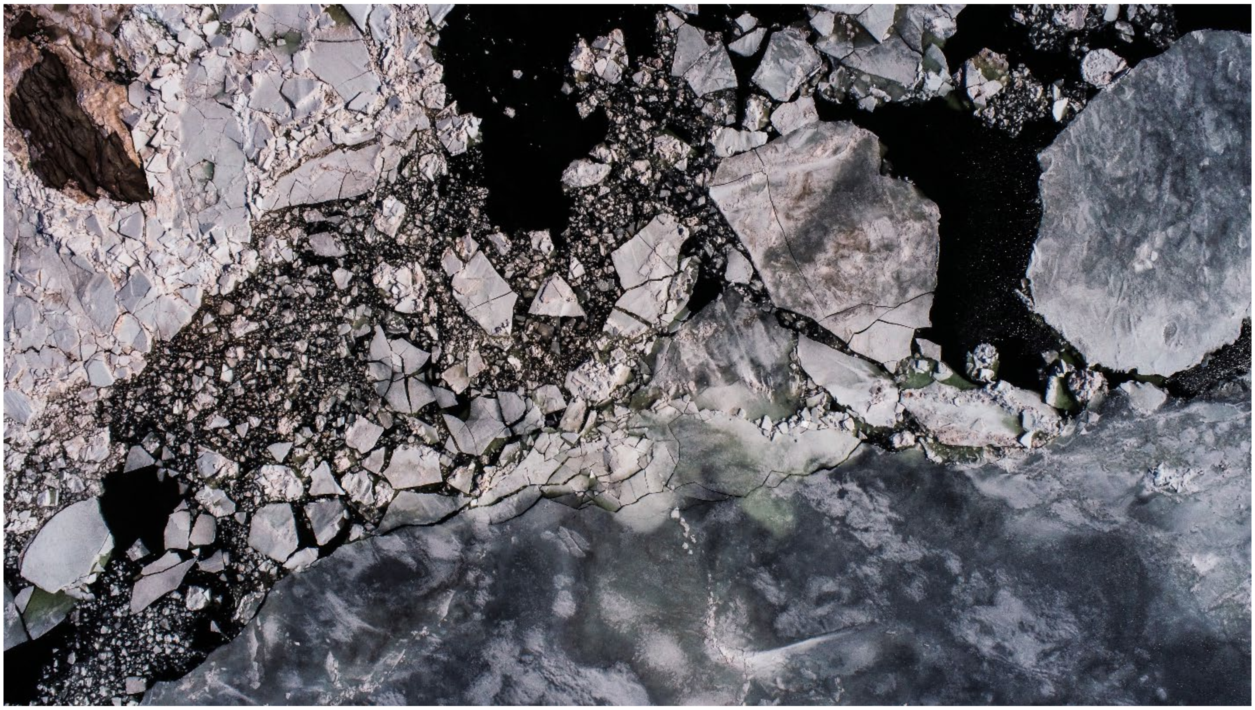

SEATAC Sea Ice Data Collection

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EXECUTIVE SUMMARY

During the months of February, March, and April of 2023 four trips were made for data collection up to the study area along the north shore of the Northumberland Strait near River John. Imagery was collected using two RPAS, a DJI Mavic Pro and a DJI M300 with an attached L1 sensor. This imagery was mosaicked and orthorectified into 13 orthomosaic images stored in TIF format. In addition to these orthomosaics, screen recordings of the M300 controller, field photos, satellite data, RPAS video, and meteorological data from local weather stations were included. The data was organized and uploaded to the NSCC's SharePoint cloud storage and shared with members of SEATAC. The folder structure is as follows:

- ControllerRecordings
- DroneOrthophotos
- FieldPhotos
- SatelliteData
- Video
- WeatherData

Additional clarifications or requests may be forwarded to Thomas Allen (Thomas.Allen2@nscc.ca)

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1. INTRODUCTION

The purpose of this project is to collect data for SEATAC to use in the exploration of the monitoring of sea ice using imagery collected with RPAS (remotely piloted aircraft system), referred to colloquially as "drones", for seafaring vessels deployed during the ice season. AGRG chose a study area along the shore of the Northumberland Strait in an area near River John for its familiarity, ease of access, and frequent inundation of sea ice. This area is also near two weather stations run by AGRG to provide relevant meteorological data. A rough outline of this study area can be seen in *Figure 1*.

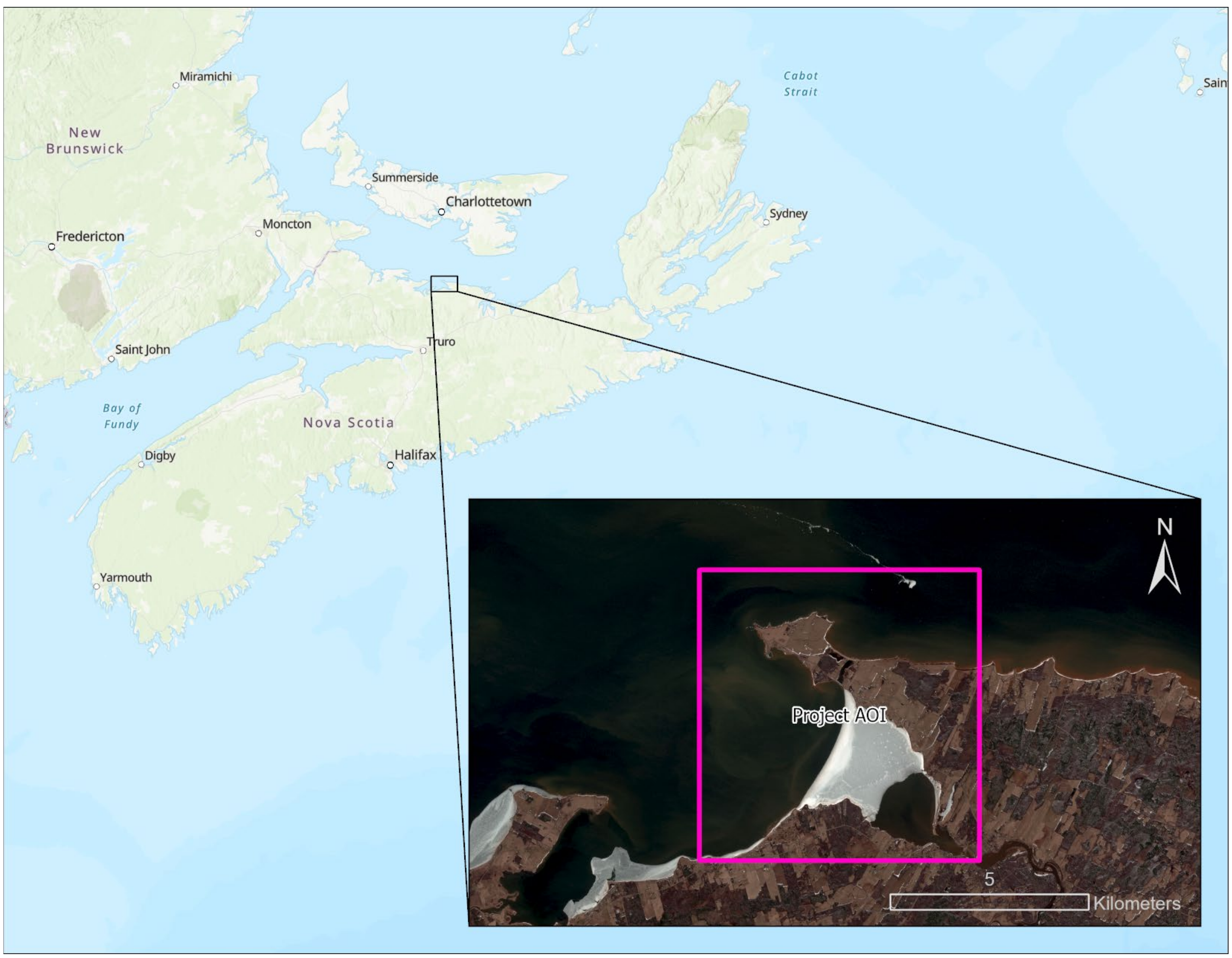

Figure 1 A rough outline of the study area for the project, overlain on Sentinel-2 imagery from the fourth and final day of fieldwork.

2. METHODS

2.1 Fieldwork

Over the course of the work done by AGRG as part of this project, four visits to the main River John study area were made. These days were chosen on short notice, mainly based on the amount of sea ice known to be in the area from satellite imagery and the forecasted meteorological conditions to determine if it is safe to operate the RPAS. Temperature and wind speed were the main concerns in drone flying. *Table 1* contains information on the dates of the visits, number of flights, RPAS used, and the areas flown in. For reference, the overall River John study area is split into two smaller areas that will be referred to as Meg's Cove and John Bay. The locations of these two areas within the main study area can be seen in *Figure 2*. On the third day of fieldwork, John Stratton of SEATAC joined AGRG in the field to see the work being done for the project and ensure desirable data was collected.

<table>
<tr><th>Date</th><th>Flight #</th><th>RPAS</th><th>Area</th></tr>
<tr><td rowspan="3">February 13th, 2023</td><td>1</td><td rowspan="3">M300 + L1</td><td rowspan="3">Meg's Cove</td></tr>
<tr><td>2</td></tr>
<tr><td>3</td></tr>
<tr><td rowspan="5">February 27th, 2023</td><td>1</td><td rowspan="3">M300 + L1</td><td rowspan="2">Meg's Cove</td></tr>
<tr><td>2</td></tr>
<tr><td>3</td><td>John Bay</td></tr>
<tr><td>1</td><td rowspan="2">Mavic Pro</td><td>Meg's Cove</td></tr>
<tr><td>2</td><td>John Bay</td></tr>
<tr><td rowspan="3">March 22nd, 2023</td><td>1</td><td rowspan="3">M300 + L1</td><td rowspan="2">Meg's Cove</td></tr>
<tr><td>2</td></tr>
<tr><td>3</td><td>John Bay</td></tr>
<tr><td rowspan="4">April 3rd, 2023</td><td>1</td><td rowspan="3">M300 + L1</td><td rowspan="3">John Bay</td></tr>
<tr><td>2</td></tr>
<tr><td>3</td></tr>
<tr><td>1</td><td>Mavic Pro</td><td>John Bay</td></tr>
</table>

Table 1 RPAS flights, sorted by date and area. Note that flight numbers are counted separately on each drone.

Figure 2 Meg's Cove and John Bay study areas.

2.2 Equipment

In order to fulfill the needs of this project two RPAS were used. The DJI M300 with the L1 sensor attached (*Figure 4*), and the DJI Mavic Pro (*Figure 3*) with its built-in camera sensor. These two units were selected to give contrast between the overall quality of the data collected and ease of use in an older, lower cost system and a much newer and more expensive system with more features.

The Mavic Pro is a compact, foldable RPAS released in 2016 at an MSRP of $999 USD, weighs 734g, is capable of recording 4k photo and video on its built-in camera system, and an estimated maximum flying time of 27 minutes on one battery with no wind. The M300 is an RPAS system meant to be used a platform to attach whatever sensor or sensors are needed for a given job. The M300 has an MSRP of $12,500 USD, weighs 6.3kg when both batteries are installed, and an estimated maximum flying time of 55 minutes on one set of two batteries with no wind. One further difference to consider is the Mavic operates planned flights with a mobile app, while the controller for the M300 has everything needed built into the unit, further simplifying M300 operation. Thanks to the size and power of the M300, the unit is also much more capable when flying during periods of high winds that smaller RPAS like the

Mavic Pro cannot fly in. One last difference between the two is the M300's ability to use real-time kinematic (RTK) positioning to provide the unit with real-time corrections to its positioning for a significant increase in positional accuracy without any extra work in post-processing the data. This makes a difference when processing the photos taken by the RPAS into orthophotos, as will be discussed in section 2.3 RPAS Data Processing.

The L1 sensor used with the M300 for this project was chosen for its high quality RGB imagery that works well with the software AGRG uses to process them.

Figure 3 The DJI Mavic Pro RPAS.

Figure 4 AGRG's DJI M300 system with the L1 sensor attached.

2.3 RPAS Data Processing

To process the data collected by the Mavic Pro and M300, Agisoft Metashape was used to perform photogrammetry on the photographs taken with both RPAS. Photogrammetry was used in this project to align and combine (mosaic) all the photos collected by the RPAS in a given flight, and then geometrically correct or “orthorectified” to create what are referred to as orthophotos. This process minimizes distortion and the tilting of objects at the edges of the photos to create a product that is more useful as a map and better representative of real-life geometry. The process is only slightly different between the two RPAS, as the previously mentioned RTK functionality of the M300 allows for faster initial alignment of photos within the Metashape software and more accurate positioning of the orthophoto/orthomosaic. An example of one of the orthomosaics can be seen in *Figure 5*.

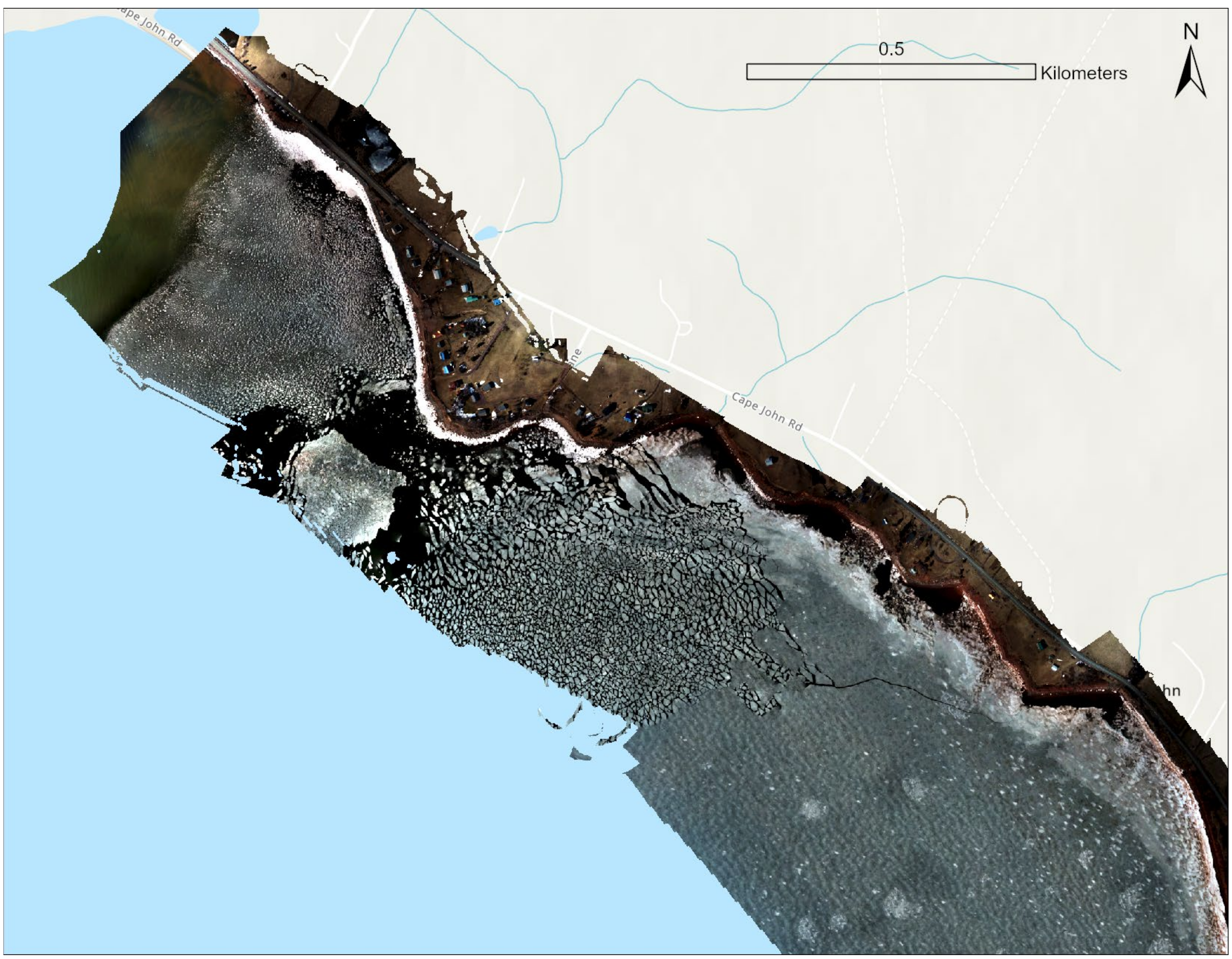

Figure 5 Example screenshot from a section of the April 3rd orthomosaic.

2.4 Supplemental Data

To further support the analysis of the data by SEATAC, meteorological data was gathered and included with the other data collected and processed by AGRG. Four sources were used. Two weather stations operated by AGRG along the coast of the Meg's Cove site, one run by Environment Canada along the coast, east of the project's AOI seen in *Figure 6*, and one station on Pictou Island with data retrieved from the Weather Underground website. The two stations run by AGRG were selected due to their proximity to the study area and more frequent observations compared to Environment Canada stations. AGRG's stations record data in intervals of 15 minutes, while Environment Canada station collects data every hour. The Caribou Point station was included in the data for this project as it has wind data, and the Pictou Island station was included to compensate for missing data in the Caribou Point station for the final visit to the study area. Unfortunately, the temperature sensor on one of the AGRG weather stations malfunctioned, starting February 27th, while the other never had a working temperature sensor. After this date, temperature data will need to be used from the Caribou Point station, with the exception of the last trip, where the Pictou Island station will need to be used.

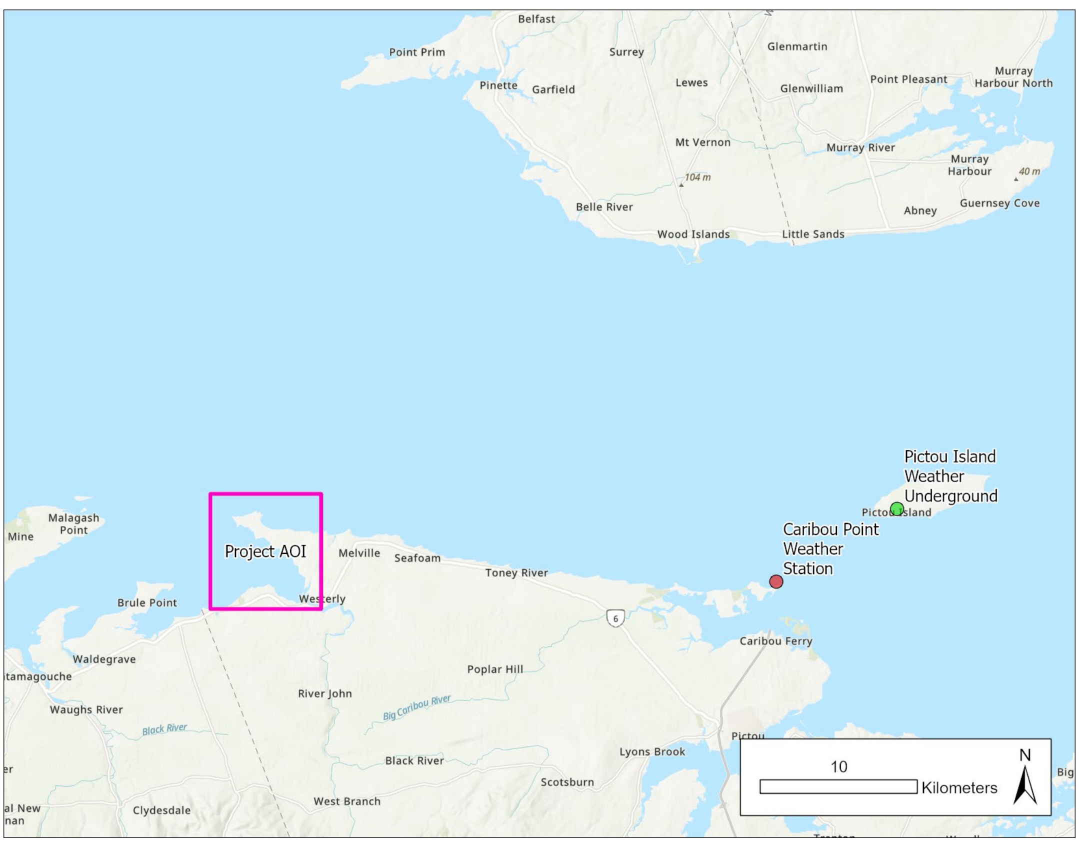

Figure 6 Location of Caribou Point Environment Canada weather station and Pictou Island station. The two AGRG-run weather stations are located within the "Project AOI".

Figure 7 One of AGRG's weather stations deployed within the study area.

3. RESULTS

3.1 Data Processing

Processing of the RPAS imagery into orthomosaics yielded one orthomosaic per flight as seen in *Table 1*, with the exception of the M300 flights on the final day of fieldwork, where all three flights were processed into one large orthomosaic. This makes for a total of 13 orthomosaics, all stored as TIF (tag image file format) images. These orthomosaics are recommended to be viewed using GIS software, due to their size and being georeferenced. This means that they can be placed on a map and viewed with related geospatial data. Esri's ArcGIS Pro and ArcMap are popular pieces of GIS software that can be used to view this data, though a paid license is needed to use it. A recommended free and open-source alternative to Esri products is QGIS.

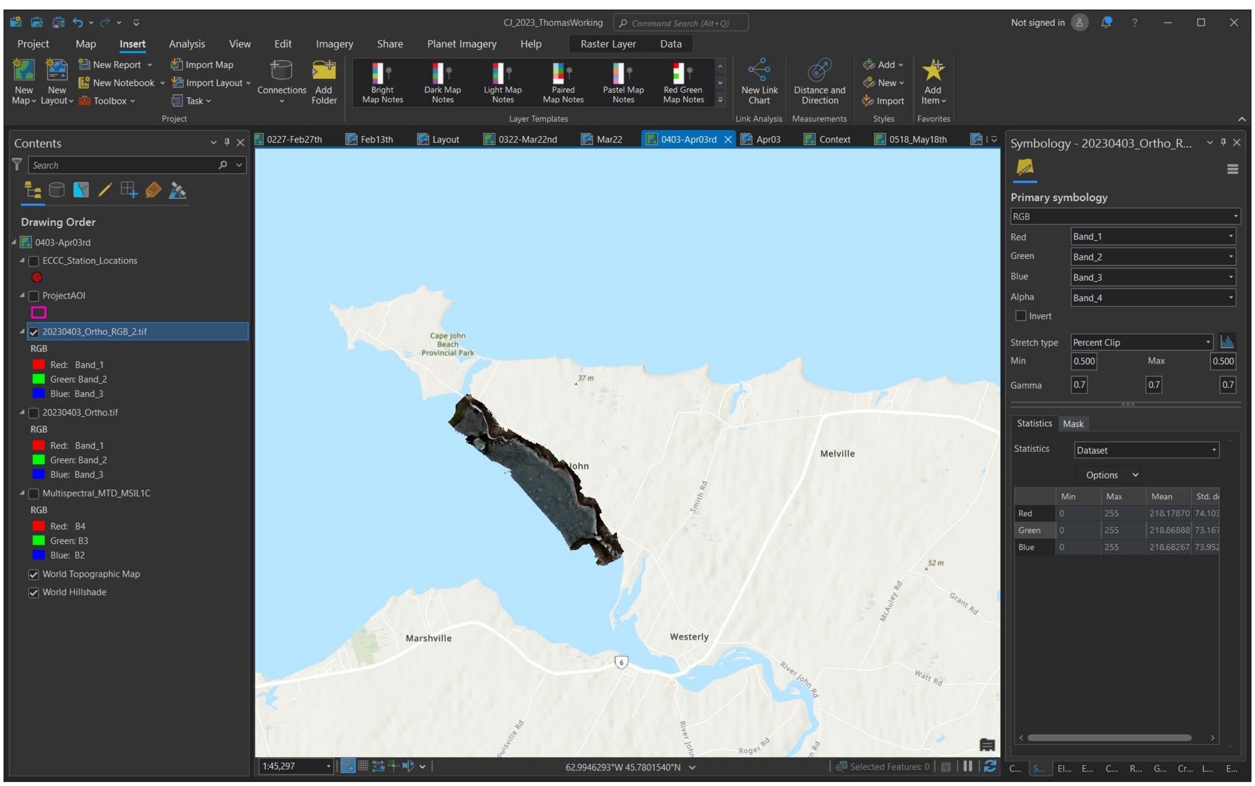

Figure 8 Viewing an orthomosaic using Esri's ArcGIS Pro.

3.2 Data Storage and Sharing

For its ease of use and no significant limitations put on storage space, Microsoft Teams was used as an interface with NSCC's SharePoint cloud storage system to upload, organize, and share the project's data with members of SEATAC. The data collected and processed over the course of the project is organized into folders accordingly:

Figure 9 View of the folder structure as seen in the Microsoft Teams interface.

- ControllerRecordings
    - Screen capture recordings of the M300 controller at various points during the flights across the four days. The screen was not recorded for the entire duration of each flight due to storage limitations of the drone's controller. Aside from showing what the drone sees, these screen recordings include useful information such as RPAS speed, wind speed, and battery charge over time.
- DroneOrthophotos
    - These folders contain the original photos taken by the M300 with the L1 sensor and the camera built into the Mavic Pro, as well as the orthomosaics generated from these photos.
- FieldPhotos
    - Photos taken with AGRG's Ricoh GRII in the field for context or use within supporting documentation or presentations as needed.

- SatelliteData
    - Supporting satellite data from the day(s) around the field work done to give more context to the ice being monitored. Not every day has associated satellite data due to the way the path the satellites take affects when the study area sees coverage and the way overcast skies interfere with imagery. The type of weather that we would expect to contribute to the formation or preservation of sea ice, cold and snowy or overcast days, also means that cloud covers the study area in that satellite image.
- Video
    - Videos recorded by the RPAS cameras. The focus of this project was on the imagery collected rather than videos, so there are only videos from the final day of work.
- WeatherData
    - Weather data from AGRG's weather stations deployed near the Meg's Cove, Environment Canada's Caribou point station, and the Pictou Island Weather Underground station. Types of data available and the dates on which data are available depends on the station.
        - CapeJohn_BankStation_forSEATAC.xlsx
            - Data from AGRG's weather station located along the coast of Meg's Cove. This station can be seen in *Figure 7*. This station contains air pressure, precipitation, and temperature data in 15-minute intervals up to February 27th, 2023, where a malfunction rendered the rest of the data for the season useless.
        - CapeJohn_YardStation_forSEATAC.xlsx
            - Data from AGRG's weather station location slightly further inland in the same general area near Meg's Cove. This station contains solar radiation, wind speed, and wind gust speed data in 15-minute intervals for the whole season, from February 1st up to April 10th, 2023.
        - CaribouPoint_EC_forSEATAC.xlsx
            - Weather station data retrieved from Environment Canada for Caribou Point. Contains temperature, dew point, humidity, precipitation, wind direction and speed, air pressure, and wind chill data in 1-hour intervals from February 1st to March 27th, 2023, where the data was unavailable

for the rest of the season. Located east of the study area as seen in *Figure 6*.

- PictouIsland_WeatherUnderground_forSEATAC.xlsx
    - Data from a weather station located on Pictou Island off the coast to the east of the study area, retrieved from Weather Underground. Units in imperial measurement systems were converted to metric by AGRG where needed. Contains temperature, dew point, humidity, wind speed and direction, wind gust speed, air pressure, precipitation, UV index, and solar radiation data in 5-minute intervals, from March 27th to April 6th, 2023, to make up for the missing Caribou Point EC data. Located east of the study area as seen in *Figure 6*.

4. DISCUSSION

Working around the limitations on RPAS operation in Nova Scotian winter environmental conditions, AGRG managed to make four total trips to the River John study area to collect imagery and supplementary data on sea ice for SEATAC.

Some challenges were encountered, including the temperature on some days being too cold in the study area and winds being too high to fly the smaller of the two RPAS used in this project. The decision to not fly certain drones was determined by the RPAS pilot based on personal experience. Conditions were not too harsh to fly the M300 thanks to the self-heating system built into its TB60 batteries and the size and power of the drone allowing for flight even in winds that would be too high for the Mavic Pro. Issues were encountered with weather station data available due to failure of sensors because of the harsh environment they are deployed in year-round. This was compensated for by acquiring more meteorological data from nearby weather stations operated by other groups, including Environment Canada.

Additional supporting data collected by AGRG and shared with SEATAC includes satellite data for the area when available, limited by the frequent cloud cover in the area for the time of year. M300 controller screen recordings were included as well, to demonstrate battery level over flight time. Photos taken in the field on the ground using a Ricoh GRII were included for extra context.

From the RPAS, video recordings and original photos taken by the sensors were included. These photos were processed into orthomosaics to show the extent of each flight made, and these orthomosaics were shared with SEATAC as well.

5. ACKNOWLEDGEMENTS

AGRG would like to thank our RPAS operator for the duration of the project, Nick Matuchet. AGRG would also like to thank SEATAC for their cooperation during this project, including John Stratton for choosing to work with AGRG and Laura White for her communications with AGRG to achieve the goals of this project.

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DJI. (n.d.). Matrice 300 RTK - Specs. DJI Enterprise. Retrieved June 2, 2023, from https://enterprise.dji.com/matrice-300/specs

DJI. (n.d.). Zenmuse L1 - Specs. DJI Enterprise. Retrieved June 2, 2023, from https://enterprise.dji.com/zenmuse-l1/specs

7. APPENDIX

7.1 Weather Station Data Sources:

Weather Underground

https://www.wunderground.com/dashboard/pws/ISUBDI78

Environment Canada

https://climate.weather.gc.ca/climate_data/hourly_data_e.html?hlyRange=1994-02-01|2023-06-05&dlyRange=1993-04-01|2023-06-04&mlyRange=2004-11-01|2007-07-01&StationID=8990&Prov=NS