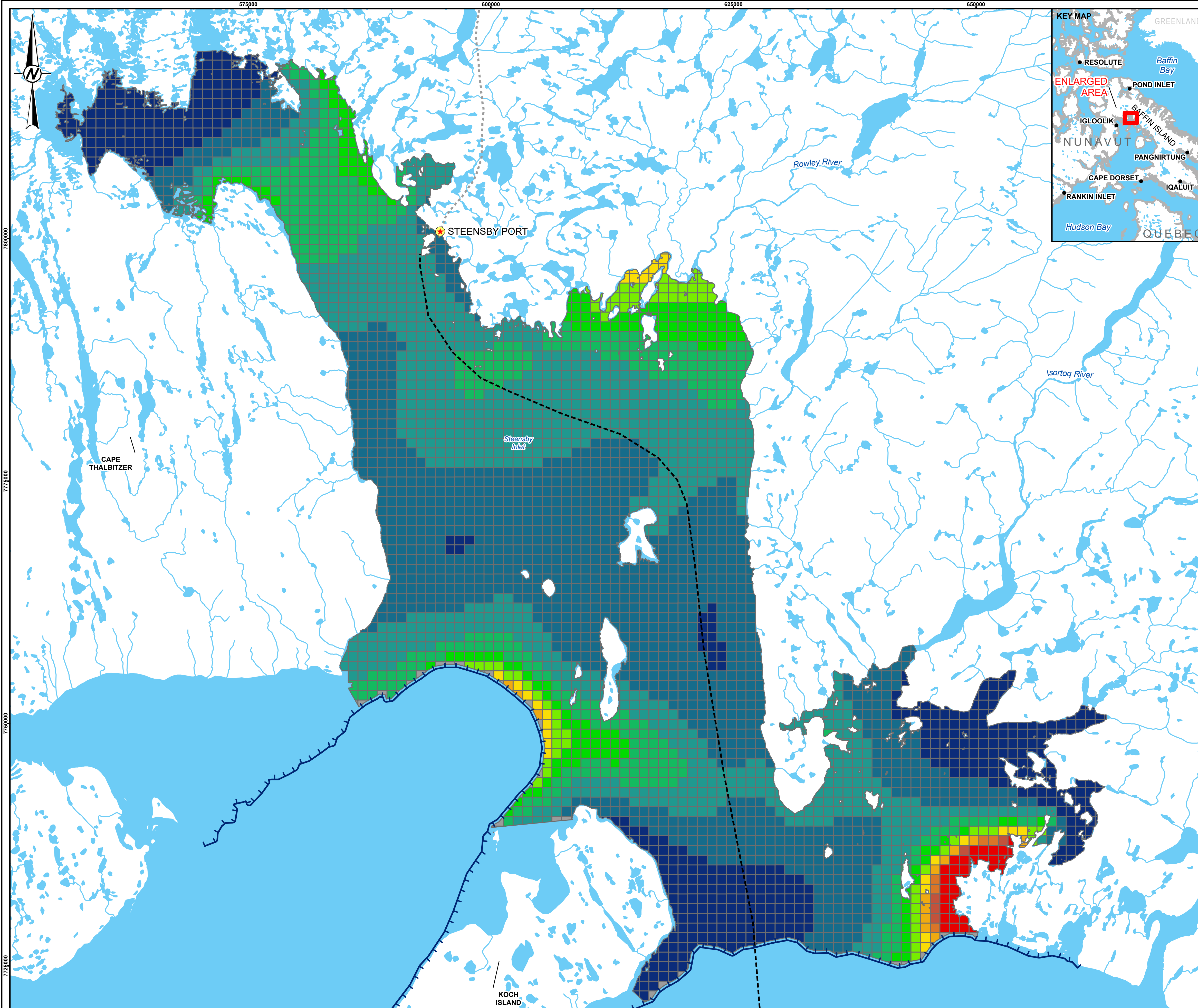

LEGEND

- PORT LOCATION
- 2021 FLOE EDGE
- PROPOSED RAILWAY
- SHIPPING ROUTE (APPROXIMATE)
- WATERCOURSE
- WATERBODY

PREDICTION DENSITY (km^2)

- 0.000000 - 0.400000
- 0.400001 - 0.800000
- 0.800001 - 1.200000
- 1.200001 - 1.600000
- 1.600001 - 2.000000
- 2.000001 - 2.400000
- 2.400001 - 2.800000
- 2.800001 - 3.200000
- 3.200001 - 3.600000
- 3.600001 - 4.000000
- 4.000001 - 8.000000
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CLIENT

BAFFINLAND IRON MINES CORPORATION

PROJECT

MARY RIVER PROJECT
2021 & 2024 RINGED SEAL AERIAL SURVEYS

TITLE

2021 RINGED SEAL PREDICTION DENSITY IN STEENSBY INLET

CONSULTANT

YYYY-MM-DD	2025-10-28
DESIGNED	TT
PREPARED	AA/JO
REVIEWED	MF
APPROVED	PA

PROJECT NO.	CONTROL	REV.	FIGURE
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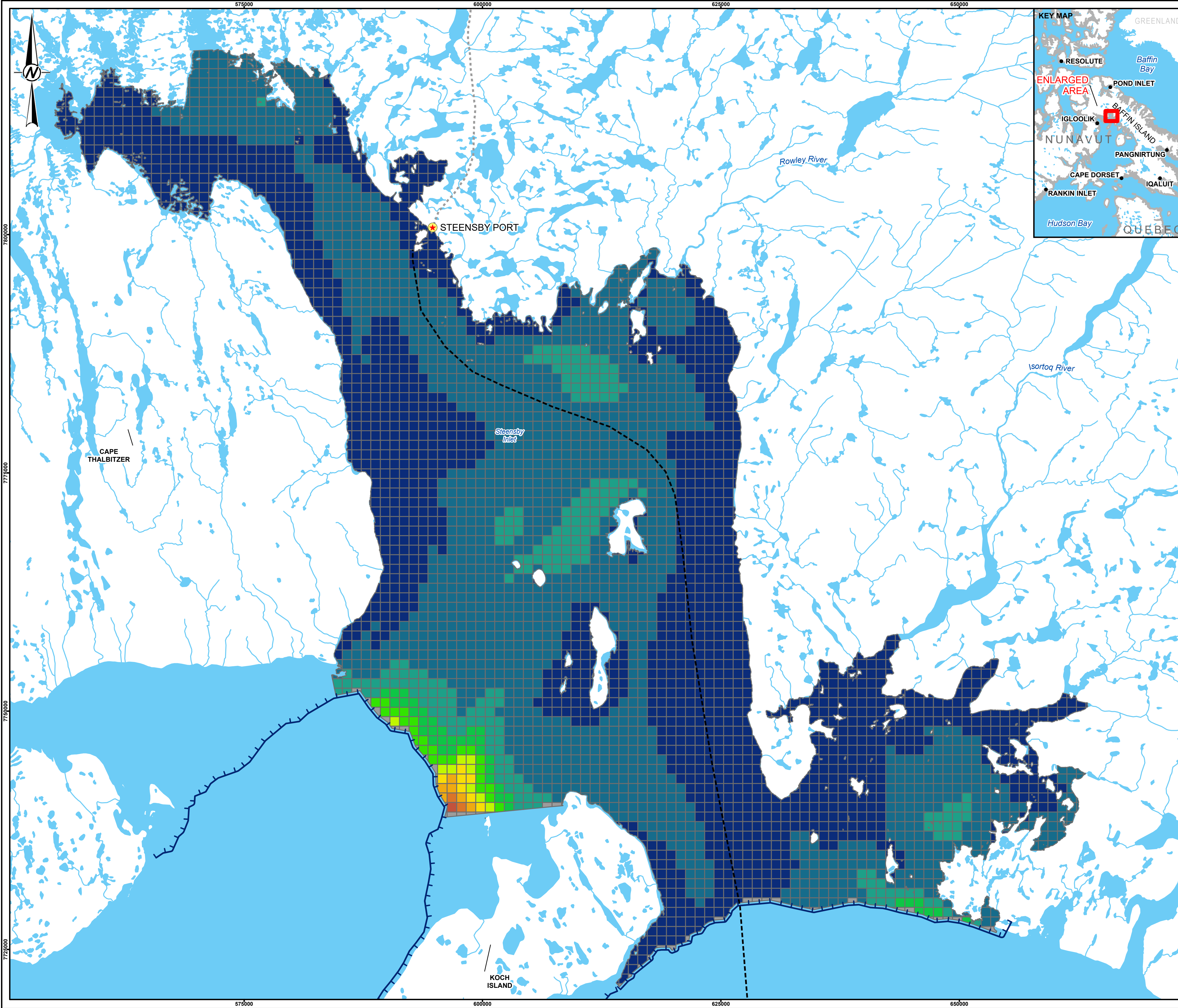

LEGEND

- PORT LOCATION
- 2024 FLOE EDGE
- PROPOSED RAILWAY
- SHIPPING ROUTE (APPROXIMATE)
- WATERCOURSE
- WATERBODY

PREDICTION DENSITY (km^2)

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- 0.400001 - 0.800000
- 0.800001 - 1.200000
- 1.200001 - 1.600000
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- 3.600001 - 4.000000
- INSUFFICIENT DATA

0 10 20

1:400,000 KILOMETRES

REFERENCE(S)

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CLIENT

BAFFINLAND IRON MINES CORPORATION

PROJECT

MARY RIVER PROJECT
2021 & 2024 RINGED SEAL AERIAL SURVEYS

TITLE

2024 RINGED SEAL PREDICTION DENSITY IN STEENSBY INLET

CONSULTANT

YYYY-MM-DD	2025-10-28
DESIGNED	TT
PREPARED	AA/JO
REVIEWED	MF
APPROVED	PA

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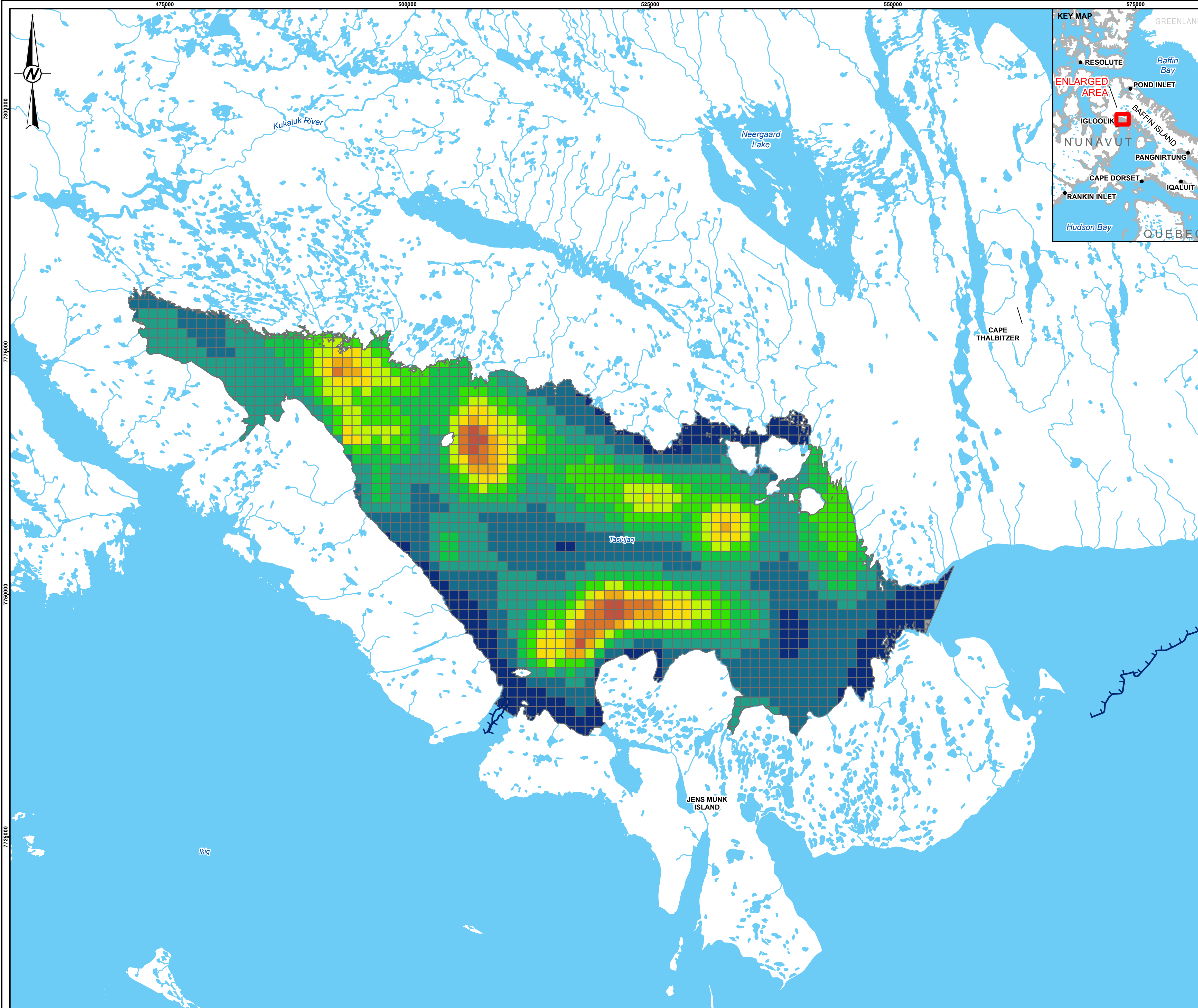

LEGEND

- 2021 FLOE EDGE
- WATERCOURSE
- WATERBODY

PREDICTION DENSITY (km^2)

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- 0.400001 - 0.800000
- 0.800001 - 1.200000
- 1.200001 - 1.600000
- 1.600001 - 2.000000
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- 3.600001 - 4.000000
- INSUFFICIENT DATA

0 10 20

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REFERENCE(S)

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CLIENT

BAFFINLAND IRON MINES CORPORATION

PROJECT

MARY RIVER PROJECT
2021 & 2024 RINGED SEAL AERIAL SURVEYS

TITLE

2021 RINGED SEAL PREDICTION DENSITY IN TASIUJAQ

CONSULTANT

wsp

YYYY-MM-DD	2025-10-28
DESIGNED	TT
PREPARED	AA/JO
REVIEWED	MF
APPROVED	PA

PROJECT NO.	CONTROL	REV.	FIGURE
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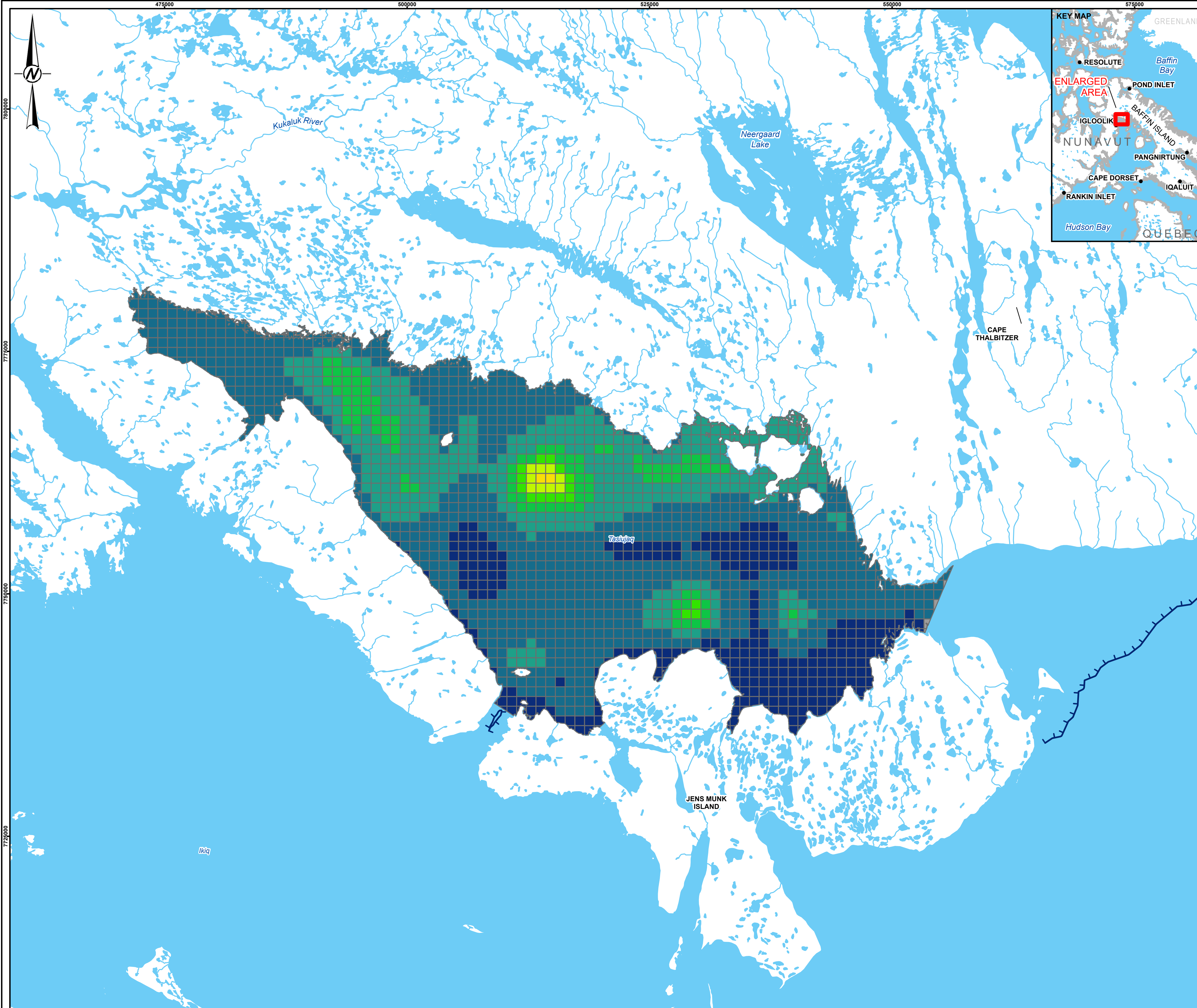

LEGEND

- 2024 FLOE EDGE
- WATERCOURSE
- WATERBODY

PREDICTION DENSITY (km^2)

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- 0.400001 - 0.800000
- 0.800001 - 1.200000
- 1.200001 - 1.600000
- 1.600001 - 2.000000
- 2.000001 - 2.400000
- 2.400001 - 2.800000
- INSUFFICIENT DATA

0 10 20
1:400,000 KILOMETRES

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CLIENT
BAFFINLAND IRON MINES CORPORATION

PROJECT
MARY RIVER PROJECT
2021 & 2024 RINGED SEAL AERIAL SURVEYS

TITLE
2024 RINGED SEAL PREDICTION DENSITY IN TASIUJAQ

CONSULTANT
wsp

YYYY-MM-DD	2025-10-28
DESIGNED	TT
PREPARED	AA/JO
REVIEWED	MF
APPROVED	PA

PROJECT NO.	CONTROL	REV.	FIGURE
CA0051512.6683		0	19

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B
25mm

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3.8 Ringed Seal Hotspots

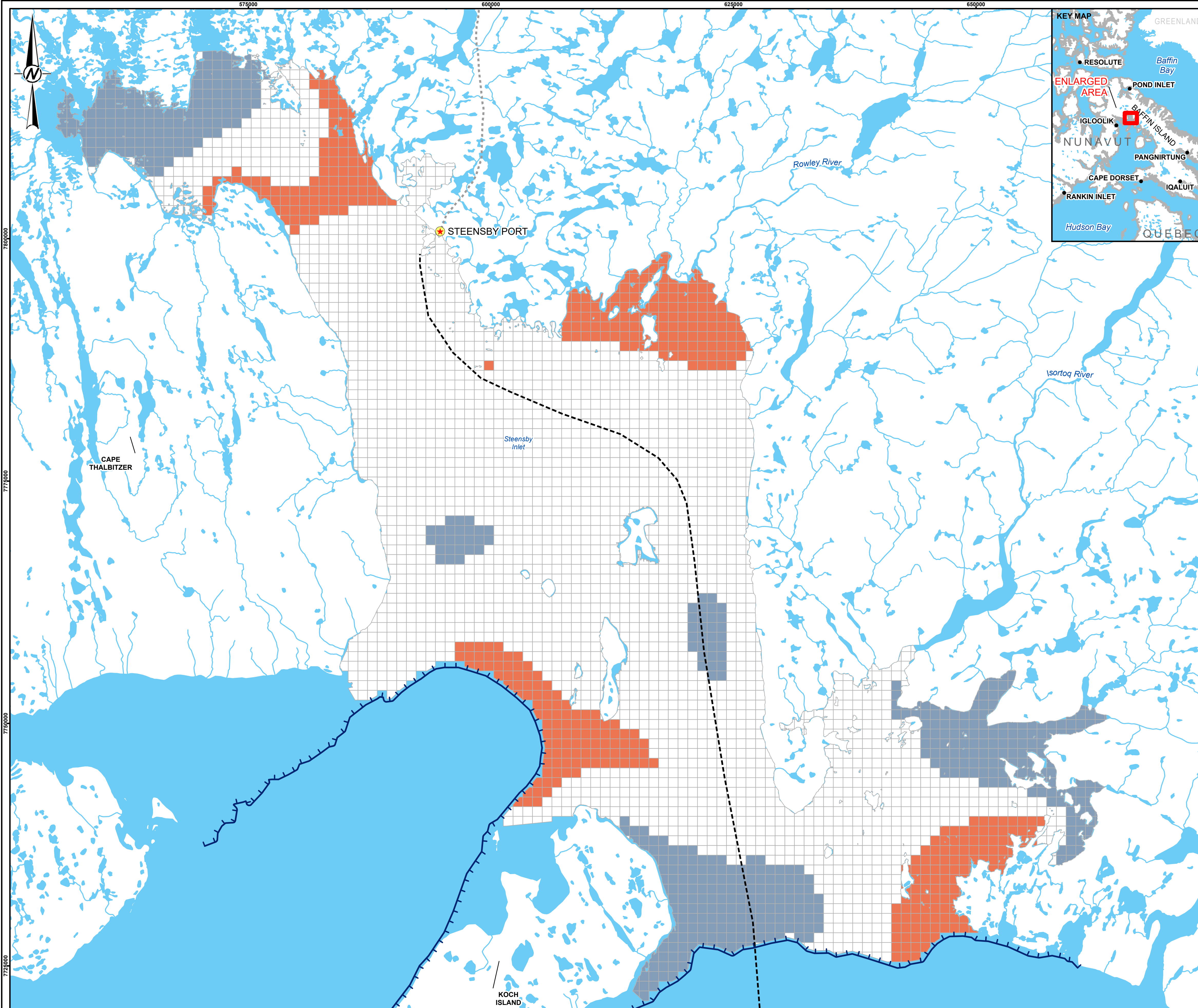
The present analysis for ringed seal hotspots highlights temporal changes in hotspot distribution, size, and coverage between the two strata. Table 5 compares spatial trends in Steensby Inlet and Tasiujaq strata for 2021 and 2024.

In Steensby Inlet, the number of hotspots increased from five in 2021 to six in 2024, with a corresponding increase in average hotspot size (84.8 km² to 87.1 km²) and total hotspot area (424.1 km² to 522.6 km²), covering a larger portion of the study area (13.3% to 15.8%). The maximum hotspot size also increased from 122.6 km² to 232.1 km², while the minimum hotspot size increased slightly from 1.0 km² to 2.0 km². In each survey year, two hotspots were consistently present: one along the southwestern floe edge and another along the eastern edge of the southeastern floe edge (Figures 20 and 21). However, the remaining hotspot locations in Steensby Inlet differed between the two survey years (see Figures 20 and 21). The spatial overlap of hotspots between survey years was 51.6 km^2, representing 12.2% and 9.9% of the total hotspot areas in 2021 and 2024, respectively.

Conversely, in Tasiujaq, the number of hotspots declined from five in 2021 to four in 2024. Despite the reduction in total hotspot area (385.0 km² to 370.7 km²) and percentage of study area covered (24.5% to 23.6%), the average hotspot size increased (77.0 km² to 92.7 km²), and the range of hotspot sizes became broader, with the minimum hotspot size decreasing from 18.2 km² to 5.0 km² and the maximum hotspot size increasing from 109.1 km² to 203.7 km². In each year, hotspots were located mainly in the central region of the strata, with 151.0 km² of hotspots overlapping between survey years, representing 39.2% and 40.7% of the total hotspot areas in 2021 and 2024, respectively. The eastern, western and southern edges of the strata showed consistently lower densities of ringed seals (Figures 22 and 23).

Table 5: Summary of hotspot locations derived from spatial (G_i* lag 1) analysis.

Year	Strata	Number of Hotspots (n)	Minimum Hotspot Size (km^2)	Maximum Hotspot Size (km^2)	Average Hotspot Size (km^2)	Total Hotspot Area (km^2)	% of Strata covered in Hotspots
2021	Steensby	5	1.0	122.6	84.8	424.1	13.3
2024	Steensby	6	2.0	232.1	87.1	522.6	15.8
2021	Tasiujaq	5	18.2	109.1	77.0	385.0	24.5
2024	Tasiujaq	4	5.0	203.7	92.7	370.7	23.6



LEGEND

- PORT LOCATION
- 2021 FLOE EDGE
- PROPOSED RAILWAY
- SHIPPING ROUTE (APPROXIMATE)
- WATERCOURSE
- WATERBODY

HOTSPOT ANALYSIS (GETIS-ORD GI*) RESULTS

- HOTSPOT WITH 95% CONFIDENCE
- NOT SIGNIFICANT
- COLDSPOT WITH 95% CONFIDENCE

0 10 20
1:400,000 KILOMETRES

REFERENCE(S)
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CLIENT
BAFFINLAND IRON MINES CORPORATION

PROJECT
MARY RIVER PROJECT
2021 & 2024 RINGED SEAL AERIAL SURVEYS

TITLE
2021 RINGED SEAL PREDICTION DENSITY IN STEENSBY INLET, HOTSPOT ANALYSIS (GETIS-ORD GI*) RESULTS

CONSULTANT
wsp

YYYY-MM-DD	2025-10-29
DESIGNED	TT
PREPARED	AA/JO
REVIEWED	TT/MF
APPROVED	PA

PROJECT NO.	CONTROL	REV.	FIGURE
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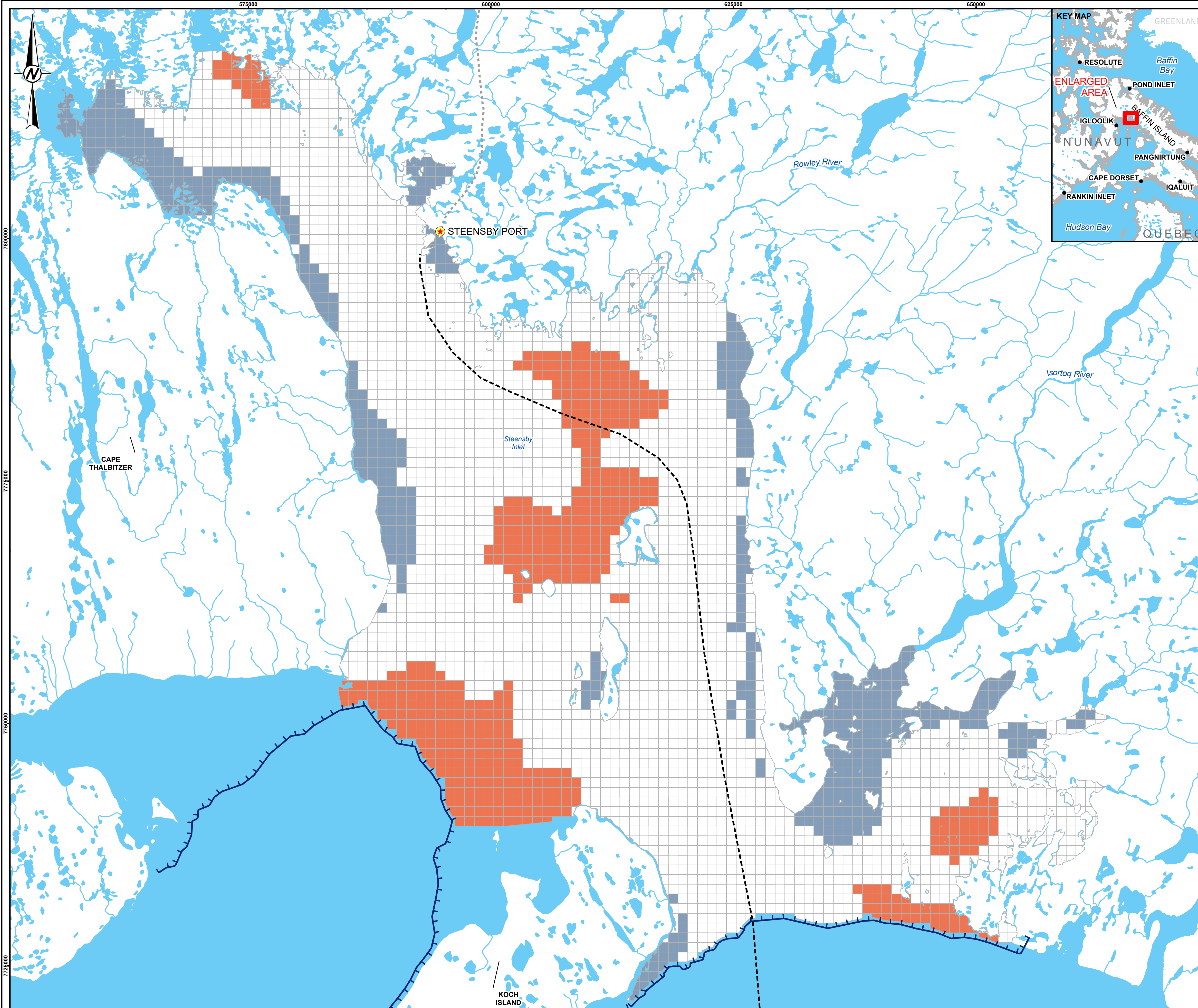

LEGEND

- PORT LOCATION
- 2024 FLOE EDGE
- PROPOSED RAILWAY
- SHIPPING ROUTE (APPROXIMATE)
- WATERCOURSE
- WATERBODY

HOTSPOT ANALYSIS (GETIS-ORD GI*) RESULTS

- HOTSPOT WITH 95% CONFIDENCE
- NOT SIGNIFICANT
- COLDSPOT WITH 95% CONFIDENCE

0 10 20
1:400,000 KILOMETRES

REFERENCE(S)
BASE DATA OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED. SHIPPING ROUTE PROVIDED BY CLIENT, JUNE 8, 2022. NUNAVUT SETTLEMENT BOUNDARY OBTAINED FROM NUNAVUT TUNNGAVIK INC., OCTOBER 9, 2012.
PROJECTED COORDINATE SYSTEM: NAD 1983 UTM ZONE 17N

CLIENT
BAFFINLAND IRON MINES CORPORATION

PROJECT
MARY RIVER PROJECT
2021 & 2024 RINGED SEAL AERIAL SURVEYS

TITLE
2024 RINGED SEAL PREDICTION DENSITY IN STEENSBY INLET, HOTSPOT ANALYSIS (GETIS-ORD GI*) RESULTS

CONSULTANT
wsp

YYYY-MM-DD	2025-10-29
DESIGNED	TT
PREPARED	AA/JO
REVIEWED	TT/MF
APPROVED	PA

PROJECT NO.	CONTROL	REV.	FIGURE
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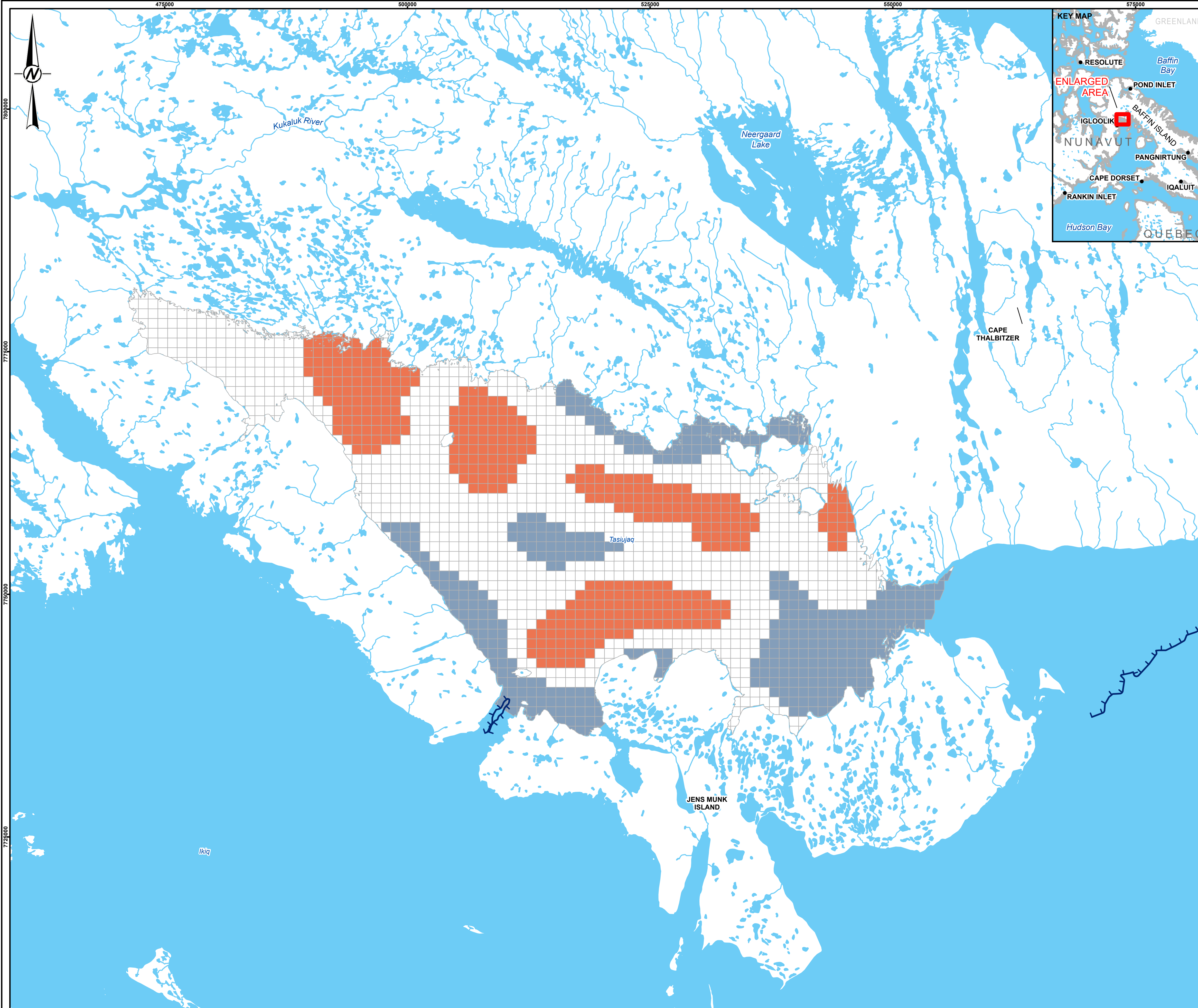

LEGEND

2021 FLOE EDGE

WATERCOURSE

WATERBODY

HOTSPOT ANALYSIS (GETIS-ORD GI*) RESULTS

HOTSPOT WITH 95% CONFIDENCE

NOT SIGNIFICANT

COLDSPOT WITH 95% CONFIDENCE

0 10 20

1:400,000 KILOMETRES

REFERENCE(S)

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CLIENT

BAFFINLAND IRON MINES CORPORATION

PROJECT

MARY RIVER PROJECT
2021 & 2024 RINGED SEAL AERIAL SURVEYS

TITLE

2021 RINGED SEAL PREDICTION DENSITY IN TASIUJAQ, HOTSPOT ANALYSIS (GETIS-ORD GI*) RESULTS

CONSULTANT

YYYY-MM-DD	2025-10-29
DESIGNED	TT
PREPARED	AA/JO
REVIEWED	TT/MF
APPROVED	PA

PROJECT NO.	CONTROL	REV.	FIGURE
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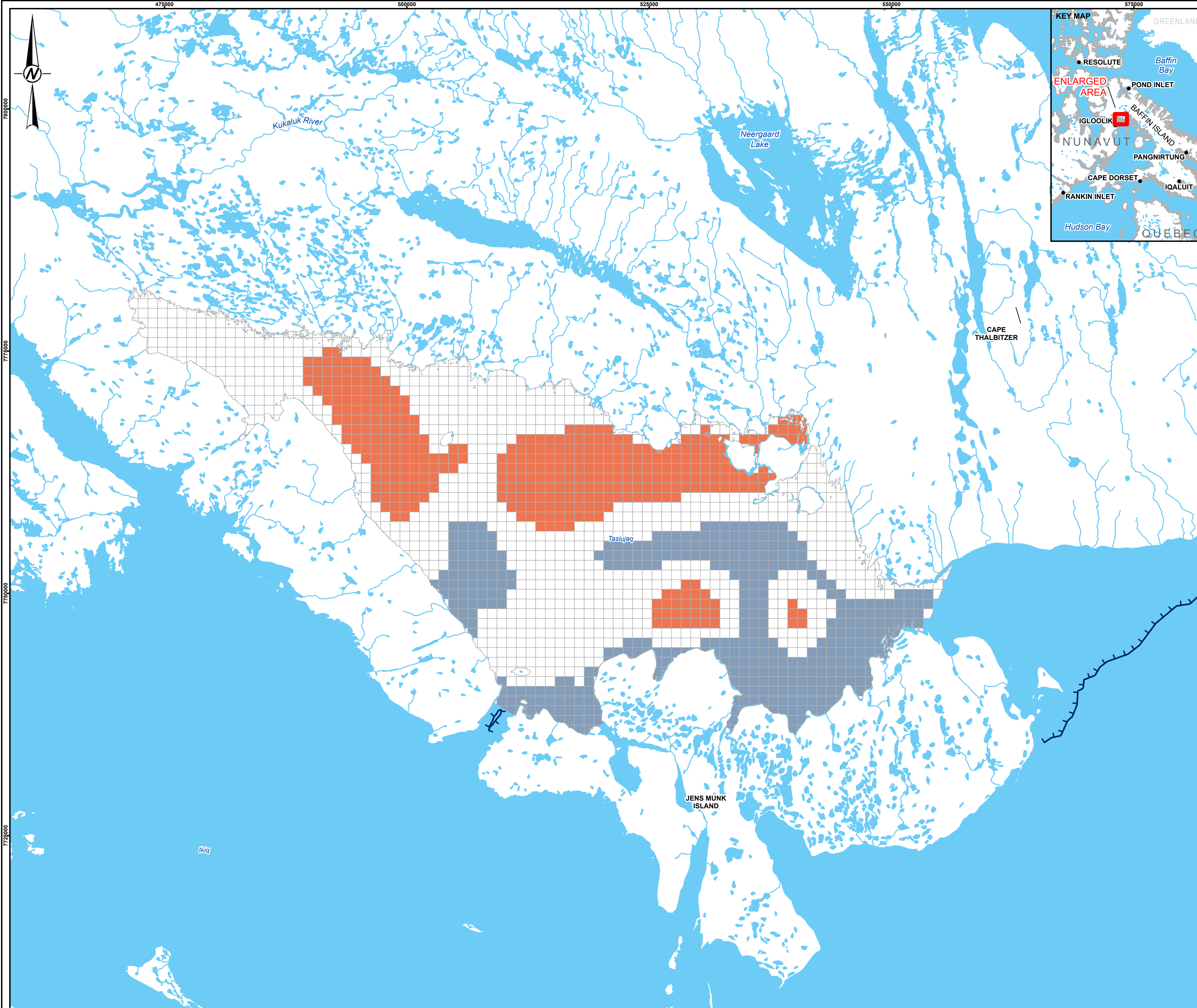

LEGEND

- 2024 FLOE EDGE
- WATERCOURSE
- WATERBODY

HOTSPOT ANALYSIS (GETIS-ORD GI*) RESULTS

- HOTSPOT WITH 95% CONFIDENCE
- NOT SIGNIFICANT
- COLDSPOT WITH 95% CONFIDENCE

0 10 20
1:400,000 KILOMETRES

REFERENCE(S)

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CLIENT
BAFFINLAND IRON MINES CORPORATION

PROJECT
MARY RIVER PROJECT
2021 & 2024 RINGED SEAL AERIAL SURVEYS

TITLE
2024 RINGED SEAL PREDICTION DENSITY IN TASIUJAQ, HOTSPOT ANALYSIS (GETIS-ORD GI*) RESULTS

CONSULTANT

YYYY-MM-DD	2025-10-29
DESIGNED	TT
PREPARED	AA/JO
REVIEWED	TT/MF
APPROVED	PA

PROJECT NO.	CONTROL	REV.	FIGURE
CA0051512.6683		0	23

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

4.0 DISCUSSION

4.1 Ringed Seal Densities

Ringed seal density estimates obtained through aerial surveys are subject to errors from availability bias. Availability bias refers to the unknown proportion of seals under the ice, where observers/cameras are unable to detect animals. The result is a negative bias in density estimation. A small proportion of hauled-out seals will dive in response to aircraft noise before the observers or camera have a chance to detect them, and this proportion may vary with environmental factors such as wind (Born et al. 1999). The proportion of seals hauled out has also been found to vary according to weather conditions, ice conditions, time of day, age class, and location (Smith and Hammill 1981; Born et al. 2002; Moulton et al. 2002; Frost et al. 2004; Carlens et al. 2006; Krafft et al. 2006; Hamilton et al. 2018; Young et al. 2015), although the variables are not consistent among studies. For example, Carlens et al. (2006) found wind to significantly affect the number of ringed seals hauled out, whereas Moulton et al. (2002), Frost et al. (2004), and Young et al. (2015) did not find a correlation between wind and the proportion of seals hauled out. The current study also highlights the complex interplay of environmental variables influencing ringed seal densities (see Section 3.6). The lack of consistent patterns across years and variables suggests that ringed seals may respond to a suite of factors rather than any single environmental cue. It is also possible that unmeasured variables contributed to the observed variation. While availability bias can impact the accuracy of absolute density estimates for ringed seals, it is important to note that when the purpose of a study is to compare potential changes in densities between shipping and control locations. Accounting for this bias is not necessary to achieve this goal. This is because the availability bias—stemming from the proportion of seals not visible during surveys—will affect both areas equally, provided survey methods and environmental conditions are consistent across sites. Therefore, relative comparisons remain valid even if the estimated densities are underestimated. If the same methodology is applied to both the shipping and control locations and environmental conditions are consistent across sites, differences in seal density should accurately reflect spatial variation.

Density indices from the 2021 and 2024 RSASP show pronounced yearly fluctuations in Steensby Inlet, with a density of 0.944 seal/km^2 in 2021 compared to 0.503 seal/km^2 in 2024. Baseline data collected in 2006, 2007 and 2008 also showed yearly fluctuations with a density of 0.20 seals/km^2 in 2006, 1.57 seals/km^2 in 2007 and 0.71 seal/km^2 in 2008 (Baffinland 2012). Year-to-year variability in ringed seal densiity has also been observed in western Hudson Bay. Young et al. (2015) documented a long-term decline in ringed seal densities from 1995 to 2013, with interannual fluctuations superimposed on the trend (Figure 24). Chambellant et al. (2012b) found evidence for decadal patterns in ringed seal density in western Hudson Bay. Young et al. (2015) found that recent survey results have continued to follow an 11-year period sine function similar to the one presented in Chambellant et al. (2012b), with the exception of 2013 which was found to be related to an episodic event (anomalous 2010 spring breakup), which were associated with poor body condition and reduced reproduction.

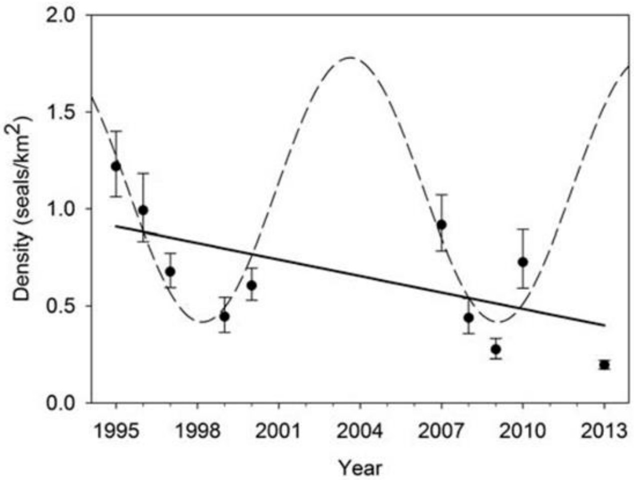

Figure 24: Density estimates of ringed seals in western Hudson Bay, estimated from aerial surveys flown between 1995 and 2013. Solid line represents linear regression of density as a function of year. Dashed line represents a sine function with an 11-year period (figure from Young et al. 2015).

Although true density estimates could not be derived (i.e., as dive data for ringed seals in Foxe Basin during June is not available), the indices reported in this study offer a comparative measure between Tasiujaq (future control site) and Steensby Inlet (future treatment site) within a specific time frame (i.e., survey year). Young et al. (2015) similarly utilized ringed seal density indices collected from Western Hudson Bay to monitor trends in ringed seal populations between 1995 and 2013. The density indices gathered in this study serve as a valuable tool to understand the natural variation in ringed seal density within the Steensby study area and reflect the baseline condition for assessing potential responses of ringed seals to future shipping activities in Steensby Inlet.

4.2 Ringed Seal Hotspots

Hamilton et al. (2022) analyzed satellite tracking data from 13 Arctic marine mammal species, including 263 ringed seals tagged from 2006–2019, to identify hotspots across the Arctic. Ringed seal hotspots were found in both coastal and offshore shelf habitats, with winter hotspots generally farther south than those in summer or fall. The authors noted, however, that ringed seal tracking data were limited. In relation to the Southern Shipping Route Study Area, Hamilton et al. (2022) identified hotspots in Tasiujaq and in Fury and Hecla Strait during the summer period. This supports the higher densities observed in Tasiujaq for the current study.

Geographic areas showing consistent hotspots of intense use by ringed seals may indicate areas of persistent concentrations of productivity that attract elevated numbers of ringed seals and result in spatial aggregations (Bouchet at al. 2015). This study illustrates an approach for detecting spatially explicit hotspots in ringed seal data for the areas of Steensby Inlet and Tasiujaq. Using surface density models, ringed seal hotspots were identified in Steensby Inlet and Tasiujaq in 2021 and 2024 (see Figures 20 to 23). The amount of spatial overlap of ringed seal hotspots in Steensby Inlet and Tasiujaq between 2021 and 2024 was generally lower in Steensby Inlet, with the locations of ringed seal hotspots varying geographically annually in both survey areas. These findings suggest that the spatial distribution and extent of hotspots can fluctuate between years, potentially reflecting changes in underlying environmental conditions, food availability, territorial pressure from other ringed seals, or other unknown variables. These patterns we can be used to identify trends and inform future monitoring and mitigations of potential shipping impacts.

Hotspots identified in the current study reflect conditions observed during early June when ringed seals are in their peak basking/moulting phase. These hotspots are potentially representative of ringed seal density during their winter breeding season (corresponding with stable landfast ice conditions) up to the start of the break-up period in late June, which would capture key life cycle periods for ringed seal including denning, pupping, nursing, and molting activities (McLaren 1958; Smith 1987). By July, ringed seals have begun to transition into their summer foraging phase where they are considerably more transitory during the open-water period.

5.0 SUMMARY

Results of the 2021 and 2024 RSASP demonstrate inter-annual changes in ringed seal density in Northern Foxe Basin. In Steensby Inlet, ringed seal density decreased from 0.9 seals/km² in 2021 to 0.5 seals/km² in 2024. In Tasiujaq, ringed seal density decreased from 1.2 seals/km² in 2021 to 0.7 seals/km² in 2024. Available historical data for the region suggests that this level of inter-annual variability is not uncommon nor unique to these locations (Baffinland 2012; Young et al. 2015). As a result, looking exclusively at year-to-year comparisons of animal density in the region may not be suitable for evaluating shipping-related effects on ringed seal. Integrating a suitable control site (i.e., Tasiujaq) into the study design allows for an effective before-after/control-impact (BACI) assessment of potential shipping effects on ringed seal despite high data variability between survey years. The present report establishes baseline conditions for ringed seals in Northern Foxe Basin, including evidence that ringed seal density in Steensby Inlet is, on average, approximately 20–30% lower than that in the control site at Tasiujaq. This information provides a basis for monitoring potential regional changes in ringed seal relative abundance in relation to Baffinland's future shipping activities.

Using surface density models, the present study has also identified ringed seal hotspots in Northern Fox Basin, including shifts in hotspot distribution and hotspot size between survey years and survey strata. In Steensby Inlet, the spatial overlap of hotspots between survey years was 51.6 km^2, representing 12.2% and 9.9% of the total hotspot areas in 2021 and 2024, respectively. In Tasiujaq, the spatial overlap of hotspots between survey years was 151.0 km², representing 39.2% and 40.7% of the total hotspot areas in 2021 and 2024, respectively. These patterns suggest that the establishment of hotspots is somewhat dynamic and likely influenced by environmental factors at play in that given year.

Overall, the RSASP results indicate that ringed seal density in the Steensby Project area exhibits natural spatial and temporal variability that must be considered in any future study design aimed at evaluating potential shipping impacts on ringed seals. The present study reinforces the importance of establishing a long-term dataset for baseline conditions and site-specific data collection, where monitoring results should be appropriately integrated into a robust follow-up monitoring program (i.e., EEM study) and adaptive management plan with measurable effect indicators, tiered thresholds and associated management actions for implementation should impacts exceed predicted levels. Following the start of shipping activities along the Southern Shipping Route, continued monitoring is recommended in collaboration with ongoing monitoring initiatives led by the relevant regulatory agencies, in order to effectively monitor for potential shipping effects on the local ringed seal population, including potential cumulative effects, particularly under future climate scenarios that may alter sea ice regimes, habitat conditions and/or prey dynamics in the region.

6.0 CLOSURE

We trust that this report meets your immediate requirements. If you have any questions regarding the content of this report, please do not hesitate to contact the undersigned.

WSP Canada Inc.

Tannis Thomas, MSc
Marine Biologist

Mitch Firman, BSc
Wildlife Biologist

Patrick Abgrall, PhD
Principal, Marine Biologist

Phil Rouget, MSc, RPBio
Principal, Senior Biologist

TT/MF/PA/PR/lih

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7.0 REFERENCES

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APPENDIX A

Density Surface Modelling Diagnostics

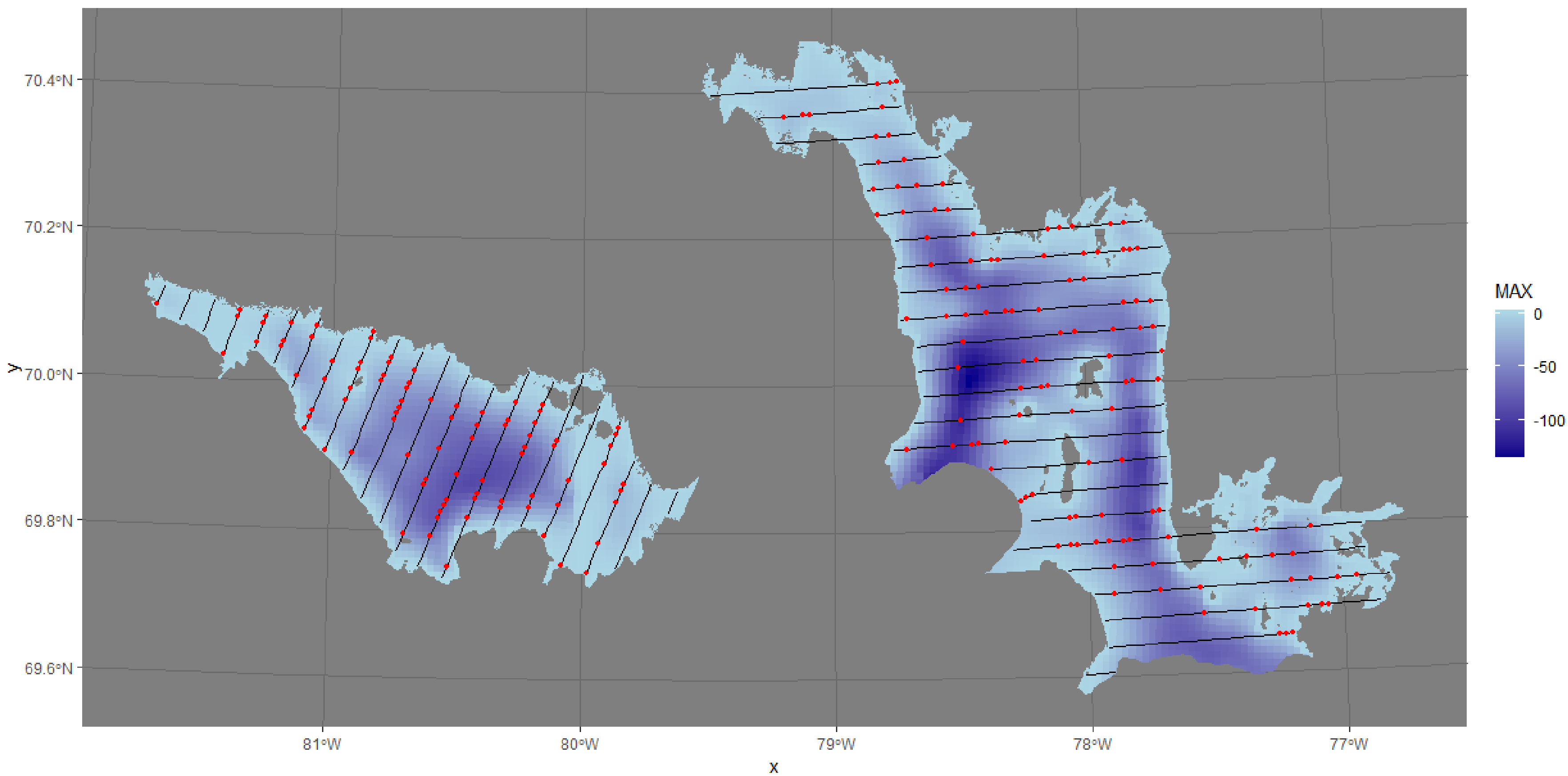

Figure A-1: Example of covariate "maximum depth", calculated for the 2021 study area. Black lines are transects and red circles are sightings of ringed seal.

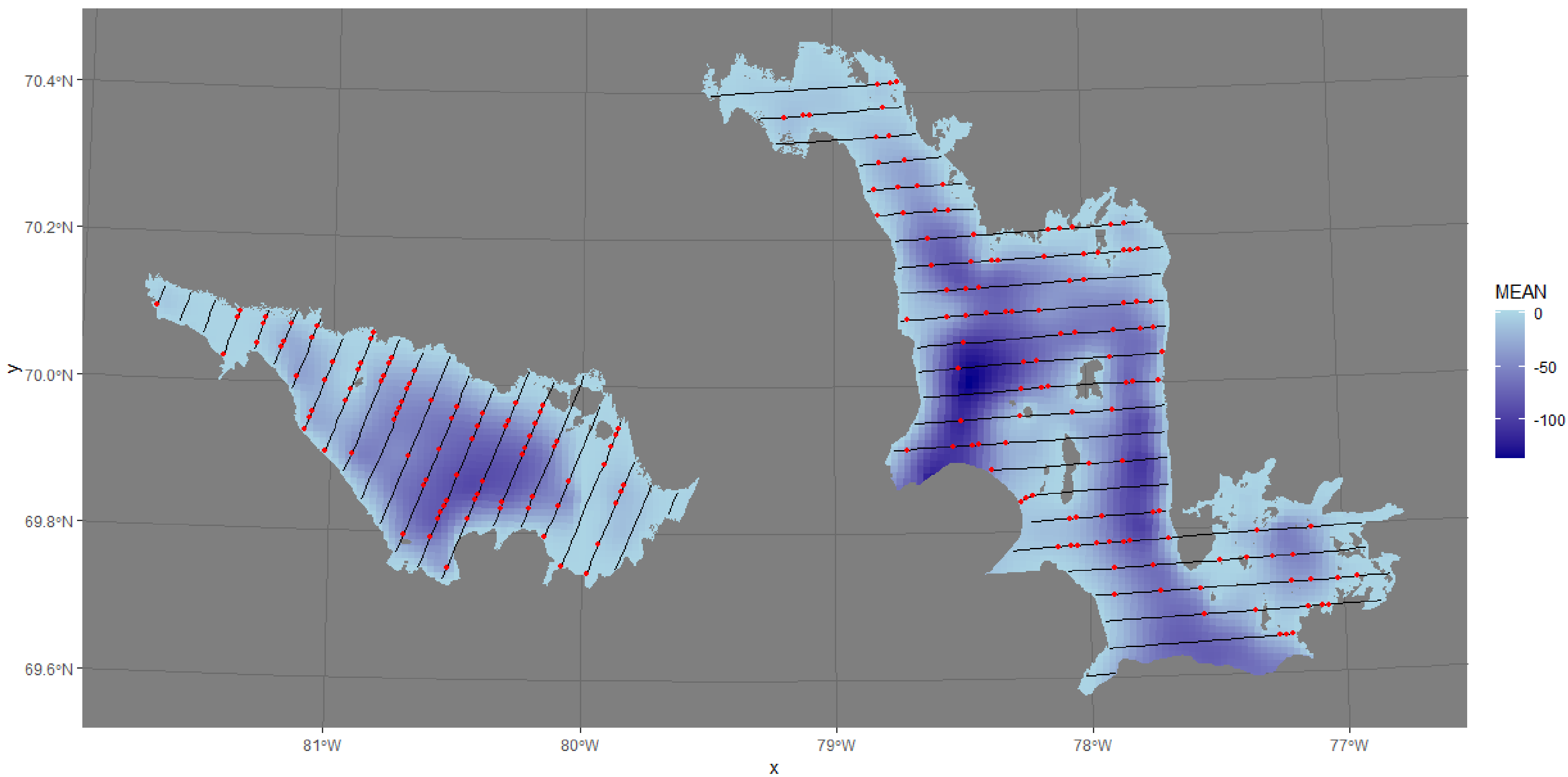

Figure A-2: Example of covariate "mean depth", calculated for the 2021 study area. Black lines are transects and red circles are sightings of ringed seal.

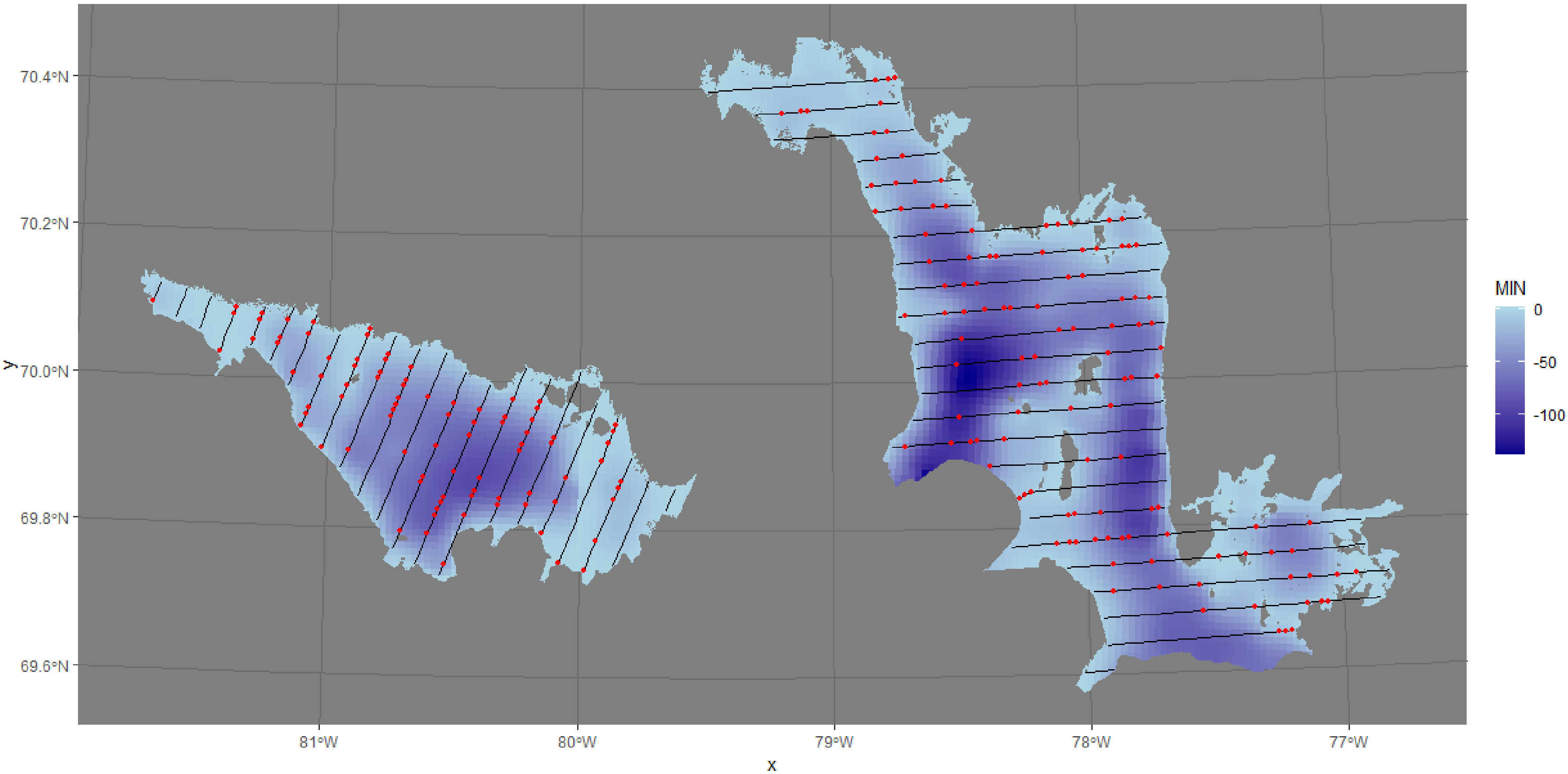

Figure A-3: Example of covariate "minimum depth", calculated for the 2021 study area. Black lines are transects and red circles are sightings of ringed seal.

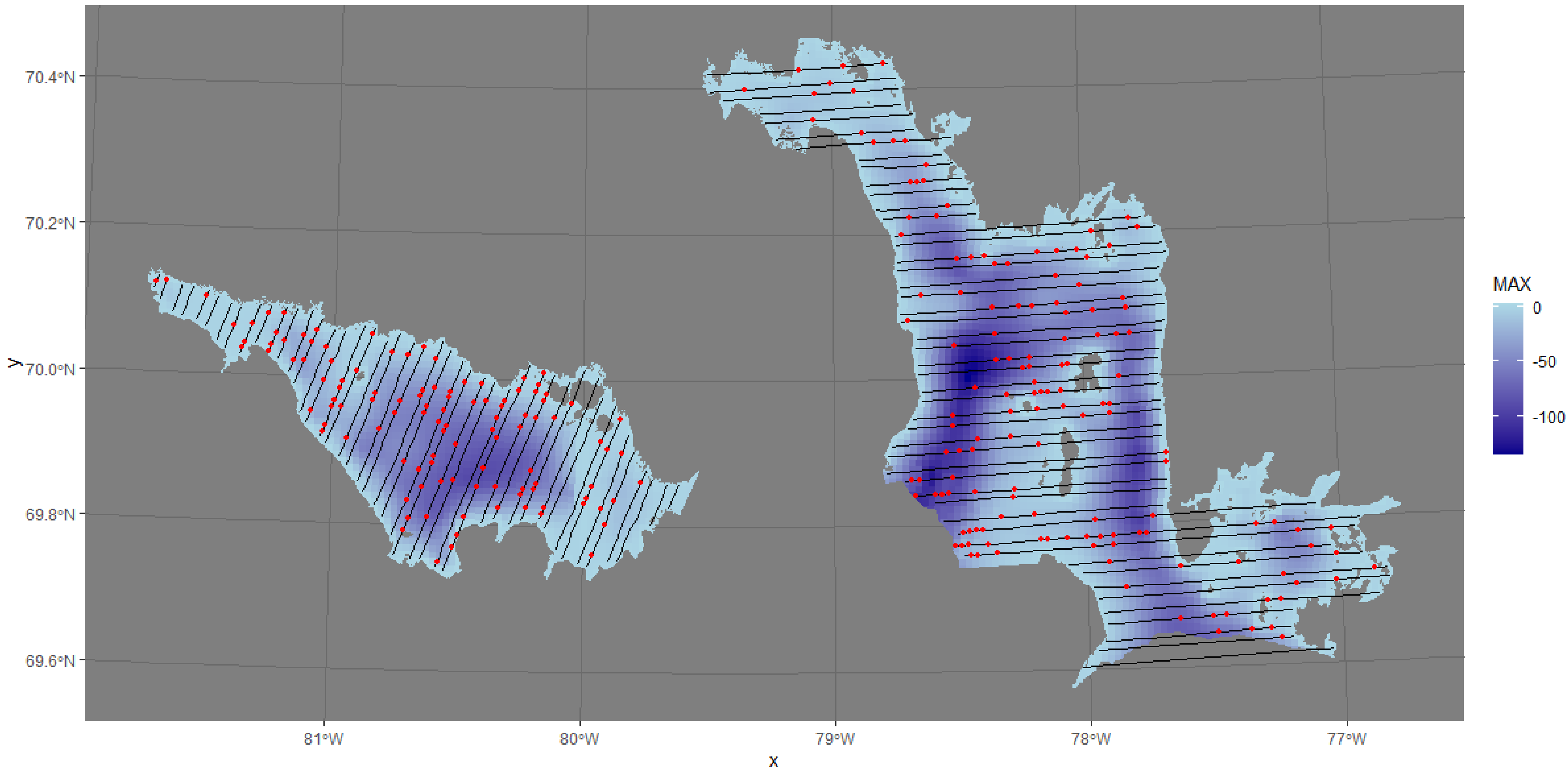

Figure A-4: Example of covariate “maximum depth”, calculated for the 2024 study area. Black lines are transects and red circles are sightings of ringed seal.

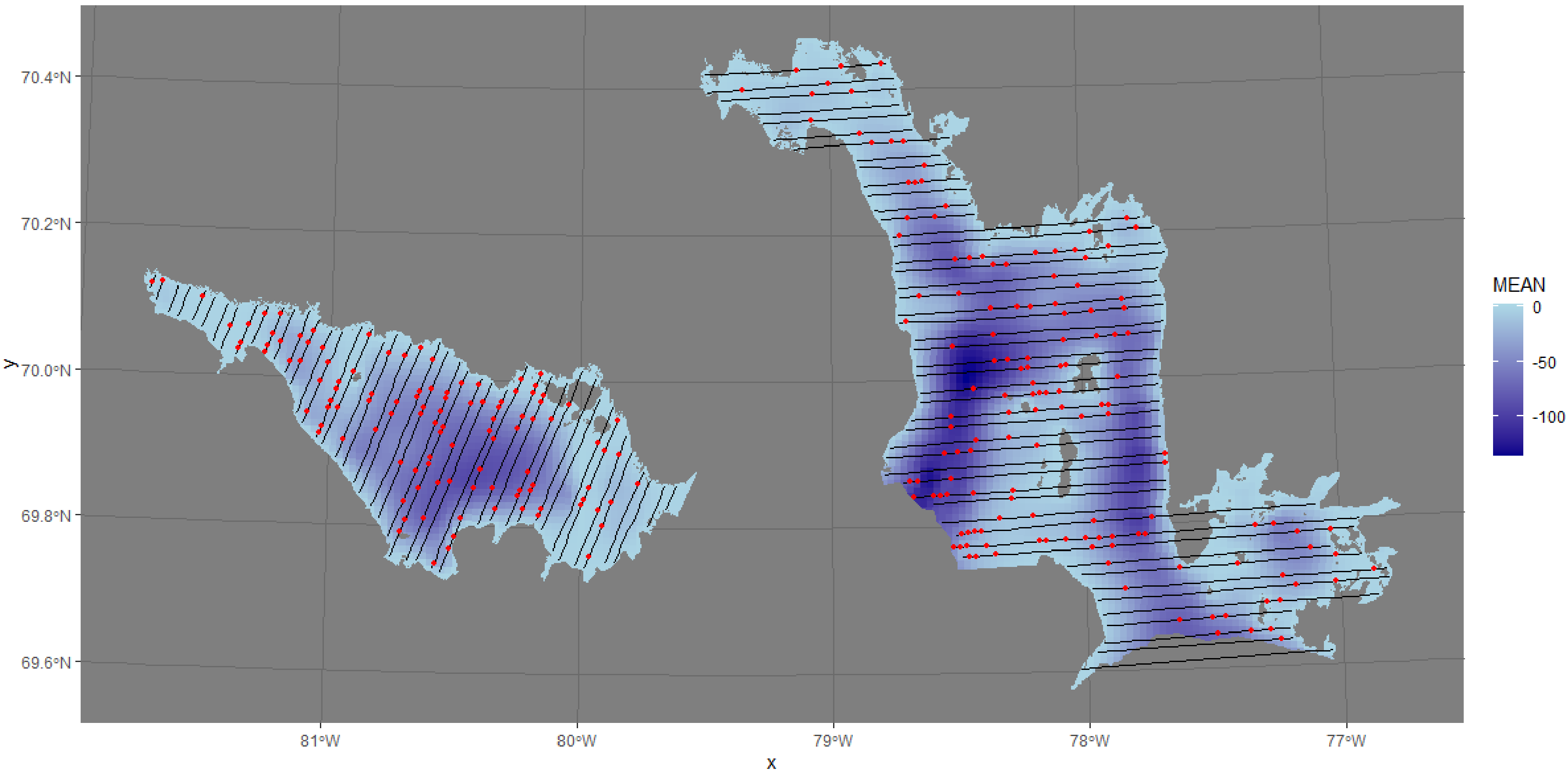

Figure A-5: Example of covariate "mean depth", calculated for the 2024 study area. Black lines are transects and red circles are sightings of ringed seal.

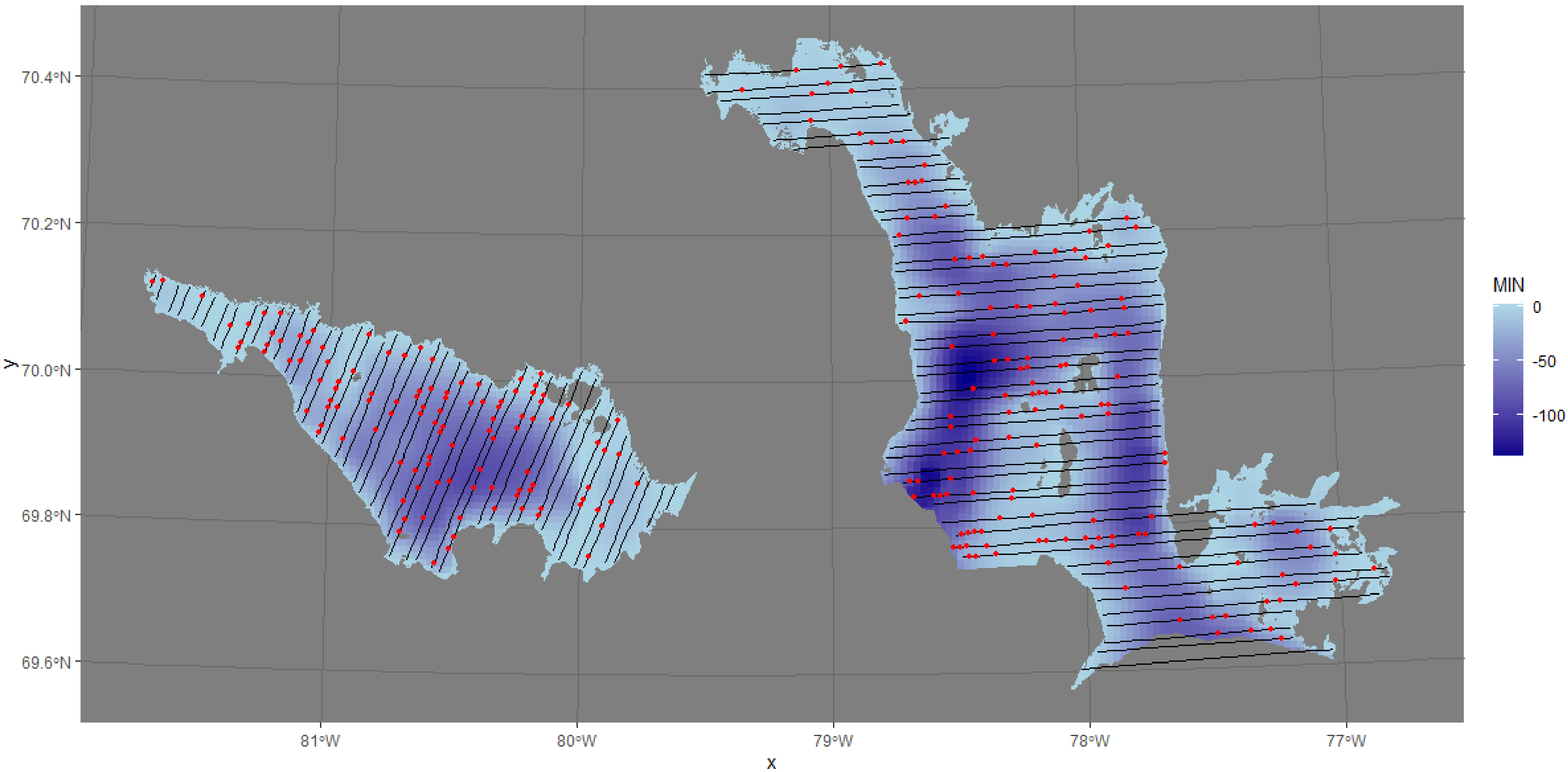

Figure A-6: Example of covariate "minimum depth", calculated for the 2024 study area. Black lines are transects and red circles are sightings of ringed seal.

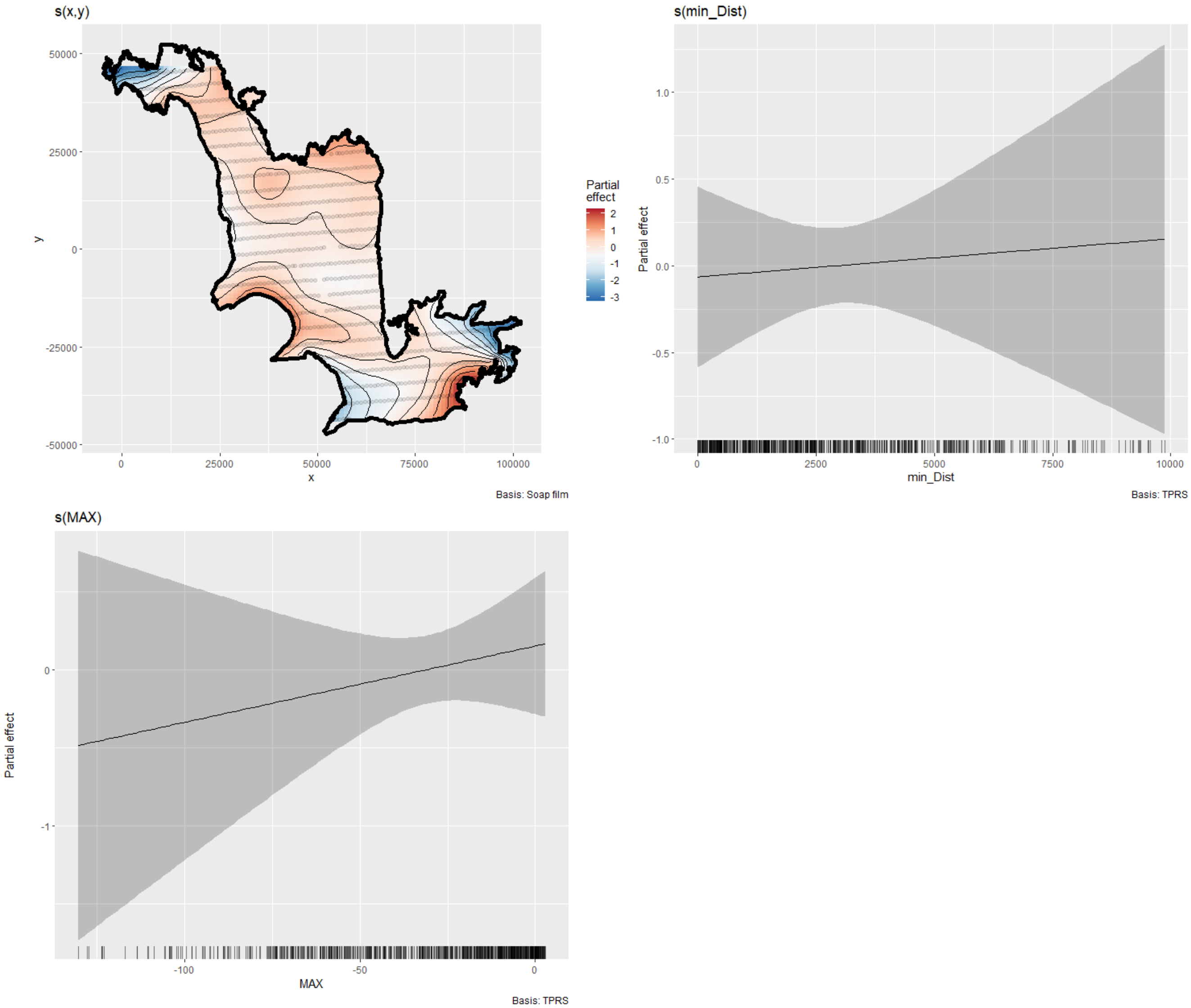

Figure A-7: Steensby 2021 GAM model spatial smoothers for: xy coordinate soap-film, minimum shore distance or floe edge distance, and maximum depth.

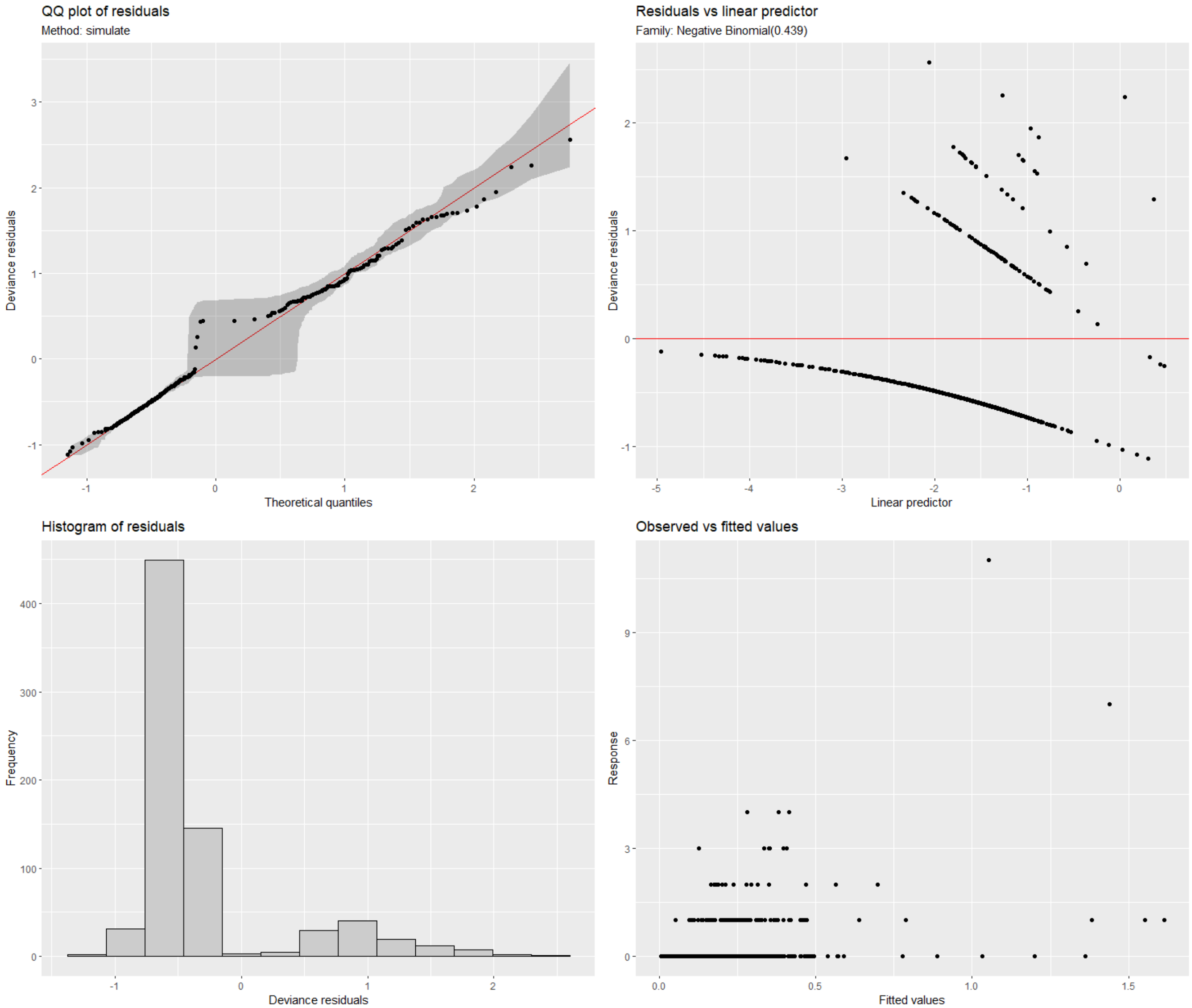

Figure A-8: Steensby 2021 Diagnostic plots for fitted GAM model using the Negative Binomial distribution.

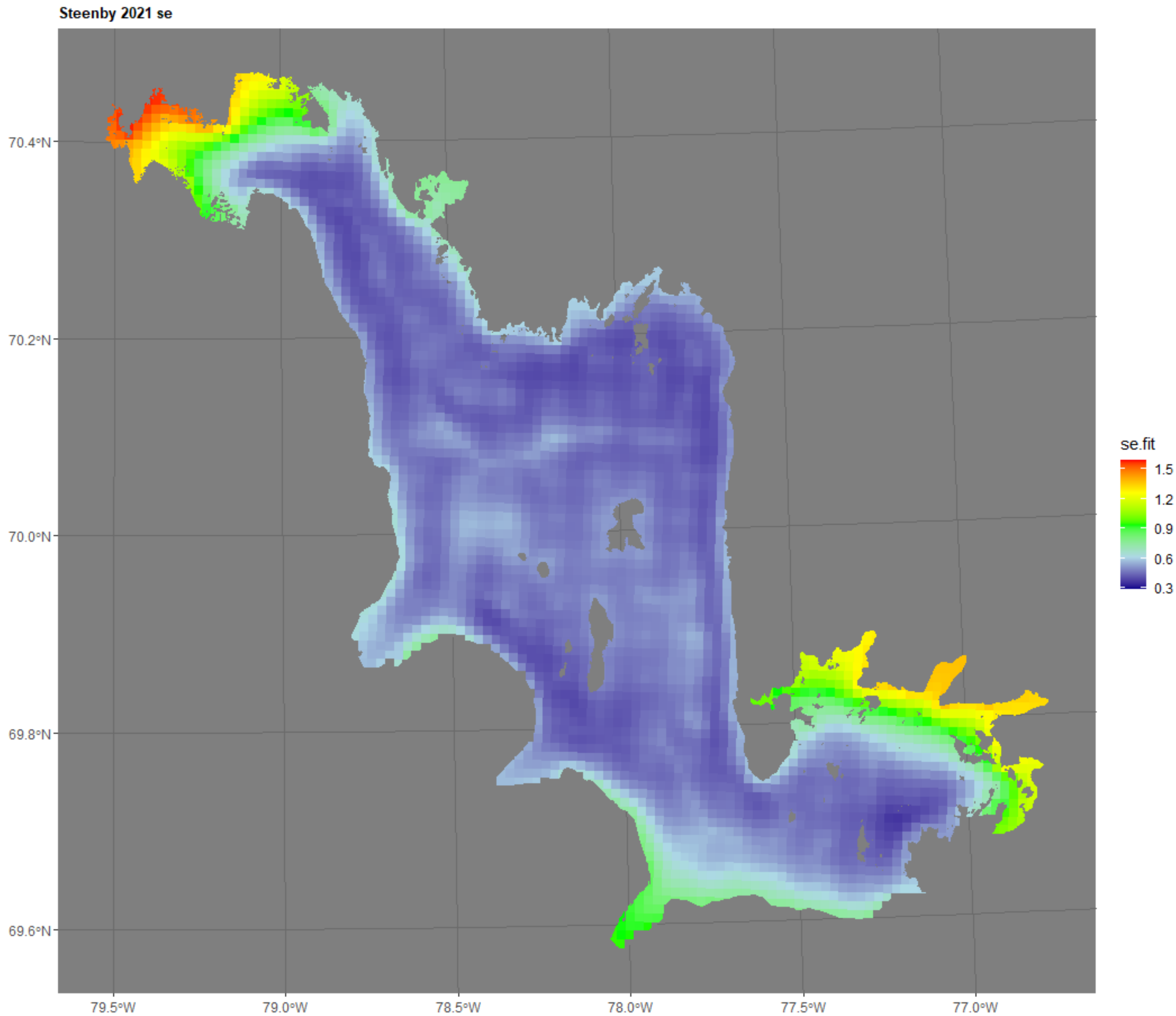

Figure A-9: Steensby 2021 GAM model spatial variance.

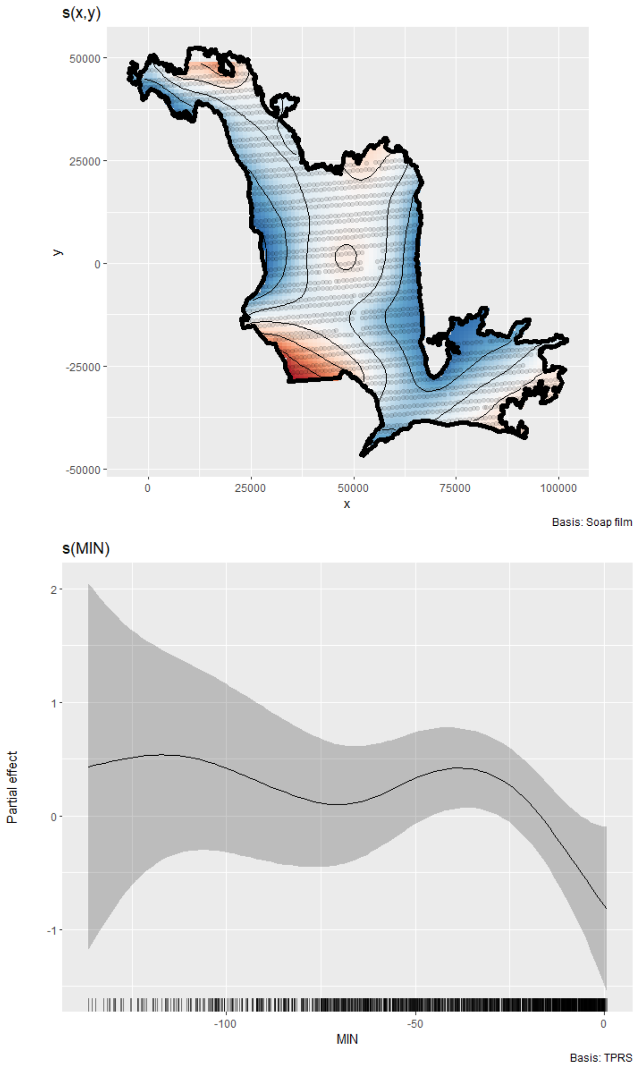

Figure A-10: Steensby 2024 GAM model spatial smoothers for: xy coordinate soap-film, minimum shore distance, and minimum depth.

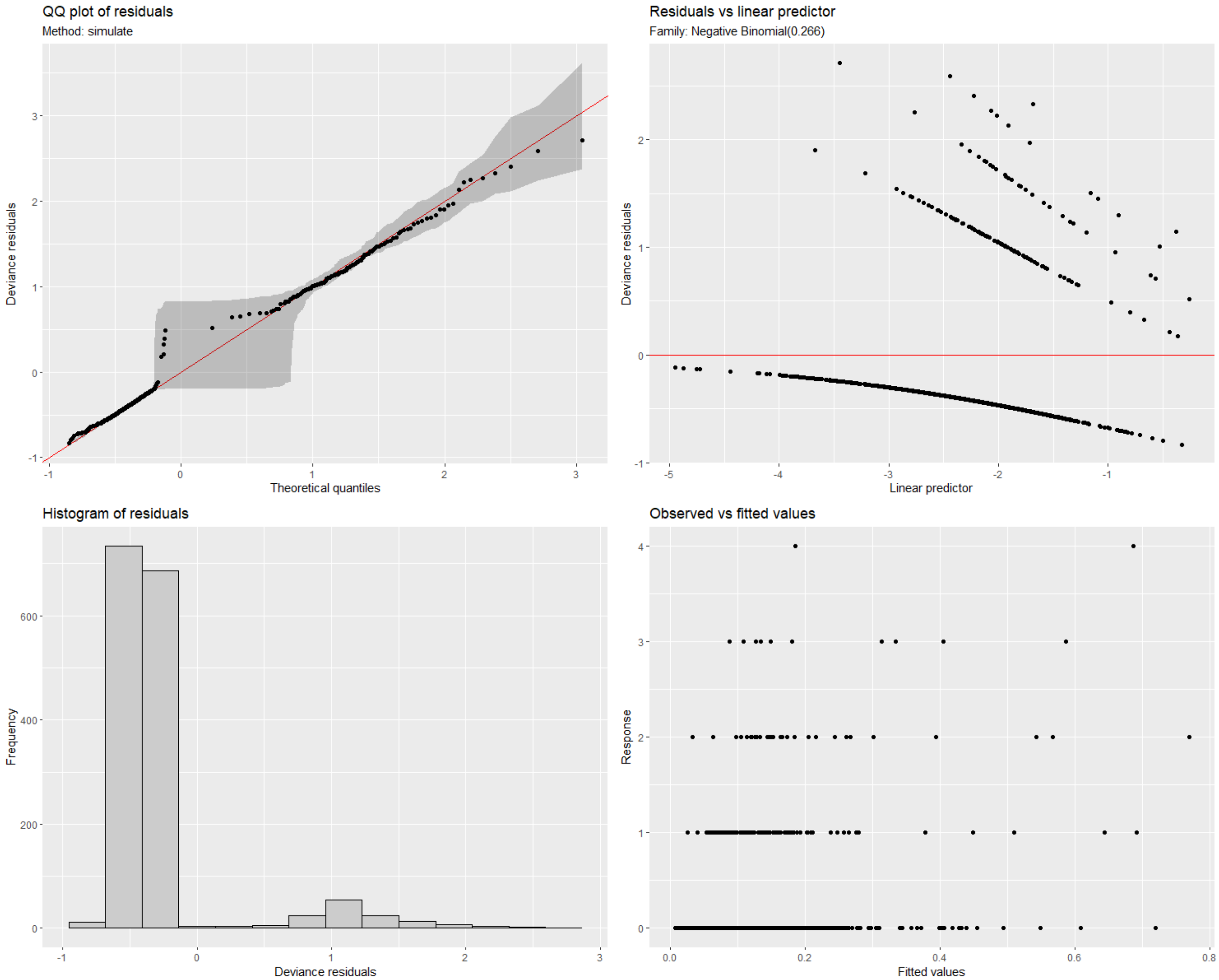

Figure A-11: Steensby 2024 Diagnostic plots for fitted GAM model using the Negative Binomial distribution.

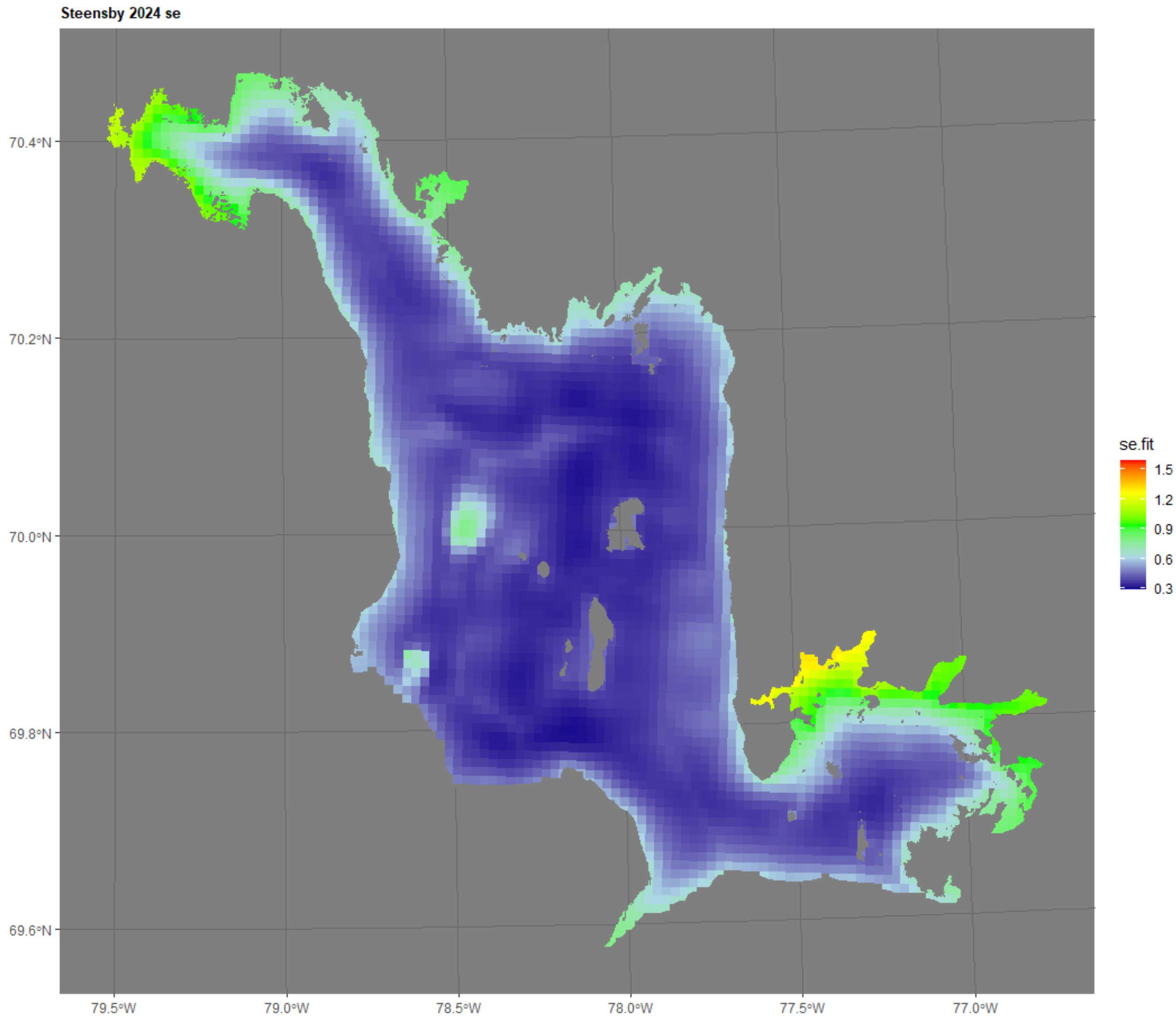

Figure A-12: Steensby 2024 GAM model spatial variance.

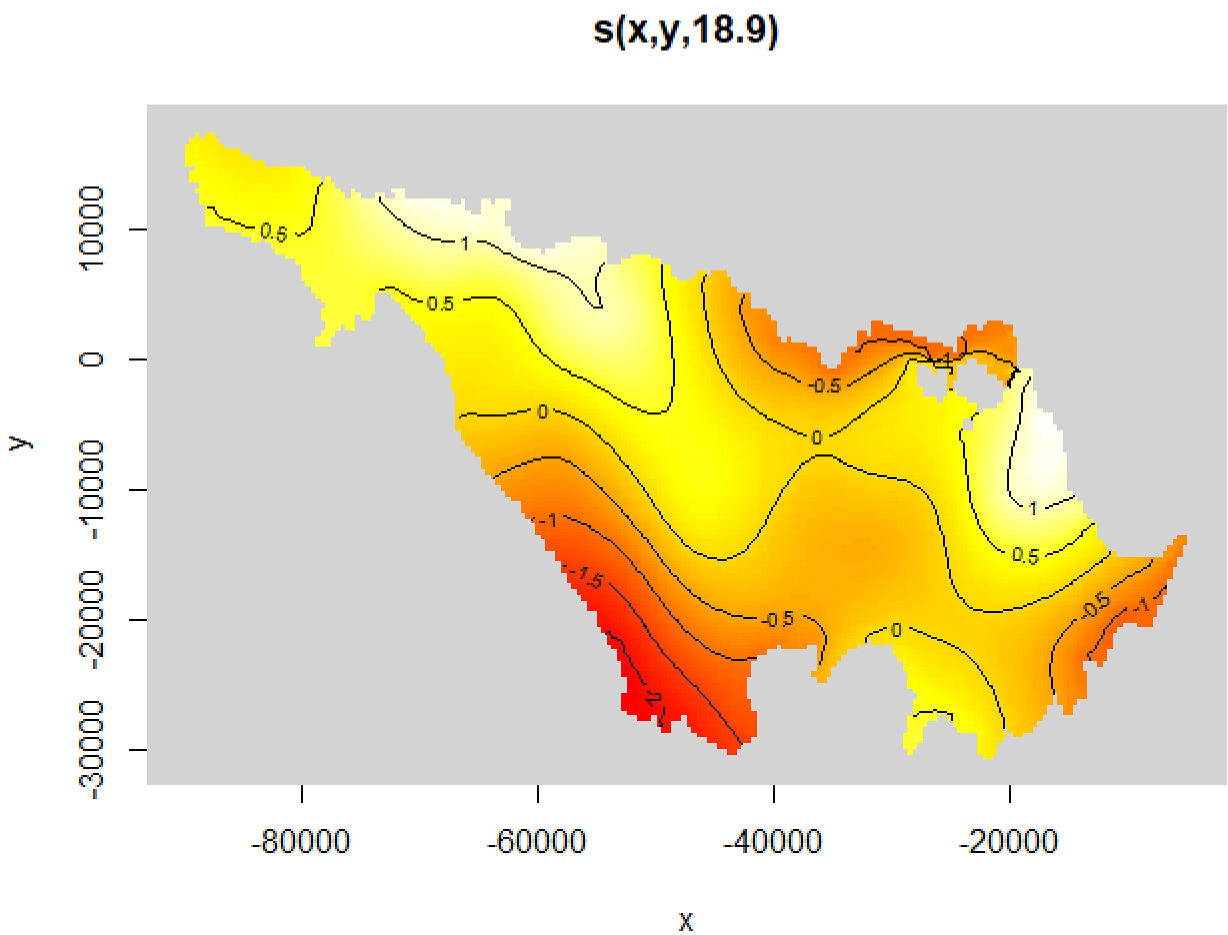

Figure A-13: Tasiujaq 2021 GAM model spatial soap-film smoother for xy coordinates.