Petrofac

ONE-Dyas B.V.
F06-IJssel Surface Well Blowout
OSCAR Modelling Report

Customer: ONE-Dyas

Version Control

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Abbreviations

API	American Petroleum Institute
BAOAC	BONN Agreement Oil Appearance Code
IBCAO	International Bathymetric Chart of the Arctic Ocean
mt	Metric ton (tonne)
Oil	Petroleum in any form including crude, condensate, fuel oil, sludge oil, oil refuse and refined products – such as diesel
OSCAR	Oil Spill Contingency and Response
ppb	parts per billion
µm	micrometre

1.0 MODELLING

The SINTEF Oil Spill Contingency and Response (OSCAR) modelling package was used to examine the potential impact of a release of crude from the F06-IJssel well. Several scenarios have been modelled to assist in quantifying the risk to the local marine and coastal environment.

The aims of the modelling were to understand:

Stochastic Modelling

- Surface Oiling
    - probability of surface oiling (with an applied threshold of ≥0.1 µm)
- Shoreline Contamination
    - probability of shoreline impact (no threshold applied)

Deterministic Modelling

- The fate of the crude (the amount that has dispersed, evaporated, and beached) and the potential impact on environmentally sensitive areas.

1.1. OSCAR

SINTEF's OSCAR modelling package, which has undergone extensive scientific research and validation (Reed M. F., 1995), (Reed M. A., 1996), was selected to undertake the simulation.

The OSCAR modelling package developed by SINTEF, is a three-dimensional oil spill model which calculates and records a range of water surface, subsurface and shoreline oiling possibilities over a stipulated period of release. OSCAR is a fully validated and calibrated model using a variety of field observations from several experimental oil spills.

The model accounts for weathering, the physical, biological, and chemical processes affecting oil at sea. OSCAR addresses the following surface processes: surface spreading and advection, entrainment in the water column, emulsification (mousse formation), and volatilisation (dissolution). Particles entrained in the water column are modelled with horizontal and vertical advection and dispersion.

OSCAR's range of predictions includes:

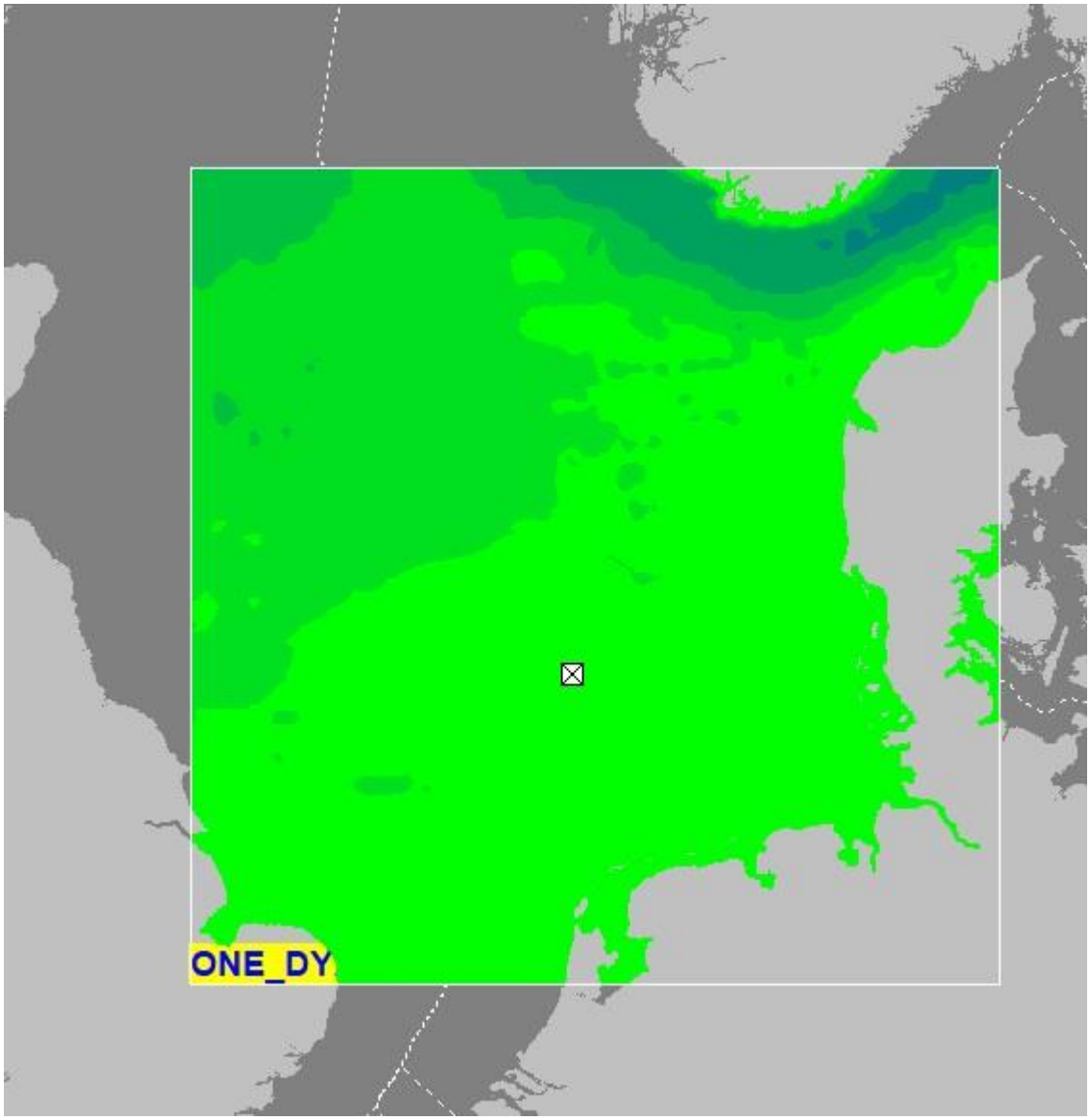
- probability of contamination - surface, sediment, shoreline, and water column
- time of arrival - oil on surface, in the water column and shoreline beaching
- maximum likely concentrations - in the water column and on water surface
- emulsified mass - of oil reaching shoreline and surface.
- exposure time - of surface oil, water column and concentration thresholds
- fate processes - including evaporation, dispersion, dissolution, sedimentation, beaching, and decay.

2.0 MODEL INPUT DATA

This section summarises the input data used for the OSCAR simulations.

2.1. Study Area (Habitat Grid)

A 650 km by 650 km (422,500 km^2) habitat grid was considered as an appropriate resolution to establish potential surface oiling, water column concentrations and shoreline impact. Each grid cell covers an area of approximately 650 m x 650 m (0.4225 km^2).



The shoreline type has a bearing on the amount of hydrocarbon that may beach and re-mobilise – this was chosen to be Sandy Beach. This shoreline type is a reasonable approximation to determine the quantities beached.

2.2. Environmental Data

Hydrodynamic Data	Daily average representative 3D current data used in the model was taken from the Hybrid Coordinate Ocean Model (HYCOM) (2008- 2014).	
Wind	Representative wind data used in the model was taken from the European Centre for Medium-Range Weather Forecasts (2008 - 2014) and provided at 3 hourly intervals.	
Air Temperature	The air temperature is not used by the evaporation model in OSCAR	
Sea Temperature[1]	**Winter**	**Summer**
Depth 0m	6.9°C	14.4°C
Salinity	34 ppt	34 ppt

2.3. Modelled Parameters

F06-IJssel Well	
Release location	Surface
Latitude / Longitude	54° 49' 12.8" N / 04° 42' 51.4" E
Release amount	1,501 m^3 per day, reducing to 1,211 m^3 per day - by day 90
Simulation duration	100 days[2]

[1] NOAA, WOA 2018 Data Access: Statistical mean of temperature on 1° grid

[2] An additional 10 days was added to the release duration of 90 days to allow for additional surface oil tracking once the release ceased.

2.4. BONN Agreement Oil Appearance Code

The BONN Agreement Oil Appearance Code (BAOAC) states that under most viewing conditions, oil layers below 0.04 µm in thickness cannot easily be detected by the human eye and appear silvery / grey up to a thickness 0.3 µm (Lewis, 2013).

BONN Agreement Oil Appearance Code				
Code	Description - Appearance	Layer thickness Interval		Litres per km^2
		µm	mm	
1	Sheen (silver/grey)	0.04 - 0.30	4e-005 - 0.0003	40 - 300
2	Rainbow	0.3 - 5.0	0.0003 - 0.005	300 - 5,000
3	Metallic	5.0 - 50	0.005 - 0.05	5,000 - 50,000
4	Discontinuous true oil colour	50 - 200	0.05 - 0.2	50,000 - 200,000
5	Continuous true oil colour	≥ 200	≥ 0.2	≥ 200,000

2.4.1. Applied Thresholds

- Based on the report finding of 'Effects of Sheens Associated with Offshore Oil and Gas Development on the Feather Microstructure of Pelagic Seabirds' (O'Hara & Morandin, 2010) and for the purpose of this study report, a surface thickness threshold of 0.1 µm (0.0001 mm) was applied to surface oiling.
- Based on acceptable oil in water discharges for onshore waters within 12nm territorial water limits, a 50-ppb threshold was set for water column concentrations.
- No threshold set for shoreline mass accumulations onshore.

2.5. Shoreline Oiling

Based on the 2011 ITPOF Technical Information Paper No. 6 "Recognition of oil on shorelines" the extent of shoreline oiling described as Light, Moderate or Heavy oiling is shown below. Where shoreline oiling is registered within the models, an overview of shoreline classification for oiling is provided.

Shoreline Oiling Classification	Volume (litres / m^2)	Avg. oil Thickness (mm)	Oiling (kg / m^2)
Light Oiling	0.1 - 1	0.1 -1	0.0914 - 0.914
Moderate Oiling	1 - 10	1 -10	0.914 - 9.14
Heavy Oiling	>10	>10	>9.14

Light Oiling example	Moderate Oiling example	Heavy Oiling example
		

Images courtesy of ITPOF – ITPOF Technical Information Paper No. 6 "Recognition of oil on shorelines"

2.6. Oil Profile

OSCAR's standard oil database does not hold F06-IJssel crude. Svale crude was chosen as a suitable representation for modelling purposes through hydrocarbon matching based on known properties.

Oil Matching Comparison						
Name	**ITOPF Group**	**SG**	**Viscosity**	**Pour Point (°C)**	**Wax Content (%)**	**Asphaltene Content (%)**
F06-IJssel	III	0.914	100	-42	4.7	0.25
Svale	III	0.914	257	-33	2.12	0.32

2.7. Response Activities

To provide a better understanding of the fate of the crude, the simulations did not incorporate any oil spill response activities.

2.8. Modelled Scenarios

2.8.1. Stochastic Scenarios

Scenario		Release Rate	Release Duration	Modelled Duration
S01	F06-IJssel Well Blowout (Winter)	1,501 m^3 per day, reducing to 1,211 m^3 per day, by day 90	90 days	100 days
S02	F06-IJssel Well Blowout (Summer)	1,501 m^3 per day, reducing to 1,211 m^3 per day, by day 90	90 days	100 days

2.8.2. Deterministic Scenario

Results from stochastic model outputs have been analysed to identify the worst-case beaching scenario - this being the simulation with the single largest beaching volume.

Scenario		Release Rate	Release Duration	Modelled Duration
D01	F06-IJssel Well Blowout (Winter)	1,501 m^3 per day, reducing to 1,211 m^3 per day, by day 90	90 days	100 days
Month of modelled release – February 2010				
D02	F06-IJssel Well Blowout (Summer)	1,501 m^3 per day, reducing to 1,211 m^3 per day by, day 90	90 days	100 days
Month of modelled release – June 2012				

3.0 OSCAR SIMULATIONS

3.1. Stochastic Simulation

In a stochastic simulation, a series of release trajectory simulations are run repeatedly with a start date that is within the time period covered by historical wind and/or hydrodynamic data. The results of the trajectories are combined to illustrate the predicted probabilities of oil pathways in defined time periods. Running multiple release simulations during a single season should provide a reliable prediction of the oil pathways and oiling probabilities for a release starting during that season and extending into subsequent seasons.

In excess of 100 simulations spanning the release period were run using a wind time series, which started on a randomly selected date. In this approach, a sufficient number of simulations should adequately model the variability in the wind speed and direction in the area identified within the simulation.

The results of the stochastic model were analysed to determine the date with the highest beaching volume. This date and time were used for the deterministic model.

3.2. Deterministic Simulation

Deterministic or trajectory models are used to predict the path of an oil slick over time. The model estimates the weathering profile under the specified hydrodynamic and meteorological conditions by using temporally, and spatially varying, numerically computed ocean currents and winds.

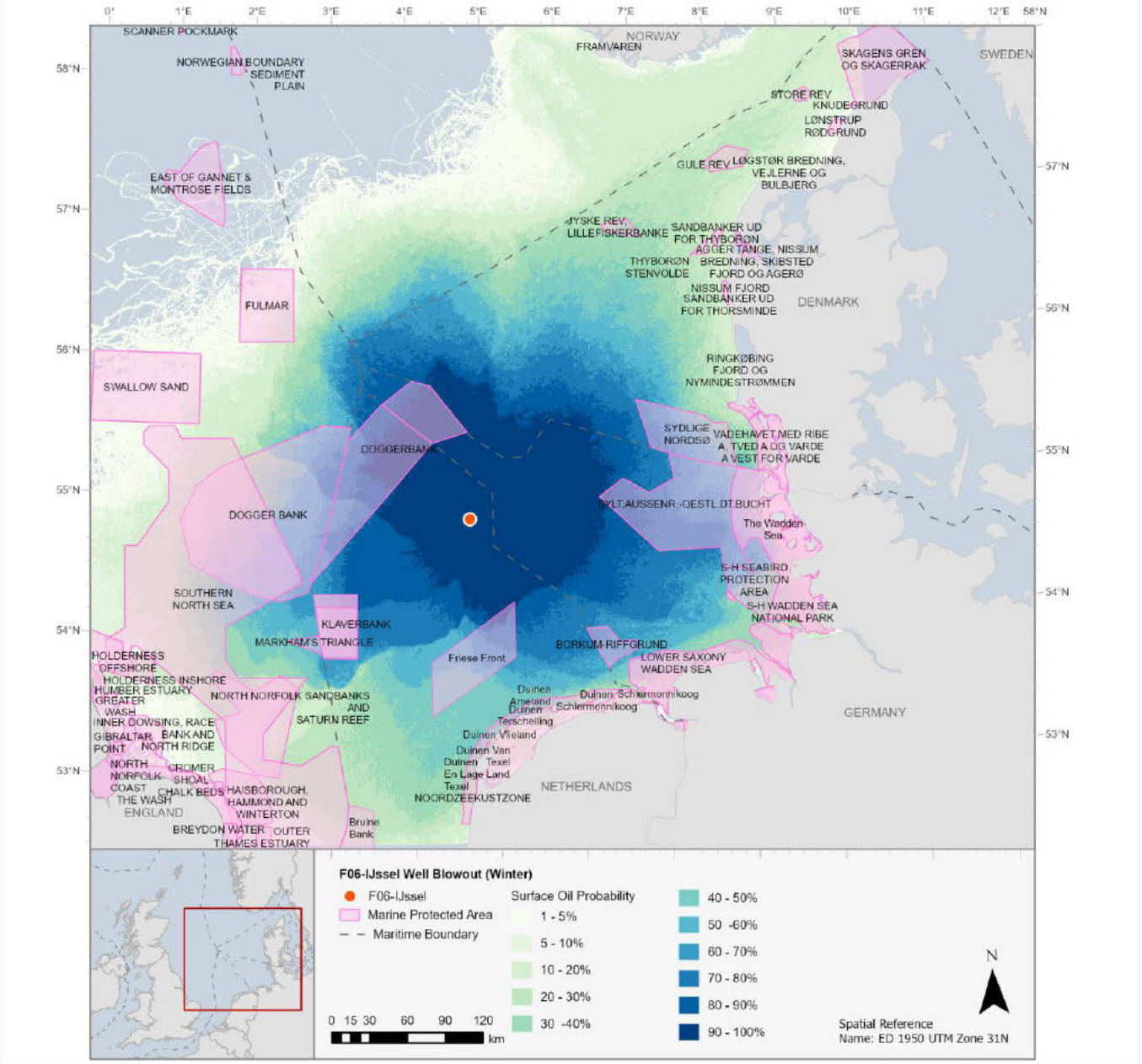
The results were analysed to determine:

- the predicted slick trajectory
- estimates of slick area
- changes to the crude properties over time
- potential impact to environmentally sensitive areas and the length of coastline impacted.
- sediment concentrations
- estimates of the total amount of beached crude.

4.0 RELEASE OUTPUTS

4.1. STOCHASTIC OUTPUTS

4.1.1. S01 – F06-IJssel Well Blowout Surface Oiling Probabilities

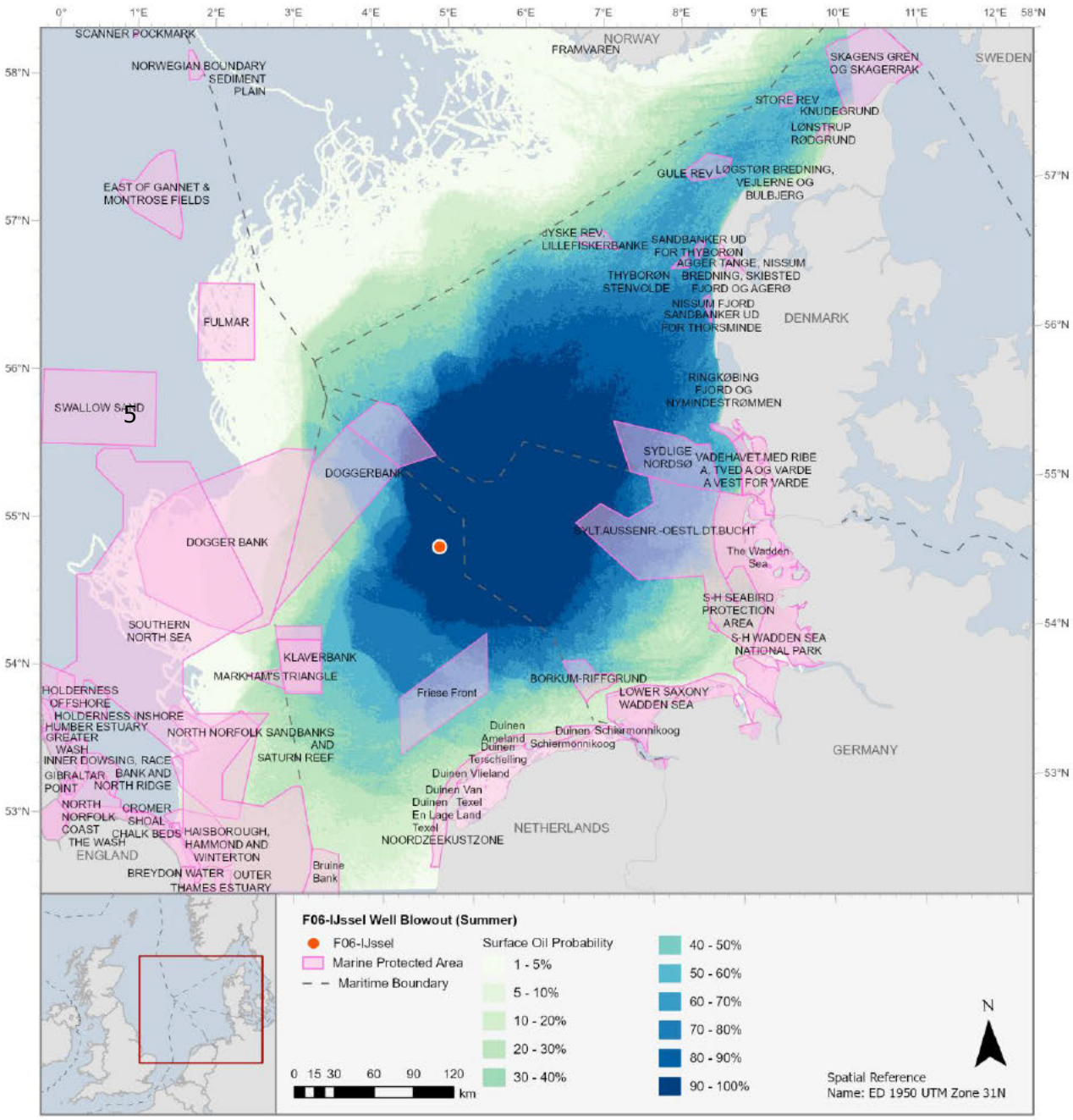


The picture does not depict the real extent of the spill; instead, it provides a statistical representation employed for risk assessment, drawing from approximately 100 distinct simulated trajectories. The anticipation of oil pathways involves amalgamating all trajectories from the simulation and illustrating them as a unified probability-density map. The plot illustrates the likelihood (>1%) of surface crude thickness being equal to or greater than 0.1µm.

Summary of S01 Surface Oiling Probabilities

- The highest probability of occurrence in a single grid cell is shown to be 90 – 100%. This area extends outwards for approximately 126 km.
- There is a 90-100% probability of surface oil crossing into German and Danish waters.

4.1.2. S02 – F06-IJssel Well Blowout Surface Oiling Probabilities

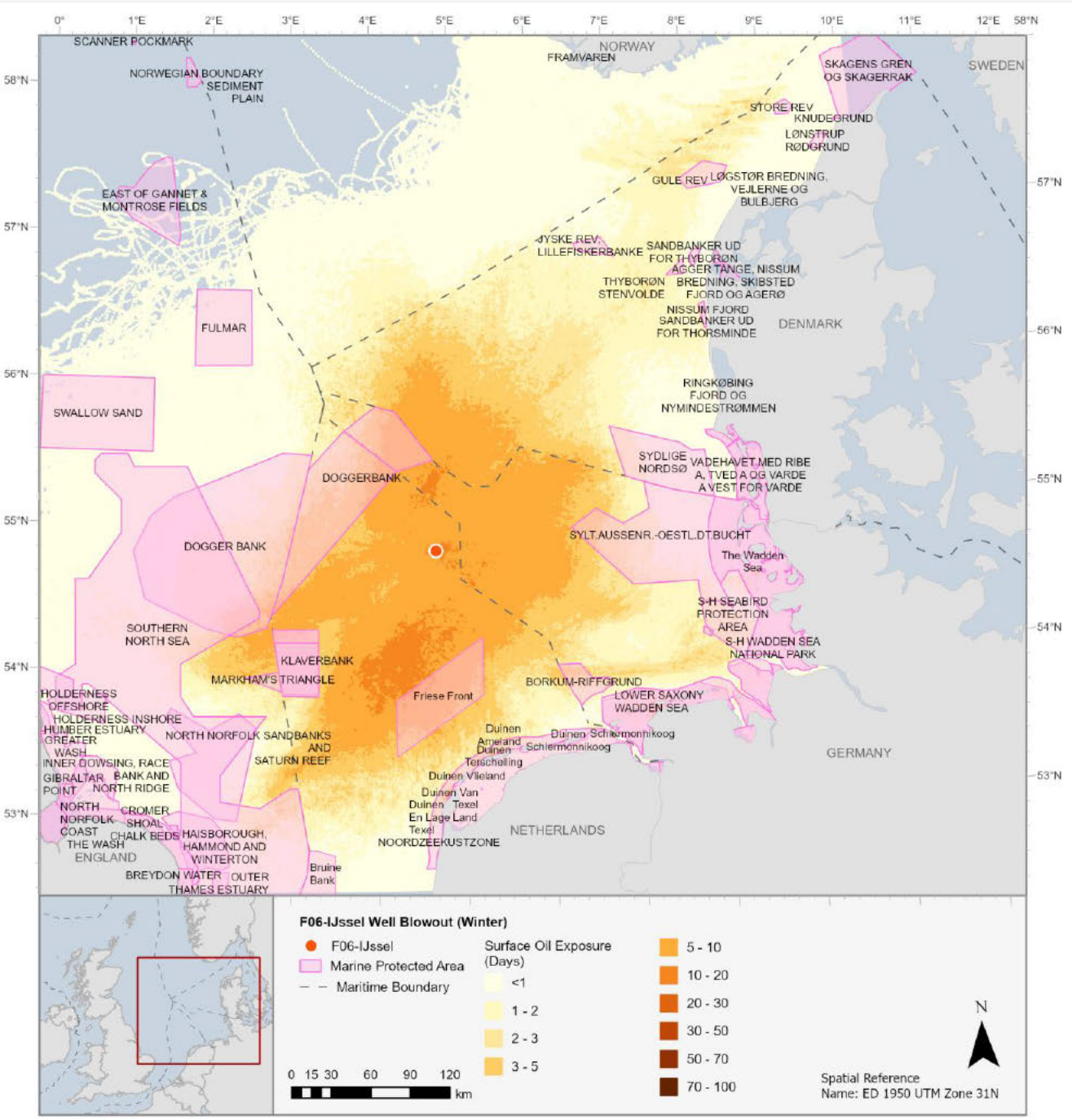


The picture does not depict the real extent of the spill; instead, it provides a statistical representation employed for risk assessment, drawing from approximately 100 distinct simulated trajectories. The anticipation of oil pathways involves amalgamating all trajectories from the simulation and illustrating them as a unified probability-density map. The plot illustrates the likelihood (>1%) of surface crude thickness being equal to or greater than 0.1µm.

Summary of S02 Surface Oiling Probabilities

- The highest probability of occurrence in a single grid cell is shown to be 90 – 100%. This area extends outwards for approximately 40 - 120 km.
- There is a 90-100% probability of surface oil crossing into German and Danish waters

4.1.3. S01 – F06-IJssel Well Blowout Maximum Exposure Time

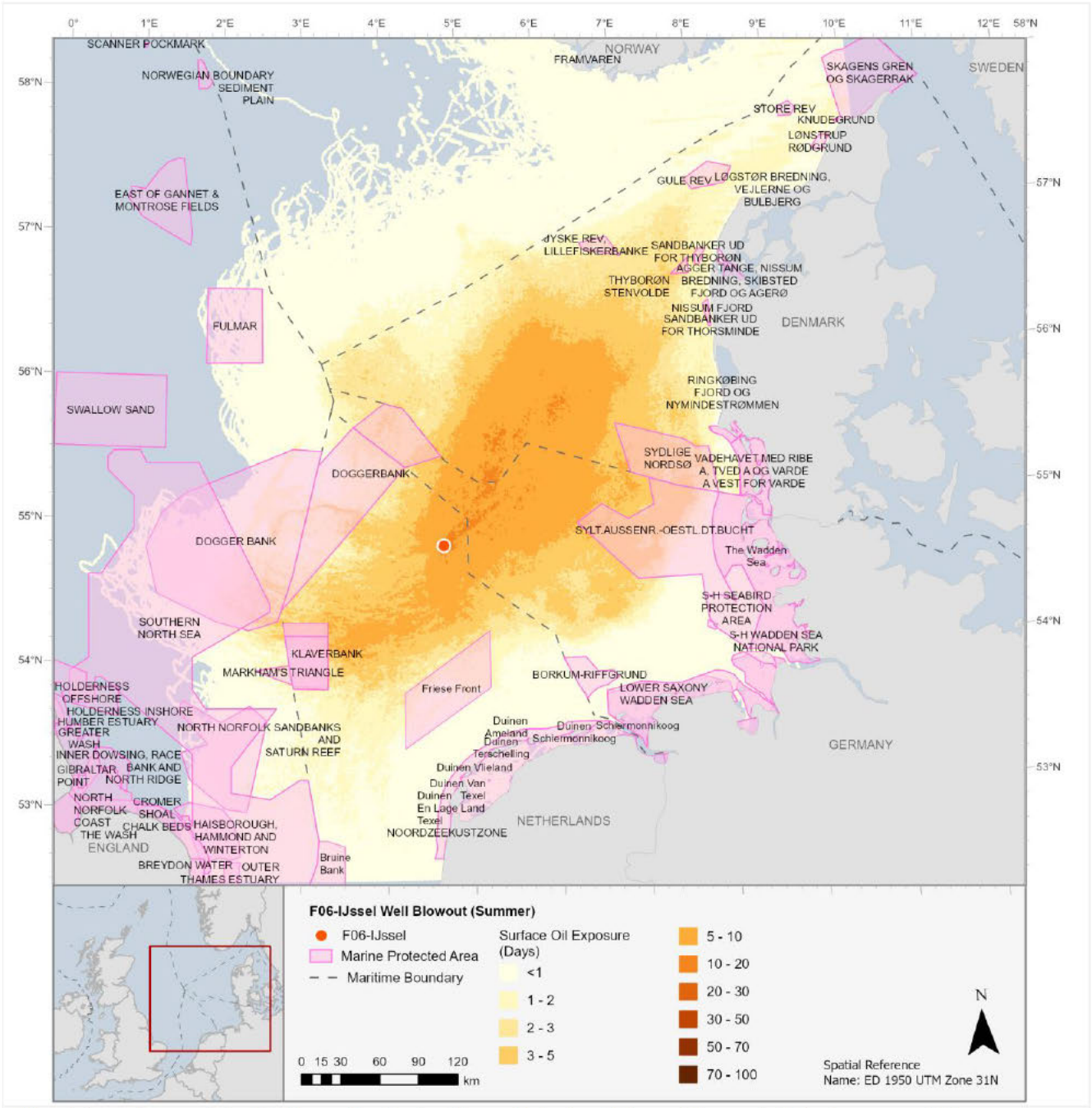


The picture does not depict the real extent of the spill; instead, it provides a statistical representation employed for risk assessment, drawing from approximately 100 distinct simulated trajectories. The image illustrates the longest duration of exposure in all simulations. Exposure time denotes the number of days a specific area has experienced oiling during a simulation.

Summary of S01 Surface Oiling Exposure Time

- The maximum exposure time indicated by the model is 89 days which is concentrated directly above and around the release site.
- The exposure time reduces to ≤10 days approximately 150 km from the release site, indicating that the surface oil is likely to persist.

4.1.4. S02 – F06-IJssel Well Blowout Maximum Exposure Time

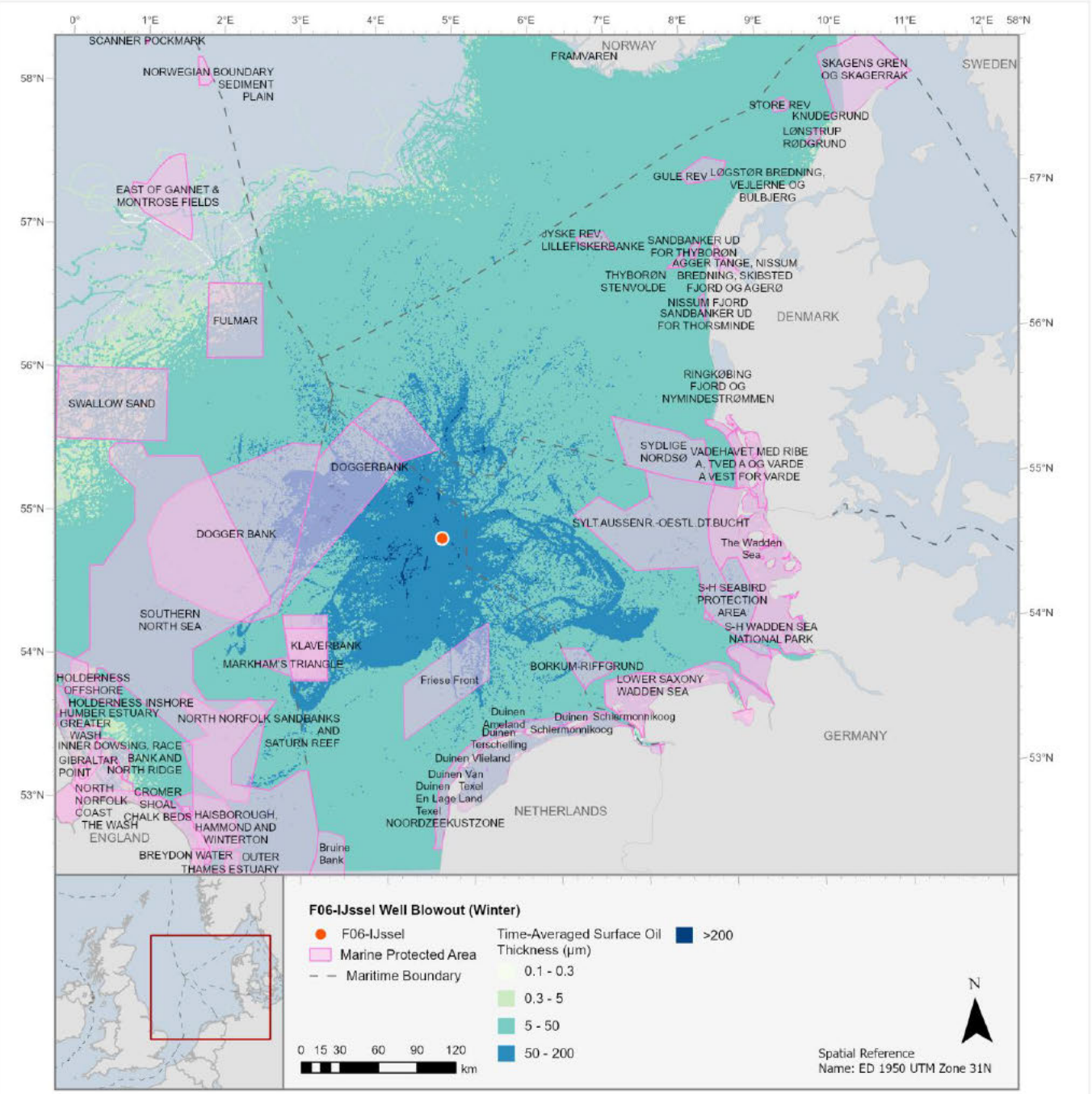


The picture does not depict the real extent of the spill; instead, it provides a statistical representation employed for risk assessment, drawing from approximately 100 distinct simulated trajectories. The image illustrates the longest duration of exposure in all simulations. Exposure time denotes the number of days a specific area has experienced oiling during a simulation

Summary of S02 Surface Oiling Exposure Time

- The maximum exposure time indicated by the model is 89 days which is concentrated directly above and around the release site.
- The exposure time reduces to ≤10 days approximately 180 km from the release site, indicating that the surface oil is likely to persist.

4.1.5. S01 – F06-IJssel Well Blowout Maximum Time-averaged Emulsion Thickness

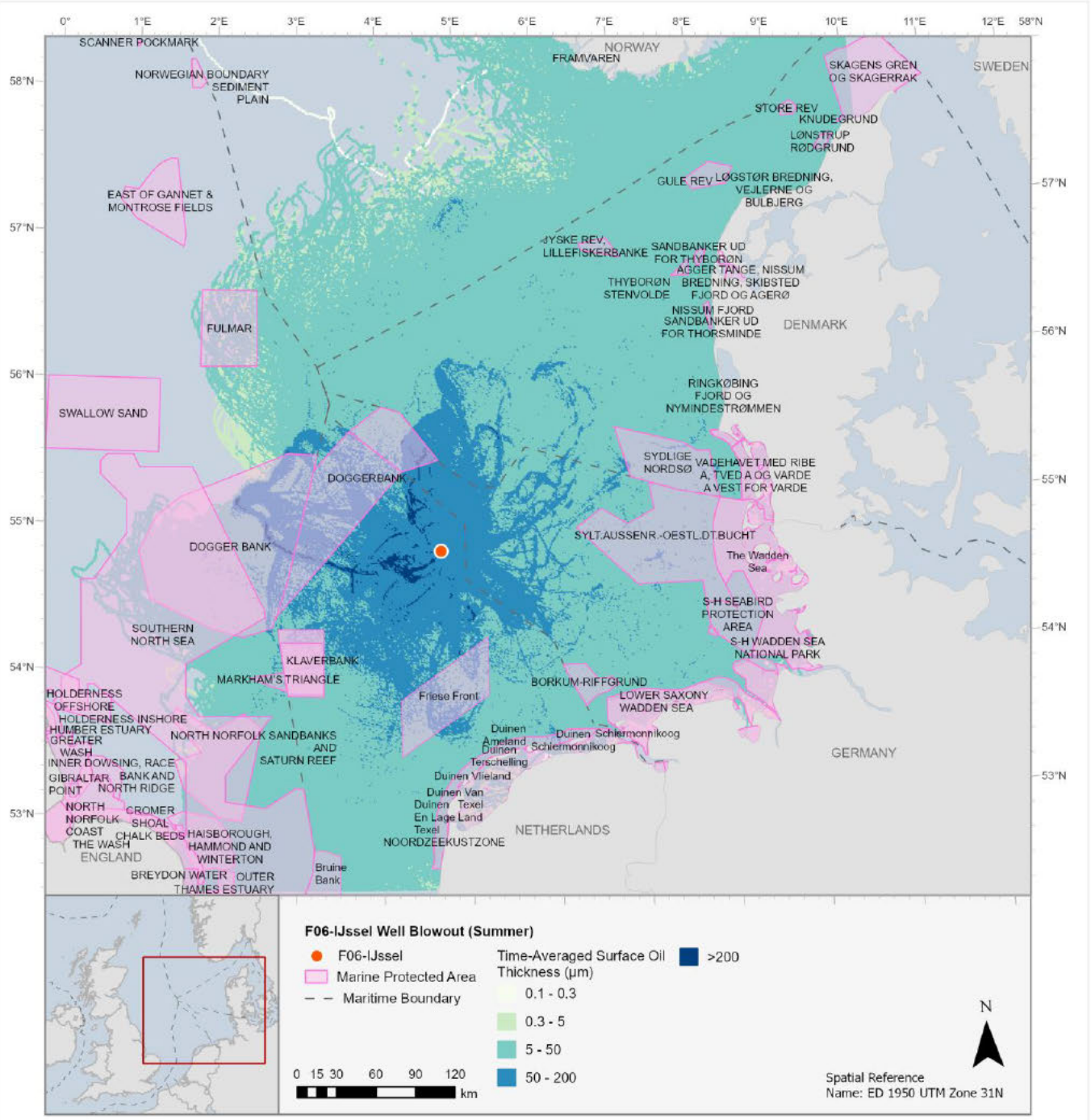


The picture does not depict the real extent of the spill; instead, it provides a statistical representation employed for risk assessment, drawing from approximately 100 distinct simulated trajectories. The image shows the maximum time-averaged thickness of surface crude over all simulations.

Summary of S01 Maximum Time-averaged Emulsion Thickness

- The maximum time-averaged emulsion thickness is indicated to be >200 µm (Continuous True colour).
- Areas of crude with a thickness of 50 µm - 200 µm (Discontinuous True colour) extend into UK, German and Danish waters).
- The average thickness is predominantly between 5 µm and 50 µm (Metallic colour) which is likely to reach UK and Norwegian waters.

4.1.6. S02 – F06-IJssel Well Blowout Maximum Time-averaged Emulsion Thickness

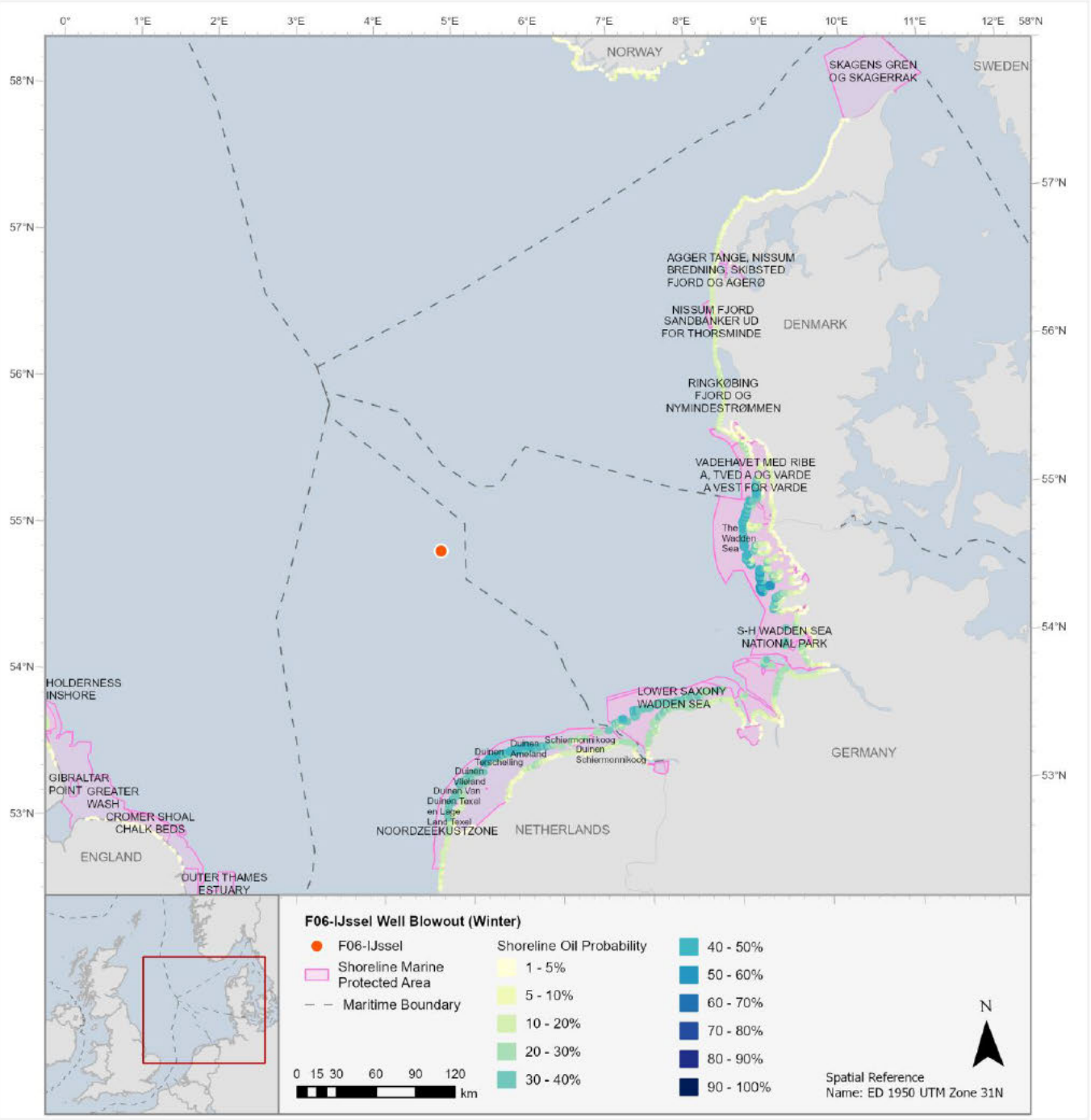


The picture does not depict the real extent of the spill; instead, it provides a statistical representation employed for risk assessment, drawing from approximately 100 distinct simulated trajectories. The image shows the maximum time-averaged thickness of surface crude over all simulations.

Summary of S02 Maximum Time-averaged Emulsion Thickness

- The maximum time-averaged emulsion thickness is indicated to be 200 µm (Continuous True colour).
- Large areas of crude with a thickness of 50 µm - 200 µm (Discontinuous True colour) extend into UK, German and Danish waters).
- The average thickness is predominantly between 5 µm and 50 µm (Metallic colour) which is likely to reach UK and Norwegian waters.

4.1.7. S01 – F06-IJssel Well Blowout Shoreline Oiling Probabilities

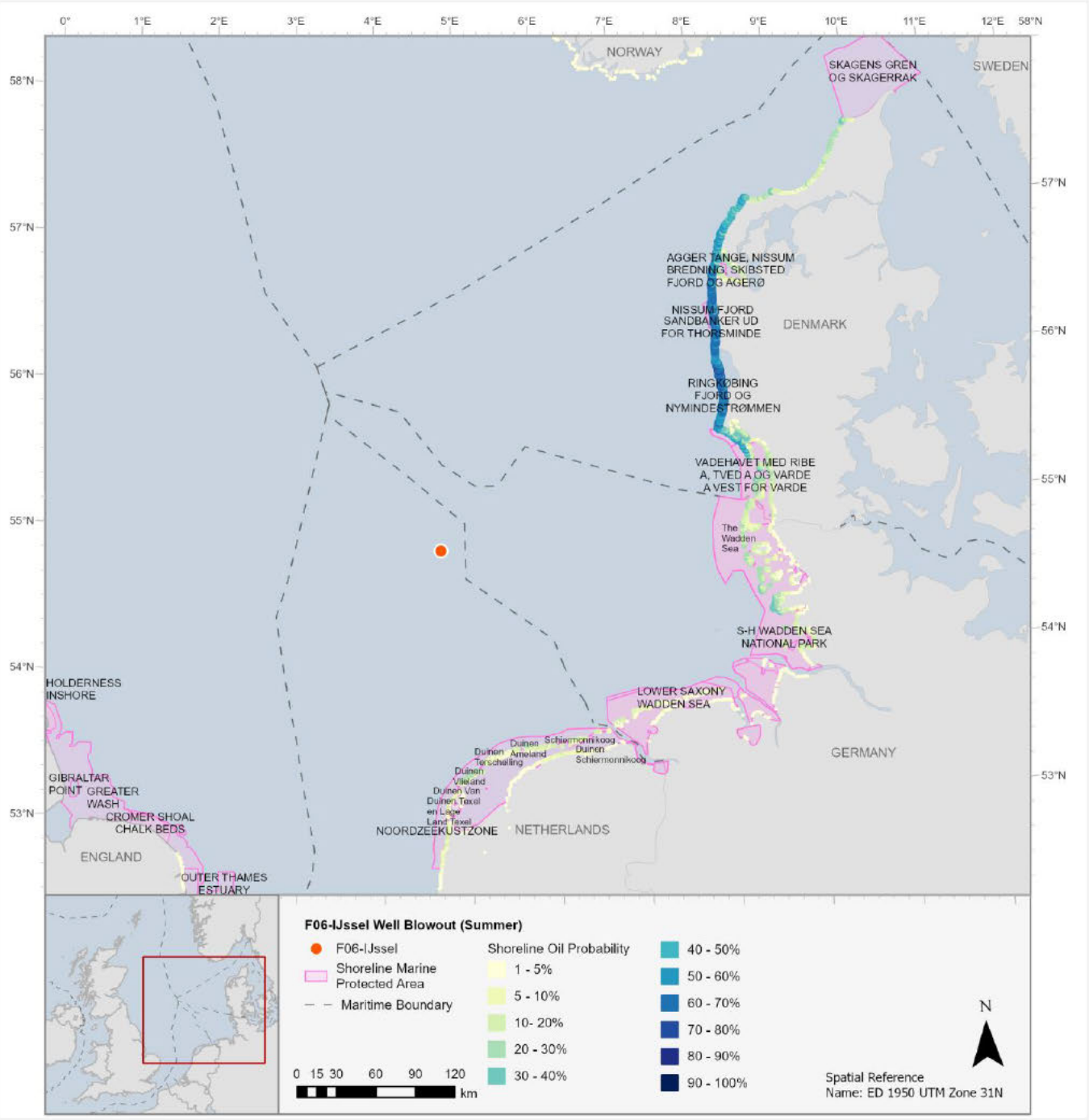


The picture does not depict the real extent of the spill; instead, it provides a statistical representation employed for risk assessment, drawing from approximately 100 distinct simulated trajectories. Oil pathways are predicted by combining all trajectories from the simulation and presented as a combined probability-density map. The plot shows the probability of shoreline oiling to >1%. No threshold set for shoreline mass accumulations onshore.

Summary of S01 Shoreline Oiling Probabilities

- The highest probability for shoreline impact is Germany 50 - 60%, Netherlands 40 – 50%, Denmark 30 – 40%.
- The shortest time for beaching is predicted to be within 5 days along the Netherlands coastline.

4.1.8. %S02 – F06-IJssel Well Blowout Shoreline Oiling Probabilities

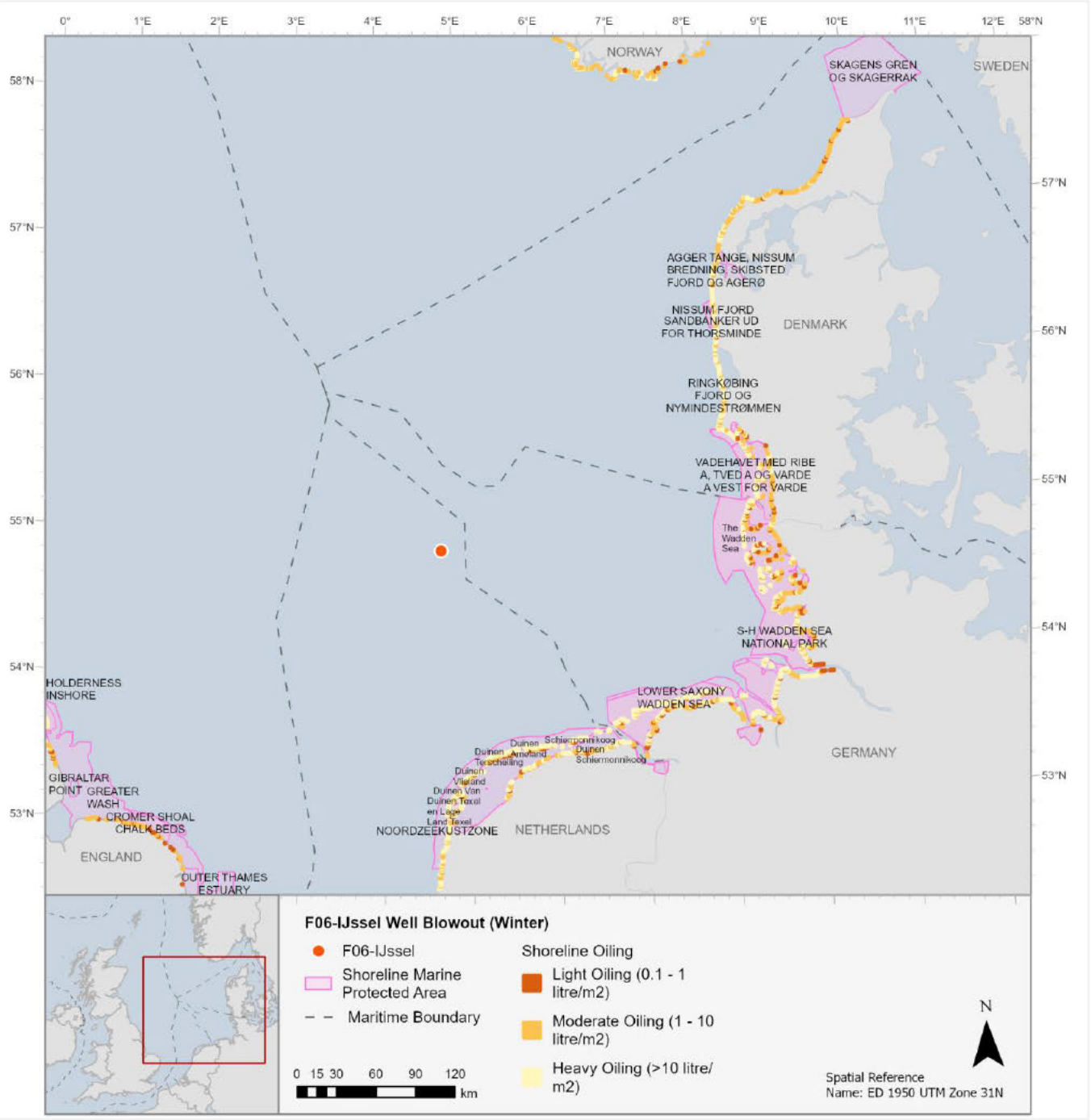


The picture does not depict the real extent of the spill; instead, it provides a statistical representation employed for risk assessment, drawing from approximately 100 distinct simulated trajectories. Oil pathways are predicted by combining all trajectories from the simulation and presented as a combined probability-density map. The plot shows the probability of shoreline oiling to >1%. No threshold set for shoreline mass accumulations onshore.

Summary of S02 Shoreline Oiling Probabilities

- The highest probability for shoreline impact is Denmark 70 – 80%, Germany 30 - 40%, Netherlands 20 – 30%.
- The shortest time for beaching is predicted to be within 7 days along the Netherlands coastline.

4.1.9. LightS01 – F06-IJssel Well Blowout Extent of Shoreline Oiling

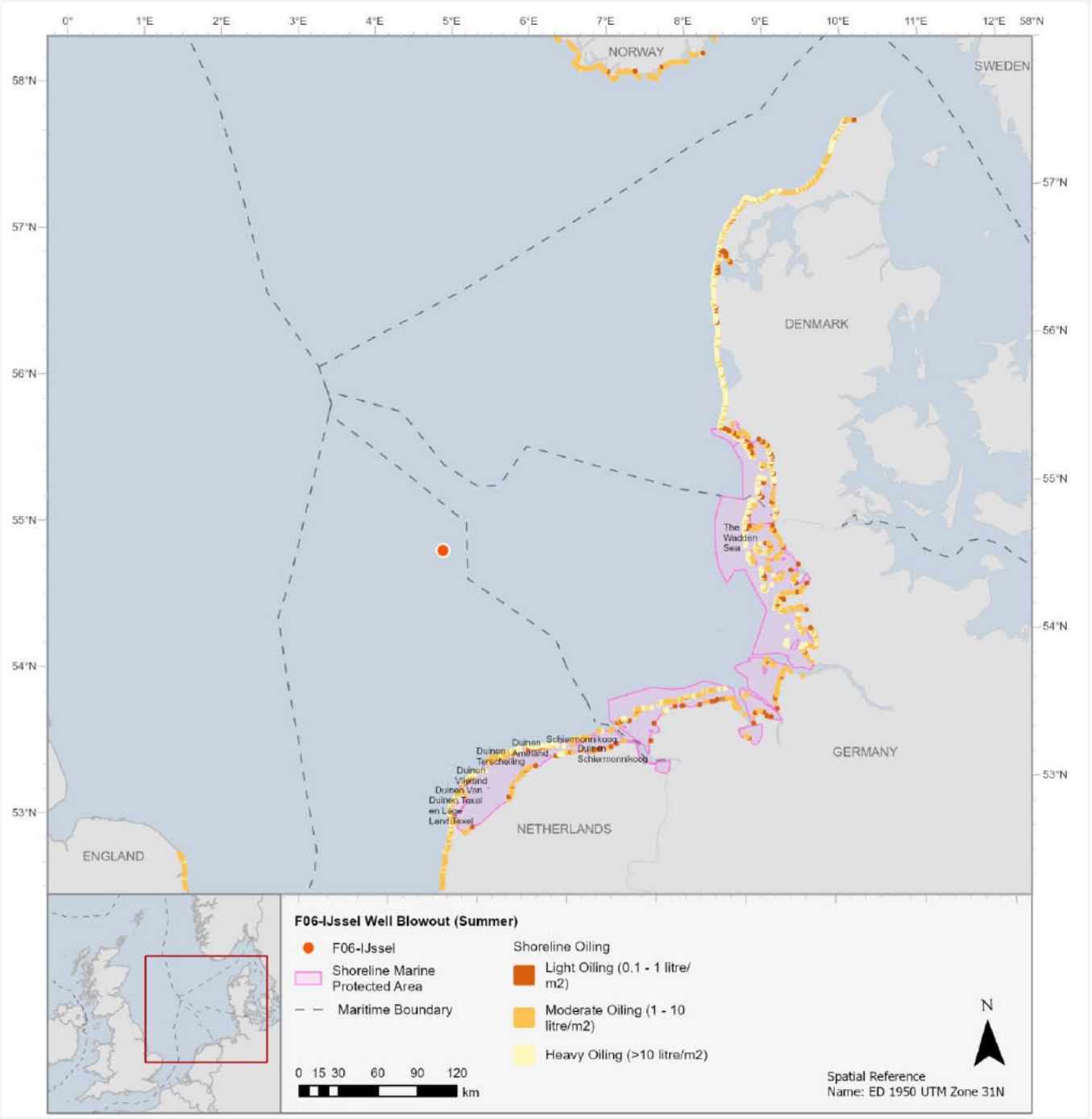


The image DOES NOT SHOW the actual footprint of a spill, they present a statistical picture used for assessing risk, based on circa 100 independently simulated trajectories. Oil pathways are predicted by combining all trajectories from the simulation and presented as a combined density map. The plot shows the extent of oiling.

Summary of S01 Shoreline Impact

- Heavy oiling (>10 litre/m^2) is predicted along the Netherlands, German and Danish coastlines, with some heavy oiling reaching as far as Norway.

4.1.10. S02 – F06-IJssel Well Blowout Extent of Shoreline Oiling



The image DOES NOT SHOW the actual footprint of a spill, they present a statistical picture used for assessing risk, based on circa 100 independently simulated trajectories. Oil pathways are predicted by combining all trajectories from the simulation and presented as a combined density map. The plot shows the extent of oiling.

Summary of S02 Shoreline Impact

- Heavy oiling (>10 litre/m^2) is predicted along the Netherlands, German and Danish coastlines, with some heavy oiling predicted to reach Norway.
- The heaviest oiling is likely to occur along the Danish coastline.

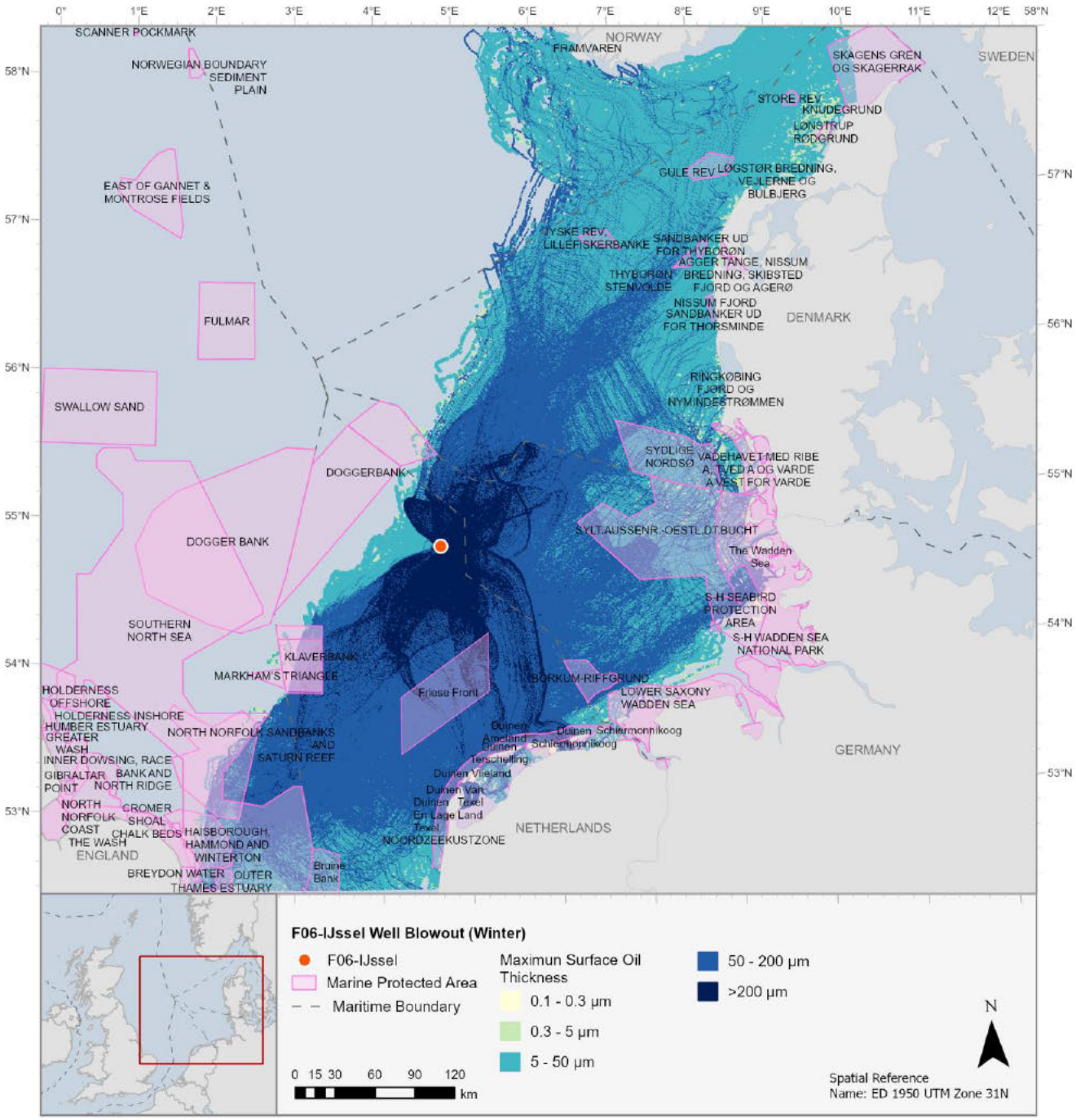
4.2. Summary of Shoreline Oiling Stochastic Outputs

Sensitivity	Shoreline Oiling Probability		Extent of Oiling	
	Summer	Winter	Summer	Winter
Netherlands				
Noordzeekustzone	20 - 30%	40 – 50%	Heavy oiling	Heavy oiling
The Wadden Sea	10 – 20%	20 – 30%	Heavy oiling	Heavy oiling
Duinen en Lage Land Texel	10 – 20%	40 – 50%	Heavy oiling	Heavy oiling
Duinen Vlieland	20 – 30%	40 – 50%	Heavy oiling	Heavy oiling
Duinen Terschelling	10 – 20%	40 – 50%	Heavy oiling	Heavy oiling
Duinen Ameland	20 – 30%	40 – 50%	Heavy oiling	Heavy oiling
Duinen Schiermonnikoog	10 – 20%	20 – 30%	Heavy oiling	Heavy oiling
Germany				
Lower Saxony Wadden Sea	10 – 20%	40 – 50%	Heavy oiling	Heavy oiling
S-H Wadden Sea National Park	30 – 40%	50 – 60%	Heavy oiling	Heavy oiling
Denmark				
Agger Tange, Nissum Bredning, Skibsted Fjord Og Agerø	50 – 60%	10 – 20%	Heavy oiling	Heavy oiling
Nissum Fjord	60 – 70%	5 – 10%	Heavy oiling	Heavy oiling
Ringkøbing Fjord Og Nymindestrømmen	60 – 70%	10 – 20%	Heavy oiling	Heavy oiling
Skagens Gren Og Skagerrak	20 – 30%	1 – 5%	Moderate oiling	Moderate oiling
Vadehavet Med Ribe A, Tved A Og Varde A Vest for Varde	50 – 60%	40 – 50%	Heavy oiling	Heavy oiling
United Kingdom				
Cromer Shoal Chalk Beds	-	1 – 5%	-	Moderate oiling
Flamborough And Filey Coast	-	10 – 20%	-	Heavy Oiling
Greater Wash	1 – 5%	10 – 20%	Heavy oiling	Moderate oiling
Holderness Inshore	-	10 – 20%	-	Heavy Oiling
Outer Thames Estuary	1 – 5%	1 – 5%	Heavy oiling	Light oiling

4.3. D01 - DETERMINISTIC OUTPUT

4.3.1. >D01 – Surface Impacted Area

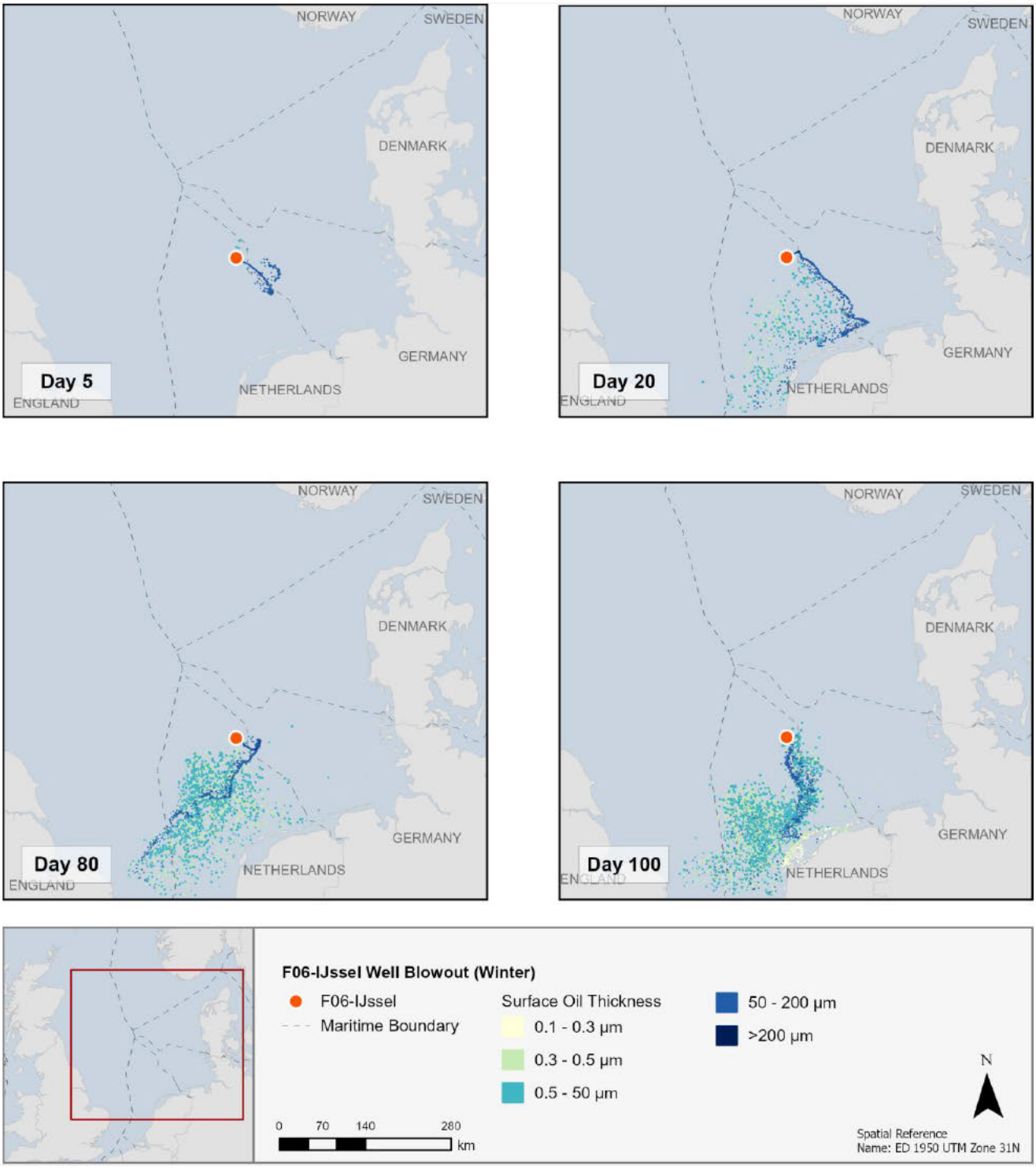
D01 – Surface Oil Impacted Area Map over 100 days



Summary of Surface Impact

- The image does not depict the specific size of the release at a single point; instead, it highlights the probable locations of the thickest crude throughout the 100-day scenario.
- Crude with a thickness of >200 µm (Continuous True colour) is indicated to reach shoreline areas of the Netherlands.

4.3.2. D01 – Surface Oiling Over Time



Surface Oiling Over Time Summary

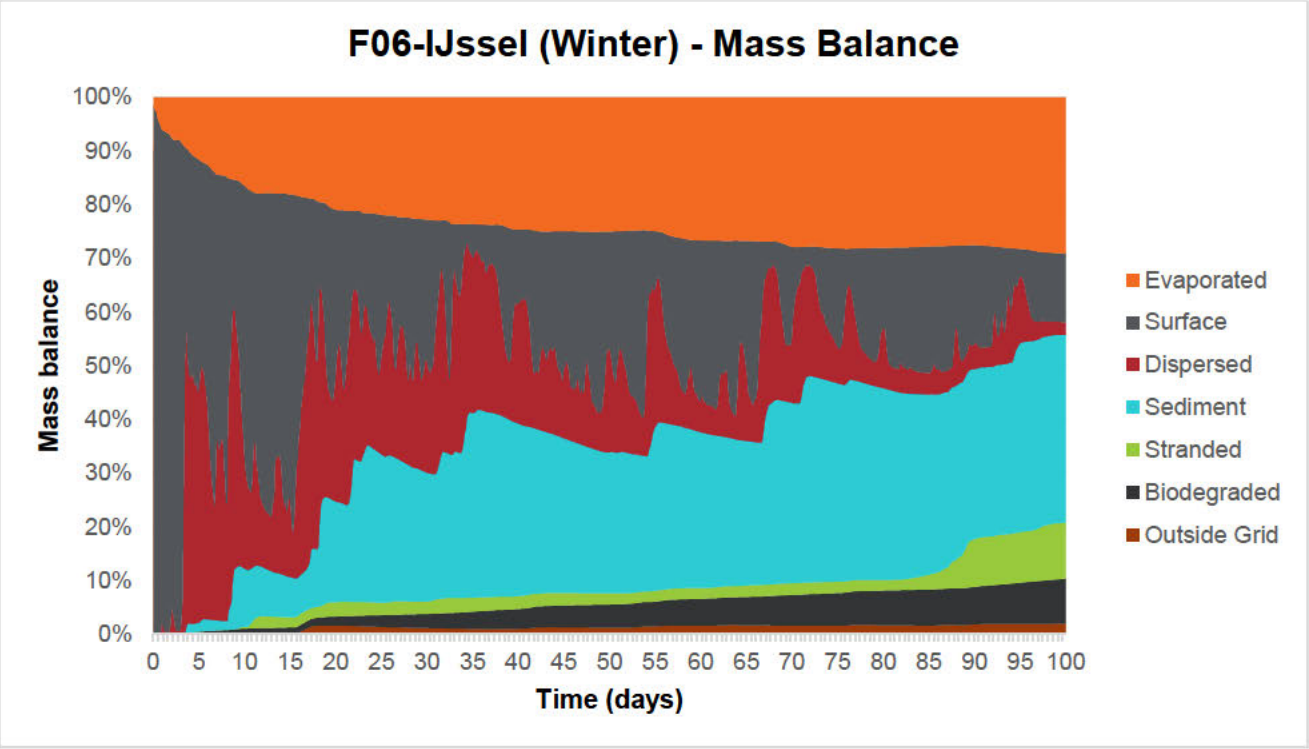
- The above series of images display surface oiling at various timeframes during the 100-day release.
- The model does show an ongoing surface slick, reaching a thickness exceeding 200 µm.
- By day 100, 10 days after the release has ceased, substantial areas still exhibit the presence of oil with thicknesses exceeding 200 µm.

4.3.3. D01- Fate of Crude after 100 days

Fate	Value (mt)	Percentage (%)
Surface	13,650	12.9
Atmosphere	30,810	29.1
Water Column	2,370	2.2
Sediments	37,080	35.0
Stranded	11,030	10.4
Biodegraded	8,852	8.4
Outside Gridded area	2,019	1.9
Total length of coastline oiled (km)	619.9	
Maximum crude ashore (mt)	11,060 (day 98)	

4.3.4. D01 - Mass Balance

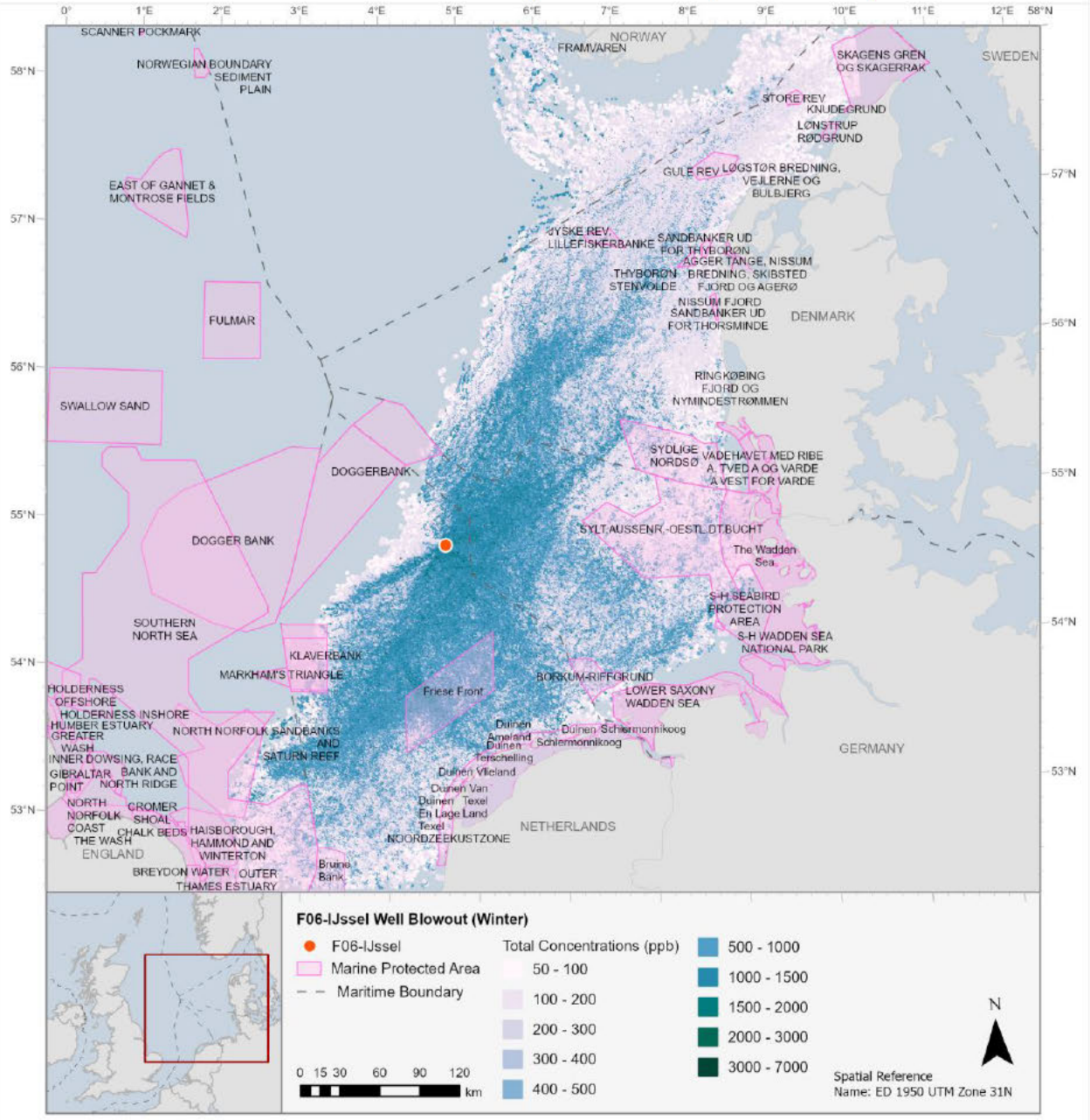
Graph shows the fate of the crude release over time.



By day 100, 12.9% of the hydrocarbon remains on the surface, 29.1% has evaporated, 2.2% has dispersed into the water column, 35.0% has deposited on the sediment and 8.4% has biodegraded, 10.4% has stranded (beached).

4.3.5. D01 - Total Water Column Concentrations

D01 – Total Water Column Concentrations Impacted Area Map over 100 days

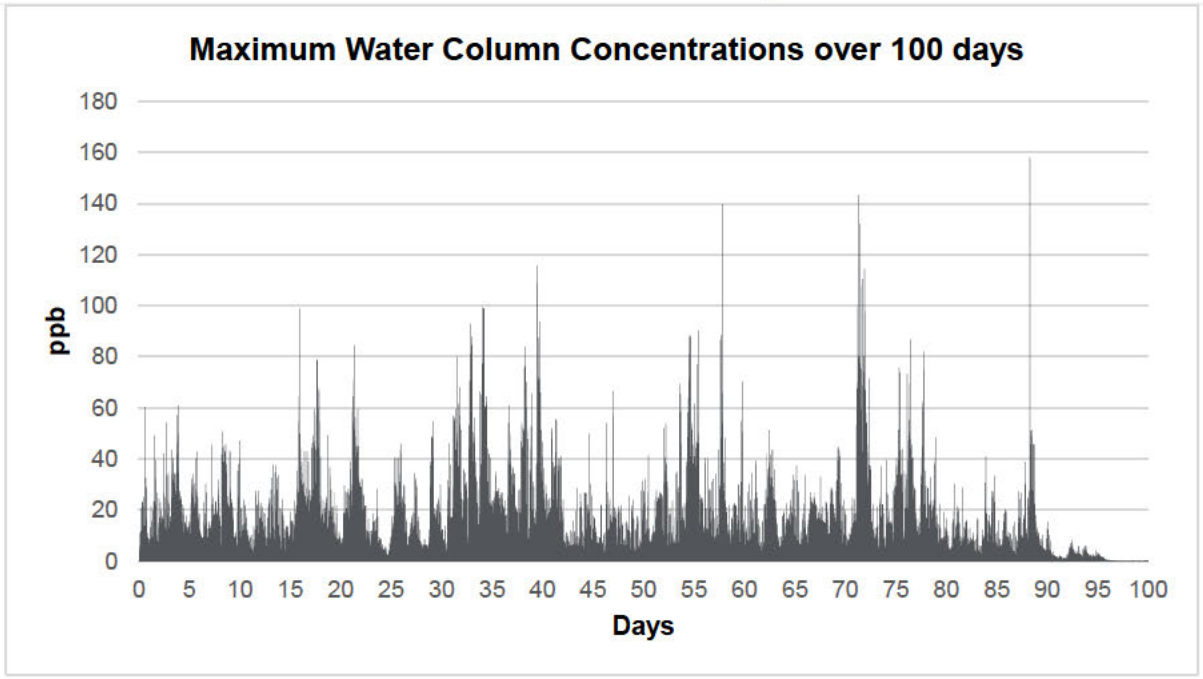


Summary of Total Water Column Concentrations

- The image DOES NOT SHOW the size of the release at any one point. The image illustrates the total concentrations (both dissolved and droplets) likely to be present in the water column across the 100-day scenario.
- The highest total concentration is predicted to be 6,748 ppb.
- Water column concentrations of liquid particles remain largely below 50 ppb throughout the 100 day scenario.

4.3.6. D01 – Maximum Water Column Concentrations Over Time

D02 - Maximum Water Column Concentrations over 100 days

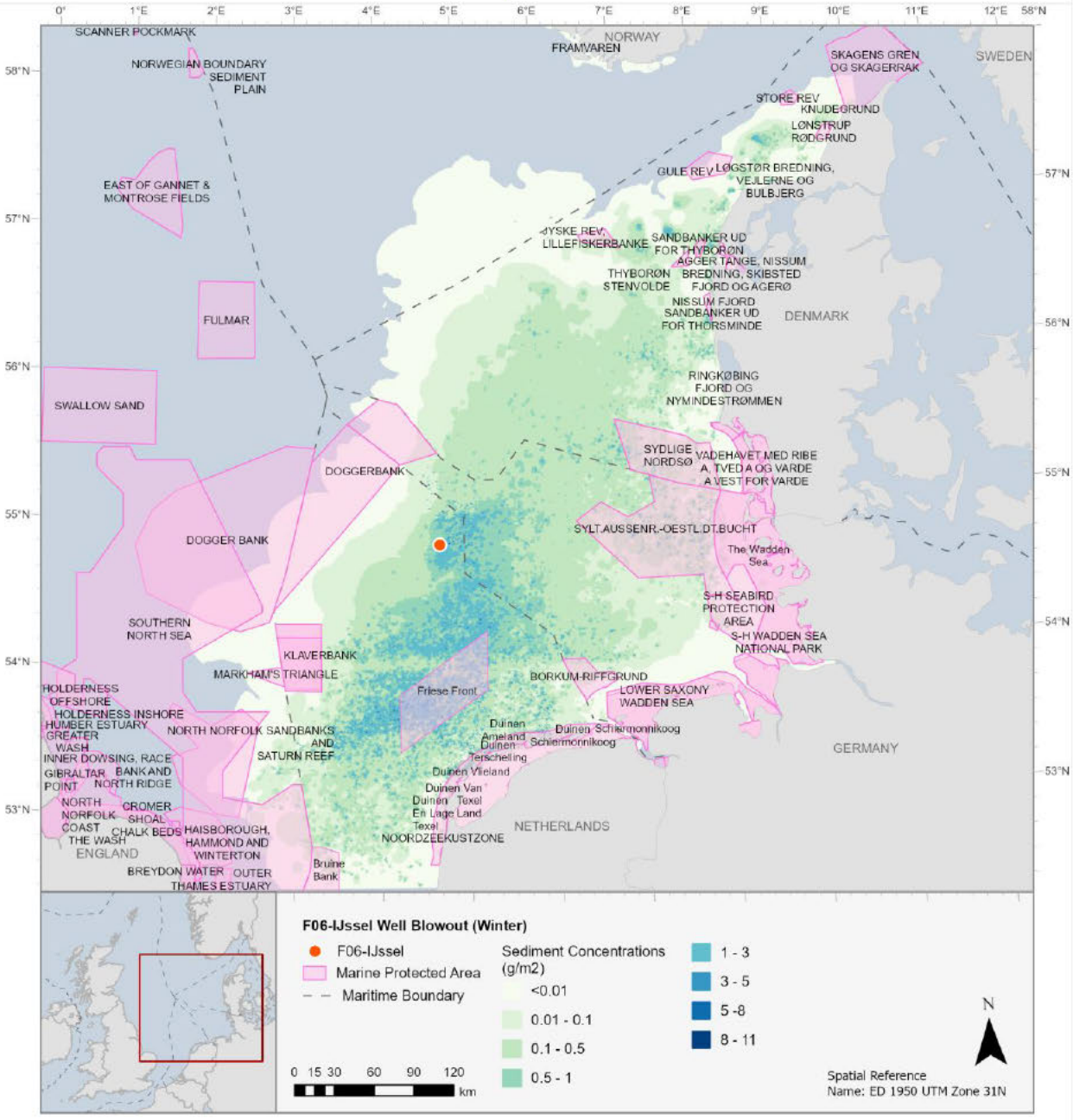


Summary of Water Column Concentrations

- Water column concentrations of liquid particles remain largely below 50 ppb throughout the 100 day scenario.
- Concentrations reduce significantly once the release is stopped.

4.3.7. D01 - Sediment Concentrations

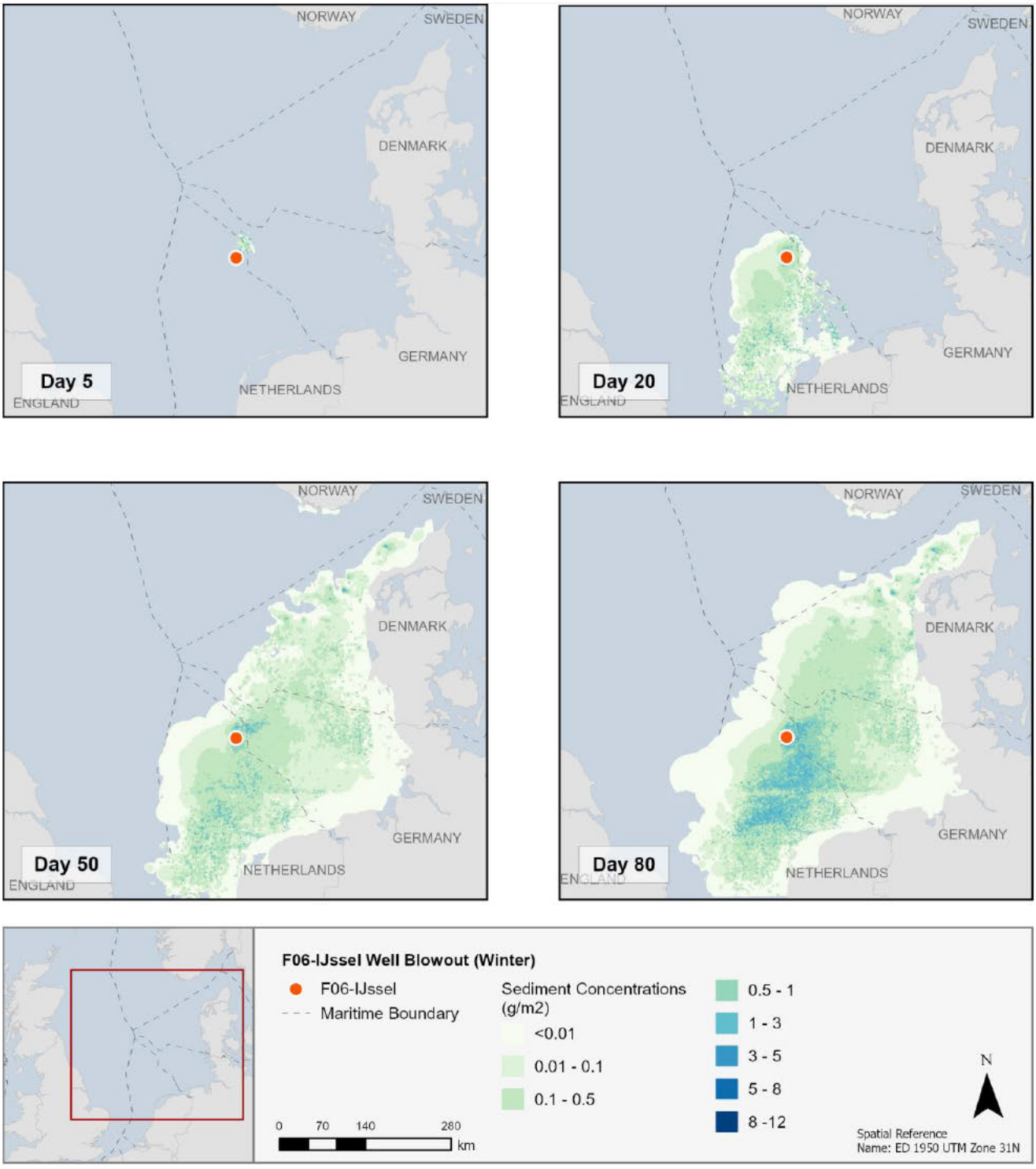
D01 – Sediment concentrations after 100 days



Summary of Sediment Concentrations

- The image shows the extent of sediment concetrations at day 100.
- The highest concentration is predicted not to exceed 10.4 g/m^2.
- Small areas of concentrations between 5 – 8 g/m^2 impact the Netherlands and Danish coastlines.
- Concentrations along the German shoreline are predominetly <0.01 g/m^2.

4.3.8. D01 – Sediment Concentrations Over Time

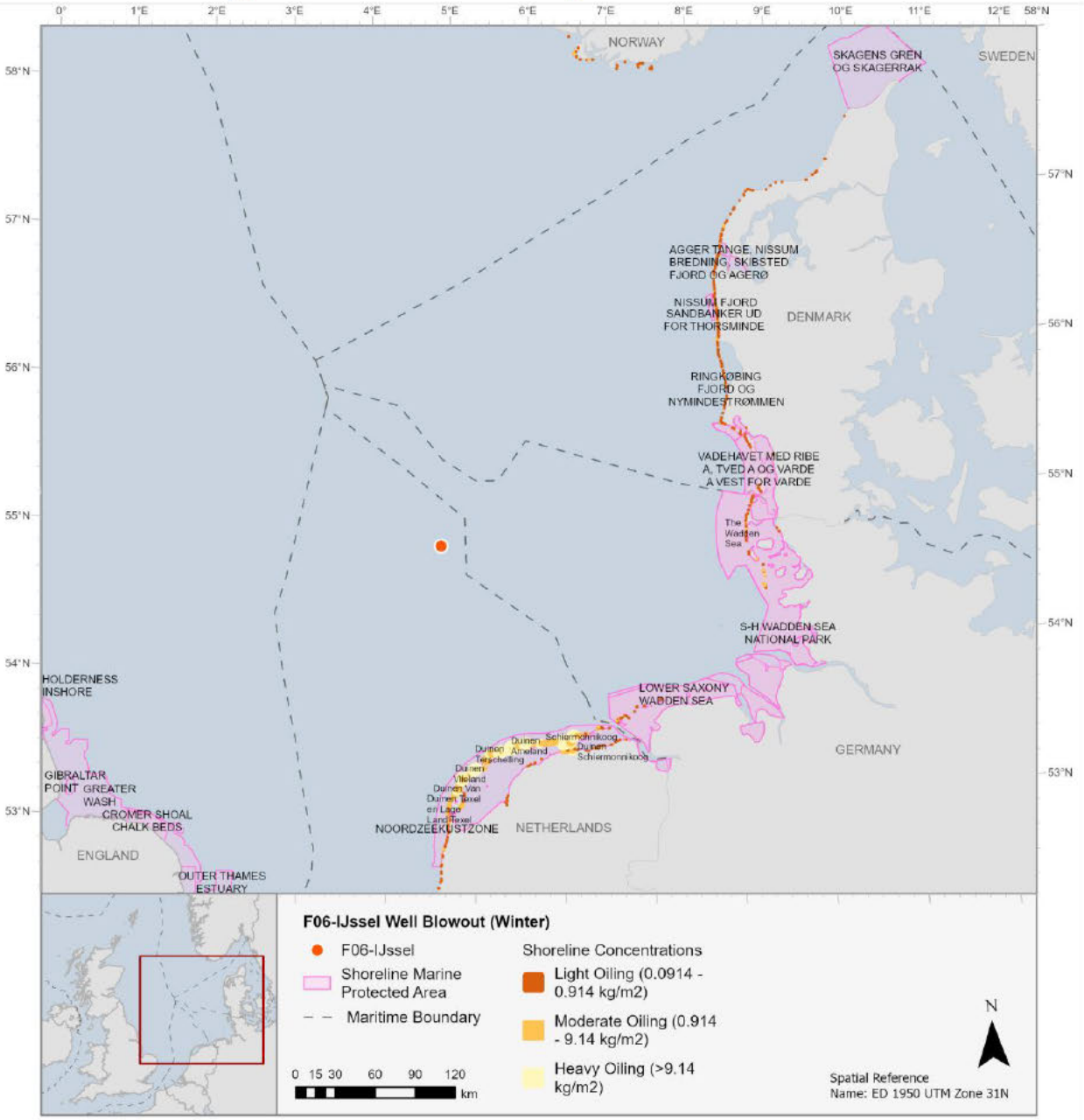


Sediment Concentrations Over Time Summary

- The following series of images display sediment concentrations at various timeframes during the 100-day release.

4.3.9. D01 - Shoreline Oiling

D01 –Shoreline oiling concentrations after 100 days



Summary of Shoreline Concentrations

- The image shows shoreline concentrations at day-100. The highest concentration is predicted to impact the Dutch coastline with large areas of heavy oiling (>9.14kg/m^2).
- Concentrations along the German and Danish coastline shoreline are shown to be impacted by Light and Moderate oiling.
- The total mass of oil beaching in this scenario is 11,030 tonnes

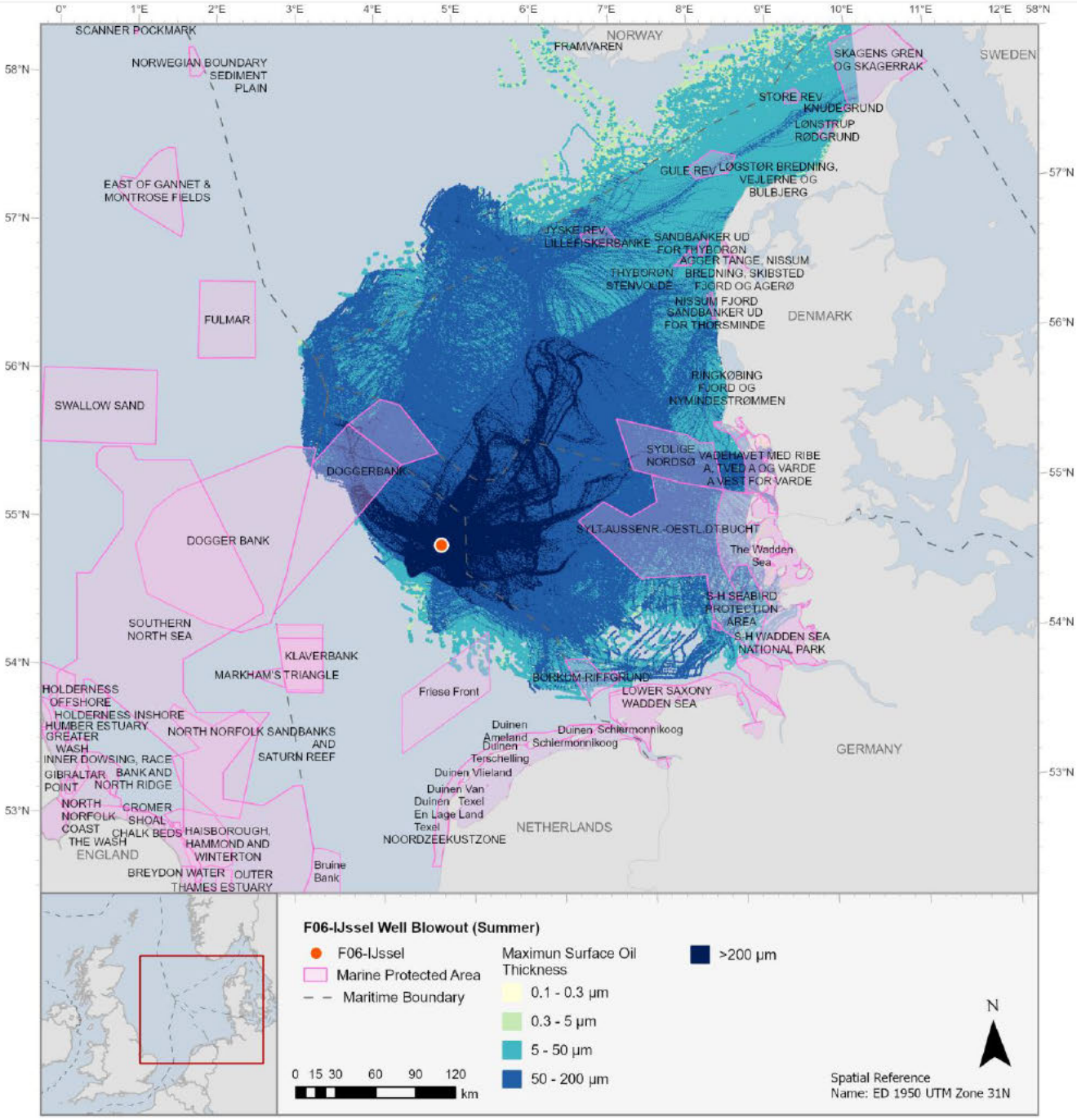
4.3.10. D01 - Impacted Shoreline Environmental Sensitivities

Sensitivity	Extent of Oiling
Netherlands	
Noordzeekustzone	Heavy oiling
The Wadden Sea	Heavy oiling
Duinen en Lage Land Texel	Moderate oiling
Duinen Vlieland	Heavy oiling
Duinen Terschelling	Heavy oiling
Duinen Ameland	Heavy oiling
Duinen Schiermonnikoog	Heavy oiling
Germany	
Lower Saxony Wadden Sea	Moderate oiling
S-H Wadden Sea National Park	Moderate oiling
Denmark	
Agger Tange, Nissum Bredning, Skibsted Fjord Og Agerø	Light oiling
Nissum Fjord	Moderate oiling
Ringkøbing Fjord Og Nymindestrømmen	Moderate oiling
Skagens Gren Og Skagerrak	Moderate oiling
Vadehavet Med Ribe A, Tved A Og Varde A Vest for Varde	Light oiling

4.4. D02 - DETERMINISTIC OUTPUT

4.4.1. D02 – Surface Impacted Area

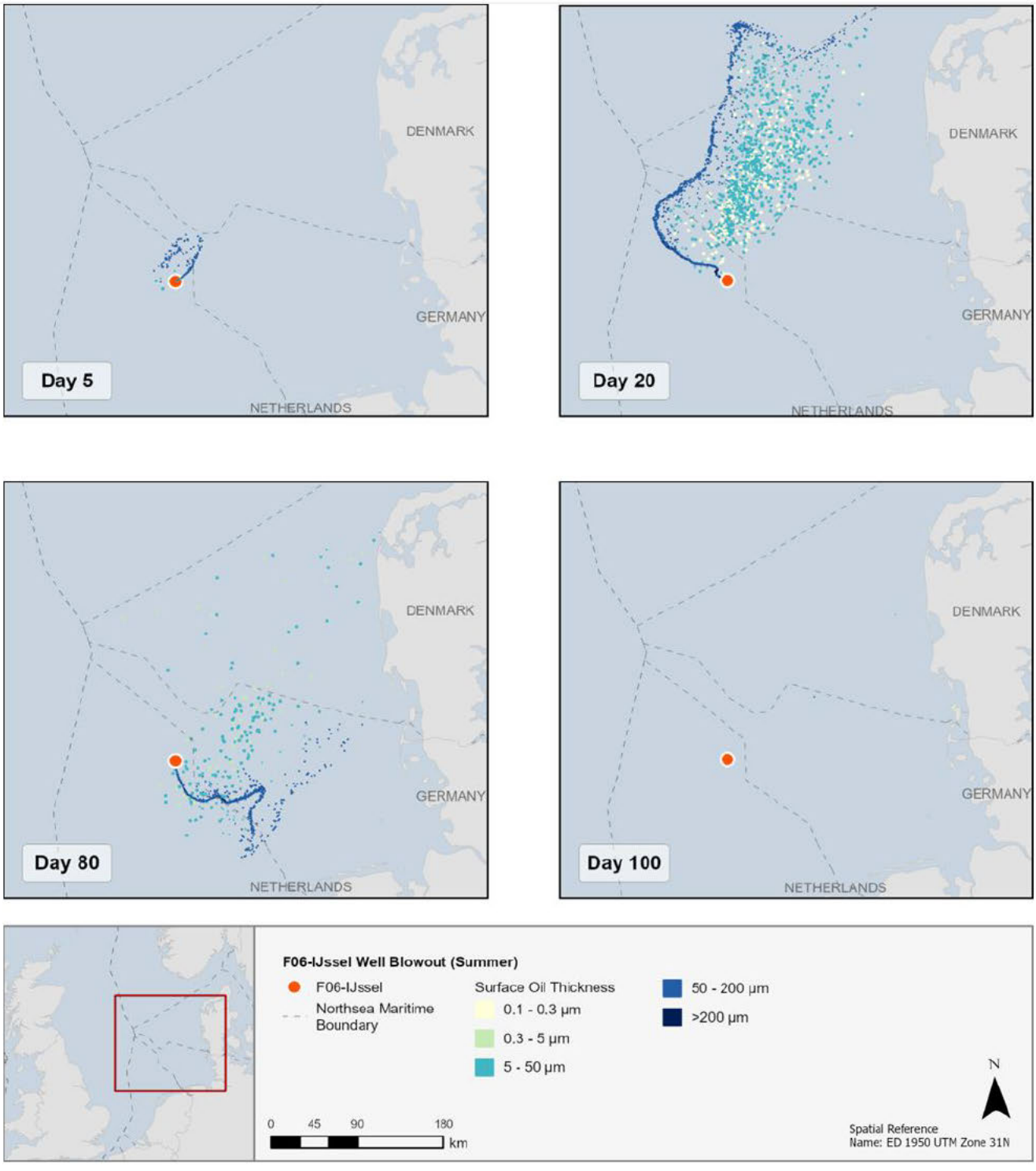
D02 – Surface Oil Impacted Area Map over 20 days



Summary of Surface Impact

- The image does not depict the specific size of the release at a single point; instead, it highlights the probable locations of the thickest crude throughout the 100-day scenario.
- Crude with a thickness of >200 µm (Continuous True colour) is indicated to remain at sea, oil between 50 -200 µm (Discontinuous True colour) is shown to reach shoreline areas along the Netherlands, German and Danish coastlines.

4.4.2. D02 – Surface Oiling Over Time



Surface Oiling Over Time Summary

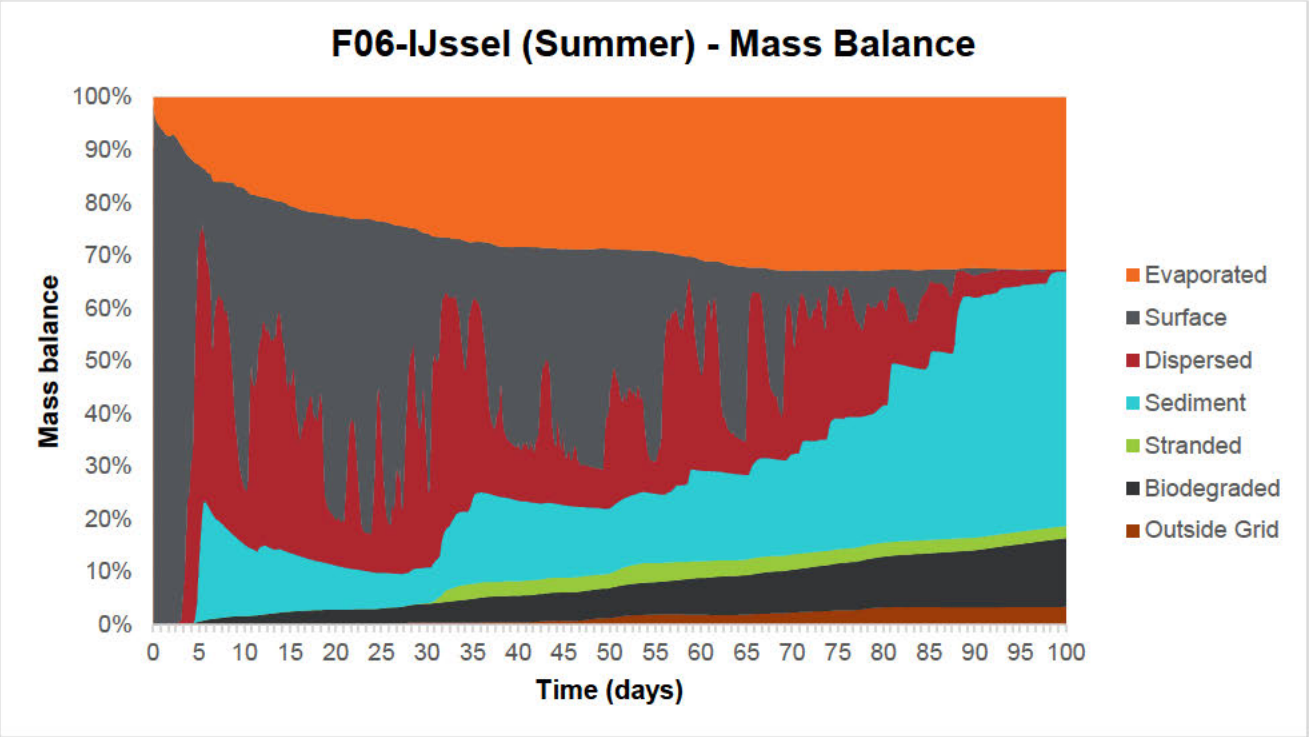
- The following series of images display surface oiling at various timeframes during the 100-day release.
- The model does indicate a continuous surface slick, of up to 200 µm.
- By day 100, 10 days after the release has ceased, only minor patches of surface oil persist. The majority of the surface oil is indicated to be below 0.1 µm, making it unlikely to be visible to the human eye.

4.4.3. D02 - Fate of Crude after 100 days

Fate	Value (mt)	Percentage (%)
Surface	3.07	0.0
Atmosphere	34,580	32.7
Water Column	364.4	0.3
Sediments	51,080	48.3
Stranded	2,457	2.3
Biodegraded	13,750	13.0
Outside Gridded area	3,578	3.4
Total length of coastline oiled (km)	414.9	
Maximum crude ashore (mt)	2,550 (day 80)	

4.4.4. D02 - Mass Balance

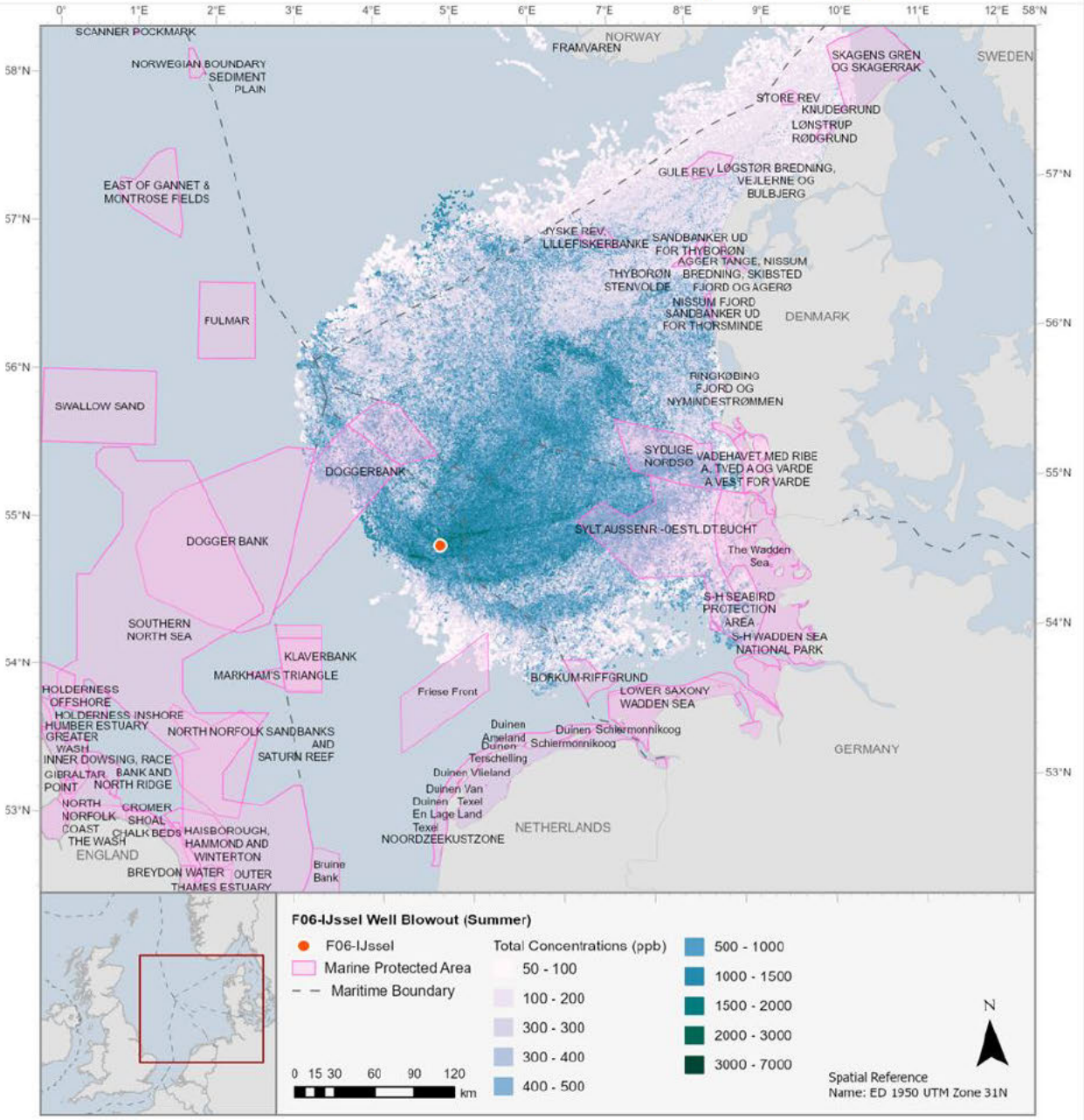
Graph shows the fate of the crude release over time.



By day 100, <0.1% of the hydrocarbon remains on the surface, 32.7% has evaporated, 0.3% has dispersed into the water column, 48.3% has deposited on the sediment and 13.0% has biodegraded, 2.3% has stranded (beached).

4.4.5. D02 - Total Water Column Concentrations

D02 - Total Water Column Concentrations Impacted Area Map over 100 days

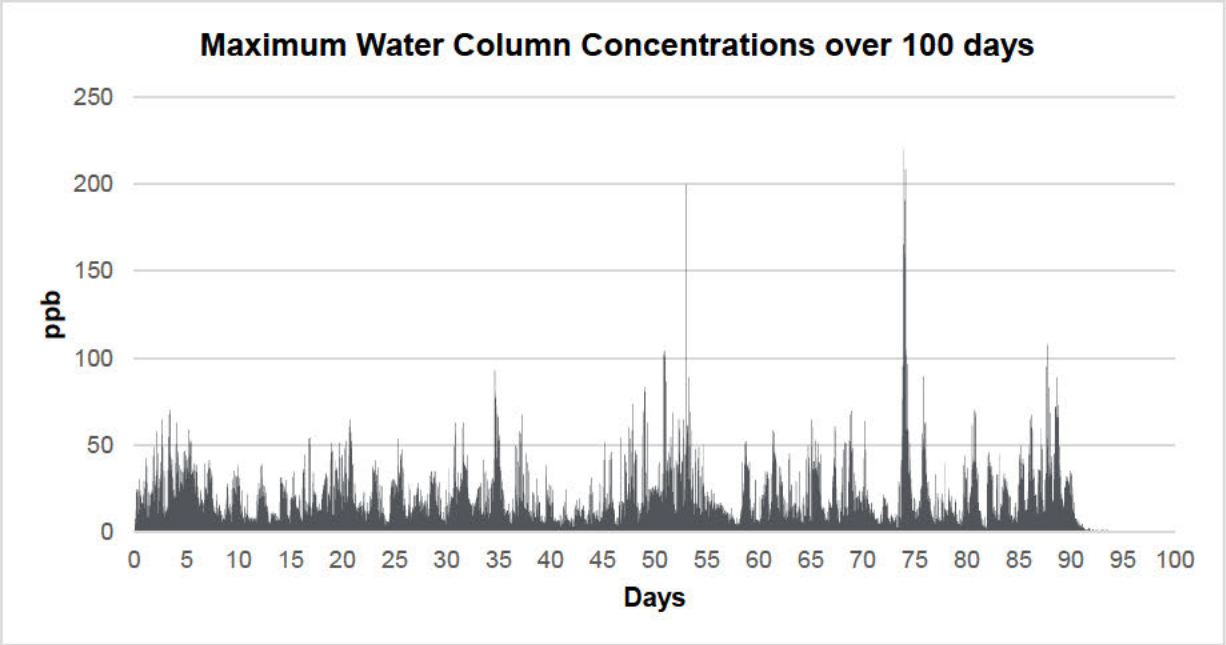


Summary of Total Water Column Concentrations

- The image DOES NOT SHOW the size of the release at any one point. The image illustrates the total concentrations (both dissolved and droplets) likely to be present in the water column across the 100-day scenario.
- The highest total concentration is predicted to be 6,748 ppb.
- Water column concentrations of liquid particles remain largely below 50 ppb throughout the 100 day scenario.

4.4.6. D01 – Maximum Water Column Concentrations Over Time

D02 - Maximum Water Column Concentrations over 100 days

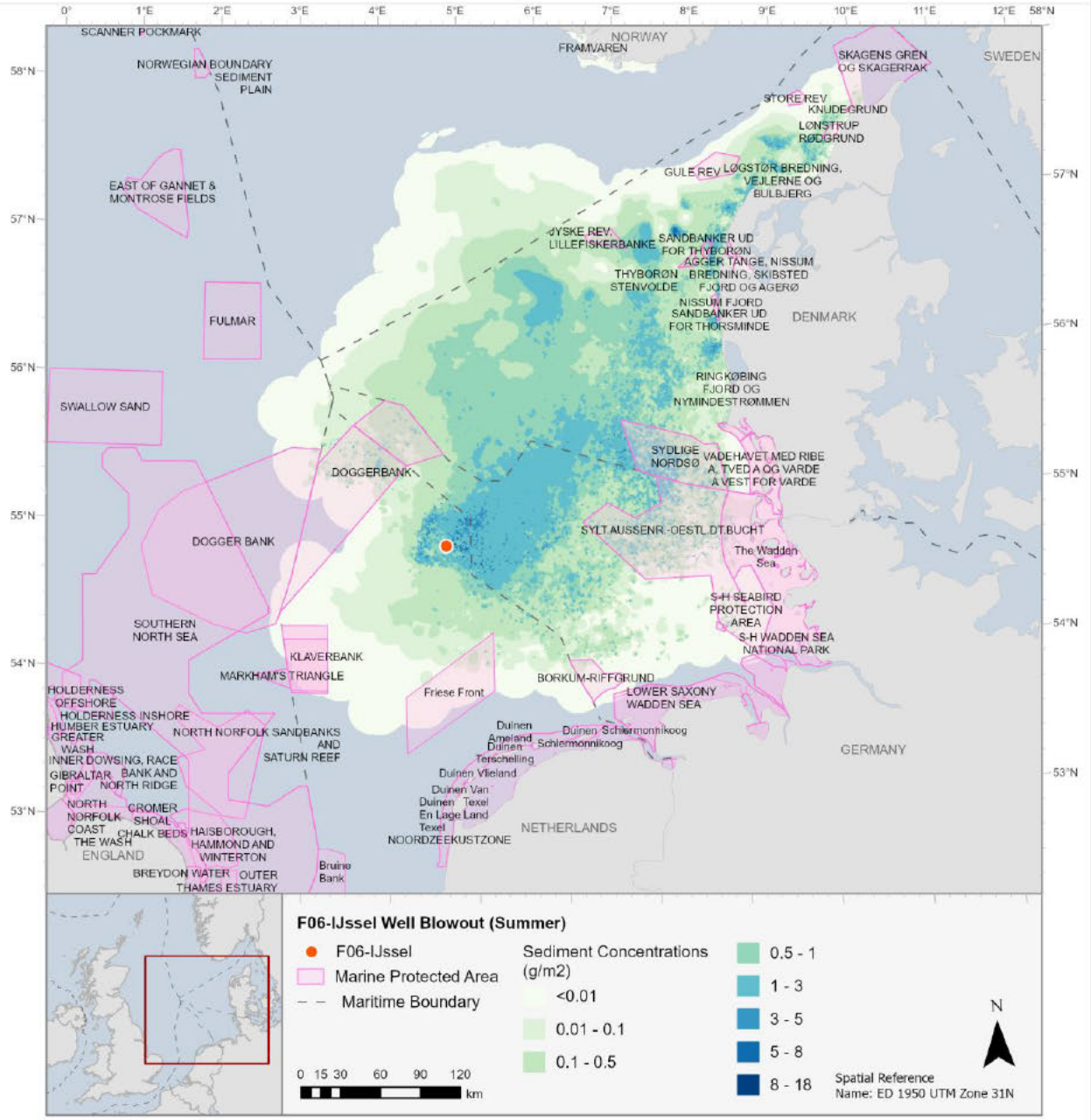


Summary of Water Column Concentrations

- Water column concentrations of liquid particles remain largely below 50 ppb throughout the 100 day scenario.
- Concentrations reduce significantly once the release is stopped.

4.4.7. D02 - Sediment Concentrations

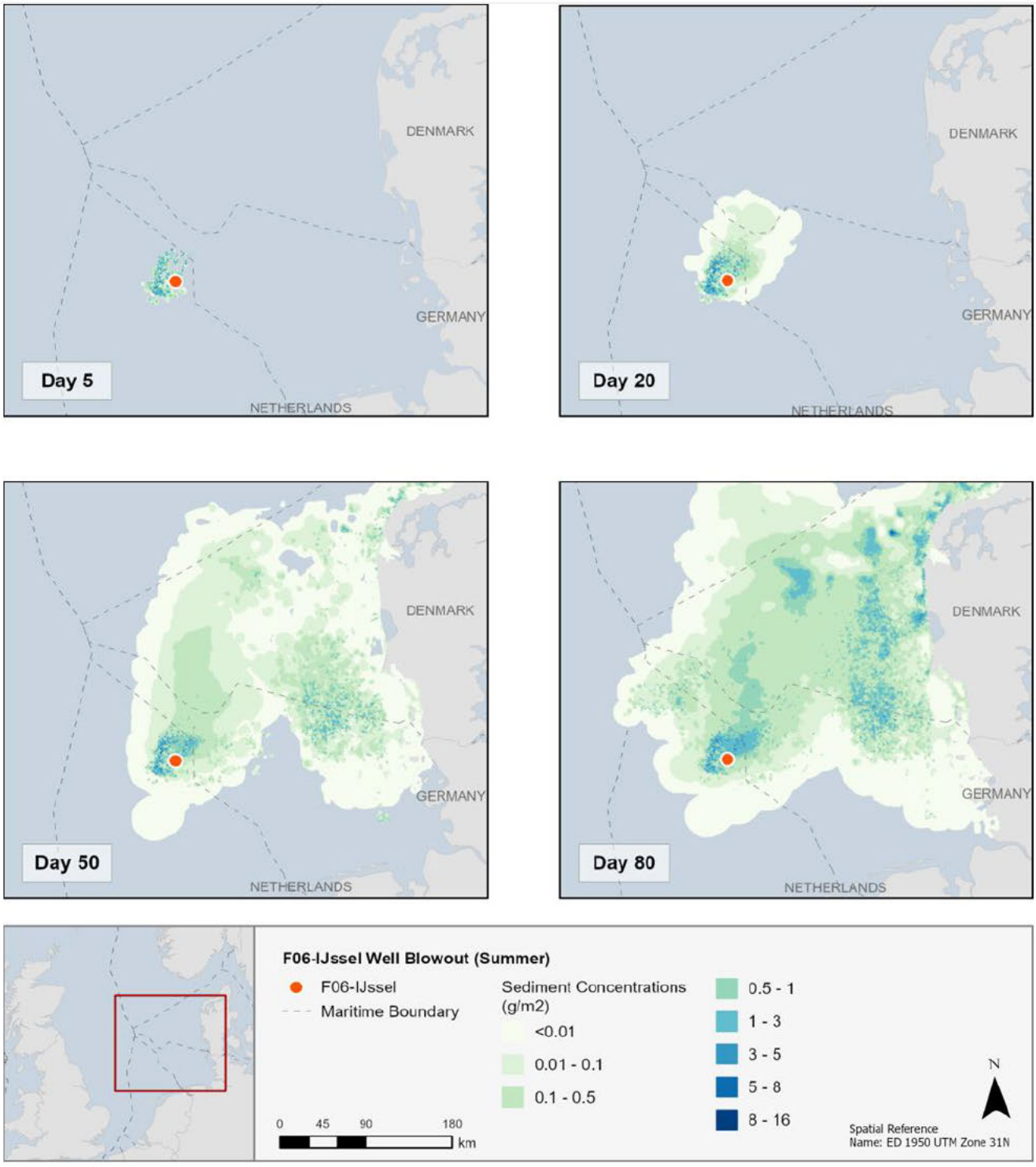
D02 – Sediment concentrations after 100 days



Summary of Sediment Concentrations

- The image shows the extent of sediment concentrations at day 100.
- The highest concentration is predicted not to exceed 18 g/m^2.
- The highest concentrations are predominetly around the release site, with some concentrations of 7 g/m^2 reaching the Danish coastline.

4.4.8. D02 – Sediment Concentrations Over Time

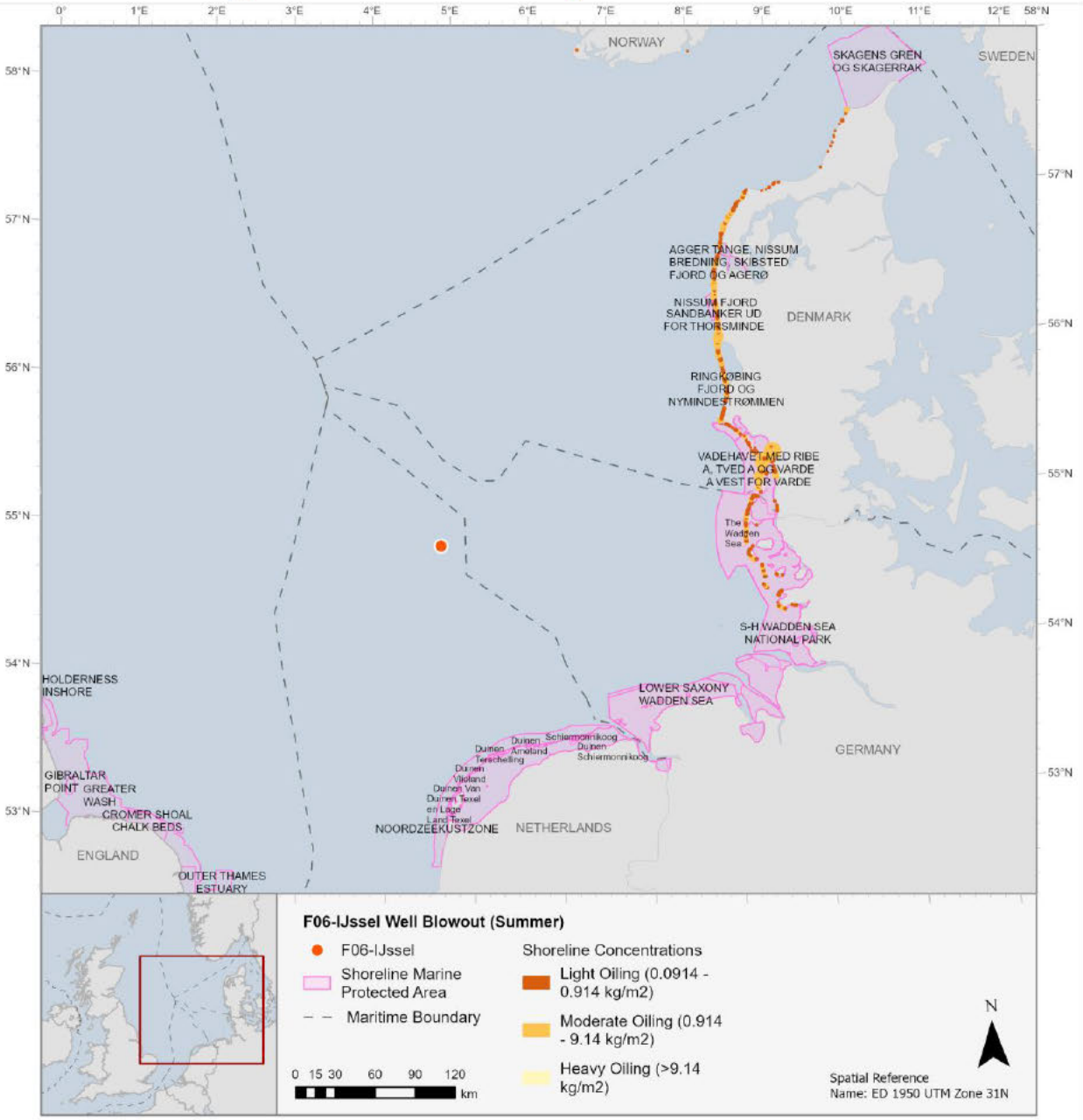


Sediment Concentrations Over Time Summary

- The following series of images display sediment concentrations at various timeframes during the 100-day release.

4.4.9. D02 - Shoreline Oiling

D02 –Shoreline oiling concentrations after 100 days



Summary of Shoreline Concentrations

- The image shows shoreline concentrations at day-100. The highest concentrations are predicted to impact the German and Danish coastlines with areas affected by light to moderate oiling (0.0914 kg/m^2 - 9.14 kg/m^2).
- The total mass of oil beaching in this scenario is 2,457 tonnes

4.4.10. D02 - Impacted Shoreline Environmental Sensitivities

Sensitivity	Extent of Oiling
Germany	
Lower Saxony Wadden Sea	Moderate oiling
S-H Wadden Sea National Park	Moderate oiling
Denmark	
Agger Tange, Nissum Bredning, Skibsted Fjord Og Agerø	Moderate oiling
Nissum Fjord	Moderate oiling
Ringkøbing Fjord Og Nymindestrømmen	Moderate oiling
Skagens Gren Og Skagerrak	Moderate oiling
Vadehavet Med Ribe A, Tved A Og Varde A Vest for Varde	Moderate oiling

5.0 RESULTS SUMMARY

The most effective means of identifying the risks is to view OSCAR's outputs concurrently. These include:

- Probability of impact
- Scale / extent of impact.

Probability of Impact

- The highest probability of surface oiling ≥0.1 µm is up to 90-100% (see S01 / S02 Sections 4.1.1 and 4.1.2).
- Maximum exposure time of surface crude in the immediate vicinity of the release site is indicated as 89 days (see S01 / S02 Sections 4.1.3 and 4.1.4). The exposure time reduces to ≤10 day beyond a radius of approximately 150 -180 km from the release site.
- Maximum time–averaged emulsion thickness of surface oiling is indicated to be >200 µm – equivalent of 'Continuous True colour' in appearance (see S01 / S02 Sections 4.1.5 and 4.1.6).
- The highest probability of shoreline impact along the Danish coastline is predicted to be 70 - 80%. (see D02 Section 4.1.8).
- The highest probability of shoreline impact along the Netherlands coastline is predicted to be 40 - 50 %. (see D02 Section 4.1.7).
- The highest probability of shoreline impact along the German coastline is predicted to be 50 - 60% (see D02 Section 4.1.7).

Water column Concentrations

- Total concentrations in the water column reach up to 7000 ppb. (see D01 Section 4.3.5 and D02 Section 4.4.5).
- The maximmum concentration of liquid particles remain predonimantly below 50 ppb. (see D01 Section 4.3.6 and D02 Section 4.4.6).

Sediment Concentrations

- The highest concentration is predicted not to exceed 18 g/m^2. (see D02 Section 4.4.7).
- Small areas of concentrations between 5 – 8 g/m^2 impact the Netherlands and Danish coastlines. (see D01 Section 4.3.7).
- Concentrations along the German shoreline is predominantly <0.01 g/m^2. (see D01 Section 4.3.7).

Shoreline Impact

- Section 4.2 provides a summary of the probability and extent of oiling affecting sensitive areas.
- In the winter release scenario outlined in D01 Section 4.3.10, Heavy Oiling impacts environmentally sensitive areas along the Netherlands coastline, whereas the coastlines of Germany, Denmark, and Norway experience primarily Moderate and Light oiling. The length of coastline impacted was 619.9 km, with a mass of 11,030 mt beaching.
- In the summer release scenario outlined in outlined in D02 Section 4.4.10, environmentally sensitive areas along the coastlines of Denmark and Germany are

mainly impacted by Moderate oiling. The length of coastline impacted was 414.9 km, with a mass of 2,457 mt beaching.

- A release during the winter season is expected to lead to the prolonged presence of surface oil and an increased amount of oil reaching coastal areas.

6.0 REFERENCES

5.1.2.e (2013, January 2007). *BONN Agreement.* Retrieved July 2013, from http://www.bonnagreement.org/eng/doc/Microsoft%20Word%20-%20CURRENT%20STATUS%20report%20final%2019Jan07.pdf

5.1.2.e (2010). *Effects of Sheens Associated with Offshore Oil and Gas Development on the Feather Microstructure of Pelagic Seabirds.*

5.1.2.e (1996). *Calibration and testing of IKU's oil spill contingency and response (OSCAR) model system.*

5.1.2.e (1995). A three dimensional oil and chemical spill model for environmental impact assessment.