



# Anchor Recovery

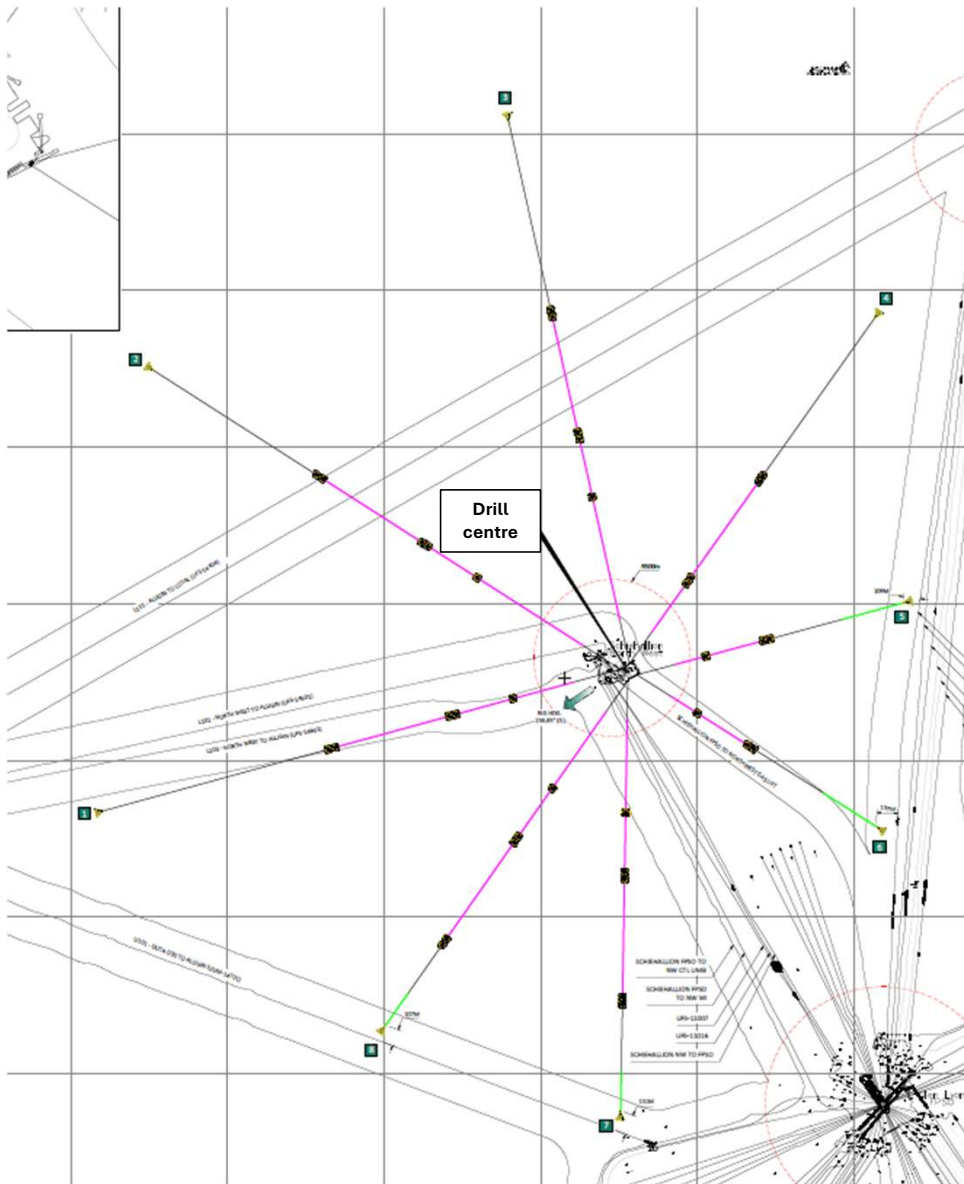
Comparison of 18te mk6 2x AHV Recovery  
and  
Bruce DENNLA



# Case Study 1

- 500m water depth
- West of Shetland
- Dense clay
- 18te Stevpris mk6 at mud angle
- High installation tension [approx. 350te]
- Anchors had been in place for over a year





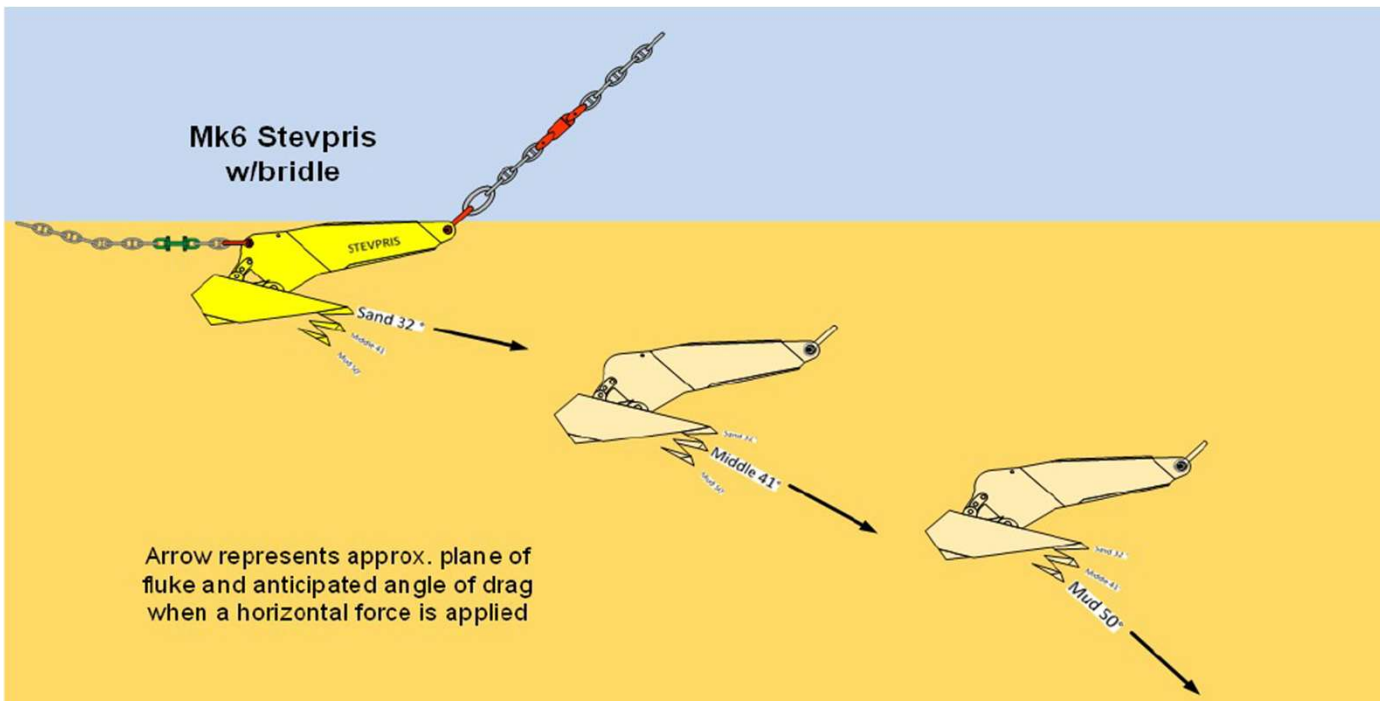
- Congested seabed
- Standard spread uses 84mm R5
- Short chain allocation on some lines due to asset proximity
- 120mm R3S used to shorten ground chain allocation without sacrificing weight / grounded length
- Max 500m x 120mm R3S on one line



**Anchors with plenty of space behind were recovered by the standard method [AHV turn 180° and pull backwards].**

**This left several anchors with assets close behind – some closer than others.**

# Identified problems / challenges



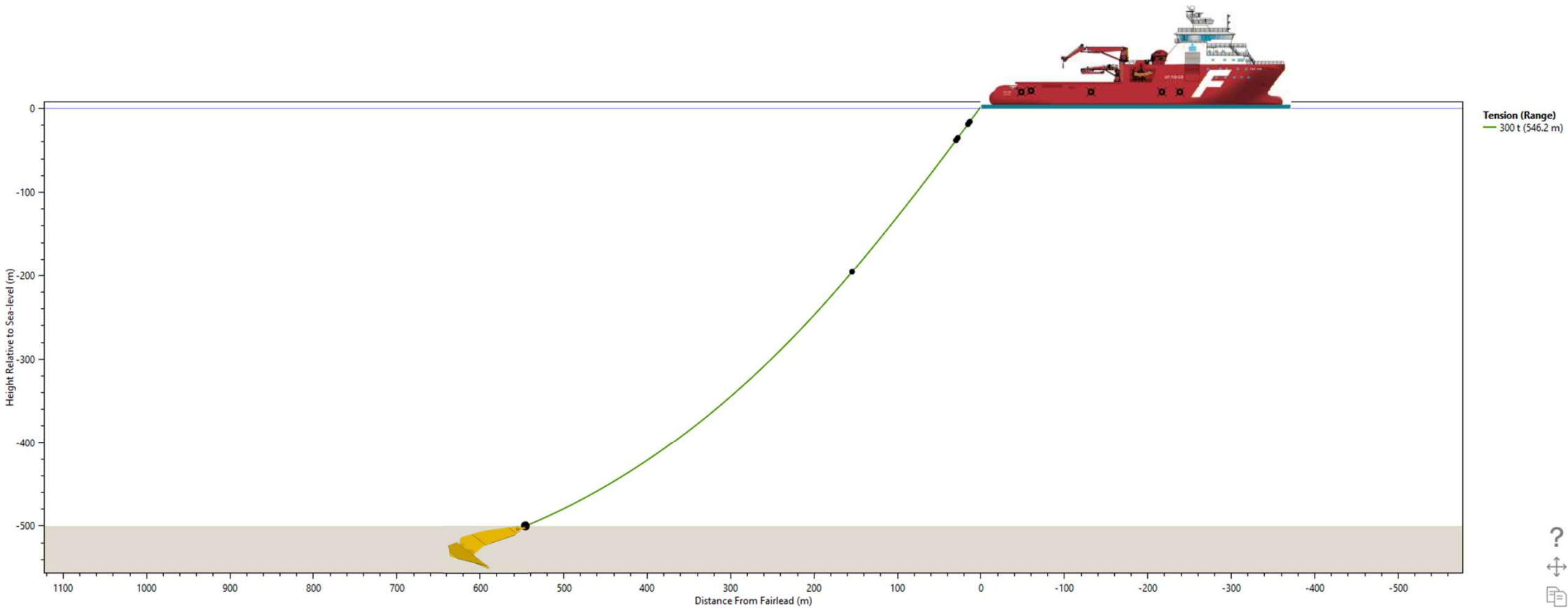
Cannot pull forwards due to mud angle setting

- Fluke angle will induce anchor to embed deeper if pulled forwards
- Short line [i.e. vertical pull] will create excessively stiff system

Anchors installed at approx. 350te

- Enormous load would be required to induce further movement pulling forwards

# Catenary calculation



anchor

Tension (t)
192.85
277.19
277.18
298.51
298.47
298.88
298.90
298.97
298.90
299.31
299.36
300.05

AHV

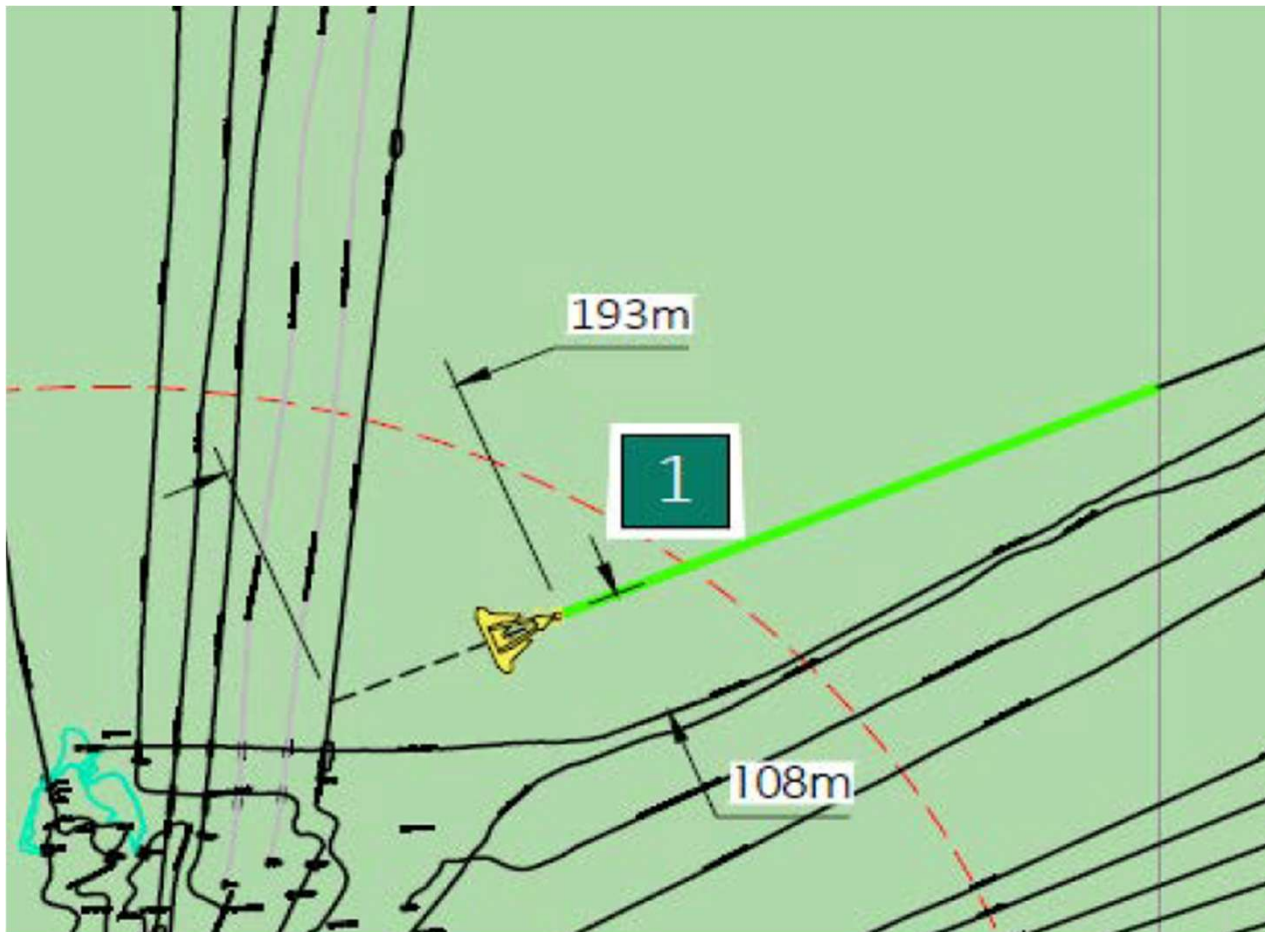
192.85

300.05

**Weight of 120mm chain suspended in water column meant that tension at anchor will be significantly lower than power applied at surface**



# Identified problems / challenges



Cannot pull backwards with 1x AHV due to asset proximity

- Asset owner will not allow AHV to span across pipelines

# Solution – round 1



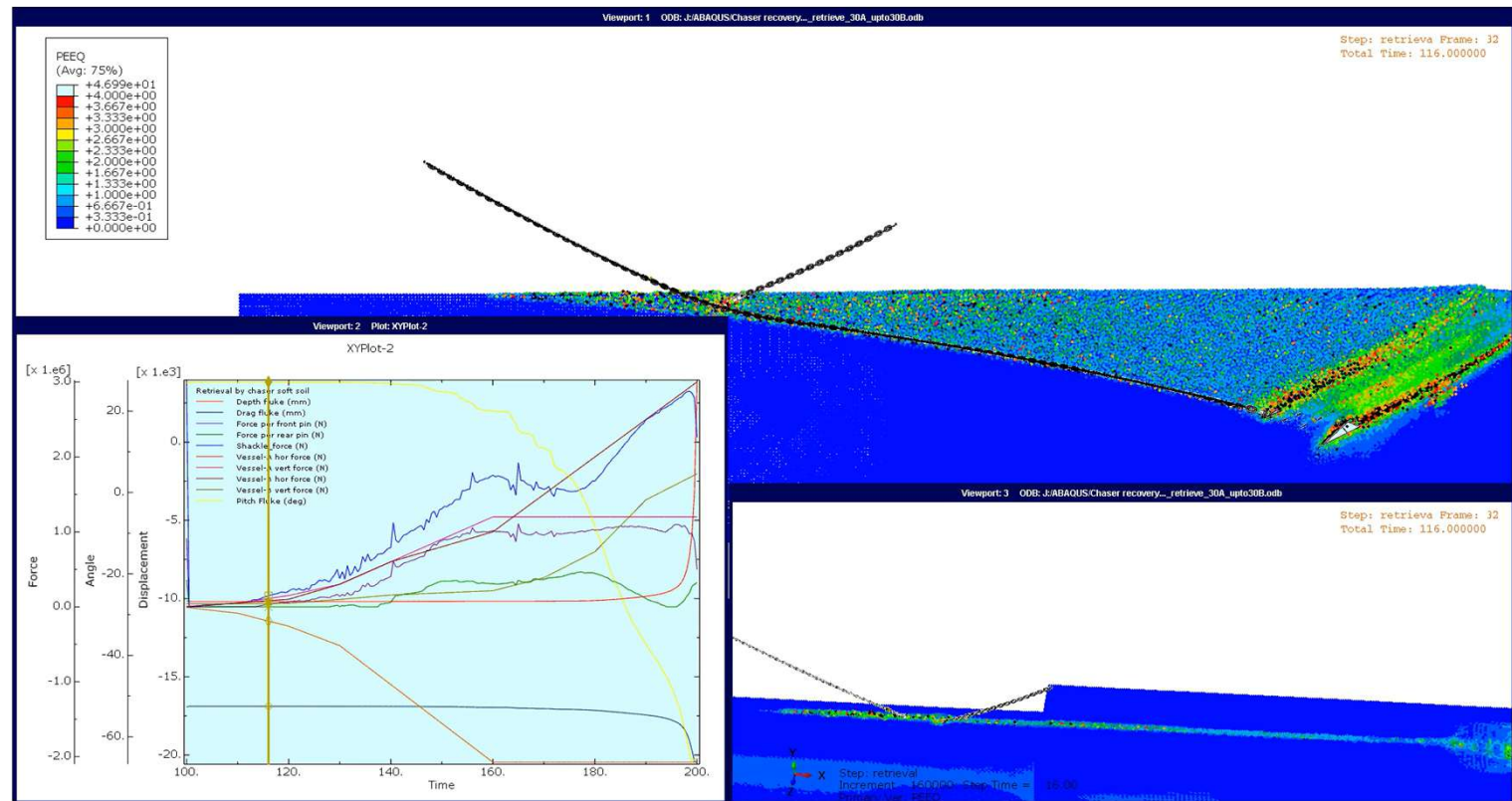
- Use 2x AHVs
- One to pull forwards on line bearing
- One to apply uplift at anchor
  - Use chaser collar as J-hook has a tendency to slip off 120mm chain
  - Load fibre on assist AHV as will be inside exclusion zone, close to assets

# Generic simulation [thanks to Victor Remmers of Delmar]



This is basically an old school chaser retrieval, but with more tension on the forward axis.

**Note:** the angle of the line pulling aft – this creates the rotation necessary to direct the plane of the flukes [open angle] towards the surface.



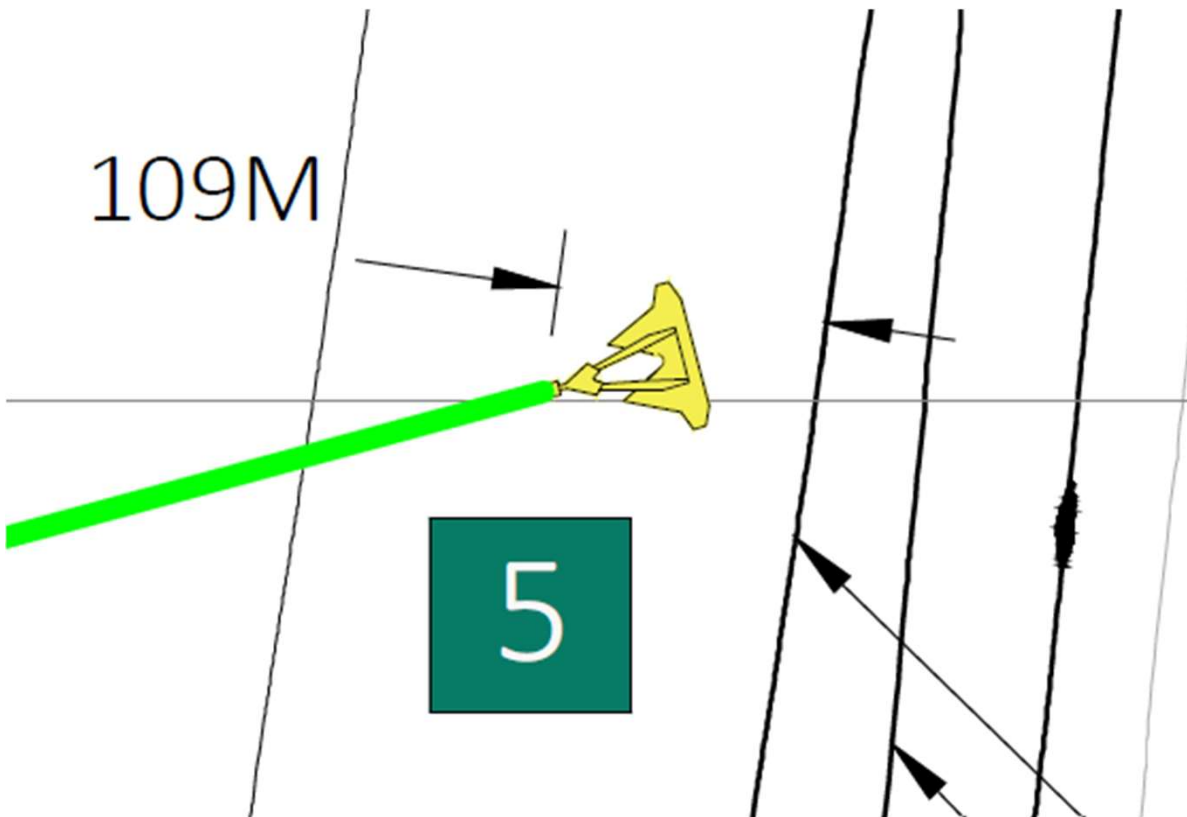
# Identified problems / challenges



- Hard to calculate load on chain when 2x AHVs pulling
- Anticipated [very] high loads

	<b>84mm R5</b>	<b>120mm R3S</b>
<b>MBL [te]</b>	<b>858</b>	<b>1126</b>
<b>30%</b>	<b>257</b>	<b>337</b>
<b>50%</b>	<b>429</b>	<b>563</b>
<b>65%</b>	<b>558</b>	<b>732</b>

# Problems / challenges on the job



The first anchors recovered in the had **some** space behind, but the others were laid much closer to assets.

- Cannot pull backwards due to asset proximity
  - AHV cannot cross pipelines due to **dropped object risk**



# Saltfjord and Sapphire



More than enough power to mangle any piece of mooring gear.

In the old days, when 5000kw was a powerful AHV, we would connect to the chain and turn everything up to 11.

Now we must be a bit more cautious ...

... use dynamic braking / fancy AHC winch to maintain constant load without over-stressing gear

- Especially important on assist vessel as line will be near-vertical



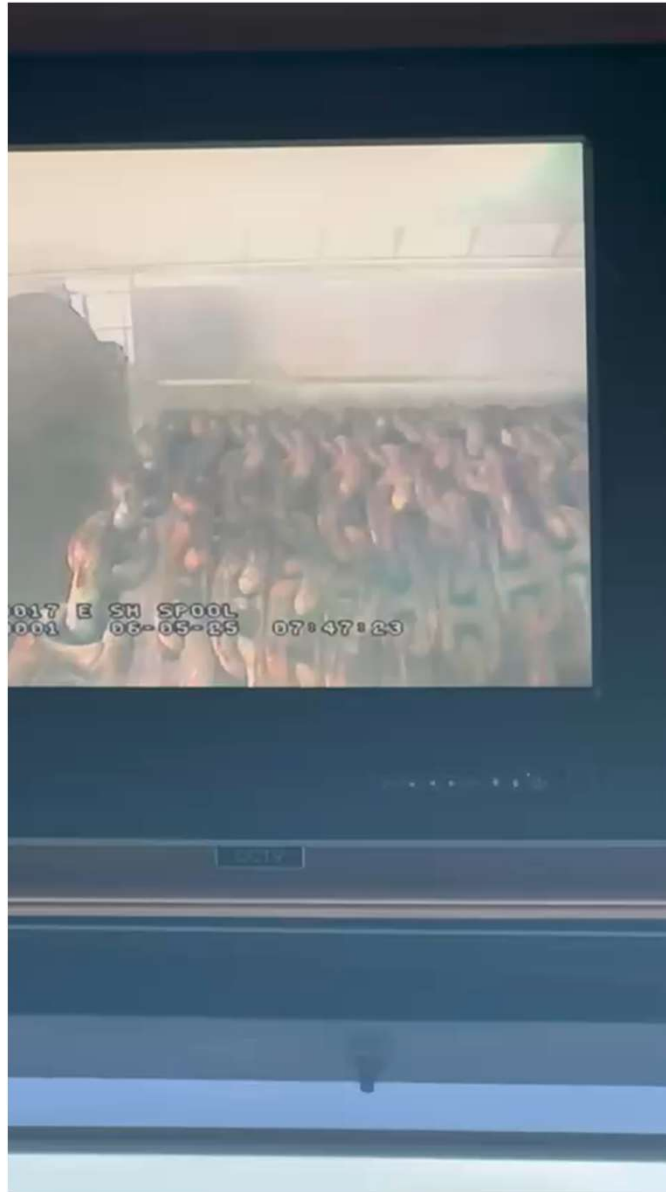
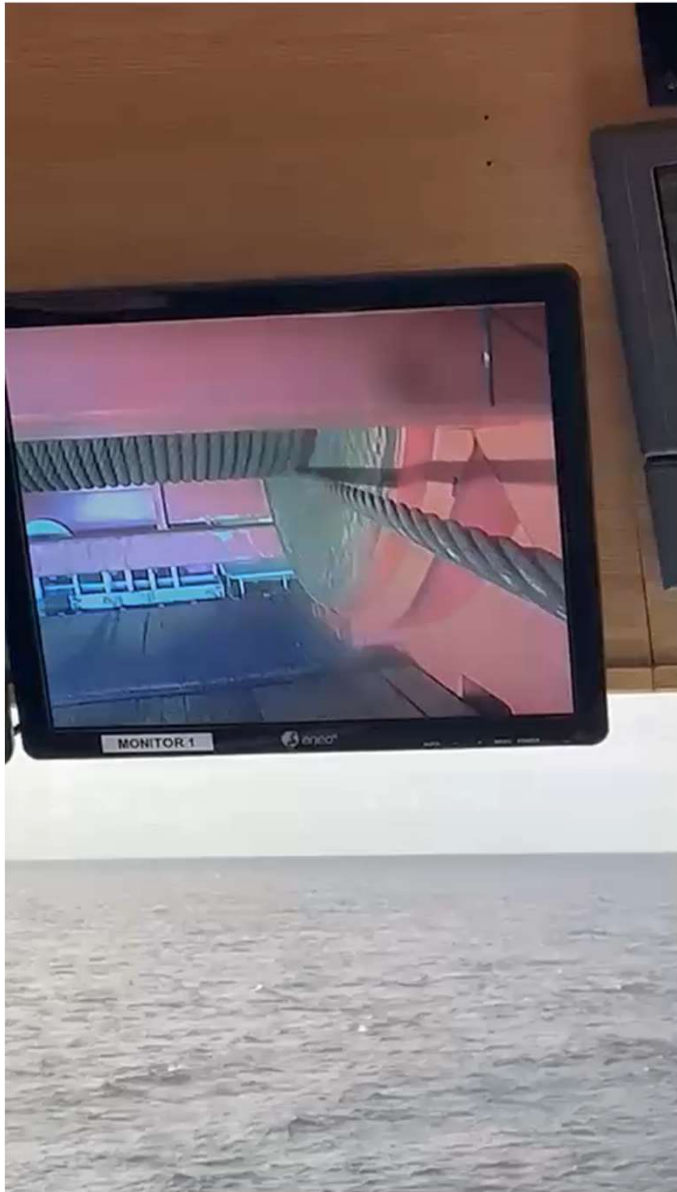
me [possibly]

fancy winch



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Dynamic  
braking / heave  
compensation  
in action



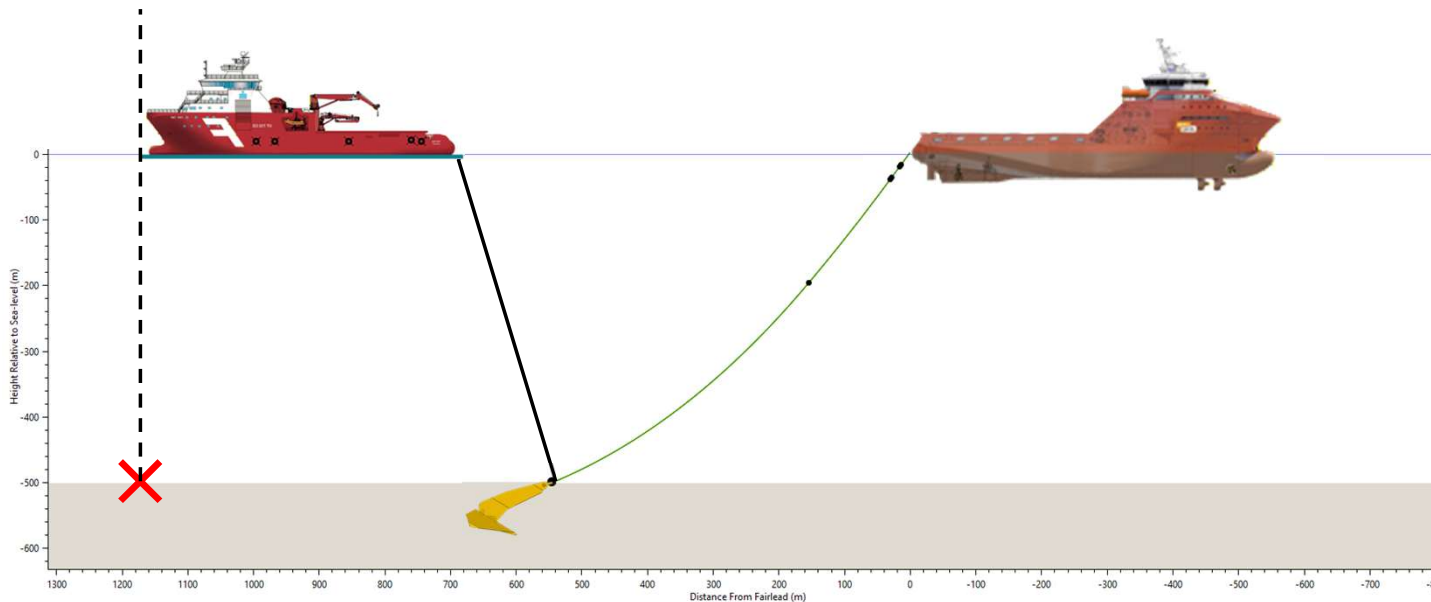
**This was ...**

**... a complete waste of time**

# Assist AHV unable to induce rotation



Due to asset proximity, AHV pulling backwards is unable to go far enough to induce sufficient rotation. Limit on forward motion means that tension can only be applied by hoisting. Lack of horizontal pull means that the collar will just slide up the line as power applied. In practice, it was hard to induce a noticeable increase in tension under these constraints.

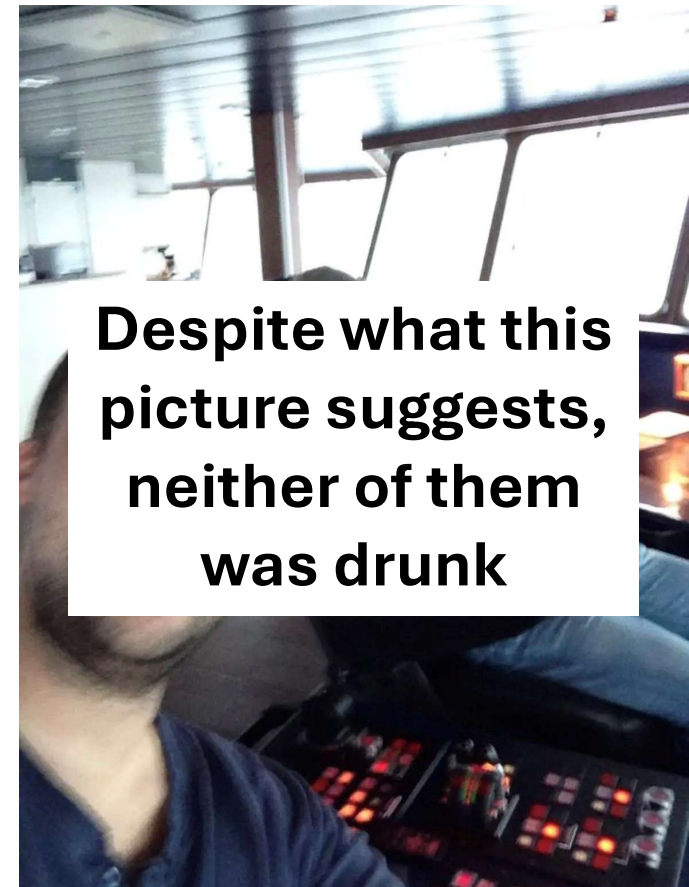


# Time to go off-piste

Enter Steff, capt Magne and capt Trond ...

**Suggested to pull sideways!**

This f\*!cked with my feng shui to a very substantial degree, and I suspect Victor Remmers' brain's MBL has just been exceeded [sorry Victor].



# Prediction

1. Likely to pop out
2. High chance of damage
  - I. I think everyone has seen this abomination by now
3. **Anchors [and my nerves] not designed to withstand these forces off the fore/aft axis**



# Result



- We started 30° off fore/aft and pulled with 2x AHVs
- Ended up pulling at about 80°/260°
- A couple of the anchors came out fine
- High tension observed on a few – exceeding acceptable % of MBL of various components in the system

# Postponed for weather



Unfortunately the weather picked up so we had to return to port.

When the next weather window appeared, we were approaching the end of the term hire agreement with Aurora:

- Return with Saldfjord and Siem Pearl = £1.5-2 million
- Abandon mooring equipment = £1.5-2 million

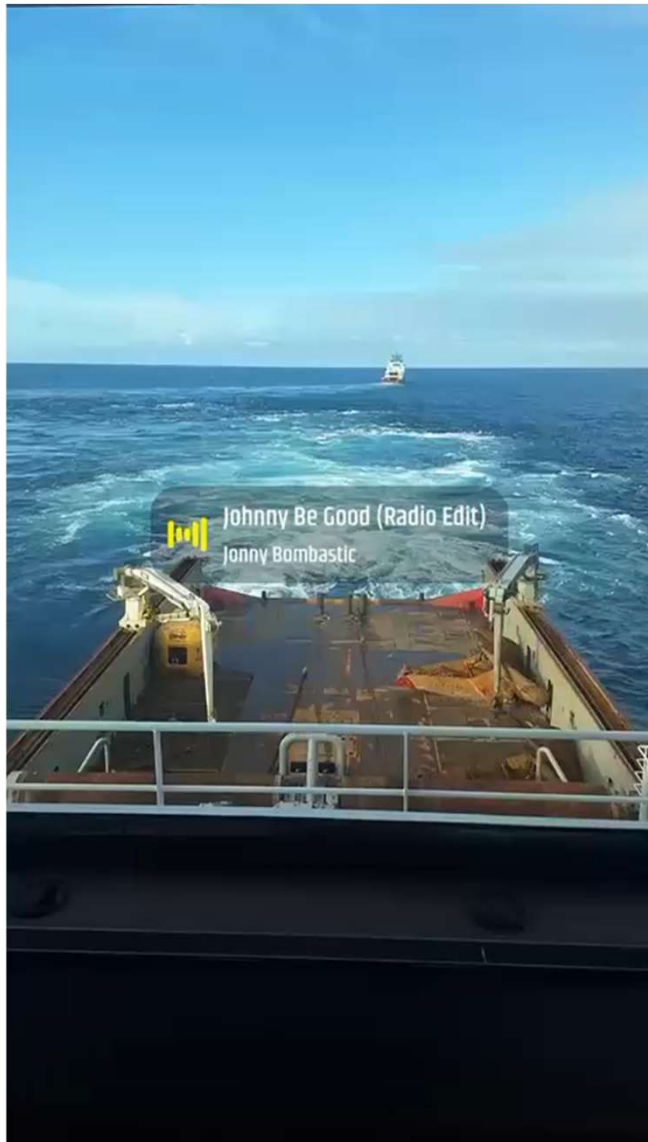
**Decision – get them out! Load a heavy-duty chaser [previously the weak link in the system] and pull until something gives**



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**Siem Pearl**  
**[with the Sapphire**  
**in the background]**



**I'll forgive Trond for the music because the anchors came out undamaged!**

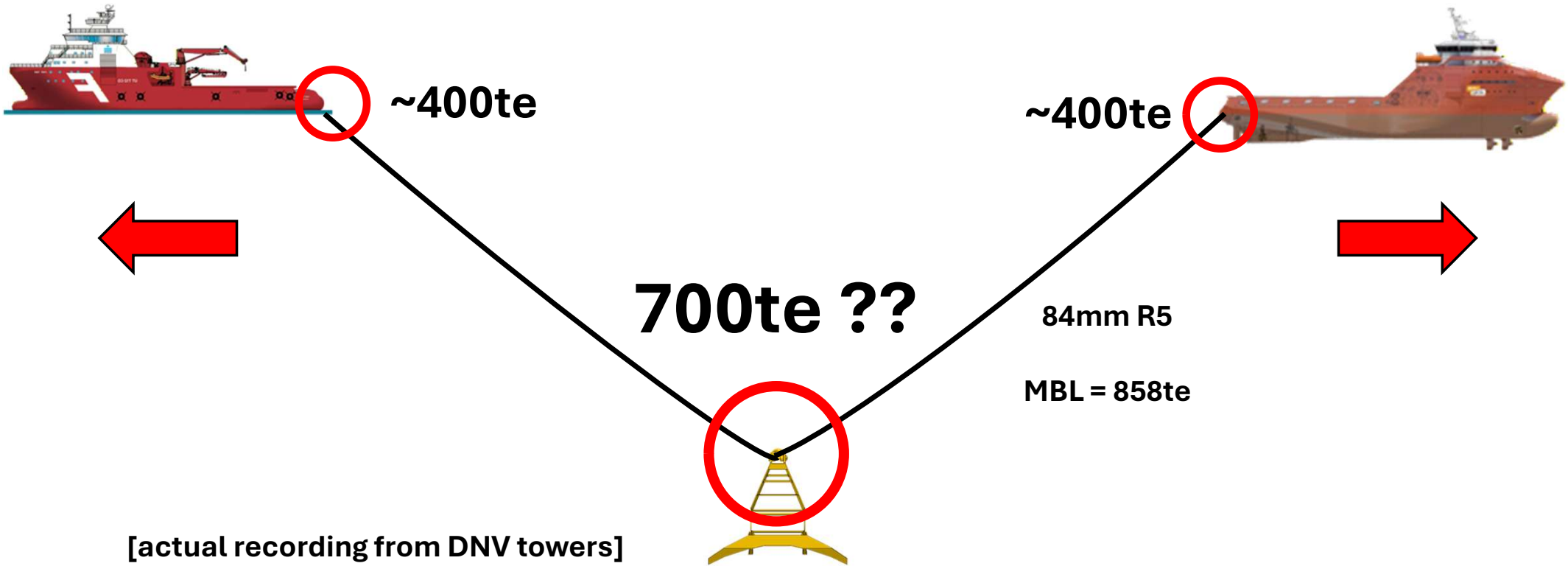
**Not sure about the chain though ...**



**I've already given Victor the heebee jeebies ...**

**... now to ruin Dag-Borre's mental well-being**

# High tension





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# **DNV-RU-OU-0300**

## **[Fleet in Service]**

	<b>84mm R5</b>	<b>120mm R3S</b>
<b>MBL [te]</b>	<b>858</b>	<b>1126</b>
<b>30%</b>	<b>257</b>	<b>337</b>
<b>50%</b>	<b>429</b>	<b>563</b>
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# Conclusion



- This is **not** the recommended way of doing things
  - Client must be willing to accept damage before committing
  - If going off-piste, careful application of power is critical
- In these conditions, place anchors so there is space for backwards recovery
- Use VLAs on catenary moorings in dense clay? Victor/Equinor have led the way with this

## Case study 2

- Caspian sea
- 500m water depth
- Low-powered AHVs [old REM UT712L]
  - Original BP approx. 180te
  - Now? *Maybe* 140te



# Mooring spread details

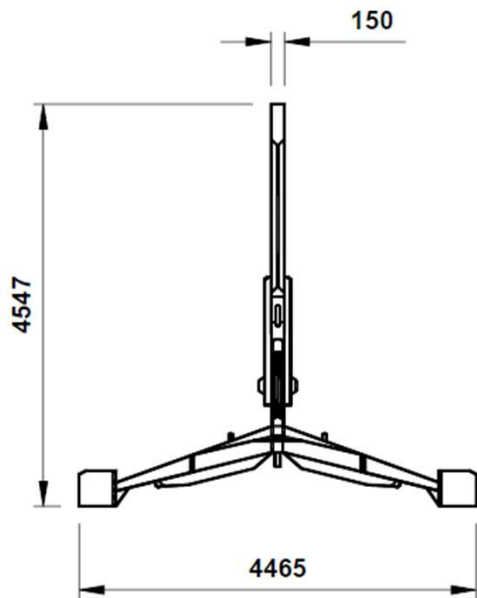


- Prelaid gear [for semi-taut spread]
  - 12m<sup>2</sup> DENNLA
  - 75m x 76mm R4 studlink
  - 700m x 90mm RHOL IWRC
- Pulled in at short scope in order to trigger the Near-Normal Load mode
  - Consequent very high tensions [relative to available AHV] during testing

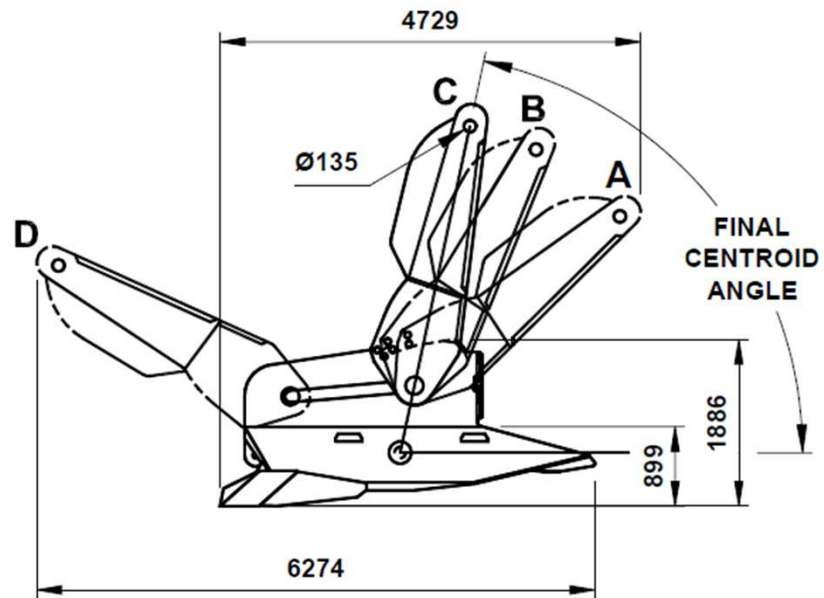
# Bruce DENNLA data sheet



Dimensions in millimetres

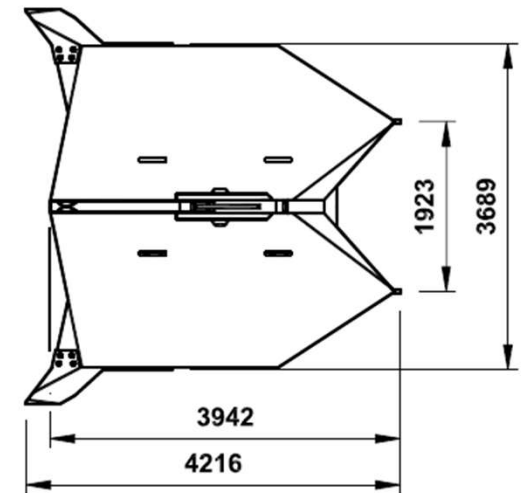


## DENNLA Mk3 12m<sup>2</sup>



## SHANK POSITION

- A : Deployment
- B : Installation
- C : Installed (Triggered)
- D : Recovery



# DENNLA design

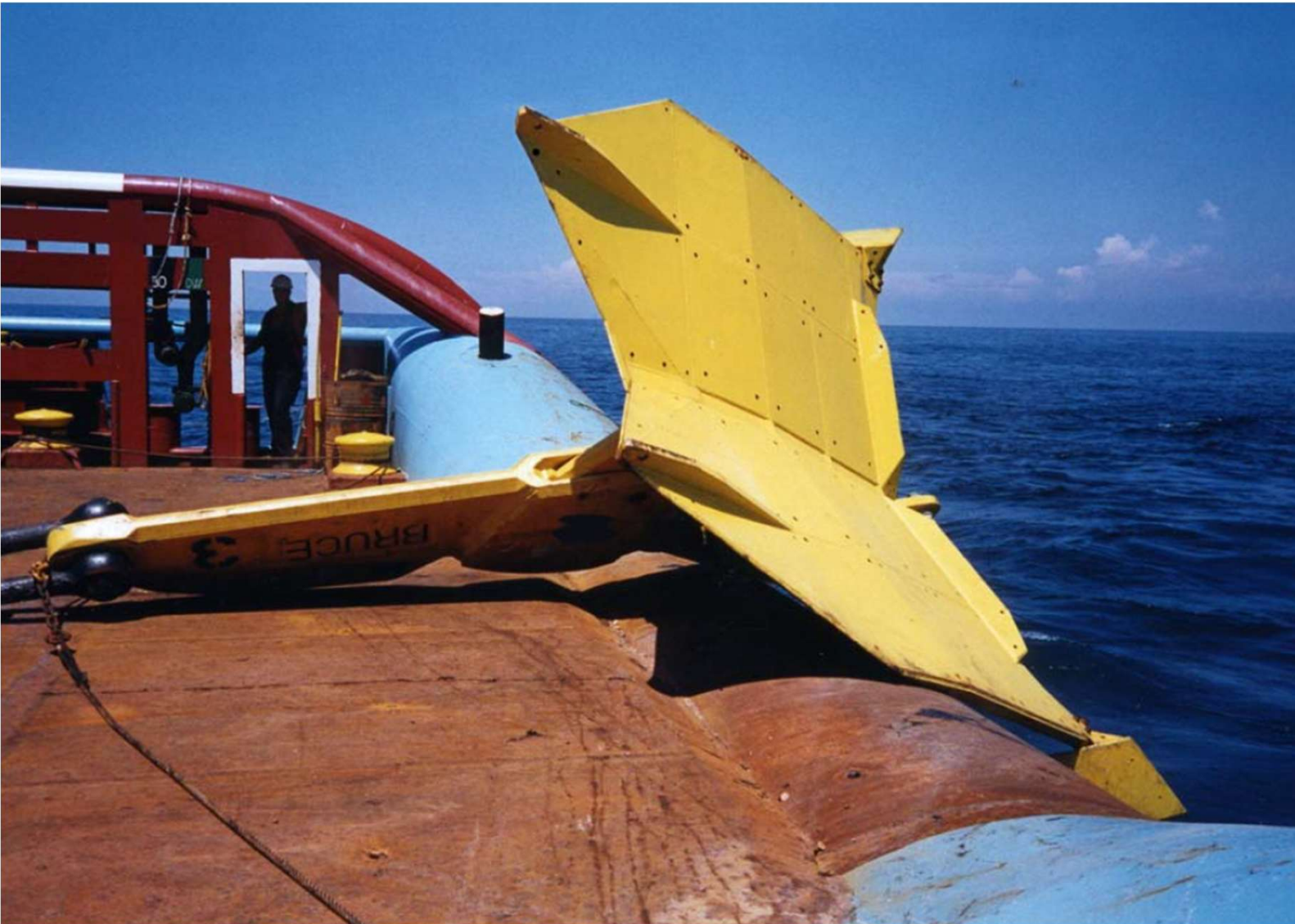


- Open design with no cross-members
  - Compare to standard DEA design w/twin shanks and multiple cross-members
- Smaller than an equivalent Stevpris or similar
- Sheds mud very easily
- No requirement for ROV intervention [though it is preferable]
- Designed to drag rather than break out when holding power is overwhelmed
- Designed to reduce recovery forces



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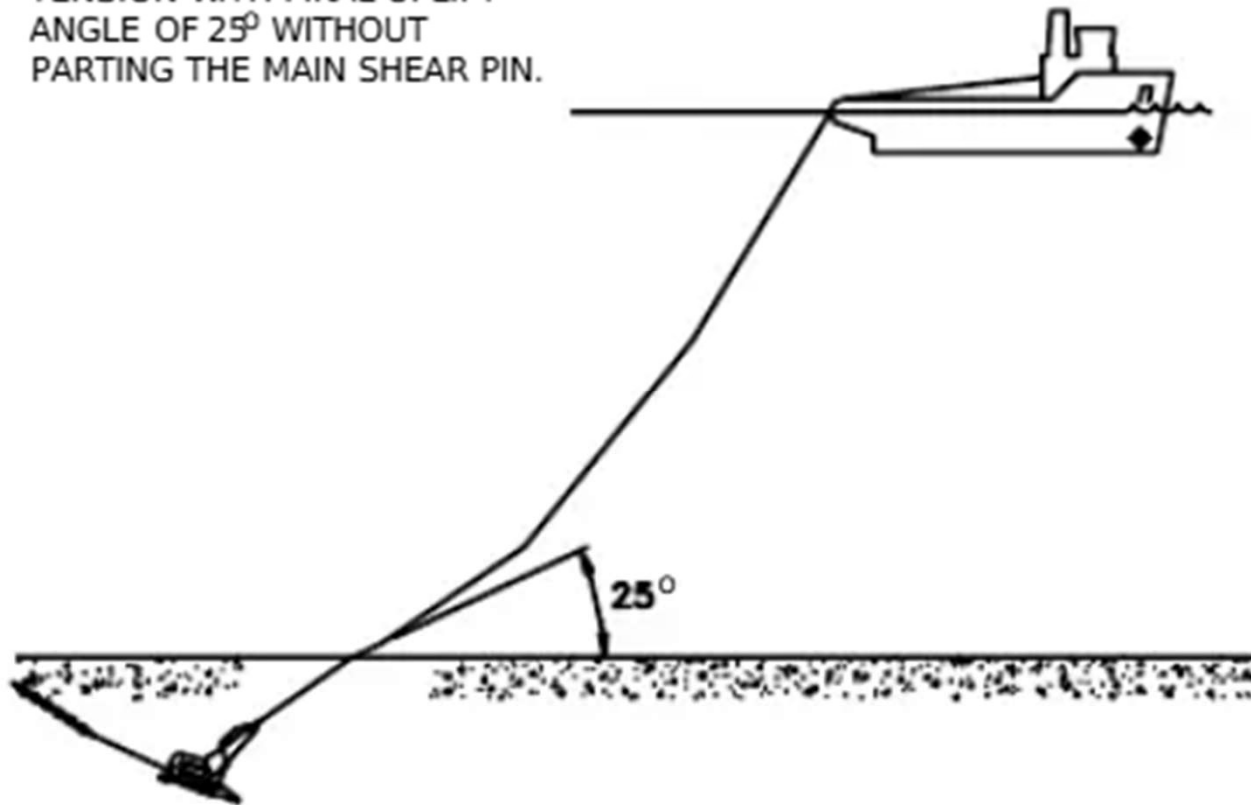
The Bruce Dennla can be installed by dragging in at short scope with an uplift angle at the seabed of up to 40 degrees.



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AHV EMBEDS DENNLA INTO  
SEA BED AT CHOSEN LINE  
TENSION WITH FINAL UPLIFT  
ANGLE OF  $25^{\circ}$  WITHOUT  
PARTING THE MAIN SHEAR PIN.



INSTALLATION STEP 3

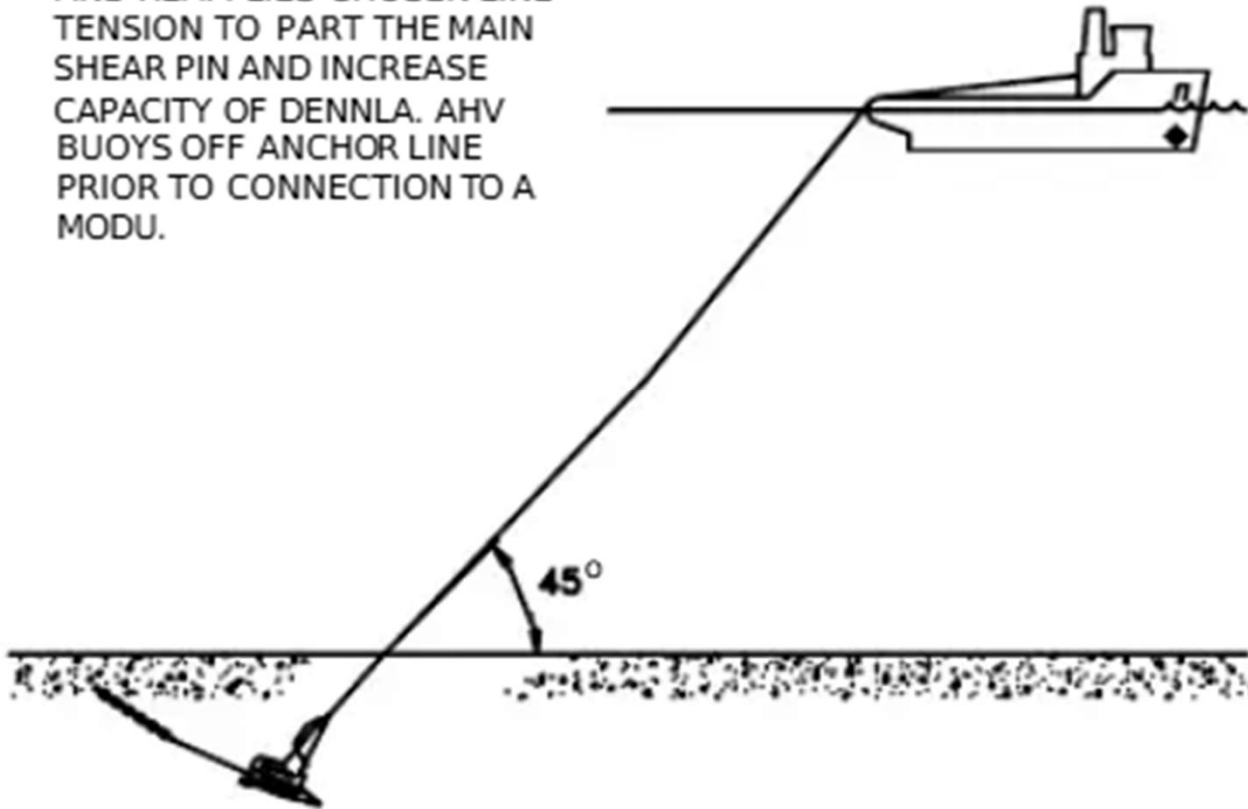


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**Initial pull = 180te  
[winch tension]**

AHV HEAVES IN ANCHOR LINE TO GIVE  $45^\circ$  UPLIFT ANGLE AND REAPPLIES CHOSEN LINE TENSION TO PART THE MAIN SHEAR PIN AND INCREASE CAPACITY OF DENNLA. AHV BUOYS OFF ANCHOR LINE PRIOR TO CONNECTION TO A MODU.



INSTALLATION STEP 4



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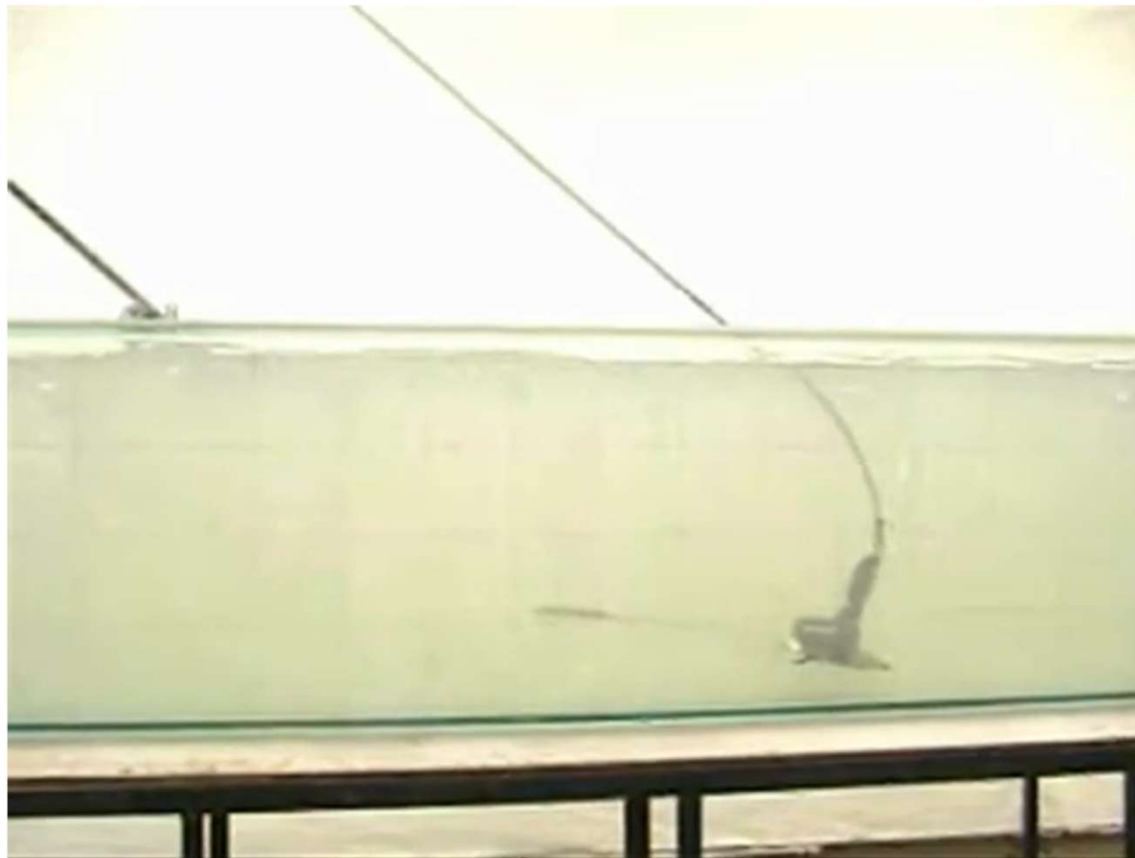
**Second pull = 240te  
[winch tension]**

# Recovery

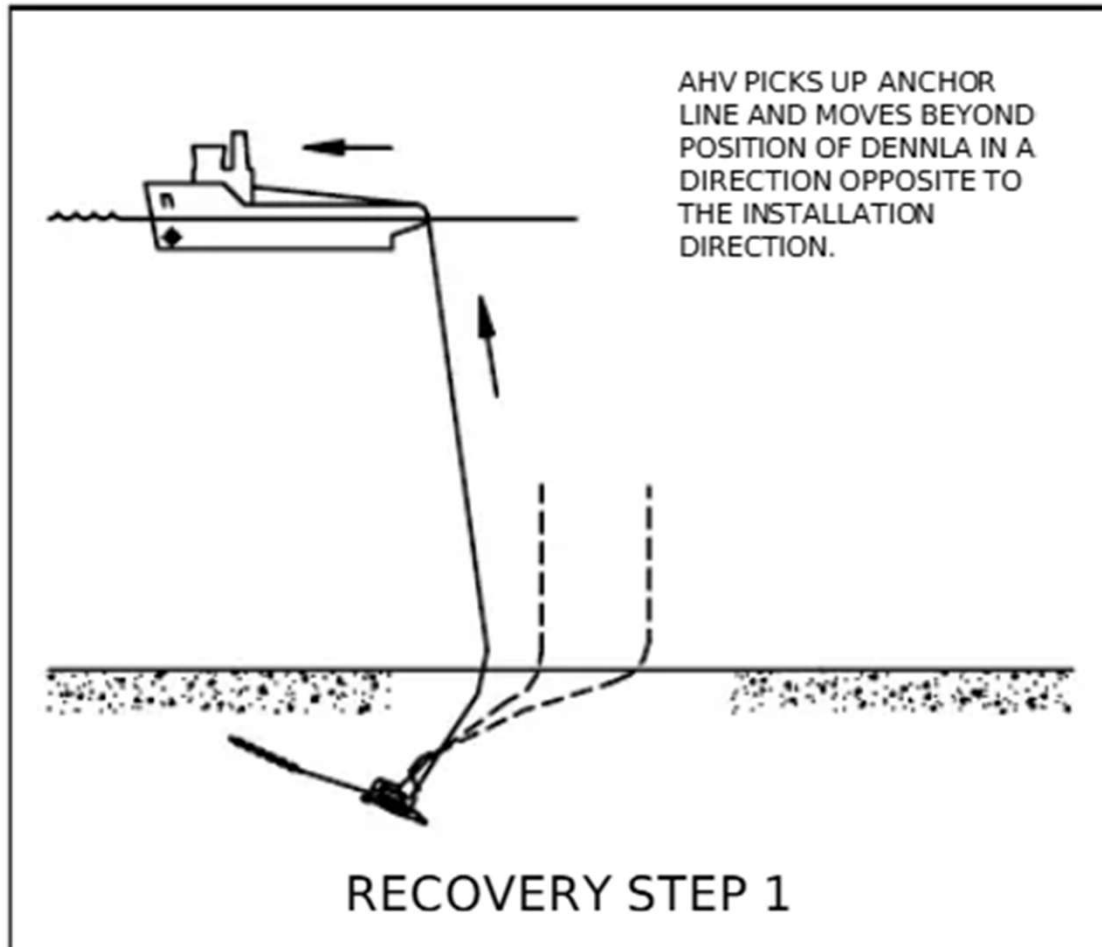


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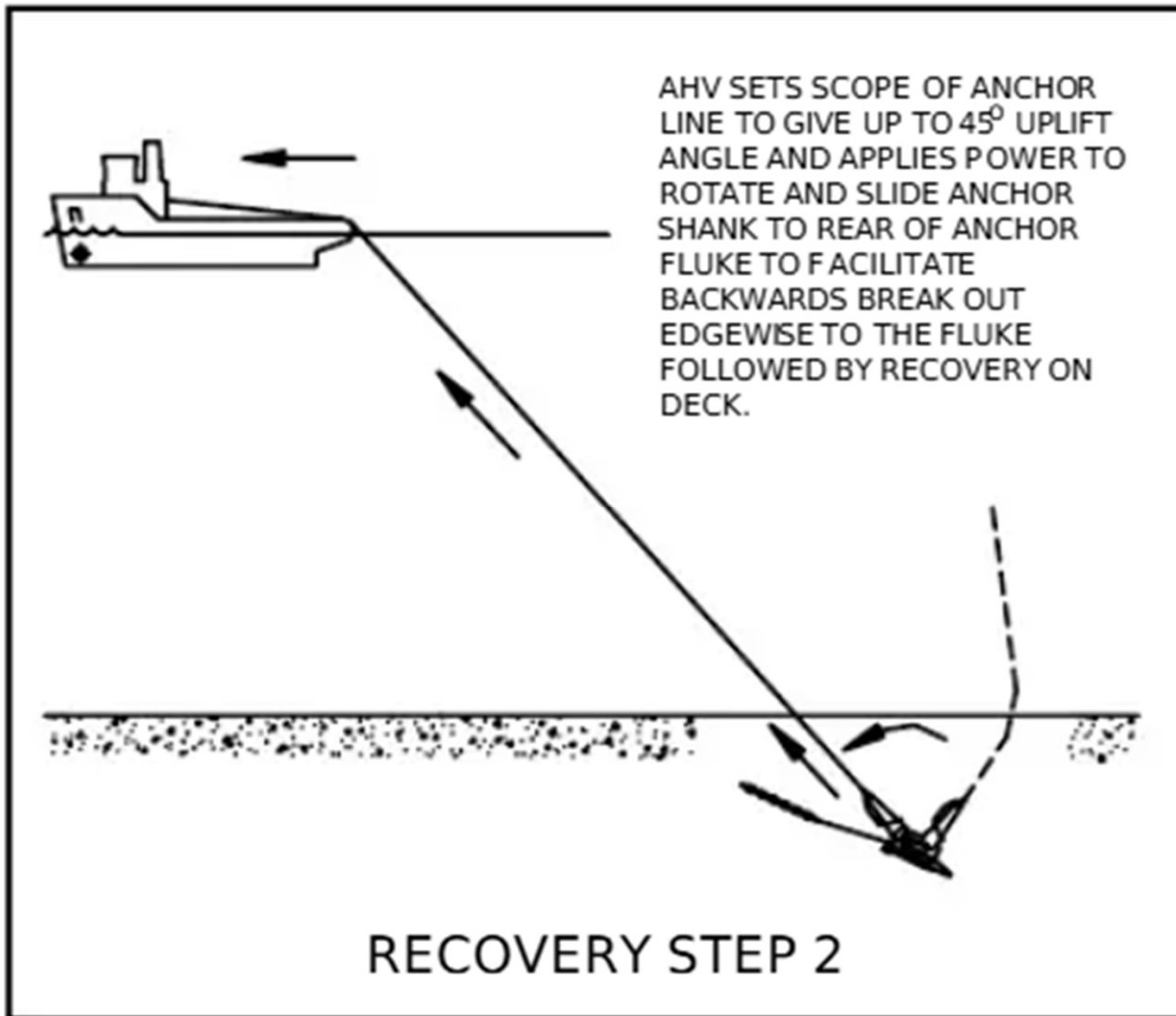


# DENNLA recovery



Catch buoy

Reverse direction 180°  
and pull out backwards



Shank triggers into recovery position

Pulls out like a spade

# Conclusions



- 500m [no fibre] is shallowest that a semi-taut spread can be installed
  - System stiffness
- Use of VLAs in catenary spreads is beneficial for installation and recovery loads
  - Equinor/Delmar have been experimenting with this approach
- Can reduce ground chain allocation?
  - Anchor can withstand uplift

# Comparison

## North Sea

Installed at ~300-350te

- BP approx. 330-380te

Recovery loads of 700te??

The AHVs we used were more than capable of handling these forces, but options for this level of work are limited.

## Caspian

Installed at 240te

- BP approx. 140te

On a UT712L, with a dubious stability programme and faulty tank sensors, this was ...

... **\*exciting\***

Recovered at 100-150te.

This was far more civilised.



# Acknowledgments



Aurora Saltfjord – captain Trond and crew

Normand Sapphire – captain Magne and crew

Siem Pearl – captain Johnny and crew

FMS for NS procedures

Interocean for Caspian procedures

Victor Remmers for simulations and advice

FMS and Delmar for mooring gear in the NS

UIS for mooring gear in the Caspian

Steff Ødegård

Scott Crookes

... last seen in Svolvær





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**Any questions?**