t tension when after the chain was cut.







Offshore Station-keeping & Disconnection

- **Mid water chain cutting of 159mm dia chain**
  - The chain was cut with a 6,5" Chain cutting DWCM
  - Mooring line tension during cut operation approx. 120t

Cleaning of 159mm Dia chain prior installing cutting tool

Offshore Tow

- Two tow vessels
  - (Max +10 % allowed BP more than weakest tug)
  - Experienced «trailing» slow alternating motions on FPSO during tow
  - Ca. 2.5 day used on the tow
- Emergency Shelter locations
  - Four locations on either side of Shetland Islands and Orkney Islands was found/planned in case of bad weather forecasted.

Analysis environmental min. constrains:

Phase	Hs [m]	Wind speed [m/s]	Current speed [m/s]
DNV holding criteria: Offshore Tow (zero speed)	5	20	0.5
Offshore Tow (forward speed)	2	15	0.5
Inshore Tow	2	10.3	0.5

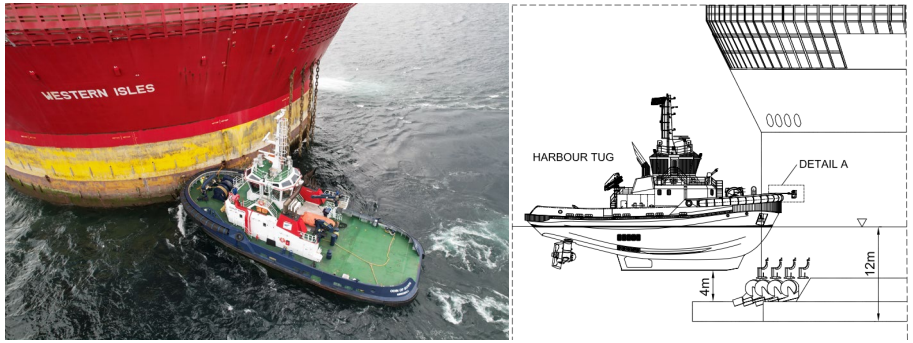
Estimated required BP pull during offshore tow:

Tow Phase	Draft [m]	Tow speed [m/s]	Min. Req.Total BP [Te]	Min. Req. BP per AHV [Te]
DNV holding criteria: Offshore Tow (zero speed)	12	0	240	120
Offshore Tow (forward speed)	12	2	387	193
Inshore/harbour Tow	12	2.1	381	190

We maintained 4 knots (2.06m/s) tow speed on average from start to final hook-up inside Scapa Flow.

Inshore Tow & Hook-up

- 2 AHVs (200Te BP min.) & 1 harbor (70Te BP min.) tug for station-keeping
  - 1 IV (AHV) for connecting mooring lines
- Challenging entrance – short entrance window & narrow sound
- Struggled with heading control through the narrowest point during inshore tow
- Prelaid mooring system
  - Needed a method on estimating required mooring line to be inserted to reach target tension dependent on varying pre laid mooring lengths and locations.
- Not allowed to drop chain connection, due to risk of remaining Unexploded Ordnances (UXO) in Scapa Flow (potential UXOs identified during pre-survey)
  - (where the Germans sunk their warships during WW1)
- Towline tensions to be maintained to avoid contact with seabed and snagging to any abnormalities (catenary control)



Harbor tug connection to sunken bit

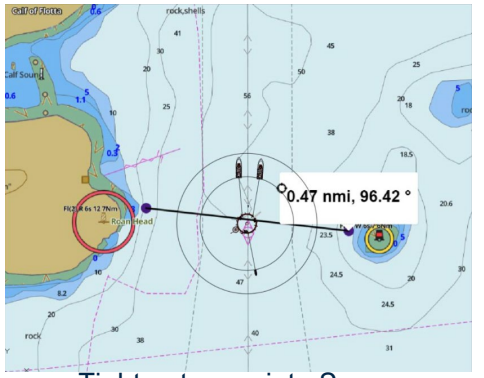
Water depth inside Scapa flow: 25 – 35m (LAT)

Scapa Flow Entrance – Challenging Tidal Currents

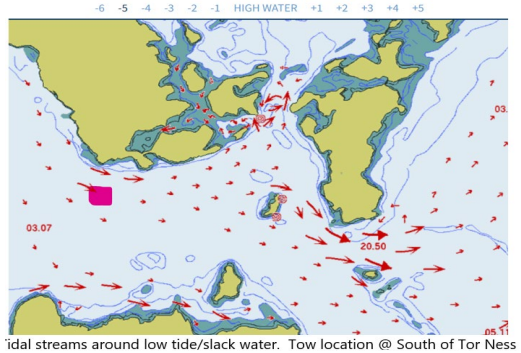
- Challenging tidal currents. Alternating currents.
  - Tidal currents stronger than combined BP when at max
- Short weather window for entering Scapa Flow
  - Timing the start of inshore tow was crucial
- Local shipping restrictions

GO / NO-GO	Start date	End date	Days
GO	29/06/2024	05/07/2024	7
NO-GO	06/07/2024	11/07/2024	6
GO	**12/07/2024**	**20/07/2024**	**9**
NO-GO	21/07/2024	28/07/2024	8
GO	29/07/2024	03/08/2024	6
NO-GO	04/08/2024	10/08/2024	7
GO	11/08/2024	17/08/2024	7
NO-GO	18/08/2024	26/08/2024	9
GO	27/08/2024	01/09/2024	6

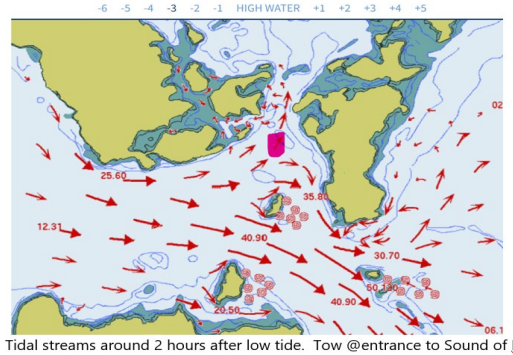
Entrance windows



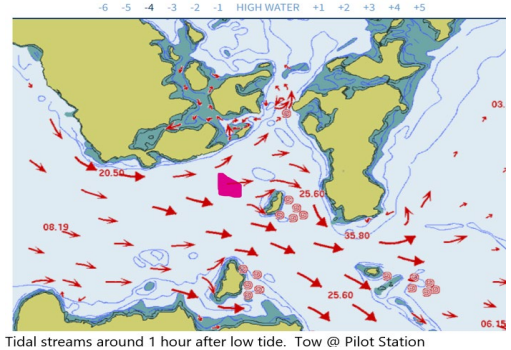
Tight entrance into Scapa Flow (outer radious 300 mtr)



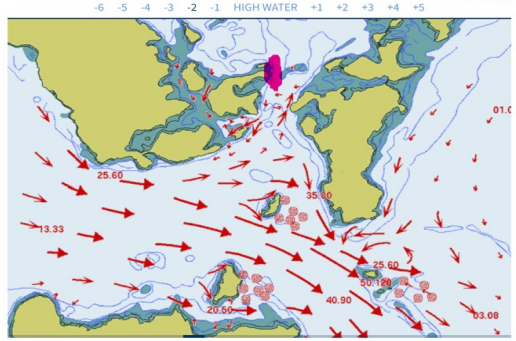
'idal streams around low tide/slack water. Tow location @ South of Tor Ness



Tidal streams around 2 hours after low tide. Tow @entrance to Sound of Hoxa



Tidal streams around 1 hour after low tide. Tow @ Pilot Station



Tidal streams 3-4 hours after LT. Tow @ Roan Head

Western approach (W/tidal charts)

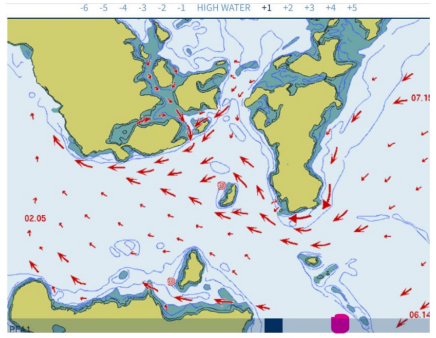


Figure 10-6; Start tow from East stby location position (HW +1)

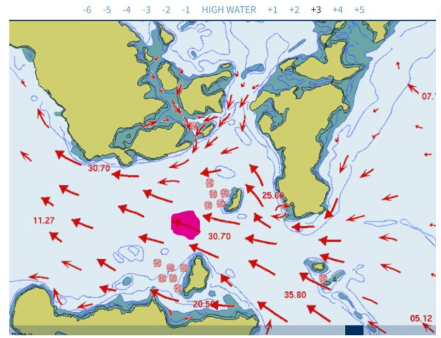


Figure 10-8: Tow @ SW of Swona (HW+3).

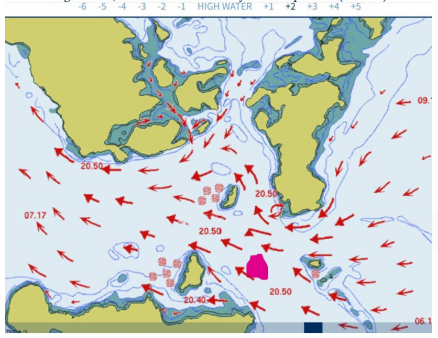


Figure 10-7; Tow W of Pentland Skerries (HW+2).

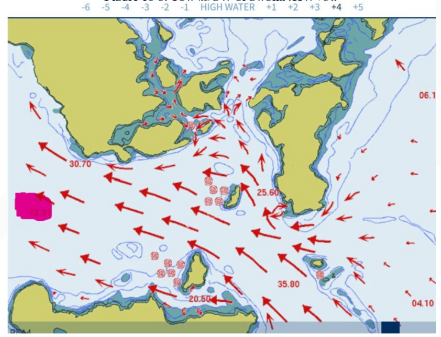


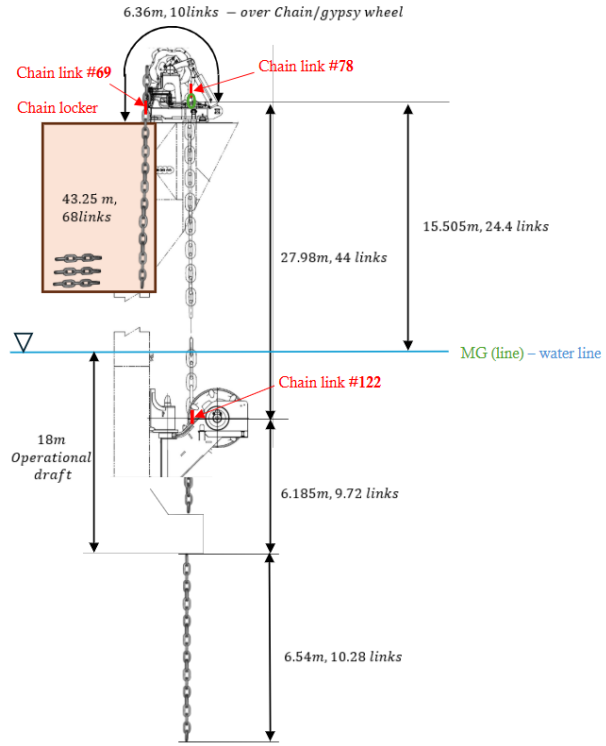
Figure 10-9; Tow thru Pentland Firth @ Western Stby position (HW+4).

Eastern approach (W/tidal charts)

SE MAR

Inshore ML hook-up

- Developed a tool to determine the exact chain length needed to reach target
  - Could estimate chain length upon varying target tensions
  - Used to prevent MG in chain lockers
  - Reduce risk of having to pull chain outside chain lockers
  - Utilized the tool to verify pre-laid mooring arrangement:
    - Identified discrepancies in the pre-laid mooring system length
      - Found that the pre-mooring was longer than reported.
- Used analysis to check tensions when hook up
  - No problem
- Analysis: Verify risk of chain contact w/seabed

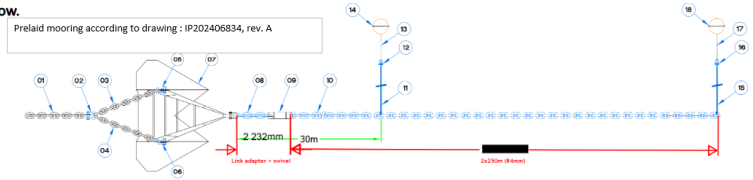


WI FPSO Additional Chain Length Calculations, Scapa Flow.

Input Output

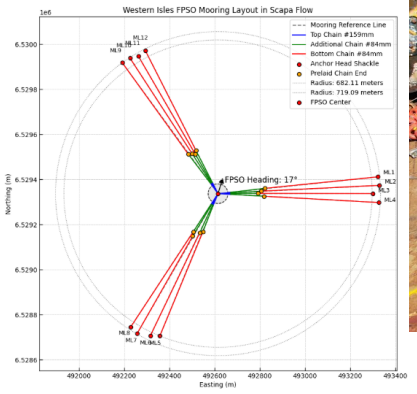
ML Target Tension @fairlead [Te]	Water Depth (LAT)	Chain Geometry	
60	36m	Chain Dia.	0.084m
		Length of link	0.336m

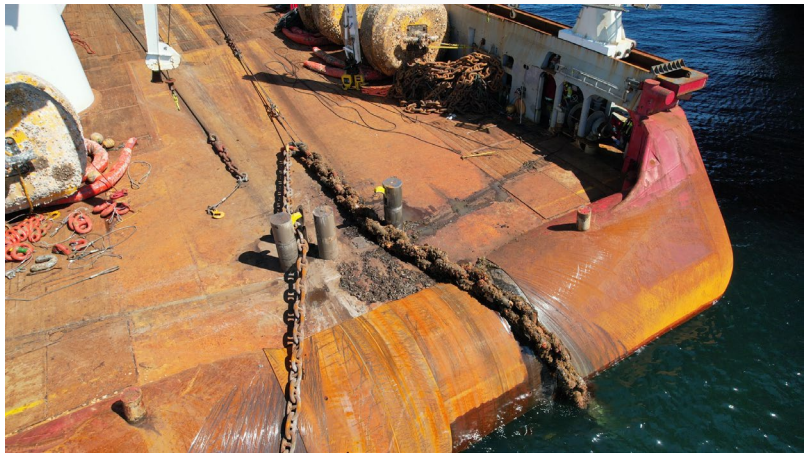
FPSO Target Center Coordinate (UTM)	Easting [m]	Northing [m]
	492616	6529337



Additional chain calculations; Chain composition: 1x125m + 1x45m (primary the 45 meter section to be cut)

Mooring Line No.	Anchor Head Shackle (post tension) UTM Coordinates		Prelaid Chain End UTM Coordinates		Chain twist (seen from chain end)		Prelaid ML length (by UTM) [m]	Prelaid ML length (by memo) [m]	Prelaid length deviation (UTM/memo) [m]	Pre-laid chain end from FPSO center (by UTM) [m]	Total Additional chain length required [m]	Connection elements [m]	1st section chain length [m]	2nd chain section(45m) required lenght		Comments
	Easting [m]	Northing [m]	Easting [m]	Northing [m]	Number of twists	Direction								Lenght in meters [m]	Lenght in chain links [no]	
1	493324.30	6529411.62	492822.84	6529360.56	1.00	CW	504.1	502.9	1.1	208.2	156.25	1.01	125.00	30.2	90	
2	493328.93	6529373.80	492806.32	6529348.23	1.50	CCW	523.2	521.9	1.3	190.7	138.72	1.01	125.00	12.7	38	
3	493300.95	6529337.29	492792.25	6529338.23	0.25	CCW	508.7	502.9	5.8	176.3	124.33	0.67	125.00	-1.3	-4	
4	493328.08	6529297.53	492818.54	6529325.49	1.50	CW	510.3	502.9	7.4	202.9	150.94	1.01	125.00	24.9	74	
5	492358.38	6528705.41	492548.93	6529167.20	0.00	NA	499.6	502.9	-3.3	182.6	130.64	1.01	125.00	4.6	14	
6	492316.61	6528706.83	492535.05	6529163.13	1.00	CCW	505.9	502.9	3.0	191.8	139.86	1.01	125.00	13.9	41	
7	492257.84	6528716.02	492503.89	6529148.71	0.25	CW	497.8	502.9	-5.1	219.1	167.21	1.01	125.00	41.2	123	
8	492230.12	6528746.15	492506.87	6529168.10	0.00	NA	504.6	502.9	1.7	201.1	149.16	1.01	125.00	23.2	69	
9	492192.25	6529917.97	492484.61	6529511.71	1.50	CW	500.5	497.9	2.6	218.6	166.67	1.01	125.00	40.7	121	
10	492226.57	6529938.26	492500.85	6529515.32	1.75	CW	504.1	502.9	1.2	212.3	160.34	1.01	125.00	34.3	102	
11	492263.80	6529946.43	492515.62	6529512.23	1.50	CW	501.9	502.9	-1.0	201.9	150.02	1.01	125.00	24.0	71	
12	492294.92	6529970.71	492518.28	6529528.34	0.00	NA	495.6	502.9	-7.3	214.8	162.92	1.01	125.00	36.9	110	
Comments:								added 2x kenterlinks. ML 9 chain lenght given to 495 mtr	Deviation explained i chain production certificates		Additional line length between fairlead+20m @159mm to prelaid chain end					





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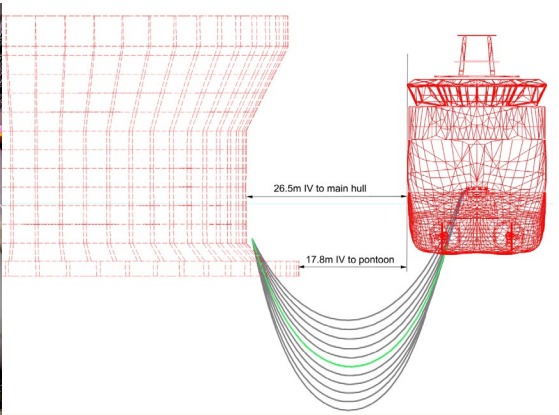
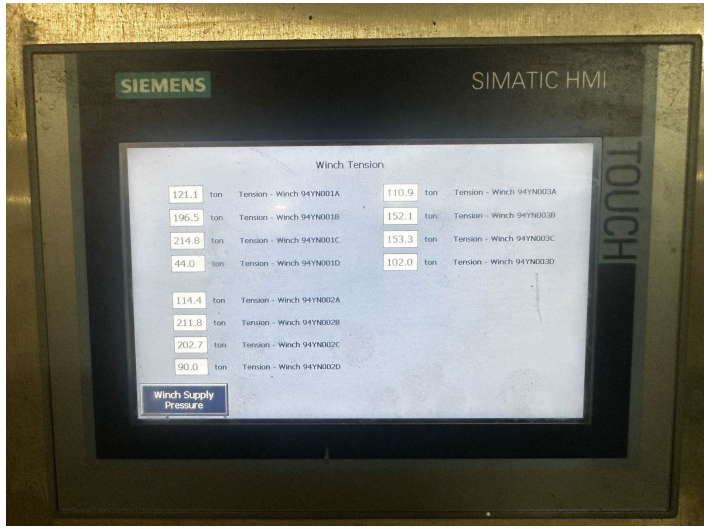
Moring line tensioning

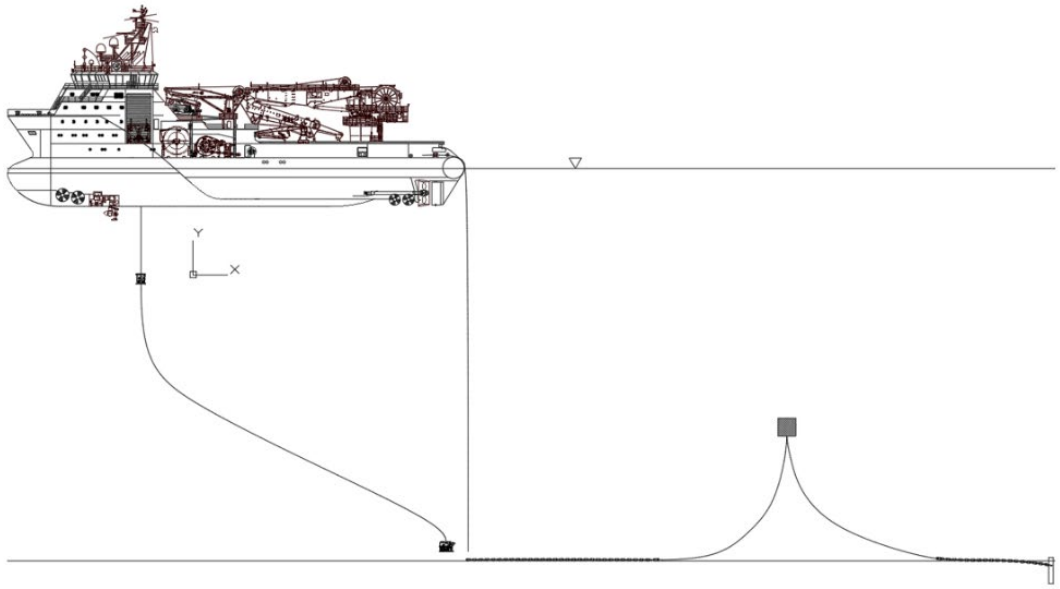


- **Target mooring line tension:** 60Te (LAT)
- **Chain connection point:** Positioned 20mtr outside fairlead
- **Sensor reliability issues:** Mooring winch sensor readings drifted shortly after calibration. Frequent recalibrations were necessary to ensure accurate and reliable tension measurements.
  - Calibration and monitoring were supported by highly experienced personnel.
- **Tension testing:** Mooring line tension test was performed when 6 lines were connected.
- **Tension verification method:** The mooring line (ML) touchdown location was used in comparison with analysis as a contingency method to verify line tensions, due to limited confidence in FPSO tension measurements.



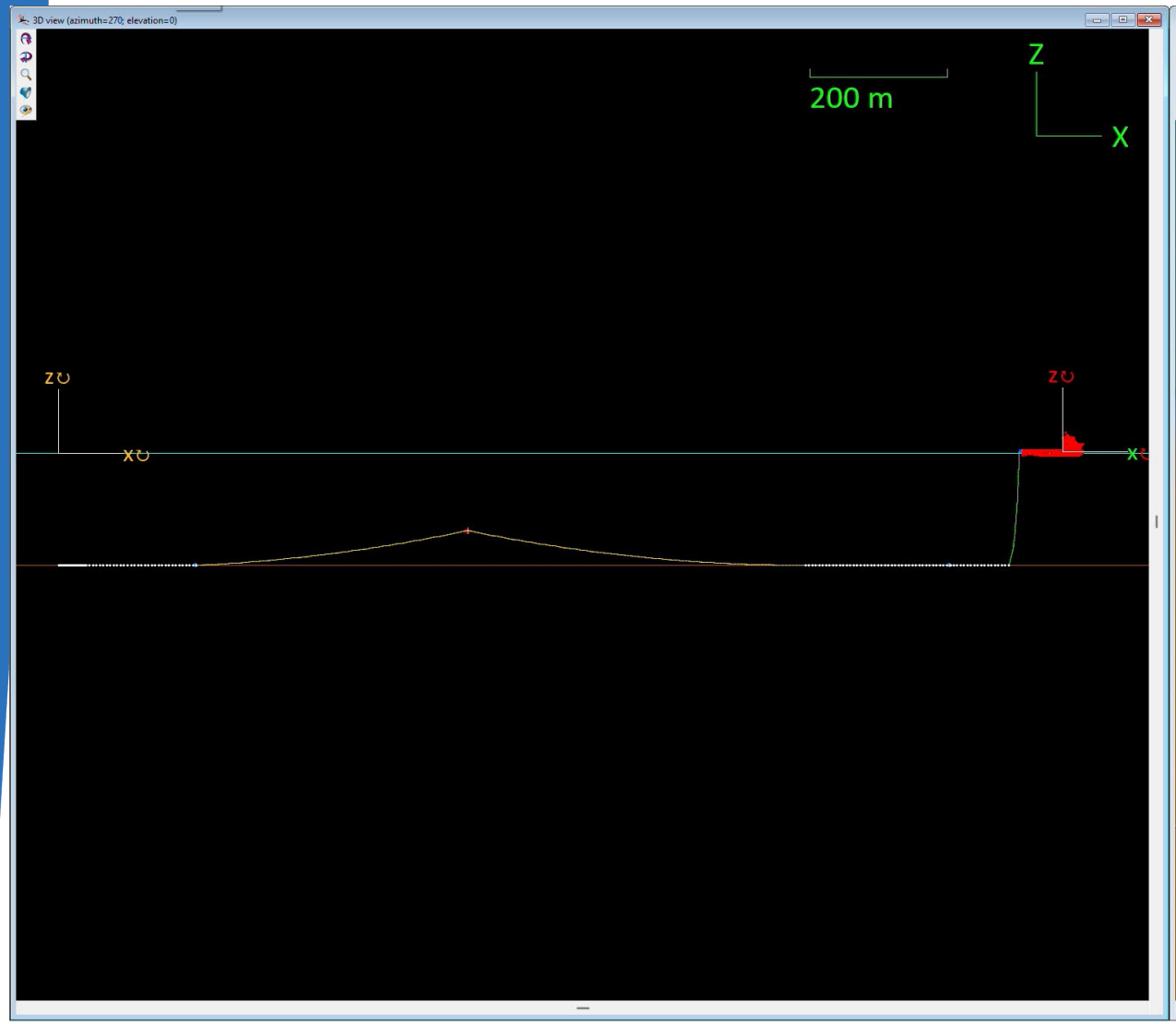
Mooring Line Recovery

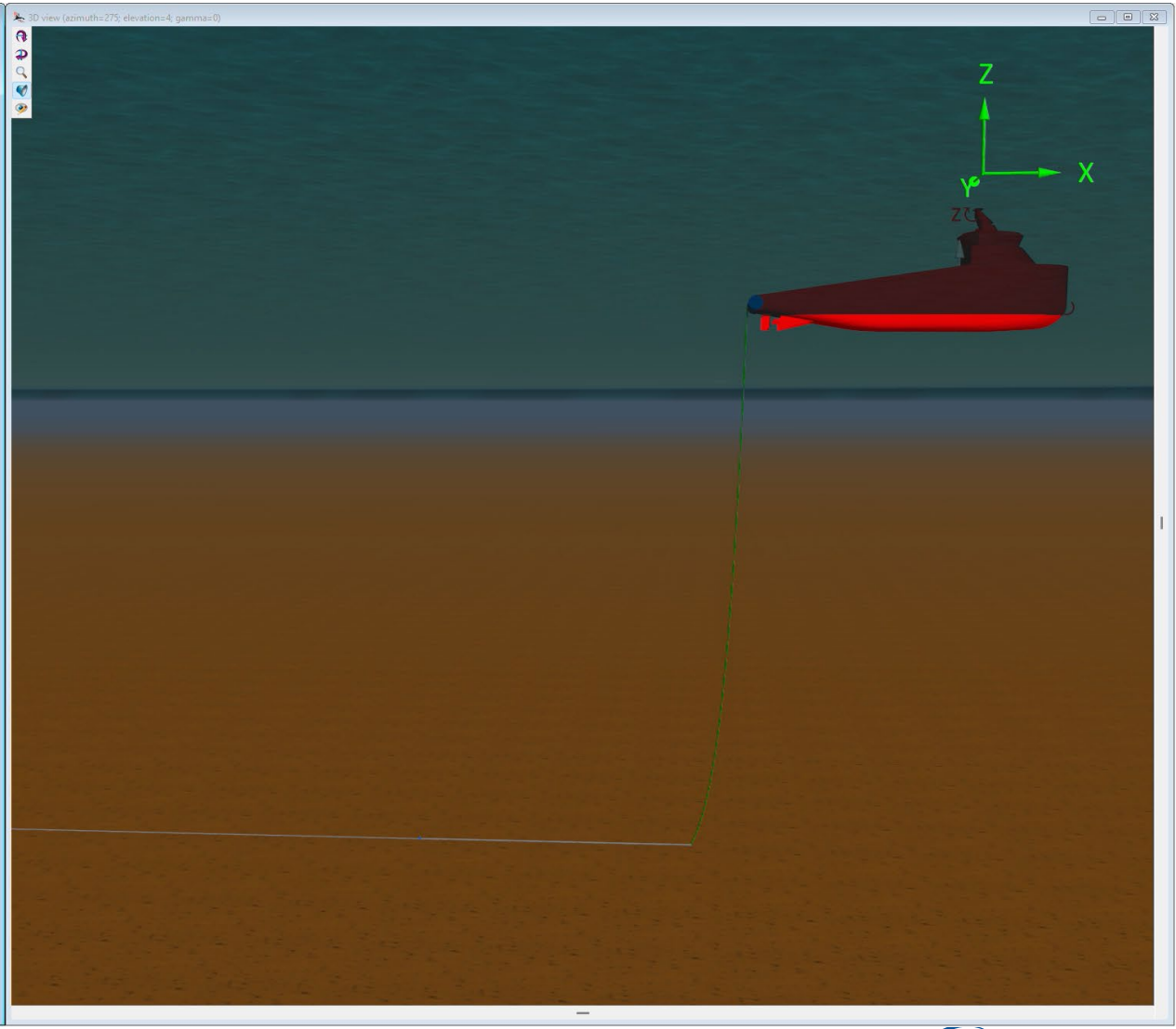
- 1 IV (AHV) for Recovery of mooring lines
- Recovered 3 complete lines each trip
- 4 trips to Lerwick to offload
- Each mooring line consisted of
  - 90m 159mm top chain
  - 700m fibre rope 266mm
  - Mooring line buoyancy
  - 400m fibre rope 266mm
  - Approx 210m159mm bottom chain
  - Pile anchor (Not recovered)



Water depth at offshore field: 150 – 165 m (LAT)

Mooring Recovery



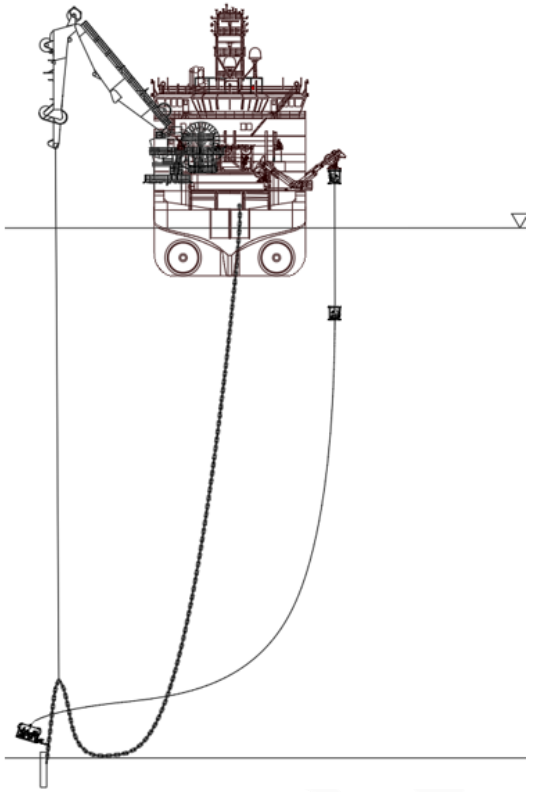


Recovery of fibre ropes and buoyancy modules

- During the planning of the fibre rope recovery the calculations showed that the whole length of 1 700m and 400m fibre rope would not fit on secondary winches.
- Picture to right shows the packing after recovery. Calculations was too conservative ☺

Chain Recovery

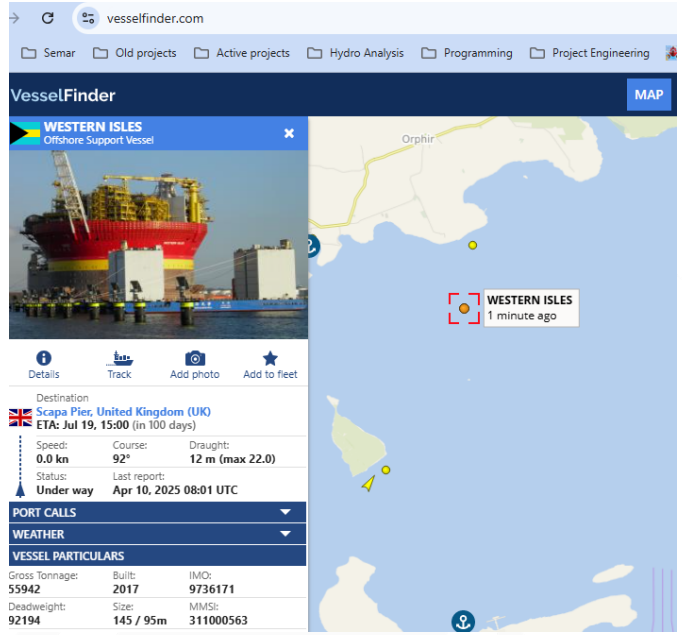
- Top chain was recovered into chain locker and interconnected with the bottom chain using a chain sling.
- 159mm was close to max size for the shark jaws and chain chutes.
- Bottom chain was cut close to pile anchor.



Wrap up – Ensuring Safe Operations

- Pre-engineering utilized to identify critical steps in the Work of Scope:
  - Optimize the WORK
  - Thorough analysis to verify and establish operational capabilities against environmental conditions
  - Rigging capacities and operational scenarios throughout examined prior operations

- It is important to allocate sufficient time before operations to identify challenges, explore solutions, and plan accordingly.
  - Navigating the tight and challenging entrance window to Scapa Flow
  - UXO
  - Rigging & vessel capacities
  - That planned methods will work
  - Chain hook-up will work



Thank you!

Contact:
lars.digerud@semar.no
oyvind.hopshaug@semar.no