Nova Scotia Coastal Property Wind Fetch Assessment – Technical Report

Prepared by

Tim Webster, PhD, Kevin McGuigan, Lucas McKay, Robertson Lobb, Cale Stevens, Lauren Douglas
Applied Geomatics Research Group
NSCC, Middleton
Tel. 902 825 5475
email: tim.webster@nscc.ca

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Peter Horne
Coastal Program Administrator
Nova Scotia Department of Environment and Climate Change

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Executive Summary

This report presents the preliminary results and wind fetch assessment of coastal properties of Nova Scotia on behalf of the Nova Scotia Department of Environment and Climate Change (NSECC). This work, undertaken by the Applied Geomatics Research Group (AGRG), utilizes a custom designed tool which analyses the maximum unobstructed wind fetch distance for each of 16 cardinal compass directions, up to a maximum distance of 100 km, for every 5 metres of the Nova Scotia coastline. This coastline is defined from the Higher-High Water Large Tide (HHWLT) intersection of provincial lidar as produced by the Coastal Hazard Map (CHM), the High Water Coastline. These maximum distances are summarized per unique property parcel (PID) along the coast as an overall maximum fetch distance as well as an average of maximums. These coastal properties are buffered by 10 metres to resolve inconsistencies between properties boundaries and the CHM Higher Water Coastline.

The objective of this process is to provide a systematic approach to identify individual risk of coastal properties to wind exposure, which can contribute to risks including wind damages, ocean wave run up, and coastal erosion. The results of this project include both a coastal property wind fetch assessment dataset built as well as a workflow/tool for replicating the process with alternative or updated datasets. The datasets used to generate the fetch assessment in this case were provided to AGRG by the NSECC, specifically, the Nova Scotia High Water Coastline and coastal properties.

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1 Introduction

1.1 Background and Study Area

The province of Nova Scotia has tasked AGRG with developing a wind fetch model to calculate the maximum wind fetch possible at each coastal property along the Nova Scotian coastline. The Province of Nova Scotia has provided High-Water coastline and Coastal properties shapefiles which cover the entire province (**Error! Reference source not found.-** top).

1.2 Statement of work

As per the contract:

1) Existing fetch models, such as the WindFetch python library and the USGS Waves ESRI tool, will be explored for their usefulness in producing a tool for the province of Nova Scotia. Methods from existing models will inform the production of the provincial model.
2) A model will be produced that calculates fetch risk for each coastal property in the province, auto-populates each Property Identifier (PID) polygon (Attribute value within an ESRI polygon feature class) with the model's results, and auto-generates a report on each PID. AGRG will work with Nova Scotia Environment and Climate Change (NSECC) to ensure that the reports contain the correct attributes and are formatted acceptably. The Model outputs will be compatible with ESRI software, and a coastal PID boundary layer will be supplied with corresponding fetch attribute values populated from the Fetch model.
3) To accompany the model, a report on the tool's methods and results and a more compact user guide will be produced. AGRG will work with NSECC to ensure that the user guide meets the needs of the province and its intended end users.

1.3 Schedule

Table 1 shows an overview of the various milestones of the project

Deliverables	Task	Delivery Date
Literature review on existing fetch models	Research existing fetch models and compare results to the desired results of the provincial model. Use the existing models as the basis for the provincial model if relevant.	Aug 30th 2024
Production of 1st draft NS fetch model	Produce a first draft of the model for NSECC to review.	September 30th 2024
Refinement of model and generated reports	Incorporate comments and suggestions from NSECC into the final version of the model. Format auto-generated reports to comply with NSECC specifications.	November 30th 2024
Reporting and user guide documents	Write a report on methods to produce the model and an overview of the types of results. Write a simplified user guide for model end users.	December 15th 2024

1.4 Project Status

The status of the project is in line with the second round of deliverables set for September 30th, 2024. Research has been completed on existing fetch models, and a first draft of AGRG's model has been completed for review.

1.5 Copyright and Data Ownership

The Applied Geomatics Research Group of the Nova Scotia Community College maintains full ownership of all data collected by equipment owned by NSCC and agrees to provide the end user who commissions the data collection a license to use the data for the purpose they were collected for upon written consent by AGRG-NSCC. The end user may make unlimited copies of the data for internal use; derive products from the data, release graphics and hardcopy with the copyright acknowledgement of "Data acquired and processed by the Applied Geomatics Research Group, NSCC". Data acquired using this technology and the intellectual property (IP) associated with processing these data are owned by AGRG/NSCC and data will not be shared without permission of AGRG/NSCC.

1.6 Literature Review

Rohweder et al. (2012) advanced geospatial models to assess wind fetch and wave action in the Upper Mississippi River System (UMRS), focusing on wave characteristics like height, length, and sediment suspension. These models were instrumental in habitat rehabilitation projects, such as the Harper's Slough Habitat Rehabilitation and Enhancement Project (HREP), where wind fetch reduction through island construction lowered sediment resuspension, improving water quality and supporting aquatic vegetation growth. Similarly, Mason et al. (2018) applied wind fetch models to the Laurentian Great Lakes, developing relative exposure indices (REI) to evaluate wind exposure at finer spatial scales. Wind exposure in large lake systems directly impacts shoreline erosion, sediment transport, and habitat conditions.

In smaller systems, Pelikan et al. (2020) analyzed the effectiveness of wave modeling schemes for inland reservoirs, highlighting that models designed for large bodies of water, such as the Coastal Engineering Manual (CEM) and Shore Protection Manual (SPM), tend to overestimate wave height and energy. Instead, smaller reservoirs benefit more from models like the American Society of Agricultural and Biological Engineers (ASABE) model, which accounts for shallow water dynamics and finite depth limitations (Young & Verhagen, 1996).

Keddy (1982) offered insights into how exposure, defined as the total effect of waves on lakeshore vegetation, directly affects the distribution of shoreline plants, either by uprooting them or through sediment erosion. Using wind data and fetch measurements in Axe Lake, Ontario, Keddy's study correlated exposure levels with sediment particle size and species distributions. Notably, species like *Eriocaulon septangulare* and *Nymphoides cordata* were positively associated with high exposure, while *Brasenia schreberi* and *Dulichium arundinaceum* were negatively associated. Fetch, whether directly measured or calculated using effective fetch, played a key role in determining wave energy, with direct fetch yielding stronger correlations. However, effective fetch, which accounted for lake basin shape, also produced significant results when calculated based on directional exceedance (U.S. Army Coastal Engineering Research Center, 1977).

The role of wave action in sediment resuspension, erosion, and habitat suitability is critical across studies. For example, Rohweder et al. (2012) highlighted how island construction reduced wave action, preventing sediment resuspension and improving water clarity in UMRS restoration projects. In small reservoirs, Pelikan et al. (2020) demonstrated that accurate wave modeling is essential to prevent dam overtopping and shoreline erosion. Keddy's (1982) research further supported the importance of wave energy in determining sediment characteristics and the distribution of shoreline plants, with wave exposure gradients providing a biologically meaningful method for ranking shorelines and assessing their ecological relationships.

While wave and wind fetch models have proven effective in rehabilitation projects, challenges persist. Rohweder et al. (2012) acknowledged limitations in their models regarding nearshore processes like wave refraction and shoaling. Moreover, models designed for large water bodies often fail when applied to smaller systems, as noted by Pelikan et al. (2020). Keddy's (1982) study also highlighted the complexity of accurately predicting wave height and energy, given the multiple interacting factors involved, including fetch, wind speed, and duration (Johnson, 1948; Pond & Pickard, 1978).

Future research should focus on refining these models to address such limitations, particularly in the face of climate change, which will likely alter wind patterns and hydrological conditions. Integrating real-time wind data and using more advanced numerical models could enhance the accuracy and applicability of wind fetch and wave models across a wider range of aquatic environments.

1.7 Review of Methods

Several methods were examined before deciding on a best approach – specifically when considering the relation of wind fetch to coastal properties.

1.7.1 USGS Wind Fetch Tool

Rohweder et al. (2012) developed a GIS tool to calculate wind fetch and wave characteristics using ArcGIS. It measures wind fetch as the longest unobstructed distance wind travels over water, using directional radials and prevailing winds (Rohweder et al. 2012). It requires input data such as a land raster dataset, where land is represented by values greater than zero and water by zero, and a text file that lists wind directions and corresponding weightings.

The model offers several methods for calculating fetch. The SPM method calculates fetch using nine radial lines spaced three degrees apart around a central wind direction, averaging the radial measurements to estimate fetch length. The Single Radial Method calculates fetch along a single radial line, while the SPM-Restricted Method averages five radials for cases with narrow fetches. The model can also compute weighted fetch if wind direction weightings are provided, multiplying the output for each direction by its respective weighting and summing the results.

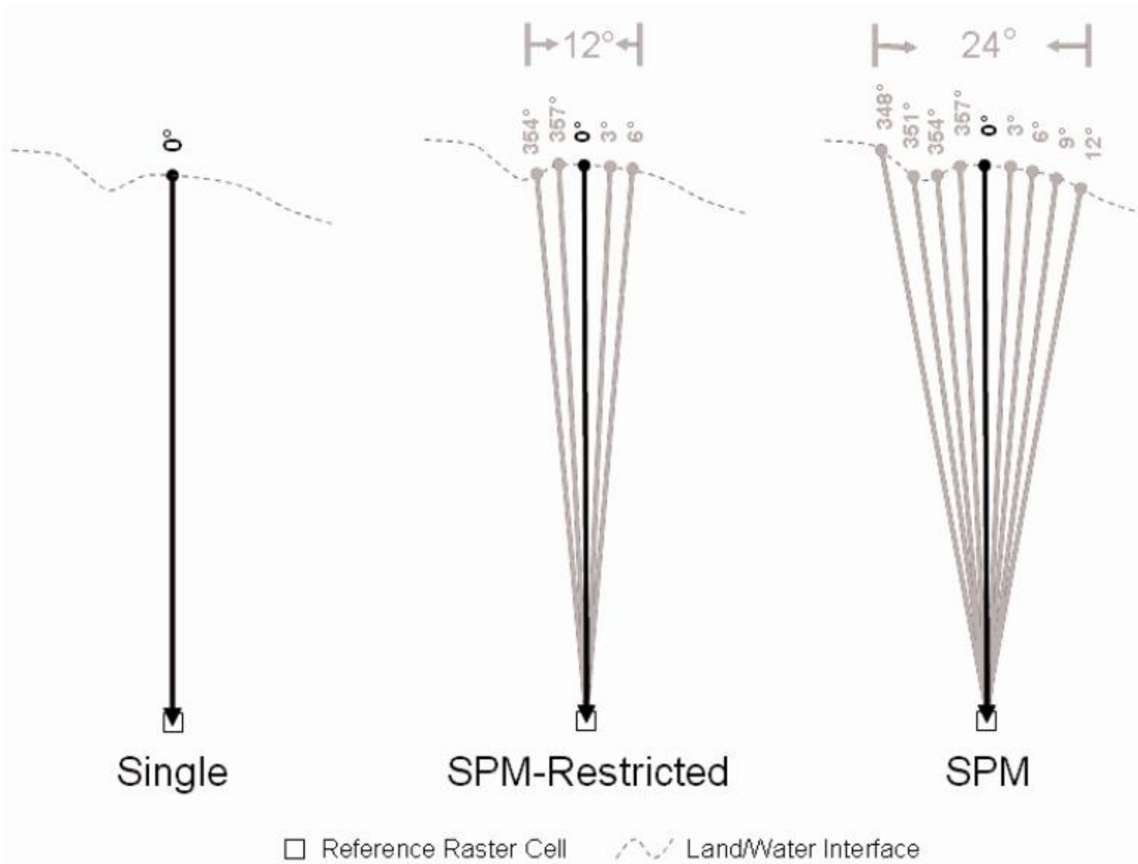


Figure 1 Examples depictions of wind fetch calculated using different methods available using the USGS wind fetch tool (Rohweder et al. 2012).

To validate the model, USGS compared the fetch lengths it calculated to those obtained by a manually measured-line method, and found differences of less than 10 metres, confirming the model's accuracy. The model outputs fetch results as raster datasets, which can then be used for further modeling, such as predicting biological responses to wind and waves. Overall, this approach allows for the evaluation of different management scenarios in habitat rehabilitation, though its objectives differ fundamentally from those outlined by NSECC. USGS targets environmental habitat restoration with adaptive models, while AGRG is focused on coastal property risk assessment with a broader, static geographical approach.

1.7.2 Python Wind Fetch Implementation

WindFetch is an open-source python library created by Kenneth Thorø Martinsen. The tool can calculate simple wind fetch from one or a list of wind directions and allows for advanced features such as setting a relative weight per wind direction. While the tool does allow for vector inputs (such as coastline polygons) the analysis is raster based. This approach is sensible for the tool as its focus is on producing fetch values for waterbodies, and not coast lines (Martinsen, 2024).

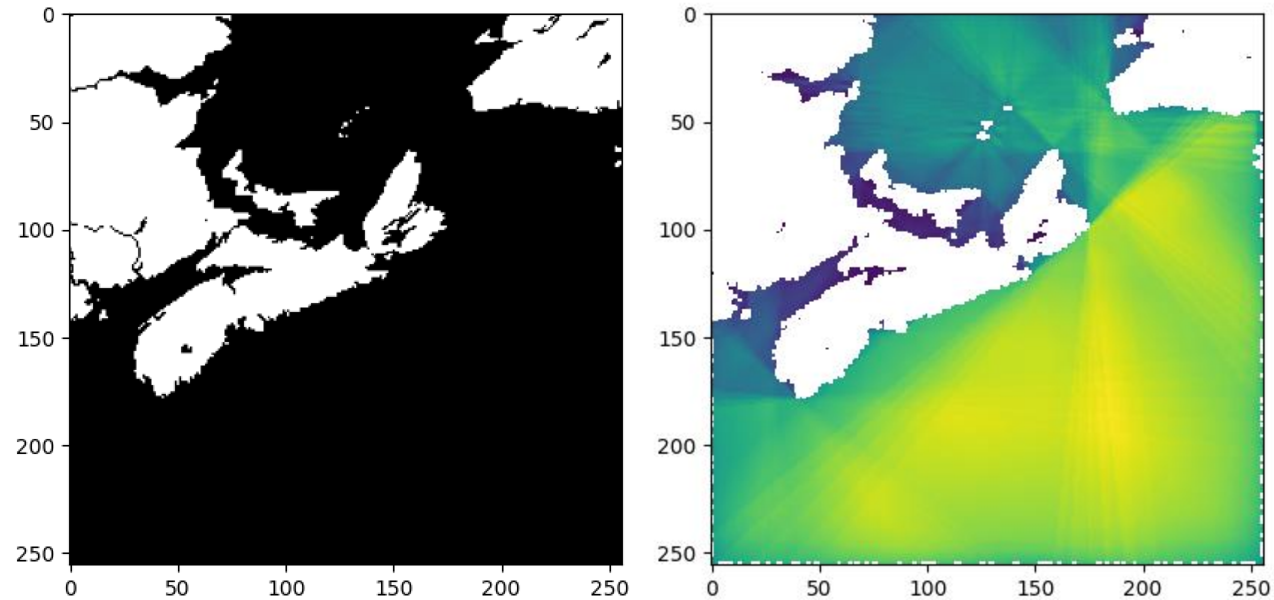


Figure 2 Result of the python library WindFetch producing a coarse raster output for the Nova Scotia region. This calculation provides total fetch information for the water body surrounding Nova Scotia, not the coastline directly.

1.7.3 Custom Raster Method

In an experimental attempt to scale a raster approach to a higher resolution, and to focus the analysis on the coast as opposed to water body – a custom raster-based fetch tool was developed which utilizes the principal of delta compression which considers only the changing values of a given raster. Using this technique, the simple count of unchanging pixels mapped to the neighboring change pixel represents a fetch distance of a given orientation. This analysis can then be performed over various rotations to perform multi-directional fetch mapping.

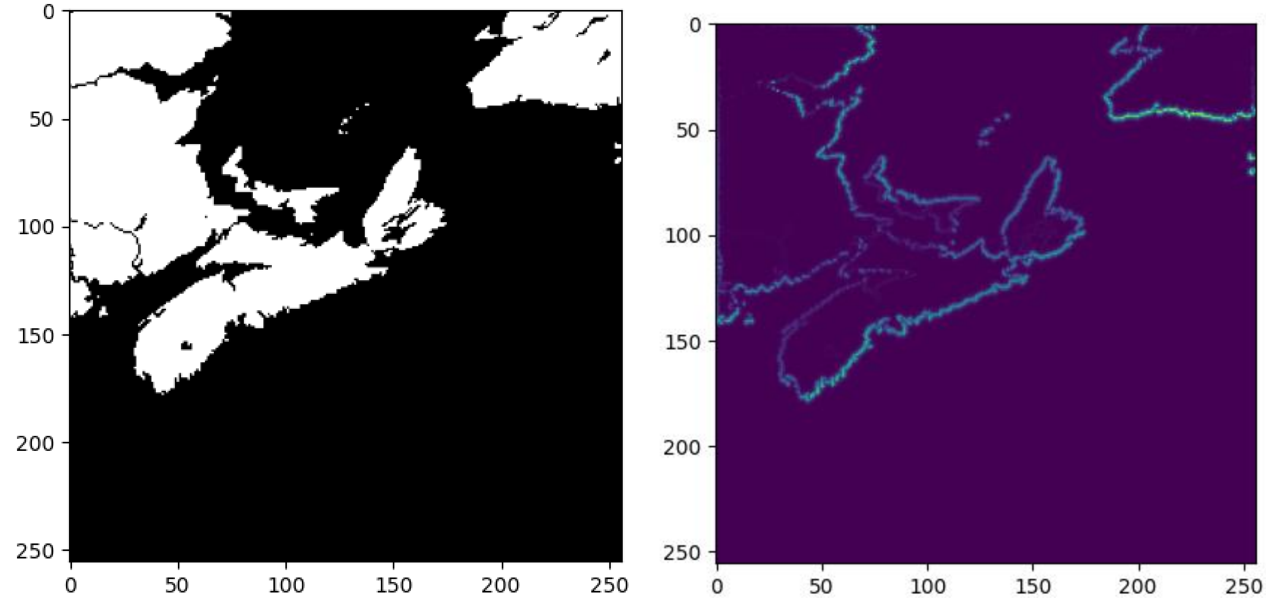


Figure 3 Input (left) and result (right) of a custom fetch calculation technique that utilizes delta encoding.

1.7.4 Proposed Method

Each of the previous discussed methods had various drawbacks when considering the fine scale of the lidar derived coastline, and the geographical scale of the entire province. As such - a custom implementation of the vector-based approach utilized by the USGS tool of single or radially spread wind vector lines was created such that the process could be computed efficiently using a GPU based calculation. This method provided to be the most viable approach and is detailed in the methods section below.

2 Methods

The process utilized by the AGRG to develop the maximum wind fetch information at a high resolution along the lidar derived coastline for the entire province of Nova Scotia is detailed bellow. Please note that this process is the result of a preliminary examination, and some aspects are in development. The results provided with and detailed in this report were developed directly from the methods as described here.

2.1 Detailed Method

The following data inputs were used in AGRG's methodology below:

- Province of Nova Scotia Coastal Properties Shapefile
- Province of Nova Scotia Coastline Shapefile
- *Province of New Brunswick Coastline Shapefile (Only sections within 100km of Nova Scotia Coastline)
- *Province of Prince Edward Island Coastline Shapefile

- *Digital Elevation Model (DEM) covering Prince Edward Island and New Brunswick
- Nova Scotia Primary Watersheds Shapefile
- *Higher High Water Large Tide (HHWLT) grid file

To begin, coastline shapefiles for Prince Edward Island and New Brunswick had to be compiled. While these shapefiles could be provided from any source, AGRG constructed these coastlines with HyVSEP points and digital elevation models (DEMs) provided by the Canadian Hydrographic Service. A raster grid surface was constructed from the HyVSEP point data, the Higher High Water Large Tide (HHWLT) grid. The HHWLT raster surface was extrapolated over DEM data covering coastal areas in Prince Edward Island and New Brunswick. A conditional statement was executed in a Python script to generate a polygon for DEM pixels below the elevation of the HHWLT surface, and a second polygon for all other pixels. A selection operation was then performed to select the intersecting boundaries of the polygons. The resulting line shapefile was then smoothed, leaving a line shapefile representation of the coastline contained within the DEM. Water bodies completely contained within land (e.g., lakes) were filtered out.

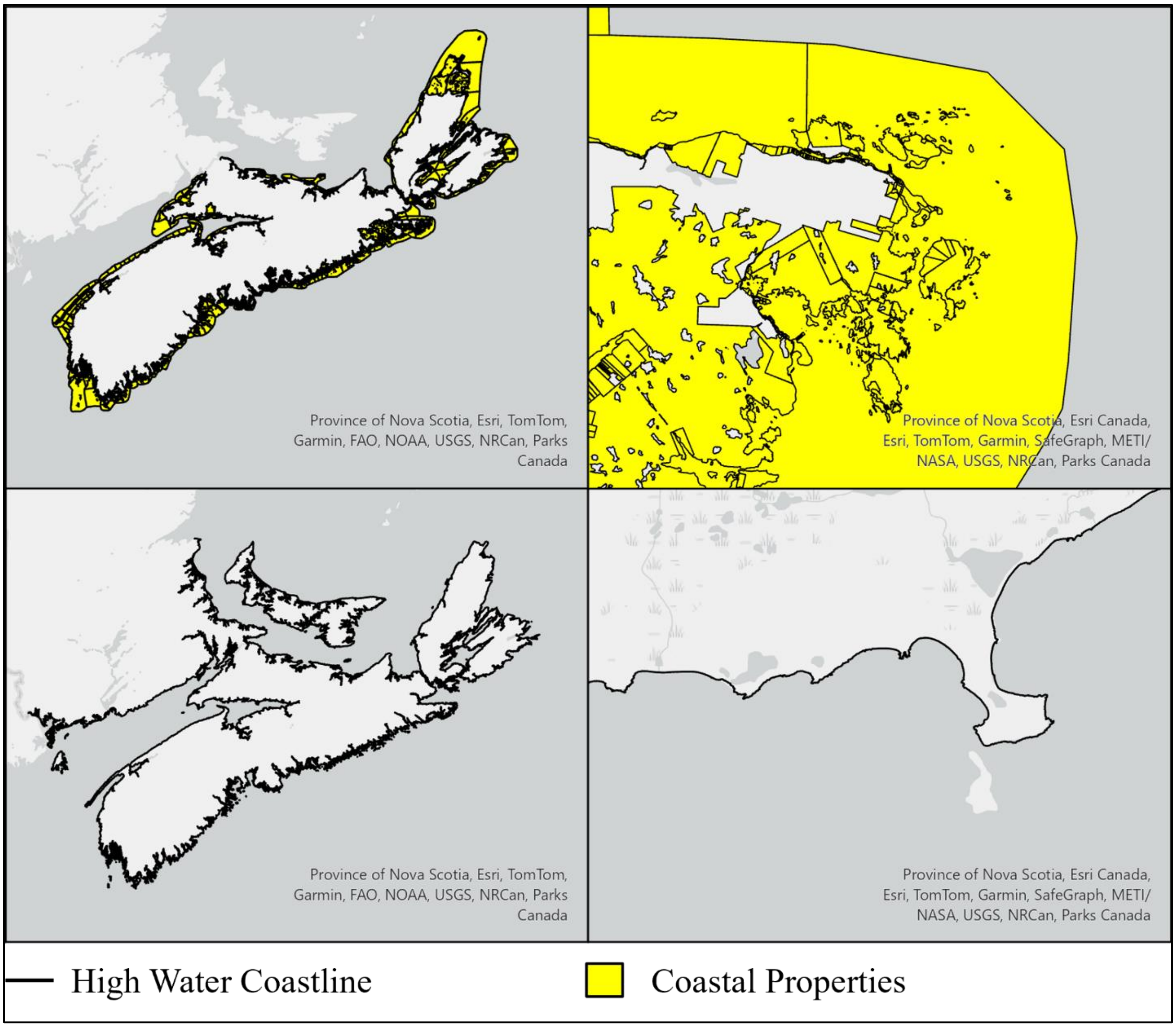


Figure 4 Coastal properties shapefile (top) and the High-Water coastline shapefile (bottom).

Coastal sections from the High-Water coastline shapefile were split by watershed using the Nova Scotia Primary Watersheds shapefile (Figure 5). This operation broke the computation workload into manageable chunks. Points were generated along each coastal segment at 5-metre intervals, creating coastal point shapefiles for each coastline segment (Figure 6). Lines-of-bearing were built for each coastal point shapefile, each point serving as the origin for 16 lines of bearing reaching outward 100km (Figure 7), creating lines-of-bearing shapefiles for each coastal segment. To avoid data overages constraining ESRI Shapefiles to the 2gb size limit, lines-of bearing, coastal segment, and coastal point shapefiles were further split when necessary. This work was performed within a Python scripting environment.

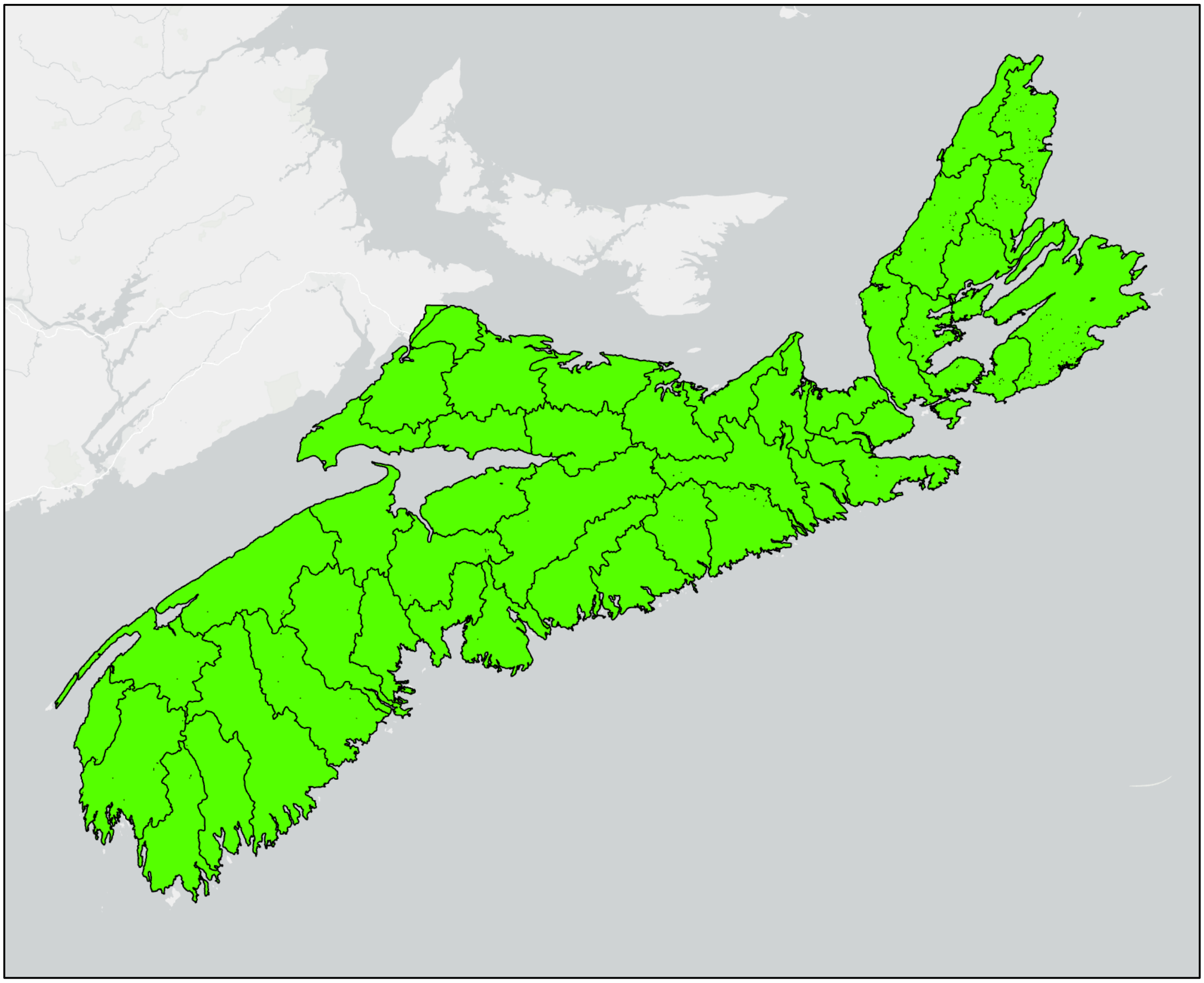


Figure 5 Nova Scotia Primary Watersheds shapefile.

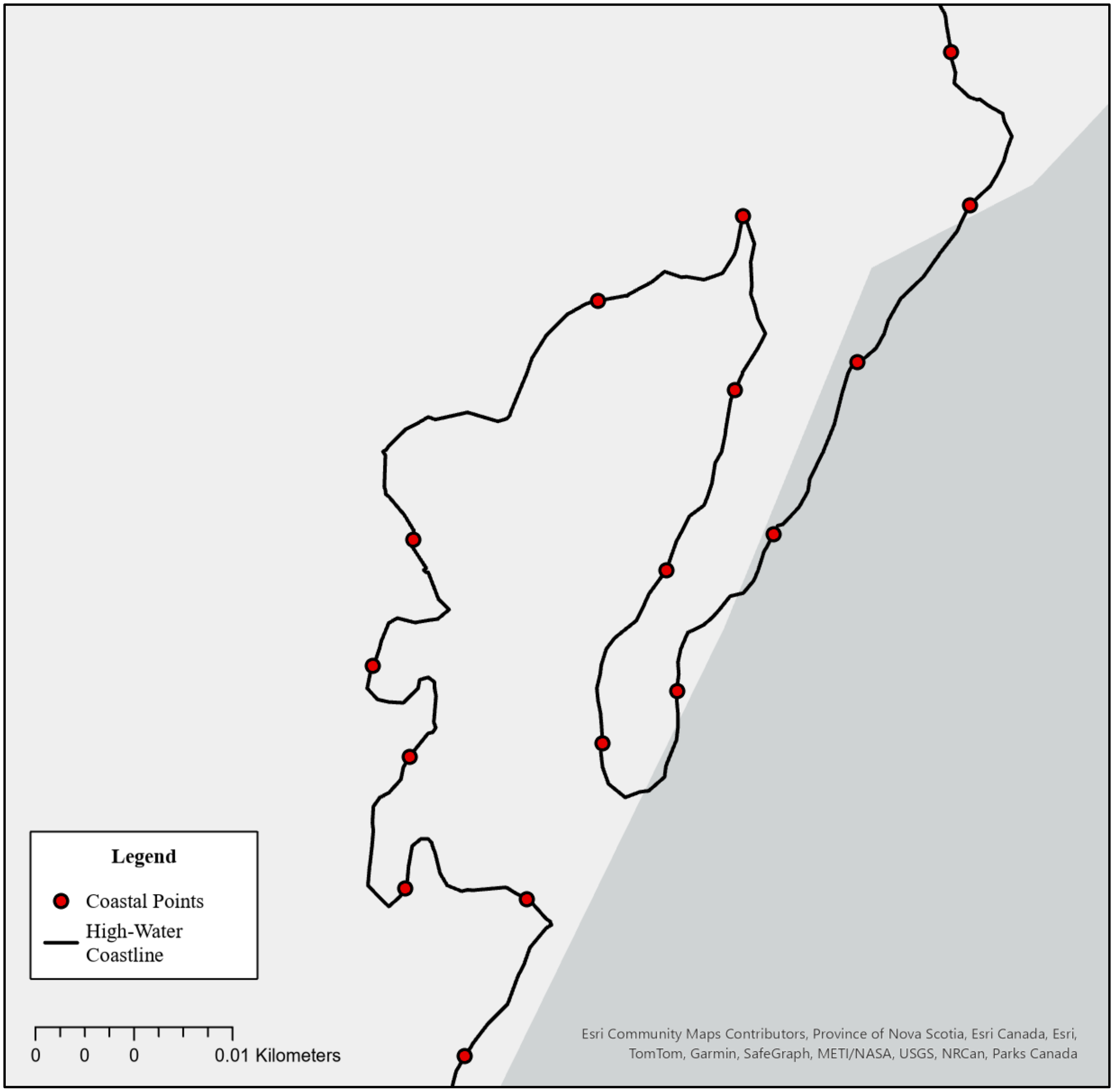


Figure 6 High-Water coastline and coastal point (5-metre interval) shapefiles.

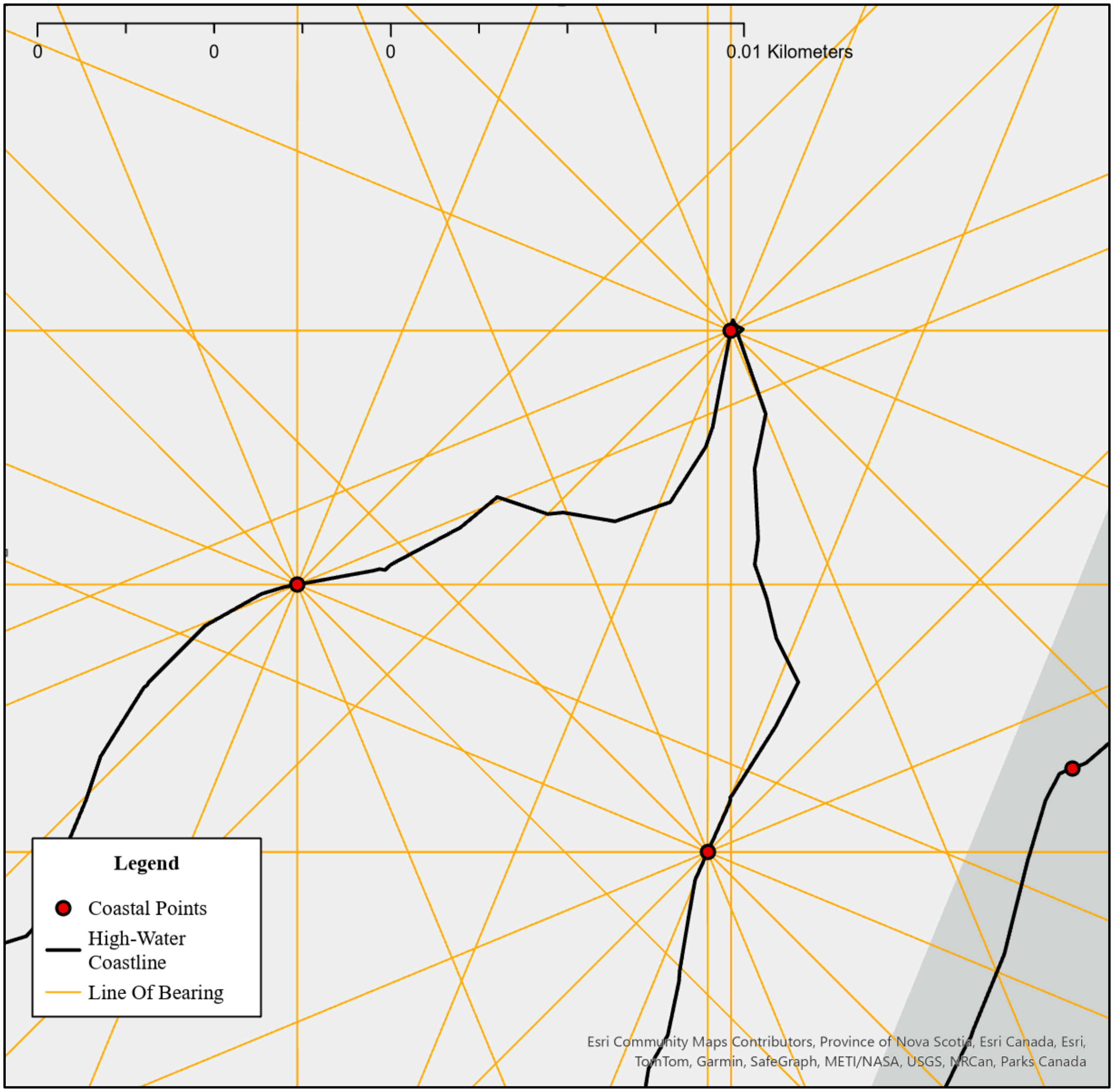


Figure 7 Lines-of-bearing shapefile in orange extruding from points within the coastal points shapefile generated along the High-Water coastline shapefile.

Another iterative Python process selected and segmented the High-Water coastline shapefile where it was within the extent of each lines-of-bearing shapefile. Each coastline segment was then converted into a polygon representing the ocean in contact with the coastline. Each lines-of-bearing shapefile and corresponding High-Water coastline polygon segment was loaded onto a Graphics Processing Unit (GPU) using CUDA to parallelize the intersection operation. A bounding box check and a series of vector calculations executed on the GPU identified all intersections between the wind fetch lines and the coast. Python search cursors were used to find the nearest intersection between each bearing line and the High-Water coastline, eliminating intersections with coastline segments beyond the first.

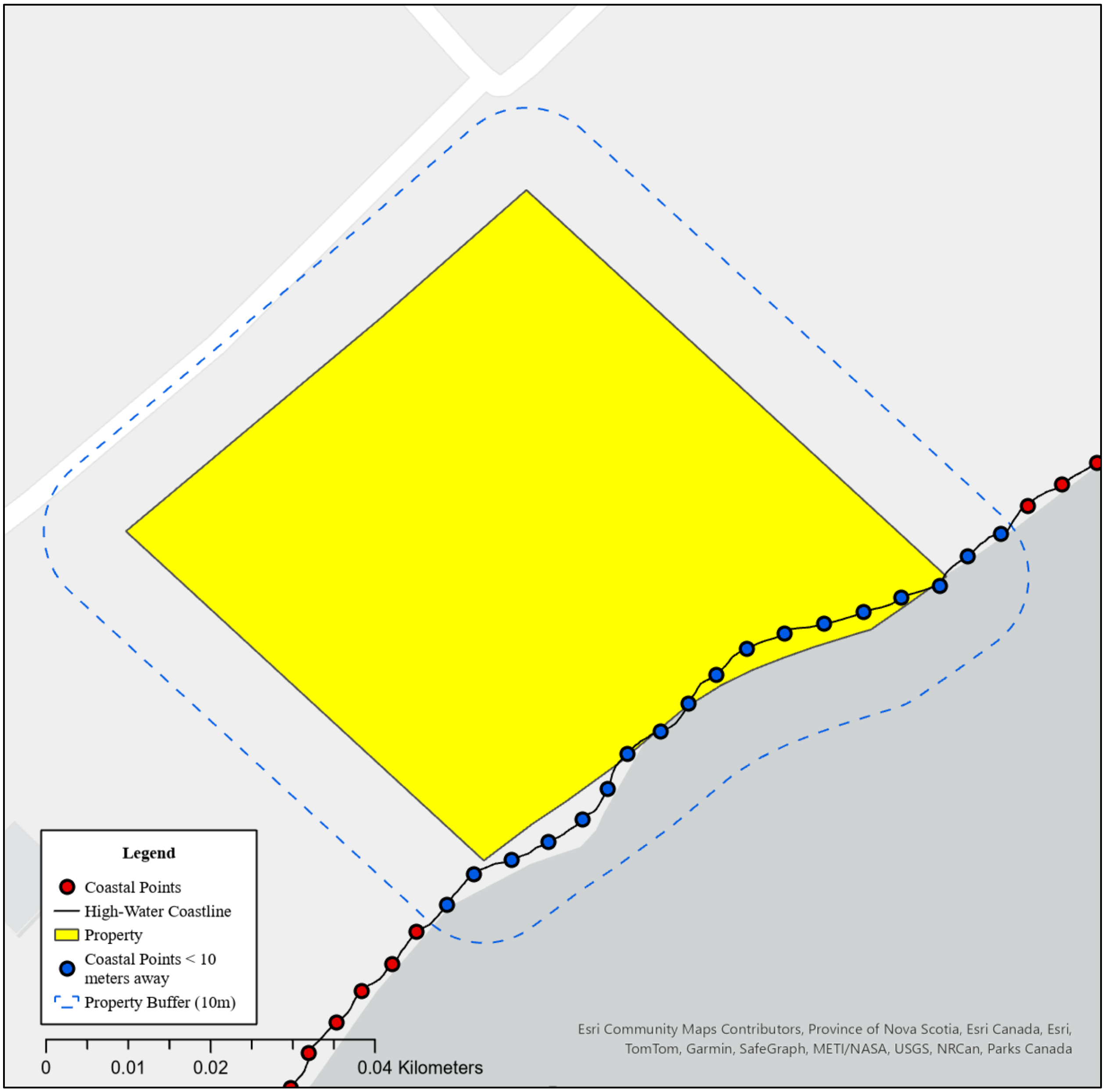


Figure 8 An example of a selection of coastal points within 10m of a property polygon in the Coastal Properties shapefile. Selected points are used to calculate the "Max_Fetch", "Mean_Fetch", and "Bearing_Range" of the property.

For each section, filtered line shapefiles were joined to their corresponding coastal points based on matching identifier fields. This resulted in a collection of coastal point shapefiles that now contained information about which wind bearings (Bearing_Range) had maximum reach (Distance) relative to all other bearings at that location. Coastal points from all sections were then merged back into a single shapefile to ensure that all points along the coastline could be queried regardless of how they had been sectioned for processing. Each point was assigned a unique identifier, and statistics describing maximum (Max_Fetch) and average maximum (Mean_Fetch) values were calculated from points within a 10-

metre distance for each unique parcel identifier (Figure 8). All coastal points within this range were further exported to a CSV file per PID for future analysis, if required.

2.2 General Method Overview

In summary, coastline shapefiles for Prince Edward Island and New Brunswick were compiled using HyVSEP points and DEMs from the Canadian Hydrographic Service. A raster surface of the Higher High Water Large Tide (HHWLT) was constructed and extrapolated over coastal DEMs, and polygons for DEM pixels below and above the HHWLT surface were generated. Intersecting boundaries were selected to produce a smoothed line shapefile of the coastline with inland water bodies filtered out. The coastline shapefile was split by watershed using the Nova Scotia Primary Watersheds, generating coastal points at 5-metre intervals. Lines-of-bearing were created for each point, extending 100 kilometres outward, and the shapefiles were split to avoid exceeding ESRI Shapefile size limits. Another Python process segmented the High-Water coastline, converting each section into a polygon. GPU parallelization using CUDA was applied to identify intersections between wind fetch lines and the coastline. Search cursors in Python selected the nearest intersection points, and these filtered lines were joined with their respective coastal points. The final coastal point shapefiles contained wind bearing and distance data, which were merged back into a single shapefile for querying. Unique identifiers were assigned, and maximum and average fetch values were calculated for each coastal point, with the data exported to a CSV for further analysis.

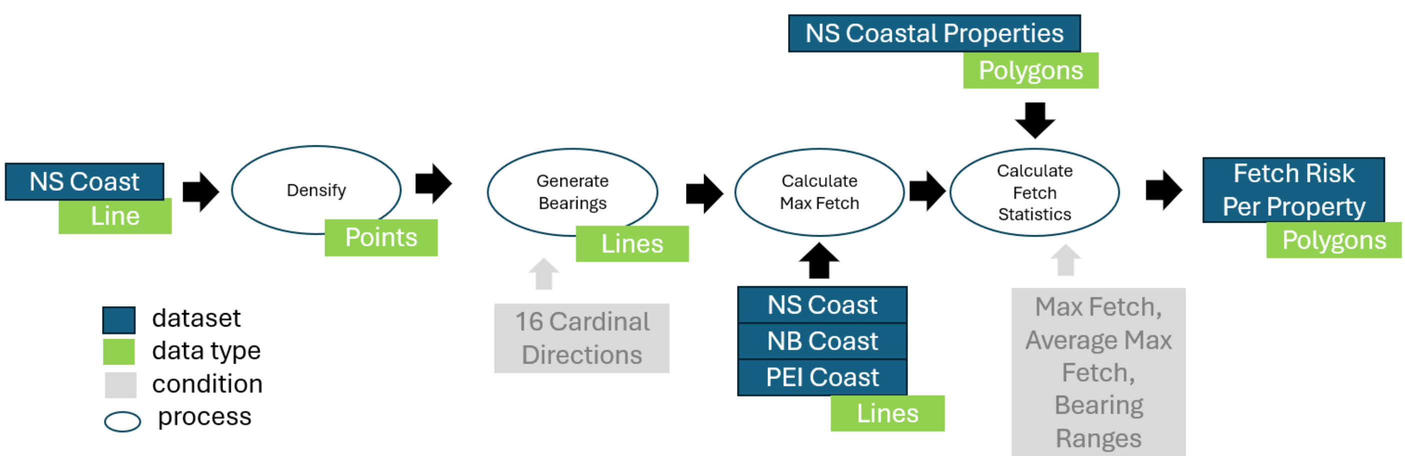


Figure 9 Overall process including inputs datasets, data types and conditions.

3 Results

As per the methodology described above, maximum wind fetch distances were computed for each 5-metre segment of the Nova Scotia Coastal Hazard Map High Water Coastline. This included a total of 3,417,155 points which were analyzed in 16 cardinal directions, where the maximum fetch distance and baring was reported. Where multiple maximums were detected (such as when multiple cardinal directions reached the 100 km limit) multiple maximum fetch bearings were reported (Figure 10). The fetch maximums of points along the coast were then summarised to a set of 64,044 coastal properties within a buffer tolerance of 10 m. This included a summary of the overall maximum fetch of the property, the baring(s) of the maximum fetch of the property, as well as the mean and standard deviation maximum fetch of each point along the coast within the tolerance distance (Figure 12, Figure 13**Error! Reference source not found.**).

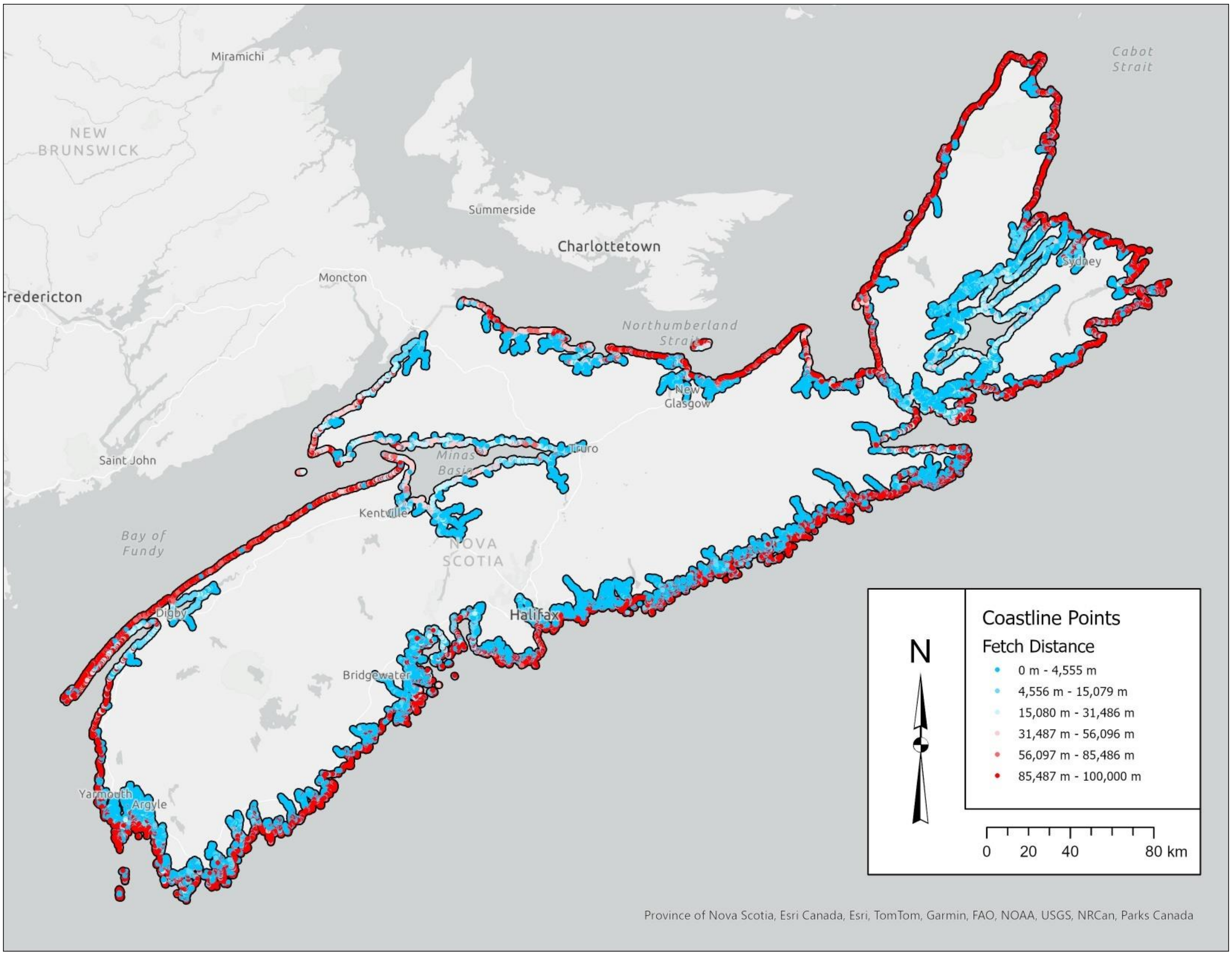


Figure 10 Overview of maximum fetch magnitudes per 5m coastal section (where red is high, blue is low). These results were computed using the custom GPU process described.

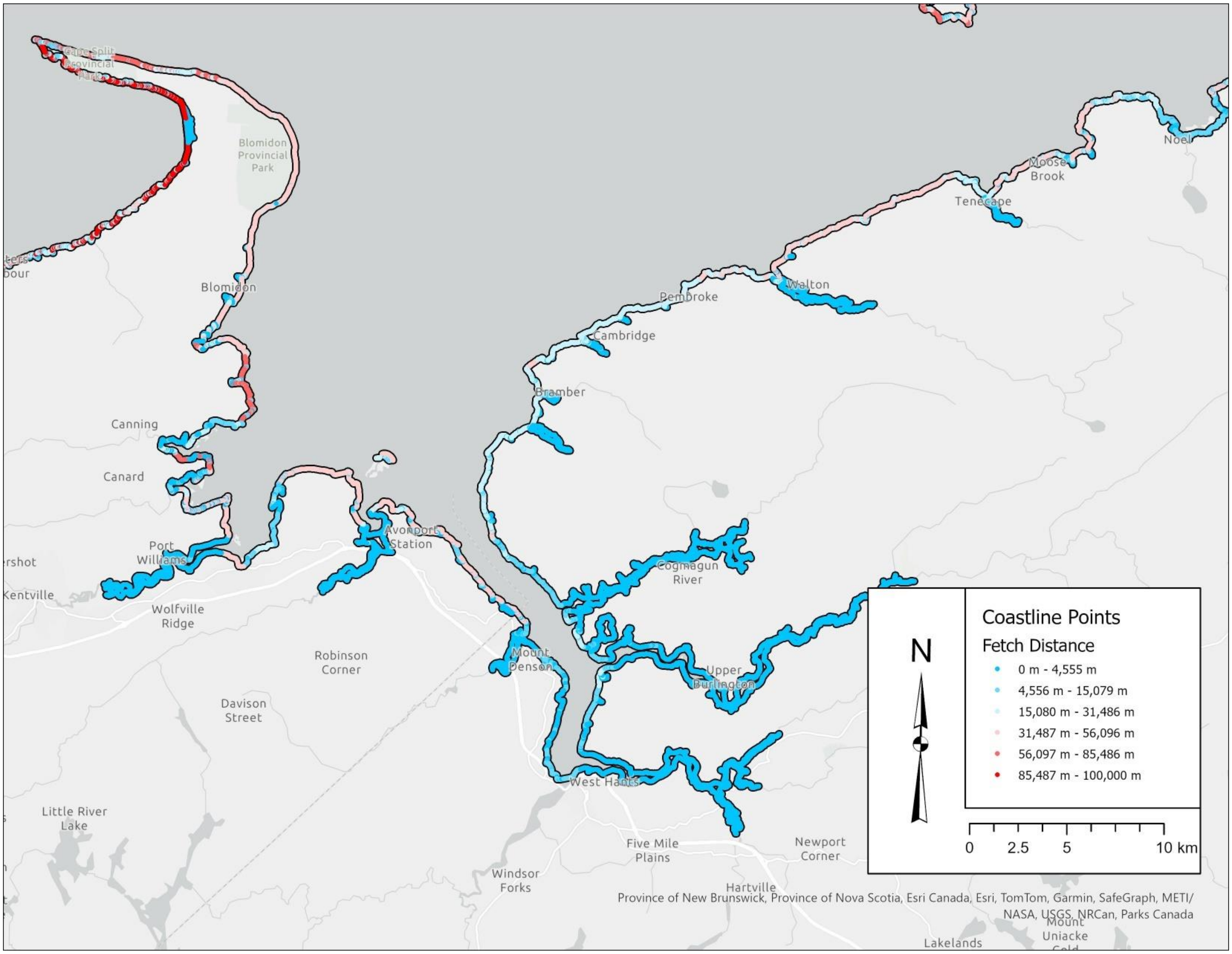


Figure 11 Inset map of the maximum fetch distances per 5m section of coast around the Minas Basin area. Note areas around The Blomidon Provincial Park and west are more exposed (red) than more sheltered sections of the basin near Windsor, for example.

The coastal property database provided from NSECC for this project seems to contain water area polygons in addition to land parcels. To avoid displaying these water properties in this section (as well as the appendix map series), the property polygons were clipped by the Nova Scotia Hydrographic Network water polygon map data (code WATO40). This choice can be refined based on the requirements of the final tools as needed.

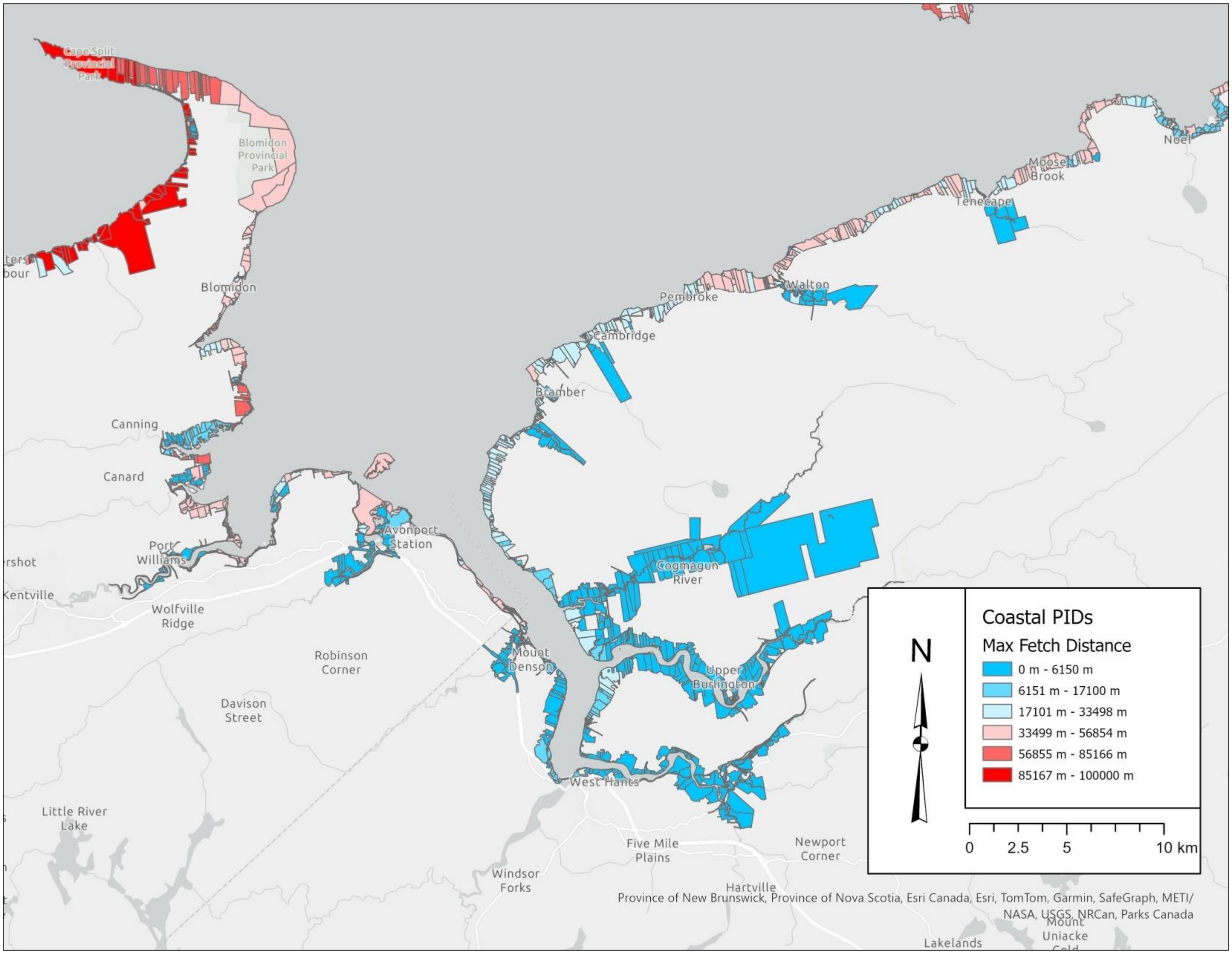


Figure 12 Area around Minas Basin shows the same maximum fetch magnitudes per 5m coastal section summarized by coastal property (where red is high, blue is low).

Initial results conform to sensible distribution of high and low fetch characteristics mapping to properties. Exposed areas return high maximum and mean aggregate fetch distances as expected. This indicates that the tool is functioning as intended. It is worth nothing that when considering the aggregate of individual fetch distances (per 5m section of coat) which are aggregated to the property database – the average or mean value of the aggregate maybe more descriptive to a property owner than simply the maximum fetch of the related sections of coast. That is to say the mean value indicates a more graduated indication risk due to fetch across the property, whereas the max alone may return high values though a relatively small section of the properties coast is exposed to this degee.

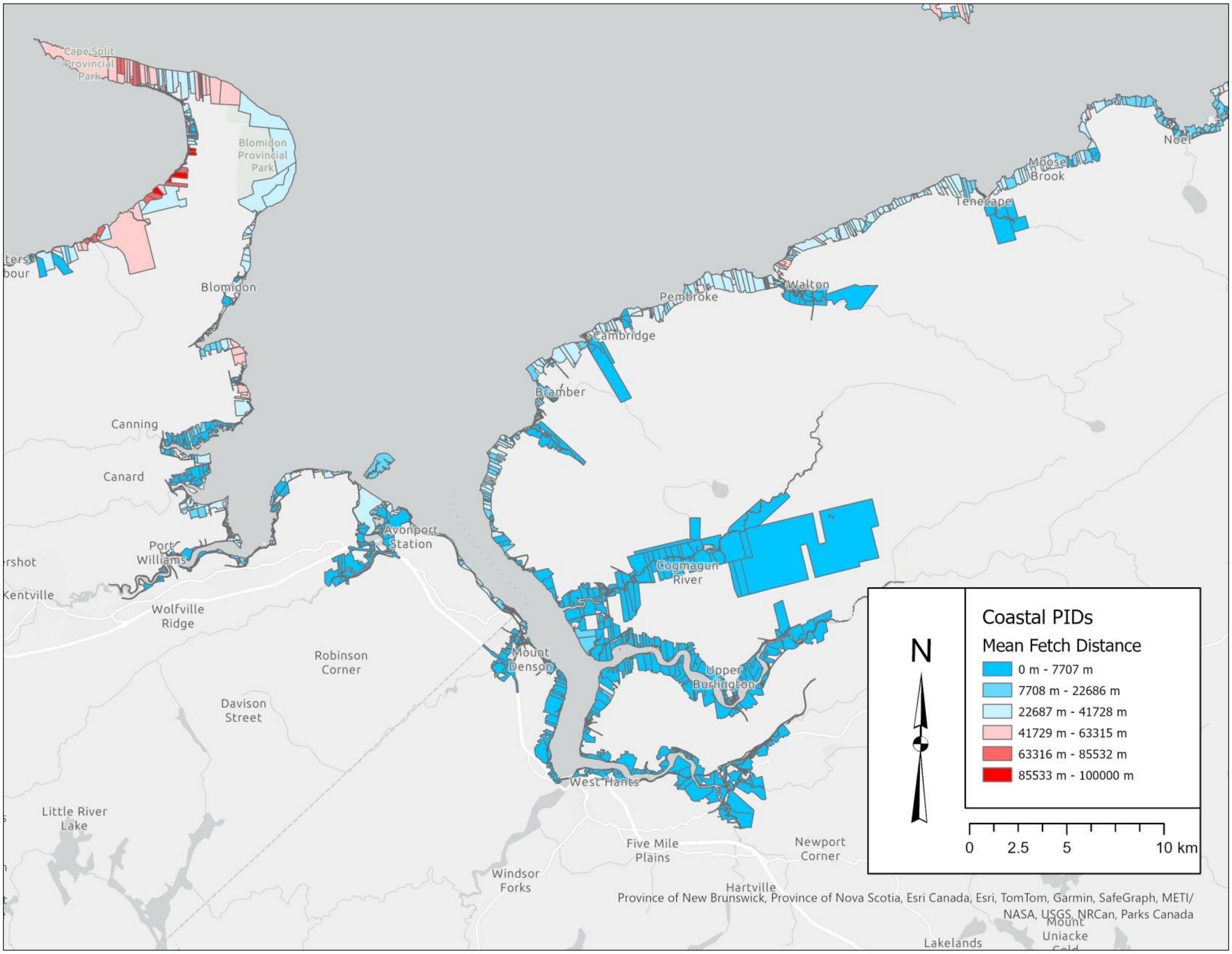


Figure 13 Area around Minas Basin shows the same mean of the maximum fetch magnitudes per 5m coastal section summarized by coastal property (where red is high, blue is low). This aggregate can be more descriptive on the property level than the overall maximum fetch alone.

The results are presented as both a point dataset of maximum fetch distances and bearings per 5m increments along the coast, and a coastal property shapefile with appended overall maximum fetch distances, maximum fetch bearings, as well as means and standard deviations of the maximum fetches from the 5m increments along coast of the property. As such, these results retain the high level of detail for the coast and property line inputs (Figure 12, Figure 13).

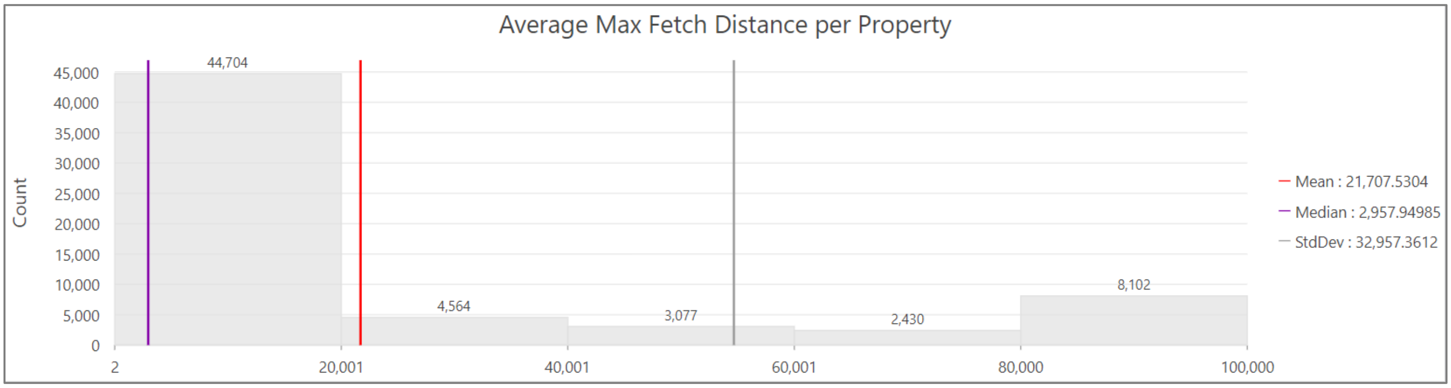


Figure 14 Overall distribution of the average maximum fetch per 5m increment along the coast aggregated per coastal property, in metres.

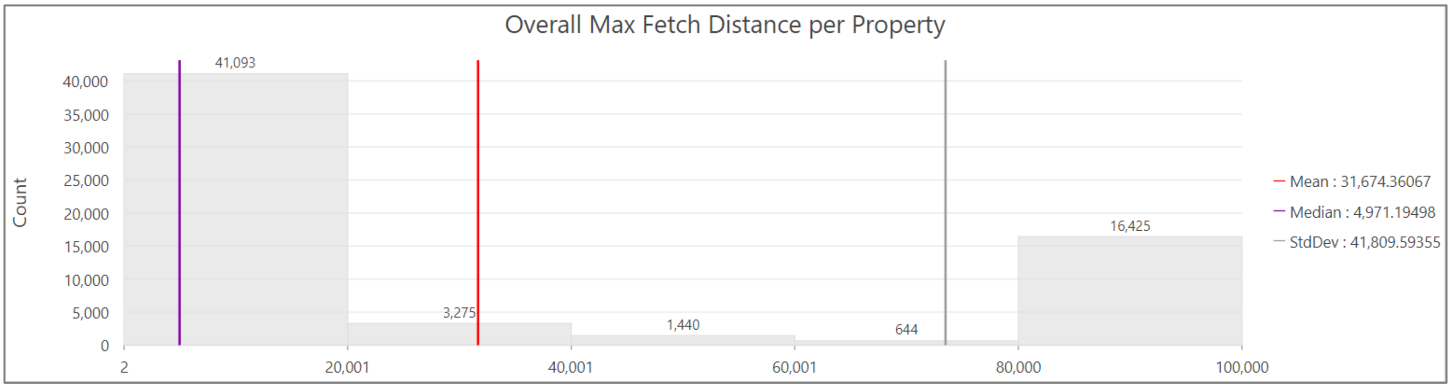


Figure 15 Overall maximum fetch observed along the coast of each coastal property, in metres.

Looking at the results statistically, the median property has an average of maximum fetches along its coast of less than 3 kilometres, indicating that much of the privately owned maybe relatively sheltered (Figure 14). Furthermore, 16,425 coastal properties have at least one 5m section of their coastline with a wind fetch greater than 80 km in one of 16 cardinal directions (Figure 15).

4 Discussion

This represents a preliminary delivery of the task of generating wind fetch. Currently the model takes approximately 48 hours to complete on a mid-level GPU. The process further requires a CUDA based GPU system which may make the tool more difficult to package. We do anticipate significant increases to the efficiency of the process with an improved method of computing intersections which is currently being tested - which may also avoid use of GPU altogether. The current implementation of the process does require some manual processing which is being addressed. Furthermore, there is some question as to the exact data inputs (specifically the property PID layer) which should be used to provide the best results possible. When comparing our results to other available tools – we believe our technique is well suited to provide insights to fetch risk as the property level specifically as opposed to focusing on analysis of the wider region.

4.1 USGS Comparison

The methodologies for calculating wind fetch in the USGS Wind Fetch and Wave Model (2012 Update) differ in their objectives, tools, and specific procedures relative to the approach described by AGRG. The USGS Wind Fetch Model targets environmental habitat restoration using adaptive models. The methodology is based on the Shore Protection Manual (SPM) guidelines, where wind fetch is calculated using radials around specific points for multiple wind directions. This method calculates effective fetch using nine radial lines spaced three degrees apart, with the final fetch distance being the average of these lines. A key aspect of this model is the ability to calculate weighted wind fetch by applying wind direction weighting percentages. This is essential for habitat management scenarios where different wind conditions are expected over time. The model produces raster outputs representing wind fetch, allowing integration with other environmental models such as wave prediction and sediment suspension. The USGS model emphasizes fine-scale environmental processes, adjusting for factors like water depth and wind speed, with added flexibility for updating as conditions change. The weighted wind fetch provides a dynamic approach to managing large-scale habitat restoration projects.

Figure 16 Results of the USGS wind fetch model (left) and AGRG model (right) calculated for south-west Nova Scotia.

In contrast, the focus outlined here is on property-specific risk assessments with a broader, static geographical approach. The fetch calculations are not weighted based on prevailing wind conditions but rather provide static maximum and average fetch distances for each property based on geographical features. The AGRG approach focuses on high-resolution coastal property analysis rather than habitat management, aiming to assess wind exposure risks such as erosion and wave run-up. Both use Python scripts for processing, but AGRG's process is highly tailored to geographic properties, emphasizing large-scale static analysis rather than adaptive management.

4.2 Model Improvements

The current implementation of the model is built in discrete sections and does not run as a single tool. Sections of the process are currently under development for external use. Major sections including the fetch coastline intersection component are functional and well optimized, however intermediate sections of the workflow are not fully implemented and. Thus, the process cannot be run full without additional intervention.

4.2.1 Improved datasets

The spatial relationship between the Nova Scotia Coastal Properties shapefile and the High-Water coastline shapefile provided is non-synchronous. Large portions of the High-Water coastline lie outside many coastal property polygons (Figure 16). As such, simple intersect or buffer selection processes are insufficient when attempting to isolate coastal properties. A more robust approach to identifying coastal properties is recommended as a straightforward way of improving this model's outputs. Water polygons should be excluded from analysis, while all terrestrial coastal properties should be included. This may include some manner of manual intervention or review on a case-by-case basis.

Figure 17 Instances of over and under inclusion in classification of coastal properties near Amherst Shore.

4.2.2 Efficiency

Future model iterations will include a revised approach for calculating intersections between lines of bearing and coastline segments. Rather than splitting the coastline by watershed and checking each line segment for intersections against each line of bearing (per coastline segment), the coastline will be split into grid cells. Intersections will first be performed for grid cells before checking line segments within the cell. As the relative position of grid cells to the point of origin of a line can be determined without having to check each cell using the slope of the line, the nearest intersecting grid cell containing coastline segments can be located near instantaneously. The intersecting line segment can then be located within the grid cell, avoiding calculations for many coastline segments that otherwise would have been pointlessly checked (Figure 13). This method has the potential to decrease processing time by a significant margin.

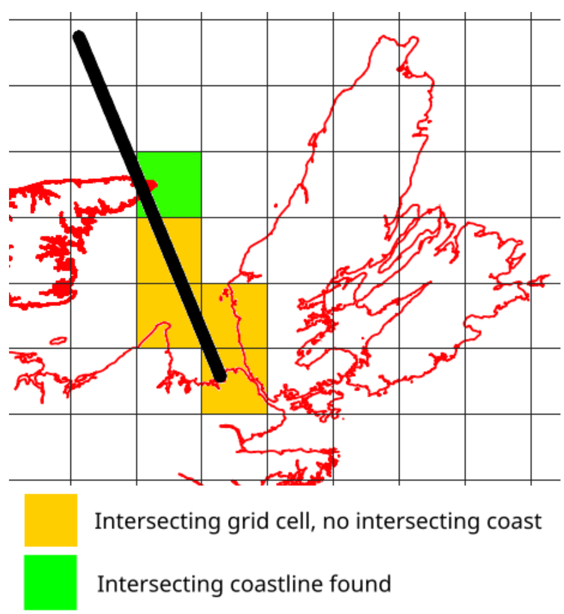


Figure 18 Intersection of grid cells. For demonstration purposes only

4.3 Validation

Validation for these data has been done visually and without a robust or systematic approach. Small computational errors on the other of a few meters is known at the 100 km maximum extent due to distortions in the universal transverse

Mercator projection at these distances, though this error is deemed insignificant in these cases. Some properties may have a misleading fetch assessment given this analysis only considers 16 cardinal directions of wind – but it is believed this impact to be relatively rare.

5 Conclusions

This process has been completed province wide based on the supplied coastline and property data. Preliminary analysis indicates that the results are perhaps adequate, and the tool is functioning as intended – tough the currently implementation does require some manual intervention. Next steps include refining the reporting of the tool as per the specific requirements of the NSECC coastal hazard system, as well as refining and the tool for the deployment outside of AGRG resources. This report presents work from an ongoing project.

6 Acknowledgements

We would like to thank the Nova Scotia Department of Environment and Climate Change for funding this project.

7 Appendix A: Data Dictionary

The following information is intended to help navigate data folders provided along with this report.

…\Deliverables\\<u>20241001_NSECC</u>

Folder containing all delivery data to accompany this report.

…\Deliverables\20241001_NSECC\\<u>preliminary_model</u>

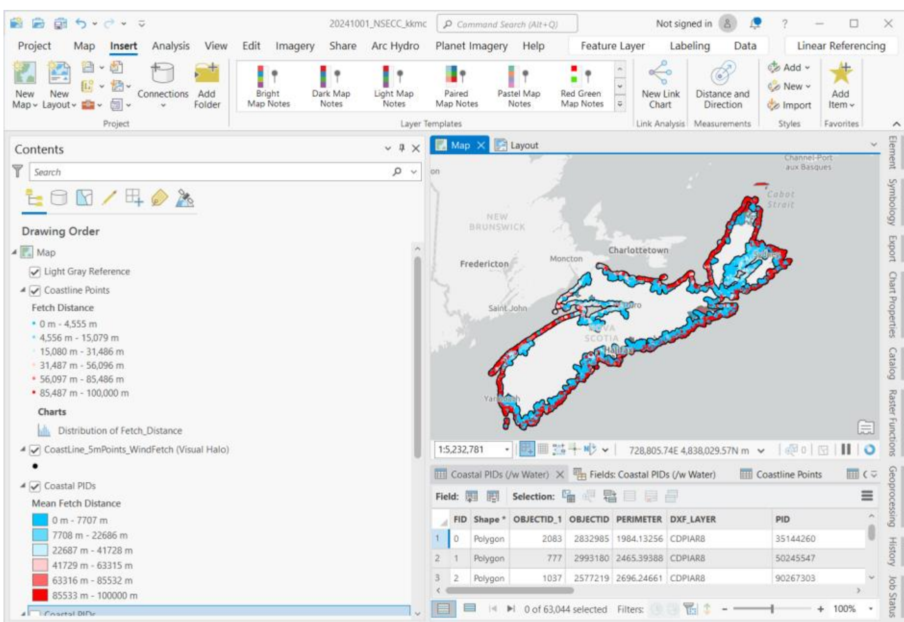
[TO BE INCLUDED]

This intention of this section is to provide tools which the NSECC can run locally to replicate this process. Unfortunately, due to some outstanding complexities in the process - unloading will require some refinement assistance from the AGRG staff in the coming weeks

…\Deliverables\20241001_NSECC\preliminary_model_results

Preliminary Results for the 2024 Nova Scotia Wind fetch model prepared by AGRG for NSECC. Layers include points every 5m along NS coast continuing largest wind fetch distance, and an example Property database containing Max, Mean, and standard deviation of coastline point wind fetch maximums within located with 10 meters of each property.

- **20241001_WindFetch_resultsMap.ppkx -** ArcGIS pro map package containing example results data as described in this report. Can be open with ArcGIS pro to explore data in a format similar to how it is presented. Example:



…\Deliverables\20241001_NSECC\preliminary_model_results\results_data

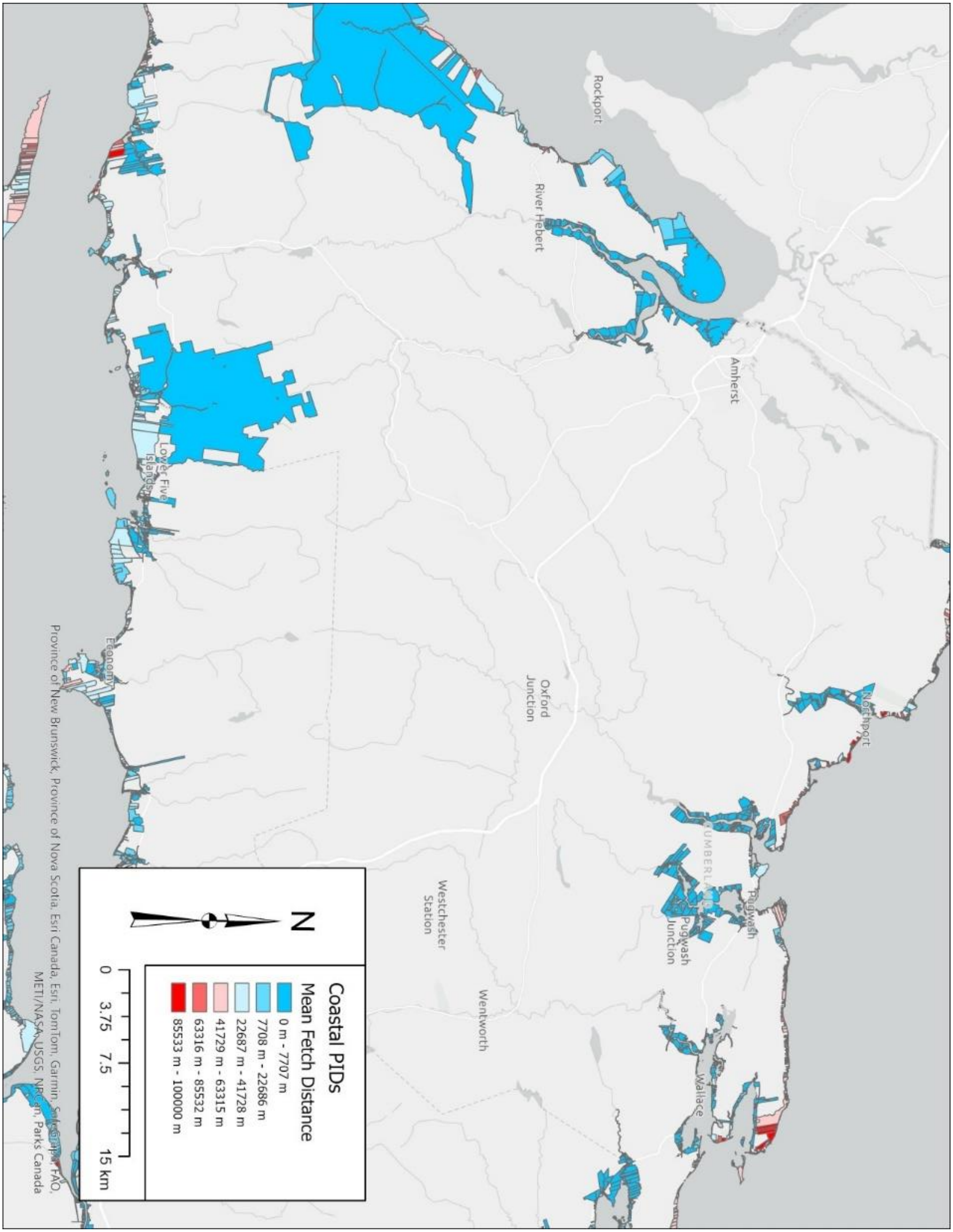
Shapefile copies of the result data packaged in the map package above. All data is presented in NAD83 CSRS UTM20N.

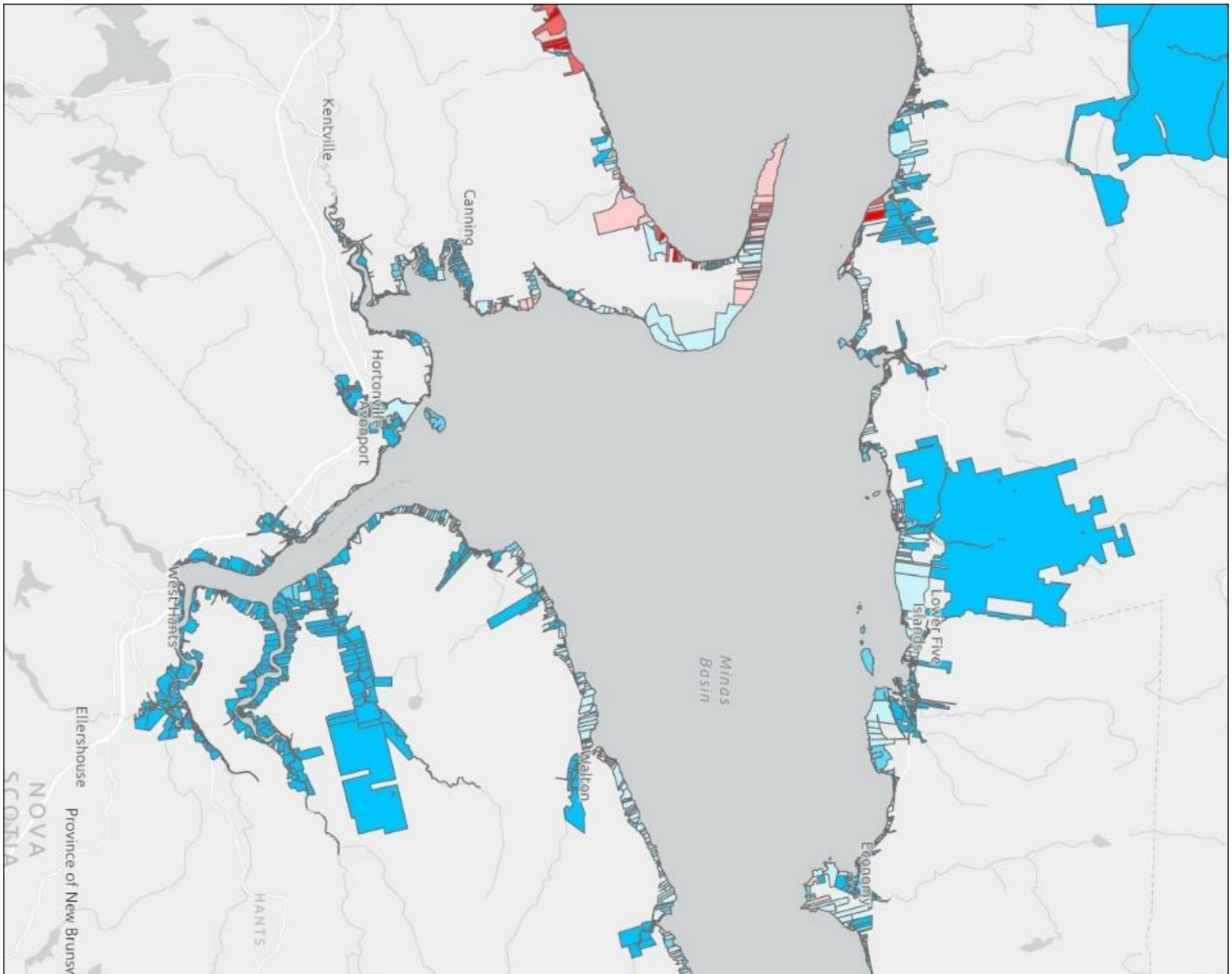
- **Lines_Of_Bearing_ALL_Filter.csv –** Raw output of the GPU process to detect intersection distance for each 5m point along the Nova Scotia Coastline. Contains Fetch_Distance (meters) and Bearing_Range (degree) fields which report the magnitude and direction of the maximum fetch per point, based on intersections with coastlines, per 16 cardinal directions – up to maximum distance of 100 km. Instances of multiple maximum fetch bearings (like at 100 km) will report multiple maximum bearing angles.
- **CoastLine_5mPoints_WindFetch.shp –** A geolocated shapefile version of the Lines_Of_Bearing_ALL_Filter.csv similarly containing the max Fetch_Distance (meters) and Bearing_Range (degree) for each 5m segment of the Nova Scotia Coastline.
- **Coastal_PIDs_WindFetch.shp** – copy of provided Coastal PID shapefile with the following additional fields:
    - **Fetch_Mean** – the AVAERAGE fetch max distance (in meters) from all coastline points within 10 meters
    - **Fetch_Max** – the MAX fetch max distance (in meters) from all coastline points within 10 meters
    - **Fetch_Std** - the STANDARD DEVIATION of fetch max distance (in meters) from all coastline points within 10 meters
- **Coastal_PIDs_WindFetch_noWater.shp -** A copy of Coastal_PIDs_WindFetch.shp (above) clipped by the water polygons (code WATO40) from the GeoNova Nova Scotia Hydrographic Network. This is used to remove water polygons from the provided PID database.

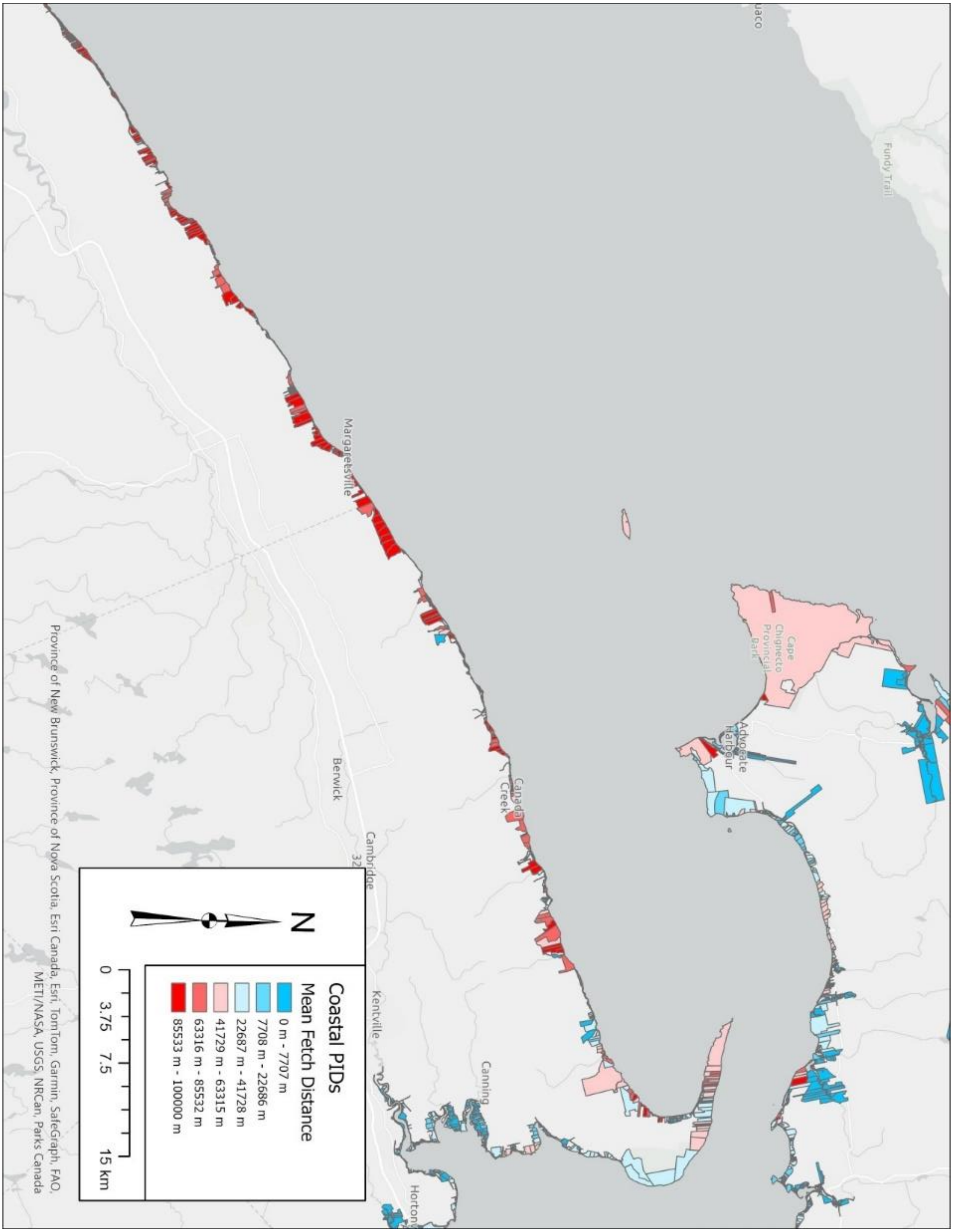
8 Appendix B: Results Map Series

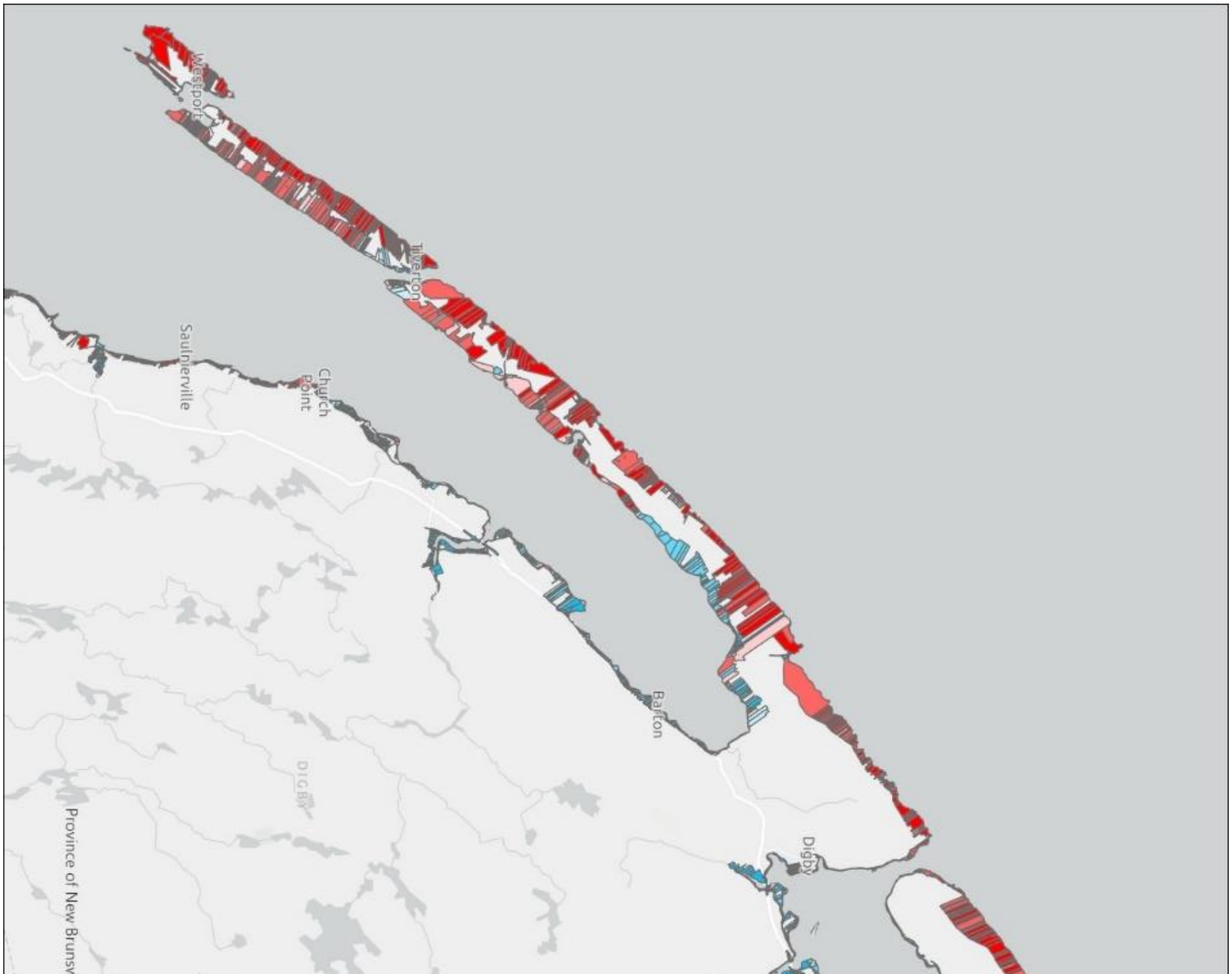
The following section contains a rough map series that covers the coastline of Nova Scotia at approximately 1:500,000 scale. This quickly shows our preliminary results across the province in relating the calculated max fetch points to each provided coastal property (PID). These maps show the MEAN aggregate of the calculated max fetch points along the coast within 10 meters of each property PID. An alternative way of showing the same data maybe the MAX aggregate fetch.

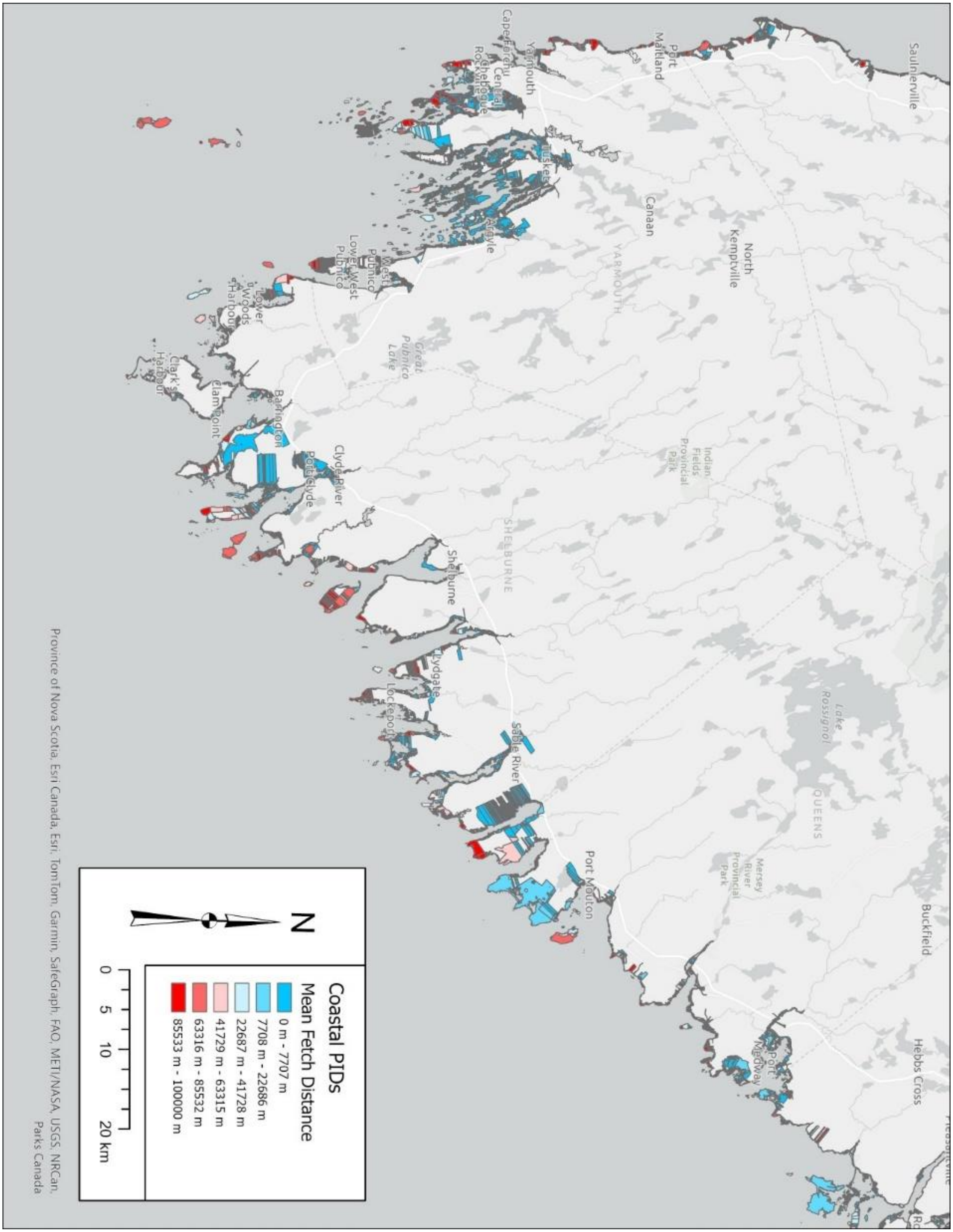
Similar plots can be constructed using the supplied map package outlined in the data dictionary
20241001_WindFetch_resultsMap.ppkx

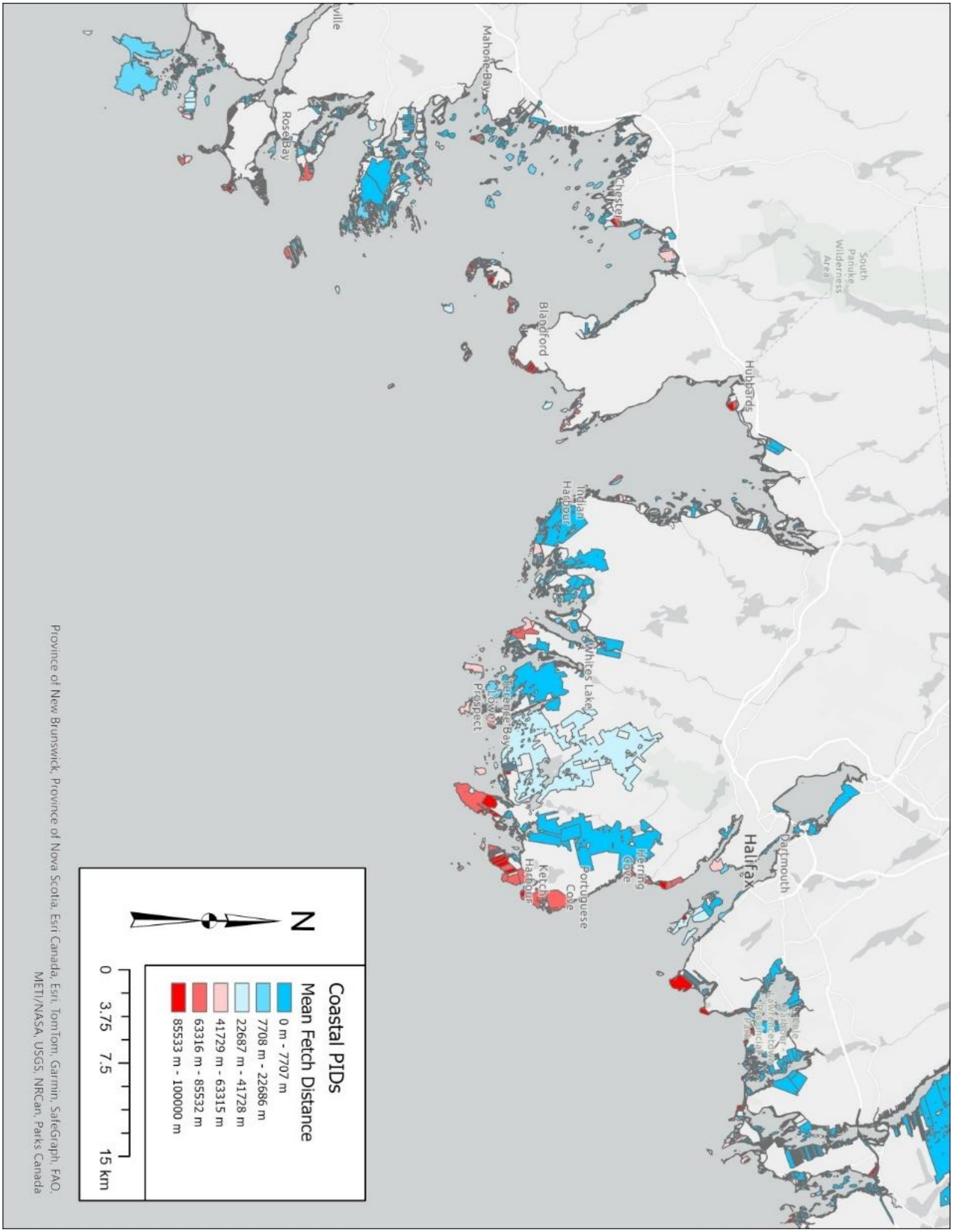

Rockport
River Hebert
Amherst
Lower Five Islands
Economy
Oxford Junction
Northport
Pugwash
Pugwash Junction
Westchester Station
Wentworth
Wallace
N
Coastal PIDs
Mean Fetch Distance
0 m - 7707 m
7708 m - 22686 m
22687 m - 41728 m
41729 m - 63315 m
63316 m - 85532 m
85533 m - 100000 m
0 3.75 7.5 15 km
Province of New Brunswick, Province of Nova Scotia, Esri Canada, Esri, TomTom, Garmin, SafeGraph, FAO, METI/NASA, USGS, NRCan, Parks Canada

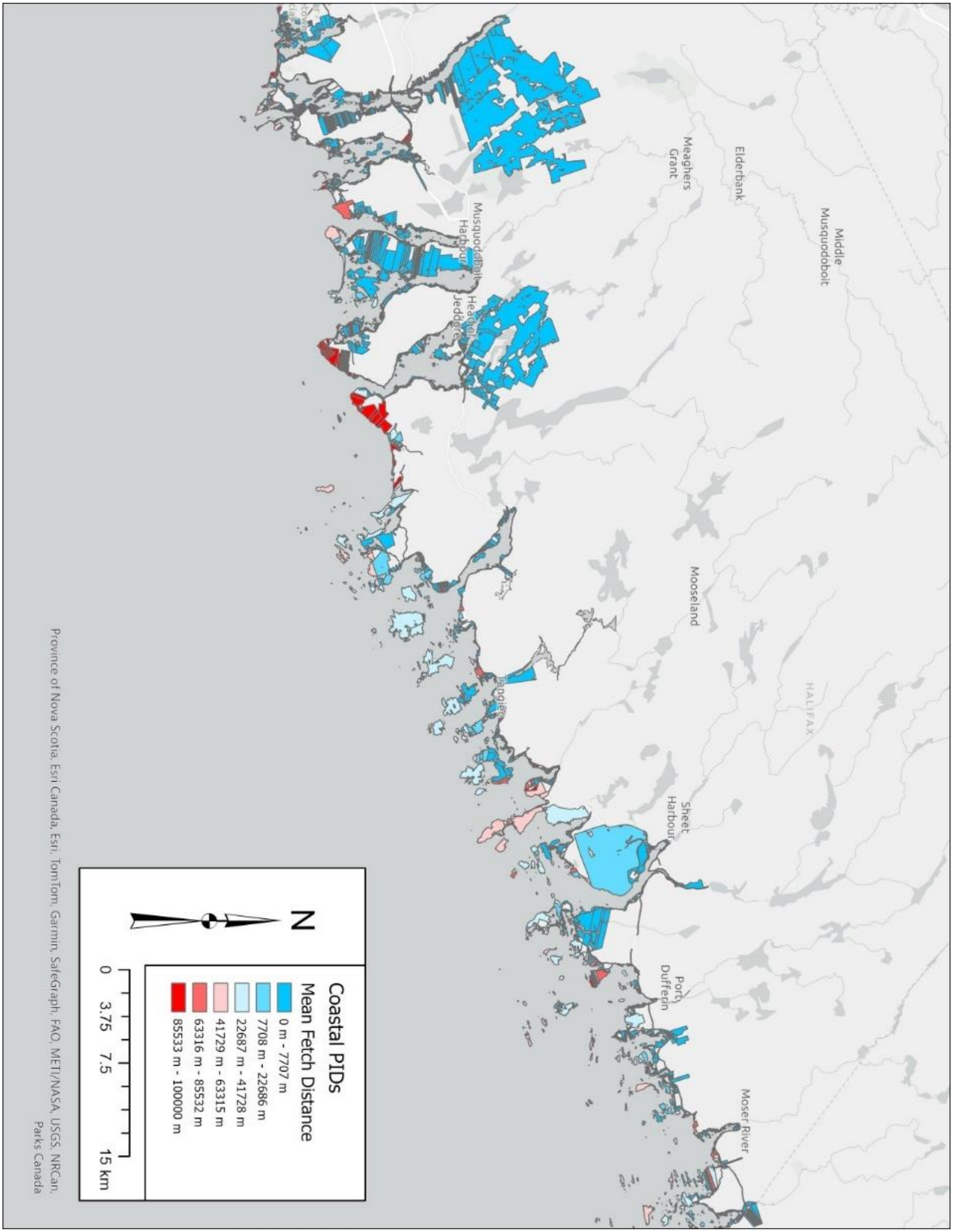

Coastal PIDs
Mean Fetch Distance
0 m - 7707 m
7708 m - 22686 m
22687 m - 41728 m
41729 m - 63315 m
63316 m - 85532 m
85533 m - 100000 m
0
3.75
7.5
15 km
N
Province of New Brunswick, Province of Nova Scotia, Esri Canada, Esri, TomTom, Garmin, SafeGraph, FAO, METI/NASA, USGS, NRCan, Parks Canada
Kentville
Canning
Hortonville
Avonport
West Hants
Ellershouse
Walton
Minas Basin
Lower Five Islands
Economy
Noel
Upper Kennetcook
Great Village
Londonderry
Debert

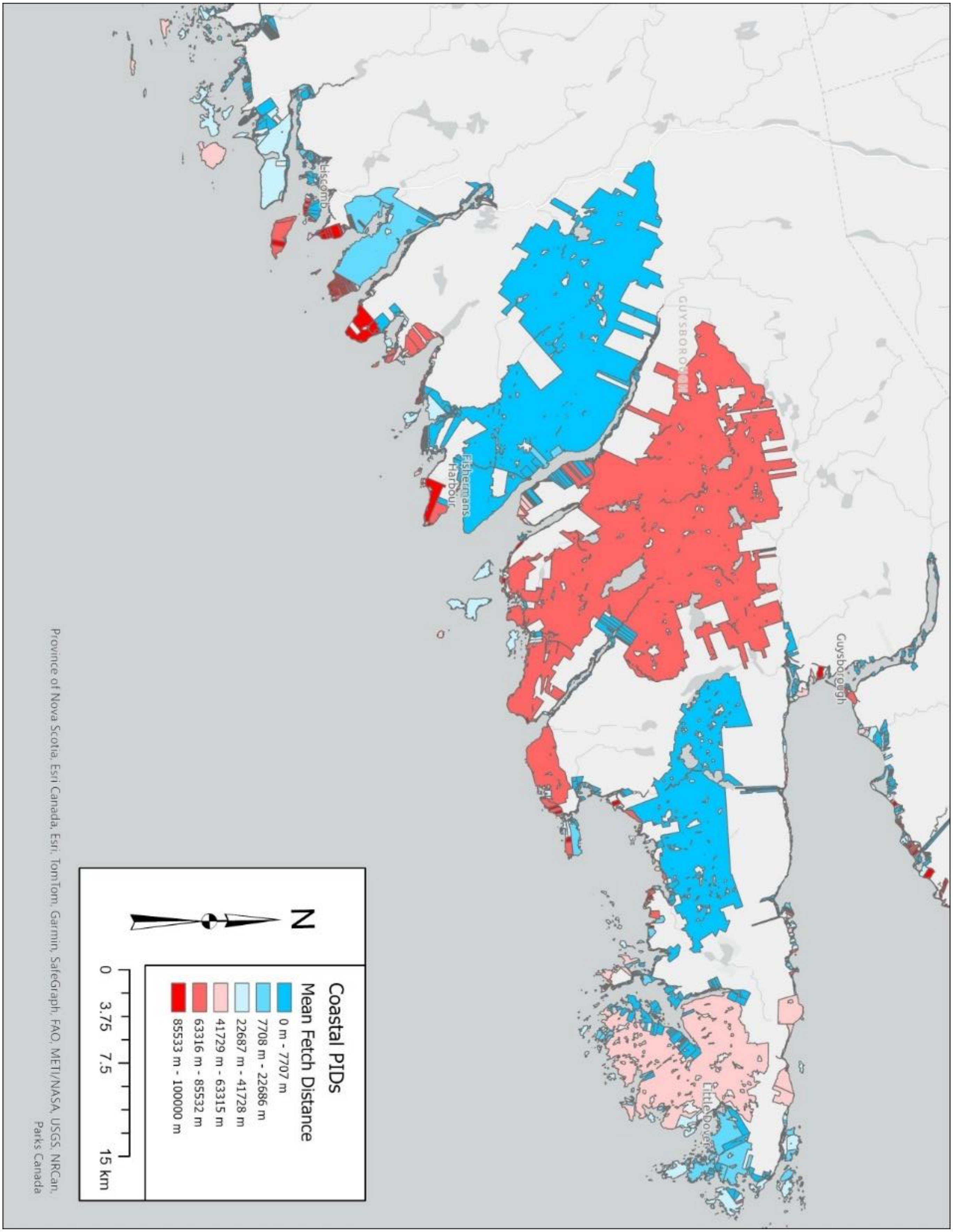

Coastal PIDs
Mean Fetch Distance
0 m - 7707 m
7708 m - 22686 m
22687 m - 41728 m
41729 m - 63315 m
63316 m - 85532 m
85533 m - 100000 m
N
0 3.75 7.5 15 km
Province of New Brunswick, Province of Nova Scotia, Esri Canada, Esri, TomTom, Garmin, SafeGraph, FAO, METI/NASA, USGS, NRCan, Parks Canada
Margaretsville
Berwick
Cambridge
Canada Creek
Kentville
Canning
Advocate Harbour
Cape Chignecto Provincial Park
Fundy Trail

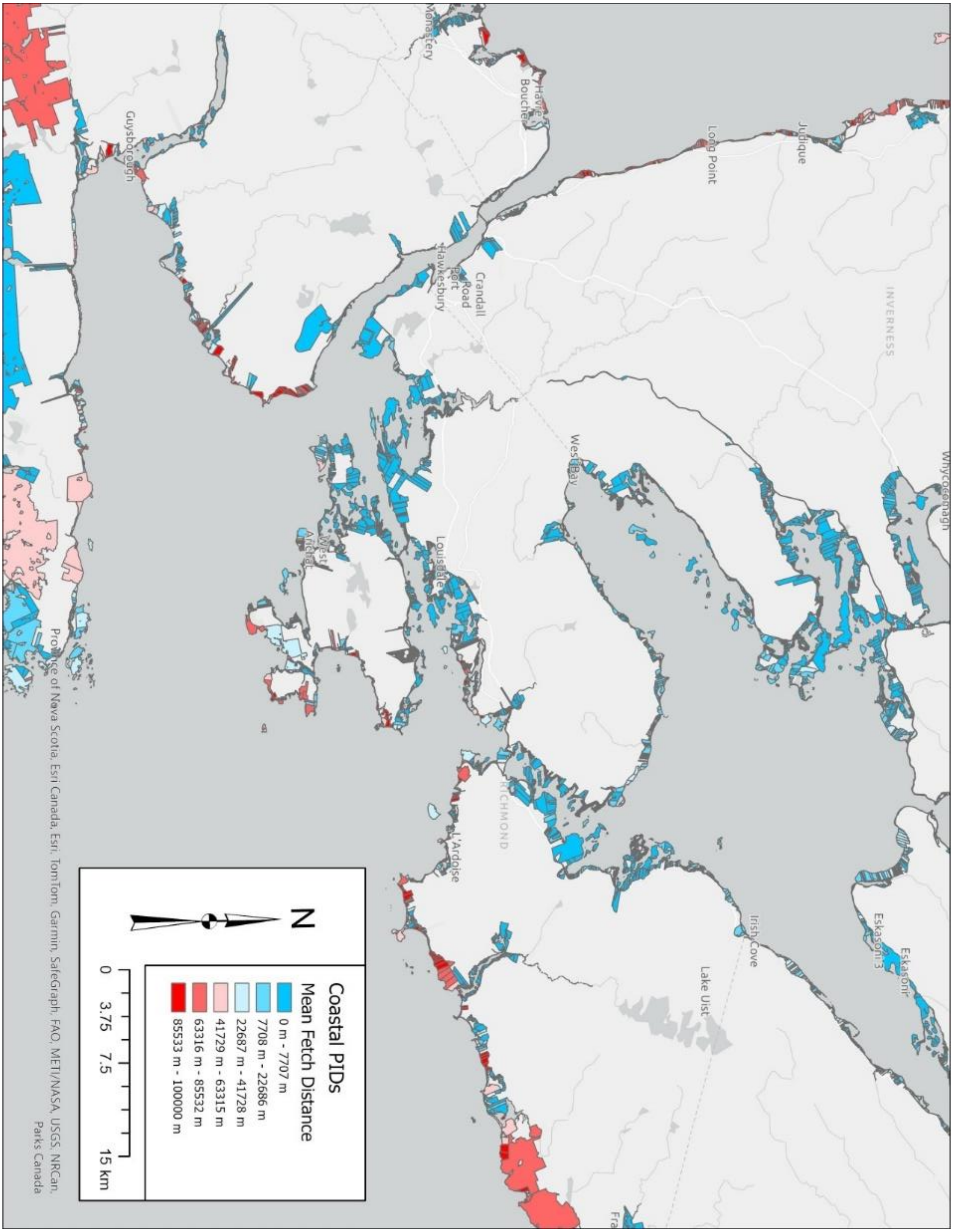

Westport
Tiverton
Saulnierville
Church Point
Barton
DIGBY
Digby
Bear River
Clementsport
Clementsvale
Annapolis Royal
ANNAPOLIS
N
Coastal PIDs
Mean Fetch Distance
0 m - 7707 m
7708 m - 22686 m
22687 m - 41728 m
41729 m - 63315 m
63316 m - 85532 m
85533 m - 100000 m
0 3.75 7.5 15 km
Province of New Brunswick, Province of Nova Scotia, Esri Canada, Esri, TomTom, Garmin, SafeGraph, FAO, METI/NASA, USGS, USFWS, NRCan, Parks Canada

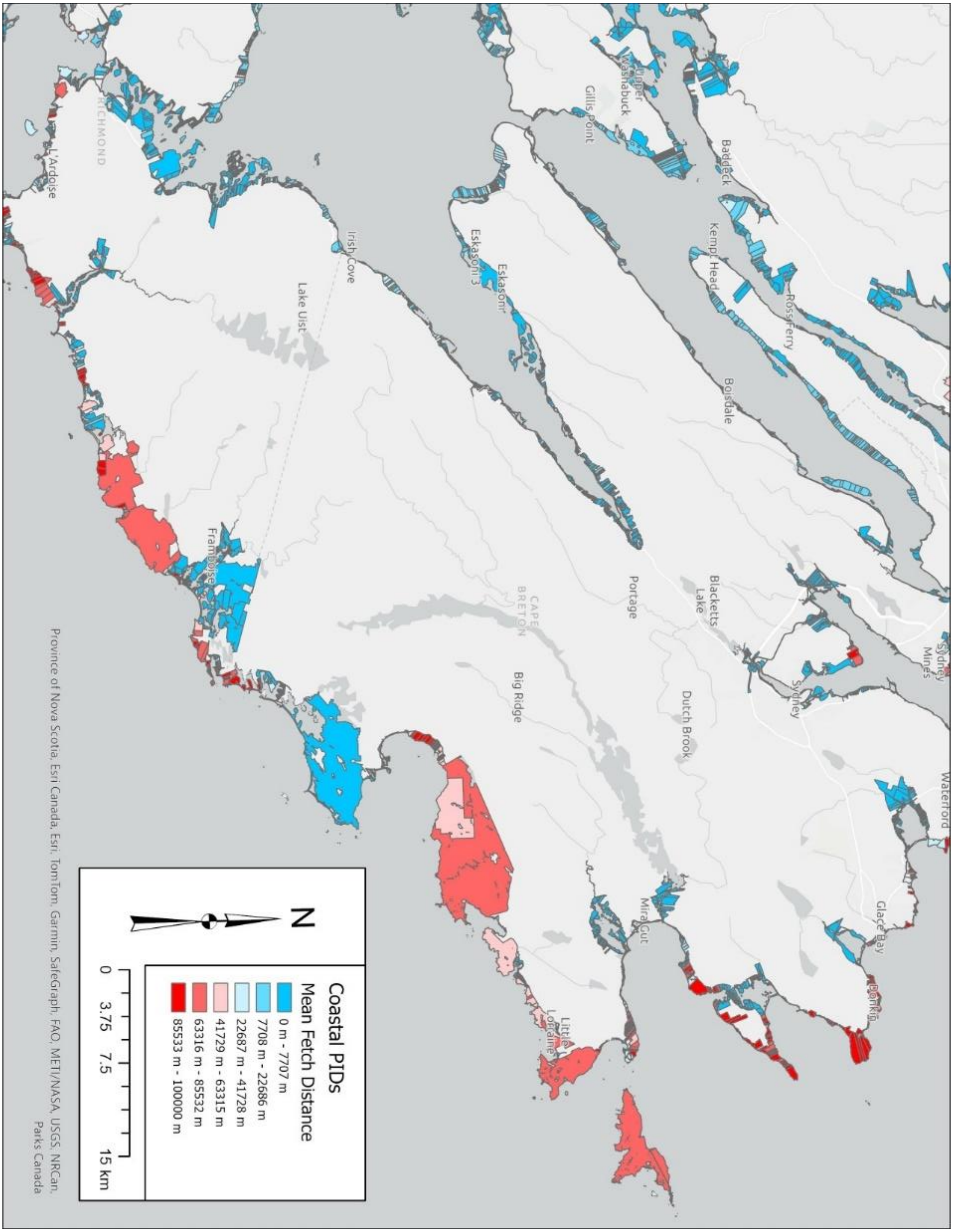

Coastal PIDs
Mean Fetch Distance
0 m - 7707 m
7708 m - 22686 m
22687 m - 41728 m
41729 m - 63315 m
63316 m - 85532 m
85533 m - 100000 m
N
0
5
10
20 km
Province of Nova Scotia, Esri Canada, Esri, TomTom, Garmin, SafeGraph, FAO, METI/NASA, USGS, NRCan, Parks Canada
Yarmouth
Port Maitland
Saulnierville
Canaan
North Kemptville
Argyle
Barrington
Clyde River
Shelburne
Lockeport
Sable River
Port Mouton
Port Medway
Buckfield
Hebbs Cross
Lake Rossignol
QUEENS
SHELBURNE
YARMOUTH

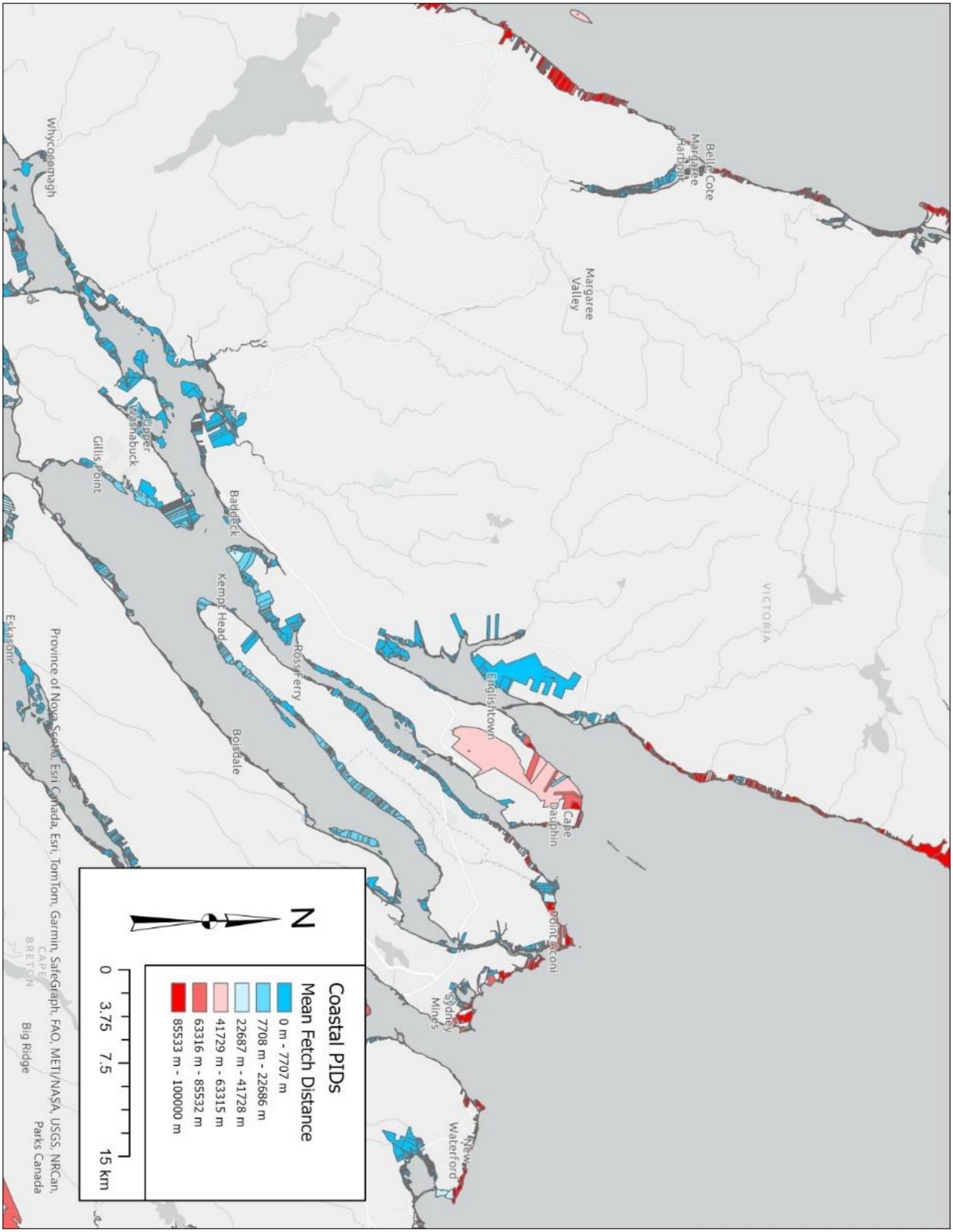

Coastal PIDs
Mean Fetch Distance
0 m - 7707 m
7708 m - 22686 m
22687 m - 41728 m
41729 m - 63315 m
63316 m - 85532 m
85533 m - 100000 m
0
3.75
7.5
15 km
N
Mahone Bay
Rose Bay
Chester
South Panuke Wilderness Area
Blandford
Hubbards
Indian Harbour
Whites Lake
Terence Bay
Lower Prospect
Prospect
Herring Cove
Portuguese Cove
Ketch Harbour
Halifax
Dartmouth
Province of New Brunswick, Province of Nova Scotia, Esri Canada, Esri, TomTom, Garmin, SafeGraph, FAO, METI/NASA, USGS, NRCan, Parks Canada

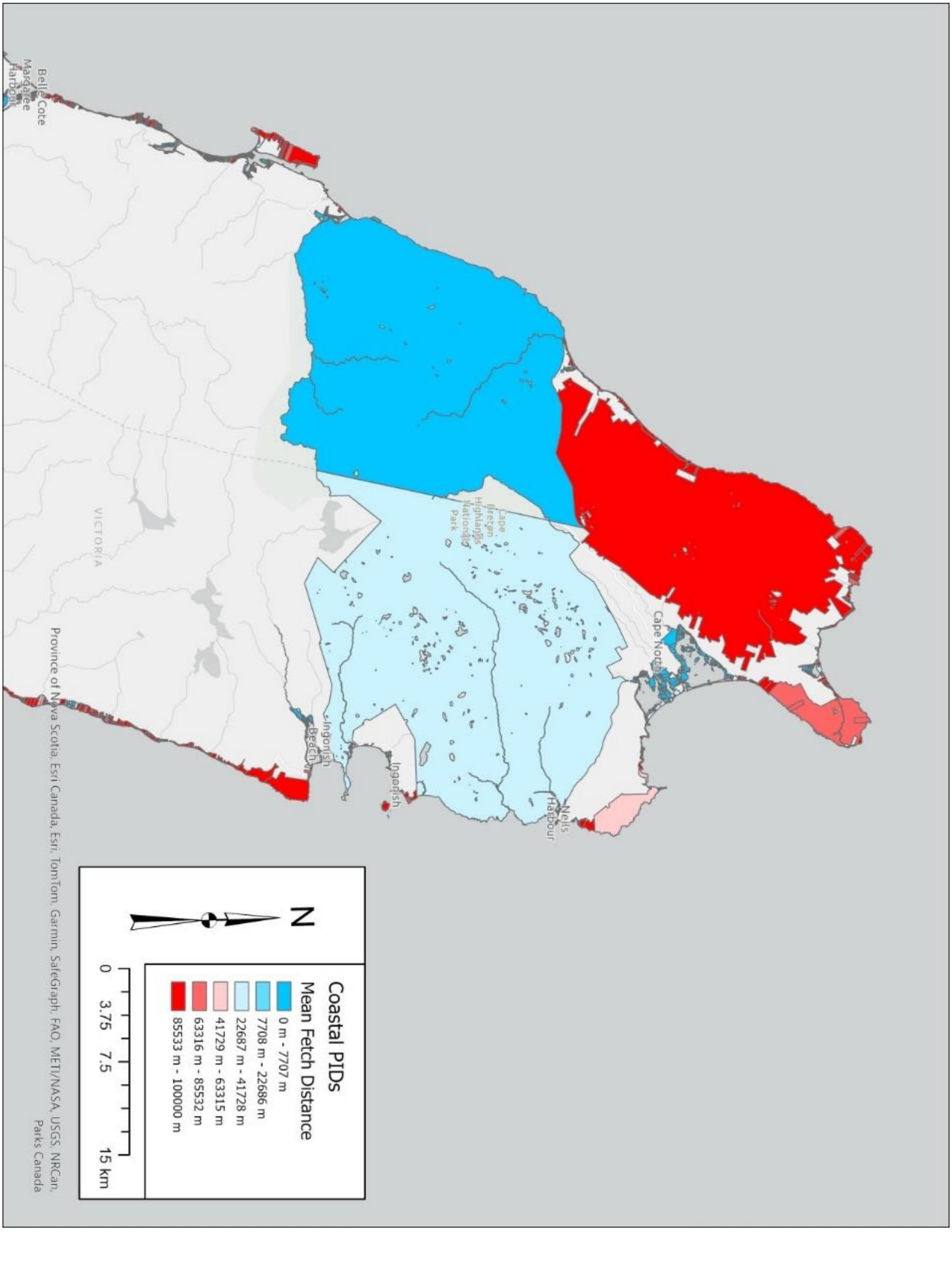

Coastal PIDs
Mean Fetch Distance
0 m - 7707 m
7708 m - 22686 m
22687 m - 41728 m
41729 m - 63315 m
63316 m - 85532 m
85533 m - 100000 m
0 3.75 7.5 15 km
N
Meaghers Grant
Elderbank
Middle Musquodoboit
Musquodoboit Harbour
Head of Jeddore
Mooseland
Sheet Harbour
Port Dufferin
Moser River
HALIFAX
Province of Nova Scotia, Esri Canada, Esri, TomTom, Garmin, SafeGraph, FAO, METI/NASA, USGS, NRCan, Parks Canada

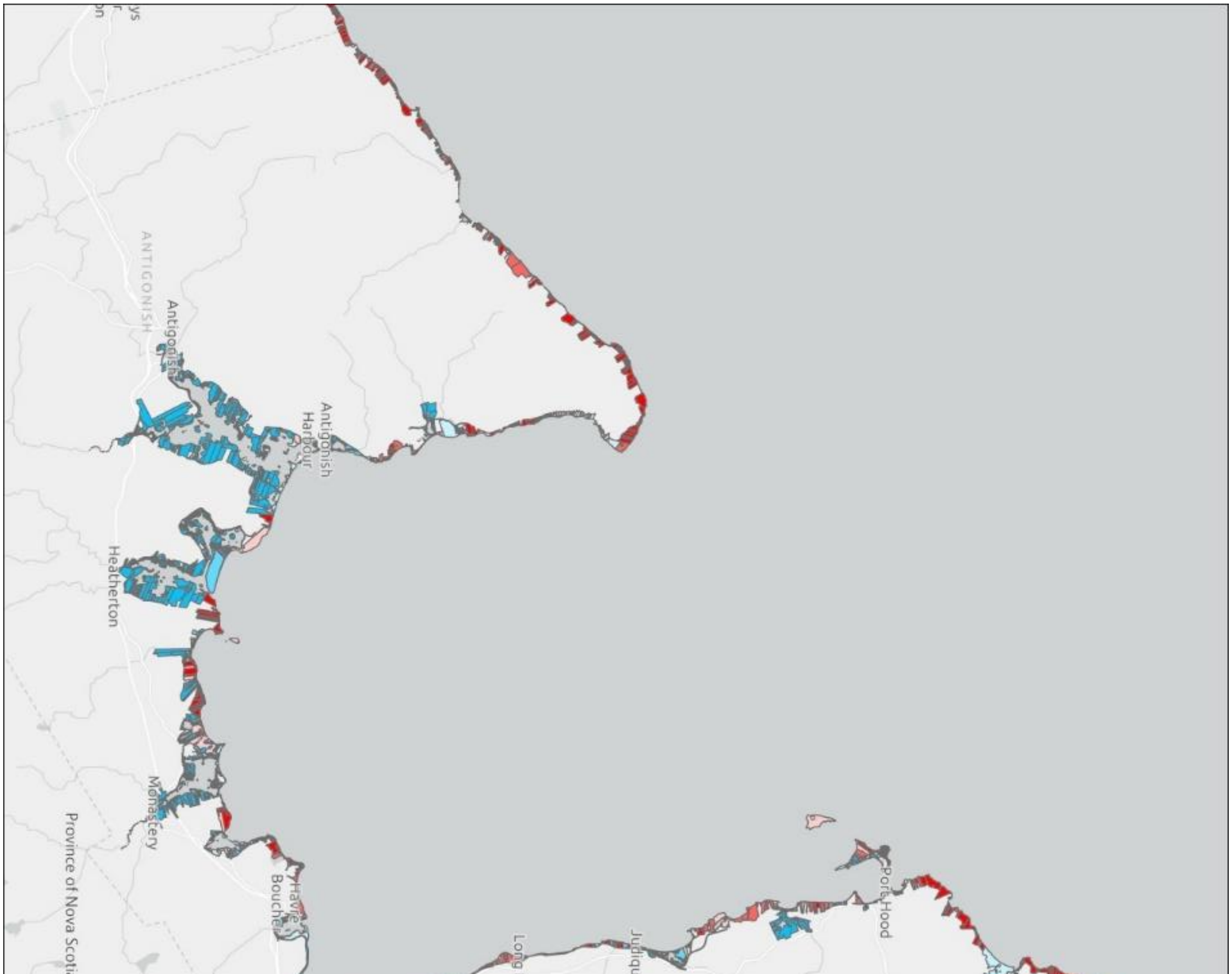

Liscomb
Fishermans Harbour
Guysborough
Little Dover
N
Coastal PIDs
Mean Fetch Distance
0 m - 7707 m
7708 m - 22686 m
22687 m - 41728 m
41729 m - 63315 m
63316 m - 85532 m
85533 m - 100000 m
0 3.75 7.5 15 km
Province of Nova Scotia, Esri Canada, Esri, TomTom, Garmin, SafeGraph, FAO, METI/NASA, USGS, NRCan, Parks Canada

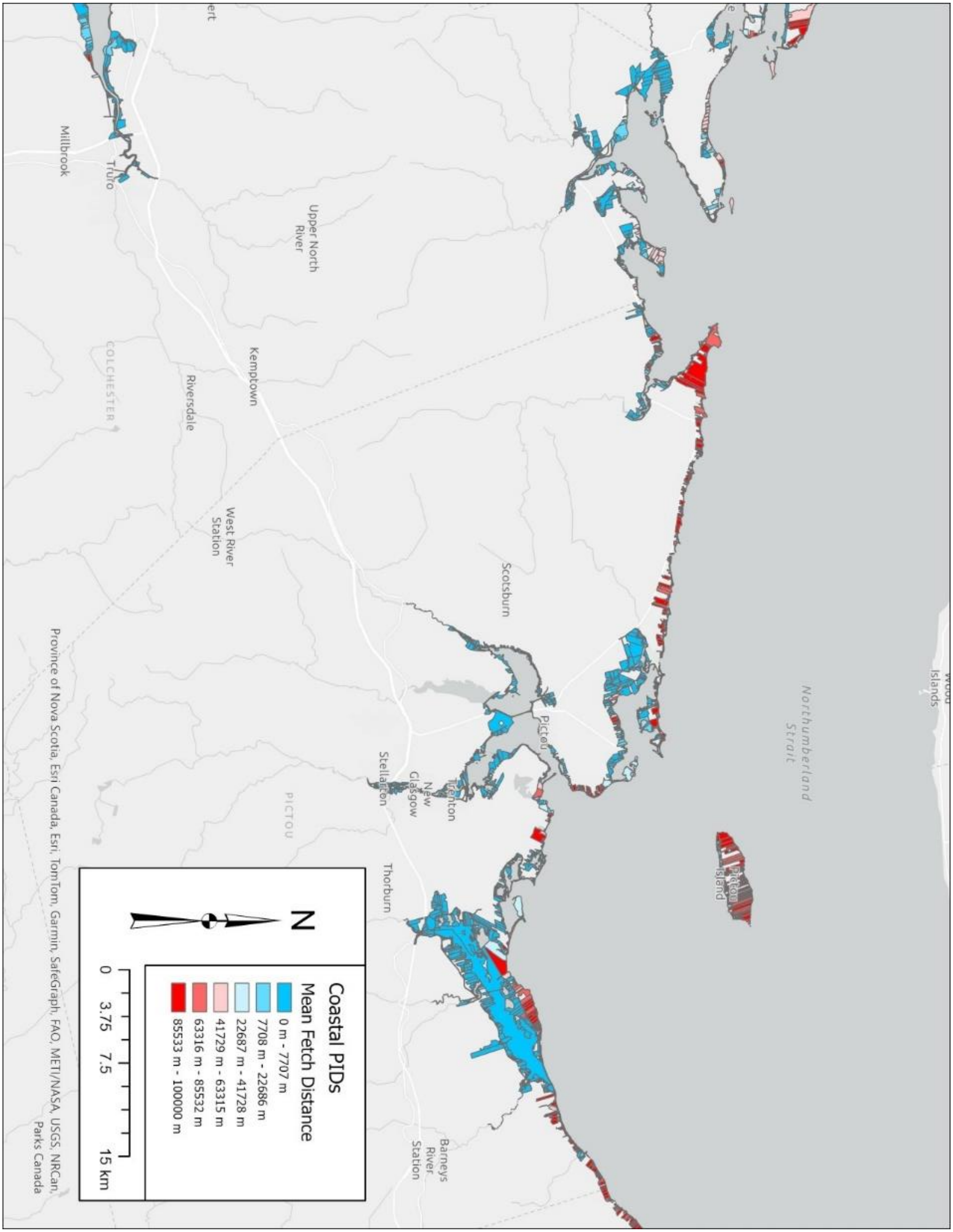

Monastery
Havre Boucher
Guysborough
Long Point
Judique
Port Hawkesbury
Crandall Road
INVERNESS
West Bay
Whycocomagh
West Arichat
Louisdale
RICHMOND
L'Ardoise
Irish Cove
Lake Uist
Eskasoni 3
Eskasoni
N
Coastal PIDs
Mean Fetch Distance
0 m - 7707 m
7708 m - 22686 m
22687 m - 41728 m
41729 m - 63315 m
63316 m - 85532 m
85533 m - 100000 m
0 3.75 7.5 15 km
Province of Nova Scotia, Esri Canada, Esri, TomTom, Garmin, SafeGraph, FAO, METI/NASA, USGS, NRCan, Parks Canada


Coastal PIDs
Mean Fetch Distance
0 m - 7707 m
7708 m - 22686 m
22687 m - 41728 m
41729 m - 63315 m
63316 m - 85532 m
85533 m - 100000 m
N
0
3.75
7.5
15 km
Province of Nova Scotia, Esri Canada, Esri, TomTom, Garmin, SafeGraph, FAO, METI/NASA, USGS, NRCan, Parks Canada
L'Ardoise
RICHMOND
Irish Cove
Lake Uist
Eskasoni 3
Eskasoni
Gillis Point
Upper Washabuck
Baddeck
Kempt Head
Ross Ferry
Boisdale
Framboise
CAPE BRETON
Portage
Blacketts Lake
Big Ridge
Dutch Brook
Sydney
Sydney Mines
Waterford
Glace Bay
Donkin
Mira Gut
Little Lorraine


Coastal PIDs
Mean Fetch Distance
0 m - 7707 m
7708 m - 22686 m
22687 m - 41728 m
41729 m - 63315 m
63316 m - 85532 m
85533 m - 100000 m
N
0 3.75 7.5 15 km
Province of Nova Scotia, Esri Canada, Esri, TomTom, Garmin, SafeGraph, FAO, METI/NASA, USGS, NRCan, Parks Canada
Whycocomagh
Margaree Harbour
Belle Cote
Margaree Valley
Upper Washabuck
Gillis Point
Baddeck
Kempt Head
Ross Ferry
Englishtown
Boisdale
Cape Dauphin
Point Aconi
Sydney Mines
New Waterford
Eskasoni
Big Ridge
VICTORIA
CAPE BRETON


Coastal PIDs
Mean Fetch Distance
0 m - 7707 m
7708 m - 22686 m
22687 m - 41728 m
41729 m - 63315 m
63316 m - 85532 m
85533 m - 100000 m
0 3.75 7.5 15 km
N
Belle Cote
Margaree Harbour
VICTORIA
Cape Breton Highlands National Park
Cape North
Ingonish Beach
Ingonish
Neils Harbour
Province of Nova Scotia, Esri Canada, Esri, TomTom, Garmin, SafeGraph, FAO, METI/NASA, USGS, NRCan, Parks Canada


Antigonish
Antigonish Harbour
ANTIGONISH
Heatherton
Monastery
Havre Boucher
Long Point
Judique
Port Hood
Mabou
INVERNESS
Whycocomagh
Coastal PIDs
Mean Fetch Distance
0 m - 7707 m
7708 m - 22686 m
22687 m - 41728 m
41729 m - 63315 m
63316 m - 85532 m
85533 m - 100000 m
N
0 3.75 7.5 15 km
Province of Nova Scotia, Esri Canada, Esri, TomTom, Garmin, SafeGraph, FAO, METI/NASA, USGS, NRCan, Parks Canada


Coastal PIDs
Mean Fetch Distance
0 m - 7707 m
7708 m - 22686 m
22687 m - 41728 m
41729 m - 63315 m
63316 m - 85532 m
85533 m - 100000 m
N
0
3.75
7.5
15 km
Millbrook
Truro
Upper North River
Kemptown
Riversdale
COLCHESTER
West River Station
Scotsburn
Pictou
Stellarton
New Glasgow
Trenton
PICTOU
Thorburn
Barneys River Station
Pictou Island
Northumberland Strait
Province of Nova Scotia, Esri Canada, Esri, TomTom, Garmin, SafeGraph, FAO, METI/NASA, USGS, NRCan, Parks Canada

9 Additional Data and Tools

Describe any additional data or tools provided along with this document not directly related to the process

https://github.com/KennethTM/WindFetch

https://github.com/kkmcgg/experiments/blob/main/kkmc_windFetch_NS.ipynb

https://github.com/kkmcgg/experiments/blob/main/kkmc_fetch_maybe_modified_rorated_NS.ipynb

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