# Ölfus Harbours Risk Assessment

## Thorlakshofn harbour

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Objective: Ship traffic risk assessment of the existing harbour of Þorlákshöfn and the planned harbour in Keflavik.

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# 1 EXECUTIVE SUMMARY

DNV Maritime Advisory (DNV) has been requested to perform a risk assessment of the ship traffic visiting the existing harbour of Þorlákshöfn and the planned harbour in Keflavik. The focus of this risk assessment entails oil spill resulting from different ship accident scenarios related to the vessel traffic and activities in the harbour area. Estimations of spilled quantities are examined for the various vessels calling the two harbours.

The Þorlákshöfn harbour constitutes a significant role as a port on Iceland, serving a mix of general commercial cargo and fishing vessels. Additionally, the harbour serves as a backup port for the Vestmannaeyjar ferry.

The new Keflavik harbour is planned to be the site of a new plant to crush Palagonite lava material into fine powder. The harbour will be used both for receiving Icelandic tuff extracted from sea mines by dredgers and for shipping out cement on cement carriers.

There are no vessels carrying oil as cargo to the harbours, which significantly reduces the size of a worst-case oil spill. The vessels calling these two harbours carry oil in smaller quantities, for fuel consumption, compared to the larger amounts transported by petroleum tankers. However, this does not mean that a spill from the current vessels would be negligible.

Risk is defined as the combination of the frequency of an accidental event and the consequences of the event happing. The risk assessment is therefore divided into an assessment of frequencies, and then an analysis of the consequences.

**Annual frequency of accidents**

Estimated accident frequencies for the harbours are found by first finding the generic accident frequencies for each ship type (i.e. number of accidents per ship year), then analysing the time spent per ship type category in the area (number of ship years), before finally multiplying to find the expected annual accident frequency and return period.

Overall, the total calculated accident frequency within the study area, including the expected future traffic to the planned new Keflavik harbour, is $1.73 \times 10^{-3}$ accidents annually, meaning that an accident is expected to occur approximately once every 580 years.

This accident frequency is low. However, it is important to keep in mind that the study area for which the frequencies are valid is a relatively small area defined by the radius of 10 nautical miles around the harbours. The analysed vessels do not spend a long time traversing the area compared to the total time of a year. One example of an accident that has occurred in this region is the 4,000dwt cement carrier that run aground at the entrance to Keflavík harbour in Iceland in 2018.

**Annual frequency of accidents with oil spill**

The probabilities for oil spills are calculated by multiplying the estimated accident frequencies with the probabilities for oil spill per ship type, which are taken from the methodology provided by the Norwegian Coastal Administration (NCAs AISyRisk tool[1]. The same source also contains an estimated amount of oil spilled, given an accident, based on the amount of oil carried in the fuel tanks and the severity of the accident.

The total frequency of accidents with fuel oil spill is calculated to be $8.47 \times 10^{-5}$ annualy, giving a return period for an accident with an oil spill of 11 806 years. This falls between extremely remote and remote in the risk matrix for oil spill from the IMO FSA Guidelines, giving a frequency index of 2 out of 7.

1 https://aisyrisk.no

The average oil spill from the analysed vessels is in the range between 100 tonnes to 1,000 tonnes, giving a severity index of 4 out of 6 in the oil spill risk matrix from the IMO FSA Guidelines.

**Consequence and risk assessment**

In summary the risk of an oil spill within the study area of Þorlákshöfn and Keflavik harbours is remote. However, should an accident occur, the consequences could be severe, where expected spill size could range between 100 tonnes to 1,000 tonnes.

The typical weather in the area, combined with the geography of the shore increases the chances of the oil mixing with the water, which will reduce the consequences for birds and other animals/plants living/feeding on the surface. This can however increase the consequences for other animals and organisms living or feeding deeper in the water column. It is unlikely that spilled oil will be present at 40 meters depth or lower.

# 2 INTRODUCTION

DNV Maritime Advisory (DNV) has been requested to perform a ship traffic risk assessment of the existing harbour of Þorlákshöfn and the planned harbour in Keflavik. The focus of this risk assessment entails oil release resulting from different ship accident scenarios related to the vessel traffic and activities in the port area. Estimations of spilled quantities are examined in for the various vessels calling the two harbours.

The traffic composition varies between the studied locations impacting the consequences of potential of oil spills near each harbour. This project is aimed at examining the navigational risks which could result in oil spills and gives a brief description of the environmental consequences. For this report, a mix of both qualitative and quantitative data have been retrieved from DNV internal resources, customer input and global databases.


**Figure 2-1 Location of existing harbour of Þorlákshöfn and planned harbour to the west of the existing harbour.**

# 3 BASIS FOR WORK

## 3.1 Ship traffic

Þorlákshöfn harbour constitutes a significant role as a port on Iceland, serving a mix of general commercial cargo and fishing vessels. Additionally, the harbour serves as a backup port for the Vestmannaeyjar ferry.

The main contributors to the traffic in the harbour is Fishing vessels, RORO-vessels and General Cargo Vessels. Fishing vessels have the most port calls, and fishing vessels with a dead weight tonnage around 500 tonnes have approximately 300 calls annually. The RORO-vessels are pure cargo vessels sailing on a route which has a weekly schedule with approximately 3 calls each week, which gives around 150 calls annually. In addition, there are various general cargo vessels visiting Þorlákshöfn, giving around 70 port calls annually /1/. The port is also becoming a hub for aquaculture related matters, with several visits from wellboats/live fish carriers and chemical tankers transporting fish silage.

The new Keflavik harbour is planned to be the site of a new plant to crush Palagonite lava material into fine powder. The harbour will be used both for receiving Icelandic tuff extracted from sea mines and for shipping out cement /2/. Annually, the harbour is expected to receive approximately 240 calls from dredgers and 100 calls from cement carriers /1/.

### 3.1.1 Port calls

Data from the Automatic Identification System (AIS) is used for selected individual ships within each ship type category to characterise the traffic in the area. Various cargo is carried through Þorlákshöfn, with most of it arriving on the RORO-vessels. The AIS data shows no visits from tankers carrying petroleum products or similar in the last few years. However, the harbour lists bunkering as an available service. RORO-vessels and general cargo vessels could be carrying petroleum products in tank containers, but it is assumed that neither of them would carry large amounts of these types of cargo, compared to carry products as bulk cargo.

The new Keflavik harbour is planned to be the site of a new cement processing plant. The harbour will be used both for receiving Icelandic tuff extracted from sea mines and for shipping out cement /2//.

There are no vessels carrying oil as cargo to the harbours, which significantly reduces the size of a worst-case oil spill. The vessels calling these two harbours carry oil in smaller quantities, for fuel consumption, compared to the larger amounts transported by petroleum tankers. However, this does not mean that a spill from the current vessels would be negligible.

### 3.1.2 Sailing patterns

The fishing vessels have an open sailing pattern to and from Þorlákshöfn, with a slight increase in the routes along the coast to the east and west. The fishing vessels occasionally perform trawling/fishing in the area near Þorlákshöfn.

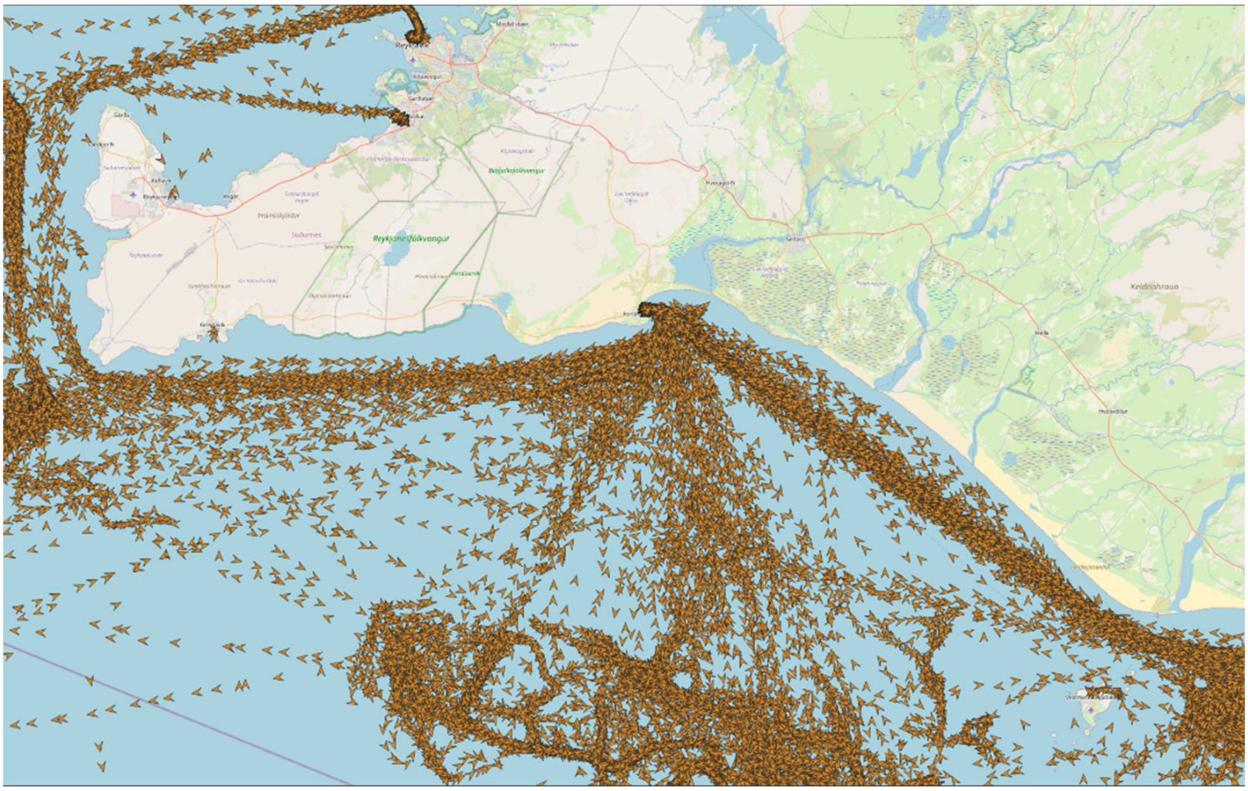


**Figure 3-1 Typical sailing pattern to/from Þorlákshöfn for a fishing vessel**

The RORO-vessels follow a fixed route between Þorlákshöfn and Rotterdam via the Faroe Islands and hence have a more predictable sailing pattern, following the same route along the coast to the southeast from Þorlákshöfn.

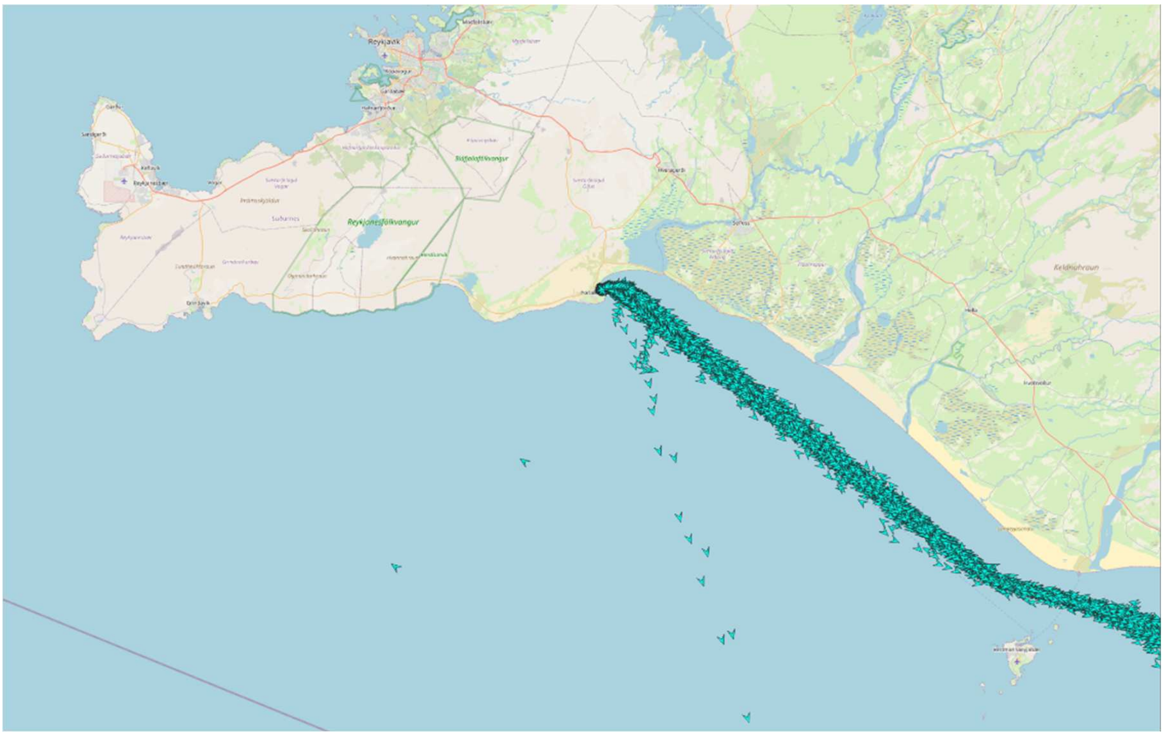


**Figure 3-2 Typical sailing pattern to/from Þorlákshöfn for a RORO vessel**

The sailing pattern of the general cargo vessels are amore dispersed compared to the RORO-vessels, with some trips to other harbours on the west side of Þorlákshöfn, giving an additional route along the coast west of Þorlákshöfn.

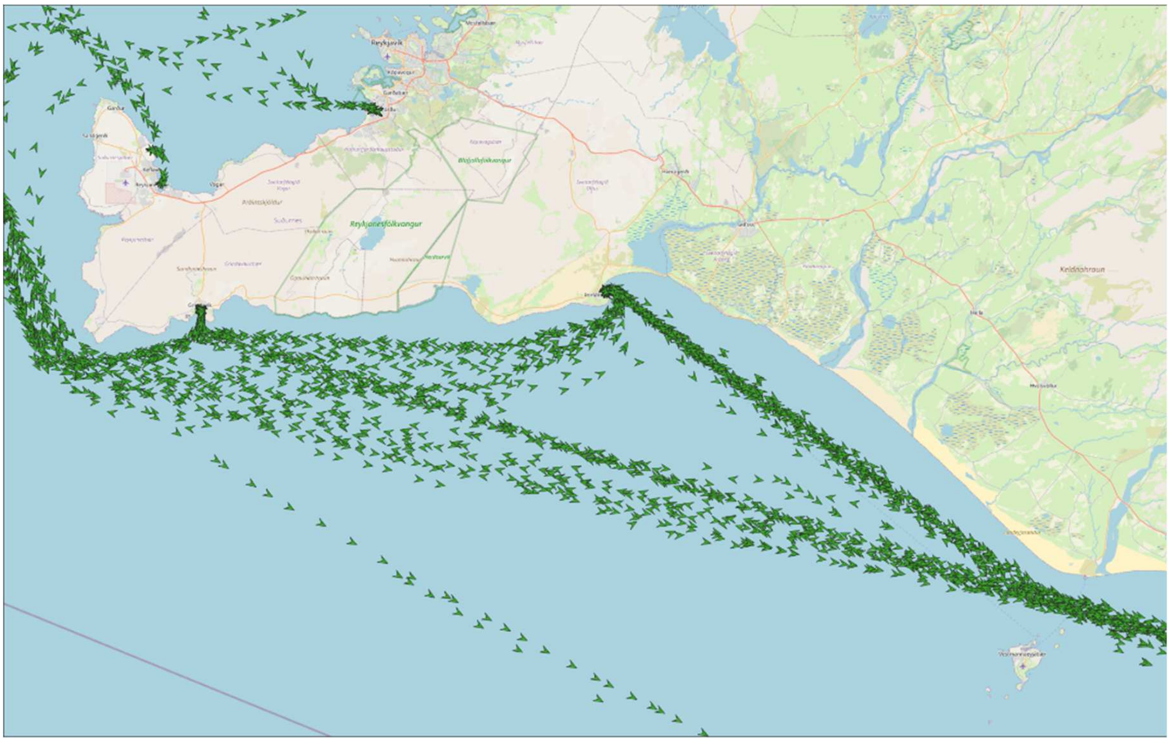


**Figure 3-3 Typical sailing pattern to/from Þorlákshöfn for a General Cargo vessel**

The cement carriers visiting Keflavik are assumed to have similar sailing patterns as RORO-vessels visiting Þorlákshöfn today. The dredgers will be going to the dedicated sea mines which are located off the shore from Markarfljót, near Vestmannaeyjar /2/, meaning the sailing pattern will most probably be quite similar to the pattern for the RORO-vessels. The speeds of these vessels are not entirely known, but a reasonable assumption would be that they have a similar operational profile to the general cargo ships already visiting Þorlákshöfn. The mining operation near Vestmannaeyjar is not considered in this analysis, as it is outside of the area of interest.

## 3.2 Location

### 3.2.1 Study area

The location for this analysis is the area around Þorlákshöfn. A circle with a radius of 10 nautical miles is used to define the limits of the study area.

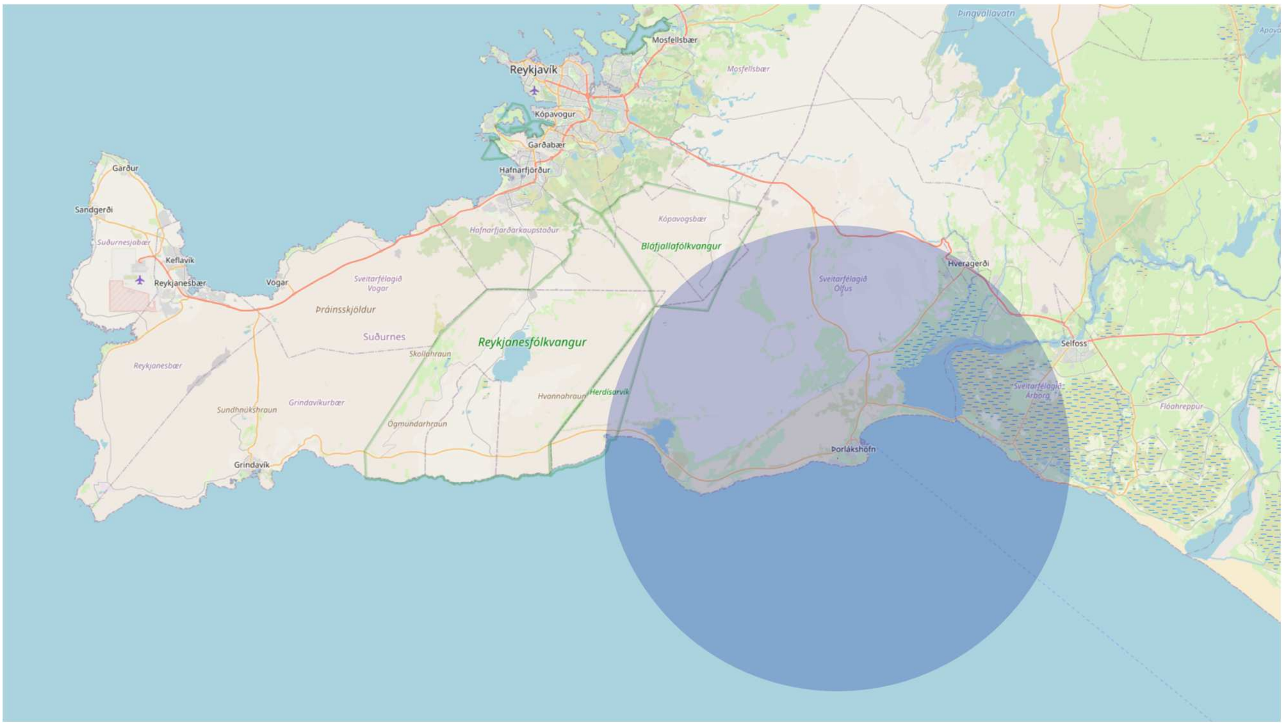



**Figure 3-4 Location of study area highlighted in blue**

## 3.2.2 Weather and wave conditions

The following paragraphs describes the weather conditions in the area. The weather conditions are derived from the data collected in /1/, as well as https://vindatlas.vedur.is/en/. The wave and wind climate of the two ports are assumed to be approximately equal due to the short distance between them.

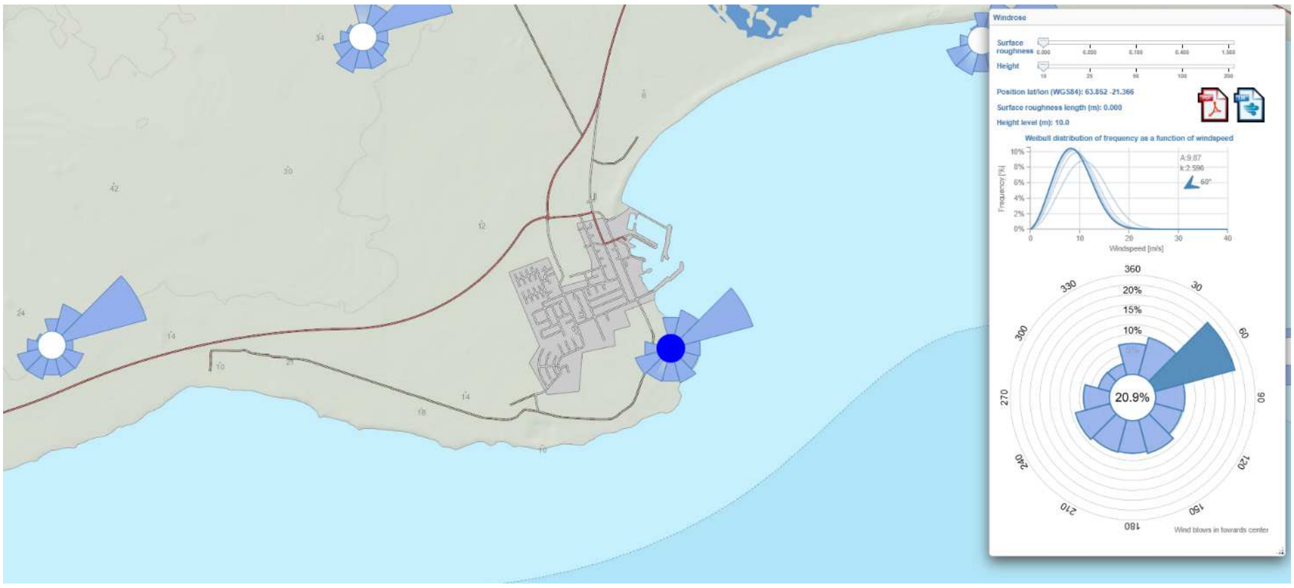


**Figure 3-5 Screenshot of https://vindatlas.vedur.is/en/ showing the wind rose near Þorlákshöfn**

Wind directions vary, with winds from the northeast being the most common and northwest being the least common. Around 20% of the time, the wind is expected to blow from the northeast. The highest windspeeds however, are more common in the southerly winds, from southwest to southeast. According to /1/, windspeeds of 20 m/s occur with a frequency of 1% and windspeeds of 15 m/s occurs with a frequency of about 2%. Provided by the physical layout of the port, 15 m/s is considered to be the highest acceptable windspeed during loading/unloading operations.

The most common wave direction is southwest with a frequency of 56%, followed by south with a frequency of 26% and southeast with a frequency of 8%. The remaining directions have a total frequency of 10%. The significant wave heights are estimated to be 3.9 meters for the frequency of 10%, and 4.7 meters for the frequency of 5% close to Hafarnes. The expected significant wave height with a return period of one year is 9.4 meters /1/.

## 3.2.3 Coast characteristics

The coast near the port of Þorlákshöfn has a variable seabed, with sand beaches on the east side of the harbor followed by cliffs and stones on the west. Additionally, the entry to Þorlákshöfn is sheltered from the most directions, excluding east and southeast by the cape Hafanarnesi. Simliarly, alongside the bay area of Keflavik leaps rocky beaches including both cliffs and stones. The port of Keflavik remains in an unsheltered bay area 5 kilometers west of Þorlákshöfn with a rocky seabed. The bottom is estimated to be 20-25 meters thick layers of pahoehoe lava sedimentation accompanied by cavities with thin top layers of mostly stones and granular material /1/.

In general, the bathymetry around Þorlákshöfn is quite deep, with a steep increase as one gets closer to shore. On the east side of Þorlákshöfn lies the Hafnarskeið beach where the bathymetry has a more gradual incline towards the shore. The beach also has a larger intertidal area compared to the shore on the west side of Þorlákshöfn.

## 3.3 Accident Scenarios

Described seabed and underwater conditions in 3.2 for each port area are linked to the relevancy of emphasised accident scenarios under this section. Listed accident scenarios will be further investigated in relation to oil spill under section 5.1.

The relevant accident scenarios for this analysis will be accidents which could lead to an oil spill in the study area. These accidents can be caused by both human error and technical faults. The included accident types are:

**Grounding** – When a vessel gets in contact with the seabed or an underwater obstacle. Resulting in hull- and structural damages, potentially leading to the vessel being stranded or sinking. In this analysis allision (when a vessel strikes a static structure such as the breakwater) is also included as a grounding accident.

**Collision** – Involves two vessels that strike each other while navigating, and can take different forms such as head-on, overtaking, merging and crossing.

**Foundering** – Refers to a vessel sinking because of heavy weather, structural damages, or other causes which does not include the other accident types.

**Fire/explosion** – Refers to accidents where a fire and/or explosion occurs on board the vessel. This can lead to the sinking of the vessel.

Accident categories like Hull/Machinery damage, Missing, Miscellaneous, War Loss and etc. have not been included in the assessment.

# 4 FREQUENCY ASSESSMENT

Risk is defined as the combination of the frequency of an event and the consequences of the event happing. The risk assessment is therefore divided into an assessment of frequencies, and then an analysis of the consequences. This chapter describes the frequency assessment, including the input data, the method used and the resulting frequencies.

## 4.1 Input data

The number of number of accidents and ship years per vessel type have been sourced from the IHS Markit database, providing a foundation for the performed frequency calculations. This database contains information about global accidents for different ship types and accident types. The database also contains the number of ship years for all ship types. By combining these numbers, it is possible to calculate generic frequency of each accident type per ship type per ship year.

**Table 4-1 Number of ship years per ship type from the IHS Markit database (1979-2024)**

| Ship type | Ship years |
|---|---|
| **RORO** | 101 983 |
| **General cargo** | 1 141 424 |
| **Fishing vessel** | 1 397 077 |
| **Dredger** | 66 604 |
| **Cement Carrier** | 23 220 |

**Table 4-2 Number of accidents in each accident category for each ship type in the IHS Markit database (1979-2024).**

| Ship type | Grounding | Collision | Fire/Explosion | Foundering |
|---|---|---|---|---|
| **RORO** | 695 | 593 | 274 | 142 |
| **General cargo** | 6995 | 5483 | 1889 | 2 362 |
| **Fishing vessel** | 1172 | 616 | 881 | 1 141 |
| **Dredger** | 137 | 147 | 44 | 79 |
| **Cement Carrier** | 103 | 87 | 21 | 18 |

## 4.2 Method

This chapter describes the method used to analyse the estimated accident frequencies. The method is divided into the following steps: Finding global accident frequencies, analysing time spent in the area per ship type, summarizing to find the expected annual accident frequency and return period.

### 4.2.1 Calculating the exposure time of the vessels

Exposure time is both vessel- and port specific. In this assessment the exposure time is found by assessing the sailing patterns of the vessels visiting Þorlákshöfn today and finding the time spent within the analysis area (10 nm radius circle covering both Þorlákshöfn and Keflavik) as highlighted in section 3.2 and shown in Figure 4-1.

As there is no harbour and thereby no traffic in Keflavik today, the sailing patterns to Þorlákshöfn is used instead as they are assumed to be approximately equal to what is expected for Keflavik.

The exposure time is based on the average time spent during arrivals and departures from each port. This is found by measuring the difference in time between the berth and leaving/entering the analysis area for the different routes each ship type uses. Time for port operations is excluded. The time spent inside the area is expressed as a share of an hour. Activities such as waiting or fishing inside the circle are excluded from the assessment as they are difficult to quantify based on port call numbers.

| Ship type(s) | Thorlaksön exposure time (% year) | Keflavik time Exposure time (% year | Time in exposed area (in 10 nm area): % 1 hour |
|---|---|---|---|
| RORO | 2.5685% | N/A | 0.75 |
| General cargo | 1.5982% | N/A | 1 |
| Fishing vessel | 6.8493% | N/A | 1 |
| Dredger | N/A | 5.4795% | 1 |
| Cement carrier | N/A | 2.2831% | 1 |

**Table 4-3 calculated exposure per port and vessel type**

Exposure time is calculated by multiplying the share of an hour spent within the 10 nm radius given in Table 4-3 with the annual number of port calls per destination. Then by multiplying this by 2 the average number of movements from arrival and departure are included. In the subsequent, exposure time is expressed as a percentage of one year by dividing with 8760 (total hours per year).

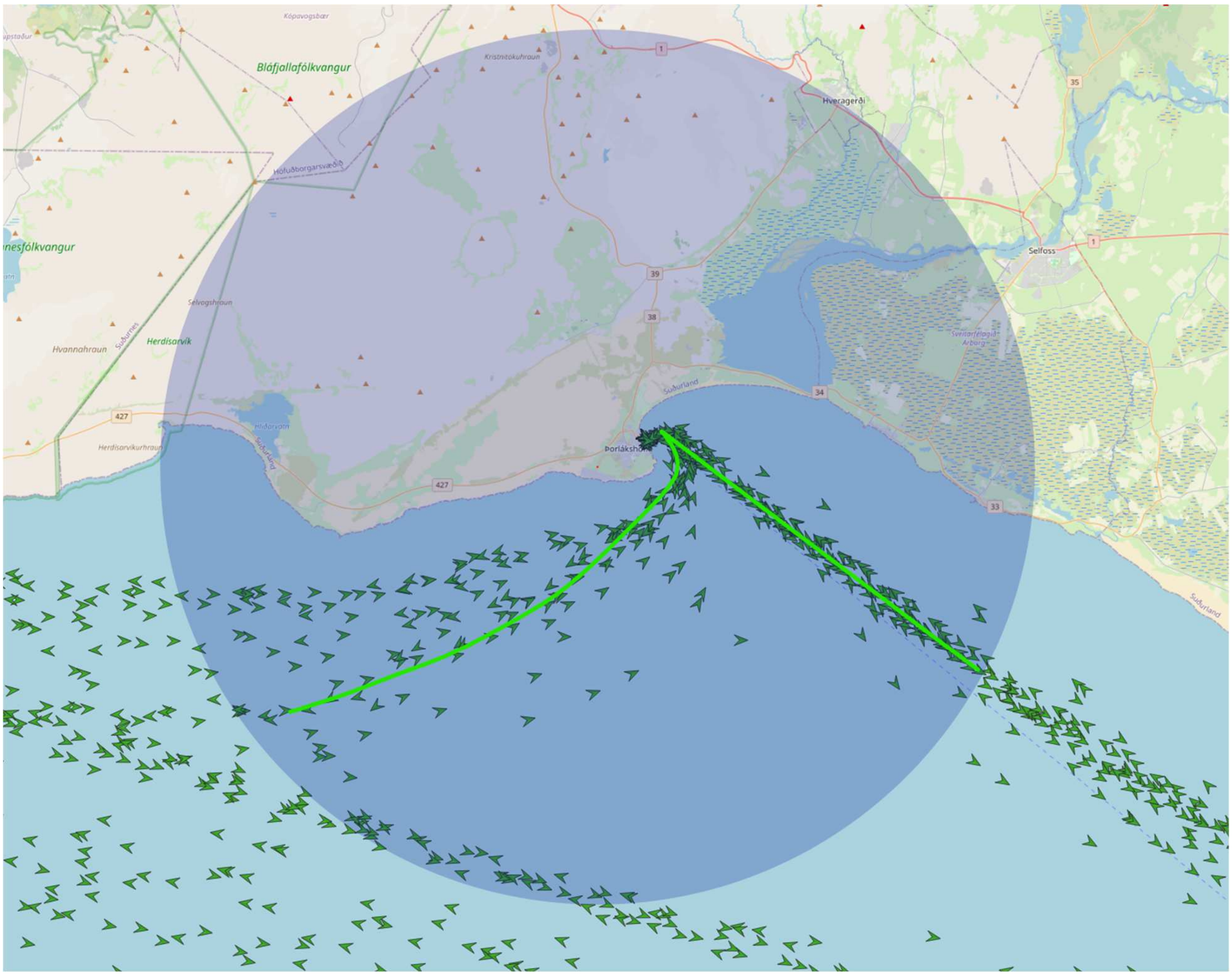



**Figure 4-1 Figure showing analysis of exposure time in the analysis area**

The average time spent in the area on an arrival or a departure is multiplied with two (number of movements through the area per port call), and the annual number of port calls per ship type to give an estimate of the total time spent inside the analysis area for each ship type. The time spent inside the port is not included, as it varies from ship to shop, and because it is assumed an oil spill within the port could be contained and cleaned without larger consequences.

The total number of hours spent inside the analysis area is then divided by the number of hours in a year (8760 hours) to get the percentage of the year spent inside the area, defined as exposure time for the remainder of this report.

### 4.2.2 Calculating accident frequencies from global accident numbers

Global accident numbers and total ship years are found from the IHS Markit database. For each ship type, the number of accidents in each accident category are found in Table 4-2 and divided by the total number of ship years per ship type given in Table 4-1 and multiplied by the fraction of the year the vessel type is sailing in the areas given in first column of Table 4-3. This gives a global accident frequency per ship year for each accident types in analysis area.

| RORO | fq (accident) Thorlaksön | fq (accident) Keflavik | fq (oil spill) Thorlaksön | fq (oil spill) Keflavik |
|---|---|---|---|---|
| Foundering | 3.58E-05 | | 6.80E-06 | |
| Collision | 1.49E-04 | | 4.48E-06 | |

| | | | | |
|---|---|---|---|---|
| Fire/explosion | 6.90E-05 | | 2.07E-06 | |
| contact (allision) | 6.85E-05 | | 2.06E-06 | |
| grounding | 1.07E-04 | | 3.20E-06 | |
| **General cargo** | | | | |
| Foundering | 3.31E-05 | | 6.28E-06 | |
| Collision | 7.68E-05 | | 2.30E-06 | |
| Fire/explosion | 2.64E-05 | | 7.93E-07 | |
| contact (allision) | 2.00E-05 | | 5.99E-07 | |
| grounding | 7.80E-05 | | 2.34E-06 | |
| **Fishing vessel** | | | | |
| Foundering | 5.59E-05 | | 5.03E-06 | |
| Collision | 3.02E-05 | | 1.51E-06 | |
| Fire/explosion | 4.32E-05 | | 4.32E-07 | |
| contact (allision) | 9.12E-06 | | 4.56E-07 | |
| grounding | 4.83E-05 | | 2.90E-06 | |
| **Dredger (bulk)** | | | | |
| Foundering | | 6.50E-05 | | 1.23E-05 |
| Collision | | 1.21E-04 | | 3.63E-06 |
| Fire/explosion | | 3.62E-05 | | 1.09E-06 |
| contact (allision) | | 3.13E-05 | | 9.38E-07 |
| grounding | | 8.14E-05 | | 2.44E-06 |
| **Cement Carrier** | | | | |
| Foundering | | 4.25E-05 | | 8.07E-06 |
| Collision | | 2.05E-04 | | 6.16E-06 |
| Fire/explosion | | 4.96E-05 | | 1.49E-06 |
| contact (allision) | | 4.48E-05 | | 1.35E-06 |
| grounding | | 1.98E-04 | | 5.95E-06 |

**Table 4-4 Calculated frequencies per accident type per vessel type for the analysis area.**

### 4.2.3 Calculating the annual accident frequency and return period

The annual accident frequency is calculated by multiplying the ship specific exposure time with the global accident frequency for each ship- and accident type. The return period is then found by dividing 1 by the expected annual accident frequency.

Summing together all frequencies of all accident types per ship type indicate a general frequency

| | Frequency accident | Years between Acc. |
|---|---|---|
| RORO Vessel | 4.29E-04 | 2330.13 |
| General Cargo Vessel | 2.34E-04 | 4269.27 |
| Fishing Vessel | 1.87E-04 | 5353.63 |
| Dredger | 3.35E-04 | 2986.56 |

| | | |
|---|---|---|
| Cement Carrier | 5.40E-04 | 1850.53 |
| Total | 1.73E-03 | 579.57 |

**Table 4 5 Total accident frequencies for ship types and return periods..**

### 4.2.4 Uncertainties

Calculated frequencies are based on the input data from the global IHS Markit database, meaning the resulting values under section 4.3 might not match the actual numbers for Iceland. Since the retrieved numbers from IHS Markit is based on global data and most reported accidents are from developed countries, a large amount of under-reporting is expected. Additionally, the retrieved data from the global data source might not match completely with the vessels examined in this report as the general tonnages are smaller.

## 4.3 Results

In this chapter the resulting frequencies per accident type have been calculated in accordance with the method in section 4.2. Overall, the total estimated accident frequency for the area is $1.73 \times 10^{-3}$ accidents annually, meaning that an accident is expected to occur approximately once every 580 years. The accident frequencies for each vessel type, as well as the total can be seen in Figure 4-2 and the return periods in Figure 4-3.

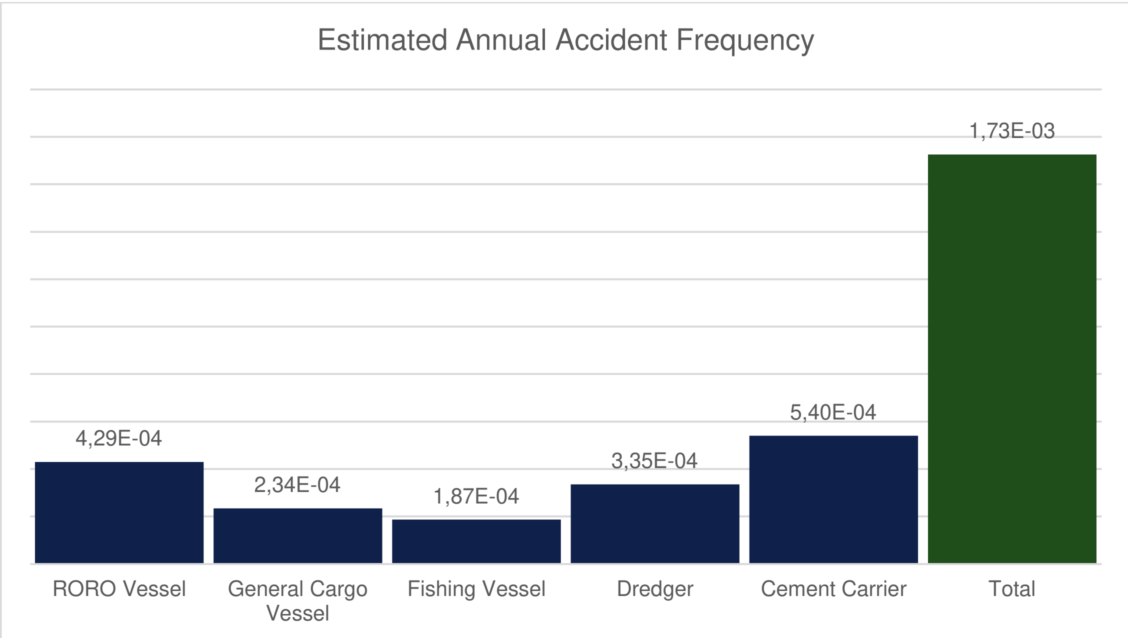



**Figure 4-2 Estimated Annual Accident Frequency per Ship Type and Total**

The frequencies in this report might seem very low, however it is important to keep in mind that the area for which the frequencies are valid is a quite small area and the analysed vessels do not spend a long time traversing the area compared to the total time of a year. One example of an accident that has occurred in this region is the 4,000 dwt cement carrier that run aground at the entrance to Keflavík harbour in Iceland in 2018. The vessel struck rocks with a breach in the hull and a small oil spill occurred. The ship had approximately 100 tons of oil on board[2].

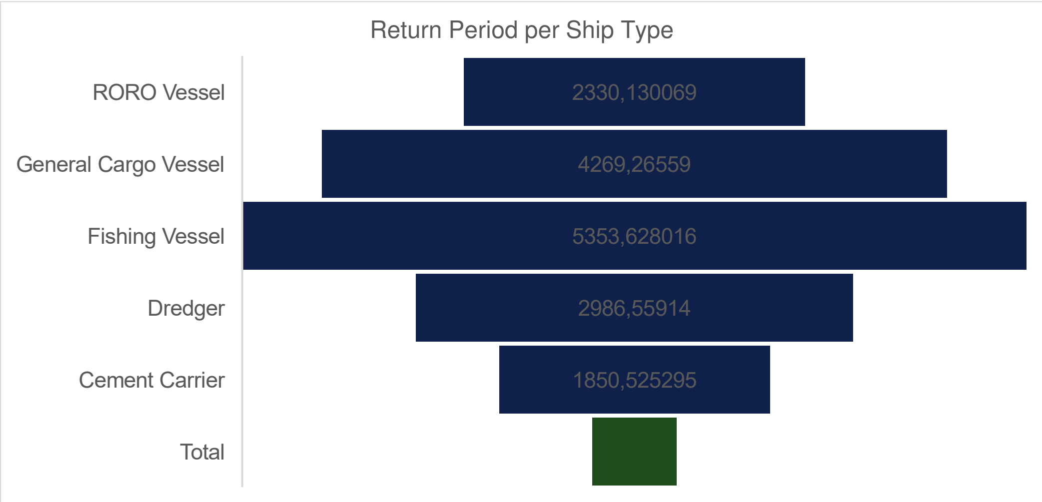



**Figure 4-3 Accident frequency per vessel type and years between every accident**

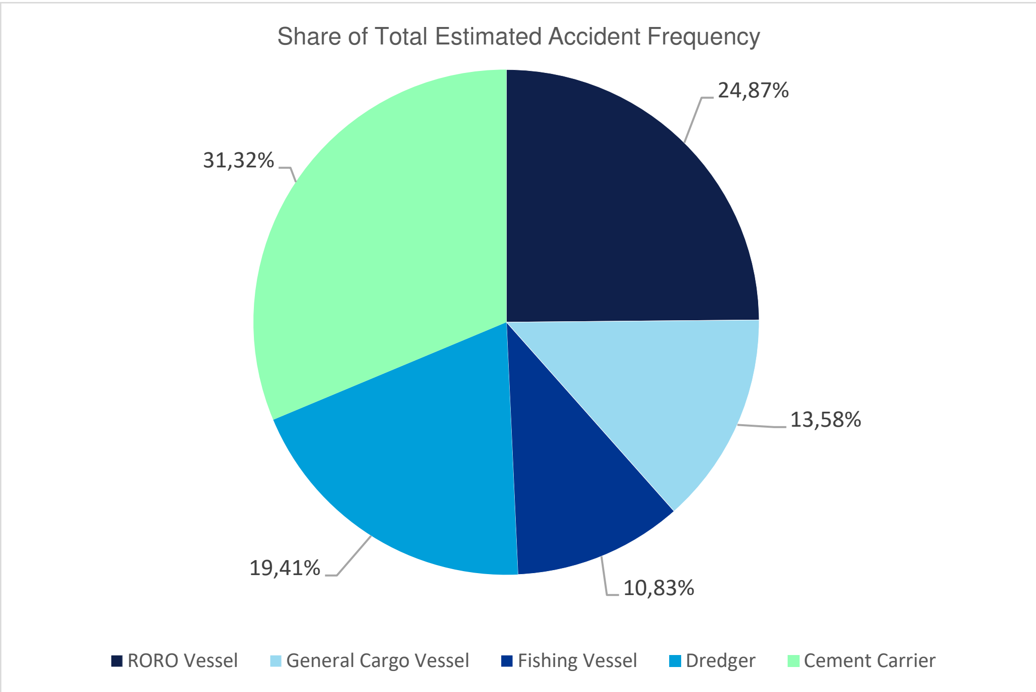



**Figure 4-4 Share of Total Estimated Accident Frequencies**

RORO vessels account for second highest share of the estimated annual accident frequency at 24.9% with a frequency of $4.29 \times 10^{-4}$ and a return period of 2,330 years. Subsequently, for dredgers a frequency of $3.35 \times 10^{-4}$ giving approximately 2,988 years return period and representing 10.8% of the total estimated annual accident frequency. For

[2] https://www.cemnet.com/News/story/165270/keflav-k-harbour-blocked-by-grounded-cement-carrier.html

General Cargo Vessels the annual accident frequency was estimated to be $2.34 \times 10^{-4}$ with expected reoccurrences every 4269 years. Consequently, the lowest annual accident frequency was identified for the Fishing Vessels to be $1.87 \times 10^{-4}$, accompanied by a return period of 5336 years.

# 5 CONSEQUENCES

This chapter describes the second half of the risk assessment, the consequences. The chapter touches upon the input data, the method used, the resulting oil spill frequencies, the resulting oil spill and the environmental consequences.

## 5.1 Input data

The IHS Markit database lacks relationships to oil spills. To close this gap DNV has allocated complementary data sources. The sources for the frequency of oil spills given an accident per ship category and accident type are based on data from the Norwegian Coastal Administration and used in previous DNV projects /3/. It is assumed the ships visiting Þorlákshöfn and Keflavik in general will be similar to ships sailing along the Norwegian coast, and that the same numbers can be utilized.

**Table 5-1 Frequency of oil spill given and accident, per accident cateogory and ship type from /3/**

| Ship type | Grounding | Collision | Fire/Explosion | Foundering |
|---|---|---|---|---|
| **RORO** | 0.03 | 0.03 | 0.03 | 0.19 |
| **General cargo** | 0.03 | 0.03 | 0.03 | 0.19 |
| **Fishing vessel** | 0.06 | 0.05 | 0.01 | 0.09 |
| **Dredger** | 0.03 | 0.03 | 0.03 | 0.19 |
| **Cement Carrier** | 0.03 | 0.03 | 0.03 | 0.19 |

The same source gives an estimation of the percentage of fuel oil spilled, given an accident with oil spill. The estimation of fuel oil spilled is divided into three categories based on the severity of the accident, where category 1 is a minor accident, category 2 is a serious accident and category 3 is a total loss.

**Table 5-2 Percentage of Total Fuel Capacity Spilled Given an Accident with Oil Spill**

| | Category 1 | Category 2 | Category 3 |
|---|---|---|---|
| **Grounding** | 15% | 30% | 100% |
| **Collision** | 50% | 100% | 100% |
| **Foundering** | N/A | N/A | 1 |
| **Fire/Explosion** | 2% | 10% | 100% |

## 5.2 Method

The oil spill probabilities are calculated by multiplying the estimated accident frequencies from section 4.3 with the probabilities for oil spill from section 5.1. To find the return period for the oil spills, 1 is divided by the estimated frequency of oil spill.

The expected oil spill amounts are found by multiplying the percentages of fuel oil spilled per accident severity category from section 5.1 with the estimated average oil quantity in the tanks of the ships from /1/.

## 5.3 Oil Spill Frequencies and Amounts from Accidents

Under this chapter, frequencies for accidents with oil spills and spilled quantities will be presented. For the spilled quantities, a range will be presented based on the severity of the accident.

The calculated oil spill frequencies for the study area can be found in Table 5-3. The total frequency of accidents with oil spill is estimated to be $8.47 \times 10^{-5}$ annualy, giving a return period for an accident with an oil spill of 11,806 years.

**Table 5-3 Frequency of accidents and accidents with oil spill per ship type**

| Vessel Types | Frequency of Accident | Frequency of Accident with Oil Spill |
|---|---|---|
| **RORO** | 4.29E-04 | 1.86E-05 |
| **General cargo** | 2.34E-04 | 1.23E-05 |
| **Fishing vessel** | 1.87E-04 | 1.03E-05 |
| **Dredger** | 3.35E-04 | 2.04E-05 |
| **Cement Carrier** | 5.40E-04 | 2.30E-05 |
| **Total:** | **1.73E-03** | **8.47E-05** |

The ship type with the highest probability for oil spills is the cement carriers at Keflavik with a frequency of $2.3 \times 10^{-5}$ , giving a return period of around 42,460 years. The spilled quantity expected from a cement carrier for the various accident types can be seen in Figure 5-1.

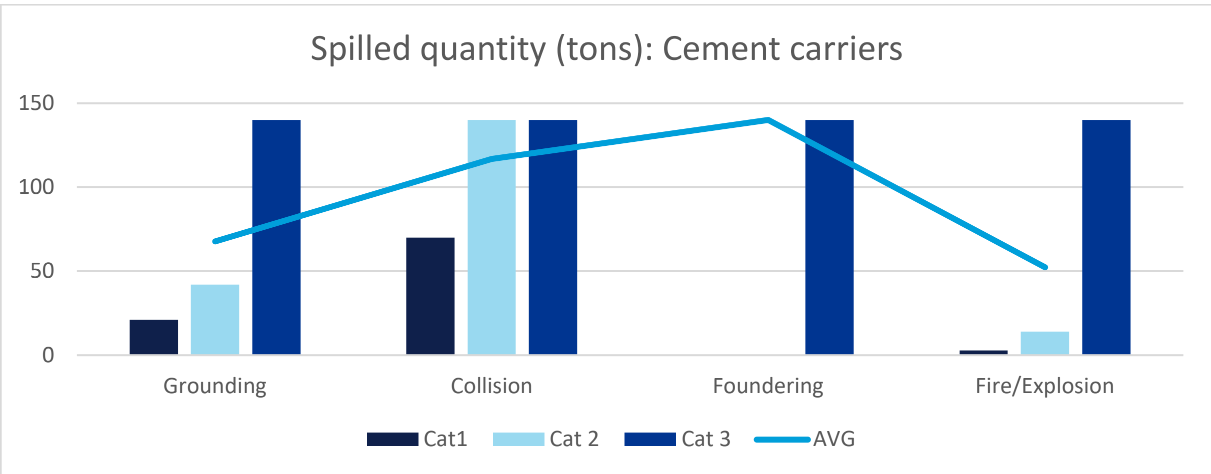



**Figure 5-1 Quantity of Oil Spilled, Cement Carriers**

The second highest probability is found for dredgers, with an oil spill expected to occur with an annual frequency of $2.04 \times 10^{-5}$, giving a return period of approximately 48,915 years.

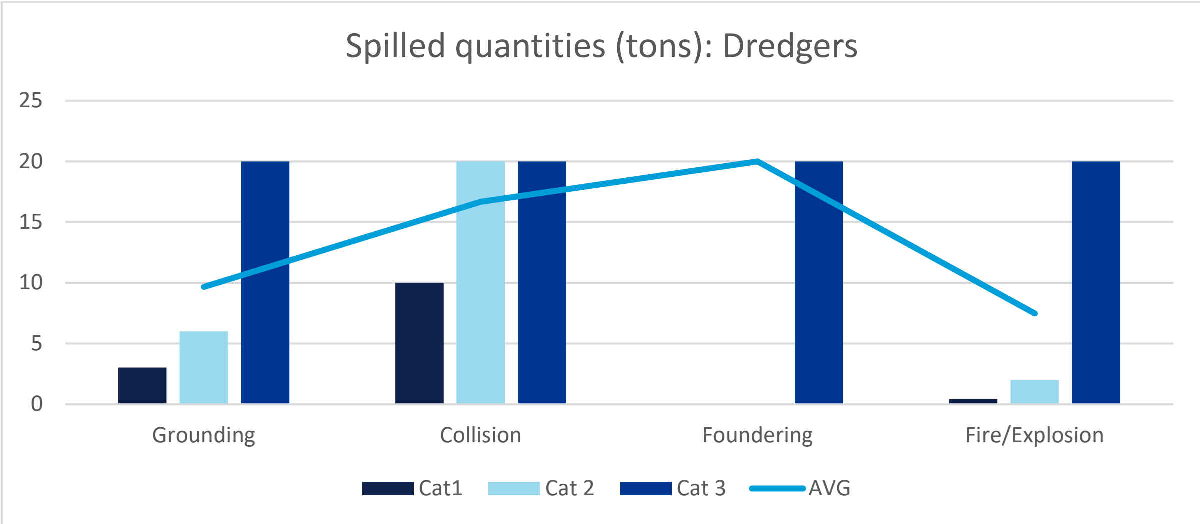



**Figure 5-2 Quantity of Oil Spilled, Dredgers**

For RORO vessels the frequency of spills is estimated to $1.86 \times 10^{-5}$ meaning the return period is estimated to be 53772 years. The RORO vessels have the largest capacity of fuel oil, at 600 tons.

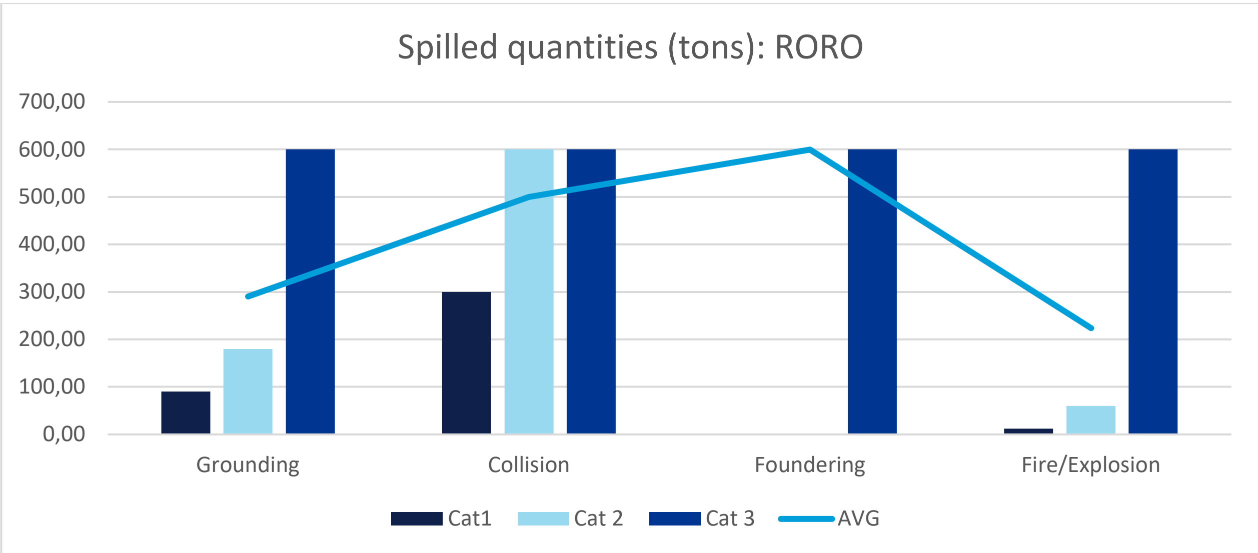



**Figure 5-3 Quantity of Oil Spilled, RORO Vessels**

Expected spills for general cargo constituted a probability of $1.86 \times 10^{-5}$ and a return period of approximately 81180 years.

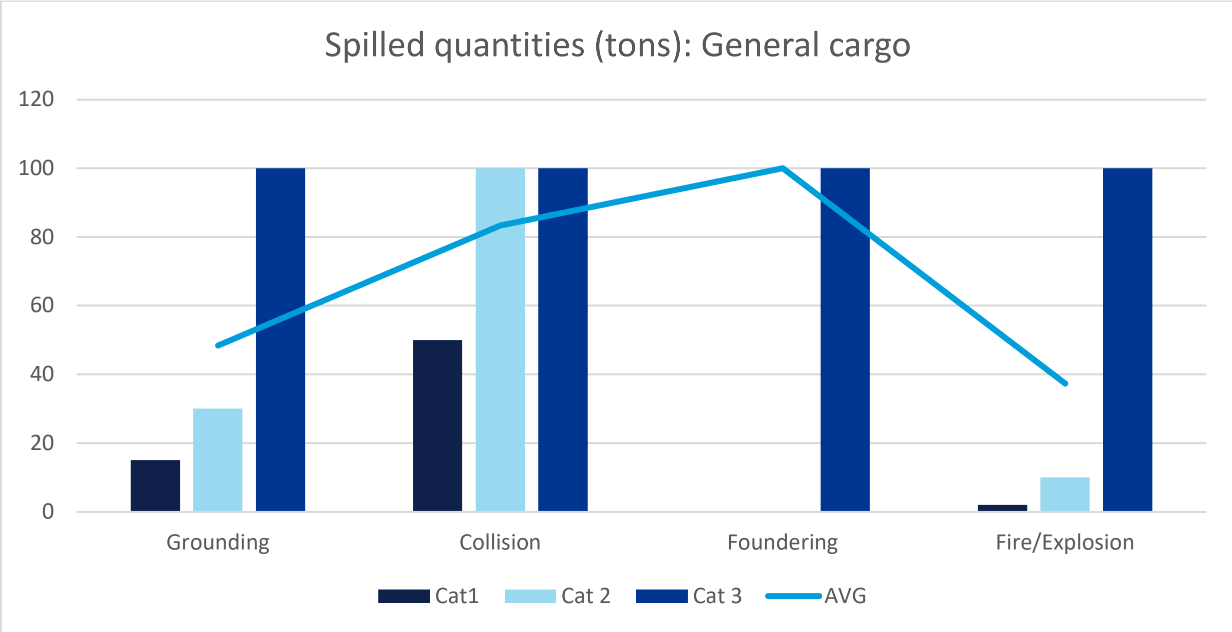
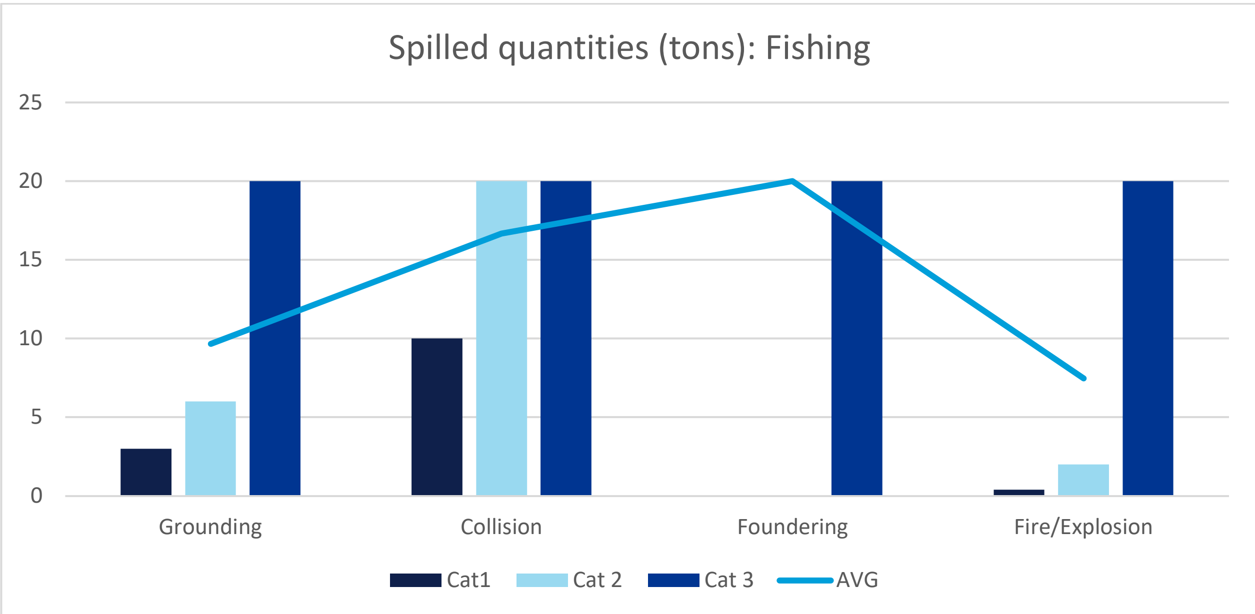



**Figure 5-4 Quantity of Oil Spilled, General Cargo Vessels**

Fishing Vessels have the lowest probability of an oil spill with an expected frequency of $1.03 \times 10^{-5}$. The fishing vessels also have the lowest oil capacity, shared with the dredgers, of 20 tons.




## 5.4 Environmental Consequences

In this chapter general environmental consequences are described based on DNVs internal knowledge and experience. The surroundings of the ports of Keflavik and Þorlákshöfn could be subject to marine accidents whose severity depends on the size and spread of oil spills. DNV has estimated the fuel oil spill amounts per accident scenario and vessel type as well as defined maximum spill amounts for the worst-case scenarios in chapter 5.1.

The consequences of the oil spill vary based on the fuel type, weather conditions and shore composition.

**Spills of Marine Diesel Oil (MDO) or Marine Gas Oil (MGO)** will usually spread quickly over the water surface, forming a thin sheen. This thin sheen tends to evaporate quickly in warm weather or persist longer in colder climates. In rougher weather conditions the fuel is more likely to mix with the seawater and be present also below the surface. As the depth increases, the possibility for the mixed fuel oil to be present will be reduced. MDO and MGO are in general considered less harmful compared to heavy fuel oil.

**Heavy Fuel Oil spill (HFO)** typically floats on the water surface as it tends to form thick rubber-like emulsions. These emulsions can eventually approach the shore depending on the location of the wreck and the direction of the wind, waves and current. A HFO spill spread along the coastline constitutes a large issue for animals feeding on the sea surface or in nearby intertidal areas such as beaches. Birds are especially subject to issues following a HFO spill. Some emulsions might sink to the sea floor but would not typically mix with the seawater.

**The rocky beach cliffs** around the southern coast of Iceland will contribute to mixing of sea water and fuel spills leading to a dilution of the oil spill. For birds and other animals/plants living/feeding on the surface the consequences could be reduced in comparison to areas where less mixing occurs, such as on the beaches on the east side of the harbours. For animals and organisms living or feeding slightly deeper in the water column, the consequences might be slightly increased.

The oil spill will drift with the wind and currents. With the given weather conditions, an oil spill would be quite likely to drift towards shore, but the detailed drift patterns have not been investigated in this study.

# 6 Conclusions

The study has calculated the annual probabilities for oil spill and range of expected oils spills amounts. The total frequency of accidents with oil spills is $8.47 \times 10^{-5}$.

RORO ships have the largest fuel oil capacity and in extreme case potential to spill largest single oil spill.

In summary the risk of an oil spill within the study area of Þorlákshöfn and Keflavik harbours is remote. However, should an accident occur, the consequences could be severe, where expected spill size could range between 100 tonnes to 1,000 tonnes.

The typical weather in the area, combined with the geography of the shore increases the chances of the oil mixing with the water, which will reduce the consequences for birds and other animals/plants living/feeding on the surface. This can however increase the consequences for other animals and organisms living or feeding deeper in the water column. It is highly unlikely that spilled oil will be present at 40 meters depth or lower.

# 7 REFERENCES


/1/ Portum verkfræðistofa (2024) Memorandum: Ships traffic in Port of Þorlákshöfn and Port of Keflavik

/2/ Heidelberg Materials (2024) https://heidelberg.is/en/

/3/ Kystverket (2023) Automated calculation of risk related to ship traffic. *Risk calculation method and data sources.*

/4/ IMO (2018) MSC-MEPC.2/Circ.12/Rev.2 - REVISED GUIDELINES FOR FORMAL SAFETY ASSESSMENT (FSA) FOR USE IN THE IMO RULE-MAKING PROCESS

DNV

## About DNV

DNV is the independent expert in risk management and assurance, operating in more than 100 countries. Through its broad experience and deep expertise DNV advances safety and sustainable performance, sets industry benchmarks, and inspires and invents solutions.

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Driven by its purpose, to safeguard life, property, and the environment, DNV helps tackle the challenges and global transformations facing its customers and the world today and is a trusted voice for many of the world's most successful and forward-thinking companies.