TECHNICAL NOTE

Equinor ASA - Heimdal jacket removal
Trawl impact risk assessment

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Tittel Heimdal jacket removal - Trawl impact risk assessment		
TN Nr. 820219	Date 24.06.2019	Rev. No. 01
Client Equinor ASA	Client contact Kari Sveinsborg Eide	Project ref:

Rev. No.	Reason	Date	Prepared	Approved
00	Draft	11.06.2019	TN	MIA
01	Final	24.06.2019	TN	MIA
Name		Date	Signatures	
Client Tjitte Nauta		24.06.2019	Signature	
Approved by Martin Ivar Aaserød		24.06.2019		

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1. Summary and conclusion

This technical note assesses the risk of trawlgear getting snagged on the remains of the Heimdal jacket for the case of partial removal of the Heimdal Main Platform Jacket, after platform abandonment.

It addresses the abandonment option where the lower part of the jacket with the piles, is left on the seabed. The upper part of the structure is cut off just above the piles and removed. The remaining structure will stick up from the sea-bed and there is a risk that the remaining structure will catch any net or trawl-gear that is attempted to be drawn over.

The probability of a trawl snagging on the Heimdal jacket remains is estimated to be in the order of $1.3.10^{-3}$ per year.

This is based on the density of trawling operations in the area as documented by the Norwegian Directorate of Fisheries and assessment of the probability of avoidance (of contact with the structure) by comparison with ship collision models.

The uncertainties with this number are caused by the uncertainty in the trawler density for the site and the uncertainty regarding the probability of avoidance. Both could be an order of magnitude. The upper uncertainty bound for the probability of a trawl snagging on the jacket remains would then be in the order of 5.10^{-2} per year.

The consequences of a trawl getting caught on the structure, may range from loss of the trawl-gear, to sinking of the trawler.

1. Introduction

Background

This technical note addresses the risk potential of trawl impact on the Heimdal jacket remains, after the installation has been removed. The concern is that the top of the jacket structure is cut loose and lifted away whereas the lower 30-35 m of the structure with the piles will be left in place such that nets and trawlgear easily could snag on it if it were unintentionally trawled over.

The main concern would be the trawl being stuck in the structure. The damage potential of such an event would be:

- The trawl can be freed by carefully manoeuvring the vessel and operating the winches
- The trawl remains stuck and has to be left on the structure by cutting the wires, or the wires break
- The trawl wires break and cause damage to the trawler and potentially injure personnel on board.
- The trawl is stuck, the vessel does not react adequately and gets a list due to sideways wire pull, takes in water and sinks. This in particular the case with trawl-door snagging giving an uneven load on the fishing vessel.

Assessment principles

There is a certain similarity between the risk of a trawlnet getting caught in a seabed structure, and the risk of a vessel collision with an offshore installation. In both cases, the position of the structure is known, marked on maps and shown on navigation systems; the main difference being that one is visible by eye and by radar whereas the other is not. The visibility is a factor that increases the probability of “detecting” the structure, thereby reducing the probability of impact.

The collision model considers two aspects:

- The number of vessels that has a course towards the installation/seabed obstruction
- The probability of these vessels having the trawlnet impacting on the seabed obstruction.

The number of vessels on course towards the seabed obstruction is normally estimated from historic vessel traffic data.

2. Number of vessels on course to the obstruction

The probability of a trawl being dragged over a specific area (such as e.g. the footprint of the Heimdal jacket ($p_{potential}$) depends on the following factors, if only geometrics are considered:

$$p_{potential} = n.v.D_{hit}$$

In this equation, n is the number of trawlers per m^2, v is the trawling speed and D_{hit} is the “hit width” (the width of the area). For consistency in dimensions, we use km, and hour.

The trawling density has been traced for block 25/4 where Heimdal is located. The block has been divided into 4 sections (shown in Figure 1). The 4 sections (marked Del1, Del2, etc) in the figure have an area of 130 to 134km^2. Section 4, with the Heimdal installation has an area of 134km^2.

Based on data from the satellite tracking of fishing vessels (data from the Norwegian Directorate of Fisheries) the average number of trawling hours in section 4 over the years 2013, 2016 and 2018 was found to be 123hr. These years are representative for the trawler activity in this area in the period 2010 –2018. This section does not show much variation between the three years. For blocks 1 and 2 the peak year is a factor 2 higher than average. All sections have between 78 and 123 hours trawling time.

123hrs trawling per year over a 134km^2 area implies a density n = 1.04x10^{-4} trawlers per km^2.

All fishing surveys show considerable variation in vessel density in the areas considered. The Heimdal location almost seems a deserted spot compared to areas further afield. It cannot be ruled out that these patterns change after the installation has been removed.

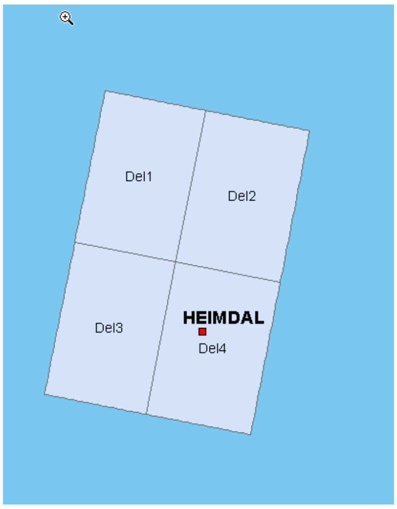

Figure 1: Location of Heimdal relative to the 4 sections for which trawler counts have been made

To estimate D_{hit}, consider that the midpoint of the trawl (for ease of the analysis, this is the trawler) must pass within a half trawl (at both sides) from the footprint. The hit-width is thus the width of the footprint + the width of the trawl. The trawl may be in the order of 70-170m wide (between trawldoors). The Heimdal jacket footprint is 75mx90m; the average width (for all directions) is in the order of about 100m. The hit-width is thus 170m – 270m, 0.17 to 0.27km, say 0.22km.

A typical trawl speed is in the order of 4-5kt, or 7-9km/hr. We will use 8km/hr in this analysis.

Using the above numbers, the probability of a trawl being dragged across an area with the same footprint as the Heimdal jacket is:

$$p_{potential} = 1.04 \times 10^{-4} \times 0.22 \times 8 = 1.8 \times 10^{-4}\ (per\ hour)$$

Figure 2 below shows a typical fishing pattern in the wider Heimdal area. Some of the trawling takes place along pipelines, etc. Other patterns are not always easy to understand.

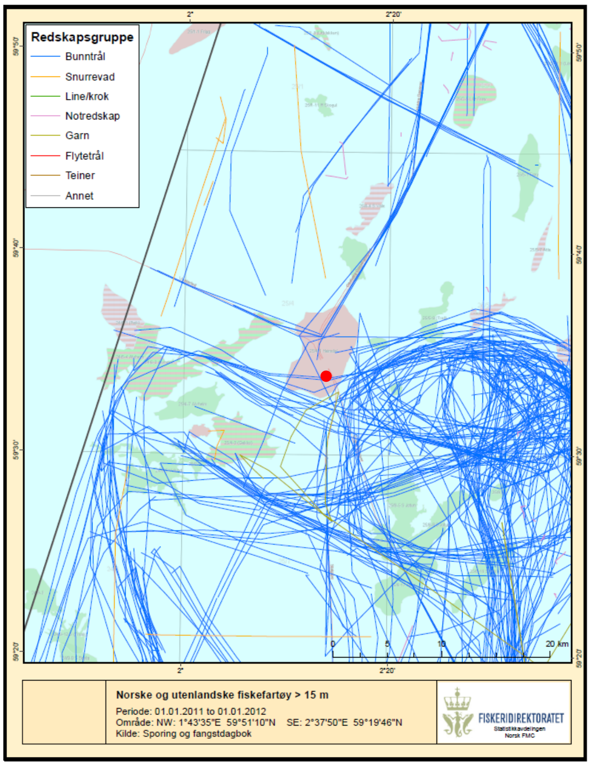

Figure 2: Fishing pattern in the area (year: 2011). Bottom trawling marked with blue lines. Map prepared by the Norwegian Directorate of Fisheries.

3. Hit probability

The approach for assessing the probability of the trawl to impact the seabed obstruction is to distinguish four factors:

1. Navigation equipment error: the obstruction is not shown on the navigation screens
2. Planning error: the course of the vessel is not planned such to avoid impact.
3. Watch keeping error: the vessel is potentially aware of the obstruction, but does not react timely to avoid impact
4. Alarm error: the navigation system does not activate an alarm prior to impact.

For a fishing vessel, there may not be a great distinction between the planning and watch keeping errors. However, watch keeping refers more to the short term there and then planning, whereas planning in this context applies to planning of actions further away in time.

Ship collision models used for the Norwegian continental shelf often use probabilities p1, p2 and p3, for the three factors covered by the bullets #2 to #4, above.

Navigation equipment error: The large trawlers typically operating in the area are mostly large vessels with modern navigation systems, including electronic sea maps. Failure of these systems may be due to e.g.:

- The equipment is on board, but develops an error during the operation. The vessel decides to continue/complete the trawling operation for a while.
- The vessel does not have the modern equipment on board, or uses outdated electronic data.

Both these factors seem unlikely.

In the assessment of ship collision probability, the navigation equipment error usually does not appear as a separate factor. This may be due mainly to the historic approach developed in a time where those systems were still under development. Further, an electronic system is more important for navigating seabed obstructions for locally operating fishing vessels than it is for other vessels sailing between from one point to another, along a preferred “straight” line.

Planning error: Planning error occurs if the vessel does not plan the track of the vessel such as to avoid the obstruction. This may be either by overlooking the obstruction, by inaccurate planning, or by not planning at all (take it as it comes). The consequence is that the trawl is heading towards the seabed obstruction (if no measures are taken to change course).

Inaccurate planning is e.g. if the effect of currents and wind-drift is not adequately accounted for, such that the course of the vessel deviates from planned.

Watch keeping error: Watch keeping error occurs if the personnel on the bridge is distracted, absent from the bridge, incapacitated, or occupied with other activities, such that the vessel is not steered away from any obstructions.

The causes for watch keeping error may typically be:

- Occupation with other duties, such as planning of other activities
- Disturbance by other activities on board, particularly unforeseen activities, equipment failures, etc that have to be handled.
- Disturbance by other nearby vessels, potentially requiring a change in course
- Incapacitation due to fatigue, illness, drugs, etc.

Such an error could typically lead to the vessel not making an avoidance manoeuvre in time, or not at all.

Alarm error: An alarm error occurs when the vessel systems give no alarm that an obstruction is being approached. The causes could be that:

- The vessel is not equipped for given such an alarm
- The vessel has an alarm system, but it is not switched on
- The vessel has an alarm system, but it does not function

The last factor is the same or similar to the “navigation equipment error”. However, an error in the alarm system only is possible as well, e.g. as a partial error. Consider e.g. the example where an alarm sound is disabled, although the system has identified an obstruction.

In the analysis of ship collision probabilities, the risk reducing potential of automatic radar and radio based anti- collision warning systems (ARPA radar, AIS) are considered rather high (Ref: OTO 99052). A similar reasoning would apply to a map-based system, albeit that the warning range may be shorter than for the ship collision scenario.

Likelihood of hitting the seabed obstruction

In ship collision modelling, a probability of planning error of some 10% (5%-15%) is used for collision with fixed installations. For newly installed installations, or mobile units, the planning error is in the order of 90%.

For ship collisions, the probability for watch keeping error and alarm system error combined may be in the range of 0.5% to 5%. These values are typically used in ship collision modelling for good visibility and bad visibility respectively. With a good collision warning system in addition (AIS and standby vessel and/or traffic surveillance system) the value is assumed to be one to two orders of magnitude lower (0.005% -0.05%).

For trawling, one would consider that the warning and avoidance systems will be less effective than for an anti-collision system based on ARPA, AIS and traffic surveillance by an additional unit.

There are a few complications with understanding these figures and extrapolating them to estimating the probability of trawl impact:

- The basic probabilities in watch keeping error, etc, date from the 1990's and before.
- The effect of collision avoidance systems is mainly based on expert judgement. Little data is available to validate the numbers
- A basic challenge with the model is that it uses probabilities without consideration of time scale (e.g. watch keeping error is related to a time span, e.g. the time to make a cup of coffee whilst on watch, the duration of a power nap, or the duration of other activities)

Considering all of the above, we would consider that the probability of trawl impact, given that a trawler is heading for the subsea obstruction, is in the range of: 0.3% to 0.03% (mid point 0.08% = 8.10^{-4}). This is based on:

- The probability of planning error is taken in the order of 50%
- The probability of watch keeping error and alarm error combined is taken in the same range as for bad visibility
- Warning systems can give a factor 10 reduction at the most
- The figures are rounded up to one significant digit

4. Probability of snagging trawl

With the probability of a trawler on course for the subsea obstruction being $1.8.10^{-4}$, the probability of a trawl snagging on the Heimdal jacket remains is: 8.10^{-4} x $1.8.10^{-4}$ $=1.4.10^{-7}$ per hour or $1.3.10^{-3}$ per year.

The uncertainties with this number are caused by the uncertainty in the trawler density for the site and the uncertainty regarding the probability of avoidance. Both could be an order of magnitude. The upper uncertainty bound for the probability of a trawl snagging on the jacket remains could then be 5.10^{-2} per year. A lower bound would be around or 5.10^{-5} per year

5. Consequences of snagging

The outcome from events with snagging varies from short stop in the fishery during the operation to loosen the wire or the door, with low risk involved, to more severe incidents. The concern with a trawl (net, door, wire) getting caught in a seabed structure, is that this may very quickly exert a strong force on the wire. The least concern would be that the wire breaks and the fishing gear is lost on the seabed. However, the snapping wire could also recoil and injure personnel on the vessel. Ultimately, the vessel itself could be threatened.

On the Norwegian shelf no dramatic incident of going fast in a free span is known. But on the British shelf the trawler Westhaven capsized and sank in March 1997 after having lodged a trawldoor inside a free span on a 30" pipeline. The report after the accident indicates wrong use of the winches as the main cause for the accident. The vessels probably pulled the trawl wires over the side of the vessel and overturned in a few minutes. The crew did not have enough time to get into the lifeboat (Scanews1998).

The consequences for the trawler if its trawl gets caught at seabed depends on:

- The type and size of the trawler
- The strength of the wires

For a beam trawler (with the trawl being suspended from overboard cranes), the cranes increase the arm of the force on the ship and thereby the turning moment on the vessel. If one of the lines is caught, this may lead to the vessel developing a list fairly quickly and taking in water, especially if hatches and doors are not closed. Beam trawlers are mainly smaller fishing vessels towing two trawls, one on each side.

The larger trawlers are stern trawlers, where a large trawl is deployed over the stern of the vessel. The net is kept open by two trawl doors on either side of the net. The lines pulling the trawl are lead over sheaves to winches on the deck of the vessel. In the event of a line snatching on a seabed obstacle, the load:

- Is acting along the length axis of the vessel
- Has a small arm relative to the axis (and centre of gravity of the vessel)

The moment on the vessel is therefore limited in this situation and it would be unlikely that this is enough to lead to capsizing of he vessel. If all wires get stuck simultaneously, that would give a symmetric pull relative to the middle of the vessel. The slack in the catenary of the wires would be taken up quickly (unless immediate action is taken to pay out the wires) and would then likely break.

Most likely, one side of the trawl gets stuck first. The one-sided pull may change the heading of the vessel and then cause a sideways pull. Given the short duration of the build-up of force, the change in heading is fairly limited.

The yield point of steel is often taken at 0.2%. With a steel wire length of e.g. 1000m, the line may be stretched elastically 2m, before reaching the yield point. The slack in the catenary may provide some additional length. With the vessel sailing at 2m/s, it takes a few seconds only before the wire(s) break. The breaking strength of a 32mm wire may be in the order of 50-70 tonnes. This is considered the maximum type of load that one wire may exert on the vessel if the trawl gets stuck. If the net gets entangled in some structure, it is likely that a lesser force is needed to break the net free. Similarly, if a smaller wire or line gets stuck, a lower force is needed to pull the gear free. If the middle of the trawl net is caught, it takes longer before the maximum pull is achieved and eventually breaking occurs. This because the slack in the net / gear is taken out before it breaks free.

The 50-70 tonne pull, compares to a displacement of e.g. 2000-4000 tonnes for large trawlers. It may also be in the same order of magnitude as the thrust of the vessel's propulsion system. On its own, this type of force is not considered to exert a sufficient moment to roll the vessel over. In combination with other loads, like heavy seas, water on deck and shifting /sloshing loads, it may be a factor to consider.

6. References

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