Hebron

HEBRON PROJECT

Comprehensive Study Report
Addendum: Results from Simulations of
Oil Spills at the Hebron Offshore Location
July 2011

ExxonMobil Chevron SUNCOR ENERGY Statoil nalcor energy

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Stantec Consulting Ltd.

ADDENDUM

Results from Extended Run Simulations of Oil Spills at the Hebron Offshore Location

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This addendum to the ASA report titled '*Results from Simulations of Oil Spills at the Hebron Well Site*' contains the results from oil spill simulations of blowout releases at the Hebron platform site using extended run times.

Additional stochastic simulations of oil spills were run in order to address concerns on the longevity of oil in the marine environment from releases at the Hebron platform site. For this reason, the 30-day and 120-day surface blowout release cases in winter and the 100-day surface blowout release case in summer were simulated for an additional 200 days after flow from the well is stopped in order to determine the fate of any oil remaining on the sea surface. The release rate, total spill volumes and oil type used in the simulations reported here are the same as those used for simulations presented in the main report, only the model run time is extended. Table 1 lists the spill scenarios modeled and reported on in this Addendum. Figure 1 illustrates the time span covered by the blowout releases and the total model simulation period over a full year.

Table 1. Extended duration oil spill scenarios modeled at the Hebron Platform location.

Scenario	Total Spill Volume	Spill Duration	Total Simulation Duration	Season
	Offshore - Hebron Platform Site (46.5440573° N, 48.49803617° W)			
Platform Blowout (D-94 crude)	1,050,000 bbl (166,936.6 m^3)	30 days	230 Days	Winter
	3,500,000 bbl (556,455.4 m^3)	100 days	300 Days	Summer
	4,200,000 bbl (667,746.5 m^3)	120 days	320 Days	Winter

Stochastic model runs of the three extended duration simulations consisted of 100 individual runs that were aggregated to come up with a statistical representation of the probability of oiling to the shoreline, sea surface, and water column. The study domain was defined as the offshore region of Newfoundland within 60°W to 30°W and 40°N to 56°N.

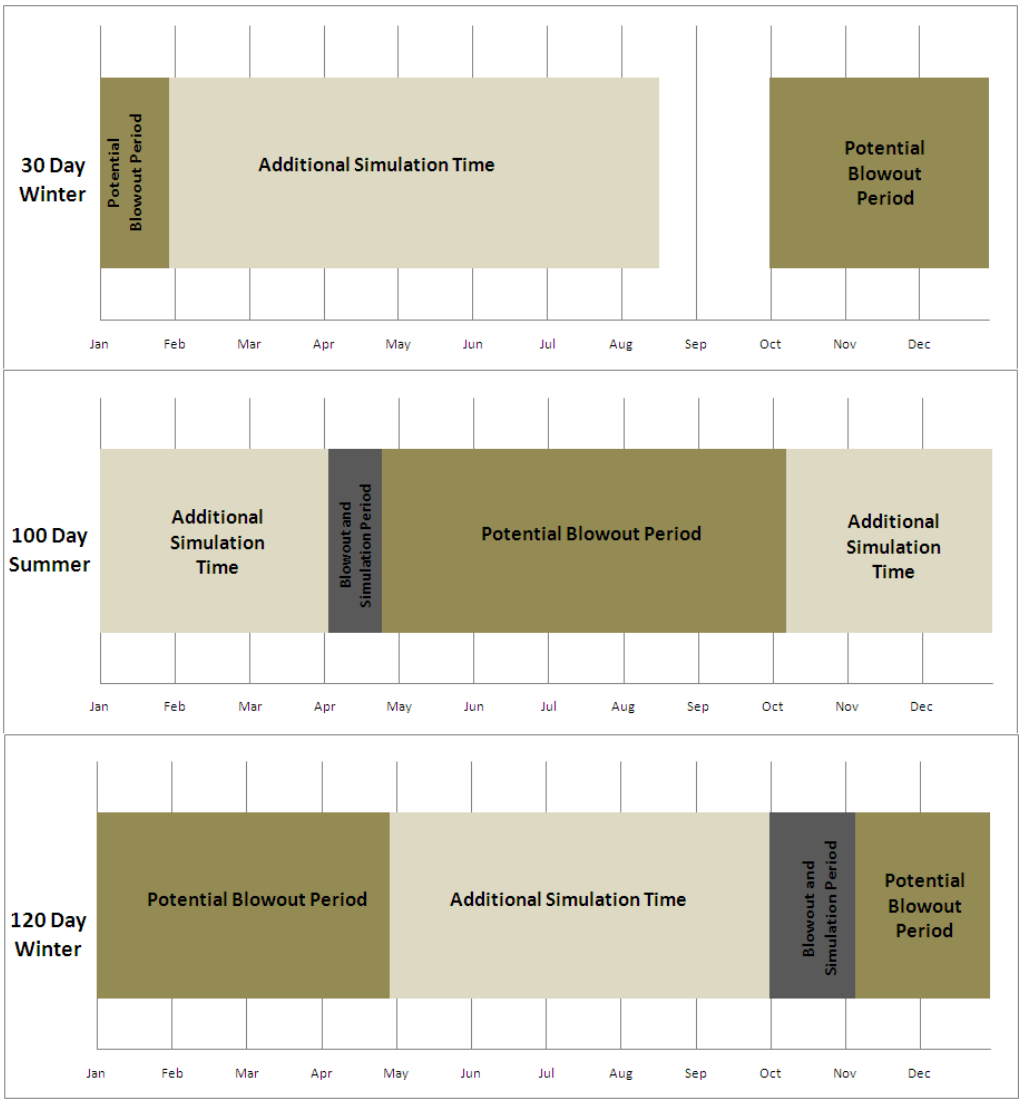


Figure 1. Time coverage for blowout simulations.

Figures 2, 3 and 4 show the time history of surface oil, shoreline oil and oil leaving the model domain over the simulation period for the 30-, 100- and 120-day blowouts, respectively. The curves in Figures 2-4 indicate oil as a percent of the total spill volume. Based on the stochastic model results from the extended run simulations the volume of oil predicted to remain on the sea surface tends toward zero once the blowout is stopped. At the end of the extended run simulations the maximum oil remaining on the sea surface ranges from 12,600 bbl (2,003.2 m^3 or 1.2% of the total release) for the 30-day winter blowout, 5,600 bbl (890.3 m^3 or 0.16% of the total release) for the 100-day summer blowout, and 46,200 bbl (9,094.1 m^3 or 1.1% of the total release) for the 120-day blowout during the winter season. The time required for the surface oil volume to reach less than 2% of the total spill volume ranges from 135 days (4.5 months) for the 30 day blowout release to 148 days (5 months) for the 120-day blowout release. Under all scenarios, less than 1% of the total spill is predicted to be on the Newfoundland shoreline. Between 44 and 62% of the total spill volume may exit the model domain.

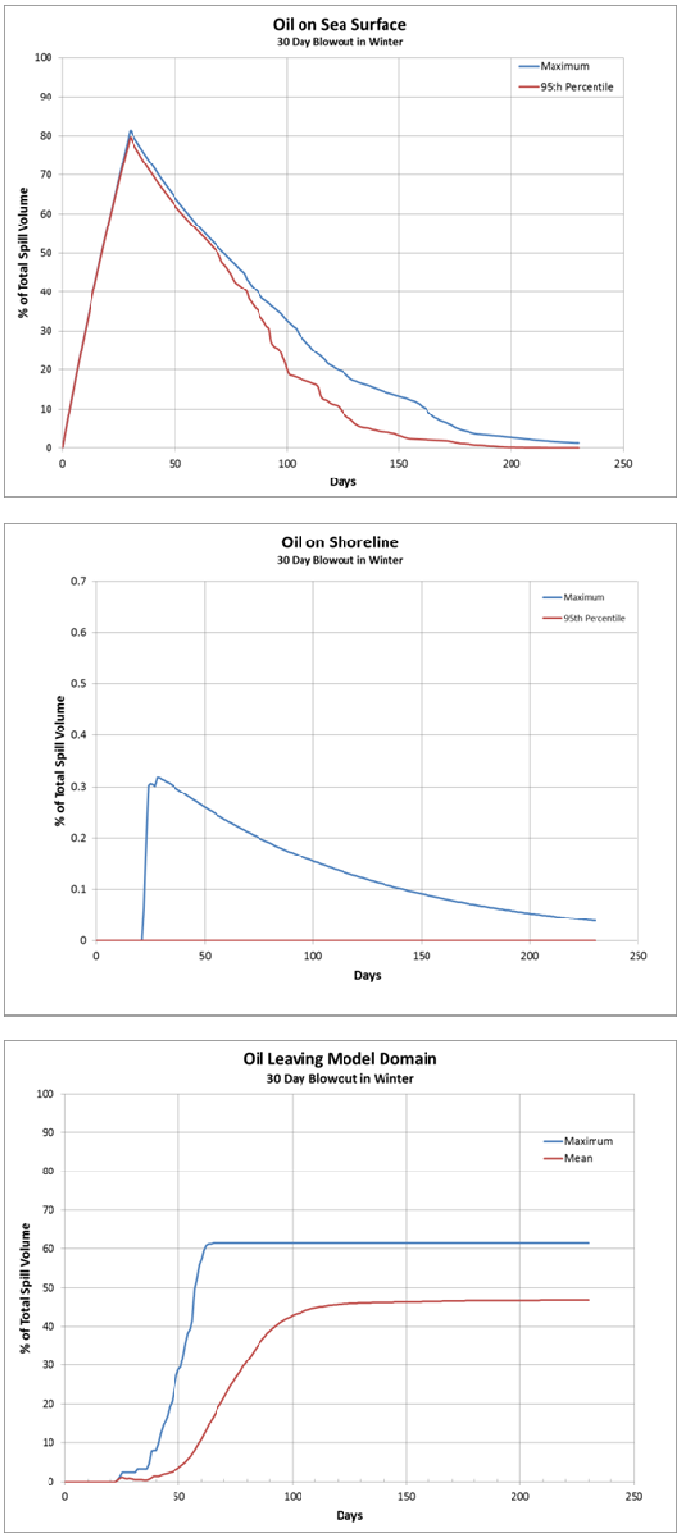


Figure 2. Oil mass balance as a percent of the total spilled volume predicted by the model from stochastic model results for the 30-day blowout release in winter. The top plot shows surface oil, the middle shows shoreline oil (note the different vertical scale) and the bottom plot shows oil leaving the model domain.

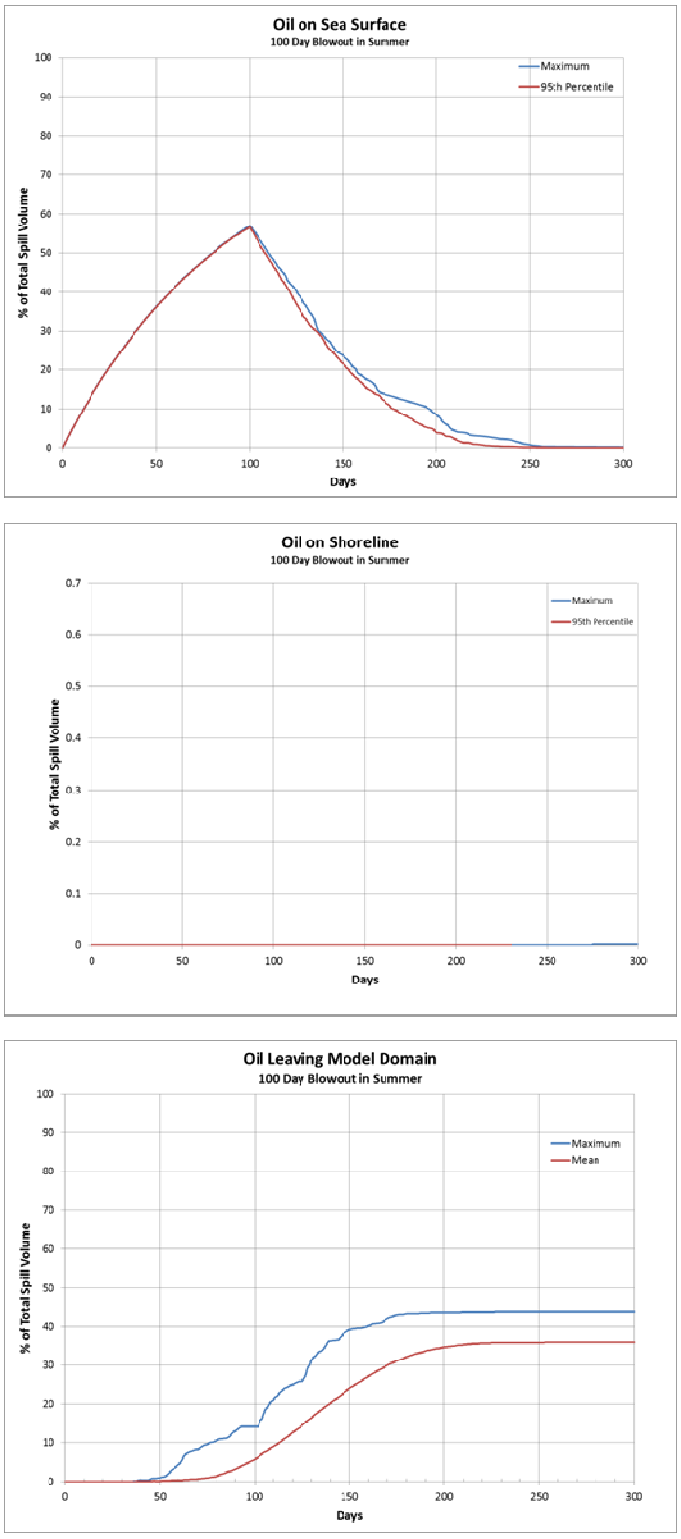


Figure 3. Oil mass balance as a percent of the total spilled volume predicted by the model from stochastic model results for the 100-day blowout release in summer. The top plot shows surface oil, the middle shows shoreline oil (note the different vertical scale) and the bottom plot shows oil leaving the model domain.

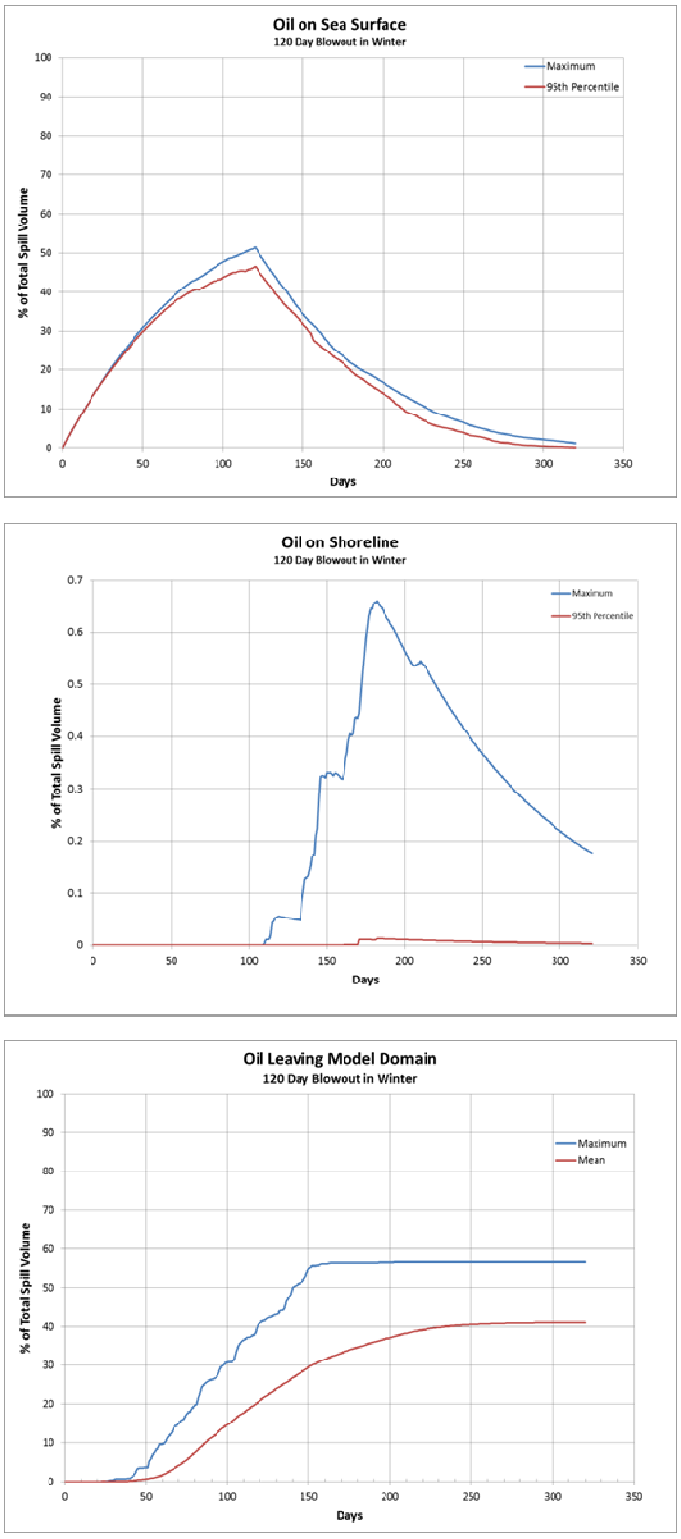


Figure 4. Oil mass balance as a percent of the total spilled volume predicted by the model from stochastic model results for the 120-day blowout release in winter. The top plot shows surface oil, the middle shows shoreline oil (note the different vertical scale) and the bottom plot shows oil leaving the model domain.

The probabilities for oil to reach the Newfoundland shoreline, sea surface and water column are shown on the maps in Figures 5 through 16. Sea surface oiling probabilities are presented first, followed by shoreline oiling probabilities and then entrained oil probabilities.

The shoreline of Newfoundland is predicted to have an 8% probability of being oiled from a spill event for the 120-day winter season surface release simulated for 320 days (the predicted probability of shoreline oiling from the previous 120-day winter blowout simulation was 1%). For the extended duration 120-day winter blowout scenario, a maximum of 785 km of shoreline along the Newfoundland coastline was oiled (the original shoreline length oiled was 285 km). For the 30-day and 100-day scenarios, there were lower probabilities and smaller potential lengths of the Newfoundland coast oiled, as outlined in Table 2. Table 2 also lists the maximum volume of oil stranded along the entire shoreline length predicted to be oiled for the three spill scenarios.

Table 2. Newfoundland shoreline oiling summary. Values listed are from the individual spill within each stochastic scenario that resulted in the largest volume of oil stranded on the shore. These three spills correspond to the spills depicted on the maps in Figures 16, 17 and 18.

Scenario	Probability of Oiling (%)	First Arrival of Oil (days)	Shoreline Length Oiled (km)	Shoreline Area Oiled (m^2)	Maximum Oil Volume Ashore (bbl) [m^3]	% of Total Spill Volume
Surface 30-day Winter	2	22	87	2.61×10^5	3,305 [525.5]	0.3148
Surface 100-day Summer	1	275	4.7	1.41×10^4	81 [12.9]	0.0023
Surface 120-day Winter	8	110	785	2.35×10^6	27,745 [4,411.1]	0.6606

Based on the maximum oil holding capacity for the exposed rocky shoreline defined in the oil spill model, shoreline oil does not exceed 2 mm thickness and the maximum volume of oil that can be stranded on 1 metre of shoreline does not exceed 0.006 m^3 (6 litres). Oil reaching a segment of shoreline that has reached its holding capacity will remain on the sea surface.

Table 3 provides a summary of the sea surface oiled, shoreline length oiled, and the volume of entrained oil within the model domain for each of the scenarios. Sea surface areas represent the area swept by the surface oil during the model simulation period, not the area of the surface slick. Shoreline length oiled represents the total length of shoreline exposed to oil above the 0.01 mm thickness threshold. Entrained oil volume is the volume of water with a whole oil concentration exceeding the 10 ppb threshold at the end of the simulation.

Table 3. Summary of the stochastic simulations of the platform blowouts at the Hebron well site. The 95th percentile values are determined by ranking all 100 spills in each scenario according to the area of sea surface exposed to oil, the length of shoreline exposed to oil and the volume of entrained (naturally dispersed) oil above the stated thresholds.

Season	Sea Surface Area Oiled (within grid) at >0.01 mm (km^2)	Shoreline Length Oiled (within grid) at >0.01 mm (km)		Entrained Oil Volume at End of Simulation (m^3)
	95th Percentile	95th Percentile	Maximum	95th Percentile
Winter 30-day	1.89 x 10^6	0	87	401
Summer 100-day	2.17 x 10^6	0	5	111
Winter 120-day	2.68 x 10^6	59	785	735

The 95th percentile values for the area of sea surface oiled, shoreline length oiled, and entrained oil are all larger for the 120-day winter blowout case modeled for 320 days relative to the 30-day winter and 100-day summer extended run simulations.

Maps of the footprint from the individual spill ranked as the 95th percentile for surface oiling are shown in Figures 14 to 16. When the stochastic model results are ranked in terms of shoreline oiling, the 95th percentile spill results in shoreline oiling for only the 120-day winter season blowout. For this reason the spills with the maximum shoreline length oiled are displayed in Figures 17 to 19. The spills that have the 95th percentile volume of oil remaining in the water column 200 days after the blowout is stopped are shown in Figures 20 to 22.

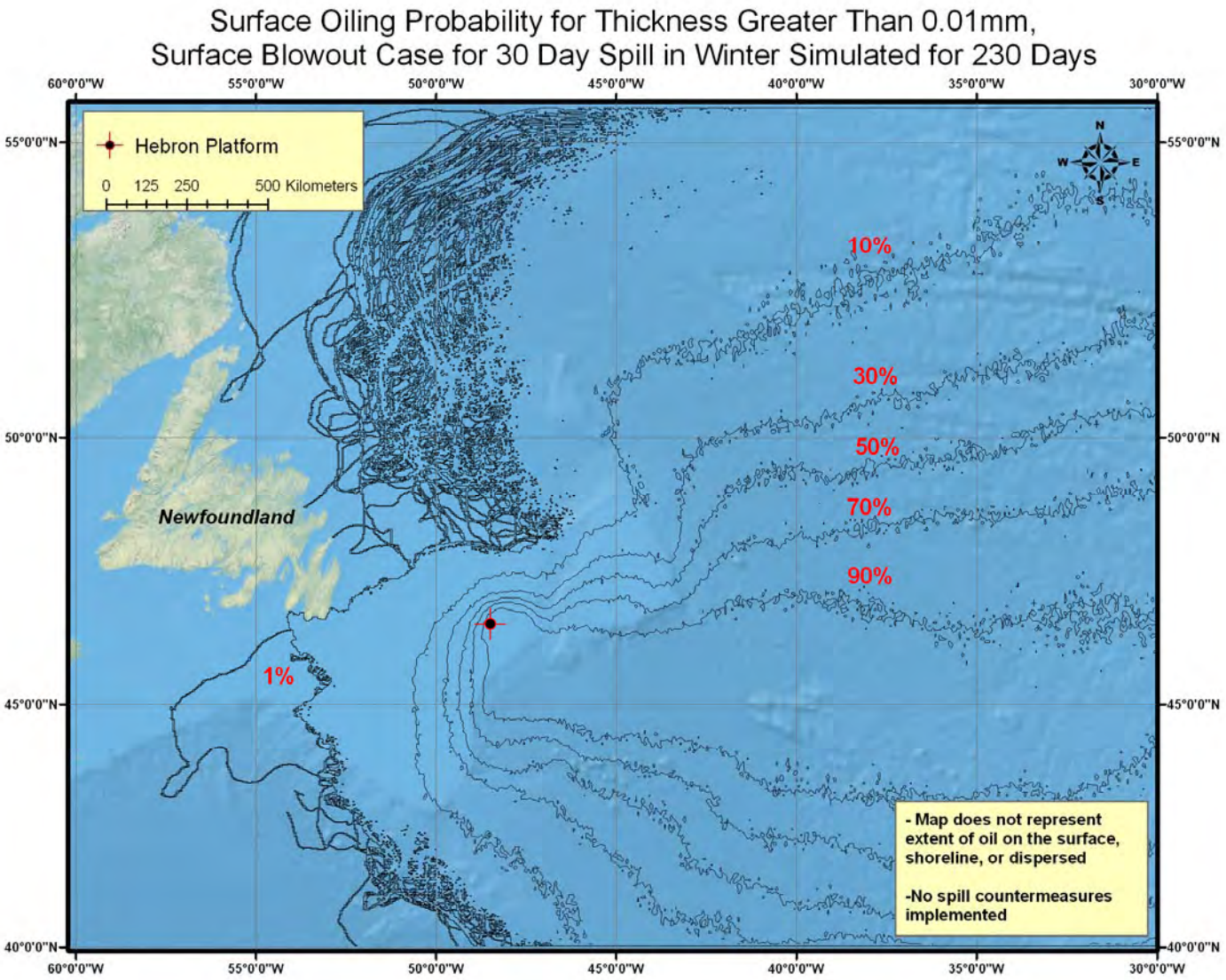


Figure 5. Surface oiling probabilities from a platform blowout of 5,600 m^3/day (35,000 bbl/day) of Hebron D-94 over a 30-day period during the winter run for 230 days.

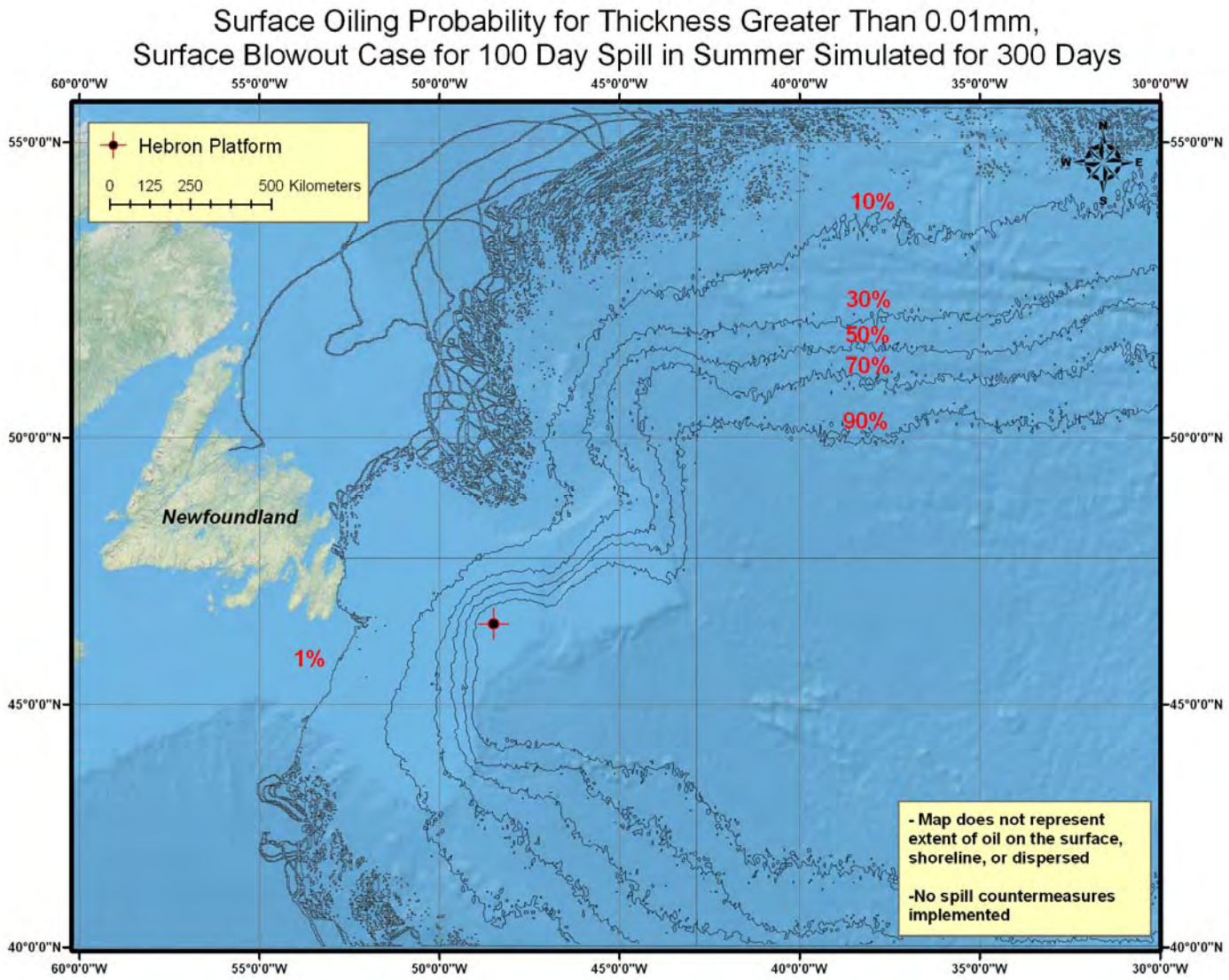


Figure 6. Surface oiling probabilities from a platform blowout of 5,600 m^3/day (35,000 bbl/day) of Hebron D-94 over a 100-day period during the summer run for 300 days.

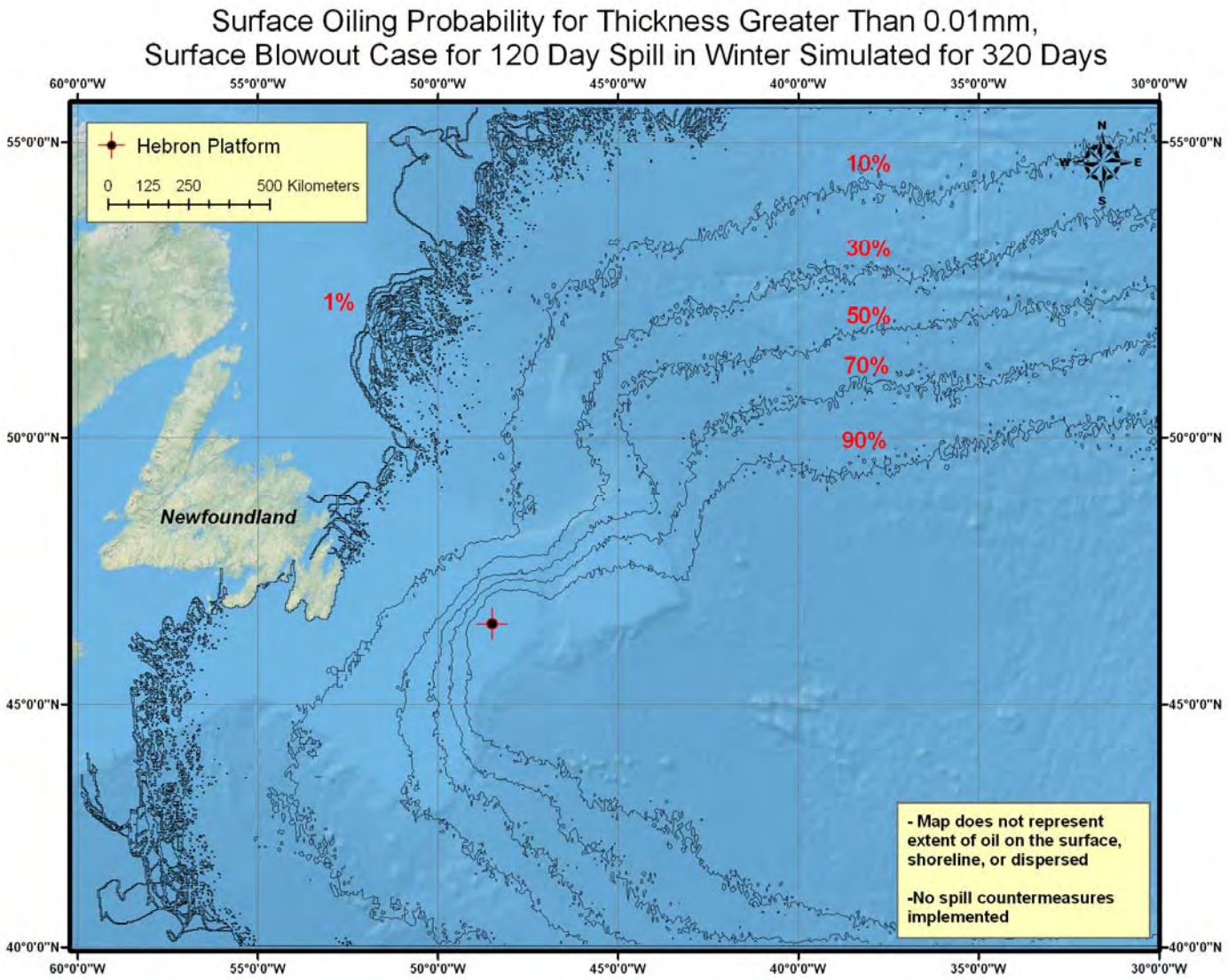


Figure 7. Surface oiling probabilities from a platform blowout of 5,600 m^3/day (35,000 bbl/day) of Hebron D-94 over a 120-day period during the winter run for 320 days.

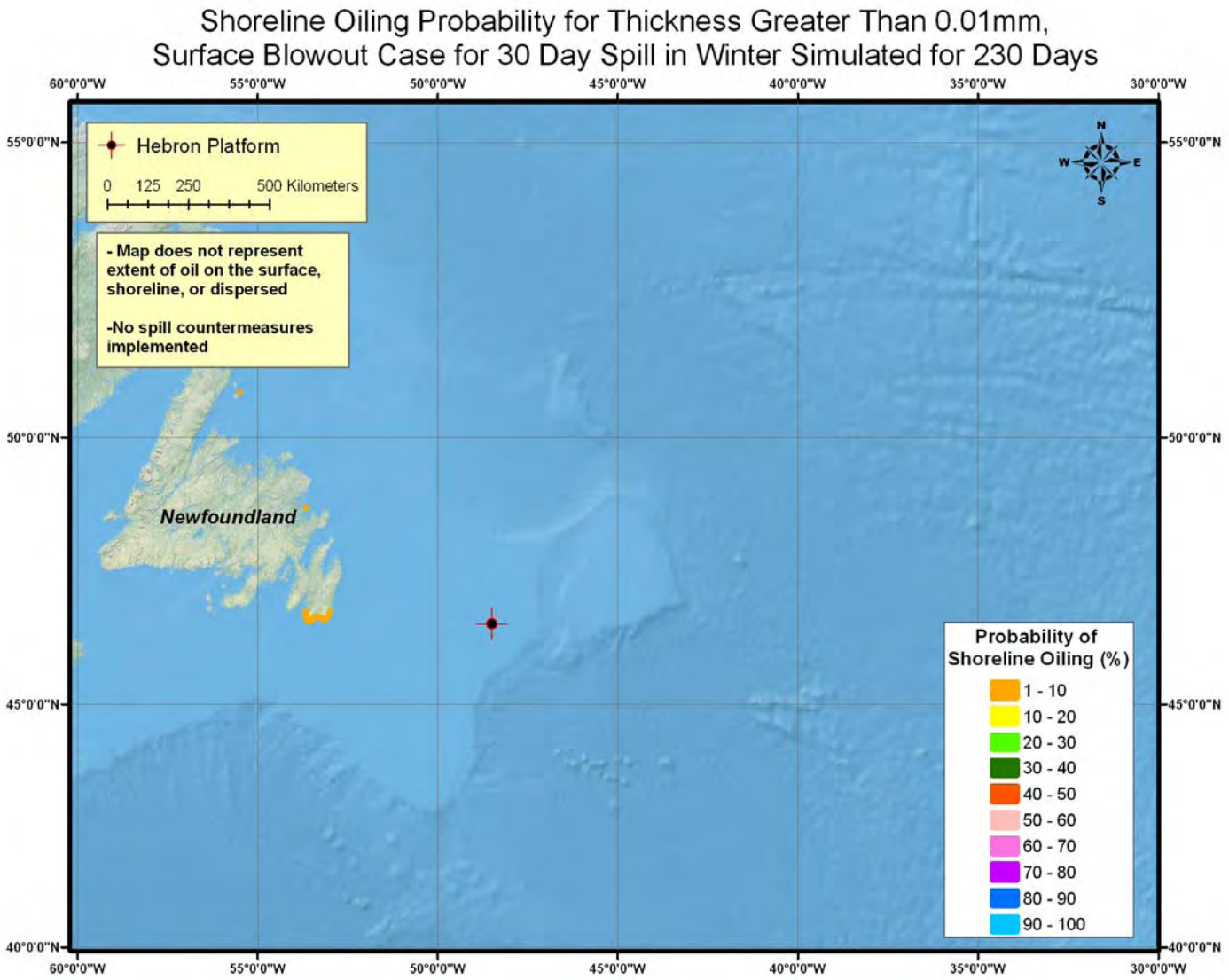


Figure 8. Shoreline oiling probabilities from a platform blowout of 5,600 m^3/day (35,000 bbl/day) of Hebron D-94 over a 30-day period during the winter run for 230 days.

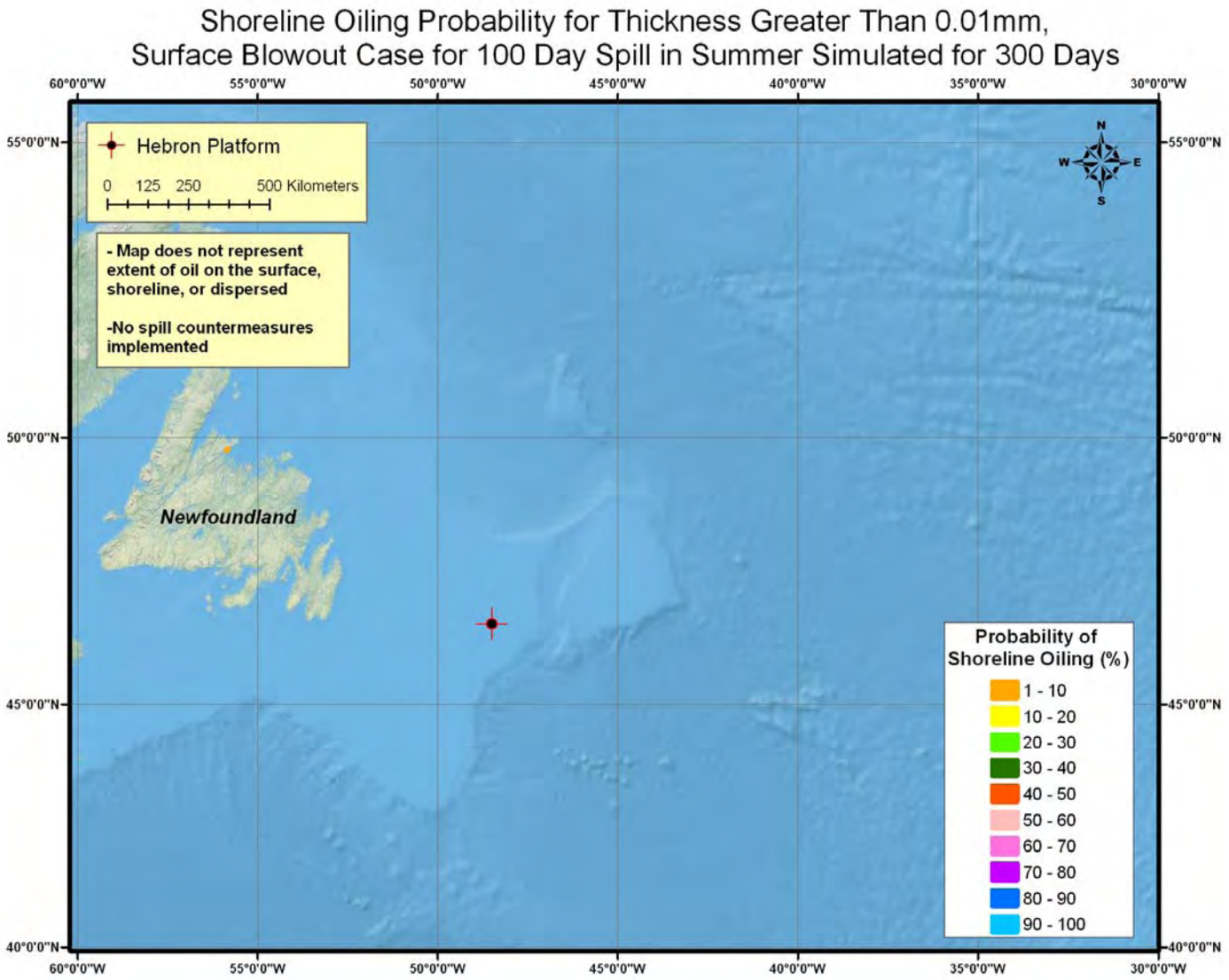


Figure 9. Shoreline oiling probabilities from a platform blowout of 5,600 m^3/day (35,000 bbl/day) of Hebron D-94 over a 100-day period during the summer run for 300 days.

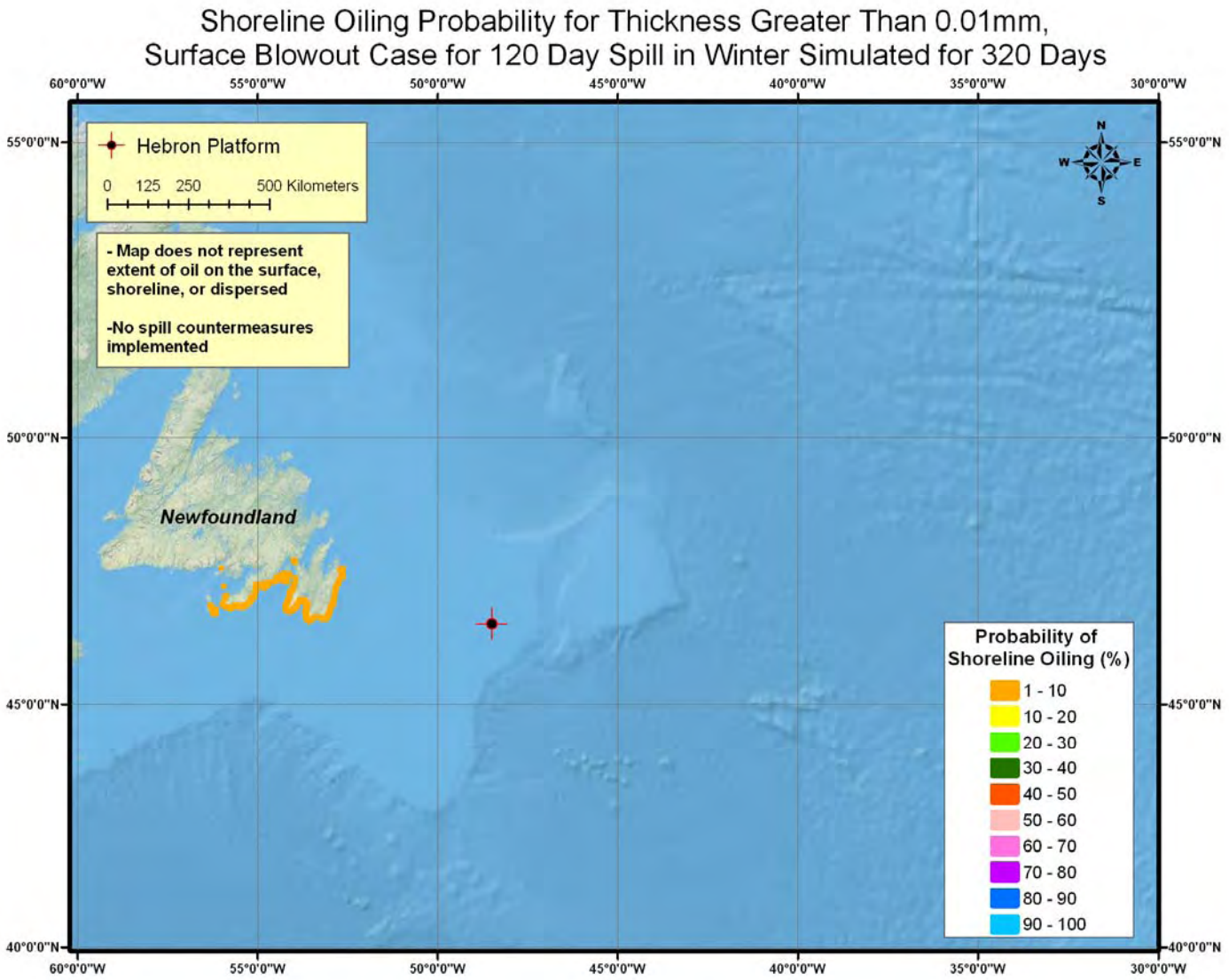


Figure 10. Shoreline oiling probabilities from a platform blowout of 5,600 m^3/day (35,000 bbl/day) of Hebron D-94 over a 120-day period during the winter run for 320 days.

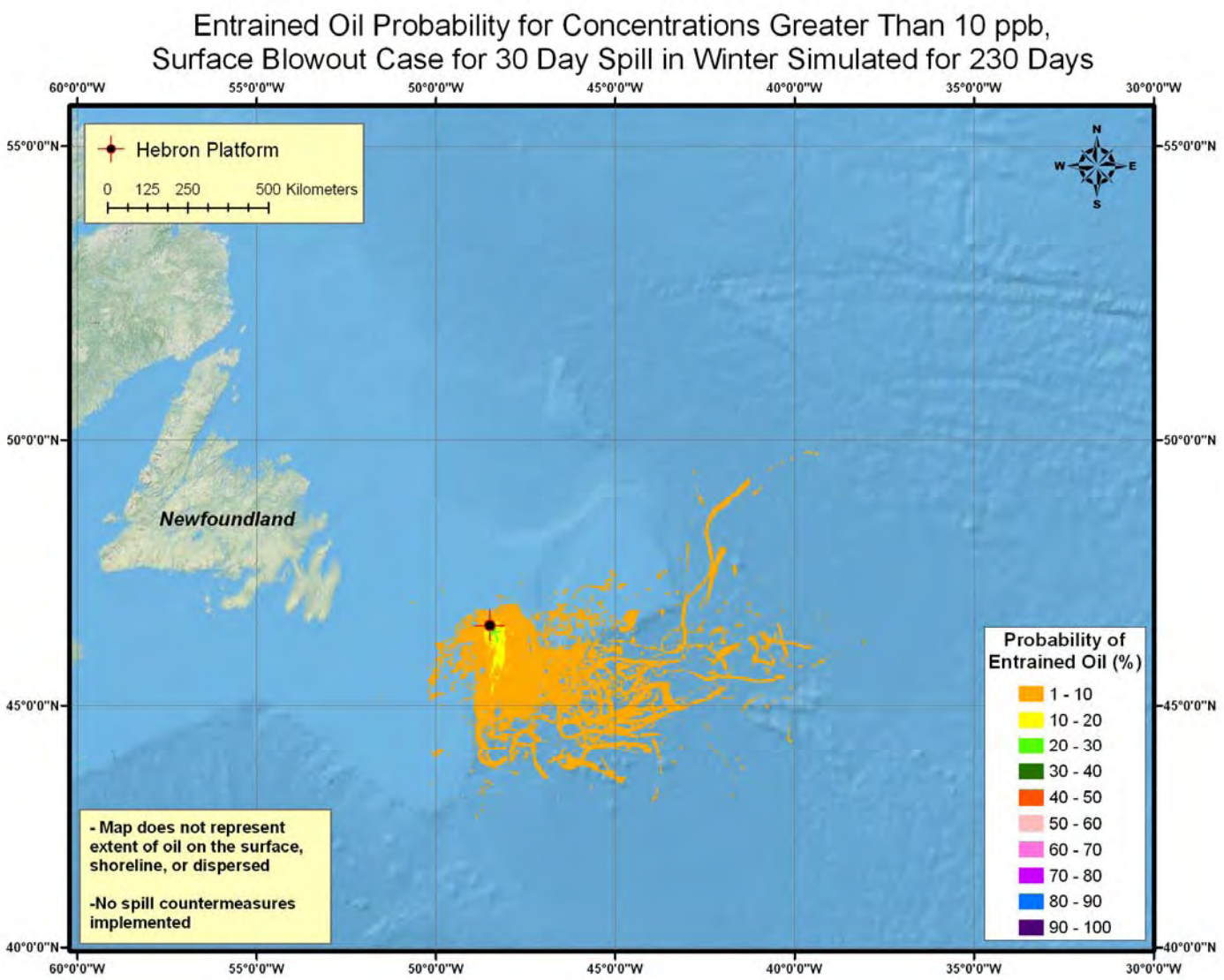


Figure 11. Entrained oiling probabilities from a platform blowout of 5,600 m^3/day (35,000 bbl/day) of Hebron D-94 over a 30-day period during the winter run for 230 days.

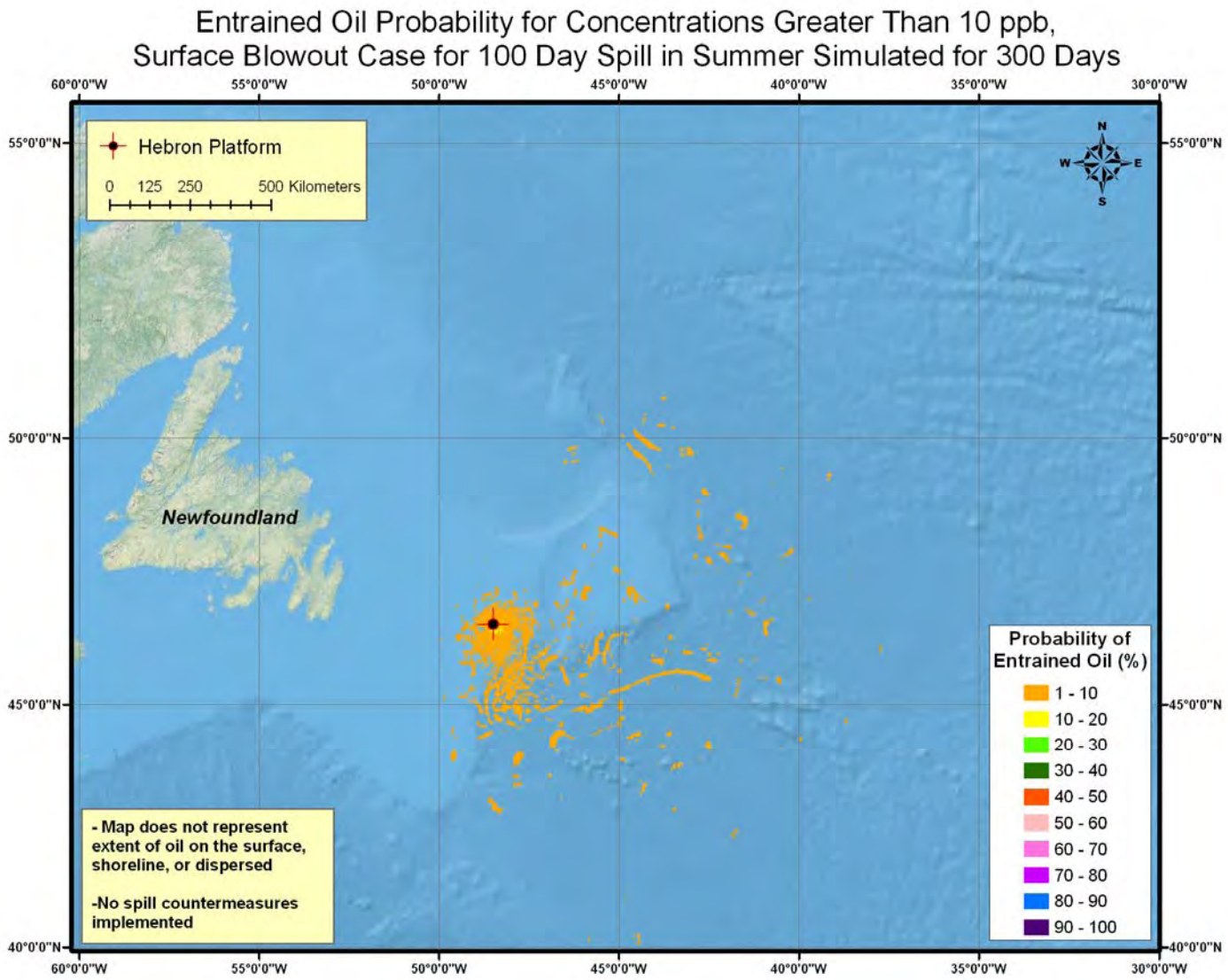


Figure 12. Entrained oiling probabilities from a platform blowout of 5,600 m^3/day (35,000 bbl/day) of Hebron D-94 over a 100-day period during the summer run for 300 days.

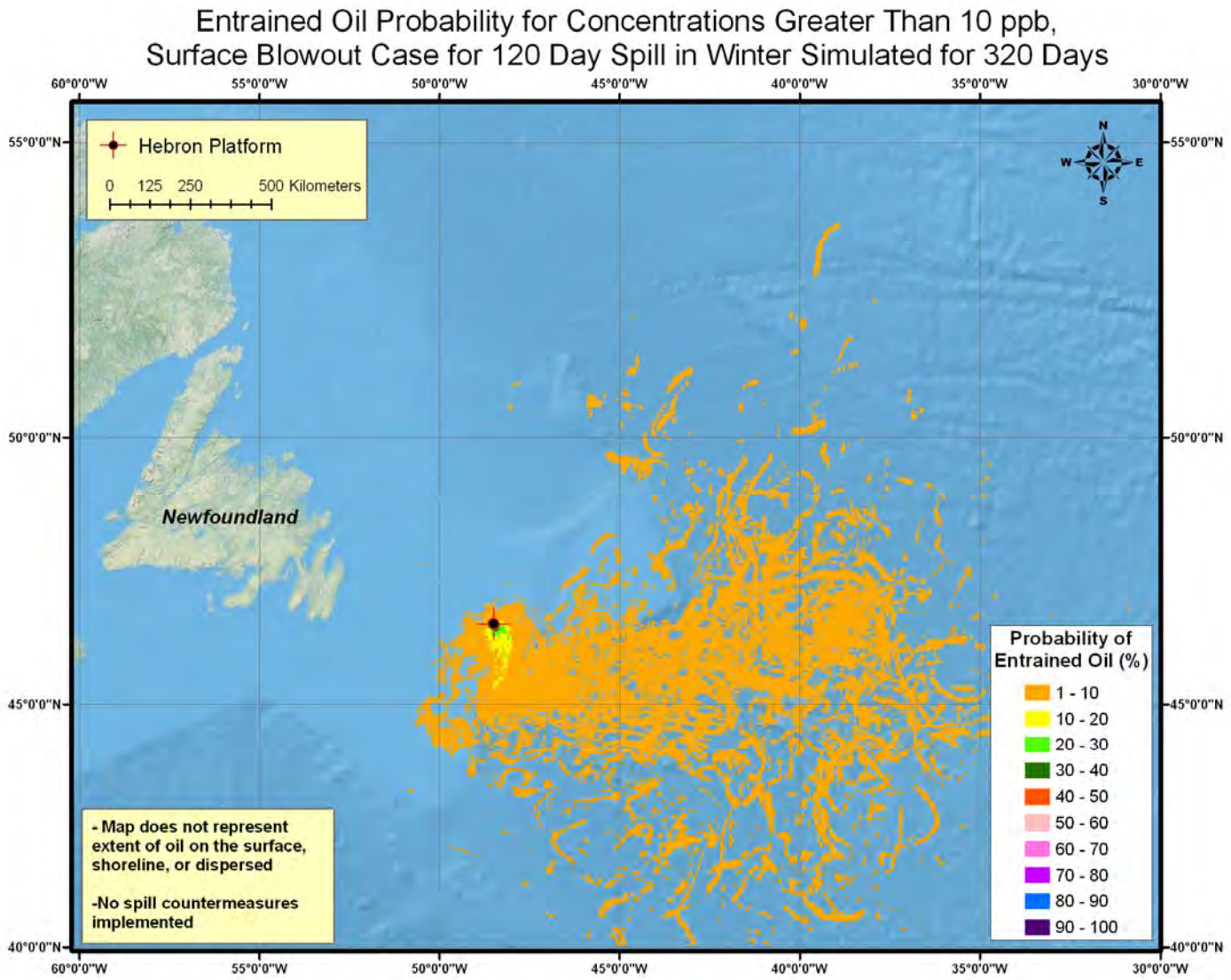


Figure 13. Entrained oiling probabilities from a platform blowout of 5,600 m^3/day (35,000 bbl/day) of Hebron D-94 over a 120-day period during the winter run for 320 days.

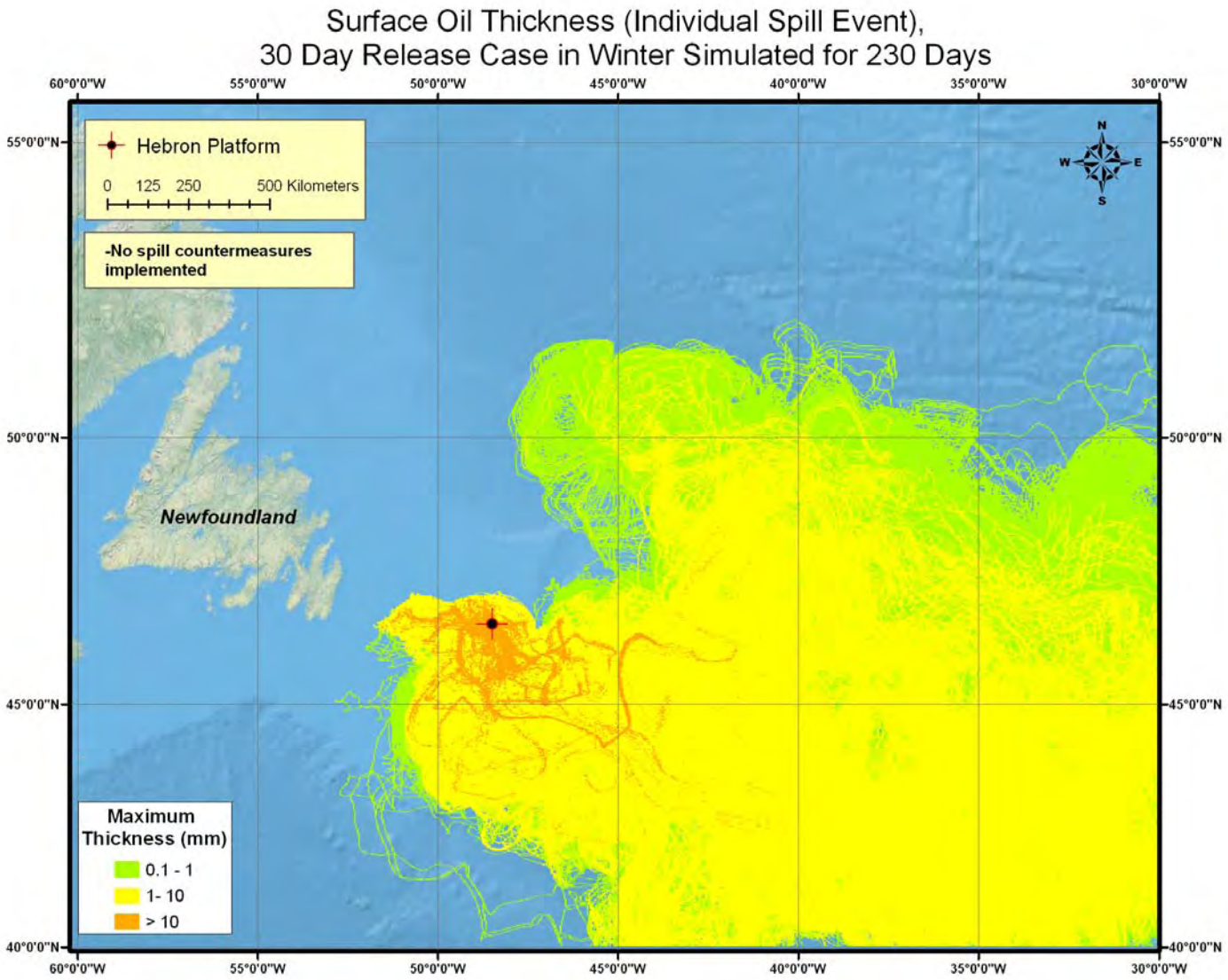


Figure 14. Maximum surface oil thickness for the 95th percentile surface oiling case based on the sea surface area oiled during a 30-day platform blowout in the winter run for 230 days.

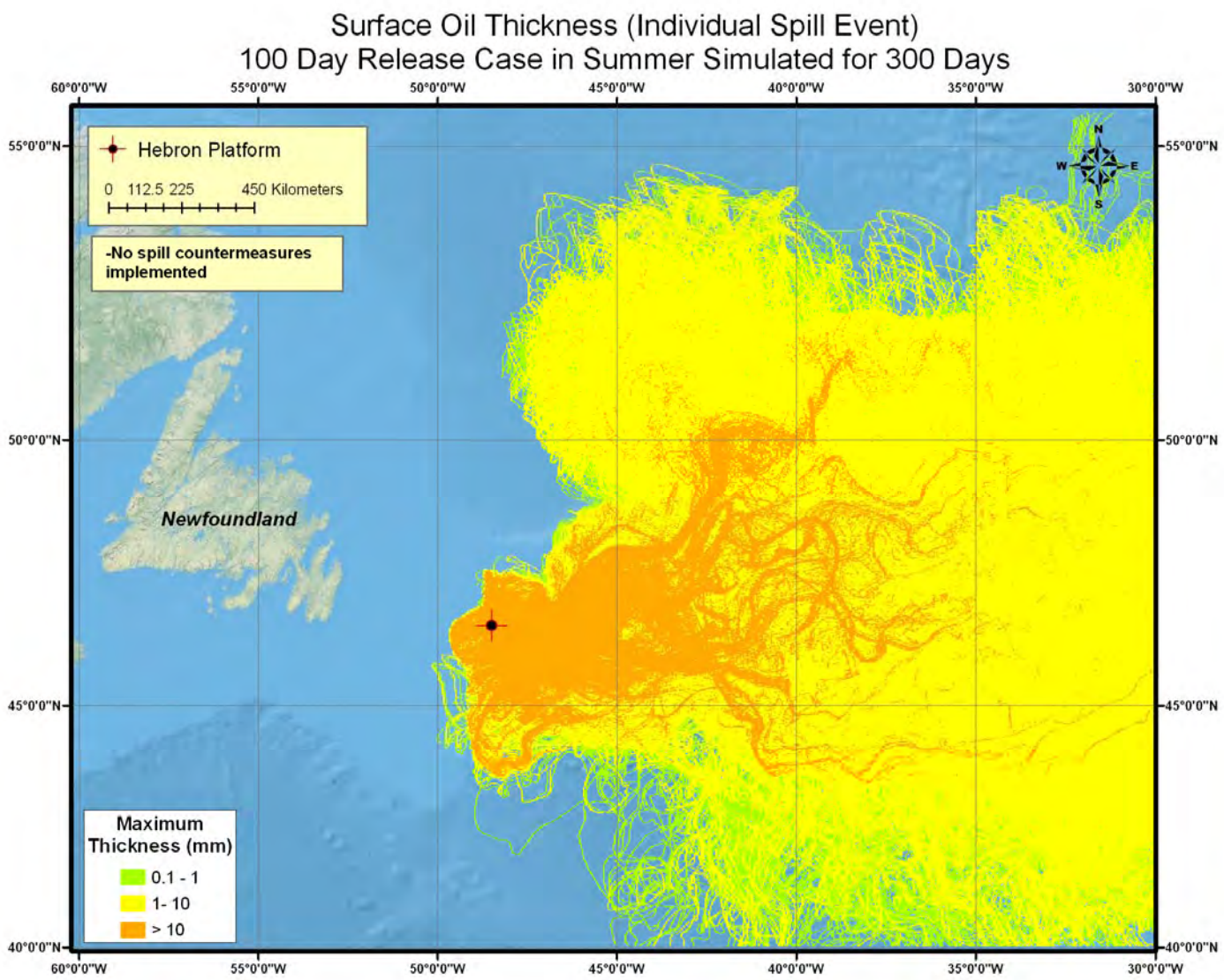


Figure 15. Maximum surface oil thickness for the 95th percentile surface oiling case based on the sea surface area oiled during a 100-day platform blowout in the summer run for 300 days.

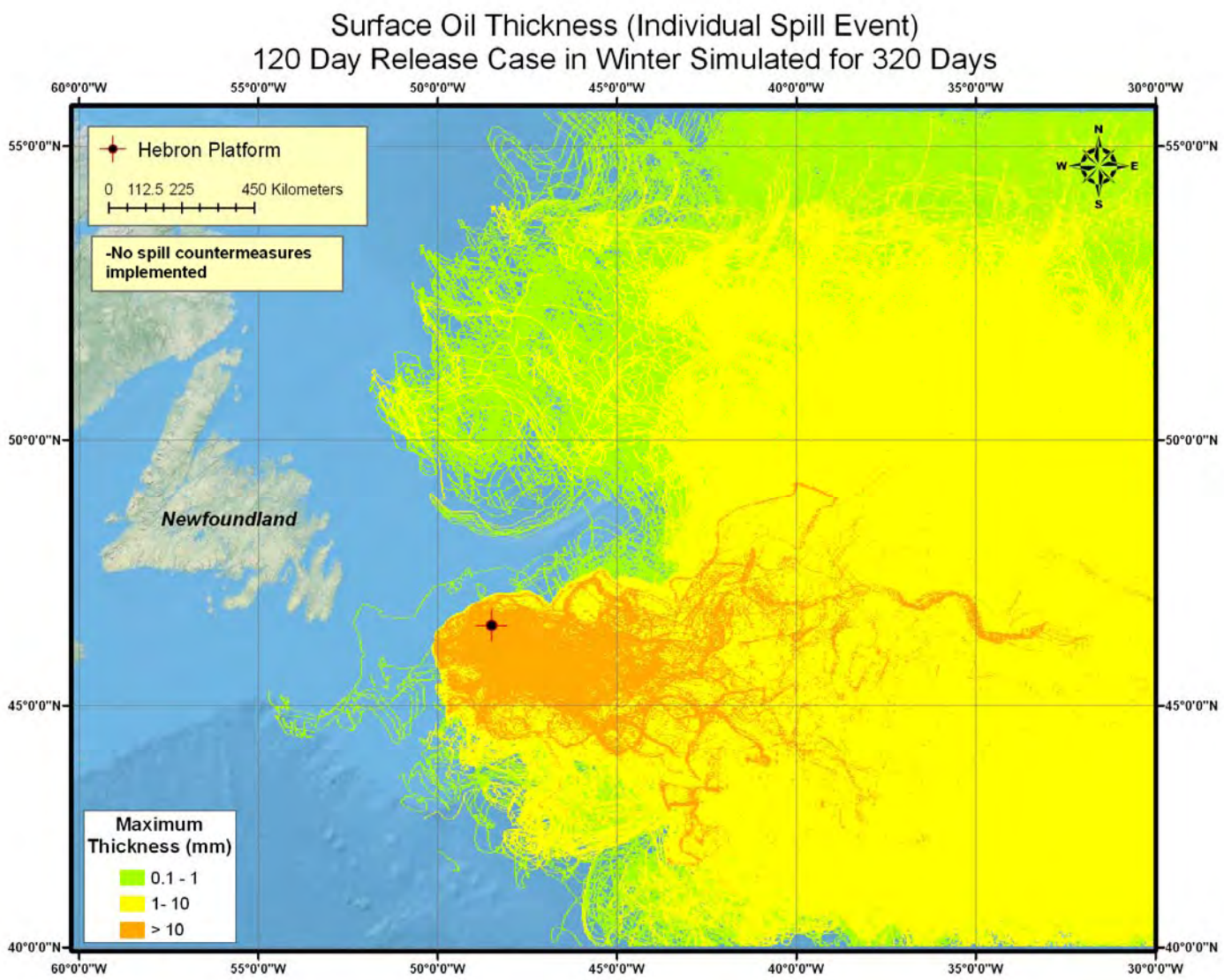


Figure 16. Maximum surface oil thickness for the 95th percentile surface oiling case based on the sea surface area oiled during a 120-day platform blowout in the winter run for 320 days.

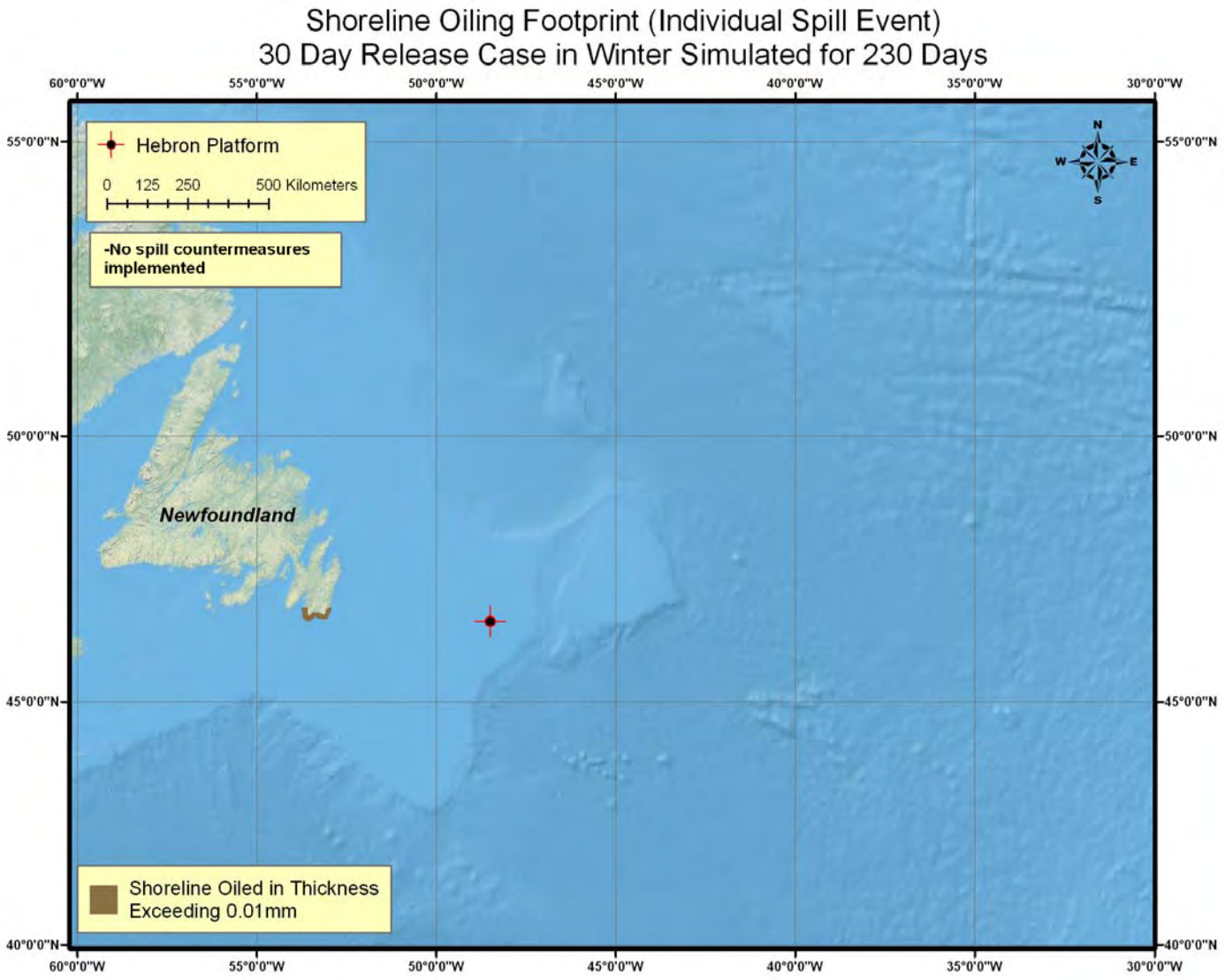


Figure 17. Location of shoreline oiling for the spill with the maximum shoreline length oiled for a 30-day platform blowout during the winter run for 230 days. 87 km of shoreline are predicted to be oiled with 3,305 bbl (525.5 m^3) of oil that has been on the sea surface for a minimum of 22 days.

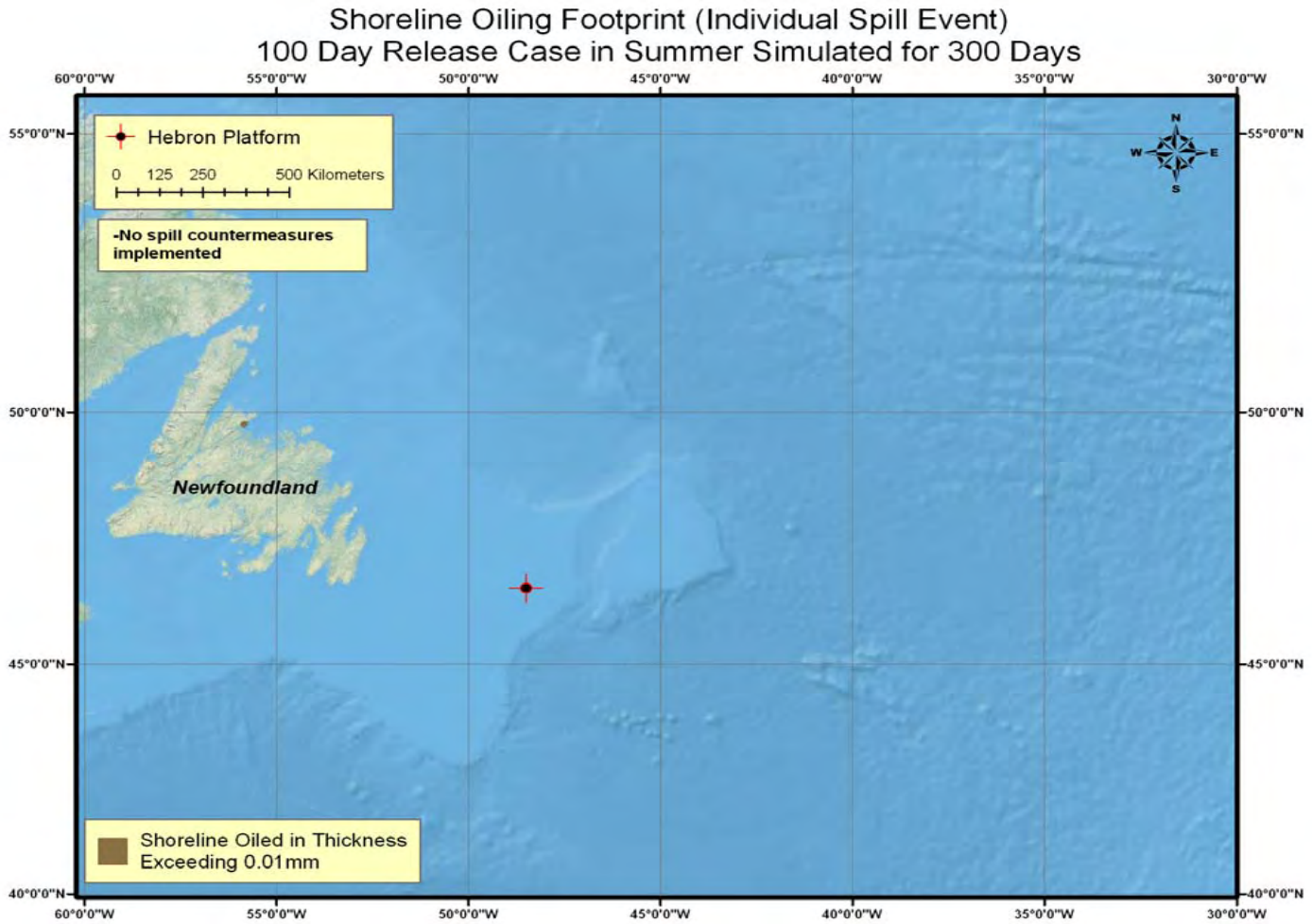


Figure 18. Location of shoreline oiling for the spill with the maximum shoreline length oiled for a 100-day platform blowout during the summer run for 300 days. 4.7 km of shoreline are predicted to be oiled with 81 bbl (12.9 m^3) of oil that has been on the sea surface for a minimum of 275 days.

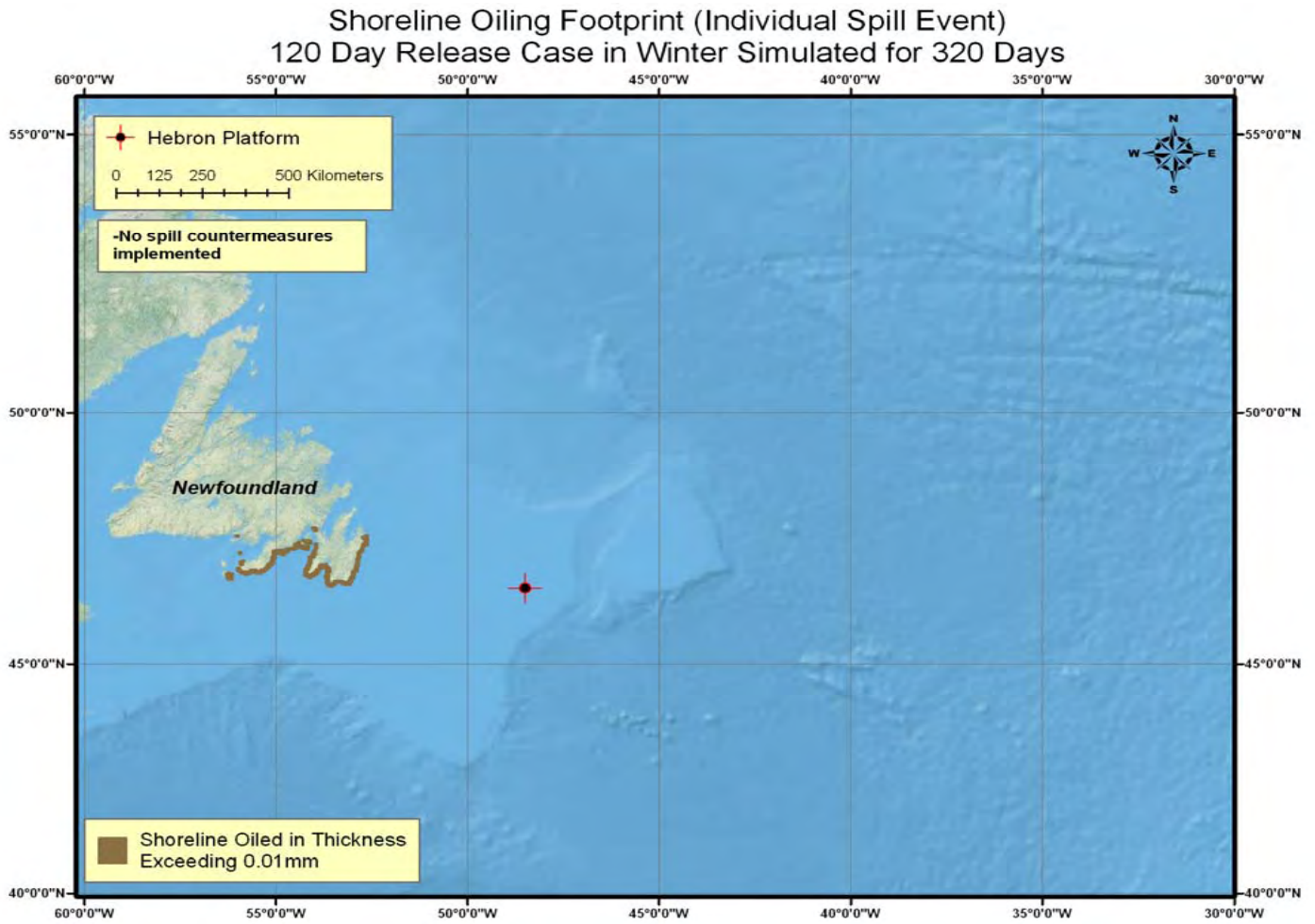


Figure 19. Location of shoreline oiling for the spill with the maximum shoreline length oiled for a 120-day platform blowout during the winter run for 320 days. 7,857 km of shoreline are predicted to be oiled with 27,745 bbl (4,411.1 m^3) of oil that has been on the sea surface for a minimum of 110 days.

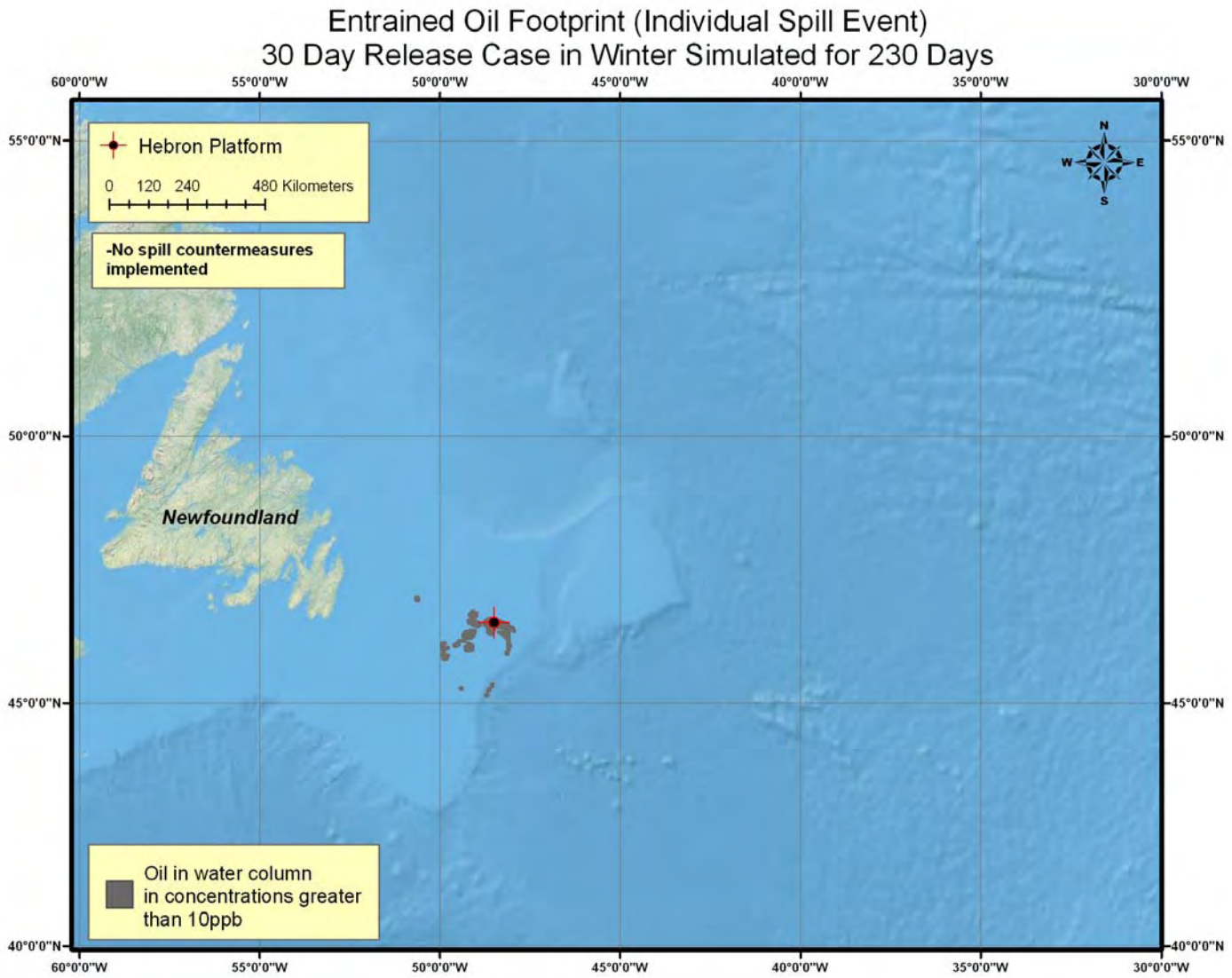


Figure 20. Area of entrained oil for the spill ranked as the 95th percentile for volume of oil entrained in the water column at the end a 230-day simulation of a 30-day platform blowout during the winter.

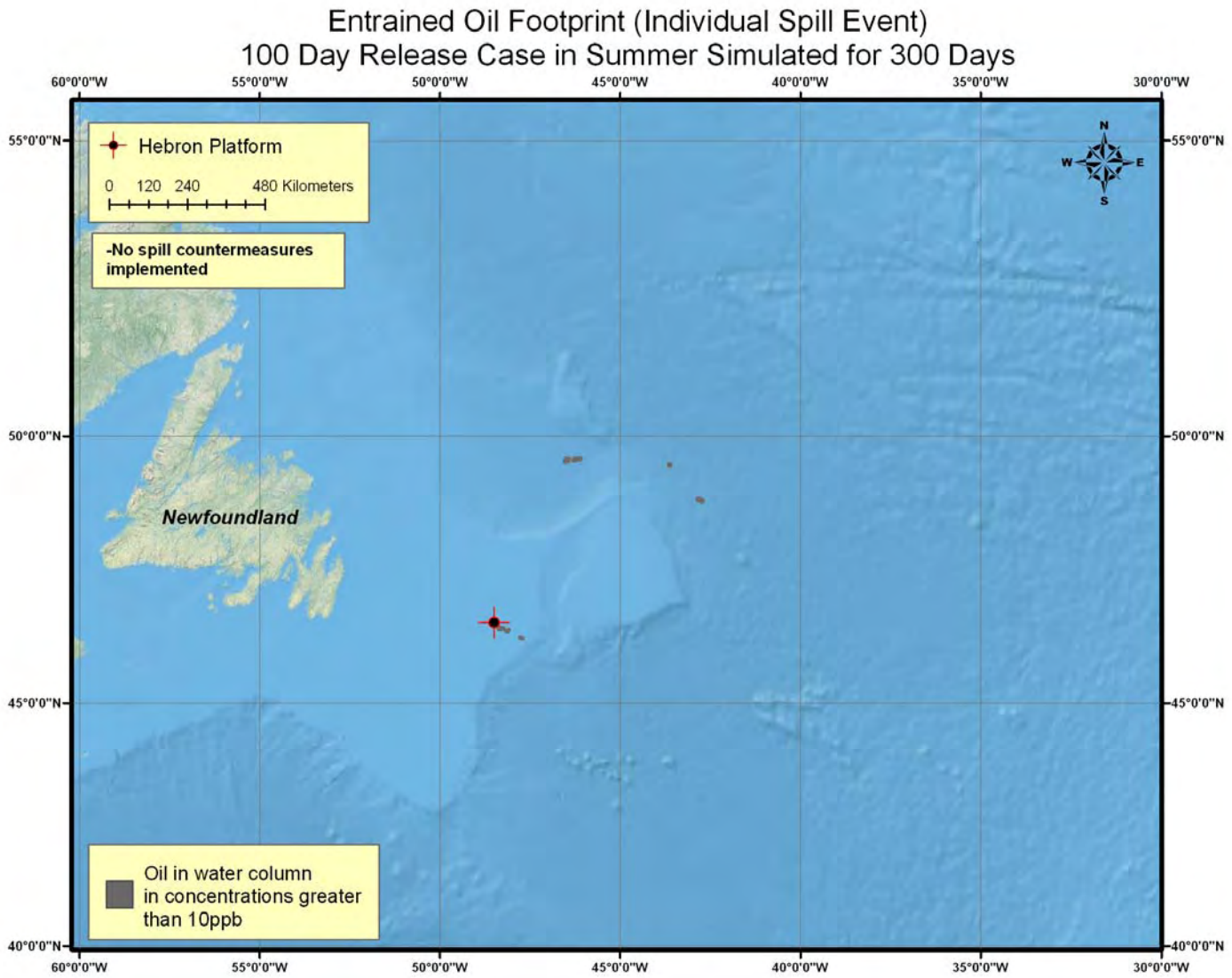


Figure 21. Area of entrained oil for the spill ranked as the 95th percentile for volume of oil entrained in the water column at the end a 300-day simulation of a 100-day platform blowout during the summer.

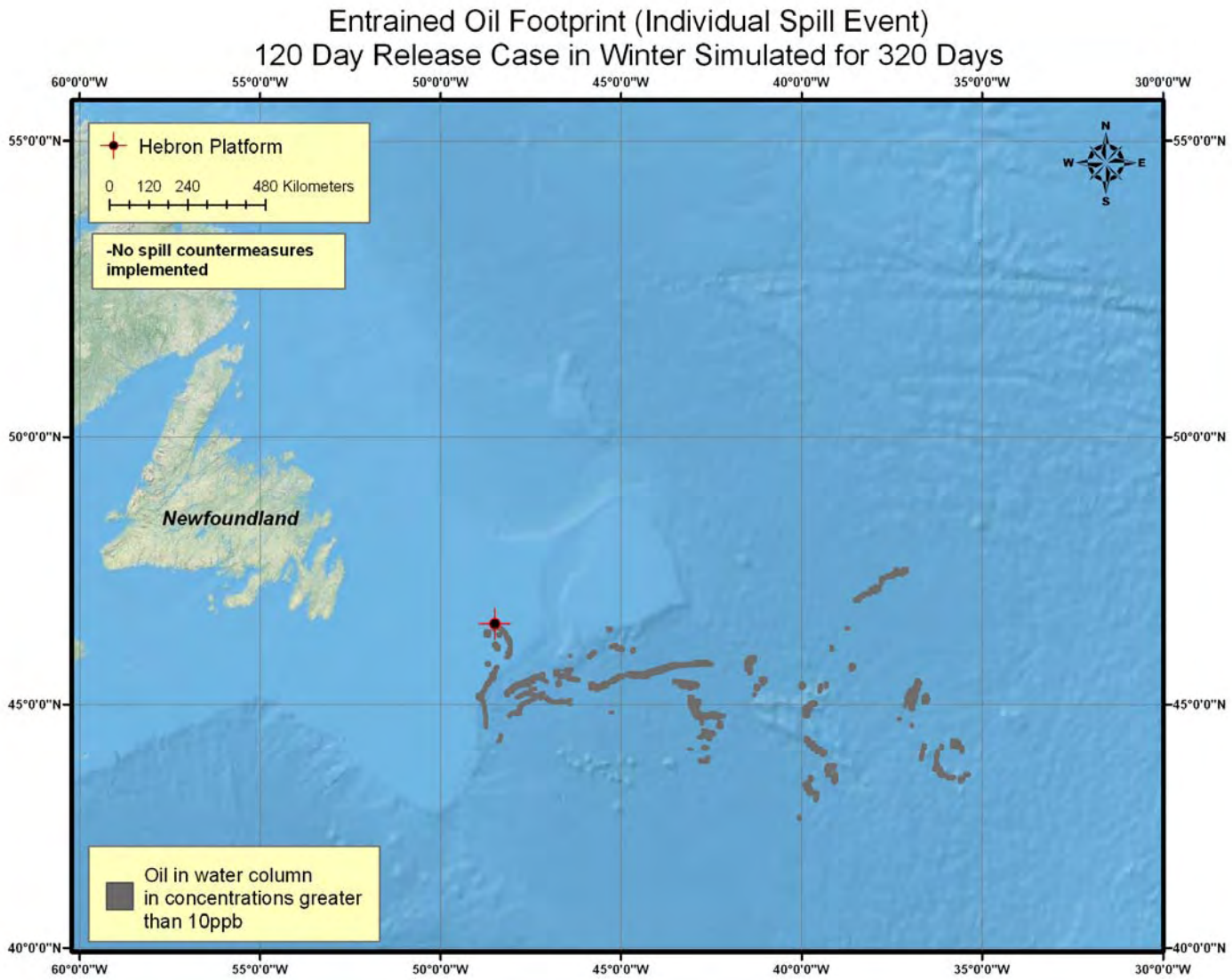


Figure 22. Area of entrained oil for the spill ranked as the 95th percentile for volume of oil entrained in the water column at the end a 320-day simulation of a 120-day platform blowout during the winter.