Fisheries and Aquaculture
1575A Lake Rd
Sandy Point, Nova Scotia
B0T 1W0
novascotia.ca

Public Notice – Adjudicative Application Posted

These documents have been submitted with respect to a New Marine Aquaculture Licence/Lease application. The application follows a Scoping period, during which the applicant collected information to support their application. The information in these documents are provided as part of the routine disclosure of information by the Department of Fisheries and Aquaculture. Some information may be redacted as business confidential information or personal information.

These documents were provided to the Department by the applicant (with the exception of the attached Schedule "A" which was generated by the Department). The Department is not responsible for the content of these documents, including, but not limited to, the accuracy, reliability, or currency of the information contained within.

Adjudicative Application for a New Aquaculture Licence and Lease	
Applicant: Paq'tnkek Mi'kmaw Nation	**Species:** American oyster
Application Received On: July 22, 2022	**Method of Cultivation:** Suspended Cultivation
Application File Number: AQ#1459	**Location:** Pomquet Harbour (Summerside), Antigonish County (Option Area AQ#4029)

To learn more about the marine aquaculture lease and license application process, please visit https://novascotia.ca/fish/aquaculture/licensing-leasing/Aqua-Licensing-and-Leasing-Overview.pdf

For information on the Nova Scotia Aquaculture Review Board, please visit https://arb.novascotia.ca/

NOTICE

Posting Date of this Notice: August 24, 2023

Please note that this application is being reviewed pursuant to the *Canadian Navigable Waters Act* by Transport Canada. Written comments regarding the effect of this work on marine navigation may be submitted to Transport Canada as follows, for a period of 30 days following the posting date of this notice.

1. On line at : http://cps.canada.ca/ under the following:
   File AQ#1459: Registry #6131 / NPP#2022-207300
2. By Mail at: Manager
   Transport Canada - Navigation Protection Program
   6th floor-95 Foundry Street, Moncton, NB E1C 5H7

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NOVA SCOTIA

Office Use Only
recd July 22/22
via email.

Aquaculture Licence/Lease Application

Applicant Information:

Applicant: Paqtnkek Mi'kmaw Nation Contact Person: Norma Prosper

Nova Scotia Registry of Joint Stocks Number: 3104962

Revenue Canada Business Number: [redacted]

Telephone No. (Work): 9023862781 (Home): _____ (Cell): [redacted]

Fax No.: 9023862043 E-mail: norma.prosper@paqtnkek.ca

Mailing Address: 7 Dillon St Afton Station

Antigonish Co. NS Postal Code: B0H1A0

Civic Address: 7 Dillon St Afton Station

Antigonish Co. NS Postal Code: B0H1A0

Proposed Site Information:

Location of Site: Summerside County: Antigonish Site Size (Ha): 15.2

Site Dimensions: 500m X 300m

Hydrographic Chart No.: RM-4447

Approximate Center Coordinates: Latitude: 45°36'53.49"N

Longitude: 61°47'25.86"W

Type of Licence Application

(Check appropriate boxes):

- ■ Commercial licence/lease
- ☐ Experimental licence/lease

☐ Marine Plants ☐ Finfish ■ Shellfish ☐ Other

Submit completed applications to: Nova Scotia Department of Fisheries and Aquaculture, Aquaculture Division
1575 Lake Road, Shelburne, NS B0T 1W0
E-mail: aquaculture@novascotia.ca

Ver. 170723

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☐ Land-based
- ☐ Freshwater
- ☐ Saltwater

- ☐ U-Fish
- ☐ Hatchery
- ☐ Nursery Facility
- ☐ Growout

■ Marine
- ☐ Cage culture
- ■ Suspended shellfish or marine plants
- ☐ Bottom shellfish with gear
- ☐ Bottom shellfish without gear

Application Materials

A complete application includes the following:

- Application fee (payable to Minister of Finance) according to Section 77 of the Aquaculture Licence and Lease Regulations for Nova Scotia made under Section 64, Chapter 25 of the Acts of 1996, *the Fisheries and Coastal Resources Act*
- Application Form
- Development Plan according to application
- Report on Public Engagement during Scoping (for all Marine applications and for other applications, as applicable)
- Copy of up-to-date Shareholder's Register which sets out the shareholdings of the company (if applicable, and if not already provided during the Option to Lease application process.

Public Notice and Disclosure

As part of the process for deciding on an aquaculture application, the Nova Scotia Department of Fisheries and Aquaculture ("Fisheries and Aquaculture") will disclose application information to other government bodies, including, if applicable, the Nova Scotia Aquaculture Review Board for use at an adjudicative hearing relating to the application.

In accordance with departmental policy, which seeks to promote public involvement in the process for deciding on aquaculture applications, Fisheries and Aquaculture may disclose application information – not including, however, personal or business confidential information – on the departmental website.

Privacy Statement

The personal and business confidential information collected as part of an aquaculture application will only be used or disclosed by Fisheries and Aquaculture for the purpose of deciding on the application.

NOVA SCOTIA

Office Use Only

All application information collected is subject to the Freedom of Information and Protection of Privacy Act ("FOIPOP") and will only be used or disclosed in accordance with FOIPOP.

By signing and submitting this form, I acknowledge that I have read, understand, and accept the above statements regarding the collection, use, and disclosure of the information provided on this form.

Signature of Applicant [redacted]

Date July 15, 2022

Signature of Nova Scotia Department of Fisheries and Aquaculture Designate [redacted]

Date Feb 16/23

*recd in office July 22/22 VIA email

Submit completed applications to:

Nova Scotia Department of Fisheries and Aquaculture, Aquaculture Division
1575 Lake Road, Shelburne, NS B0T 1W0
E-mail: aquaculture@novascotia.ca

SCHEDULE A

Aquaculture Site
1459

Corner	Latitude	Longitude
1	45° 36' 55.496"	-61° 47' 13.819"
2	45° 36' 50.094"	-61° 47' 16.707"
3	45° 36' 45.580"	-61° 47' 19.120"
4	45° 36' 52.180"	-61° 47' 40.770"
5	45° 36' 56.136"	-61° 47' 37.123"
6	45° 37' 1.140"	-61° 47' 32.510"
Centre	45° 36' 53.348"	-61° 47' 27.302"

DATUM NAD 83 CSRS UTM Zone 20
The above coordinates are not from a legal survey

License/Lease Holder	County	Waterbody	Hectares	Species Type	Culture Type	Chart
Paqtnkek Mi'kmaw Nation	Antigonish	Pomquet Harbour	15.5	Shellfish	Suspended Culture	4447

Proposed Application
Other Issued Lease

0 0.5 1 2
Kilometers

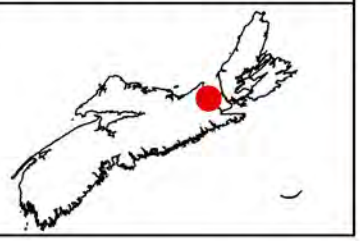
NOVA SCOTIA
Fisheries and Aquaculture

Disclaimer
This map should not be used for navigation or legal purposes. It is intended for general reference purposes only.

Date: 2022-09-27 Created By: MK

Internal Services Department

SCHEDULE A



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Paqtnkek Mi'kmaw Nation	Antigonish	Pomquet Harbour	15.5	Shellfish	Suspended Culture	4447

Proposed Application
EC Restricted Area
TC Approved Area

0 30 60 120 180
Meters

NOVA SCOTIA
Fisheries and Aquaculture

Disclaimer
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Date: 2022-09-27 Created By: MK

Marine Suspended Oyster Aquaculture Development Plan for Summerside, NS

For more information, contact:
Norma Prosper
norma.prosper@paqtnkek.ca
Submitted: July 22, 2023
Revised: June 05, 2023

SECTION 1: THE OPTIMUM USE OF MARINE RESOURCES

Paqtnkek Mi'kmaw Nation is requesting a marine shellfish licence/lease in Pomquet Harbour in Antigonish County, NS. This proposed site is within the Option to Lease # 4029 and is located in Church Cove, near Summerside, NS. The proposed site will allow Paqtnkek to harvest 800,000 oysters per year using suspended culture, once it reaches maximum production, with a standing inventory of 3.1 million oysters. Because the area is restricted for harvesting shellfish, the oysters will be moved elsewhere for cleaning prior to market according to requirements of the Canadian Shellfish Sanitation Program. Seed for the operation will come from spat collection that occurs adjacent to the site. Paqtnkek has been successfully trialing the grow out of oysters on an experimental site (AQ 5000) site for the past four years. The proposed commercial site overlays the experimental site. Results from this experimental work have been used to create the business plan for the development. The land adjacent to the proposed site is part of Welnek Indian Reserve No. 38, and managed by Paqtnkek Mi'kmaw Nation.

It is anticipated that this oyster aquaculture development by Paqtnkek will contribute to the surrounding communities by supporting the employment of five persons directly on the farm and promoting the purchase of goods and services from local suppliers.

There are no commercial fisheries in the area. Recreational and traditional fisheries occurring in the county include eels, brown trout, sea trout and speckled trout, as well as bass, smelt, and salmon. Church Cove, the body of water containing the proposed aquaculture lease, is no longer a common recreational fishing ground for finfish but is well used by the Mi'kmaq. The traditional fisheries activities practiced by Paqtnkek Mi'kmaw Nation will be able to continue in the area adjacent to the lease area. The proposed aquaculture site will be managed in association with the other Mi'kmaw activities in the waters. A single group within Paqtnkek manages both the fisheries and aquaculture portfolio of the Band and will ensure that they are complementary.

The oceanographic and biophysical characteristics of the public waters surrounding the aquaculture operation suggest the success of the oyster aquaculture operation. The area was subject to intensive study by the Nova Scotia Community College whose geomatics group produced a suitability model that demonstrated the chosen area to be well suited for suspended oyster aquaculture.

The human users of the area are the Paqtnkek people and a few local land owners. A stated concern of local residents is the importance of keeping the area clean, and ensuring the gear remains on site. Responsible farm practices will ensure these concerns are not materialized. These practices include a waste management plan and procedures for ensuring that gear is properly maintained on site and frequent checks are performed for finding and retrieving loose gear. Risks to wildlife users of the region will also be mitigated via these management measures and others that reduce interaction and the potential for interaction with wildlife, especially birds.

A Notice of Works application has been submitted online. Outcomes from Transport Canada's assessment will be applied to ensure the public right of navigation through compliance with the Canadian Navigable Waters Act.

The region is one of a handful of regions in Nova Scotia where Atlantic salmon populations still exist. Paqtnkek works with local angling associations to restore salmon habitat and will continue to do so. Responsible farm practices, as described previously, will ensure little to no impact of operations on these salmon populations or habitat restoration efforts.

The requested site is not in waters directly shared with other aquaculture sites so that interaction between sites would not be expected to occur passively by water movement (currents or tides).

The proposed operation has the potential to contribute to economic development of Paqtnkek Mi'kmaw Nation and the local region in general. Mitigation practices will reduce impacts to other users of the local waters, including the fishery, wildlife, and local residents. This includes the public right to navigation. Therefore, because of the expected minimal negative impacts and anticipated positive impacts described according to the factors to be considered in decisions related to marine aquaculture sites, this request should represent an optimum use of marine resources.

It is notable that Pomquet Harbour and waters beyond have been traditionally used by the Paqtnkek people for their livelihood. The Nation looks forward to applying its knowledge of the waters to promote economic and food security for their people using the sustainable practice of oyster aquaculture. Development of this oyster aquaculture site is an economic and social venture that embodies the past, present and future of Paqtnkek Mi'kmaw Nation.

SECTION 2: THE CONTRIBUTION OF THE PROPOSED OPERATION TO COMMUNITY AND PROVINCIAL ECONOMIC DEVELOPMENT

2.1 Production plan

Method: Suspended
Species: American oyster (*Crassostrea virginica*)
Gear unit type*: Oyster Gro cages with 6 bags/unit (dimensions approximately 54" X 36" X 12")
Maximum number of gear units: 1,440 (if all lines full with OysterGro cages)
Maximum number of lines: 72 lines @ 20 cages/line
Maximum line length: 220'
Maximum shellfish introduced (annually): 1,000,000
Maximum shellfish on site: Up to 3.1 million
Seed source: Spat collected on site using hats coated with cement (600 collectors)
Expected time to achieve maximum production: 4 years

*Experimentation with a new suspended "BOBR" type gear is underway. These would produce oysters at a similar density within the lease area, but possibly improve growth and shape. Because outcomes from using bobbers is unknown at this time, the production plan described above has been developed assuming the use of OysterGro gear.

This body of water is classified as "restricted" for shellfish harvesting. As a result, product will not be marketed directly from this site. Paqtnkek has an agreement with Bill & Stanley Oyster Company to purchase the oysters from this restricted area. See Appendix A.

As additional avenues for the future, Paqtnkek has applied for a lease in an approved area (Havre Boucher) to allow relay of the product. The Havre Boucher lease application was submitted concurrently to this Summerside site application. In addition, water sampling is being conducted in Church Cove to determine whether the area can be reclassified at some point.

2.2 Infrastructure

Paqtnkek has been operating an experimental lease/licence in Church Cove for the past four years. During this time, they have acquired a significant amount of the infrastructure necessary to operate the site commercially. This includes the following:

- 4 of 40' trailers used for housing site-required equipment in a secure and tidy manner and a fresh water supply, both on the above-mentioned land
- Adjacent building with toilet and washing facilities available for use by the staff
- Slipway for removing and launching boat (requires an upgrade) as well as a small wharf
- Steel quonset hut complete with office facilities to be used for maintenance, lab, and additional storage (e.g. for boats, truck, other equipment) (within 700m of the site)
- Fenced in storage area adjacent to quonset hut
- Security system for equipment area
- 18' flat bottom aluminum boat (8' wide), stability tested and approved for use by Transport Canada, complete with outboard motor and 1000-lb winch and powerpack for lifting cages

- 10’ aluminum boat
- 16’ fiberglass boat with 40hp motor
- Half-ton truck
- Two boat trailers
- Moorings and rope for 40 backlines
- 800 Oyster Gro cages
- Shaker grader
- Tumbler
- Power washer
- Totes
- Spat collectors (hat-style)
- Tractor

The land adjacent to the proposed site is part of Welnek Indian Reserve No. 38, and managed by Paqtnkek Mi’kmaw Nation. See Figure A below.

Figure A: Church Cove, as labelled, and the shore side work location (circled in yellow) for the proposed lease. Approximate center of the proposed lease is shown as the yellow arrow. Welnek Indian Reserve No. 38 is indicated by the red boundary line.

Infrastructure to be acquired in the future to make the operation more efficient and/or commercialize the operation follows:

- Improved wharf and slipway (at the shore-side location managed by Paqtnkek Mi’kmaw Nation)
- Insulated boxes
- Additional totes

- Anchors, rope, and gear for installation of 32 additional lines
- Site marking buoys

2.3 Services and suppliers

Goods required for the farming operations include aquaculture specific equipment (e.g. OysterGro units and bags), aquaculture/fishery related equipment (personal protective equipment, gaffs, rope, other), general hardware (cable ties, knives, tools, etc.), fuel, and other day-to-day requirements. Although the OysterGro units will not likely be available locally, the other needs will be sourced from the nearest communities, with preference to Paqtnkek Mi'kmaw Nation. Services that will be required on an interim basis include welding, general contracting, cement production, carpentry, diving and others. Again, these will be preferentially sourced from Paqtnkek Mi'kmaw Nation then to surrounding communities. Such communities that are likely to benefit from the purchase of goods and services include Havre Boucher, Whycocomagh, Antigonish, Port Hawkesbury, Pictou, and New Glasgow.

Spat collection will occur through a spat collection licence on the shore side of the proposed lease area.

Although processing and sales may not be direct from Paqtnkek Mi'kmaw Nation initially, they will occur from the general area. It is anticipated that Paqtnkek will eventually develop its own processing capacity.

Current suppliers to the Paqtnkek Oyster Project are listed in Appendix B.

2.4 Employment

It is anticipated that the oyster development plans will continue to employ five persons directly on the farm. These include a farm manager and four farm technicians. An additional person acts as the project manager/administrator. Employees will continue to be drawn from the Paqtnkek Mi'kmaw Nation, whenever possible. Additional direct local jobs may eventually be created in the processing of the oysters.

2.5 Other economic contributions to the local community and Province

Spin off economic benefits to the local communities would be expected to occur. A past report on the economic impact of aquaculture in Nova Scotia indicates that 1.55 indirect jobs result from every person directly employed at an aquaculture operation (Foster, 2019).

2.6 Financial viability

See business plan attached as Appendix C. Additional financial information is available upon request.

2.7 Adverse economic impacts

No adverse economic impacts are expected.

SECTON 3: FISHERIES ACTIVITIES IN THE PUBLIC WATERS SURROUNDING THE PROPOSED AQUACULTURAL OPERATION

3.1 Status of fisheries activities

Commercial fisheries

There are no known commercial fisheries in Church Cove, the proposed site location. It is classified as a restricted area for shellfish harvesting.

Recreational fisheries

Recreational fisheries in the general area include brown trout, sea trout and speckled trout, as well as bass, smelt, and salmon. This body of water is located in Recreational Fishing Area 2 (Antigonish, Guysborough and Pictou Counties).[1] Antigonish County is renowned for Atlantic salmon fishing. A description of the status of local salmon populations can be found in Section 7.1. The recreational fishery is supported by the Antigonish Rivers Association whose goal is to "protect and enhance the ecological integrity of the aquatic habitats in Antigonish County in order to sustain a healthy fishery".[2] It is notable that the area within Church Cove that is proposed for the aquaculture lease is no longer a common recreational fishing ground for trout or salmon, with the exception of traditional use by the Mi'kmaq, as described separately.

Traditional fisheries

Traditional fisheries for Paqtnkek Mi'kmaw Nation include those listed above for the recreational fishery as well as American eel which is described in more detail below.

Mi'kmaq have been fishing *K'at* (American eel) for thousands of years. Its significance to the culture is recognized by elders and the community and is well-documented, including within historical records, and treaties. The profound relationship of the Paqtnkek Mi'kmaq with Ka't has been described in a case study[3] which explores how, in addition to the importance of Ka't as a resource for food and a textile, Ka't embodies important cultural meanings and practices, including the traditional principles of sharing and reciprocity - *utkunajik*. Ka't is also recognized for its spiritual qualities, and used in ceremonies and medicinally.

It is not insignificant that the waters proposed for this aquaculture site are where Donald Marshall Jr., a status Mi'kmaw, and two other eel harvesters, were apprehended and charged by Fisheries and Oceans Canada for fishing infractions in 1993. The six-year court battle that followed resulted in a Supreme Court of Canada ruling that all Mi'kmaq have a 1760-61 Treaties of Peace and Friendship treaty right to participate in the harvesting of marine resources for commercial purposes, as long as commercial fishing is intended to provide a 'moderate livelihood'.

Eeling continues to be viewed as an important activity: promoting community bonds, allowing the passing down of customary practices through generations, allowing a catch that can be shared with

[1] https://beta.novascotia.ca/sites/default/files/documents/1-2412/anglers-handbook-en.pdf
[2] https://www.antigonishriversassociation.ca/
[3] Davis, A., Prosper, K., Wagner, J. & Paulette, M.J. (2004). The Paqtnkek Mi'kmaq and Ka't (American Eel). A case study of cultural relations, meanings and prospects. The Canadian Journal of Native Studies, 24(2), 359-390

others not able to fish for themselves, and being central to many spiritual offerings[4]. It is currently harvested primarily by spearing, in the winter through the ice or during summer from watercraft, as well as via nets, hooked lines, pots, and polls.[5]

Wild oyster populations

Information on wild oyster stocks can be found in the attached "Development of a Bay Management Tool to Support Sustainable Aquaculture for Paqtnkek Mi'kmaw Nation Using Bathymetric Lidar, Hydrodynamic Modelling, and GIS" (Appendix D). This document includes figures showing known wild oyster locations (Figure 27), wild oyster spat producers (Figure 28), and other distribution data. These demonstrate that there are wild oyster populations in the surrounding waters, including the spawning populations needed for spat production. Modelling of expected spat distribution shows that the spat collectors are in an area of expected high spat concentration for an incoming tide (Figure 69). However, the proposed lease area is not on top of these wild populations.

[4] Noble, M. Duncan, P., Perry, D., Prosper, K., Rose, D., Schnierer, S., Tipa, E.W., Woods, R. & Pittock, J. (2016). Culturally significant fisheries: keystones for management of freshwater social-ecological systems. Ecology and Society, 21(2):22

[5] SRSF Research Report #4 The Paqtnkek Mi'kmaq and Kat (American Eel – *Anguilla rostrata)*. Prepared by Social research for Sustainable Fisheries (SRSF) St. Francis Xavier University in Collaboration with The Paqtnkek Fish and Wildlife Society, 2002.

Traditional ecological knowledge on fish habitat

The habitat ranges of molluscs and migratory fish, defined by traditional ecological knowledge collected by DFO[6], are shown in Figure B below. The proposed lease area is over American eel habitat and may overlap slightly with American smelt habitat.

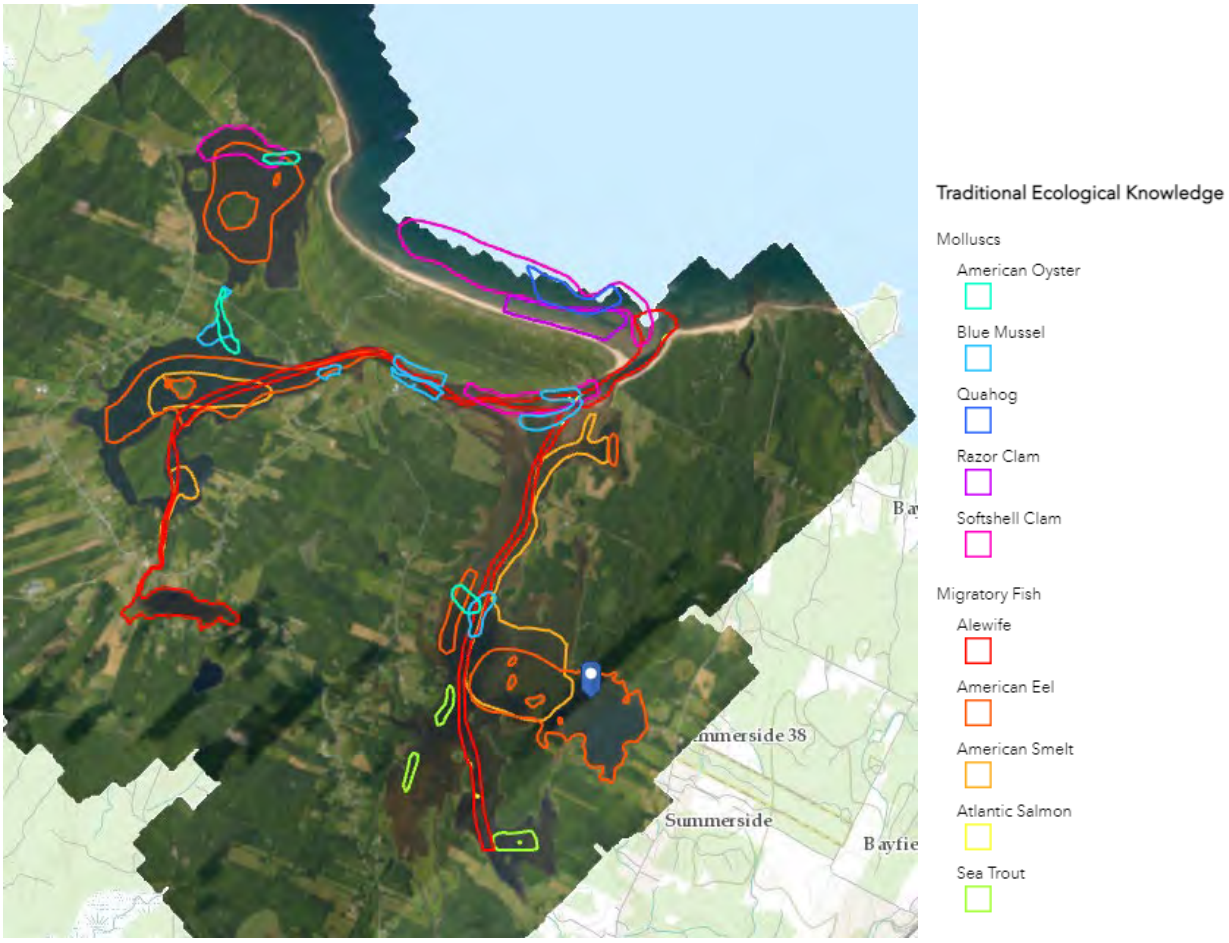


Figure B: Distribution of habitat for marine species according to traditional knowledge, as provided by DFO[7] and clipped into the map of the area. The location of the proposed site center is indicated by the blue marker: Data acquired and processed by the Applied Geomatics Group, NSCC.

[6] As indicated within "Development of a Bay Management Tool to Support Sustainable Aquaculture for Paqtnkek Mi'kmaw Nation Using Bathymetric Lidar, Hydrodynamic Modelling, and GIS." (Attached as Appendix D.)

[7] As indicated within the attached report ""Development of a Bay Management Tool to Support Sustainable Aquaculture for Paqtnkek Mi'kmaw Nation Using Bathymetric Lidar, Hydrodynamic Modelling, and GIS." (Attached as Appendix D.)

Eel grass habitat

Areas of eel grass determined from orthophotos, lidar information collected by NSCC and information from local scientists[8] are shown in Figure C. The proposed lease area does not overlap with these areas.

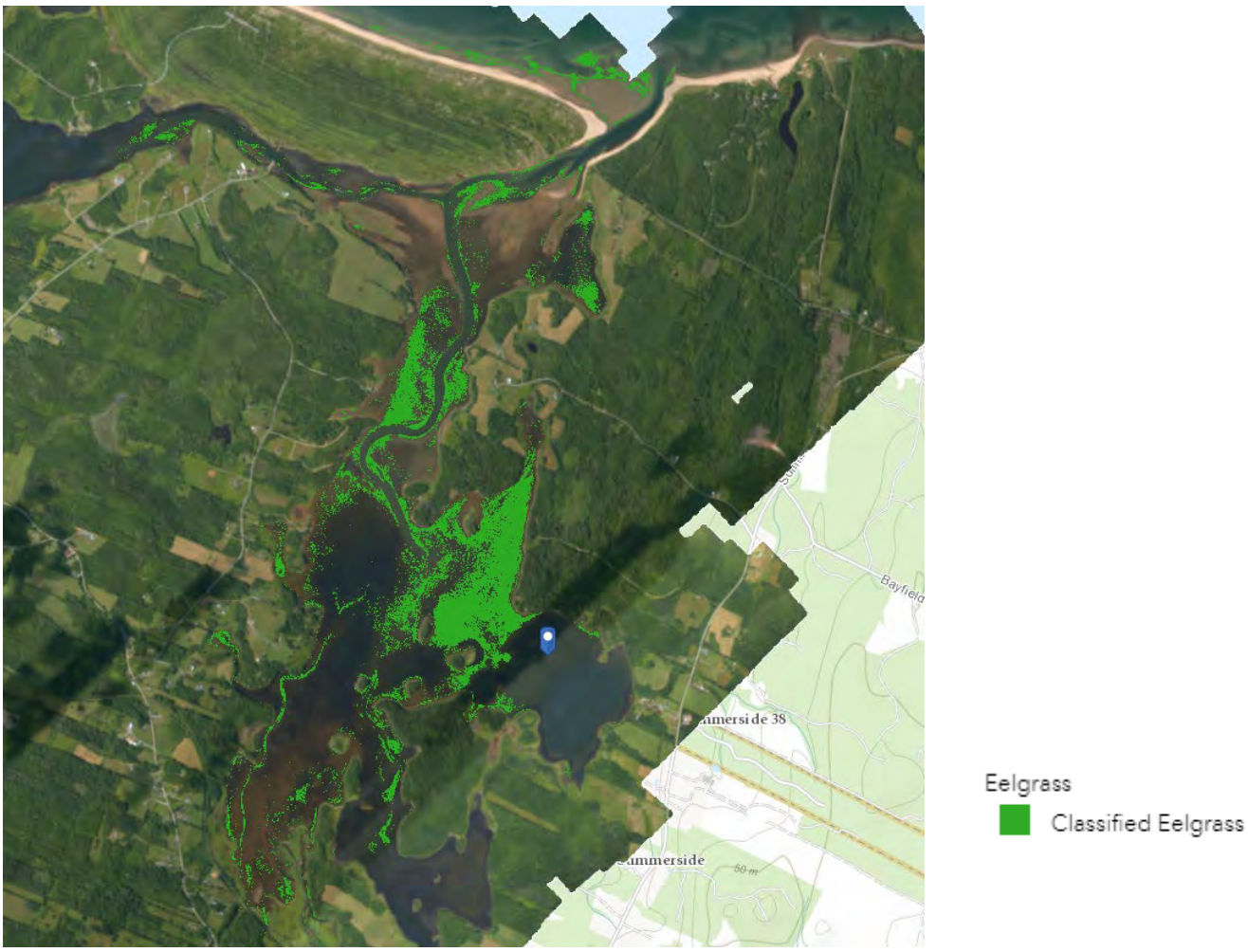


Figure C: Distribution of eelgrass as derived from orthophotos, lidar information and information from local scientists. The location of the proposed site center is indicated by the blue marker: Data acquired and processed by the Applied Geomatics Group, NSCC.

3.2 Impacts on fisheries activities

As stated previously, there is little to no recreational fishing in Church Cove. The traditional fisheries activities practiced by Paqtnkek Mi'kmaw Nation will be able to continue in the area adjacent to the lease area. The proposed aquaculture site will be managed in association with the other Mi'kmaw

[8] As indicated within the attached report ""Development of a Bay Management Tool to Support Sustainable Aquaculture for Paqtnkek Mi'kmaw Nation Using Bathymetric Lidar, Hydrodynamic Modelling, and GIS." (Attached as Appendix D.)

activities in the waters. A single group within Paqtnkek manages both the fisheries and aquaculture portfolios of the Band and will ensure that they are complementary.

It is notable that impact to fisheries was not noted as a concern the formal public meeting conducted in Summerside on June 12, 2022. Outcomes from public engagement activities can be found in the attached Public Scoping Report, Summerside.

Responsible farm practices will ensure little to no impact of operations on fisheries activities. In particular, waste management will be controlled under a waste management plan within the Farm Management Plan that is required for active aquaculture sites in Nova Scotia. Similarly, farm operations procedures, also required as part of the Farm Management Plan, will include the timely and regular maintenance of infrastructure and retrieval of loose gear.

SECTION 4: OCEANOGRAPHIC AND BIOPHYSICAL CHARACTERISTICS OF THE PUBLIC WATERS

4.1 Oceanographic environment

Currently available data on the biophysical characteristics of the site environment are tabled or stated below with supporting references and figures provided, as relevant.

Characteristic	Value	Reference	Comments
Speed of maximum wind gust (km/hr)	64-km/hr	Value stated for 2020 at climate.weather.gc.ca. Accessed February 7, 2022[9]	Value listed is that stated for 2020. The previous years' listed values were less than this. Additional wind data can be found in the attached "Development of a Bay Management Tool to Support Sustainable Aquaculture for Paqtnkek Mi'kmaw Nation Using Bathymetric Lidar, Hydrodynamic Modelling, and GIS." This includes wind speeds and their impacts on waves and hydrodynamics of the waters of the proposed location (Appendix D, pages 62-65).
Maximum wave height (m) and direction of maximum wave	0.26-m, resulting from wind blowing in the southerly direction.	"Development of a Bay Management Tool to Support Sustainable Aquaculture for Paqtnkek Mi'kmaw Nation Using Bathymetric Lidar, Hydrodynamic Modelling, and GIS." Attached as Appendix D.	Wave data was collected using an ADCP deployed at the proposed site June 7, 2018 to July 10, 2018. Additional information on the deployment and data collection can be found in the cited reference which has been attached. Plots with Significant Wave Height, peak period, and water level are shown as Figure 21 in the attached reference. The wave height spectra and directional spectrum for the time when the maximum wave height was observed are shown in Figure 23 of this reference. According to modelling, described in the cited reference (pages 69-71, Figure 60), the Hs (significant wave height) in the proposed area is expect to be "low".

[9] https://climate.weather.gc.ca/climate_data/almanac_e.html?timeframe=4&Year=2021&month=12&day=31&hlyRange=2003-01-20%7C2022-02-06&dlyRange=2003-01-17%7C2022-02-06&mlyRange=2004-01-01%7C2007-07-01&StationID=41575&Prov=NS&urlExtension=_e.html&searchType=stnProv&optLimit=yearRange&StartYear=1840&EndYear=2018&selRowPerPage=25&Line=275&lstProvince=NS&time=LST

Characteristic	Value	Reference	Comments
Low water level	0.56-m	https://tides.gc.ca/en/stations/0159 Accessed January 1, 2022	As per nearest reporting station - Antigonish Harbour.
Lowest astronomical tide	0.15-m	https://tides.gc.ca/en/stations/0159 Accessed January 1, 2022	As per nearest reporting station - Antigonish Harbour.
High water level	1.16-m	https://tides.gc.ca/en/stations/0159 Accessed January 1, 2022	As per nearest reporting station - Antigonish Harbour.
Highest astronomical tide	1.45-m	https://tides.gc.ca/en/stations/0159 Accessed January 1, 2022	As per nearest reporting station - Antigonish Harbour.
Current speed range and averages (cm/sec)	Current speeds and characteristics are described in the attached "Development of a Bay Management Tool to Support Sustainable Aquaculture for Paqtnkek Mi'kmaw Nation Using Bathymetric Lidar, Hydrodynamic Modelling, and GIS." (Appendix D, pages 66-69, page 75, and pages 84-86). Mean and maximum current speeds, even at a storm surge is expected to be low because of how protected the proposed area is (Figure 66 of the stated reference).		
Minimum temperature at 1-m depth	-5.745°C	As recorded November 5, 2020 by HOBO temperature logger	See Figure D.
Minimum temperature at 2-m depth	n/a	HOBO logger not deployed at 2-m over winter months	See Figure E.
Maximum temperature at 1-m depth	27.862°C	As recorded July 30, 2020 by HOBO temperature logger	See Figure D.
Maximum temperature at 2-m depth	30.9°C	As recorded June 24, 2020 by HOBO temperature logger	See Figure E.
Minimum and maximum salinities	26 ppt to 28 ppt	"Development of a Bay Management Tool to Support Sustainable Aquaculture for Paqtnkek Mi'kmaw Nation Using Bathymetric Lidar, Hydrodynamic Modelling, and GIS."	See Figure F. Temperature and salinity probes were deployed on site in 2021. However, the data had not been retrieved at the time of the submission of the development plan.

Characteristic	Value	Reference	Comments
Depth of water at site corners	A hydrographic chart of the area is shown as Figure G. 5000C1-8ft (2.43m), 5000C2-8ft (2.43m), 5000C3-9ft (2.74m), 5000C4-9ft (2.74m), 5000C5-10ft (3.04m), 5000C6-10ft (3.04m).		

Temperature profiles for the site, as collected in 2020 and 2021 are shown in Figures D and E.

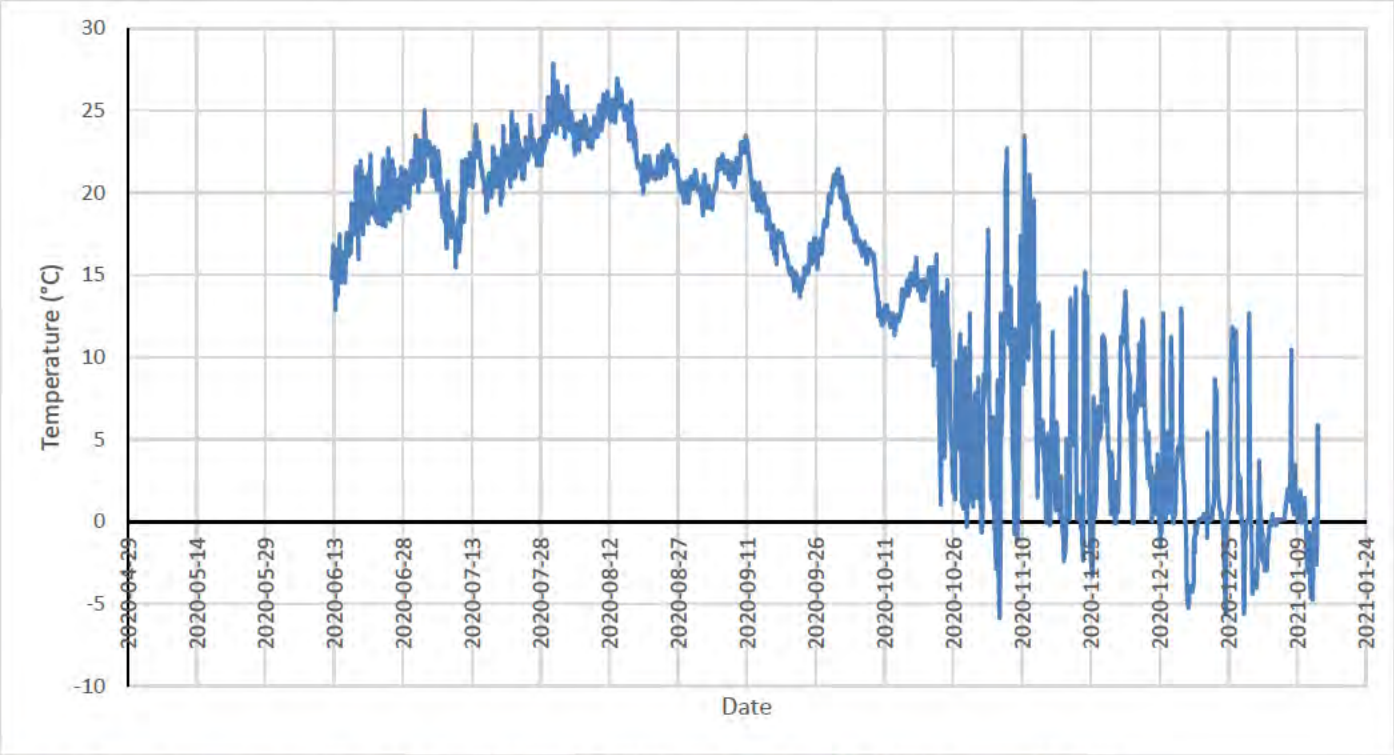


Figure D: Water temperature profile at 1-m depth taken with HOBO data logger June 12, 2020 to January 13, 2021.

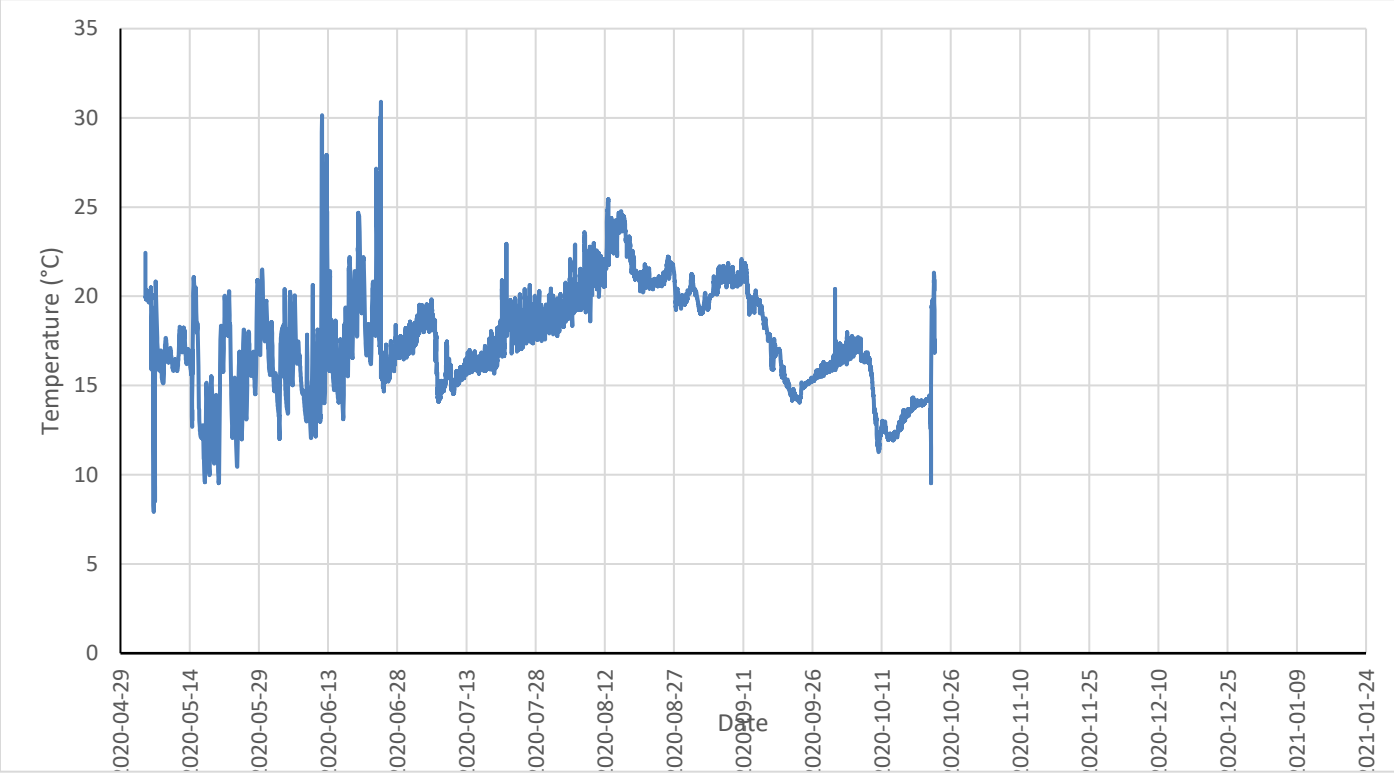


Figure E: Water temperature profile at 2-m depth taken with HOBO data logger May 4, 2020 to October 22, 2020.

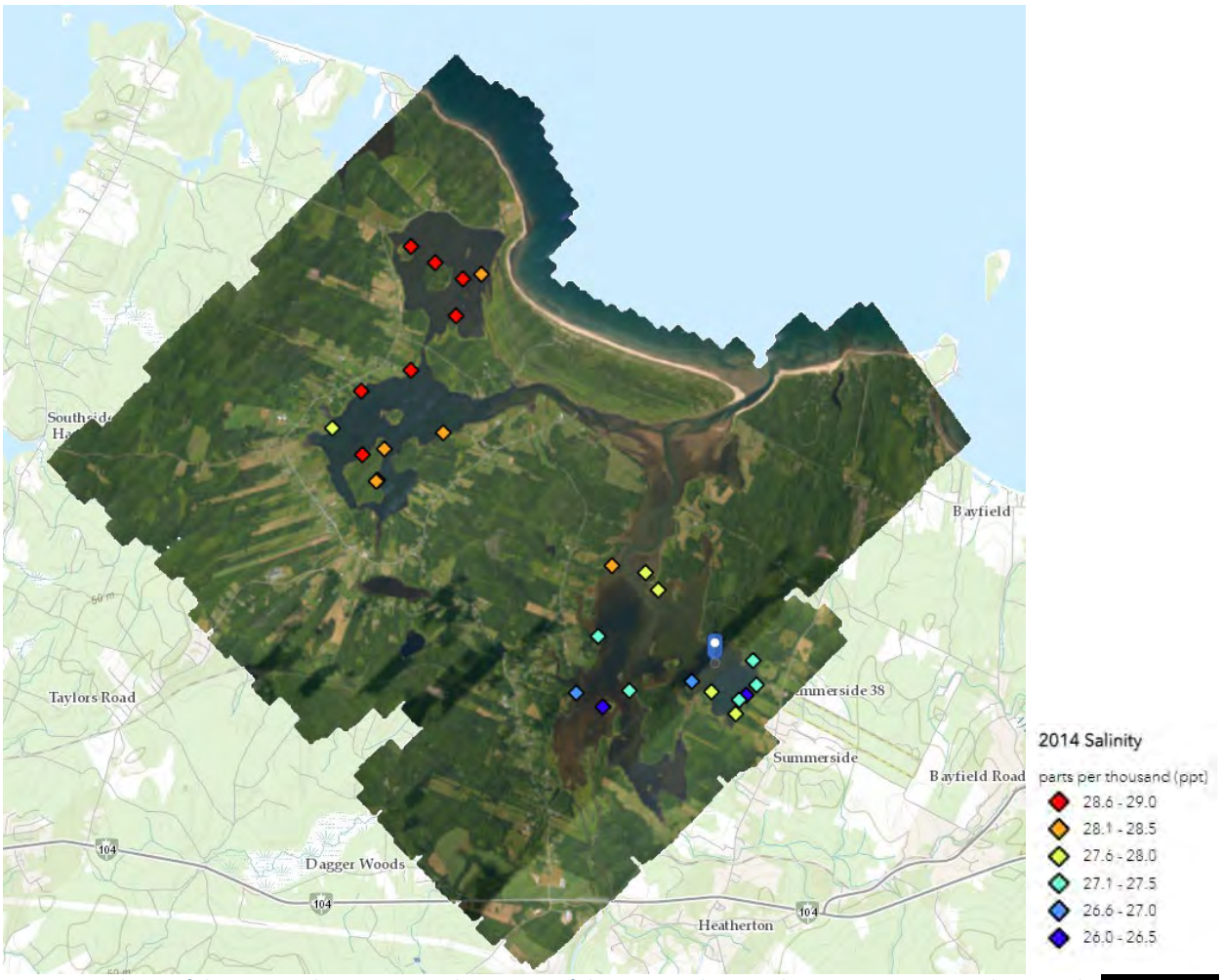


Figure F: Salinity of the surrounding waters in the vicinity of the proposed aquaculture site, as measured in 2014 by [redacted] while conducting oyster stock surveys. The location of the proposed site center is indicated by the blue marker: Data acquired and processed by the Applied Geomatics Group, NSCC.

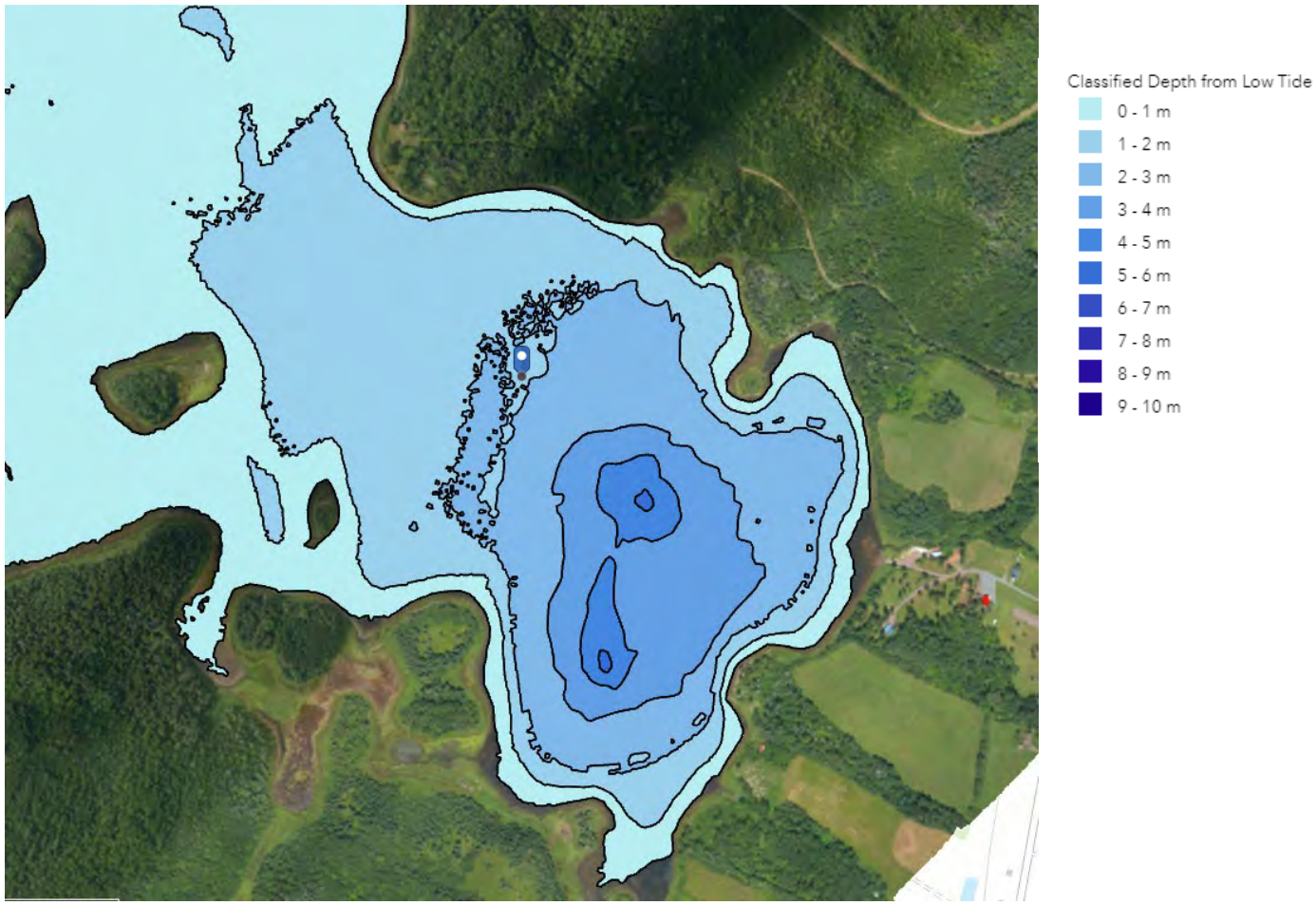


Figure G: Bathymetry of Church Cove area, shown as 1-m contours. The location of the proposed site center is indicated by the blue marker: Data acquired and processed by the Applied Geomatics Group, NSCC.

Growing location classification

The site is currently classified as restricted for growing shellfish. As such, relay or depuration will be required prior to market. See Section 2.1 for information.

Primary production information

No information on primary production could be found.

Biotoxin information

Surveys planned to determine the possibility of reclassifying the site, as mentioned in Section 2.1, may include biotoxin information. But at this time, biotoxin information is not available.

4.2 Baseline environmental monitoring

NSDFA completed the baseline EMP. The video footage showed mostly muddy bottom, with little plant and animal life.

4.3 Site design

An experimental lease was operated in this body of water for several years. Results from activities conducted during this tenure, as well as other factors, informed the scale, location, and set-up of the proposed lease.

Scale

Previous years' spat collection adjacent to the proposed site (under collection permit 156547) has demonstrated an ability to collect between 500,000 and 1,000,000 spat annually. This is enough for the venture to be financially viable and the commercial site has been sized to accommodate this amount of annual input. The production plan described in Section 2.1 reflects this intended scale of production. The production plan also incorporates the growth rate of the oysters seen during the tenure of the experimental lease using OysterGro cages.

Location

The location was originally chosen primarily according to the bathymetry of the water and temperature profile. The cove is deep enough to enable sinking of the oyster cages during the winter (Figures G and H), to keep them below potentially damaging ice; and the depth allows oyster production to occur over bottom that does not have sensitive habitat (i.e. eel grass, Figure C). Limited exchange with the open ocean promotes the high-water temperatures that are important to support a high rate of oyster growth. The temperature profile at 1-m (Figure D), shows that the near-surface waters reach the relatively warm temperatures (above 20°C) necessary to support oyster growth, but do not exceed the upper thermal threshold for Eastern oyster of ca. 32°C [10]. Although the temperature profile at the 1-m depth (Figure D) shows unacceptably low temperatures near the surface during the winter, the oyster cages would be sunk to the bottom at this time and not exposed to these lows. The salinity in the area is also at the preferred range of this species which is 20 to 27 ppt.[11]

[10] Fisheries and Oceans Canada. 2003. Profile of the American oyster (*Crassostrea virginica*), Gulf Region. Policy and Economics Branch, Gulf Region. 59pp.

[11] Fisheries and Oceans Canada. 2003. Profile of the American oyster (*Crassostrea virginica*), Gulf Region. Policy and Economics Branch, Gulf Region. 59pp.

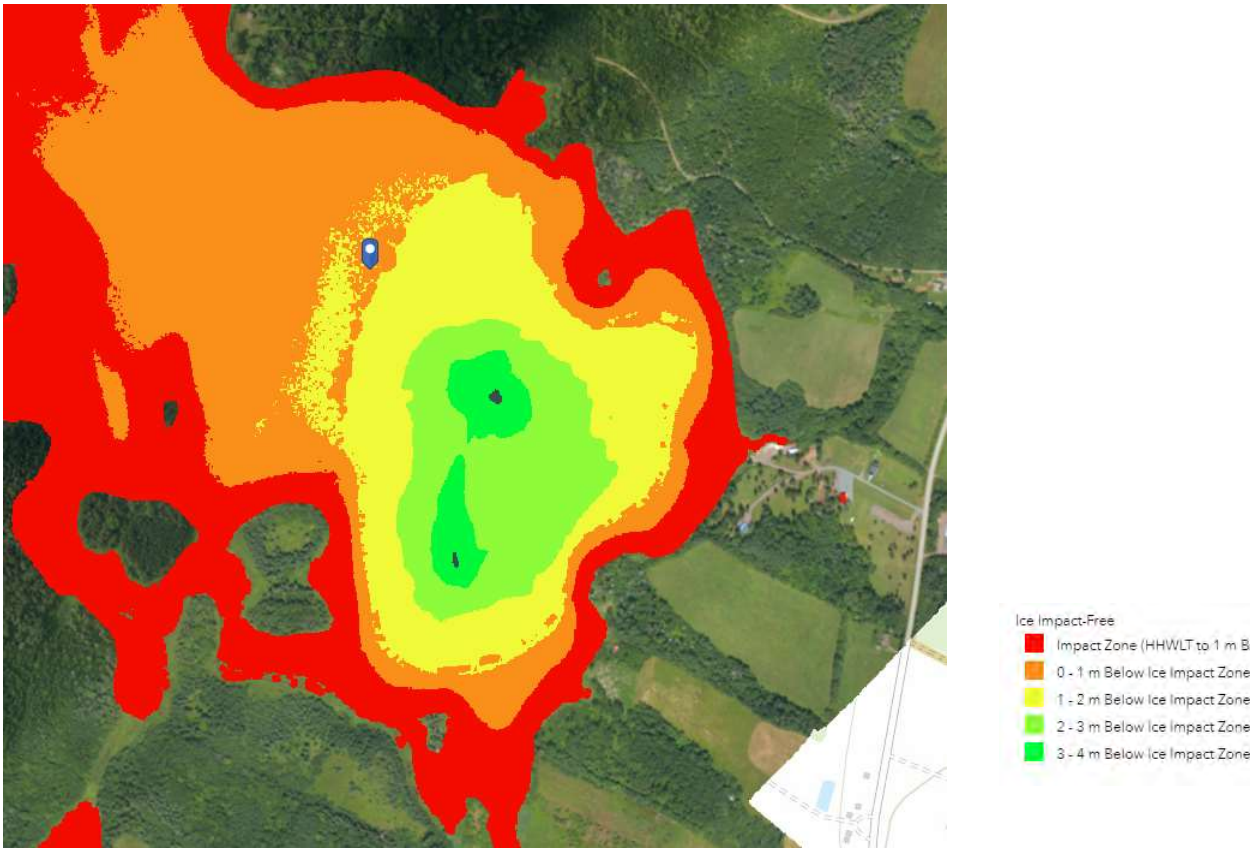


Figure H: Map of local waters showing areas that are expected to be impacted by ice (red zones), and those that will be below the expected ice, color-coded according to depth available below ice cover. The location of the proposed site center is indicated by the blue marker: Data acquired and processed by the Applied Geomatics Group, NSCC.

Models estimating the proposed area's suitability can be run using the recently developed "Pomquet AFF Aquaculture Suitability Web Map"[12] using a number of different inputs and variable weightings of inputs. NSCC ran the model using inputs suggested by DFO, NSDFA and CMAR. The results from their chosen inputs are shown below as Figure I. The inputs used for this model are listed on page 91 of the attached "Development of a Bay Management Tool to Support Sustainable Aquaculture for Paqtnkek Mi'kmaw Nation Using Bathymetric Lidar, Hydrodynamic Modelling, and GIS" as well as in Appendix D. This model's outcome indicates that the proposed lease area has medium to high suitability for suspended aquaculture development (Figure I).

The model was re-run using inputs suggested by the project's biologist ([redacted]). These modified inputs and those of the original model can be found in Appendix E. This revised model's outcome indicates that the proposed lease area has high suitability for suspended aquaculture development (Figure J).

[12] Access to the model may be available by request, for internal use only.

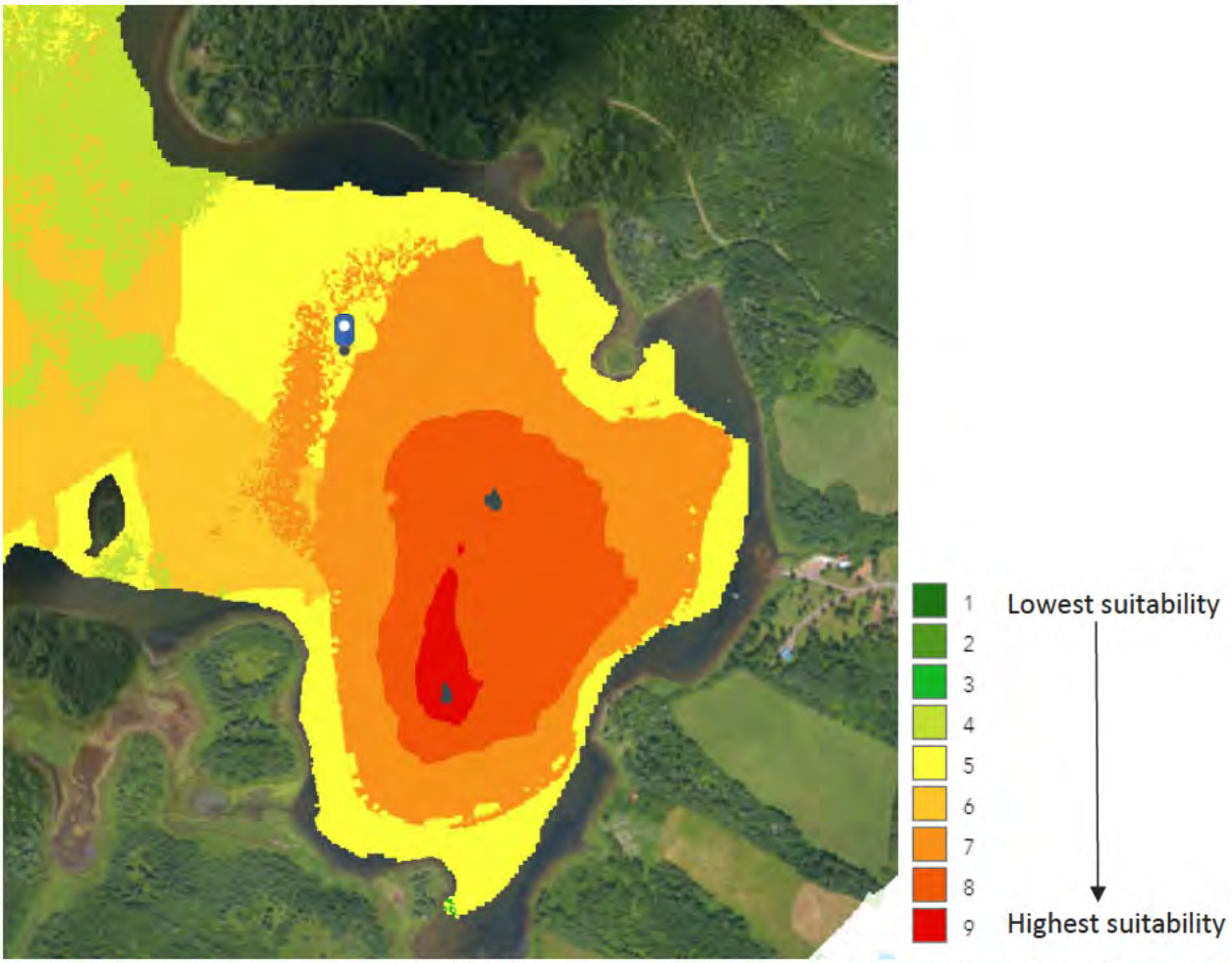


Figure I: Map of local waters showing relative suitability of the area for suspended aquaculture development according to model run with inputs suggested by DFO, NSDFA and CMAR and described within ""Development of a Bay Management Tool to Support Sustainable Aquaculture for Paqtnkek Mi'kmaw Nation Using Bathymetric Lidar, Hydrodynamic Modelling, and GIS.". The location of the proposed site center is indicated by the blue marker. Data acquired and processed by the Applied Geomatics Group, NSCC.

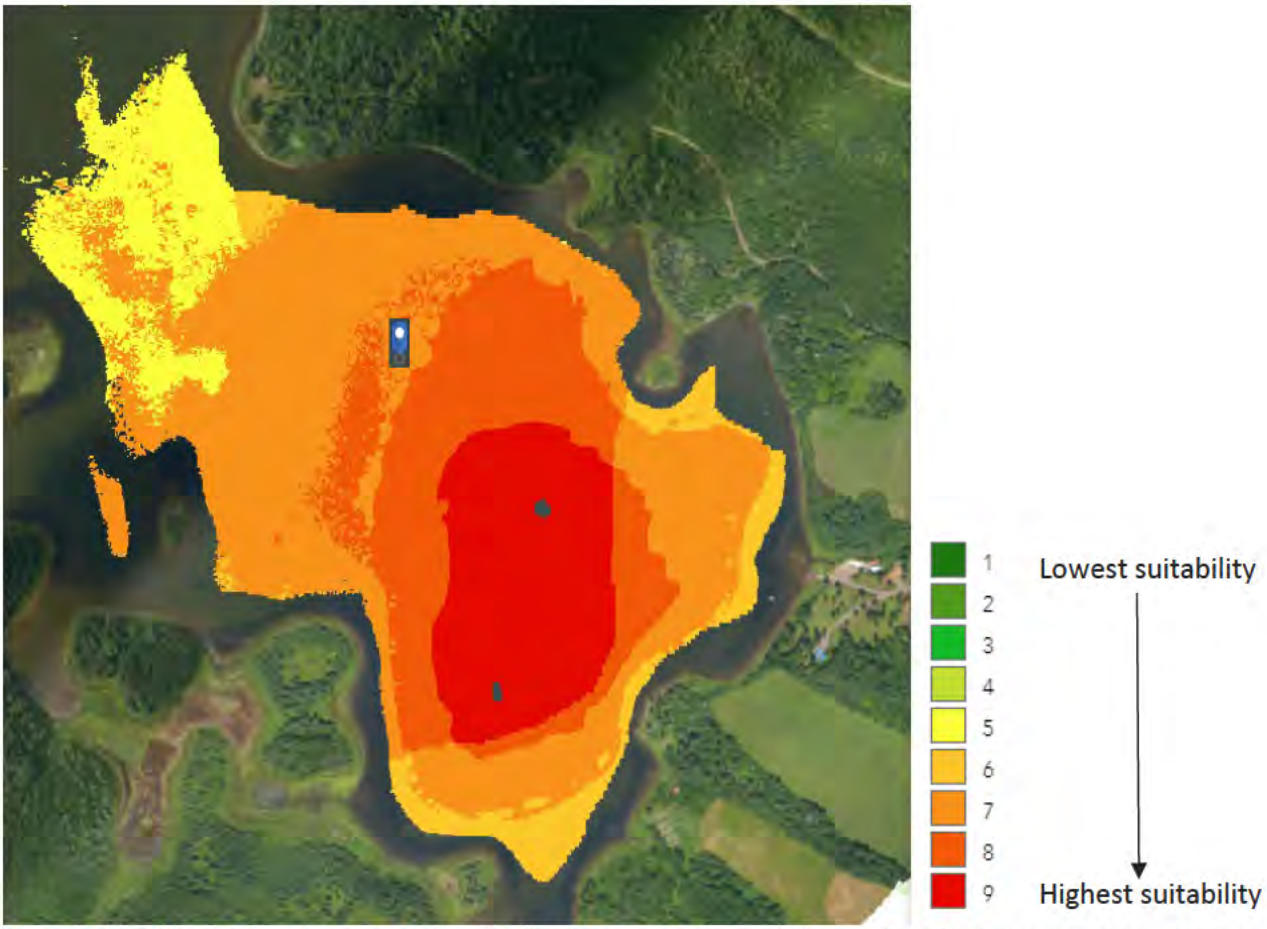


Figure J: Map of local waters showing relative suitability of the area for suspended aquaculture development according to model run with inputs suggested by project biologist [redacted]

The location is also easily accessible for conducting on-lease activities.

Furthermore, this is an area of significant historical importance to Paqtnkek Mi'kmaw Nation and has traditionally provided a livelihood so that the location was an obvious fit for this venture. See Section 5.1 for additional information in this regard.

<u>Set-up</u>

The long lines will be run in a northwest to southeast direction, parallel with the nearest shore, and parallel to the greatest wind fetch. They will be 220' long and allow the lease to be divided into 4 equal sections. A similar arrangement has been effective for the experimental lease, looks tidy, and facilitates inventory tracking.

Diagrams of the gear configuration, to be submitted to Transport Canada follow: Figures K (side view), and L (top view). Corner coordinates are listed after Figure L.

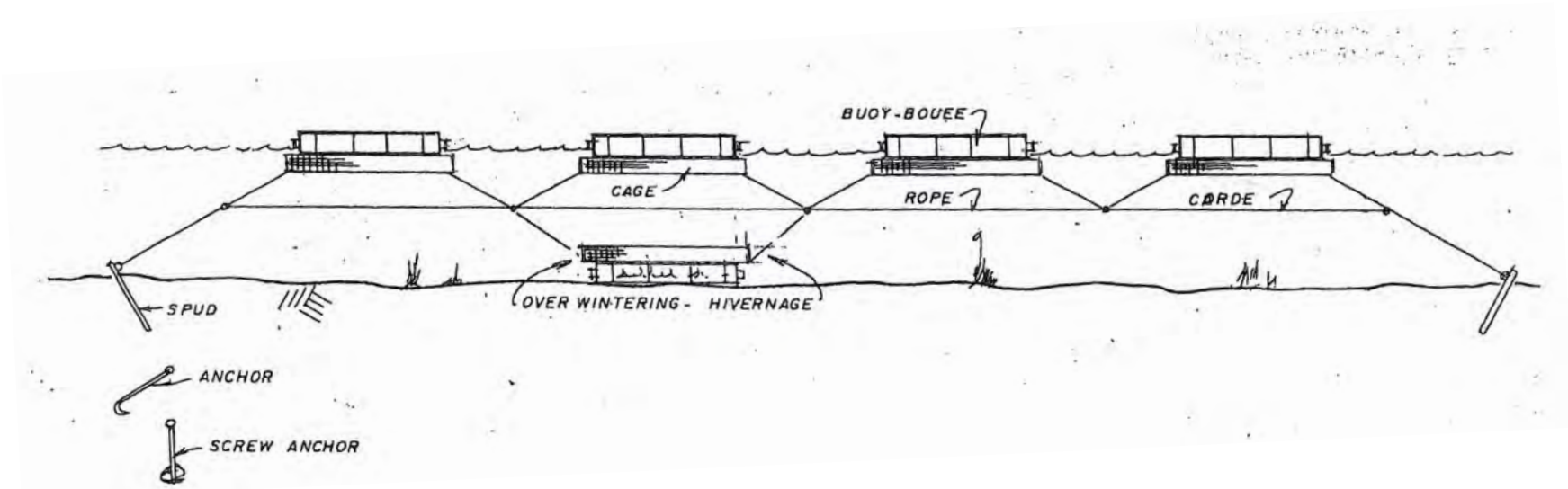


Figure K: Side view of oyster line installations

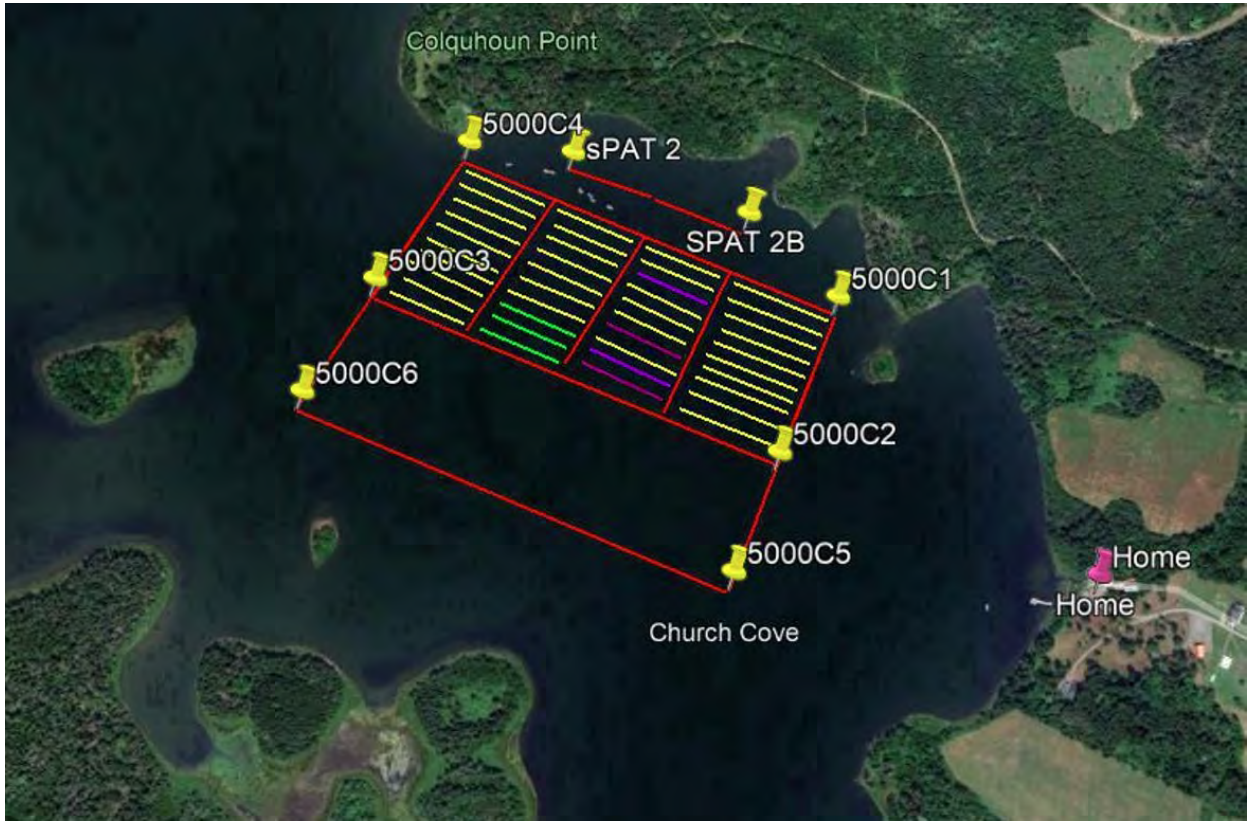


Figure L: Top view of oyster aquaculture gear layout at Summerside site. Lines in the south half of the site are not depicted but will mirror those in the north half. Corner coordinates are listed below in the text.

Corner coordinates:

5000C1	45° 36' 55.53"N	61° 47' 13.81"W
5000C2	45° 36' 50.27"N	61° 47' 17.44"W
5000C3	45° 36' 56.19"N	61° 47' 37.19"W
5000C4	45° 37' 1.14"N	61° 47' 32.51"W
5000C5	45° 36' 45.84" N	61° 47' 19.12"W
5000C6	45° 36' 52.18" N	61° 47' 40.77" W

SECTION 5: THE OTHER USERS OF THE PUBLIC WATERS SURROUNDING THE PROPOSED AQUACULTURAL OPERATION

5.1 Description of other users

Users of the land area and waters surrounding the proposed operation have been grouped according to their proximity to the proposed site.

Users within 1-km

As shown in Figure M, much of the shoreline surrounding the proposed site is undeveloped.

As mentioned in Section 2.1, the land adjacent to the site, where activities required to support the site will occur, is part of Welnek Indian Reserve No. 38, and managed by Paqtnkek Mi'kmaw Nation. Paqtnkek's other use of this area is described below under the heading "Traditional and current use by Paqtnkek Mi'kmaw Nation"

There are three private properties that have developed water access within 1-km of the site. One has a camper on site, the other two have cabins. All seem to be seasonal residents.

Because of the lay of the land, only one of these (M-3) is likely able to see the site from the shore.

There are no businesses known to be within 1-km of the proposed farm. There are some agricultural operations in the vicinity with cleared land adjacent to the water but uncultivated riparian zones between the land and the water are evident to protect the waters from run-off. There is thought to be some trapping activity in the wooded areas in the vicinity of the site.[13]

[13] [redacted], personal communication

.....

Figure M: Google Earth image of the proposed site area with a 1-km radius around the site center shown as a red circle. Buildings or developments within this radius are numbered in yellow and listed in the text. The boundary of Welnek Indian Reserve No. 38 is indicated by the orange hashed outline.

Users within 2-km

As shown in Figure N, there are four private properties (N-1, N-2, N-3, N-4) that have developed water access between 1 to 2-km from the site center. These property owners would be too far away to experience visual impact from the farm.

There are no businesses known to be within 2-km of the proposed farm.

Use of the waters would be the most likely source of interaction with other users, although the waters outside of Church Cove are very shallow (0 to 1-m deep, shown in Figure G) so possible boating activities are extremely limited.

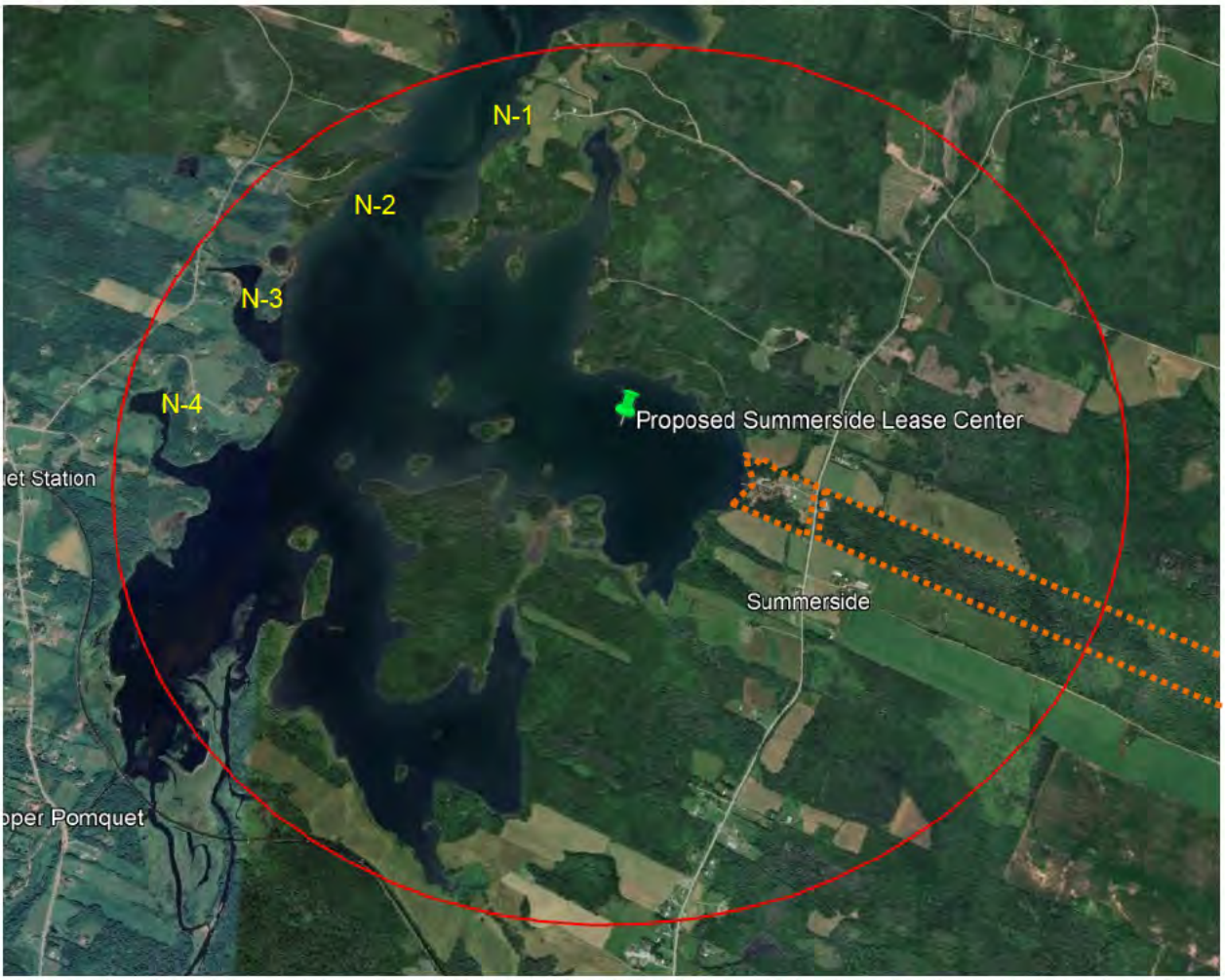


Figure N: Google Earth image of the proposed site area with a 2-km radius around the site center shown as a red circle. Buildings or developments within this radius and not mentioned earlier are numbered in yellow and listed in the text.

Users within 5-km

Users between a 2-km and 5-km radius are shown in Figure O. They are described below, according to the numbers designated on the map in Figure O.

O-1: Pomquet Beach Provincial Park: 3-km seasonally supervised beach (July and August) with a prograding dune system. The beach is wheelchair-accessible and the park is available for group use. This beach is on the Tracadie Bay side of the coast.[14]
O-2: Bayfield Wharf: Public fishing harbour managed and operated by the Harbour Authority of Bayfield through a lease agreement with Small Craft Harbours (DFO). There are several businesses and a Harbour Authority Building associated with the wharf.[15]
O-3: Area with multiple duck or geese hunting blinds (hashed blue outline)
O-4: Sea'scape Cottages: 160-acre property with three 2-bedroom cottages and a 1-unit bachelor cabin for rent seasonally by the night or by the week.[16]
O-5: Pomquet Beach Cottages: Four fully equipped two-bedroom cottages available for rent year-round, by the night or by the week.[17]
O-6: Captains Cabs: Taxi service based near Pomquet.[18]
O-7: Bayfield Beach Provincial Park: seasonal small sand-and-pebble beach offers supervised swimming in July and August, change houses, vault toilets and a picnic area. This beach is on the Tracadie Bay side of the coast .[19]
O-8: Old Barn Gallery & Gardens: seasonal art gallery and boutique in a loft of an 1845 barn on Beaver Dam Farm, featuring fine art paintings, sculpture, antique quilts, woolens, folk art, garden art, tea cozies, aprons, clothespin bags, and shabby-chic treasures.[20]
O-9: Redline Sport & Cycle: Yamaha motorcycle sales and service[21]

These users of the local area would be too far away to experience any visual impact from the farm. Those that are located on the water are either on another body of water (e.g. the Tracadie Bay side of the water) or would have to navigate a very narrow channel to reach Church Cove - as shown by Figure P, the bathymetry map of the general area.

Community of Heatherton: Small community with a community center, post office, Catholic church, group home and bakery. Local economy consists of farming, forestry and fishing. Many people work in the town of Antigonish.[22]

Community of Pomquet: 900-person Acadian-settled community (late 1700's), previously inhabited by Mi'kmaw families. Community currently has its own P-12 french school (Ecole Acadienne de

[14] https://www.novascotia.com/see-do/outdoor-activities/pomquet-beach-provincial-park/1753 Accessed January 22, 2022
[15] https://highlandconnect.cioc.ca/record/ACO0085 Accessed January 22, 2022
[16] https://www.seascapecottages.ca/ Accessed January 22, 2022
[17] https://www.pomquetbeachcottages.com/ Accessed January 22, 2022
[18] https://www.facebook.com/people/Captains-Cab/100063489496460/ Accessed January 22, 2022
[19] https://www.novascotia.com/see-do/outdoor-activities/bayfield-beach-provincial-park/2044 Accessed January 22, 2022
[20] https://www.oldbarngallery.ca/ Accessed January 22, 2022
[21] https://www.redline-yamaha.ca/about/ Accessed January 22, 2022
[22] https://en.wikipedia.org/wiki/Heatherton, Nova Scotia Accessed January 22, 2022

Pomquet), Pomquet Museum, church, fire department, historic Chez Deslauriers property (a heritage home converted to a tearoom, an interpretive center, and an outdoor stage) and other businesses and services. Farming and fishing continue to be practiced in Pomquet, but most residents have found employment in the larger center of Antigonish.[23]

Paqtnkek Mi'kmaw Nation has a registered population of approximately 600 persons. Pomquet Harbour and its adjacent waters are recognized areas of cultural, recreational, and social significance for this nation. The name Paqtnkek, meaning "by the bay", is a distinction emphasizing the importance of the local bay and its resources to the Mi'kmaq.[24] The proposed aquaculture site is a significant part of Paqtnkek business development plans. It will be managed in association with the other Mi'kmaw activities in the waters. A single group manages both the fisheries and aquaculture portfolios of the Band and will ensure that they are complementary.

[23] http://www.pomquet.net/en/village.html Accessed April 3, 2022
[24] http://paqtnkek.ca/about-paqtnkek/community-profile/ Accessed April 3, 2022

Figure O: Google Earth image of the proposed site area with a 5-km radius around the site center (red circle). Buildings or developments within this radius and not mentioned earlier are numbered in yellow and listed in the text. The approximate locations of Welnek Indian Reserve No. 38 and Paqtnkek-Niktuek Indian Reserve No. 23 are indicated by the orange hashed lines.

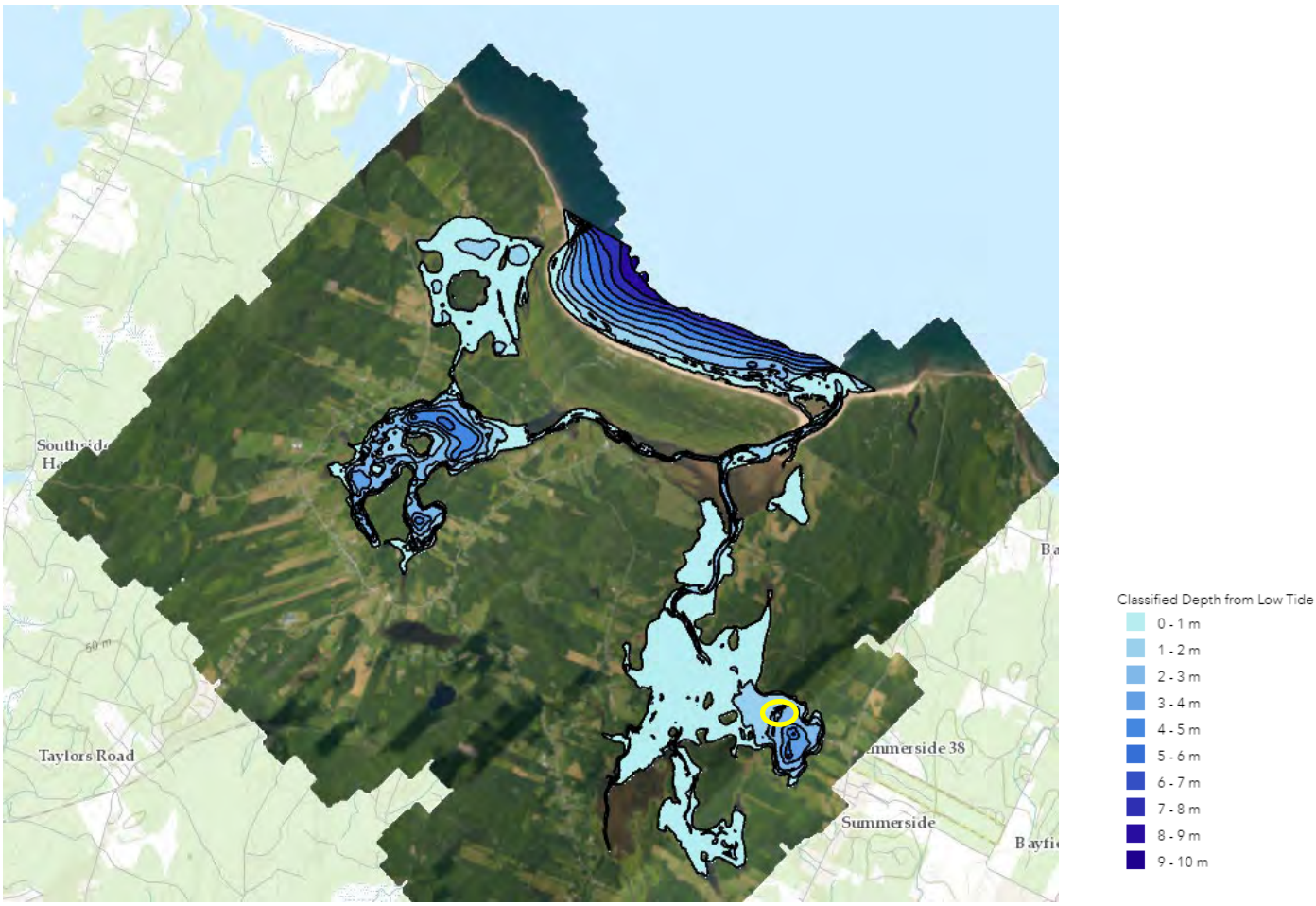


Figure P: Bathymetry of general area, shown as 1-m contours. The approximate location of the proposed site is indicated by yellow circle: Data acquired and processed by the Applied Geomatics Group, NSCC.

Traditional and current use by Paqtnkek Mi'kmaw Nation

The significance of this area to the Paqtnkek Mi'kmaw Nation is too deep and rich to be captured effectively on paper. It is best explored by listening to a community elder recite in the oral tradition. A summary has been attempted below, as derived from communications with [redacted]: Mi'kmaw Elder, Pipe Carrier, published author, and inaugural Knowledge Keeper of StFX.

The name Paqtnkek means "by the bay" demonstrating the significance of the local waters and its resources to this Mi'kmaw Nation. The proposed site for this oyster lease has been consistently used by Paqtnkek since long before colonialism. This cove is called *Welnek*, meaning "nice spot", recognized for generations as a welcoming resting spot for the local people as well as travelers passing by, on their way to or from *Unama'ki* (Cape Breton) or other destinations. Historically, it represents one of the two most well-used sites for Paqtnkek.

In the past, summer and winter locations for each family of the Paqtnkek Nation could be found on the shore along the bay. Rabbit, deer, and porcupine were hunted, and trapping occurred for mink, muskrat, fox, and beaver. Migratory birds, partridge and eggs were harvested. The islands were places for gathering sweet grass, and bogs supplied cranberries. Blueberries, blackberries, and raspberries were harvested for food; other berries and flowers were dried for decorative purposes; and pine cones, rose hip, evergreen needles and other plant parts were gathered for use, including for medicinal purposes. Wood ash was used in axe handles. This and other wood were fashioned into hoops of lobster traps, hoops for sail boats, and handles for picks, shovels, and hammers. Baskets used for harvesting and gathering were woven using local plants. The shoreside was a popular area, not just for hunting and gathering, but also for processing food for winter. Many of these activities continue today. This area continues to be a gathering place for the Paqtnkek Mi'kmaw Nation with its community church and burial nearby.

The cove and adjoining waters also hold great significance to Paqtnkek Mi'kmaw Nation. The Mi'kmaq share a long cultural history with the water and its bounty. The waters have been fished by Paqtnkek, and others, for American eel, brown trout, sea trout and speckled trout, as well as bass, smelt, salmon, crabs, bay scallops, clams and oysters. Use of this area for fisheries is described in Section 3.

This area has provided income and employment for Paqtnkek. The shore-side was a site for local trade, including in shellfish and eels. In the 1970's, it housed an eel farm that sold live eels, locally fished by flight and fluke nets and eel pots. This commerce was shut down when Pomquet Harbour was deemed contaminated due to the sewage treatment plant.

The shore-based activities that will support the lease will be located on land adjacent to the cove, legally identified as Welnek No. 38, a Mi'kmaw reserve that is part of Paqtnkek Mi'kmaw Nation. Paqtnkek-Niktuek Indian Reserve No. 23 is within 5 km of the proposed site and is home to the governing center for Paqtnkek Mi'kmaw Nation.

Because of the centuries of use of the area, articles of historical significance to the Mi'kmaq are likely to be found during operation of the farm, as through any normal use of the area. In such an instance, the item will be brought to the Paqtnkek Band Office.

Feedback from public meeting
The public meeting regarding this site is described in the attached Public Scoping Report, Summerside. The greatest concerns expressed were to ensure that the gear stayed on site, to ensure the cove is still navigable and whether people could use the slipway for access to the cove.

5.2 Significance of proposed area to wildlife

Known Managed and Significant Areas are identified in Figure Q below, as extracted from: Atlantic Canada Conservation Data Centre, DATA REPORT 7145: Paqtnkek Summerside, NS which is attached as Appendix F. A summary of the ecologically significant areas listed in the report follows.

The managed areas within 5-km of the proposed site include the following:

- Monks Head Provincial Park

- Pomquet Protected Beach
- Pomquet Beach Significant Ecological Area
- Pomquet Beach Provincial Park
- Bayfield Protected Beach

The biologically significant areas within 5-km of the proposed site include the following:

- Pomquet Beach Region Important Bird Area
- Church Cove Significant Ecological Area
- Point a Roche Significant Ecological Area
- Pomquet Island Significant Ecological Area
- Bayfield Pond No. 2 Significant Ecological Area
- Bayfield Pond No. 1 Significant Ecological Area
- Pomquet Beach Significant Ecological Area
- Bayfield Beach Significant Ecological Area
- Jack Dans Cove Significant Ecological Area

Most of these areas are several kilometers away and unlikely to interact on a regular and significant basis with the proposed site location, other than via animals travelling between them. The animals of concern in this area are described below under the heading "Rare and Endangered Species".

Point a Roches Significant Ecological Area and Church Cove Significant Ecological Area, as identified in Figure Q, are adjacent to the site.

Point a Roches Significant Ecological Area: The specifics for the designation of this island as a significant ecological area is unknown. It is listed as AT 144 ("other habitat") within the Provincial Landscape Viewer (https://nsgi.novascotia.ca/plv/). It was described as "a significant island" by one of the Regional biologists with Nova Scotia Department of Natural Resources and Renewables. The reason is unknown.[25] No additional information on this island could be found. The water surrounding the island, and beyond, is listed as AT 818 and described as a bald eagle and osprey feeding area.[26] No additional information on this area could be found.

Church Cove Significant Ecological Area: The specifics for the designation of the cove as significant ecological area is unknown. It is listed as AT 76 ("other habitat") within the Provincial Landscape Viewer (https://nsgi.novascotia.ca/plv/); but its descriptions and habitat coding are inconsistent within this database.[27] No additional information could be found.

[25] Frances MacKinnon, Wildlife GIS Analyst, Nova Scotia Department of Natural Resources and Renewables
[26] Frances MacKinnon, Wildlife GIS Analyst, Nova Scotia Department of Natural Resources and Renewables
[27] Frances MacKinnon, Wildlife GIS Analyst, Nova Scotia Department of Natural Resources and Renewables

Figure Q: Managed and Significant Areas in the vicinity of the proposed site, as identified by the Atlantic Canada Conservation Data Center (Extracted from Atlantic Canada Conservation Data Centre, DATA REPORT 7145: Paqtnkek Summerside, NS, attached as Appendix F.) The site center is indicated by the dot labelled 7145.

Rare and endangered species

The afore-mentioned data report from the Atlantic Canada Conservation Centre provides more in-depth detail on the possibility of the presence of rare and endangered species that may use the proposed development area. A summary follows:

<u>Rare species list</u>

Within 5-km of the proposed site center, records indicate the presence 48 species of rare or endangered vertebrates (all birds, except Atlantic salmon), and 2 species of rare or endangered invertebrate fauna. Records also indicate the presence of 18 rare or endangered vascular plants. The vast majority of the rare or endangered species are associated with Pomquet Beach located more

than 2.8-km to the north of the site, as shown as "O-1" in Figure O. Near-water or in-water rare species whose presence has been recorded within 5-km of the proposed site are listed below.

Shoreside or wading species of birds:

- Piping plover *melodus* sp.
- Lesser yellowlegs
- Common tern
- Bank swallow
- Red knot *rufa* subspecies
- Nelson's sparrow
- Least sandpiper
- Semipalmated plover
- Arctic tern
- Willet
- Cliff swallow
- Killdeer
- Wilson's snipe
- Greater yellowlegs
- Semipalmated sandpiper
- Sanderling
- Black-bellied plover
- Spotted sandpiper

Waterbirds or ducks:

- Common goldeneye
- Blue-winged teal
- Red-breasted merganser
- Bufflehead
- Gadwall

Fish:

- Atlantic salmon – Gaspe -Southern Gulf of St. Lawrence pop

Neither of the invertebrates found within 5-km would be expected near a salt water shore, nor in the water.

Shoreside flora:

- Wooly beach heath
- Greene's rush
- Estuarine sedge
- Seaside spurge

Species at Risk

Ten Species at Risk are on record as being in the region. They are listed in the table below. The piping plover, red knot and bank swallow are the only coastal species, with the others preferring inland habitat.

Table 1: Species at risk within 5-km radius of proposed site as extracted from Atlantic Canada Conservation Center Report 7145. Species habitat and other comments were obtained from sources referenced in footnotes.

Scientific name	Common name	SARA status	Habitat, other comments
Charadrius melodus melodus	Piping Plover *melodus* ssp	Endangered	Wide sand, gravel, or cobble beaches; barrier island sandspits; or peninsulas in marine coastal areas[28]
Chaetura pelagica	Chimney Swift	Threatened	Forests along the water's edge, the edges of tropical lowland forests, regenerating shrub areas, farmland, suburban areas and city centre zones.[29]
Riparia riparia	Bank Swallow	Threatened	Nests in burrows excavated in eroding banks of coastal cliffs and other steep vertical soft soil faces[30]
Dolichonyx oryzivorus	Bobolink	Threatened	Open grasslands and hayfields[31]
Contopus cooperi	Olive-sided Flycatcher	Threatened	Spruce and fir swamps and bogs[32]
Contopus virens	Eastern Wood-pewee	Special Concern	Woodlands[33]
Euphagus carolinus	Rusty Blackbird	Special Concern	Utilize wetlands around lake edges, bogs, swamps and edges of fens for breeding.[34]
Hirundo rustica	Barn Swallow	Threatened	Forage over a wide range of open country habitats. Nests are commonly situated inside or outside of buildings, under bridges and wharves and in road culverts. A small portion

[28] https://novascotia.ca/natr/wildlife/species-at-risk/docs/RECOVERY_PLAN_Adopted_Piping_Plover_22Feb2021.pdf. Accessed January 19, 2022

[29] https://wildlife-species.canada.ca/species-risk-registry/species/speciesDetails_e.cfm?sid=951 . Accessed January 19, 2022

[30] https://novascotia.ca/natr/wildlife/species-at-risk/#bank-swallow. Accessed August 12, 2021

[31] https://novascotia.ca/natr/wildlife/species-at-risk/#bobolink. Accessed August 12, 2021

[32] https://novascotia.ca/natr/wildlife/species-at-risk/#olive-sided-flycatcher. Accessed August 12, 2021

[33] https://novascotia.ca/natr/wildlife/species-at-risk/#eastern-wood-peewee. Accessed August 12, 2021

[34] https://novascotia.ca/natr/wildlife/species-at-risk/#rusty-blackbird. Accessed August 12, 2021

Scientific name	Common name	SARA status	Habitat, other comments
			of the population nests on cliff faces. [35]
Chordeiles minor	Common Nighthawk	Threatened	Nests on the ground in open land or forest clearings, and on gravel roofs in cities.[36]
Calidris canutus rufa	Red Knot *rufa* subspecies	Endangered	Nest on the ground within 500 m of a freshwater wetland or other water body During migration and winter, Red Knots require habitat relatively free of human disturbance; the species uses sandy beaches, sandspits, sandbanks, tidal mudflats, restingas (i.e., intertidal, wave-cut, rocky platforms), intertidal rocky flats, and salt marshes at stopover sites.[37]

Location sensitive species

The only location sensitive species recorded in the region are bats (Little Brown Myotis, Long-eared Myotis, and Tri-colored Bat). They would not be expected to spend much time in the proposed area.

Wildlife of cultural significance

The Paqtnkek Mi'kmaq have enjoyed a close relationship with the wildlife in the area for generations. Sweet grass is known to grow in the area but erosion is removing its habitat. Similarly, sweet flag is in the area, as are other medicinal plants collected by Paqtnkek.[38]

As mentioned in Section 3.1, eel (*Ka't*) is of cultural significance to Paqtnkek and is found in the area of this proposed site.

[35] https://novascotia.ca/natr/wildlife/species-at-risk/docs/RECOVERY_PLAN_Adopted_BARN_SWALLOW.pdf . Accessed January 19, 2022

[36] Nova Scotia Department of Lands and Forestry. 2021. Recovery Plan for the Common Nighthawk (Cordeiles minor) in Nova Scotia [Final]. Nova Scotia Endangered Species Act Recovery Plan Series.

[37] Environment and Climate Change Canada. 2017. Recovery Strategy and Management Plan for the Red Knot (Calidris canutus) in Canada. Species at Risk Act Recovery Strategy Series. Environment and Climate Change Canada, Ottawa. ix + 67 pp.

[38] [redacted], personal communication

5.3 Impacts to other users including wildlife

Impacts to other human users

As described in previous sections, potential human users of the area are the Paqtnkek people, local land owners, Summerside, and Heatherton area residents.

Paqtnkek Mi'kmaw Nation is the applicant for this lease. The potential impacts of this lease on social sustainability are described in Section 2.2 of this Development Plan. This development will be co-managed with other activities to prevent conflicts between user groups within Paqtnkek.

As mentioned in Section 5.2, there is only one property owner who may be able to see the site from the shore. The others are either too far away or on another shoreline.

The most likely interactions with other users would be via the water and these are expected to be minimal. The site will be marked according to Transport Canada requirements to permit safe navigation. The Farm Management Plan (FMP) will be used to describe procedures for ensuring that site markings following the Transport Canada requirements are maintained. Perhaps most significant is that use of the surrounding waters by watercraft is extremely limited since the immediate waters outside of Church Cove are very shallow (0 to 1-m deep, shown in Figure G); and access by water is further limited by the need to navigate a very narrow channel to reach Church Cove - as shown by Figure P, the bathymetry map of the general area.

Several persons from the local community were consulted regarding the proposed development and their comments have been captured in the Public Scoping Report, Summerside. One concern expressed was the importance of ensuring the gear remains on site. A weekly check of the site and its adjoining shorelines will be completed in order to ensure that any required maintenance is prompt. Loose gear will be retrieved as soon as it is safe to do so. The FMP will be used to describe procedures for ensuring that gear is properly maintained on site and frequent checks are scheduled for finding and retrieving loose gear. The community will be encouraged to let Paqtnkek know if they see anything out of place. The chance of loose gear will also be lessened by the use of screw anchors for mooring.

In order to ensure that impacts to local human users are minimized, continued and frequent communication with the community will occur.

Impacts to wildlife

Because of the small amount of on-water activity associated with the site and the contained shore-side activity, there are few interactions with wildlife expected.

To mitigate interactions with birds, in particular:

- Shore-side activity beyond the identified work area (Figure A) will be avoided, with the exception of clean-up of loose gear or other targeted shoreline clean-up activities. Clean-up

will be scheduled at times that will not disturb nesting behaviour; and staff will not go ashore in areas where activity involving these birds is observed.

- Shoreside birds and other wildlife will be given a wide berth for all operations-related and clean-up activities, and physical interaction with birds will not be allowed, nor will scare tactics to disperse birds be allowed.
- When sensitive bird species are observed in the water or on shore, boat captains will reduce boat wake and keep as much distance as reasonably possible between the boat and the bird(s).
- Steady boat speeds will be maintained when moving to and from the work site.
- Vessels will be well-muffled to reduce noise and constant engine noise level will be maintained, as reasonably as possible, and the use of sharp or loud noises (e.g. horns or whistles) will be avoided.
- Litter will be properly contained and disposed of.
- All reasonable means will be taken to avoid spills or leaks of oil; and a contingency plan to manage a spill will be in place, complete with the needed equipment to carry out the plan.

The above impact mitigation measures will also serve to protect any sensitive vegetation that may be found along the shore.

Since the oyster gear will not inhabit the intertidal area and the above measures will be employed, feeding of migratory birds in the intertidal area should not be affected. Similarly, feeding and nesting of shoreline birds should be minimally affected.

5.4 Impacts by other users including wildlife

The gear will provide an artificial roosting site for birds which could raise concerns regarding contamination.[39] To mitigate this, the oysters will be depurated at another site prior to market using an approved procedure.

The greatest concern regarding other users is the potential import of invasive species by boats from other locations. Invasive tunicates or disease (e.g. MSX) may be transported by foreign boats that are not properly disinfected prior to being launched in this area. Education of boaters regarding these possibilities will be promoted by Paqtnkek to reduce this risk. Because of the restricted access to the area via water due to bathymetry, boaters for this area would most likely launch off Paqtnkek's slipway or wharf.

[39] Comeau, Luc & R., Chiasson & A., Chiasson & Pernet, Fabrice & T., Landry. (2006). Birds perching on oyster culture gear in eastern New Brunswick, Canada. Can. Tech. Rep. Fish. Aquat. Sci. 2681.

SECTION 6: THE PUBLIC RIGHT OF NAVIGATION

6.1 Navigation Protection Act (NPA) approval

A Notice of Works application has been submitted online through Transport Canada's portal. The coordinates listed in the enclosed schedule A are correct and confirmed in the field.

SECTION 7: THE SUSTAINABILITY OF WILD SALMON

7.1 Identification of local salmon populations

This site is within Salmon Fishing Area SFA 18A, which is included in Designatable Unit 12, as defined by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). There are a number of salmon bearings rivers and tributaries in the region which support a recreational salmon fishery Possible salmon bearing rivers, as reported by the Atlantic Salmon Federation[40], are shown in Figure R. All rivers shown are also recognized as Atlantic Salmon rivers by DFO and have been characterized.[41]

West River (Antigonish), shown in Figure R, is an index river. Here, catches from the recreational fishery were up in 2018 relative to the previous year, but down in 2019. Catches for both of these years were lower than historical values for both large and small salmon with the long-term trend of the median for the past 12 years showing a decline.[42] There is a food salmon fishery on the Pomquet and Afton Rivers by Paqtnkek.[43]

[40] Rivers shown on the Atlantic Salmon Rivers of North America map produced by the Atlantic Salmon Federation (ASF) were highlighted in Google Earth to produce the figure. The rivers highlighted include all status classifications, including those that are unknown. For more information on the ASF map used as reference, see https://www.asf.ca/news-and-magazine/in-the-field/the-meaning-of-our-map.

[41] DFO. 2022. Definition of Precautionary Approach Reference Points for Atlantic Salmon, DFO Gulf Region. DFO Can. Sci. Advis. Sec. Sci.Advis. Rep. 2022/027.

[42] DFO. 2020. Update of indicators of Atlantic Salmon (*Salmo salar)* in DFO Gulf Region Salmon Fishing Areas 15-18 for 2019. DFO Can. Sci. Advis. Sec. Sci. Resp. 2020/028

[43] [redacted], personal communication

Figure R: *Known salmon bearing rivers within the region of the site are indicated in red with labels in yellow. Rivers and locations determined from the Atlantic Salmon Rivers of North America map produced by the Atlantic Salmon Federation. The proposed site center is indicated by the yellow pin circled in orange.*

7.2 Support of the sustainability of wild salmon

It is not expected that the proposed lease will affect the sustainability of wild salmon or salmon recovery or restoration efforts.

There have been stream habitat restoration programs conducted in the area. These have included restoration work on nearby Pomquet River and its watershed where agriculture, forestry and land clearing have impacted habitat and quality of spawning areas. Activities by The Antigonish Rivers Association here have included habitat assessments, tree planting to re-establish riparian zones on tributaries, bank stabilization and the installation of digger logs. This work has been done in association with local land owners and Paqtnkek First Nation.[44] A full scope of river restoration in the area can be viewed at https://antigonishriversassociation.ca/restoration-map/ .

Responsible farm practices will minimize impact of operations on both salmon recovery and restoration efforts. These practices include procedures for ensuring that gear is properly maintained on site and frequent checks scheduled for finding and retrieving loose gear; properly containing and disposing of litter; and using all reasonable means to avoid spills or leaks of oil, including having a

[44] https://antigonishriversassociation.ca/portfolio-items/pomquet-river-antigonish/ Accessed May 30, 2022

contingency plan to manage a spill. These procedures will be approved for implementation by NSDFA, as required within the Aquaculture Management Regulations for aquaculture sites in Nova Scotia.

SECTION 8: THE NUMBER AND PRODUCTIVITY OF OTHER AQUACULTURE SITES IN THE PUBLC WATERS SURROUNDING THE PROPOSED AQUACULTURAL LOCATION

8.1 Identification of other aquaculture sites

Paqtnkek Mi'kmaw Nation is presently the lease/licence holder for AQ 5000 – an experimental lease/licence authorized for American oysters. The boundaries of the proposed commercial site will overlap with this site. This and other nearby sites are listed below and shown in Figure S.

A) Marine American oyster site (AQ 1385) held by Sam McKinley
B) Commercial marine American oyster sites (AQ 1442, 1443, 1444), proposed by Town Point Consulting
C) Land-based facility licensed for American oyster held by Town Point Consulting
D) American oyster site (AQ 1386), held by Future Seafood Inc.
E) Paqtnkek' s current Experimental site (AQ 5000)

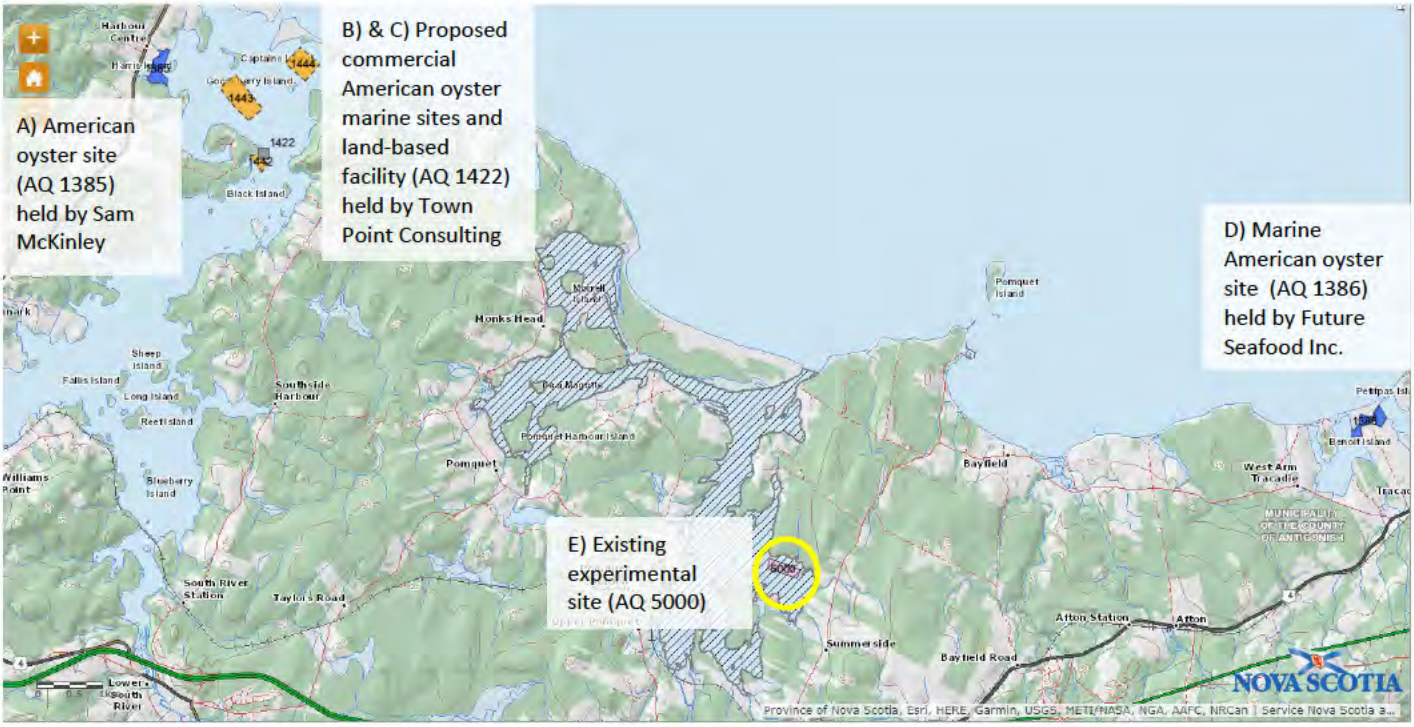


Figure S: Map of the region showing aquaculture sites. They appear as colored polygons (orange for proposed marine sites, blue for existing commercial marine sites, pink for existing experimental marine sites and grey for existing land-based sites) and are lettered and listed. The approximate location of the proposed site is circled in yellow. The hashed area is the option area given to Paqtnkek and represents the area explored for aquaculture development. The area requested for the lease is much smaller and can be seen in Section 4.3. The base map was acquired from https://novascotia.ca/fish/aquaculture/site-mapping-tool/ . Accessed February 28, 2022.

8.2 Interactions with other aquaculture operations

The requested site is not in waters directly shared with the other sites so that interaction between sites would not be expected to occur passively by water movement (currents or tides). Movement of boats, equipment and personnel would be the primary means for interaction between sites.

As mentioned in Section 5.4, the greatest concern regarding other users is the import of invasive species by boats from other locations.

BILL & STANLEY
– Oyster Company –

February 12, 2020

Paqtnkek First Nations
Attn: Norma Prosper
7 Dillon Street
Antigonish County, NS B0H 1A0

Dear Ms Prosper:

Further to recent meetings and telephone conversations, this is to confirm that Bill & Stanley Oyster Company Limited is in agreement to purchase oysters from Paktnkek First Nations, in principle from both open and closed areas.

I refer back to your visit to our plant and water sites late last summer. The offer for you to send several of your workers to Whitehead to train alongside our water crew still stands. We would certainly welcome them.

We look forward to a productive ongoing relationship between the two operations.

Sincerely

[redacted]

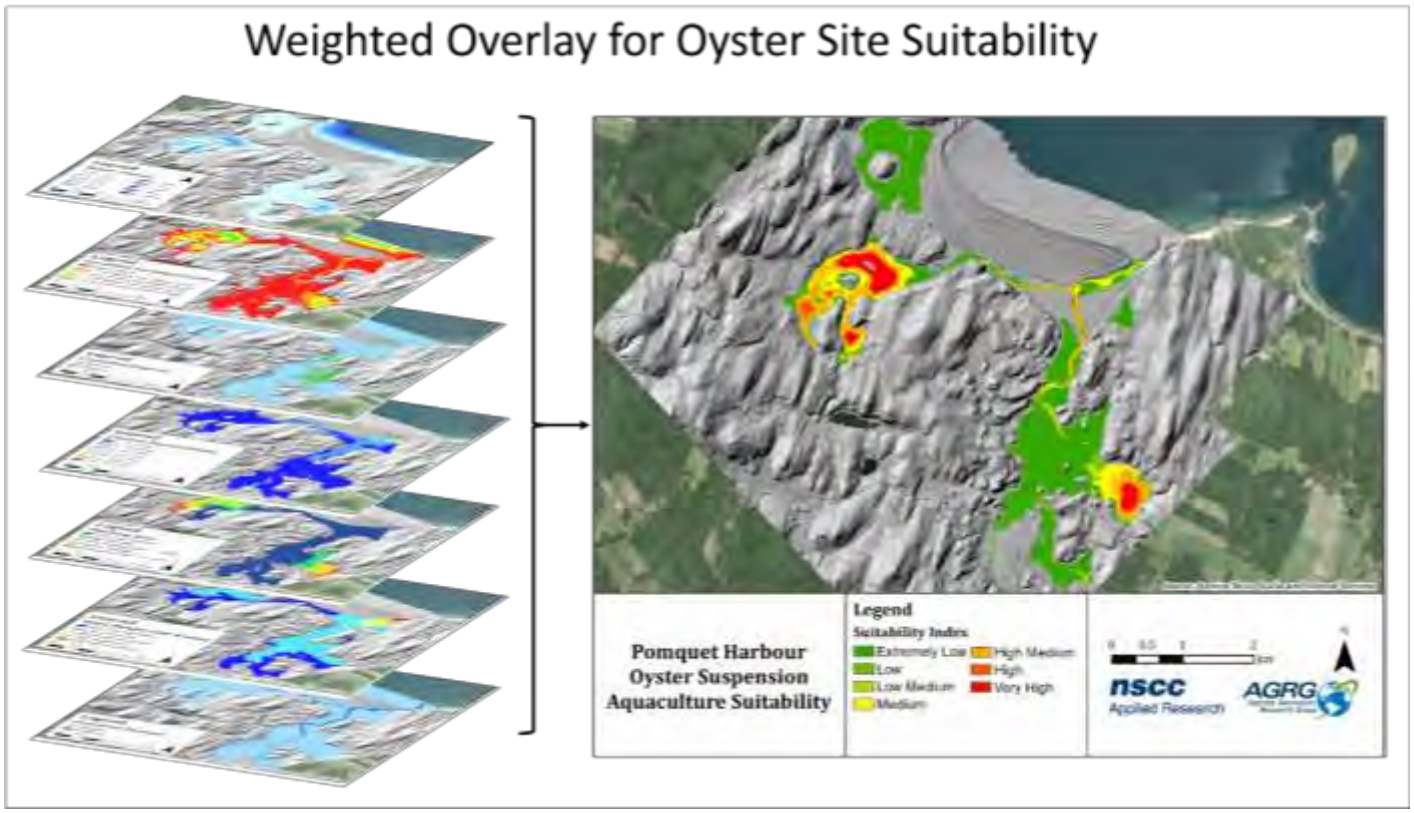
[redacted] for

931 Brush Wharf Road,
Orwell Cove, PE C0A 2E0
CANADA

31 Deming Point Road (Lower White Head) R.R. #2
Larry's River, NS B0H 1T0
CANADA

Appendix B: Suppliers to Paqtnkek Oyster Project

Acadian Bay Enterprises
Admiral Auto Glass
Antigonish Farm and Garden Co-op
Antigonish Rent-all
Aquaculture Association of NS
Barrier Spray Foam
Bayside Development Corp
Bell Aliant
Best Western Glengary
Bio-liquid Waste Disposal Inc.
Bill & Stanley Oyster Company Ltd.
Bouctouche Bay Industries Ltd.
Bowman Electric
Casey Concrete ltd.
Caper Developments LTD
Capital Paper
Causeway Diver Supply
Denis Office Supplies
Dyna Medical Technical Service
East Coast Marine & Mechanical LTD
Eastern Fence Erectors Limited
East Coast Home Heating
Eastern Sanitation
Ed's Hydraulic & Marine Services
Entreprises Shippagan LTEE
FEEDSnNEEDS Antigonish
Fisheries Safety Association of Nova Scotia
Fraser Hatt Law
Francis Boyle Construction
GS Equipment Limited
GM MacDonald Welding Ltd
Grant Thornton
Gypsom Cove Oysters
Hampton Homewood Suites
Highland Building Supplies
Highland Marine Products
Highland Multimedia
J.R. Rahey Stores Ltd
K&D Pratt
Kent Building Supplies
Kmac Plumbing Services
Lengkeek Vessel Engineering
MacDonald Chrysler Limited
Marie's Flowers
Micro Machining 2016 Limited
Monastery Petro Can
Municipality County of Antigonish
Myers Welding inc
NAPA Antigonish Auto Parts
Paq'tnkek Gas Bar
Purolator Courier Ltd
Quality Concrete
Rainbow Net & Rigging Ltd
Redline Sport and Cycle
Robertson Electrical Supplies Ltd
Robotnik
[redacted]
S.A. Electrical
Scotia Diesel Services Ltd.
Sobeys Atlantic
Staples
Stevens Solutions & Design Inc.
Strait Engineering Ltd.
Strait Supplies
Leroy Supernault
Sustain Aqua
Transport Canada Marine Safety
Trouw Nutrition Can Inc
Vernon d'Eon Fishing Supplies Ltd
Waycobah First Nation



DEVELOPMENT OF A BAY MANAGEMENT TOOL TO SUPPORT SUSTAINABLE AQUACULTURE FOR PAQTNKEK MI'KMAW NATION using Bathymetric Lidar, Hydrodynamic Modelling, and GIS

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Submitted to

Paqtnkek Mi'kmaw Nation

How to cite this work and report:

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Executive Summary

The Applied Geomatics Research Group of NSCC supplied data for Pomquet Harbour based on their aircraft-mounted topo-bathymetric lidar sensor and camera to collect land and sea elevation data and high-resolution air photos. Topo-bathymetric lidar is a relatively new remote sensing technology that uses lasers to acquire accurate measurements of the topography of the land and the bathymetry of the seabed. Bathymetric lidar depth penetration is limited by water clarity and therefore the survey must be completed under optimal conditions to maximize data quality. NSCC supplied data from an Acoustic Doppler Current Profiler (ADCP) deployed for one month in Pomquet Harbour. Supplemental bathymetry data were collected using a multibeam echo sounder for an area where the lidar sensor did not penetrate to the seabed. Maps were generated from the lidar data including a Digital Elevation Model (DEM) of the land and seabed, an intensity map that provides data on the seabed cover, and a high resolution (50 cm) multispectral aerial photo ortho-mosaic. A Mike-21 hydrodynamic model was developed to simulate current speeds and direction within the harbour under normal tidal conditions and in the case of a 1.5 m storm surge. The model was used to characterize harbour circulation, calculate flushing rates, and track the fate of particles that represent oyster spat. The layers for a GIS suitability map of potential oyster aquaculture sites include the development of a bottom classification map derived from the lidar and photo products, showing substrate cover, modelled currents, flushing time, water depth and depth below the ice impact zone among other GIS layers. The GIS suitability layers were classified and ranked in preparation for the GIS overlay to show optimal locations for aquaculture sites. The suitability maps were influenced by advice from DFO, NSFA, and CMAR. A web-based GIS mapping system was developed to display the GIS layers (model output, lidar-derived layers, etc.) and suitability maps. Suitability maps can be customized using the web-tools by assigning weights and scores to each GIS layer to determine suitability. See the User Guide to understand how the GIS layer selection and how the weighting-scoring of map classes function to construct suitability maps.

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1 Introduction

1.1 Project Description

Paqtnkek Mi'kmaw Nation (PMN) is a First Nations community near Antigonish, NS. The name Paqtnkek, meaning "by the bay", is a distinction emphasizing the importance of the local bay and its resources to the Mi'kmaw people. For this science partnership project, PMN collaborated with the Nova Scotia Community College's (NSCC) Applied Geomatics Research Group (AGRG) to carry out research on sustainable aquaculture development in Pomquet Harbour, NS. The AGRG has been conducting remote sensing research, mapping, and analysis since 2000 and specialize in coastal zone applications. Part of the motivation of this project was the result of a previous project conducted by AGRG for Monique Niles, DFO Science, Gulf Region where an aquaculture suitability map was developed for Little Harbour as well as an interactive website (AGRG, 2018) "Aquaculture Decision Support Tool Demonstration Project. Technical report". A proposal was submitted to the Atlantic Fisheries Fund which is funded by Department of Fisheries and Oceans (DFO) and the Nova Scotia Fisheries and Aquaculture (NSFA) by PMN to build the appropriate layers for a web-based suitability and mapping tool for Pomquet Harbour.

1.2 Background and Study Area

Studies show that there is an abundance of natural shellfish seed (oyster, bay scallops) in the Pomquet Harbour, suggesting that the harbour is an ideal shellfish larvae nursery beyond the current experimental lease. Paqtnkek Mi'kmaw Nation, with the assistance from Ulnooweg Development Group, wishes to apply to NS Fisheries and Aquaculture for oyster aquaculture leases, but requires quantitative information on the biophysical conditions of the harbour to suggest optimal lease locations. PMN began a commercial oyster spat collection business in Pomquet Harbour in 2016, with varying degrees of success. Quantitative biophysical information is required to improve the success of the oyster spat collection industry so that it can be developed into a commercially viable operation with the potential to improve access to seed for the whole province. The biophysical information provided by AGRG will help in site selection and farm management for full oyster production.

Pomquet Harbour is a small, shallow, estuary near Antigonish, NS, connected to the eastern Northumberland Strait by a narrow channel inlet (Figure 1). Monks Head Harbour is located north of the Pomquet Harbour and is connected by a narrow channel. Church Cove and areas around Île à Magotte island are deeper than rest of the harbour.

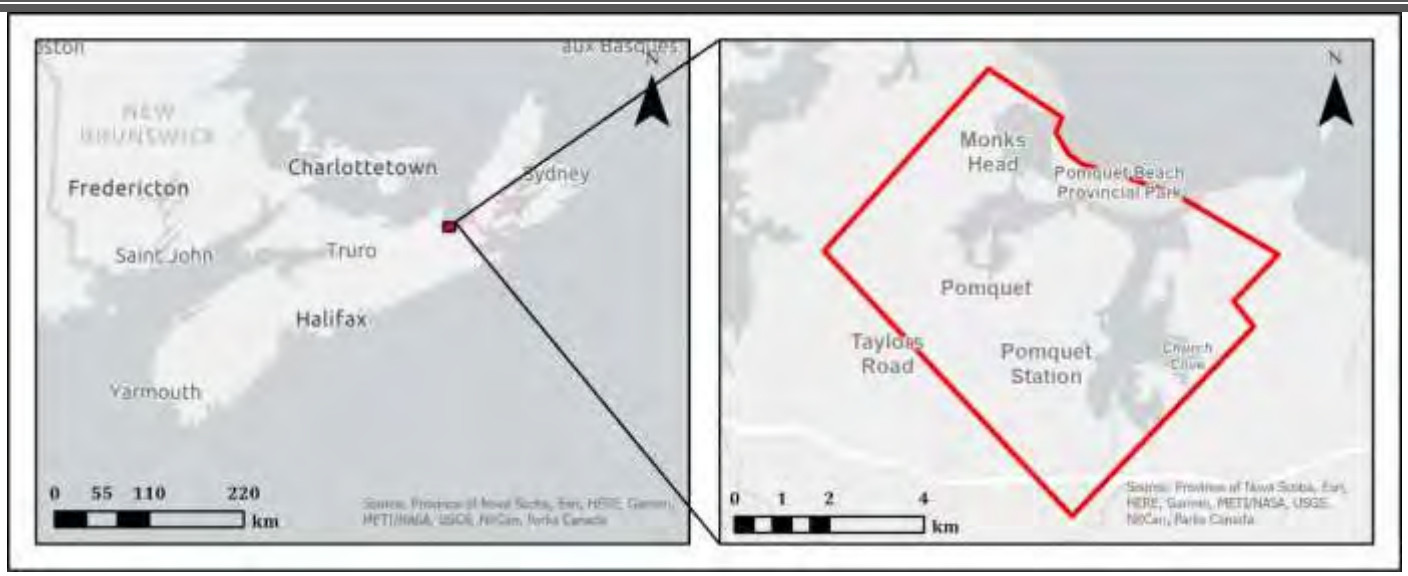


Figure 1: Pomquet Harbour, NS, the study area used for the Bay Management Tool project.

2 Methods

2.1 Lidar Sensor Specifications and Installation

The lidar sensor used in this study was a Chiroptera 4X integrated topo-bathymetric lidar sensor equipped with a 60-megapixel multispectral camera. The system incorporated a 1064 nm near-infrared laser for ground and sea surface returns and a green 515 nm laser for bathymetric returns (Figure 2). The lasers scanned in an elliptical pattern which enabled coverage from many different angles on vertical faces and resulted in fewer shadow effects in the data including those caused by wave interaction. The bathymetric laser was limited by water clarity and has a depth penetration rating of 1.5 x the Secchi depth (a measure of turbidity or water clarity using a black and white disk). The Leica RCD30 camera collected co-aligned RGB+NIR motion-compensated images which could be mosaicked into a single image in post-processing or analyzed frame by frame for maximum information extraction.

AGRG-NSCC does not own an aircraft, only the sensor. AGRG partnered with Leading Edge Geomatics to contract a twin-engine aircraft that was certified to carry the Chiroptera II sensor suite and had a hole suitable to house the sensor head. The lidar sensor was installed in the aircraft in Fredericton, NB. The laser systems and camera were calibrated and aligned with the navigation system which consisted of a survey-grade GPS mounted on the roof of the aircraft and an inertial measurement unit (IMU) mounted above the laser system (Figure 3a).

The system also included a 5-megapixel quality assurance camera that the lidar operator could view during the flight, along with the waveform of the returning green laser pulse and the flight plan (Figure 3b). The aircraft had a hole cut in the bottom for the laser to face the ground and installation involved fitting the sensor head into the hole (Figure 3c). Figure 3d shows the downward-facing portion of the sensor head, including the red (topographic) and green (bathymetric)

lasers, which shoot and return through the large red circles. The lenses on the left and right were the low and high-resolution cameras, respectively.

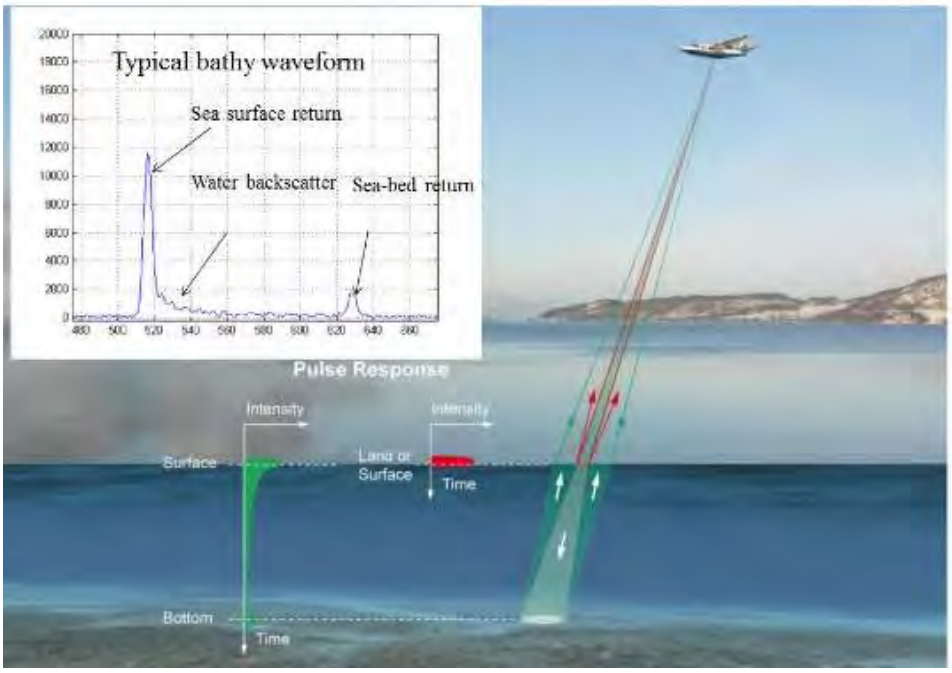


Figure 2: Principals of topo-bathymetric lidar. The system utilizes two lasers, a near-infrared and a green laser to surface the land and marine topography. Inset of green laser waveform.

Figure 3: (a): Aircraft used for lidar survey; (b): display seen by lidar operator in-flight; (c): main body of sensor (left) and laser pointing through a hole cut in the bottom of the plane (right); (d): large red circles are the lasers; the RCD30 lens (right) and low-resolution camera (left).

2.2 Lidar Survey Details

The lidar survey was conducted on August 6th, 2018 (Table 1). The surveys were planned using Mission Pro software. The 54 flight lines are shown in Figure 4. The aircraft required ground-based high precision GPS data to be collected during the lidar survey to provide accurate positional data for the aircraft trajectory. The Nova Scotia Active Control Stations (NSACS) network was used to provide geodetic control from the Antigonish station which was used to process the trajectory of the aircraft. The NSACS network was also used to establish base station coordinates for real-time kinematic collection of ground truth data within the study area.

Survey	Lidar System	Survey Date	Survey Time (UTC)	Survey Duration	Number of Flight Lines	Flight Altitude (m)
Afton River and Pomquet Bay Part 1	Topo-Bathymetric	Aug 6	13:15	3 hours 20 mins	32	400
Afton River and Pomquet Bay Part 2	Topo-Bathymetric	Aug 6	17:15	2 hours 40 mins	22	400

Table 1: Summary of lidar surveys, 2018.

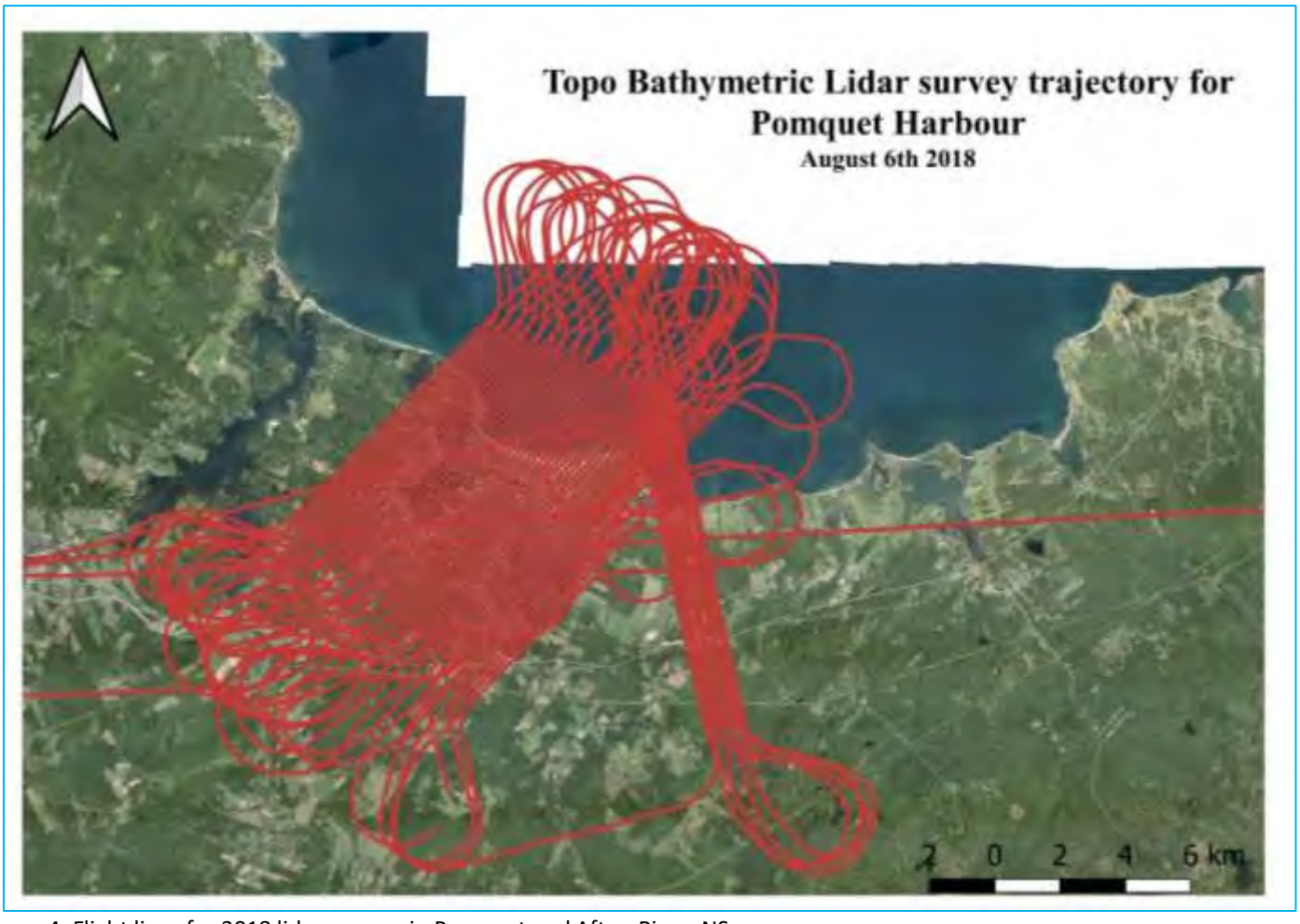


Figure 4: Flight lines for 2018 lidar surveys in Pomquet and Afton River, NS.

2.3 Lidar Data Processing

Aircraft GPS data were differentially corrected using base station observations, and the aircraft trajectory was calculated by linking the corrected GPS data with the aircraft attitude measured by an inertial measurement unit (IMU). Lidar Survey Studio (LSS) was used to process Chiroptera II waveforms, which were georeferenced into discrete points by linking laser returns to the processed aircraft trajectory to produce georeferenced point clouds in the LAS format. The data were inspected to ensure there was sufficient overlap (30%) and the AOI was fully covered by lidar returns.

The LAS files were read into TerraScan™ with the laser returns grouped by laser type so they could be easily separated, analyzed, and further refined. Points were classified into discrete classes based on their physical characteristics including relative geometry and reflective properties (Table 2).

Classification Value	Meaning
1	Unclassified
2	Ground
4	Medium vegetation
7	Low point (noise)
9	Topographic water surface
18	High noise
40	Bathymetric point
41	Bathymetric water surface
42	Derived water surface
80	Bathymetric vegetation

Table 2: Lidar point classification values and descriptions.

The original elevation of the lidar products were referenced to the same datum as the GPS unit they were collected with. This model is a theoretical Earth surface known as the ellipsoid, and elevations referenced to this surface are in ellipsoidal height (GRS80). The elevations were converted to orthometric heights relative to the Canadian Geodetic Vertical Datum of 2013 (CGVD2013).

The classification was further refined in ArcMap 10.8.3 and gridded at 1 m to produce a bare-earth, Digital Elevation Model (DEM), Digital Surface Model (DSM) and an Intensity model.

2.4 Multibeam Survey

2.4.1 Data Collection

A multibeam survey was conducted on Oct 23rd, 2020 in Church Cove where the ADCP (Acoustic Doppler Current Profiler) was deployed in 2018. The main intention for this survey was to fill in the area where the lidar did not penetrate due to the water quality on depth constraints. An R2sonic 2026 multibeam with an integrated Applanix Wavemaster Navigation unit was mounted on the 17' Boston Whaler along with two Global Positioning System (GPS) units to aid the position and heading of the vessel which was used to collect data for 14 survey lines (Figure 5).

Figure 5: AGRG Boston Whaler with deployed multibeam system on an arm that rotates to submerge the echo sounder.

The Whaler was launched from the marina at Bayfield, NS. Real-Time Kinematic (RTK) corrections were not applied during the survey. A single Sound Velocity Profile (SVP) was performed during the survey as the duration of the survey was only an hour. Data from the SVP was applied to the sonar pings in post-processing. The location of the SVP drop along with the multibeam survey lines is shown in Figure 6. The SVP exhibited a prominent thermocline (or halocline) at 1.5 – 2 m depth from the surface (Figure 7).

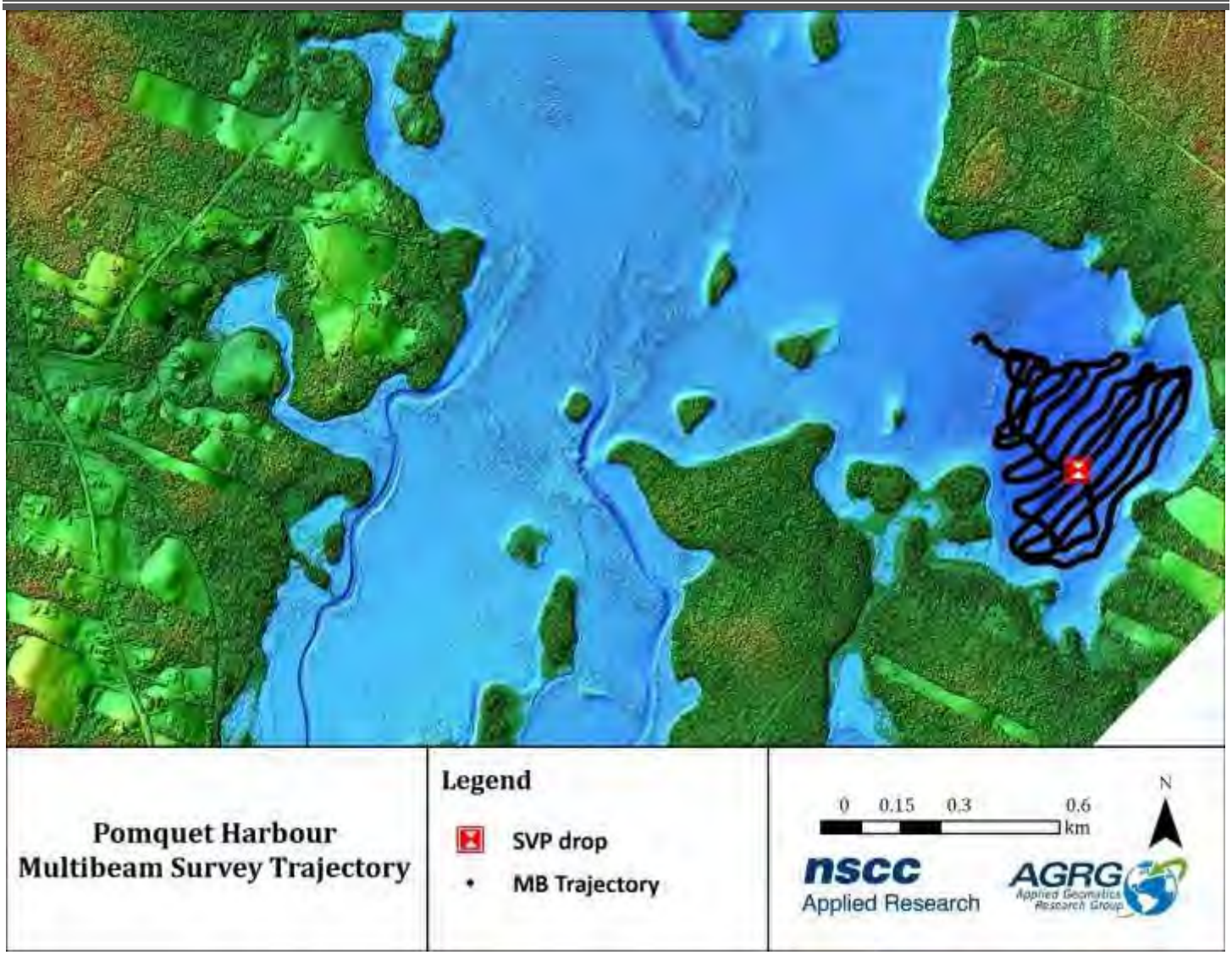


Figure 6: Pomquet lidar seamless Digital Surface Model with 2020 multibeam survey trajectory (dark points), and SVP drop location.

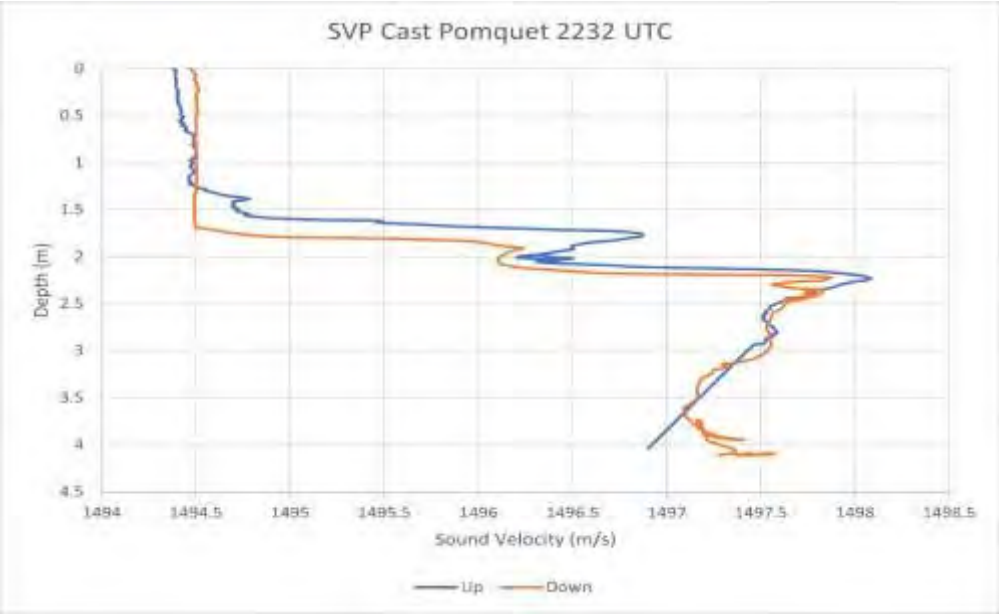


Figure 7: Sound Velocity Profile taken in Pomquet Harbour on October 23rd, 2020.

2.4.2 Data Processing

Multibeam data were processed using Qimera 2.1.1 software. Raw sonar files were cleaned using various filters for noise removal. Trajectory from the GPS and motion unit was post-processed in POSPac *MMS* with the active control station in Antigonish as the base station, resulting in a Smoothed Best Estimate of Trajectory (SBET) file that was applied to the sonar points. The post-processed sonar points were exported as LAS files. These files were gridded in ArcMap using the LAS dataset tools to obtain a raster. This raster was merged with the lidar data to obtain a continuous and complete raster.

2.5 Ground Truthing

2.5.1 GPS points

A total of 1,410 GPS points were collected on July 27th, 2018 to validate the lidar data, as shown in Figure 8. Out of these, 1,399 points were collected on hard surfaces using a Leica GS14 GPS receiver unit obtaining Real-Time Kinematic (RTK) corrections through SmartNet, which was mounted on a truck collecting data every second. 11 points were collected in the harbour using the GPS receiver threaded on a painter's pole. Other areas in the Harbour where the lidar did not penetrate to the seabed were supplemented with point soundings of nautical charts. These points were post-processed in Leica Geo Office with Antigonish as the base station to provide centimetre level precision.

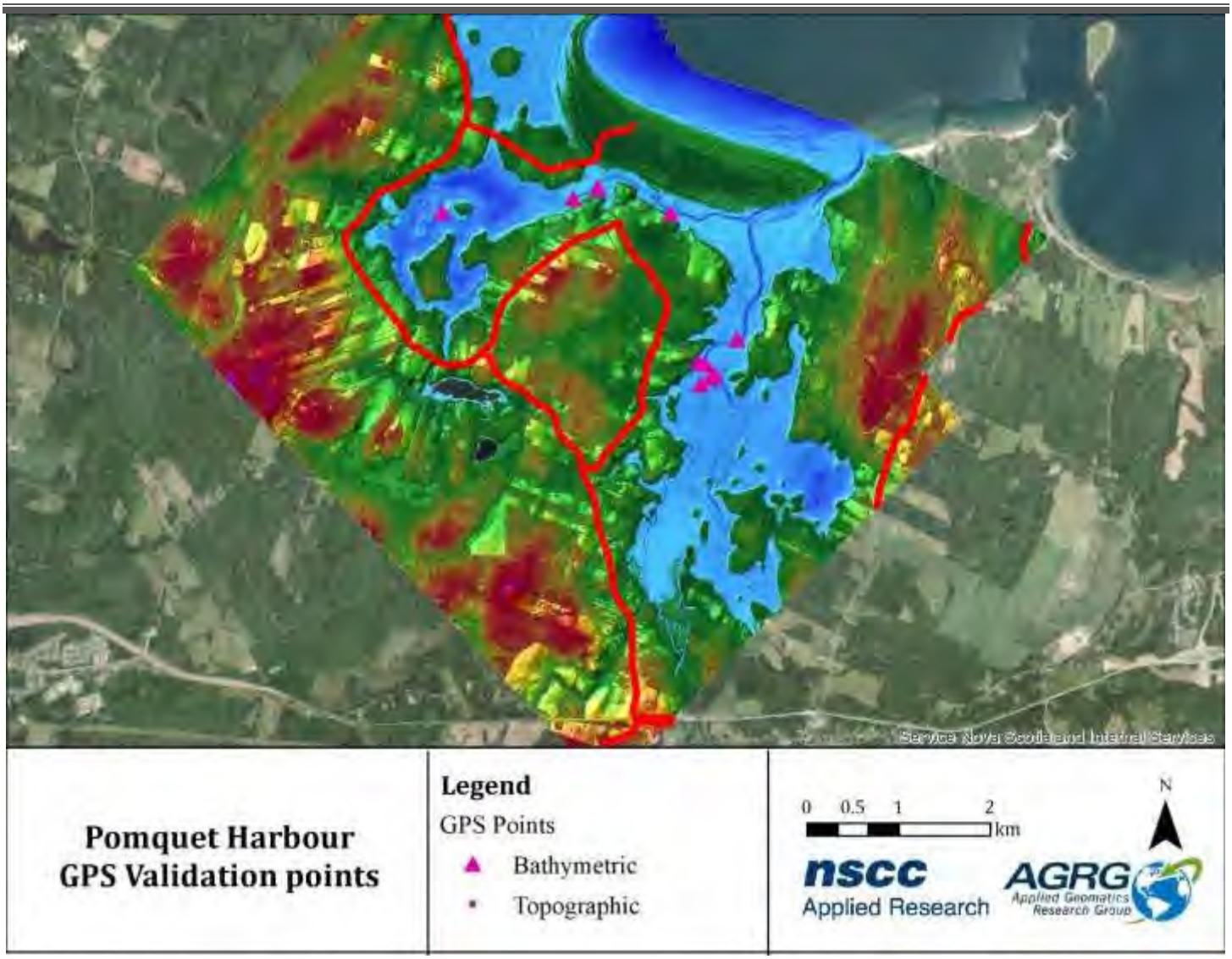


Figure 8: Global Positioning System (GPS) points for validating the topo-bathymetric lidar overlaid on a Colour Shaded Relief (CSR) lidar Digital Surface Model (DSM).

2.5.2 Video Ray

Underwater videos were collected on July 27th, 2018 using Video Ray Class I Remotely Operated Vehicle (ROV). The system consisted of the ROV, plus a control tether and reel, and was controlled by a deck box which included a laptop with preloaded control software and a joystick (Figure 9). The Video Ray was borrowed from NSCC's Oceans Technology program at the Ivany Campus, while the control unit was originally from Defence Research and Development Canada Atlantic, both of which are in Dartmouth, NS.

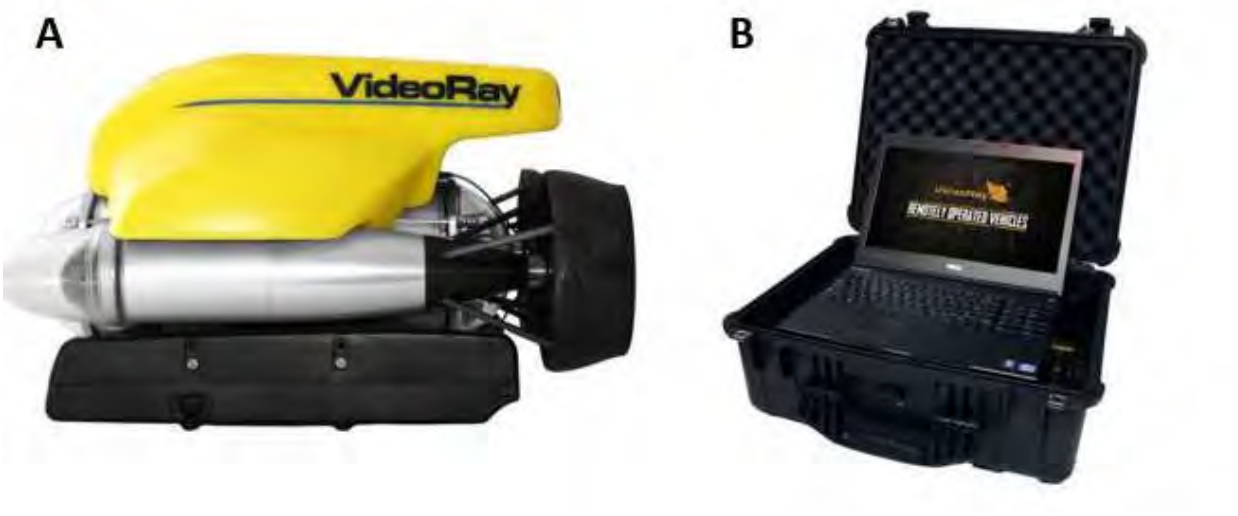


Figure 9: (A) The left side of the figure shows a Video Ray ROV; (B) The right side shows a Video Ray control unit.

The Video Ray had an integrated camera in the forward plexiglass bubble with pan and tilt capability. The piloting screen in the control unit displayed the camera view with heading, depth, and water temperature information overlaid on the video feed from the ROV. The control unit was used to take video using the Video Ray's camera.

The video ray was towed alongside AGRG's Boston Whaler with a 10 m tether which communicated the data to the control unit. A GPS receiver was mounted on the vessel to collect positions. The track from the GPS unit along with the Garmin (Boat GPS) is shown in Figure 10.

Figure 10: Video ray track obtained from the GPS units Garmin (autonomous >5 m accuracy) and Leica GS 14 (RTK corrections < 0.05 m accuracy) overlaid on a CSR.

The video obtained from the system showed that one area was dominated by moss and algae, while the other contained areas of fucus interspersed with bare rocky patches. The rocky areas (and probably the areas of subaquatic vegetation as well) were strewn with oyster shells, presumably the leftovers from harvesting operations. The various types of bottom coverage in the video ray survey site by matching the timestamp with the GPS points (Figure 11).


A


7/27/2018 11:47:01 AM
H: 214.8 °
D: 0.71 m
Temp: 23.0 °C


B


7/27/2018 11:48:14 AM
H: 299.2 °
D: 0.21 m
Temp: 23.1 °C

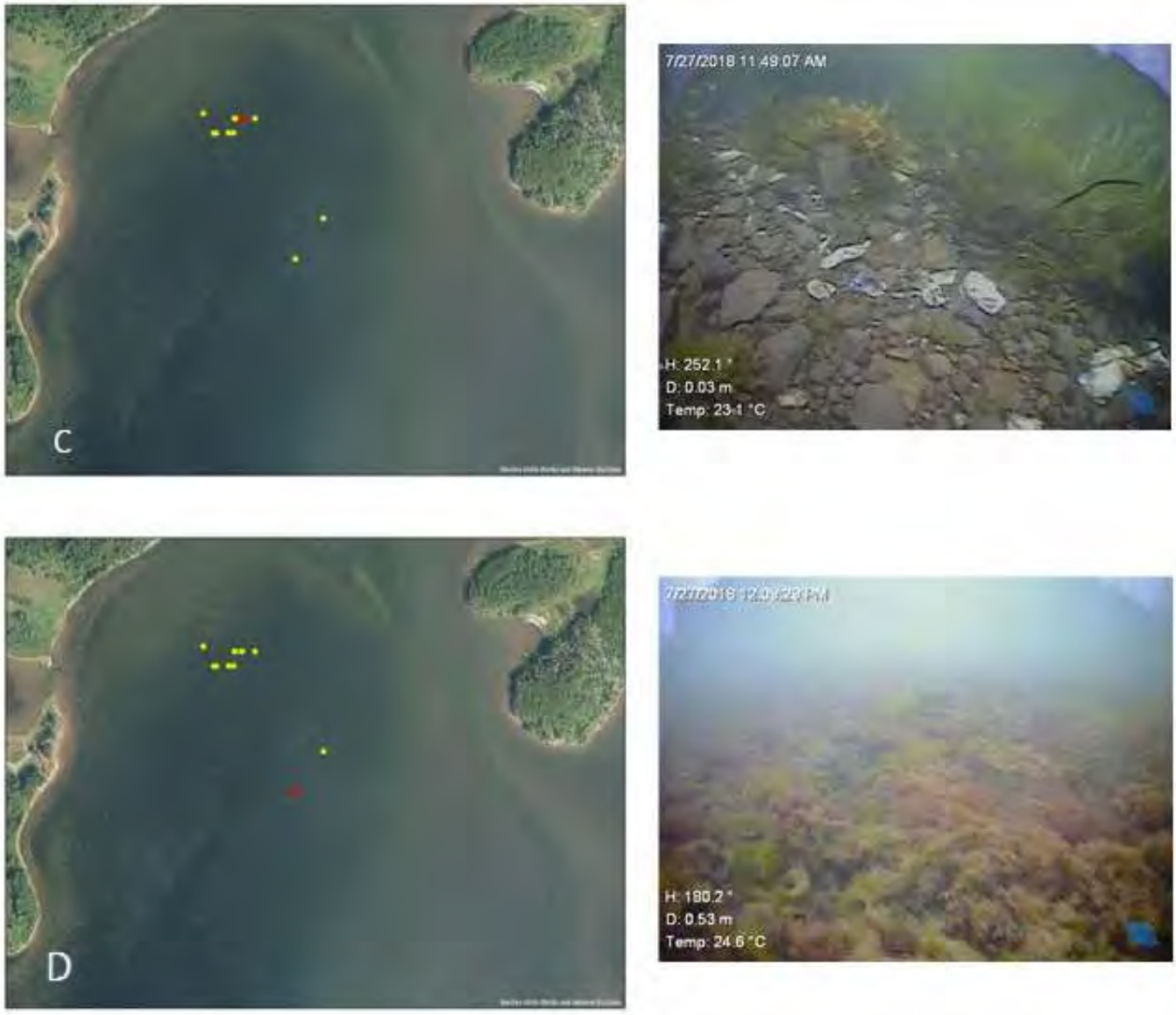


Figure 11: The right side of the figure shows screen shots from video taken using a Video Ray ROV, with the location of the video shown marked on the orthophoto to the left. The video frames were matched using time stamps from the video correlated with time stamps from the Leica GNSS log. The site at location (a) shows the bottom type as focus. The dark patch at location (b) is Sand(60)/Moss (30)/Fucus(10) along with oyster shells. Location (c) shows the presence of rock and eelgrass. Location (d) shows moss and algae in deeper water farther from shore than the previous three locations.

2.5.3 Acoustic Doppler Current Profiler (ADCP)

An ADCP measures water current velocities within the water column and waves. This is achieved through the Doppler effect of sound waves passing through a medium. The ADCP deployed in Church Cove was a Teledyne Sentinel V20 which had 5 transducers, a pressure and temperature sensors. Velocity was calibrated prior to deployment.

2.5.3.1 Deployment

The Sentinel V20 was deployed in Church Cove in Pomquet Harbour on June 7th, 2018 and recovered on the July 10th, 2018. The unit sat on the bottom of the harbour in the same location at an average depth of ~4.7 metres, recording data over

the course of 29 days, from 1800 UTC on the day it was deployed until 1900 UTC on the 4th of July 2018. The geographic location of the deployment site can be seen in Figure 12a.

The ADCP was mounted on a metal frame as shown in Figure 12b. Additional weights were added to the frame, and a 70-pound (lb) pyramid anchor was attached to the frame using a line sized to deployment depth (in this case ~ 5 m). A marker buoy was attached to the pyramid anchor to assist in recovering the instrument at the end of its deployment. Two zinc anodes were also attached to the frame to reduce galvanic corrosion.

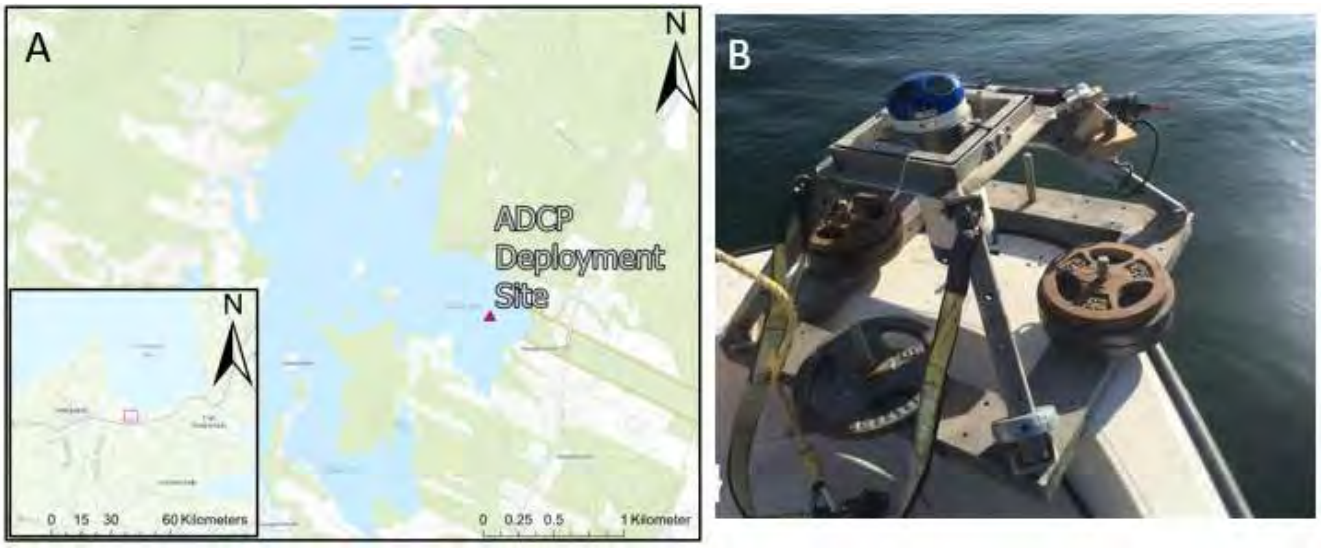


Figure 12: (a) ADCP deployment location in Pomquet Harbour; (b) Sentinel V20 on a frame being deployed from Boston Whaler.

2.5.3.2 Data Collection

The system was setup to collect tidal current data in 3 bursts of 3 minutes each in every hour on the clock, with 15 minutes between the start of each burst, and the first burst of each ensemble taking place 20 minutes past the hour as shown in Table 3. The waves profile collected one burst for 17.7 minutes on the hour every hour.

Waves Setup (Profile 1)	
Ensemble interval	3600 s
Ping interval	0.5 s
Number of pings	2100
Number of bursts	1
Sampling interval (ping interval x number of pings)/60 s	17.5 minutes
Cell size	0.3 m
Currents Setup (Profile 2)	
Ensemble interval	3600 s (1 hour)
Ping interval	1 s
Number of pings	180
Sampling interval (ping interval x number of pings)/60 s	3
Cell size	0.3
Depth of deployment	7.8 m (range)
Sequential offset	1200 s (20 mins)
Burst interval	900 s (15 mins)
Burst count	3

Table 3: Wave and Currents Setup for the Sentinel V20 for the Pomquet deployment.

The resultant data represents waves every hour and currents three times an hour at the 15-, 30- and 45-minute mark. Data were retrieved at the end of the deployment time to be processed in Velocity, developed by Teledyne, the manufacturers of the Sentinel V series of ADCP.

2.5.3.3 Data Processing

Currents

Processing for currents was done in Teledyne's Velocity software. The most basic processing settings that need to be taken into consideration before conducting any kind of analysis are displayed in Figure 13.

Figure 13: Sample "Basic" post-processing setting window.

Much of post-processing involved cleaning up the data, reducing interference, and ensuring that the information extracted was as accurate as possible. An averaging interval of 1 hour for the currents data was used as it best filled out the data without losing too much detail to be useful. The next step of currents processing was to remove *side lobe interference*, which removed the interference caused by currents near the measurement cells. *Range to boundary* typically remains set

to *Range (pressure)*, meaning the pressure transducer on the unit was used to determine the range to the water column boundary. Next, the *magnetic variation offset was supplied*. This step was necessary to correct the data to get the most correct representations of the vector components of the measured currents. As most compasses do, the one on board the Sentinel V20 detects its orientation by finding *magnetic north*. True north and magnetic north vary by latitude, longitude, and over time. Using the *Magnetic declination calculator* web tool found on *Natural Resources Canada*'s website, we determined this offset to input into Velocity.

Waves

Data were processed using Velocity 1.7.22 WavesMon 4.05 (a package within the Velocity software). A profile averaging an interval of 15 minutes was set to match the average current profile. As the ADCP sat in a frame above the seabed, the measurement in metres from the bottom to the sensor (60 cm) was added in the initial stages of the processing. The measurement was useful for applying the correct gain in the lower bins. In the more advanced options, a magnetic variation of -16.87 degrees was applied to calculate the direction information with respect to true north as shown in Figure 14. As the waves data were set up to be collected every hour for 17.5 minutes on the hour, the samples/bursts processed along with the frequency were adjusted to process all the data. Only the top three cells, which were 0.9 m from the water surface, were considered for height of the wave and direction spectrum.

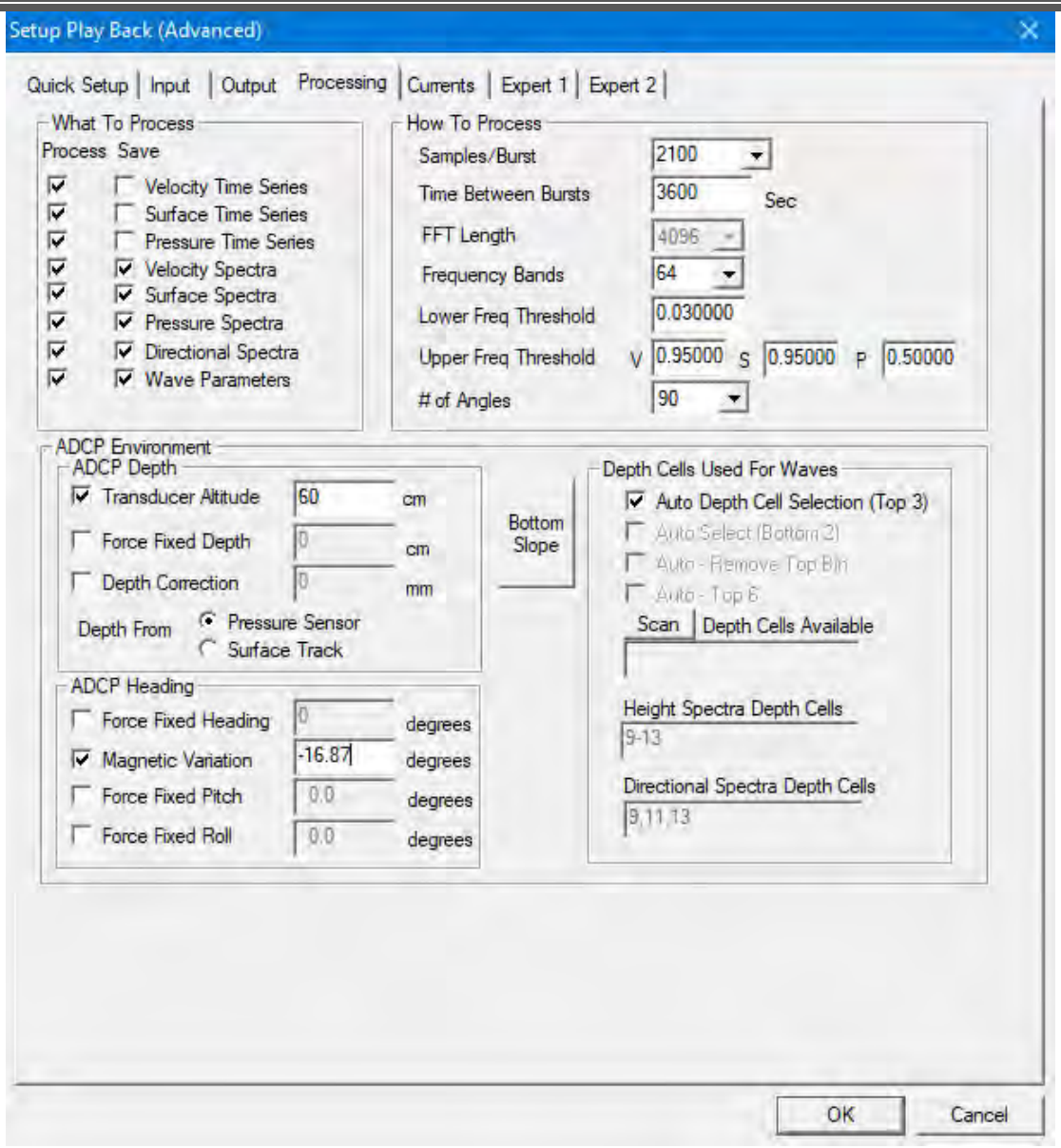


Figure 14: Parameters set up in the processing tab of WavesMon.

In the more advanced settings for the WavesMon package, expert 1 and 2 tabs were set such that data was processed with a sample rate at 2 Hz between ensembles. It was also set up so that all the time series for the duration was processed and flagged for bad data that exceeded four times the standard deviation. Only bursts with good data more than a threshold of 90% were processed, along with auto bias removal, and the negative values in the spectra were set up to be clipped.

2.5.3.4 Data Overview

Currents

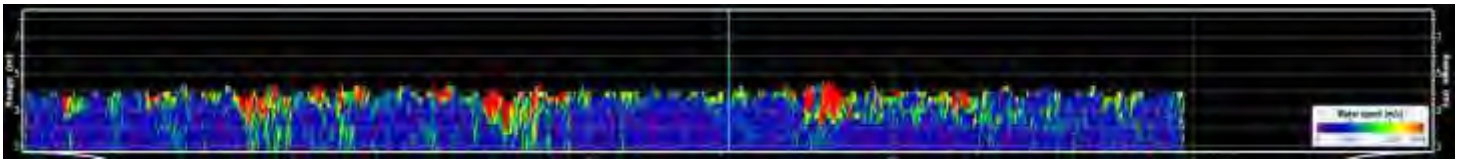


Figure 15: Water binned current speed (m/s). X-axis represents time and consists of approximately 30 days.

Within the protection of the sheltered Church Cove in Pomquet Harbour, the waters were typically calm and lacking dramatic changes in speed. Most of the water moved at 0.015 m/s or lower most days, as Figure 15 illustrates. We can also see that days with noticeable increase of water speed near the water's surface coincide with increases in wind speed in the hours prior (Figure 16). This increased water speed near the surface brings water up from the bottom of the water column. This can be seen especially on June 12th, June 18th, and June 25th. Red indicated the increase in water velocity/speed, and roughly one day later a dramatic spike in upward component of the currents can be seen in Figure 17, Figure 18 and Figure 19. An increase at the surface of the water also trickled down to the bins beneath it, over a period of hours, slowing as it reached the bottom. Figure 20 shows the effect of the tidal cycle on water flow in the harbour. The water current direction changed through the water column in a predictable way, with exception of the outliers previously mentioned. The current flow in a particular direction rose through the column over a period of roughly 6 hours, which is the amount of time it takes to go from a high tide to a low tide and vice versa.

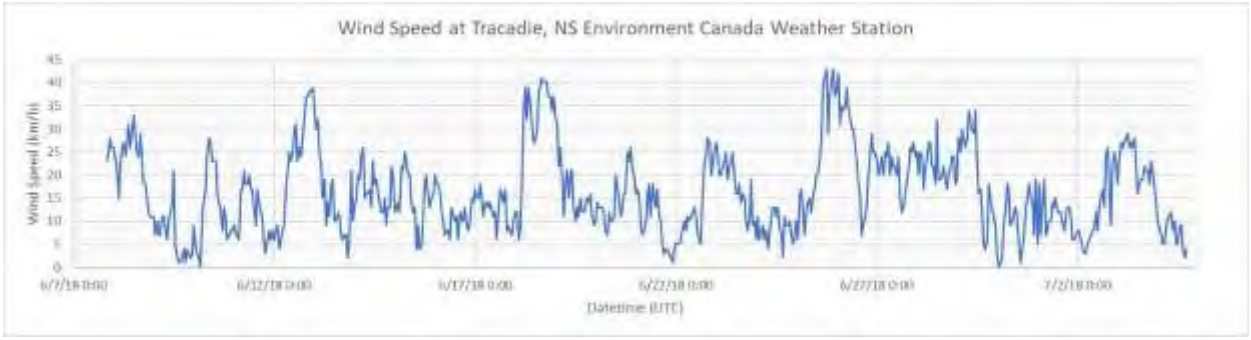


Figure 16: Wind speed at nearby Tracadie weather station.

Figure 17: Binned Water Velocity, Northern Component.

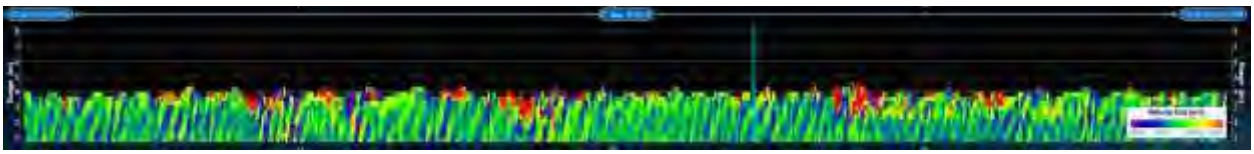


Figure 18: Binned Water Velocity, Eastern Component.

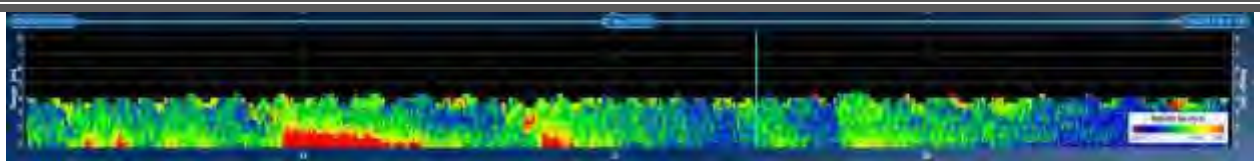


Figure 19: Binned Water Velocity, 'Up' Component.

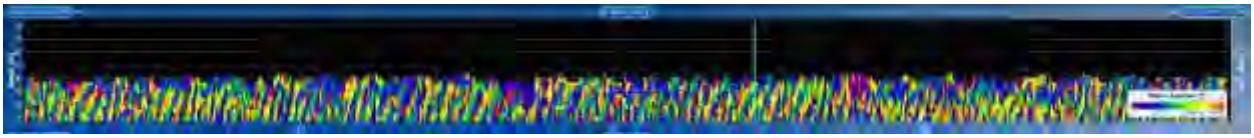


Figure 20: Binned Water Direction, corrected for true north. The repeating pattern represents the daily tidal cycles.

Waves

Data from WavesMon was exported in two formats: A Waves Log file containing the summary of the wave parameters, and a Waves record file to visualize the data in WaveView. A time series plot with Significant Wave height (Hs), Peak Period (Tp) along with the Water Level (WL) is shown in Figure 21.

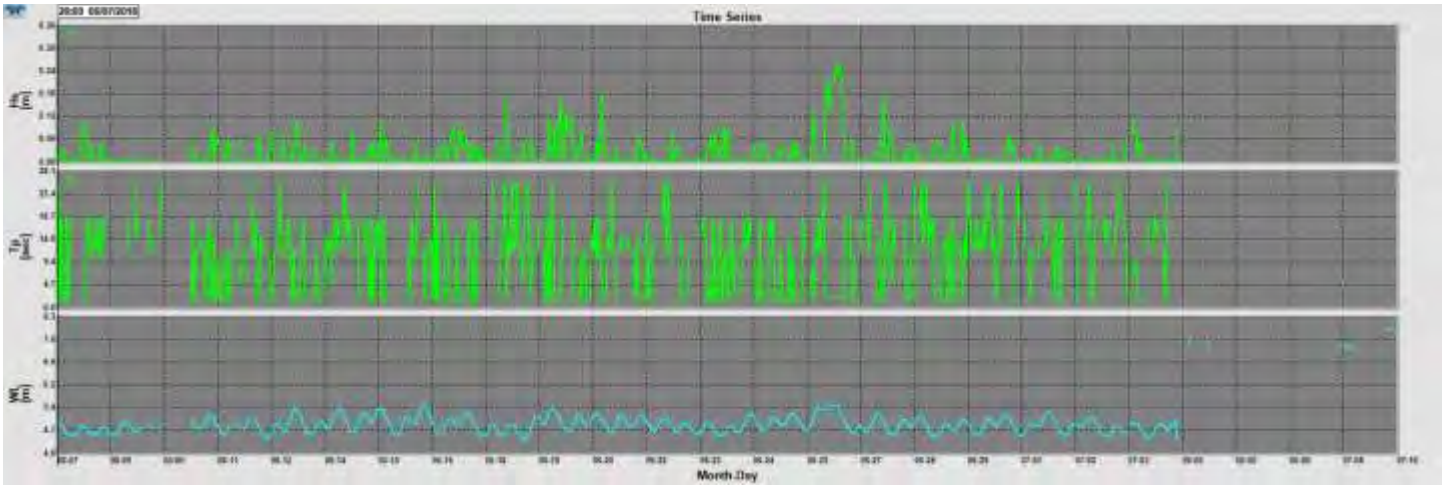


Figure 21: A plot showing the Hs (top graph), Tp (middle graph) and WL (bottom graph) during the ADCP deployment time frame.

Hs in the harbour was close to 10 cm with an average peak period of 1 second. An exception to this was during the major wind event that happened on June 26th, 2018, when it was 26 cm with the peak period of 1.86 seconds. The plot of wind data from Tracadie station and wave height shows that strong winds blowing in the south direction resulted in an increase in Hs on the 26th of June, 2018 (Figure 22).

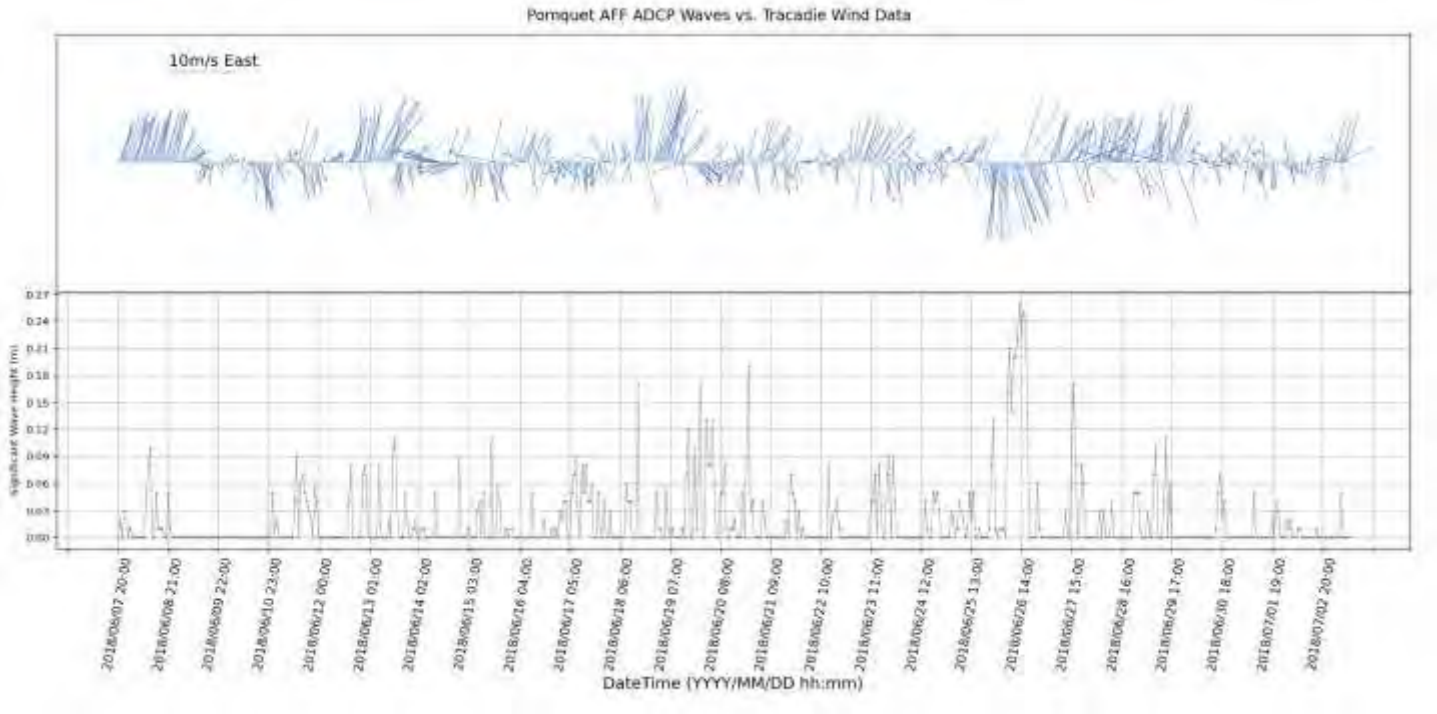


Figure 22: Wind data from the Tracadie station (top graph) plotted with the ADCP Significant Wave Height (Hs) (bottom graph) in metres.

The direction reported for wind and waves indicate where the wind was blowing from. For example, waves travelling to the west, as shown in Figure 23. The wave height spectra and directional spectrum plots exhibit the wave frequency and direction during the June 26th, 2018 event (Figure 23).

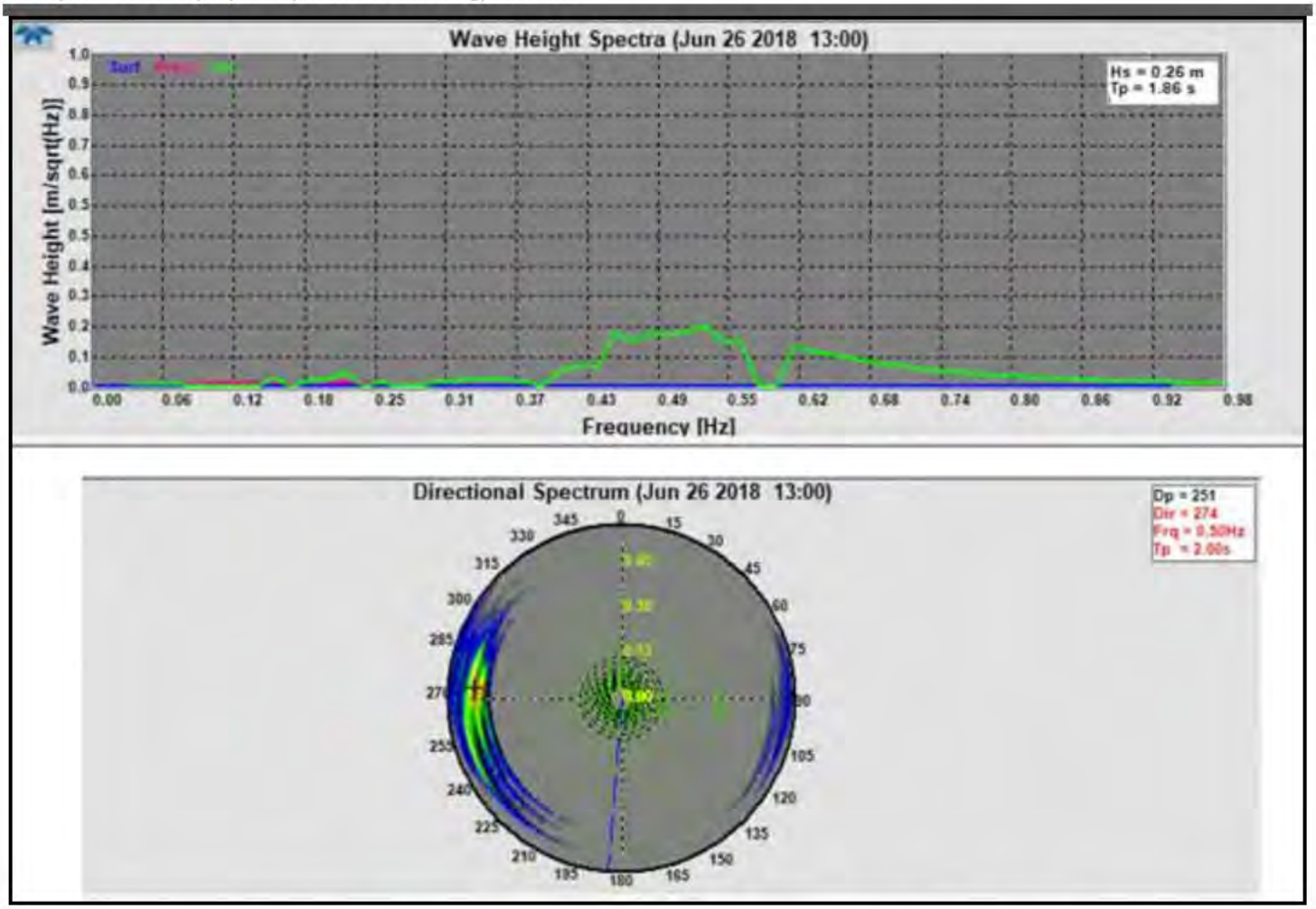


Figure 23: Wave Height Spectra and Directional Spectrum on June 26th, 2018 at 13:00. Top graph shows the significant wave height (Hs). Bottom graph is a rose diagram showing where the direction the waves are coming from and their period.

During the event on June 26th, there were high frequency waves. The dotted blue line is the average direction during the deployment period. Peak Direction (Dp) during the event was 251 degrees (waves are from the west travelling to the east).

2.6 GIS Datasets

2.6.1 Traditional Ecological Knowledge (TEK)

The Department of Fisheries and Oceans provided Traditional Ecological Knowledge (TEK) polygon data representing the habitat of several migratory fish species (alewife, American Eel, American smelt, Atlantic salmon, sea trout), molluscs (American oyster, blue mussel, quahog, razor clam, softshell clam) and invasive species (green crab). These layers were clipped to the Pomquet Harbour study area (Figure 24; Figure 25; Figure 26). The mollusc data layers were converted from polygons to binary presence/absence rasters for use in the web application's Suitability Modeller widget.

Figure 24: Migratory fish presence identified from Traditional Ecological Knowledge.

Figure 25: Mollusc presence identified from Traditional Ecological Knowledge.

Figure 26: Invasive species presence as reported by the Department of Fisheries and Oceans (DFO).

American eels had the largest habitat extent of the migratory fish species present in Pomquet Harbour, with an area of 2.40 km^2. American smelt and alewife also had significant habitat extents, with areas of 1.42 km^2 and 0.98 km^2, respectively. The mollusc species with the largest habitat extent in Pomquet Harbour was the softshell clam (1.09 km^2). Green crabs were identified in two locations in Pomquet Harbour. Both observations were made in 2001 and were in the eastern bay.

2.6.2 Oyster Stock Survey Data

Secondary data for oyster stock surveys conducted at Pomquet Harbour in 2014 were obtained from Robin Stuart on behalf of Paqtnkek First Nation and in agreement with DFO (Stuart, 2014). The location of each of the 29 oyster surveys was used to generate the Wild Oyster Location layer (Figure 27). The Wild Oyster Spat Producer layer was extracted from the nine oyster survey sites identified as having a good oyster habitat (Figure 28).

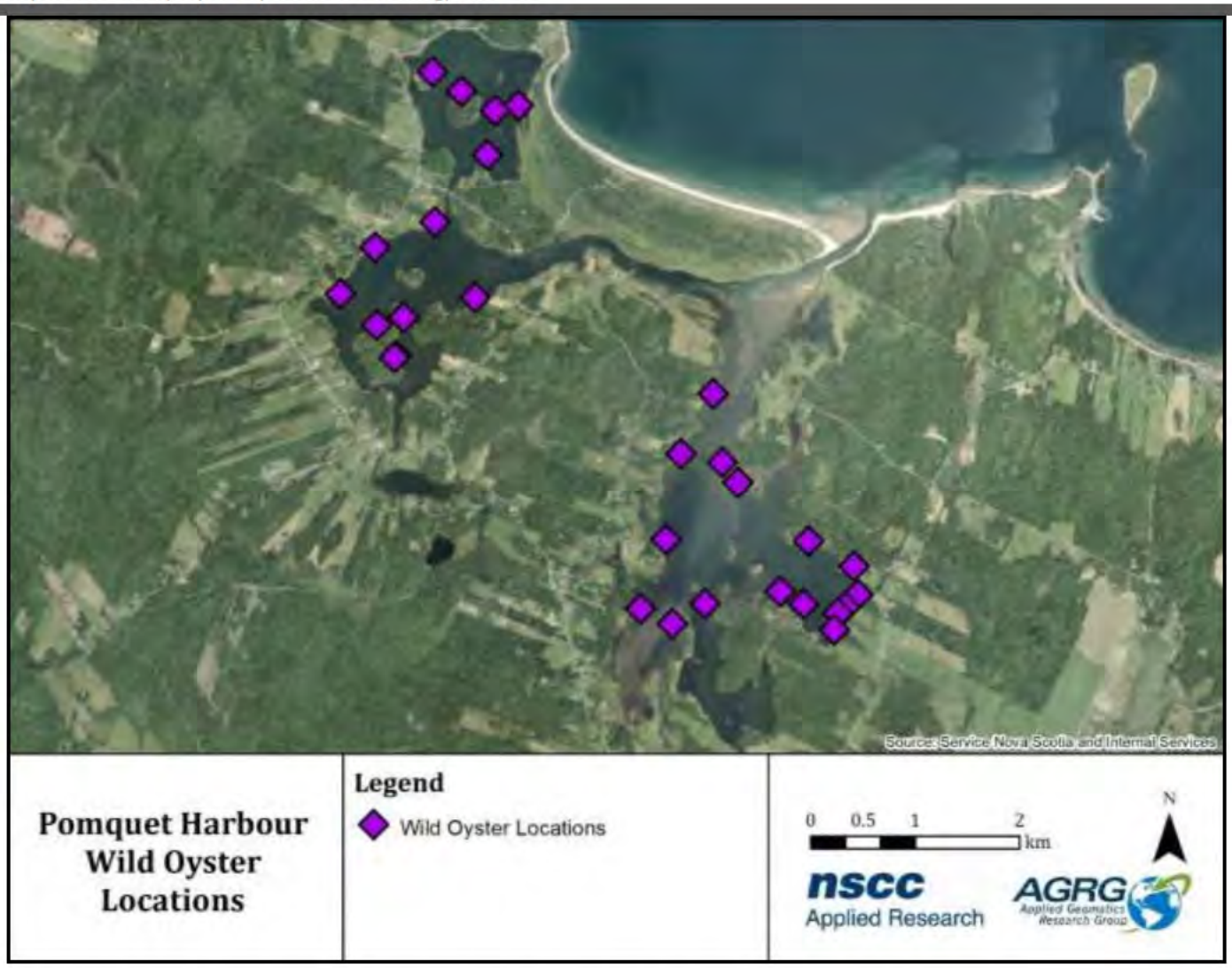


Figure 27: Location of oyster stock surveys conducted by Robin Stuart on behalf of Paqtnkek First Nation.

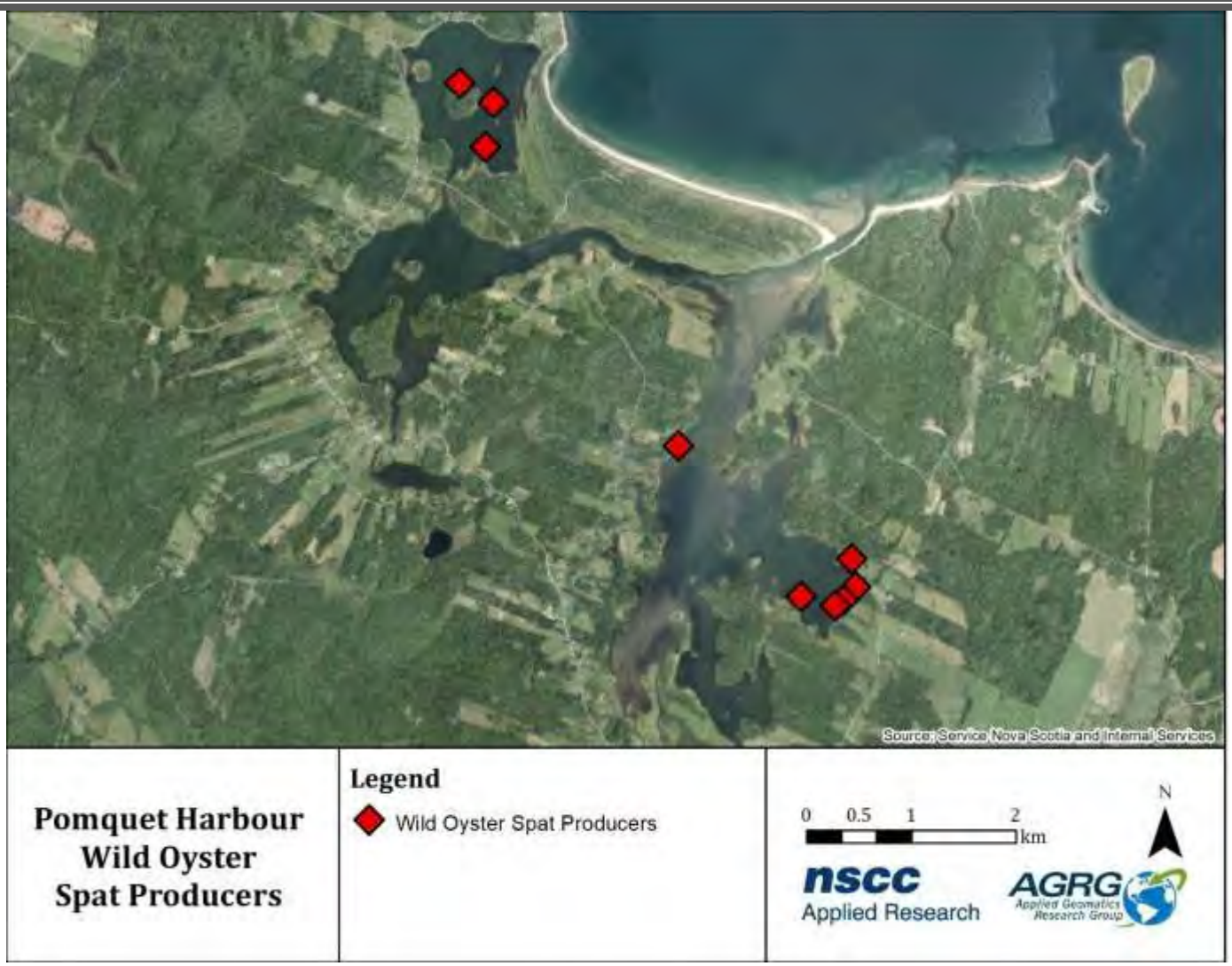


Figure 28: Location of oyster survey stations with significant oyster habitat as identified by Robin Stuart on behalf of Paqtnkek First Nation.

The Number of Oysters Times Average Size layer was generated by multiplying the total number of reported oysters by the mean size at each oyster sampling station (Figure 29). The oyster survey stations with the highest Number of Oysters Times Average Size (mm) were station 13 and station 21, with 27,696 mm and 17,399 mm, respectively. Station 13 was located near the western bay, and station 21 was in Monks Head Harbour.

Figure 29: Number of Oysters Times Average Size (mm) was determined by multiplying the total number of recorded oysters by the mean size at each station during oyster stock surveys conducted by Robin Stuart on Paqtnkek First Nation's behalf.

Maps that show the count values of each oyster shell size class (e.g., 0 – 20 mm, 20 – 30 mm, 30 – 40 mm, 40 – 50 mm, 50 – 60 mm, 60 – 80 mm, 80 – 100 mm, and > 100 mm) at each sampling station have been included in Appendix 1: Number of Oysters per Length.

2.6.3 Temperature and Salinity

Temperature and salinity layers were extracted from data collected with a YSI salinity/temperature meter for each of the oyster stock survey locations (Figure 30; Figure 31). The temperature recorded during each survey ranged from 13.0°C to 16.8°C and had a mean value of 15.3°C. Salinity varied from 26 ppt and 28.7 ppt and had a mean value of 27.8 ppt.

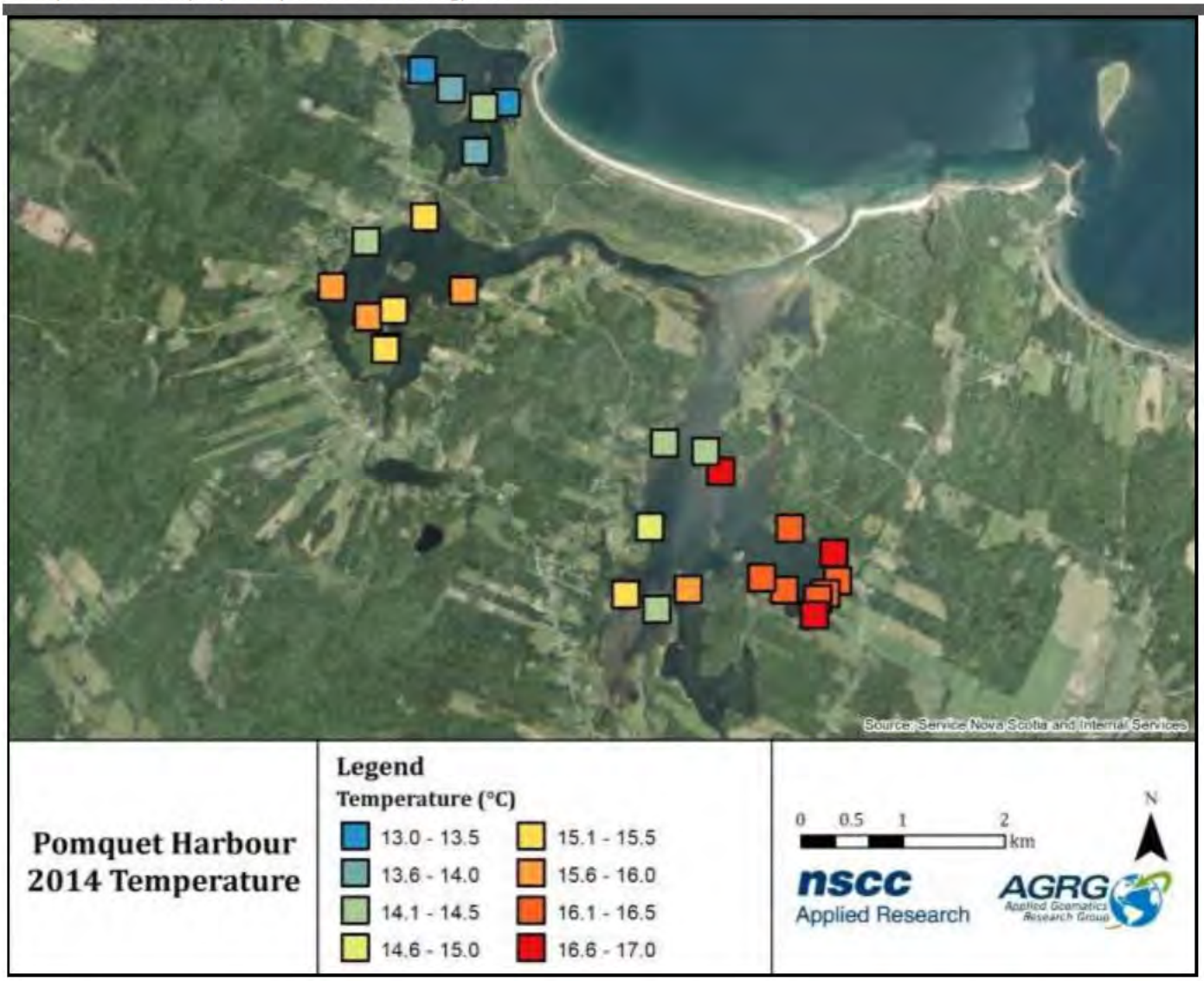


Figure 30: Temperature data collected at each station during oyster stock surveys conducted by Robin Stuart on Paqtnkek First Nation's behalf

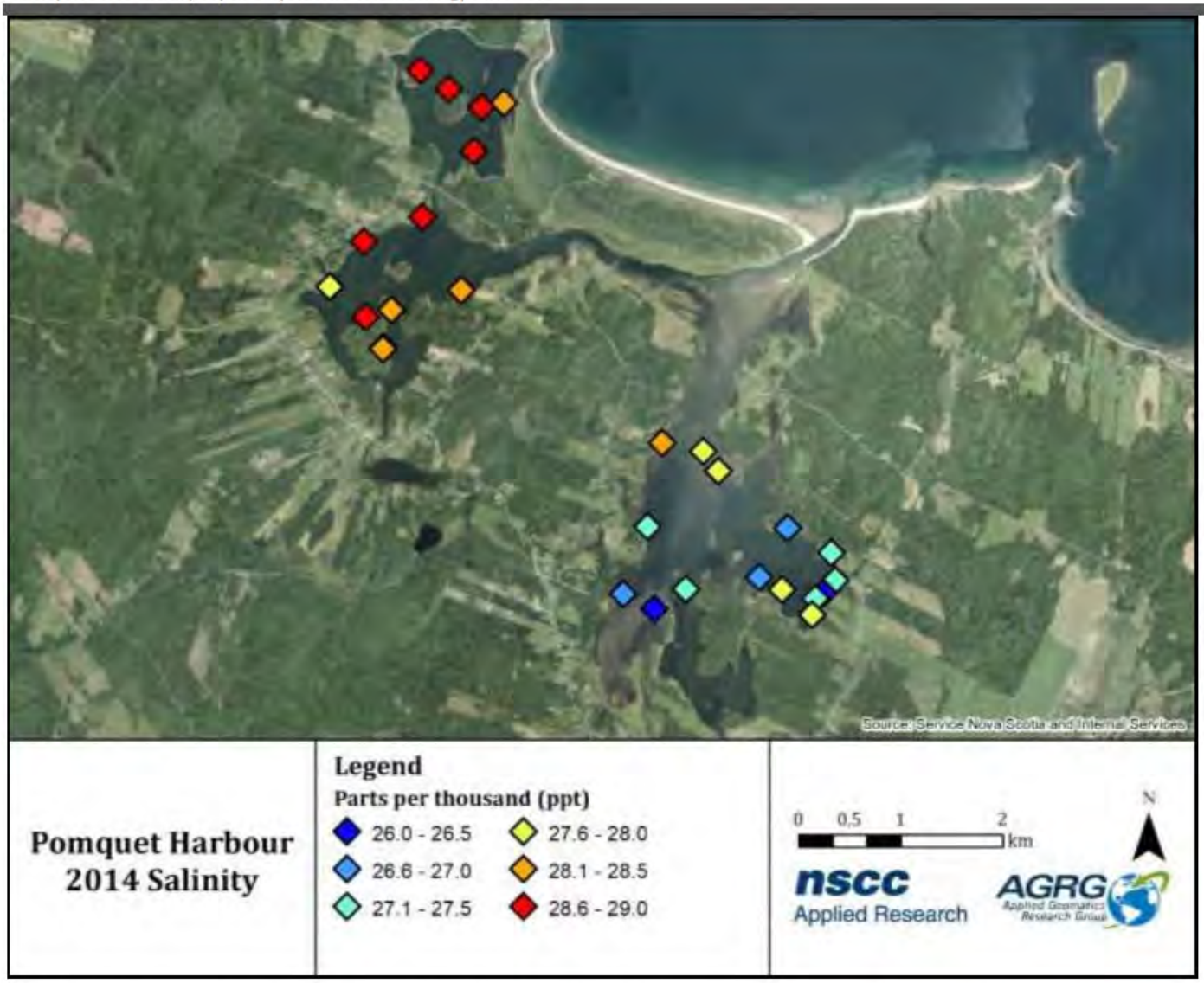


Figure 31: Salinity data collected at each station during oyster stock surveys conducted by Robin Stuart on Paqtnkek First Nation's behalf.

2.6.4 Supporting Data

Issued marine aquaculture leases along the Nova Scotian coast were obtained from the Nova Scotia Fisheries and Aquaculture (NSFA) website and clipped to the Pomquet Harbour study area (Figure 32). For use in the web application's Suitability Modeller widget, the aquaculture lease layer was converted from a polygon to a binary presence/absence raster.

Figure 32: Aquaculture leases in Pomquet Harbour as of November 2020. Most recent information is available at http://novascotia.ca/fish/aquaculture/site-mapping-tool/

As expected, the only license in Pomquet Harbour is an experimental license for American Oyster owned by Paqtnkek Mi'kmaw Nation. More information on Nova Scotia aquaculture leases is available through the NS Fisheries and Aquaculture web services.

2.6.5 Land Use

The Nova Scotia Department of Lands and Forestry provides a data layer called the Forest Resource Inventory which is used to describe the land use for all of Nova Scotia. The layer is derived from air photos and uses codes to define how land is being used (e.g., agriculture, forest, infrastructure). The Forest Resource Inventory layer for Antigonish County was updated in 2007. Several non-forested land codes (FORNON) were merged to reduce the number of classes. The final classes are represented in Table 4.

Merged Class	FORNON Code(s)
Agriculture	86, 91
Barren	84, 85
Beach	94
Cliffs, Dunes, Coastal Rocks	76
Forest	0, 1, 3, 5, 6, 7, 8, 9, 12, 20, 33, 38, 39
Forest Harvest (Clear Cuts)	60, 61
Infrastructure	92, 95, 96, 97, 98, 99
Lakes	77
Urban	87
Wetland	70, 71, 72, 73, 74, 75

Table 4: NS Department of Lands and Forestry Land Use layer definitions.

The land in the Pomquet study area was 61% forested (28.5 km^2), 19% agricultural (8.7 km^2), and has wetlands that cover approximately 7% (3.1 km^2) of the region (Figure 33). Clear-cuts, and cliffs/dunes/coastal rocks made up 4% (2.0 km^2) and 3% (1.5 km^2) of overall land use, respectively.

Figure 33: The Nova Scotia Department of Lands and Forestry Forest Resource Inventory land use classification, with simplified categories.

2.6.6 Intertidal Zone

The elevations between Lower Low Water Large Tide (LLWLT) and Higher High Water Large Tide (HHWLT) defined the intertidal zone. In Pomquet Harbour, LLWLT is -1.01 m, Mean Sea Level (MSL) is -0.20m and HHWLT is 0.45 m relative to CGVD2013. These values were provided by the Canadian Hydrographic Service (CHS) (Table 5). The values in between LLWLT and HHWLT were extracted from the Digital Elevation Model using Raster Calculator, and the resulting raster was cleaned using Majority Filter (Figure 34).

	CGVD2013
HHWLT	0.45 m
MSL	-0.20 m
LLWLT	-1.01 m

Table 5: Tidal range values obtained from Canadian Hydrographic Services (CHS) relative to CGVD2013.

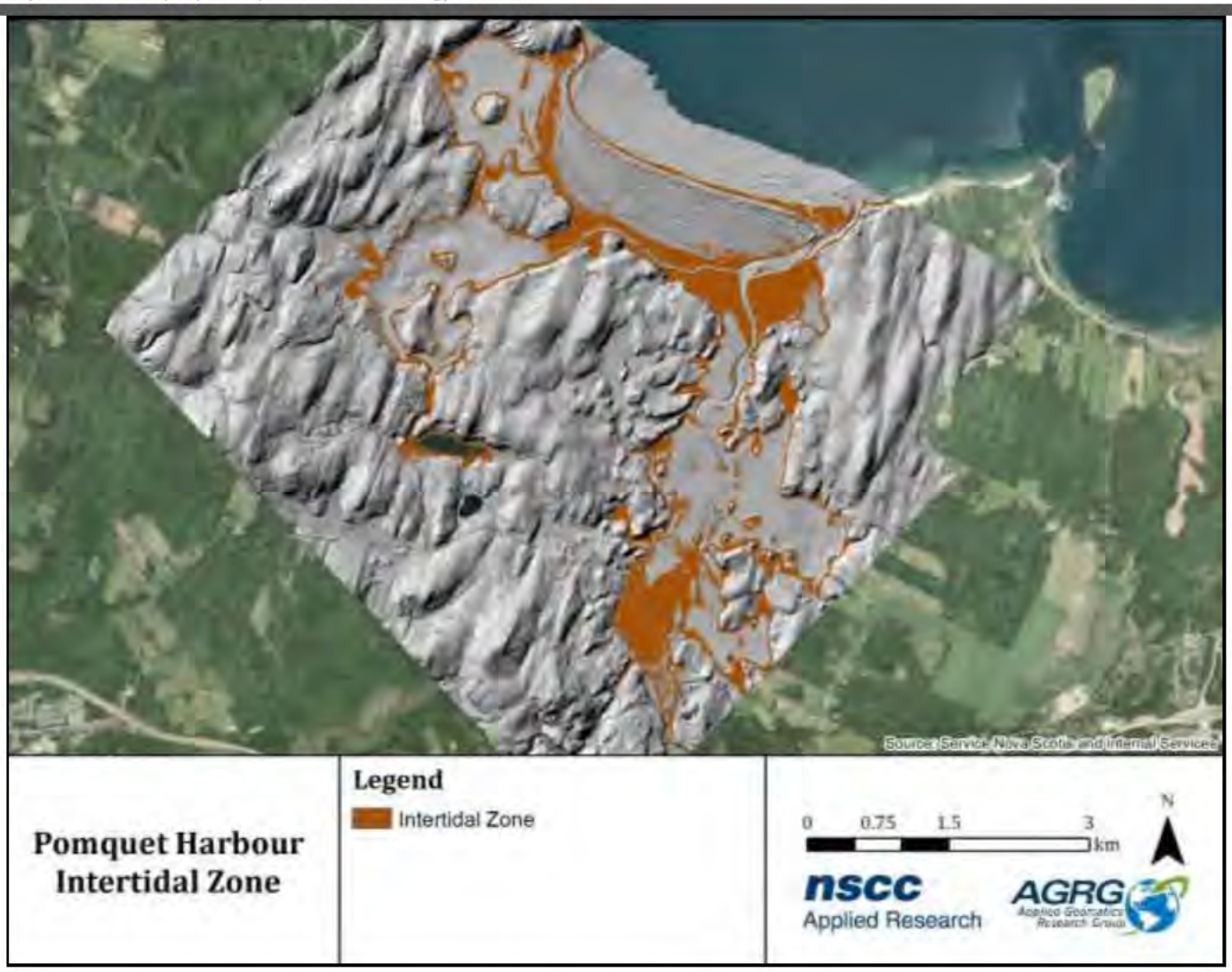


Figure 34: The intertidal zone, defined as the region on the elevation model between 0.45 m (HHWLT) and -1.01 m (LLWLT).

2.6.7 Channel Map

The channel location layer was derived from the continuous depth layer. Values above 2.2 m were selected from the depth layer and were reclassified. The reclassified raster was converted to polygons to remove speckle and deep areas. A few areas of the channel were digitized from the orthophoto and DEM. The final polygon layer was smoothed and converted to a raster to obtain the channel layer (Figure 35). The channel layer was converted to a presence/absence raster for use in ArcMap's Weighted Overlay tool and the web application's Suitability Modeller widget.

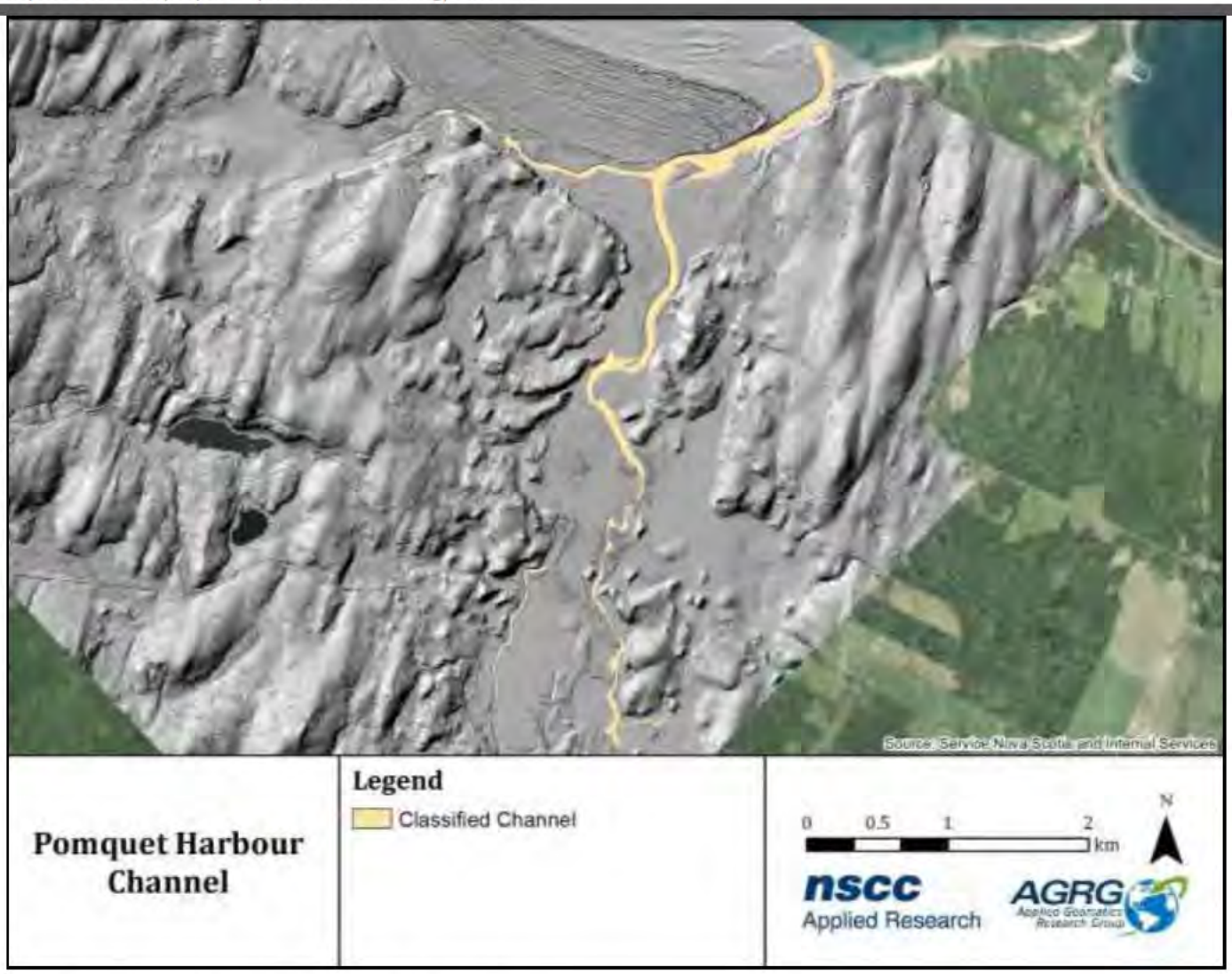


Figure 35: Classified channel obtained from the depth layer.

2.6.8 Ice Impact Zone

An Ice Impact Zone layer was derived from the seamless Digital Elevation Model (Figure 36). The ice impact zone was defined as the elevations between Higher High Water Large Tide (HHWLT) and 1 m below LLWLT. To generate this layer, the DEM was nullified in areas greater than HHWLT, and the ice impact zone was classified as the area between 0.45 m (HHWLT) and -2.01 m (LLWLT - 1 m). The ice-free zone was defined as values deeper than -2.01 m, classified into 1 m bins (e.g., -2.01 m, -3.01 m, -4.01 m, and -5.01 m). Small NoData holes were filled using the Elevation Void Fill function.

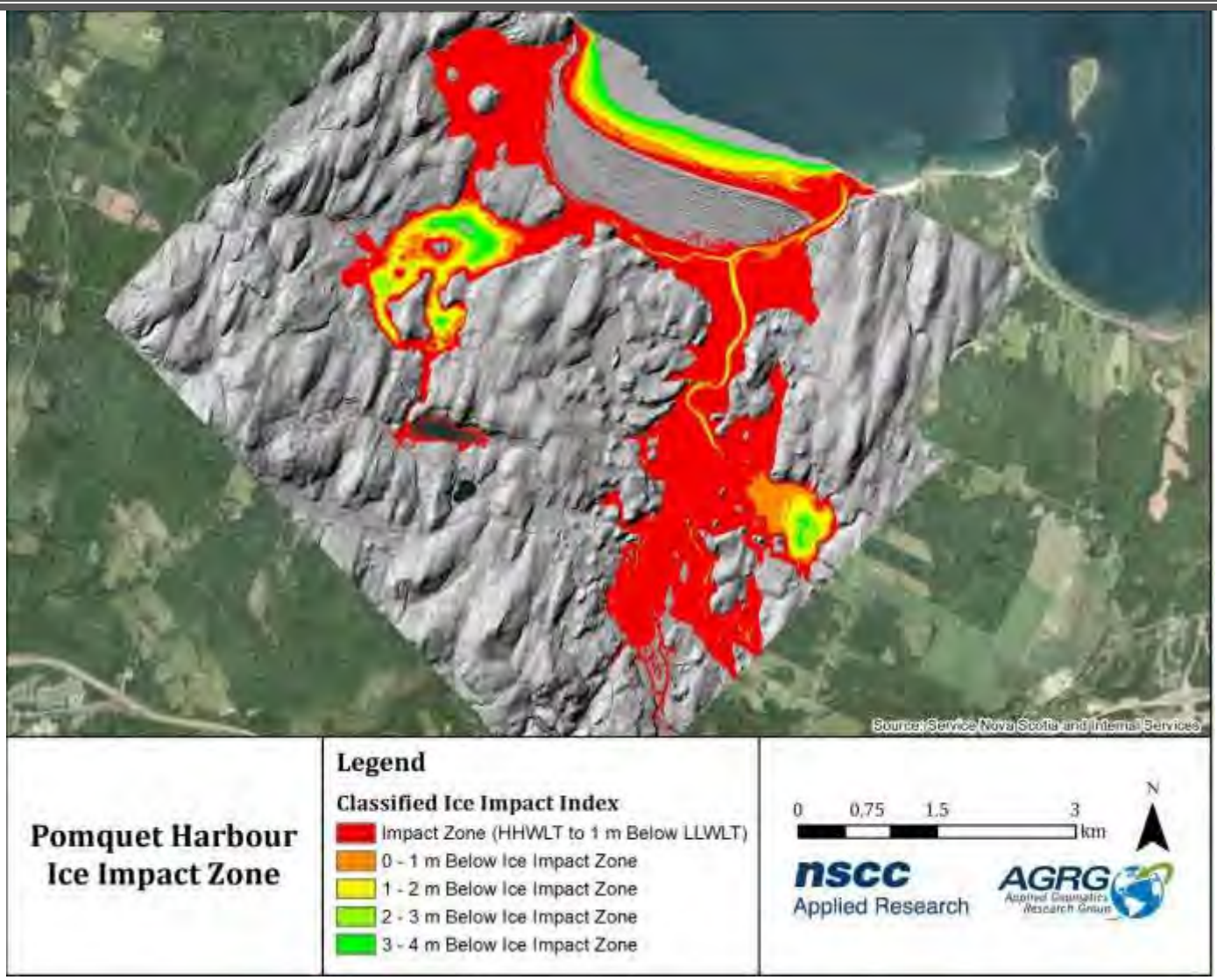


Figure 36: The Ice Impact Zone is defined as the level of HHWLT to 1 metre below LLWLT, with the ice impact-free zone divided into 1-metre increments below the impact zone.

Ice-impact zones were present over the majority of Pomquet Harbour. Ice-impact free zones were identified in the channel, the western bay, and a small portion of Church Cove (Figure 36).

2.6.9 Depth Map

Depth relative to Lower Low Water Large Tide (LLWLT) was generated by using the Raster Calculator tool in ArcMap to subtract the DEM from the LLWLT value (-1.01 m) and to nullify any value of the resulting raster greater than 0 m. This is shown as a Continuous Depth map in Figure 37. The Reclassify tool was then used to bin the Continuous Depth layer into 1 m bins to generate a Classified Depth layer (Figure 38). Small NoData holes were filled by applying the Elevation Void Fill Function in ArcMap's Image Analyst. The Majority Filter and Boundary Clean tools were also used on the Classified Depth layer to decrease speckle. One-metre contours relative to LLWLT were derived from the Classified Depth layer (Figure 38).

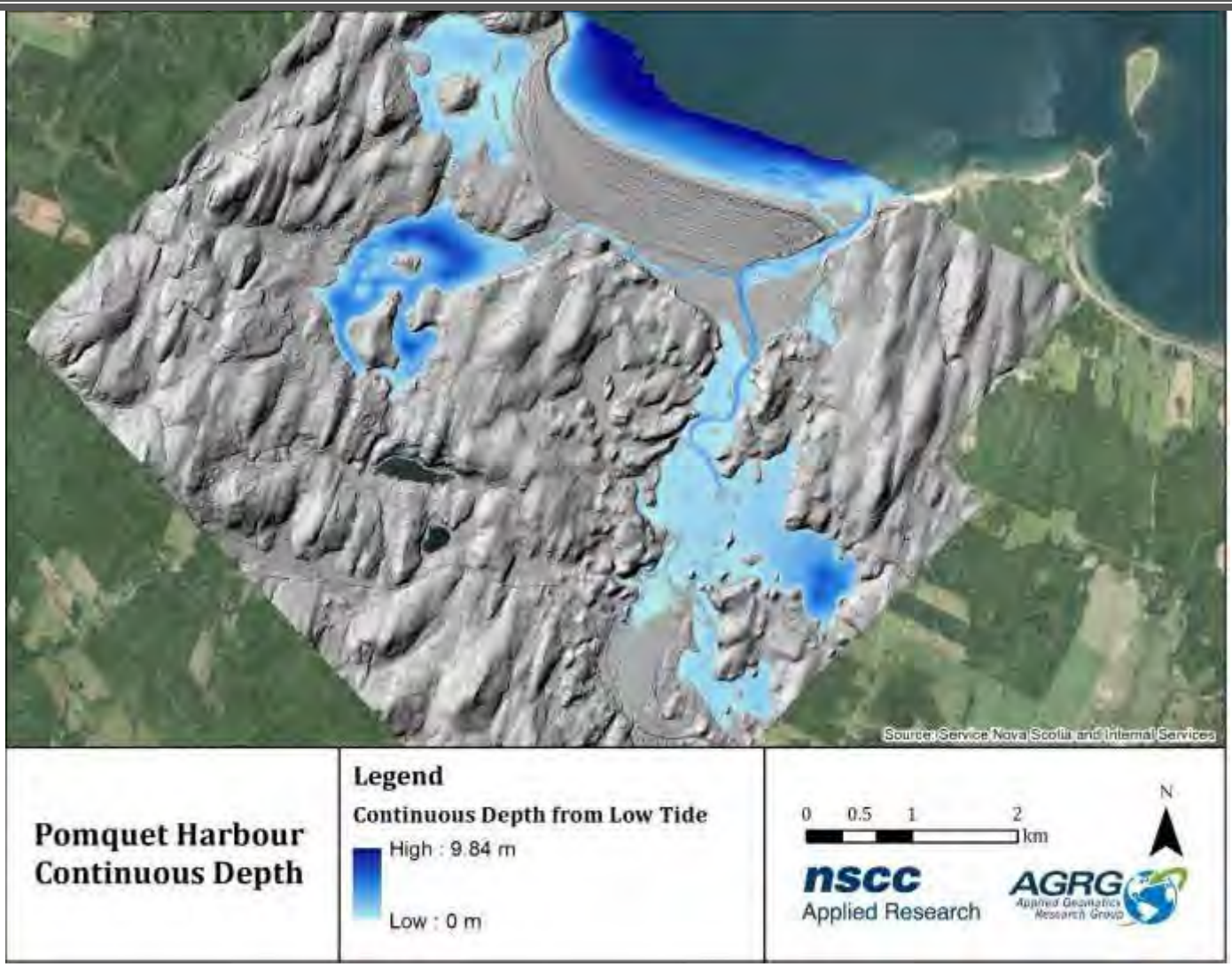


Figure 37: Continuous depth model, with depth relative to LLWLT.

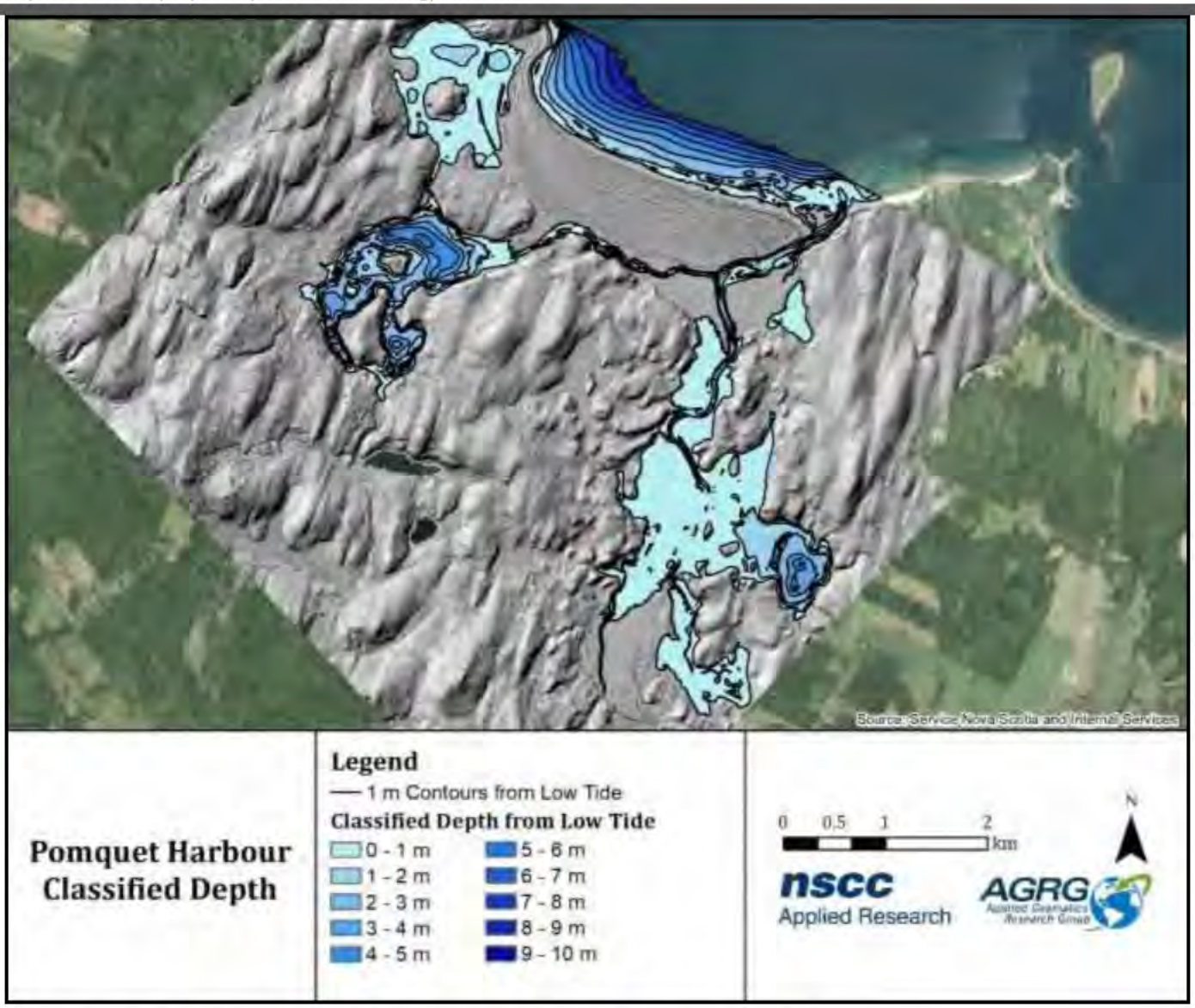


Figure 38: Classified depth model, with 1 m depths relative to Lower Low Water Large Tide.

The maximum depth in Pomquet Harbour was approximately 10 m below LLWLT with the deepest areas located seaward, near the mouth of the harbour, and in small portions of Church Cove and the western bay.

2.7 Eelgrass

The orthophoto imagery was combined with the lidar green laser intensity and the lidar seabed roughness and used in a Fuzzy K-Means unsupervised classification for cover material below the higher high-water line. The results of the classification tended to group features at too coarse of a level. The method was revised to include the use of band ratios from the orthophoto RGB bands. The band ratios help with variable light conditions between photo frame exposures and sun glint from the water surface. The band ratios were calculated using the following method: (B1 - B2)/(B1 + B2), which resulted in an image ranging from -1 to +1. These images were then scaled to a range of 0-255 and used for the Fuzzy K-Means unsupervised classification with an output of 16 classes. Some classes were aggregated to produce a final eelgrass presence and absence map since this was the only class that represented an ecosystem health indicator and steps should

be taken to avoid damaging eelgrass beds. There was minimal ground truth information available of the distribution of eelgrass and other benthic cover material (with the exception of the Video Ray transects which shows SAV). We reached out to various stakeholders and eelgrass experts for data and received some generalized areas from [redacted] a student of Dr. [redacted] from the Biology department at St. FX University. We used these areas for a qualitative assessment and interpretation of the imagery and results.

2.8 Hydrodynamic Modelling

A hydrodynamic model (HD) was developed for the Pomquet Harbor using DHI Mike 21 Flow model Flex mesh application. A variety of modules within the Flex mesh were used to obtain the project outputs.

The model was used to produce four layers: flushing time, mean and maximum monthly currents, and significant wave height from the dominant wind direction and speed. Flushing time was determined using the transport module of Flex Mesh. Mean and maximum monthly current magnitudes were calculated directly using Mike 21 from the hydrodynamic model. The significant wave height was derived by applying strongest south winds to the Spectral Waves Module.

2.8.1 Mesh Generation

The hydrodynamic model was driven by two major inputs: a surface generated from bathymetric and land elevation points, and boundary conditions. As the Flex Mesh module works with meshes instead of a grid, a mesh was developed using the Mesh Generator tool in Mike Zero. Raw data for generating the mesh was land boundary (3 m contour) and bathymetry (resolution of 3 m) in XYZ format. Bathymetry was obtained from lidar, multibeam surveys and CHS chart data (converted to CGVD2013) where the lidar did not penetrate the deeper water. A mesh was generated with larger mesh resolution in the deep water and fine mesh resolution in the harbour and channel as shown in Figure 39. The mesh was interpolated using the linear interpolation method. The output mesh file contained geographical position information along with water depth at each node point.

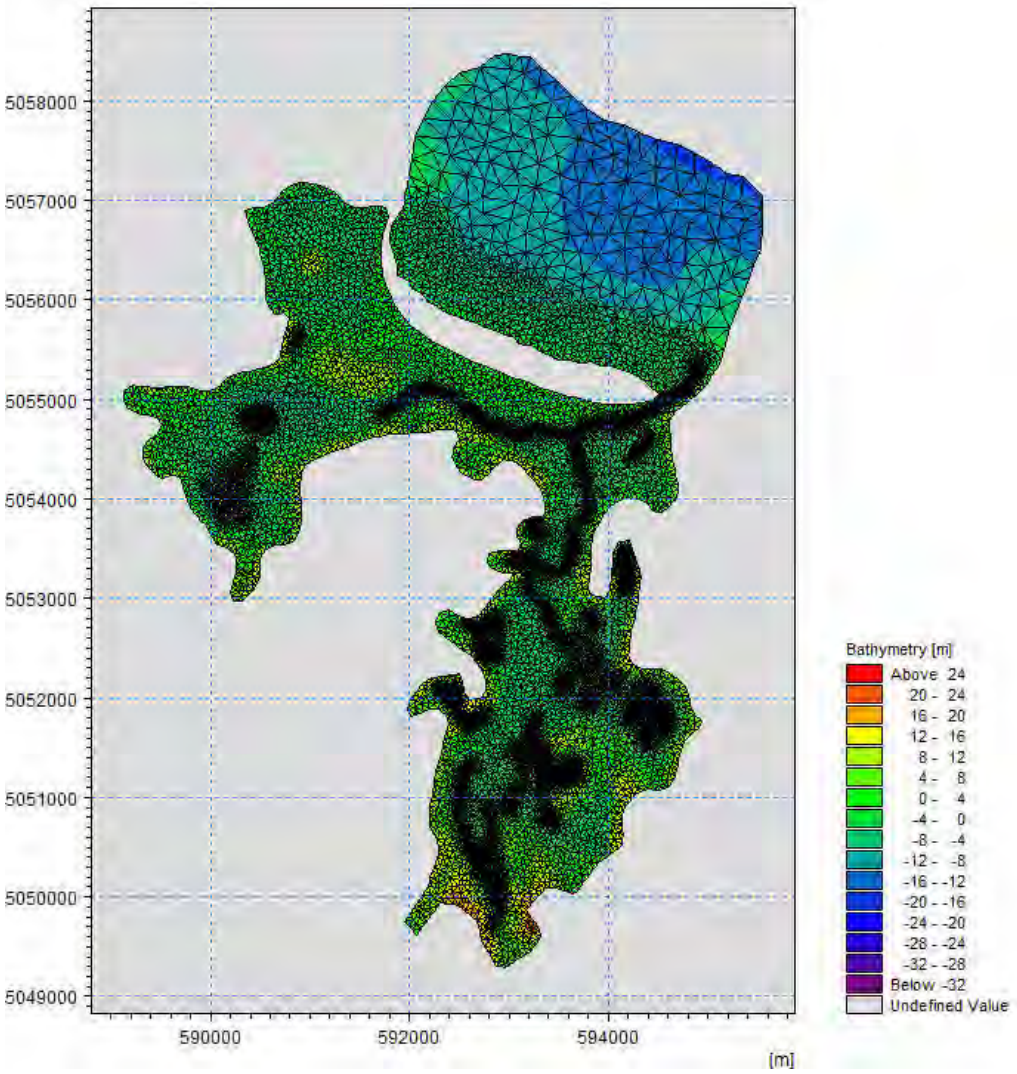


Figure 39: Mesh generated using Mike Mesh Generator tool showing fine resolution in channel and small branches of the harbour.

The mesh file showing the bathymetry with contours plotted using Plot Composer, a tool in Mike Zero, is as shown in Figure 40.

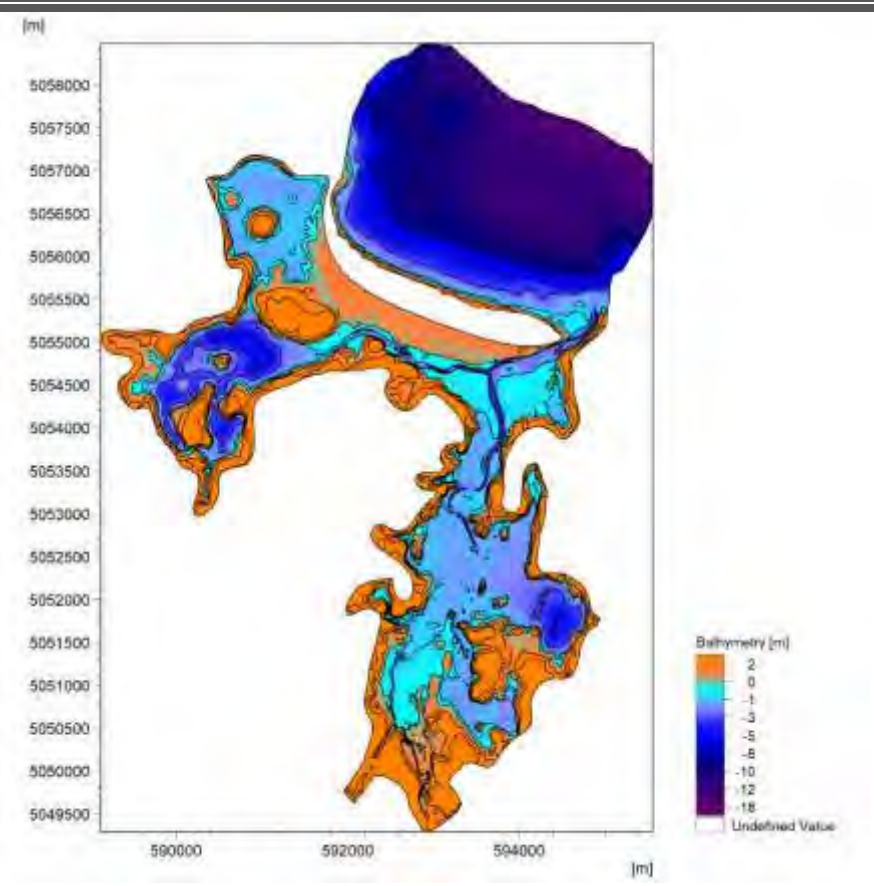


Figure 40: Mesh file showing bathymetry plotted using Mike plot Composer.

2.8.2 Boundary Conditions

The other major inputs for the models were the boundary conditions. Predicted tide generated by the XTide program, which was written by [redacted] from Biological Sciences department, University of South Carolina, was extracted at the Antigonish Harbour station from Tbone tide website (Pentcheff). The tide file in chart datum (LLWLT) was converted to CGVD2013 and used to drive the model (Figure 41).

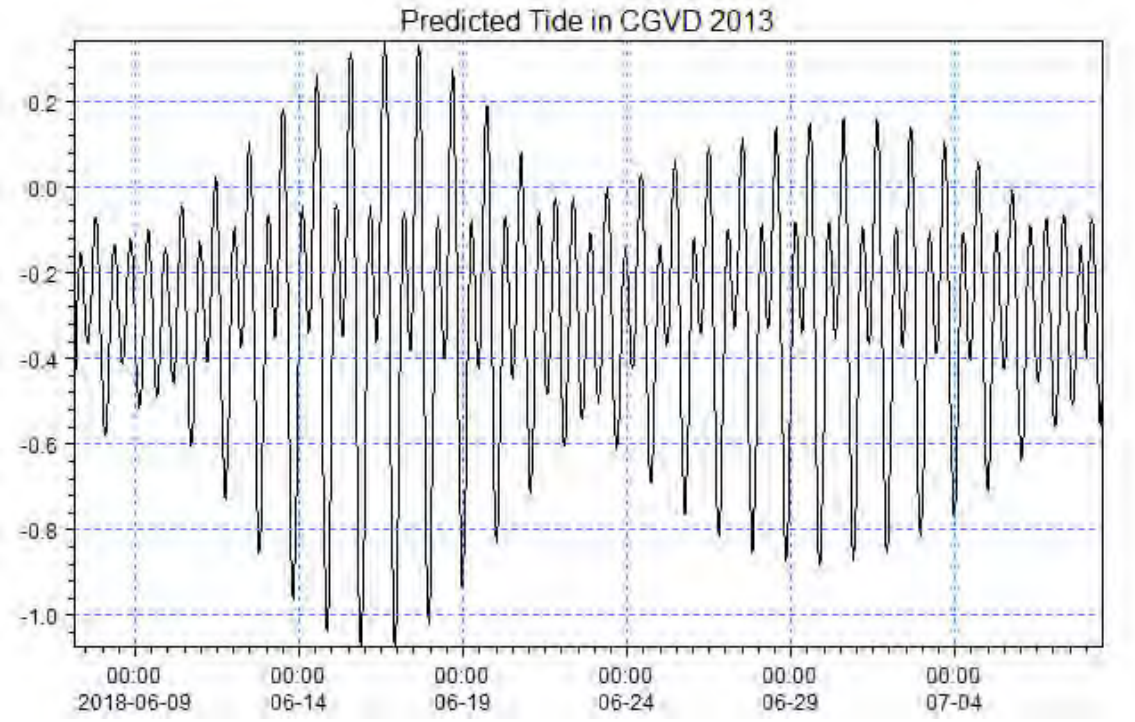


Figure 41: Predicted Tide obtained from http://tbone.biol.sc.edu/tide/ at Antigonish harbour plotted using Mike Plot Composer.

2.8.3 Hydrodynamic Simulation

The Hydrodynamic Model ran from the 5th of June to July 8th, 2018, a span of 33 days covering the one-month timeframe when the ADCP was deployed. Real time wind data obtained from the nearby Environment and Climate Change Canada station (ECCC) - Tracadie was also included in the model (Figure 42).

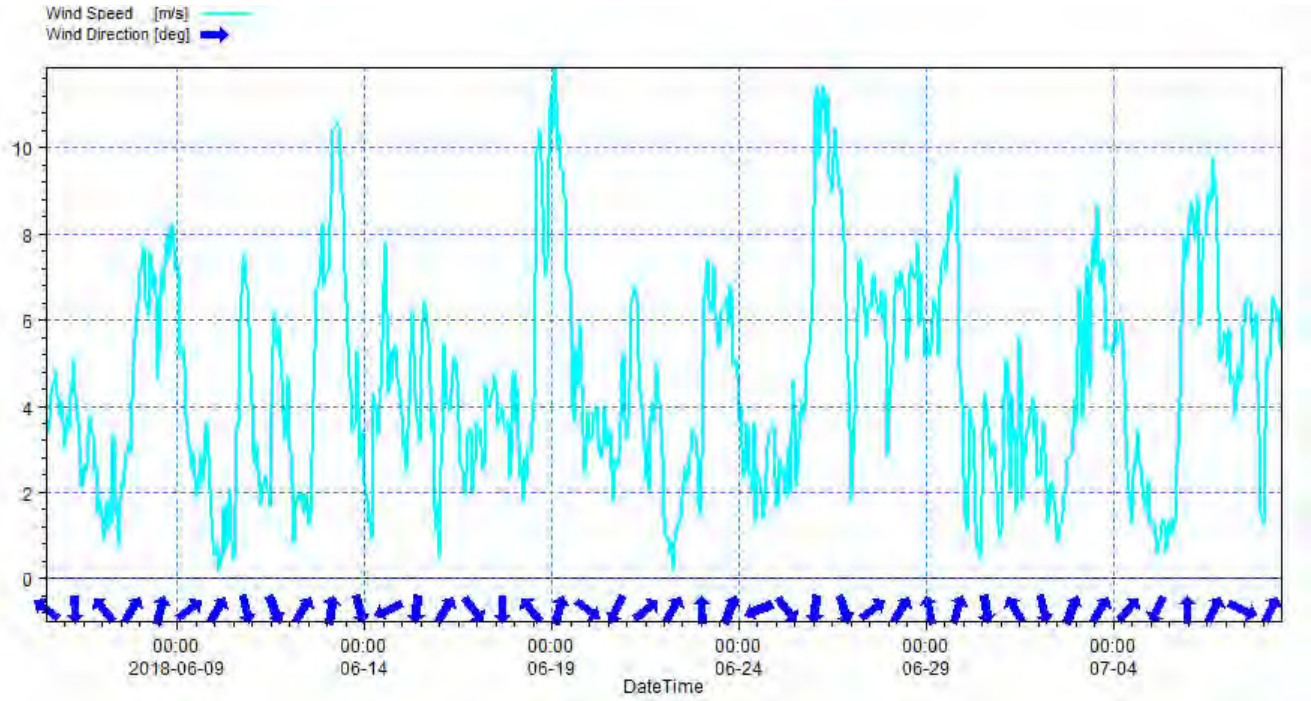


Figure 42: Wind data from Tracadie ECCC station.

For the hydrodynamic model, a temperature of 10 °C and salinity of 32 Practical Salinity Unit (PSU) were added to the model along with wind and bed resistance of 38 m^ (1/0)/s. Fresh water input was also included in the model to represent the streams draining into the harbour.

A storm surge value of 1.5 m was applied on the high tide to identify potential areas of flooding and changes in current speed. The value of 1.5 for a storm surge was typical for the type of storms that occur in the Maritimes. The hydrodynamic simulation ran for four tidal cycles to obtain water levels and currents.

2.8.4 Transport Module Simulation (Flushing time)

The Transport module in the Flex Mesh was used to calculate the minimum concentration that remained in the harbour based on the flow conditions. A concentration of one was added to the harbour on the first day and the model ran for a period of 33 days. Fresh water sources at four locations were also included with no concentration coming into the harbour. No decay factor was added. The results showed the time it took for the concentration to go to zero, thus replaced by fresh water while other areas still showed a concentration of 50%. The results were interpreted for flushing time estimates.

2.8.5 Spectral Waves Module Simulation

The Spectral wind wave model, which simulates growth and decay of wind generated waves and swell in coastal areas, was used to derive significant wave height (Hs) in the harbour. This simulation ran for four tidal cycles with south winds applied. Metrological data of Tracadie from 2003 to 2020 was summarized to obtain the significant winds in the region. When 15 m/s winds were applied, Hs in the harbour near the ADCP changed from 1 μm to 1 mm. Wave boundary conditions obtained from the ADCP waves data was used to drive the model.

2.8.6 Particle Tracking

The particle tracking module in the Flex Mesh of MIKE 21 was used to determine the fate of the suspended substance released from the best oyster sites in the harbour. The prime state for a female oyster to begin spawning is when they reach a size of 40 mm. Spawning is also dependent on environmental cues, where oysters prefer to spawn at water temperatures between 20°C to 30°C (68°F to 86°F) and at salinity levels above 10 ppt, which the harbour exhibits (Section 2.6.3 Temperature and Salinity) (Doiron, 2008). The fertilized eggs take about two weeks in the water column to reach the pediveliger stage (larva with a foot), which is when they begin to concentrate at the bottom of the river seabed system to search for a hard substrate. For this reason, the model ran for a period of one month with higher settling rate after the first two weeks.

As the female oyster releases a high number of eggs, only a fraction of them were considered by scaling the model's values to limit the simulation time. This number was obtained by summing the count of oysters in the size range of 30 mm to 100 mm and then assuming half of that number would be females. The resultant number was multiplied by 50 million, as each female oyster can produce that many eggs, and then divided by one million to facilitate the processing. These particles

were released per hour over a tidal cycle in the model at the best oyster locations (Figure 43). A horizontal dispersion constant of 0.002 m^2/s was also used along with water levels and bed resistance from the validated hydrodynamic model.

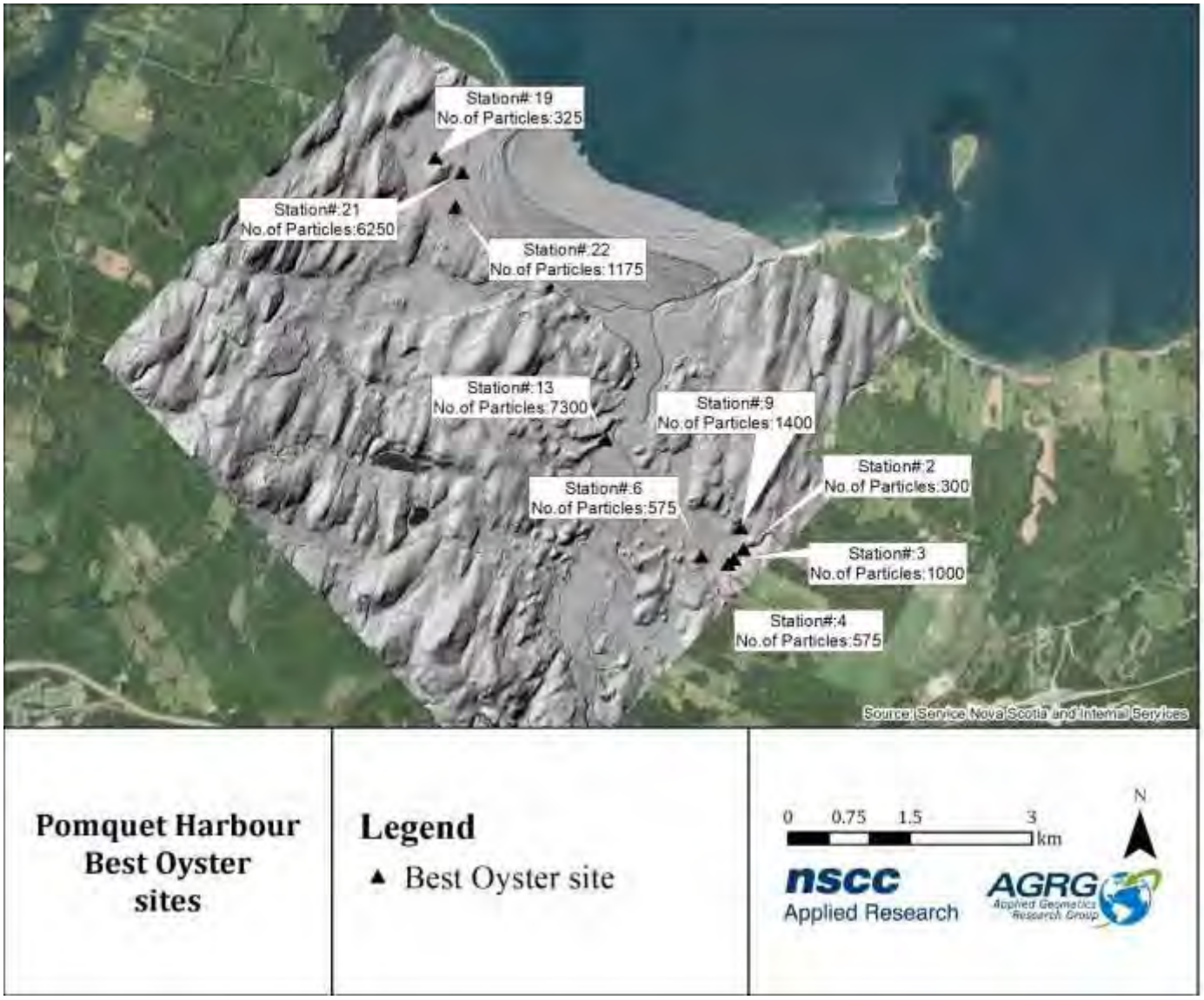


Figure 43: Number of particles released per hour from the station in the simulation.

3 Results

3.1 Digital Elevation Model (DEM)

The bathymetry obtained from the lidar, multibeam survey and CHS data, along with the topographic data from the Chiroptera topo-bathymetric lidar, is shown as a colour shaded relief (CSR) model in Figure 44. A hillshade model of the DEM is included in Appendix 2: Hillshade Models.

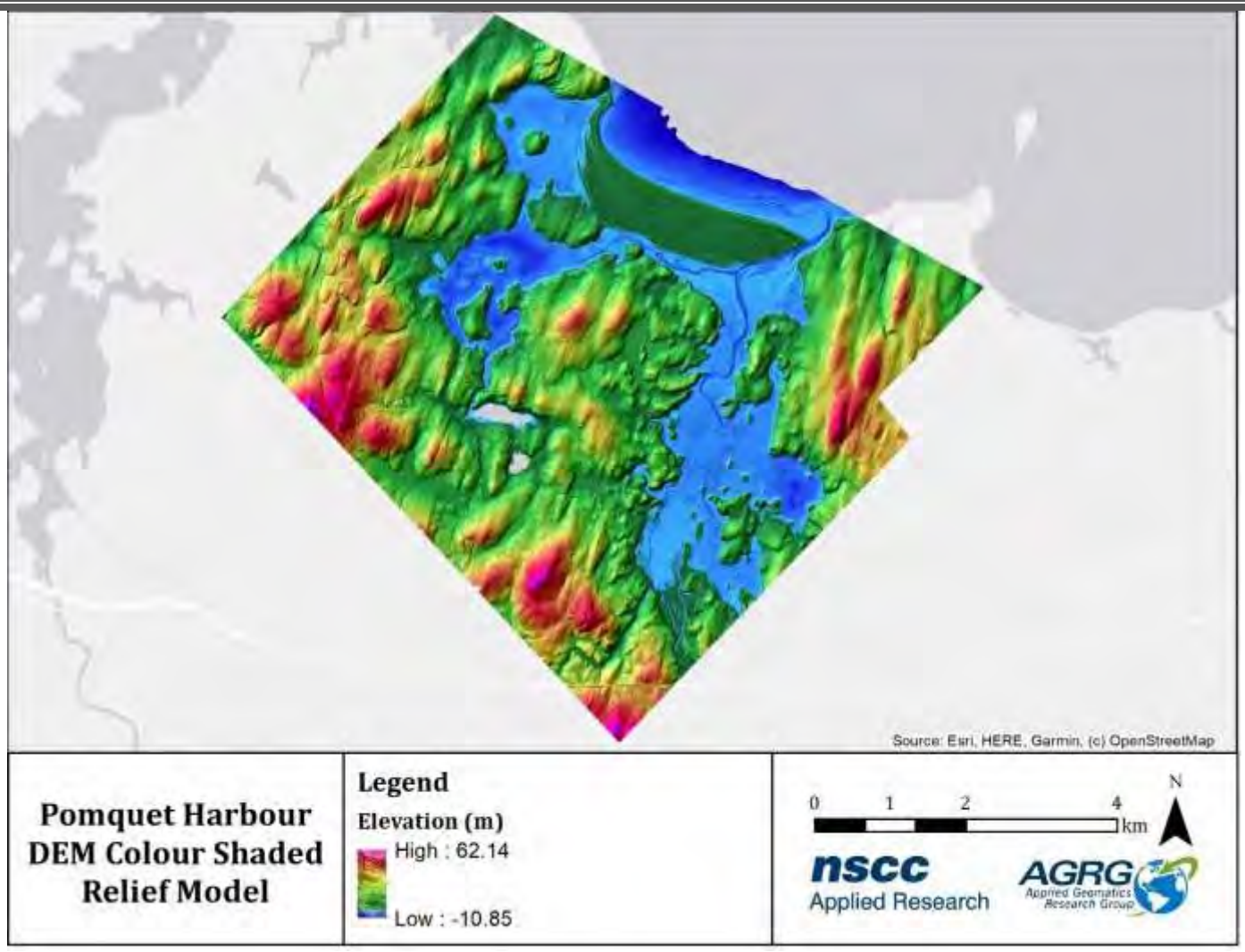


Figure 44: Colour shaded relief model generated from the digital elevation model.

3.2 Digital Surface Model (DSM)

The topo-bathymetric lidar survey, along with the multibeam data and CHS soundings, was processed into a digital surface model of the Pomquet study region. A DSM captured both the natural and built/artificial features of the environment whereas the DEM represented bare earth surface. This is presented as a colour shaded relief model in Figure 45. A hillshade model of the DSM is included in Appendix 2: Hillshade Models.

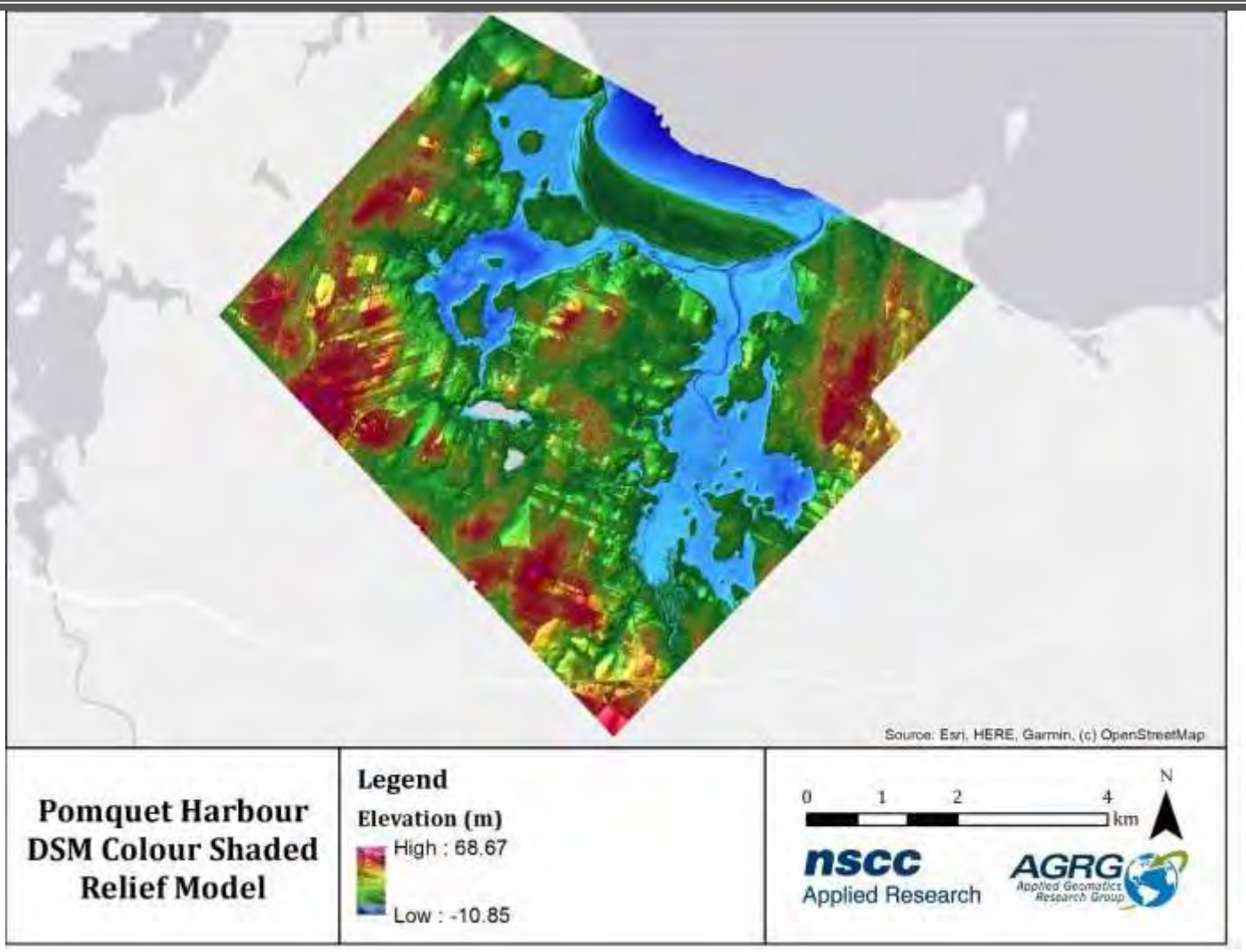


Figure 45: Colour shaded relief model generated from the digital surface model.

3.3 Intensity

The intensity model provided information on how much light was reflected by the ground and cover material surfaces that the green laser reflected off (Figure 46). Bright areas in the intensity model indicated that the laser reflected strongly off the land (e.g., sand), while dark areas indicated a weaker reflection of the laser (e.g., dark seaweed). The normalized bathymetric model compensated for the variation in depth in Pomquet Harbour and the impact on the amplitude of the reflected green laser pulses (Figure 47). A colour shaded relief of the intensity model is shown in Figure 48.

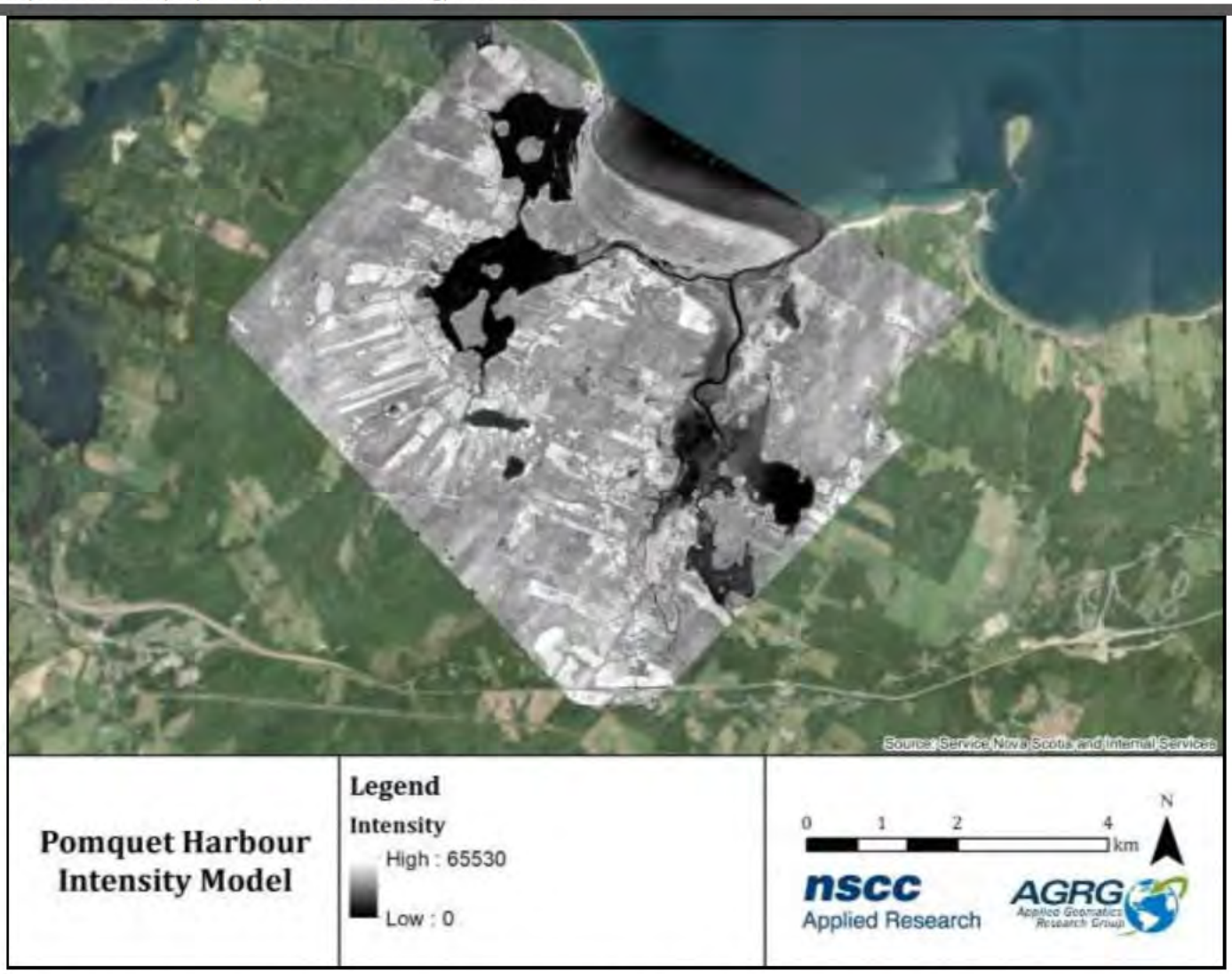


Figure 46: Intensity map of the lidar return data that incorporates all green laser returns above and below the water line (HHWLT).

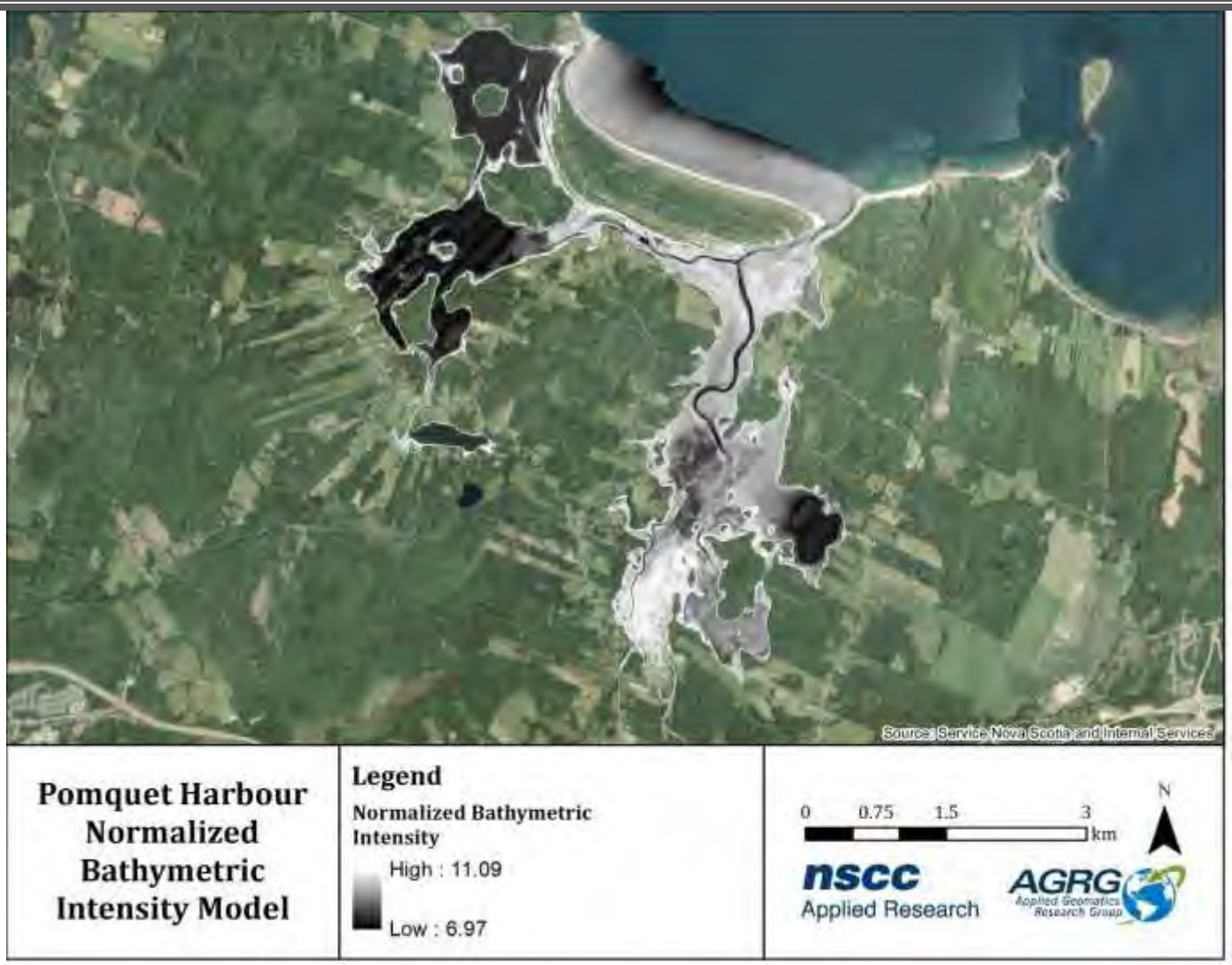


Figure 47: Normalized intensity map of the lidar return data that incorporates lidar returns below the water line (HHWLT).

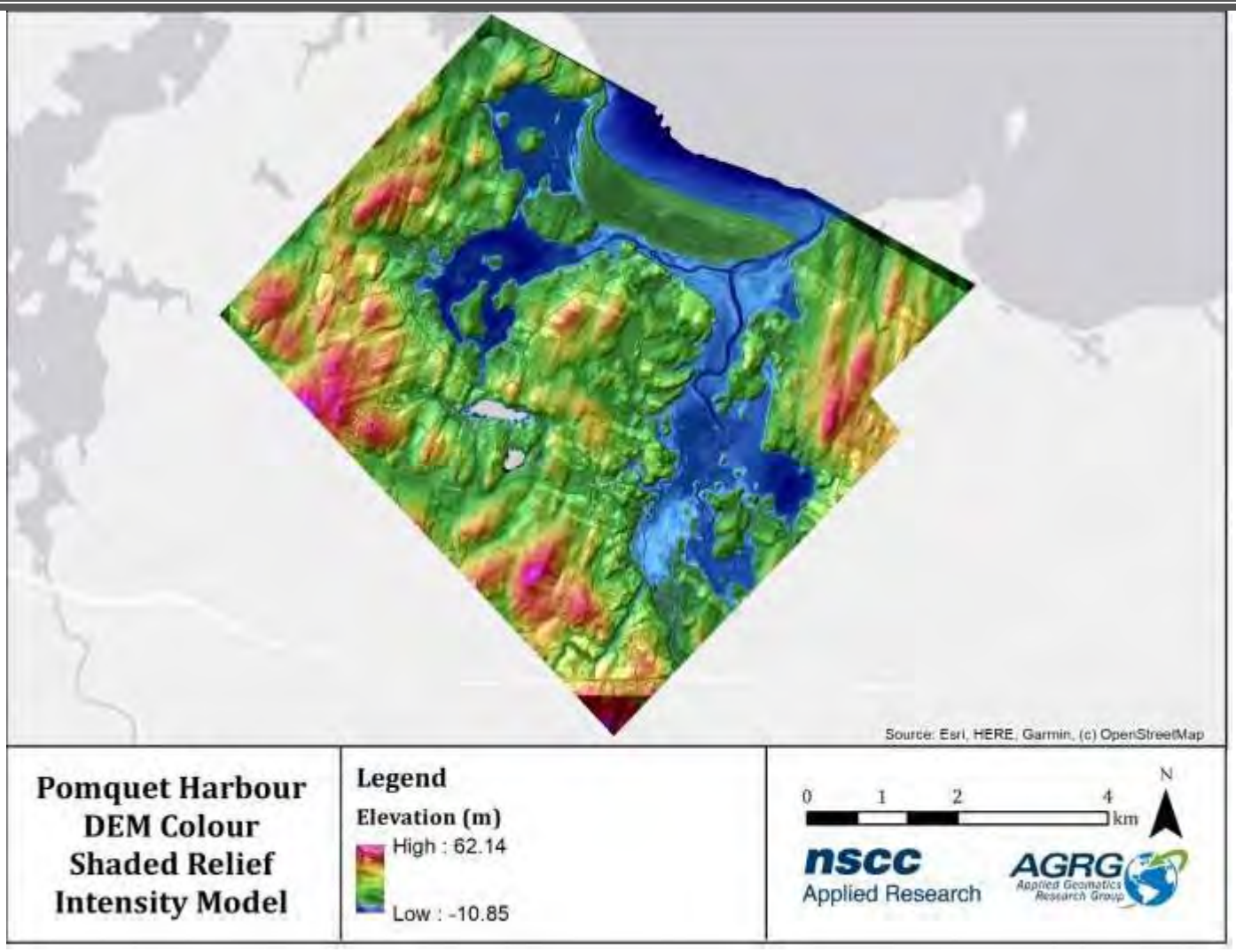


Figure 48: Colour shaded relief intensity model generated from the digital elevation model and lidar intensity data.

3.4 Orthophoto

The orthophoto layers were invaluable for assisting with the interpretation of the DEM, validating land use, and for use in the generation of lidar derived products, such as eelgrass. The orthophoto true colour mosaic (50 cm) showed areas of sand, vegetation, and identified the channel; the NIR orthophoto mosaic in shades of red was helpful in distinguishing between sand or pavement and vegetation on land (Figure 49; Figure 50).

The RCD30 imagery was processed using Agisoft Photoscan Professional. Captured imagery was georeferenced using an aerial triangulation model. Where photo positions were unable to be resolved, imagery was directly georeferenced using the known camera position and orientation. Photo orientations were calculated by linking the exterior orientation (EO) extracted from the aircraft trajectory GPS position (X, Y, Z) and the IMU attitude (omega, phi, kappa) at shutter events to the engineered internal orientation (IO) of the RCD30 (CCD dimensions, focal length, lens curvature). These orthophotos were displayed in the web application as a NIR image and an RGB image.

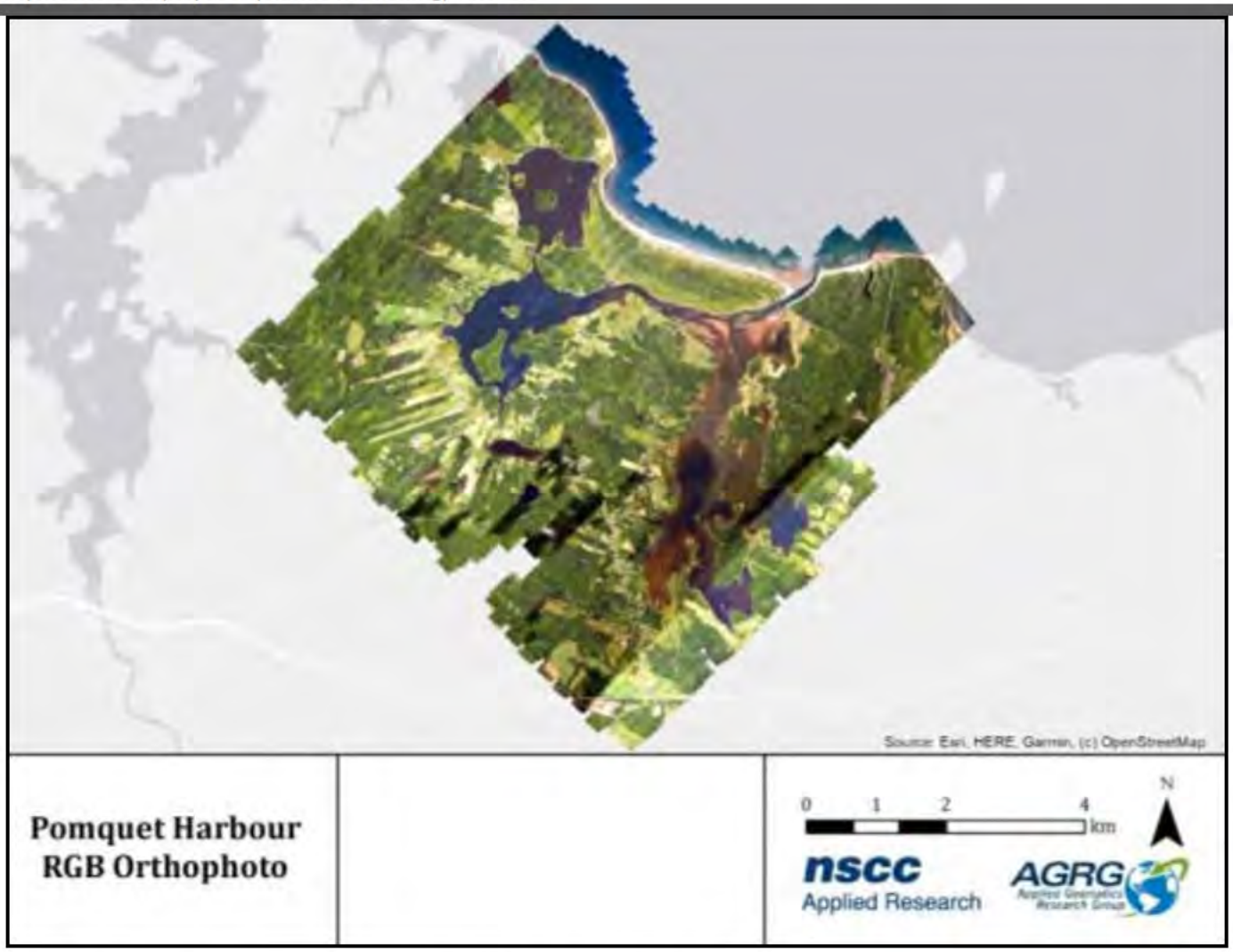


Figure 49: True colour image (50 cm), generated from the RCD30 orthophoto mosaic.

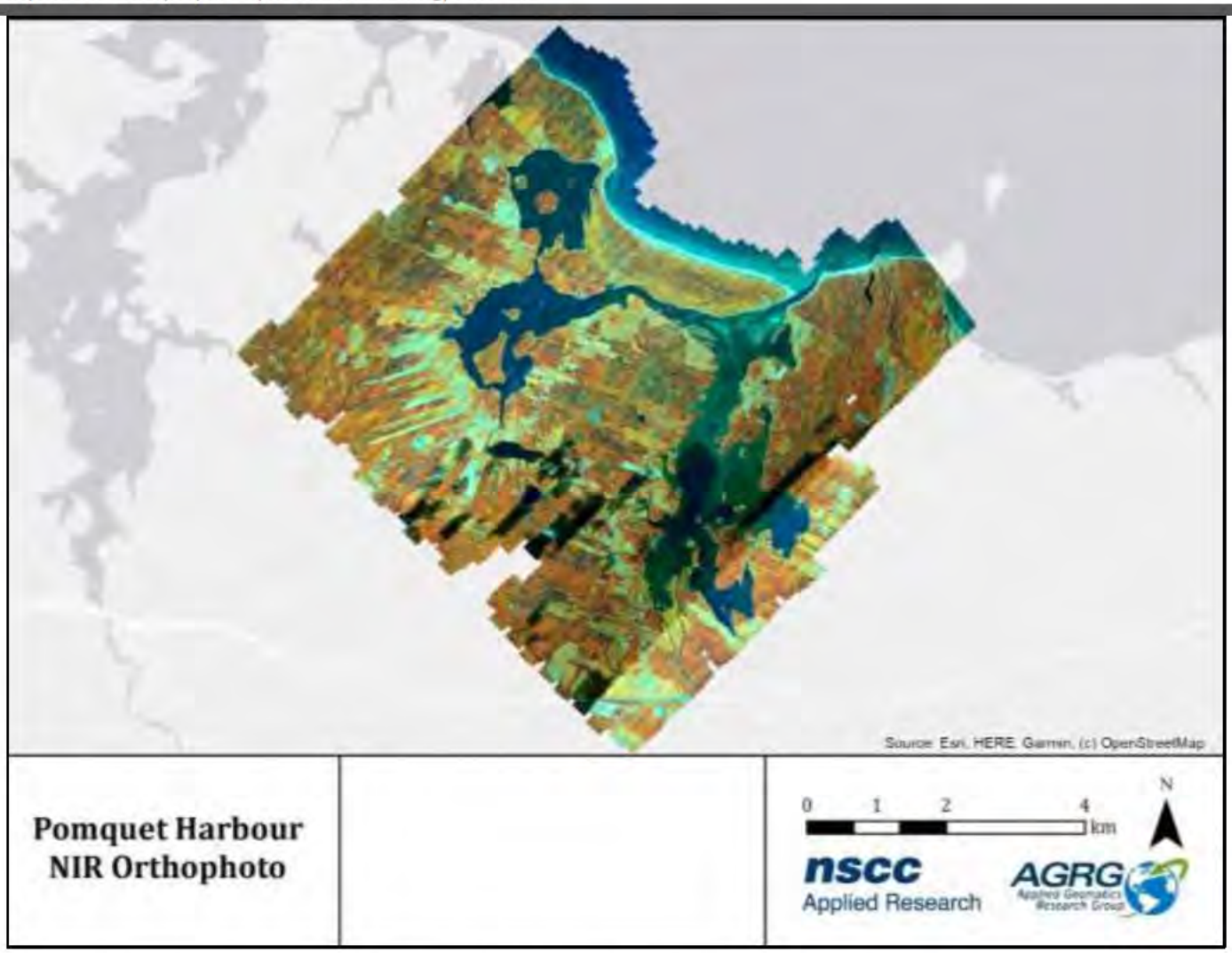


Figure 50: False colour NIR image (50 cm), generated from the RCD30 orthophoto mosaic with band combinations near infrared, green, and blue.

3.5 Eelgrass

The variation of the lighting condition across the survey area and the presence of cloud shadows affected the resultant classification, even after the use of band ratios. The results were validated qualitatively against interpreting the RGB orthophoto imagery. The map represented the healthiest eelgrass, although it may have underestimated the full extent of eelgrass presence as it did not pick up the outer boundary of some of the clumps (Figure 51).

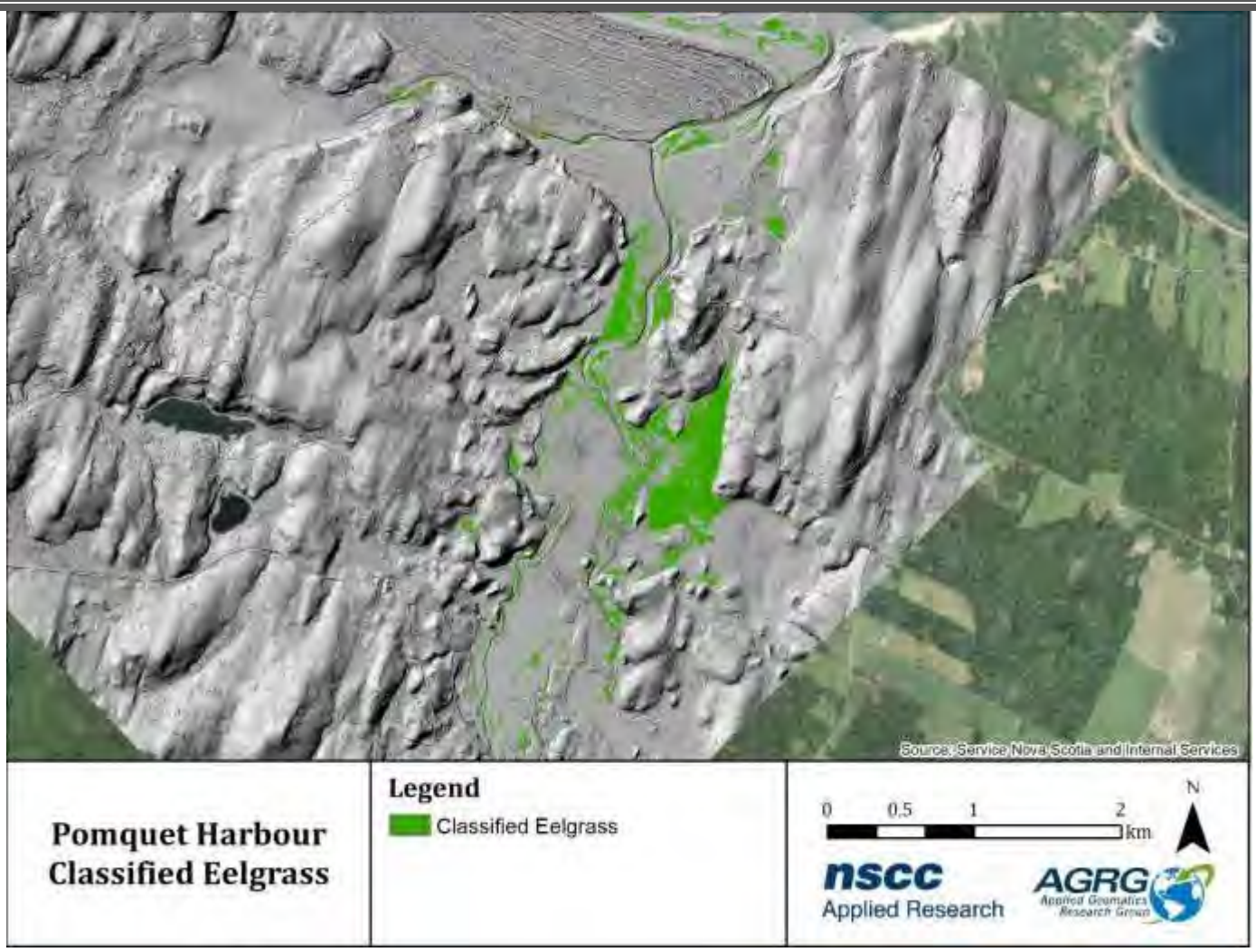


Figure 51: Classified eelgrass presence in Pomquet Harbour.

3.6 Acoustic Doppler Current Profiler (ADCP)

The ADCP measured waves on the hour and currents every 30 cm from the sensor to the sea surface every 15 minutes. In addition to measuring the current speed and direction for these vertical bins (30 cm increments), the ADCP also measured water level from a pressure sensor. The data were integrated into an animation to aid in visualizing the ADCP current and water level results in relation to wind speed and direction. Frames from the animation showed the water level and current speeds during normal tidal events with variable wind conditions (Figure 52). The current speed was denoted by the x and y-axis in m/s, and the direction by the four cardinal points (N, E, S, W red lines and text) and the water level above the sensor was denoted on the z-axis (m).

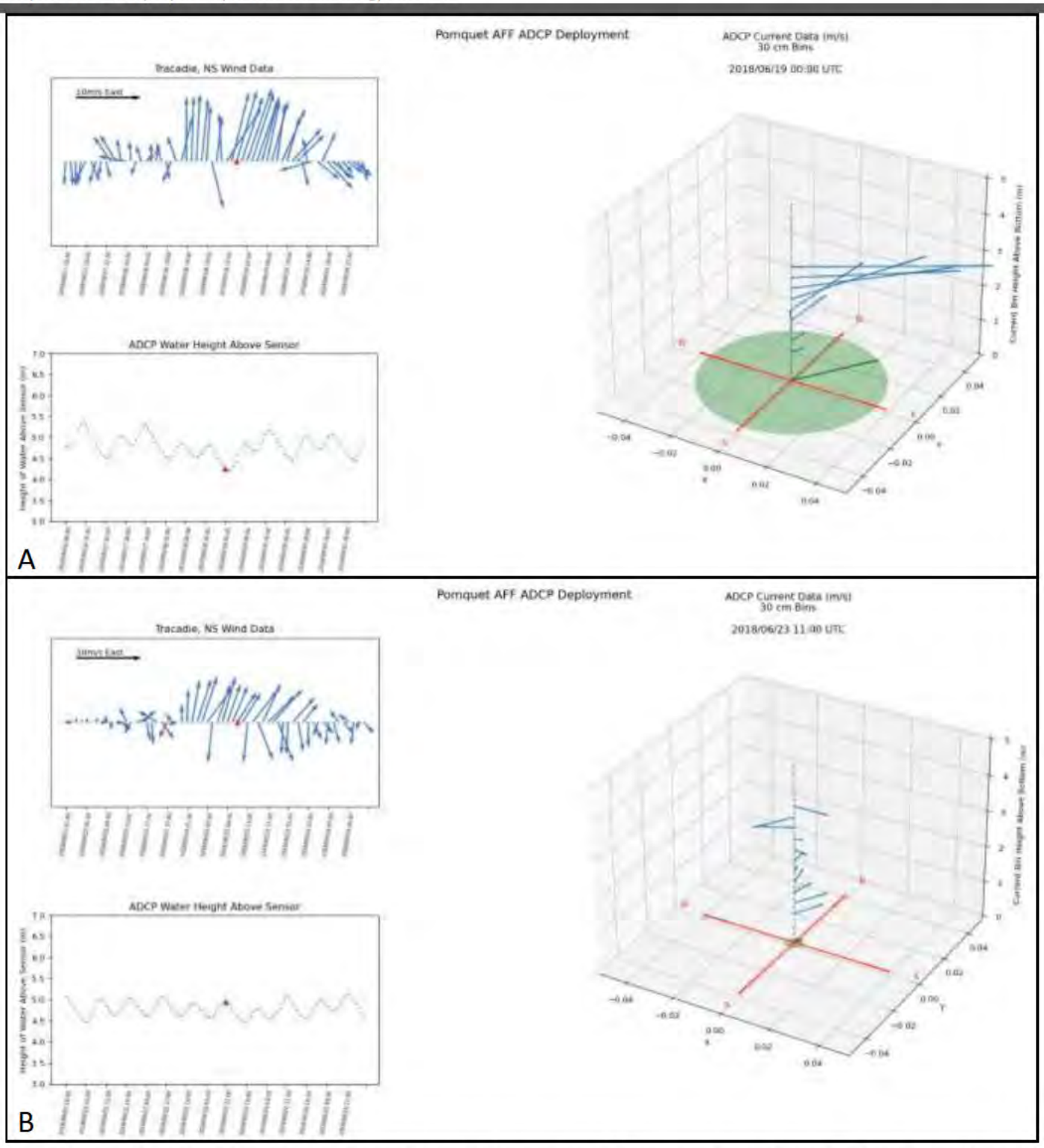


Figure 52: Frames from the ADCP animation. Upper left graph shows the wind direction and speed from the Tracadie weather station. The bottom left graph shows the water level above the sensor. The right graph shows the 30 cm bins of current velocity (magnitude and direction) as well the depth averaged current (green line and circle). (A) Currents during low tide with strong southerly winds. (B) Currents during high tide with moderate southerly winds.

The ADCP also captured two anomalous events on June 18-19 and a storm surge event on June 26th. Although the winds on June 26th were from the north-northeast, the currents increased dramatically to the northeast, and the water level increased by 20 cm (Figure 53).

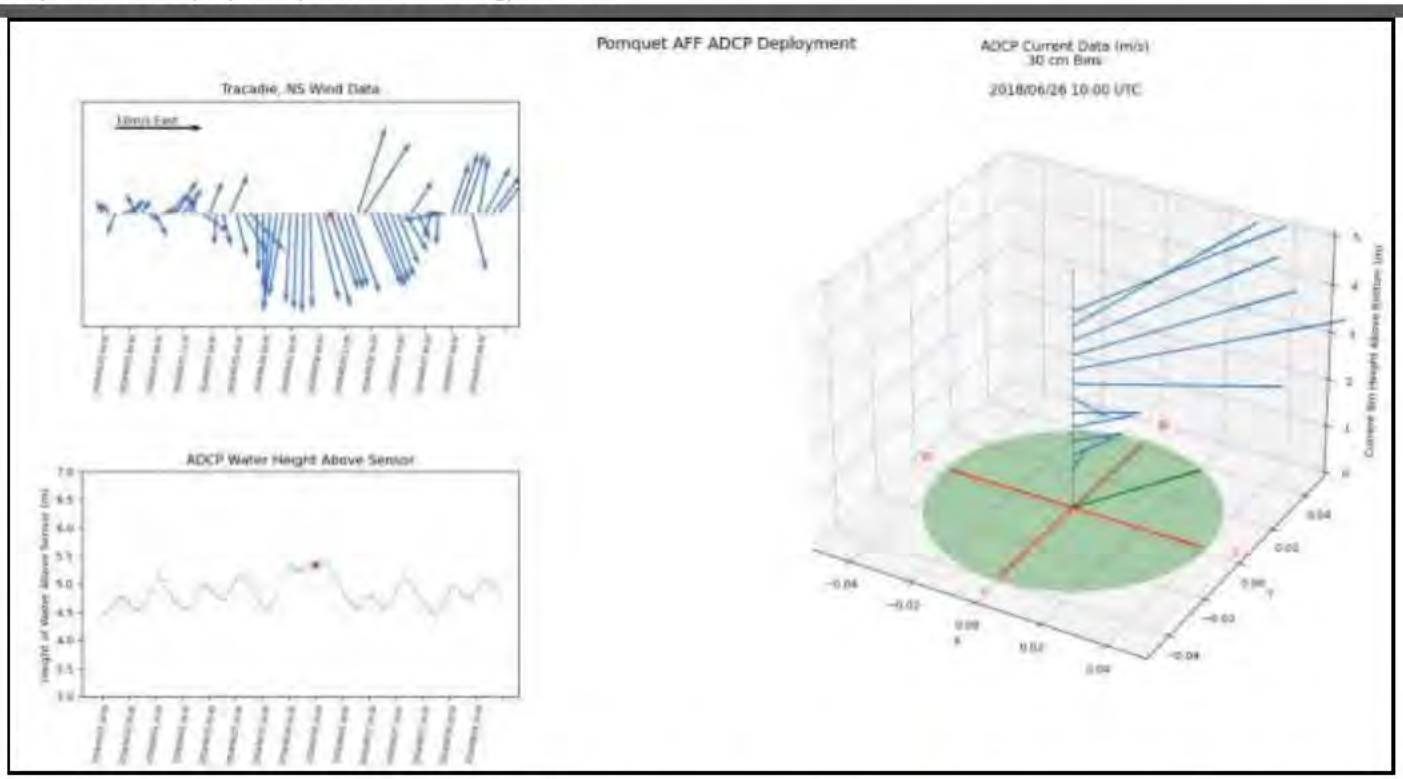


Figure 53: Frame from the ADCP animation for June 26th storm surge. Upper left graph shows the wind direction and speed from the Tracadie weather station. The bottom left graph shows the water level above the sensor. The right graph shows the 30 cm bins of current velocity (magnitude and direction) as well the depth averaged current (green line and circle).

The current speed and direction are strongly influenced by wind events even though Church Cove, where the ADCP was deployed, is quite sheltered (Figure 54). Although the currents increased during these events, it did not appear that the waves significantly increased, apart from June 26th, when waves reached magnitudes of 20-30 cm (Figure 22). The lack of significant waves was probably a result of the lack of fetch for the wind to generate large waves. The strong winds also affected the water level, for example, the strong southerly winds on June 19th produced a lower than usual water level and the strong northerly winds on June 26th produced higher than normal water levels (Figure 55).

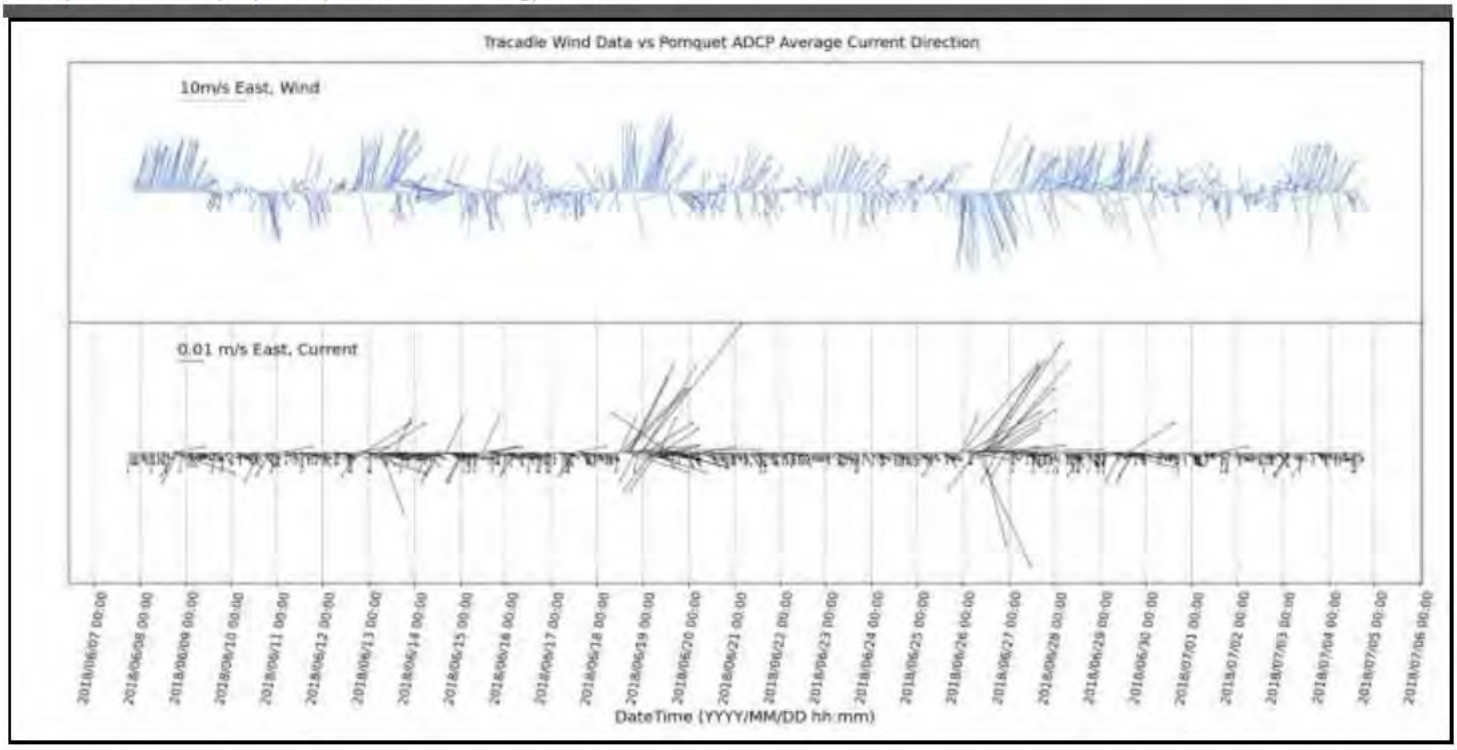


Figure 54: Wind from Tracadie weather station (top) and average current velocity from the ADCP (bottom) for the June-July 2018.

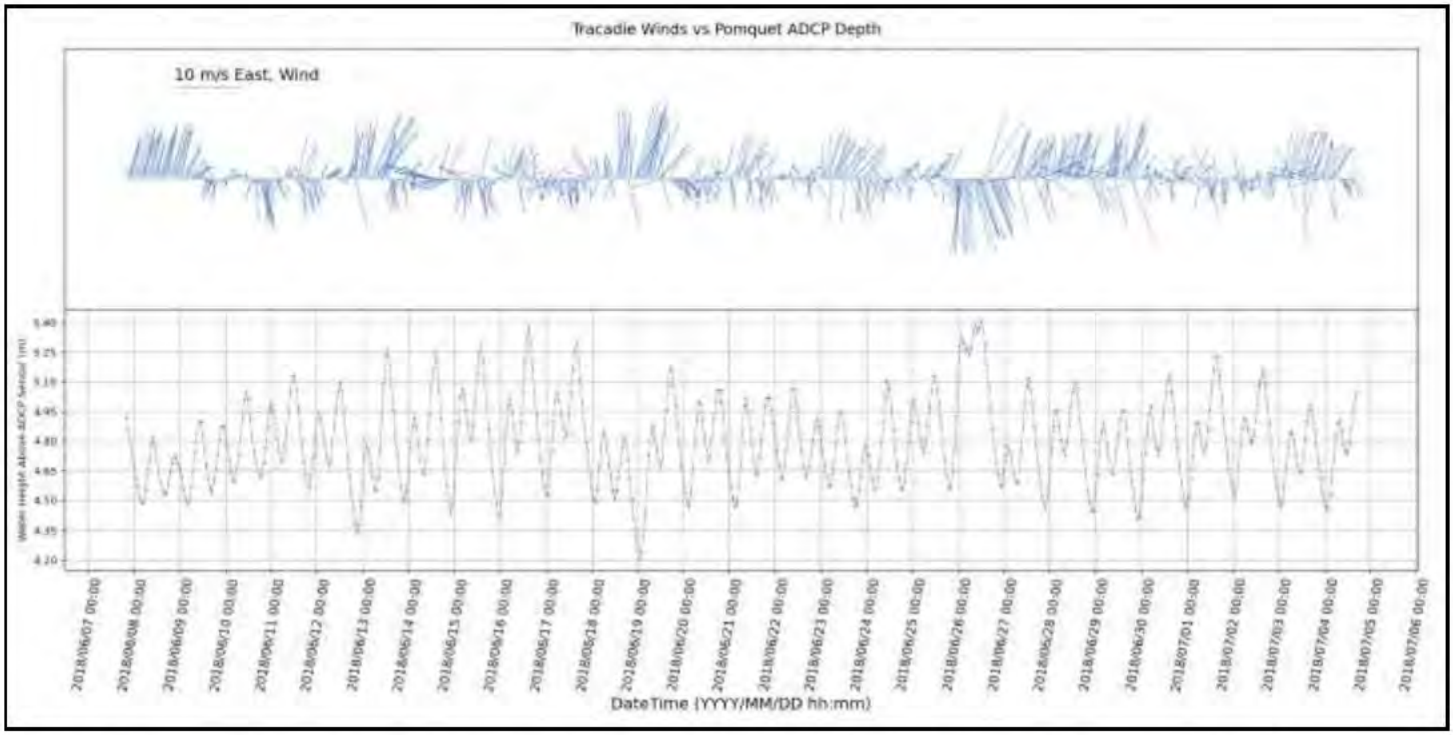


Figure 55: Wind from Tracadie weather station (top) and water height above the ADCP (bottom) for the June-July 2018.

3.7 Hydrodynamic Model Products

Several map products were derived from the results of the hydrodynamic modelling, including mean and maximum monthly currents, flushing time, significant wave height from the predominant wind based on data from Tracadie from 2003-2020, particle tracking for oyster spat, and the impact of a 1.5 m storm surge.

3.7.1 Mean and Maximum Currents

Mean and maximum monthly currents were extracted directly from the hydrodynamic model. A Txstat tool from Mike Zero toolbox was used to calculate the statistics on the converted unstructured mesh file. The continuous mean currents raster showed the actual values (Figure 56). The classification scheme chosen for the currents showed that the mean currents in most of the harbour, including the deep pools in Church Cove, were less than 0.1 m/s (Figure 57).

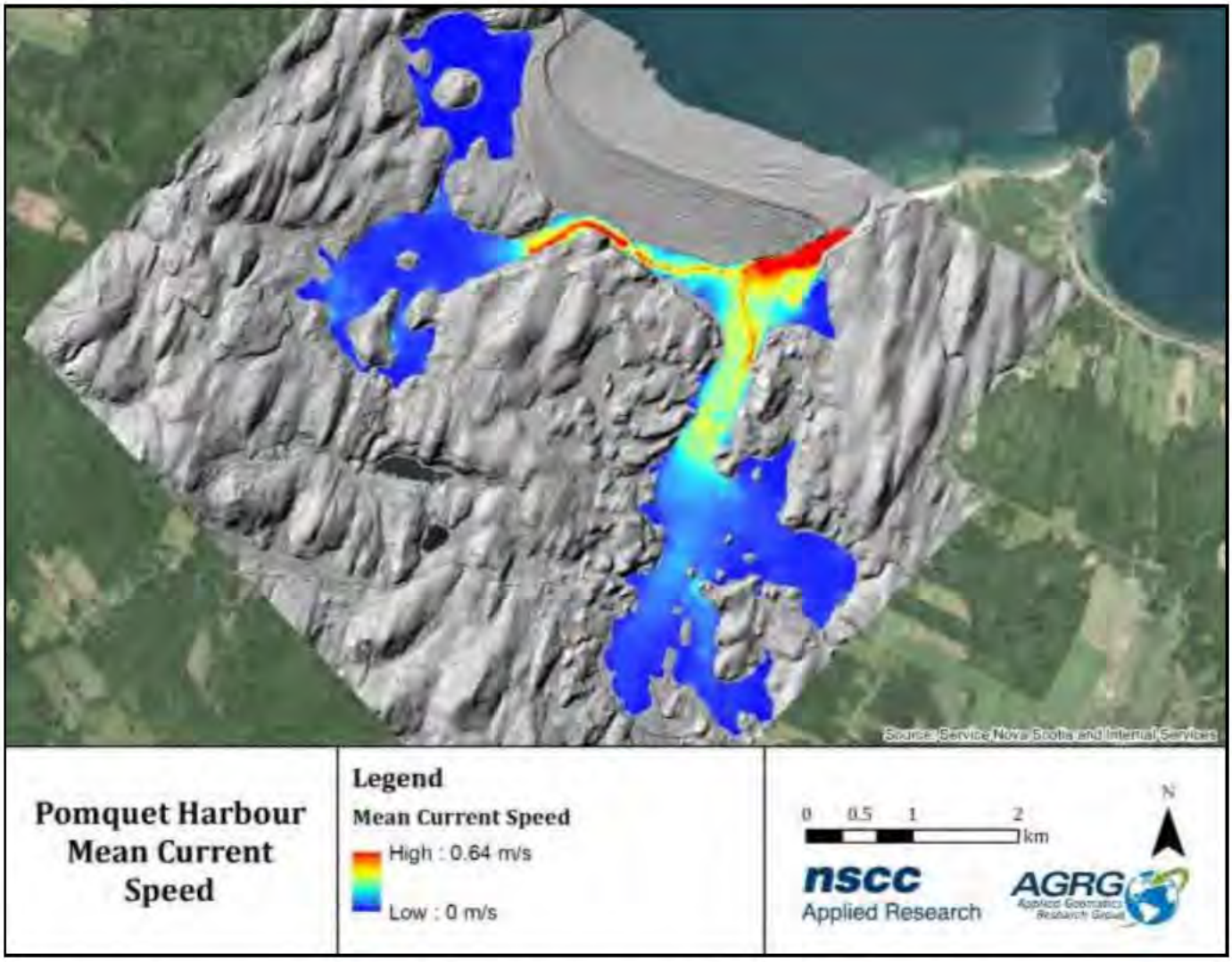


Figure 56: Mean of current magnitudes (m/s) during a 33-day simulation of the hydrodynamic model displayed as a continuous raster.

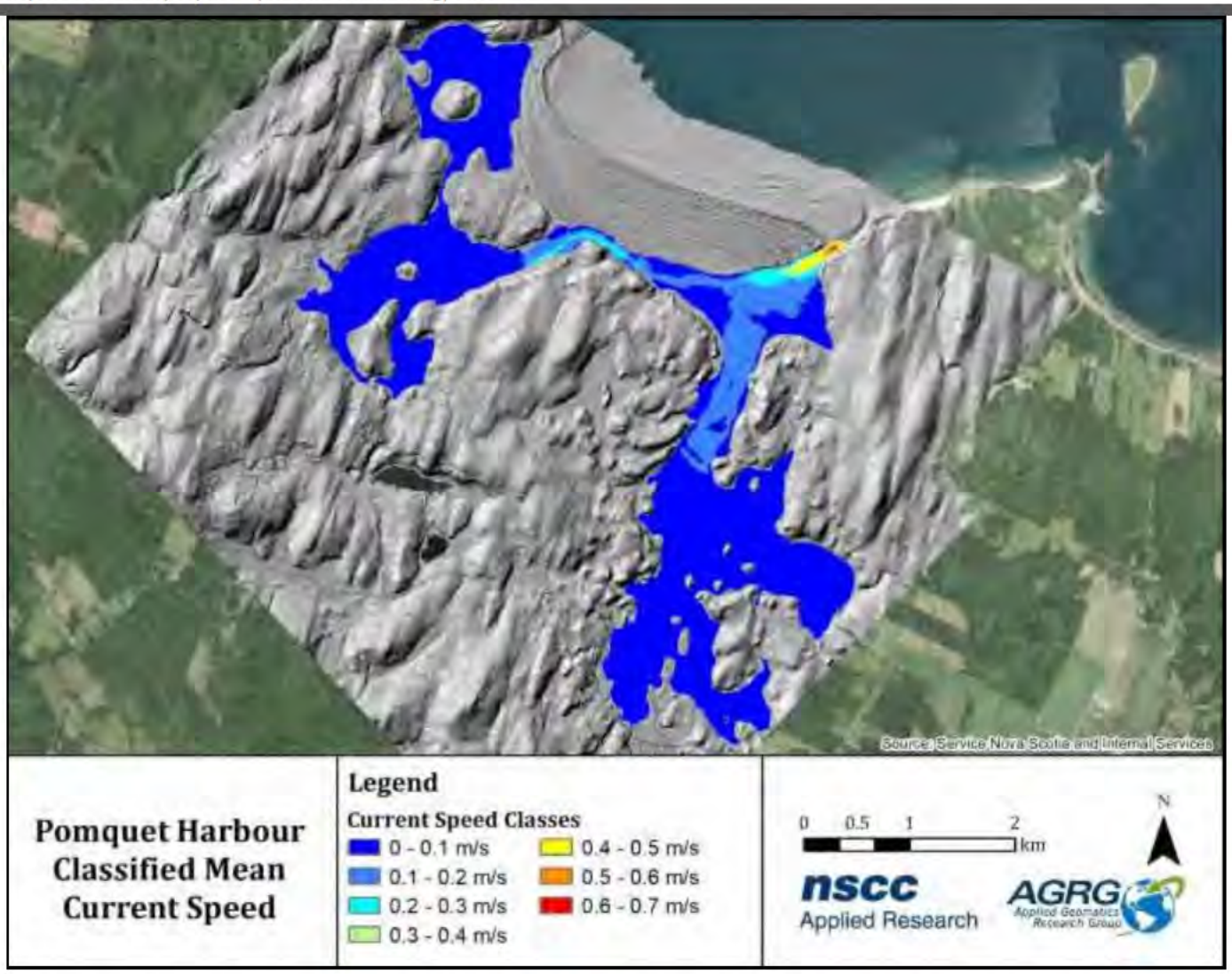


Figure 57: Mean of current magnitudes (m/s) during a 33-day simulation of the hydrodynamic model classified into seven speed categories.

The continuous maximum monthly current speed raster showed that near the mouth of the harbour, the speed was the fastest, with 1.27 m/s, and the current magnitudes varied in the channels coming to the east and west side of the bay (Figure 58). The monthly maximum current magnitudes were classified into thirteen categories (0.1 m/s increments) and show that the maximum currents were between 0 and 0.1 m/s in most of the harbour, faster in the channels (0.2 – 0.6 m/s) and were greater than 0.6 m/s at the mouth (Figure 59).

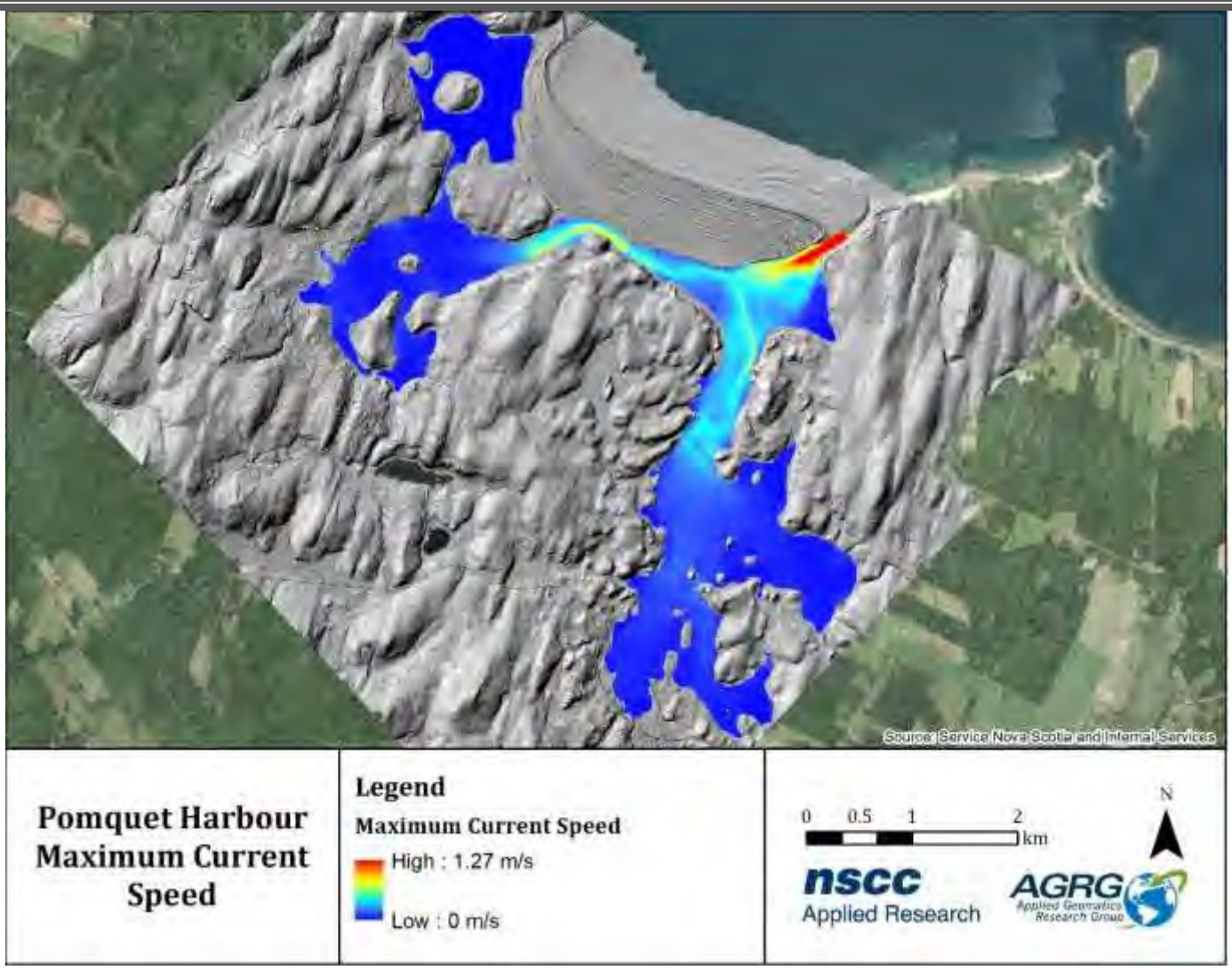


Figure 58: Maximum value of current magnitudes (m/s) during a 33-day simulation of the hydrodynamic model displayed as a continuous raster.

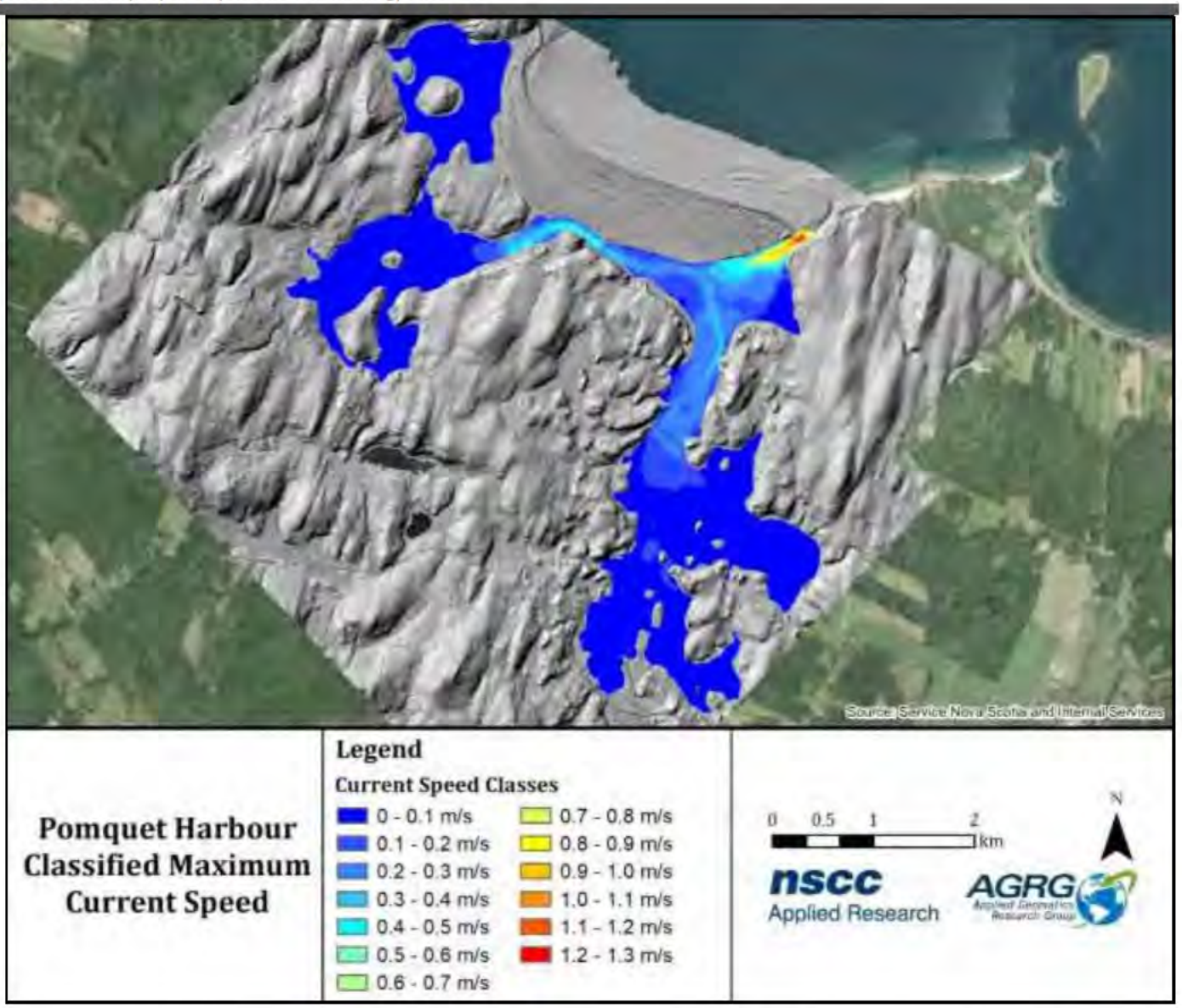


Figure 59: Maximum value of current magnitudes (m/s) during a 33-day simulation of the hydrodynamic model classified into thirteen speed categories.

3.7.2 Significant Wave Height (Hs)

Waves modelled using the Spectral Wave module showed that the Hs in the harbour was very minimal. The continuous raster showed that in most of the harbour Hs was less than 2 cm when strong south-southwest winds (200°) were applied (Figure 60). The classified raster showed that the harbour had low exposure to south winds which was likely due to the land mass surrounding it (Figure 61).

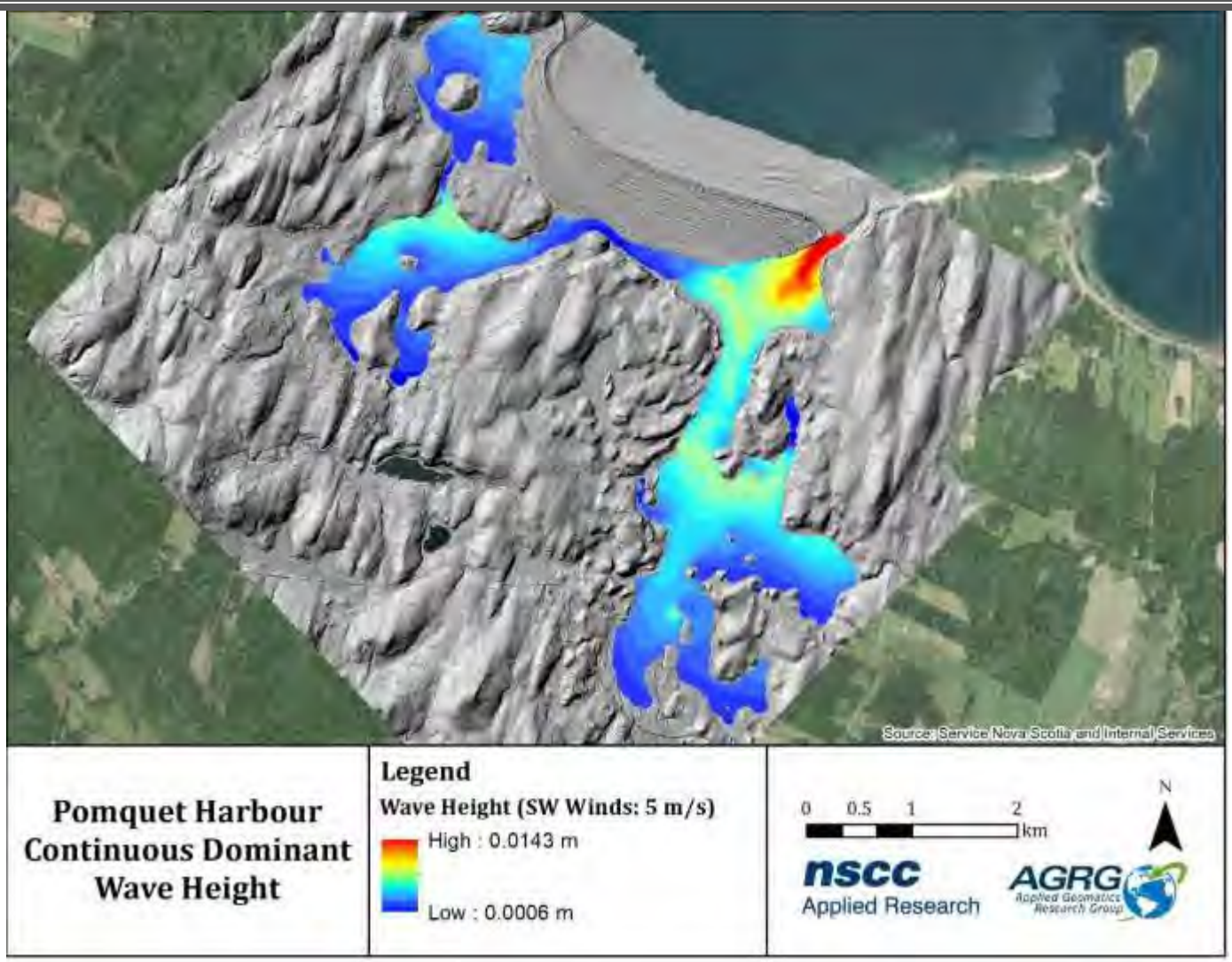


Figure 60: The continuous dominant wave height layer was generated by applying strong south-southwest winds to the model.

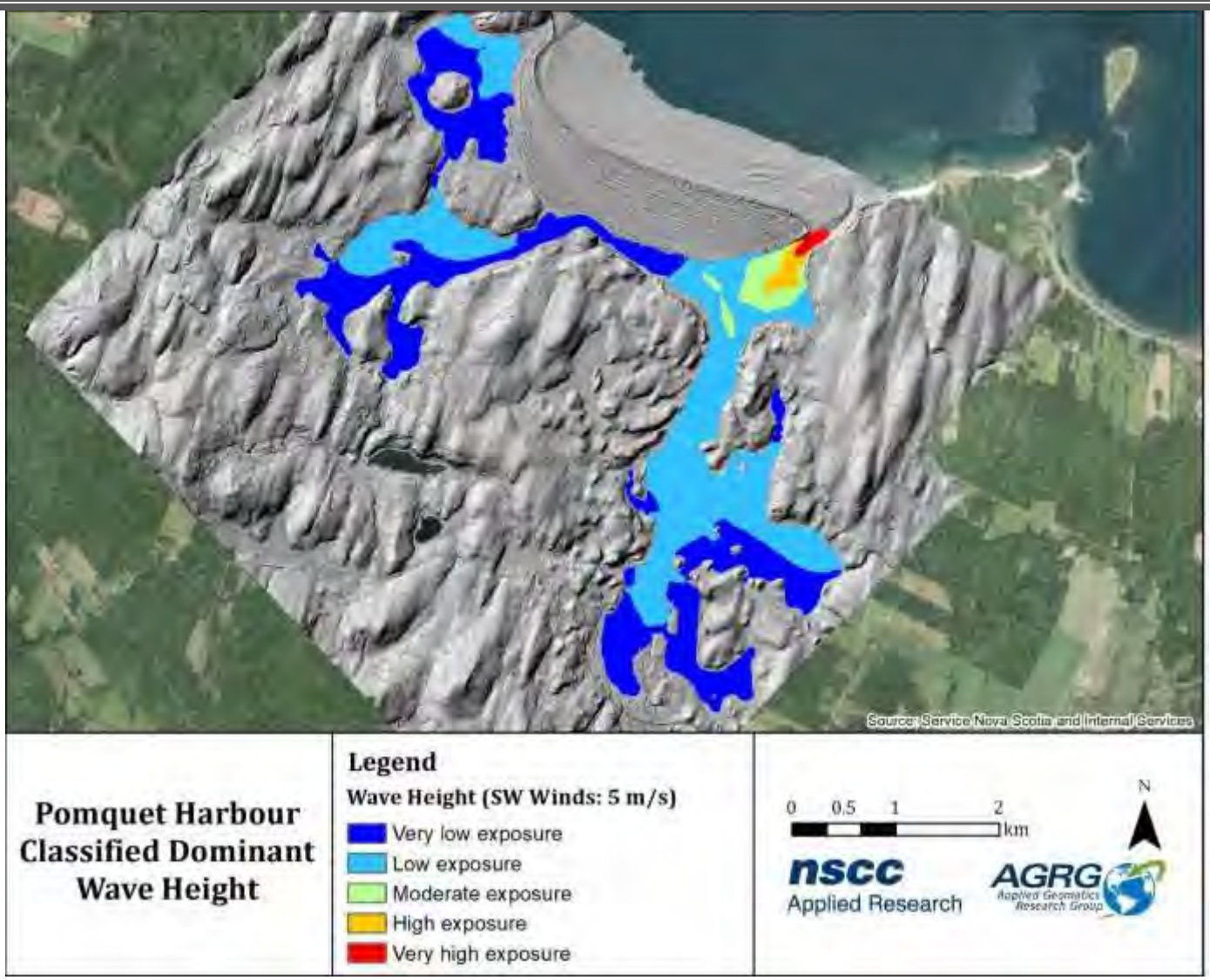


Figure 61: The classified dominant wave height layer was generated from modelled exposure to a south-southwest wind.

3.7.3 Flushing Rate

The minimum concentration left in the harbour after an initial concentration of one was added on the first day and then the transport model was run for 33 days indicated that the Church Cove area was flushed slowly compared to the rest of the harbour (Figure 62).

The flushing rate showed that the channels got flushed at a faster rate than at Church Cove and Monks Head. Fresh water into the bay also helped to flush the concentration (Figure 63). The classification of the flushing rate values represented five classes from very well flushed (0 - 20% concentration after one month), well flushed (20 - 40% concentration), 50% flushed (40 – 60% concentration), poorly flushed (60 – 80% concentration), and not flushed after one month (80 – 100% concentration) (Figure 63).

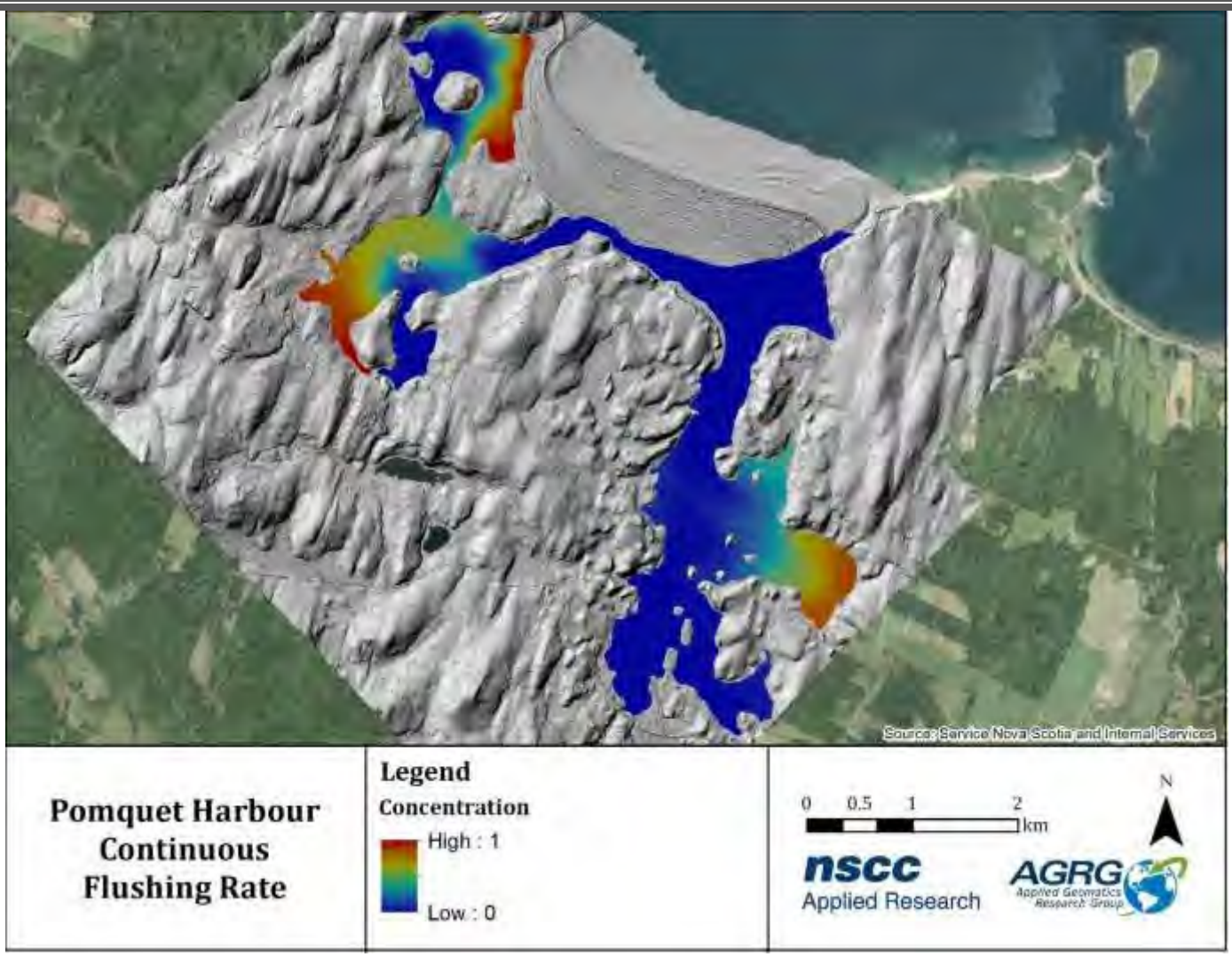


Figure 62: The continuous flush layer was generated from the minimum concentration left in the harbour after a 33-day simulation of the hydrodynamic model. The blue indicates faster flushing rates than the red areas.

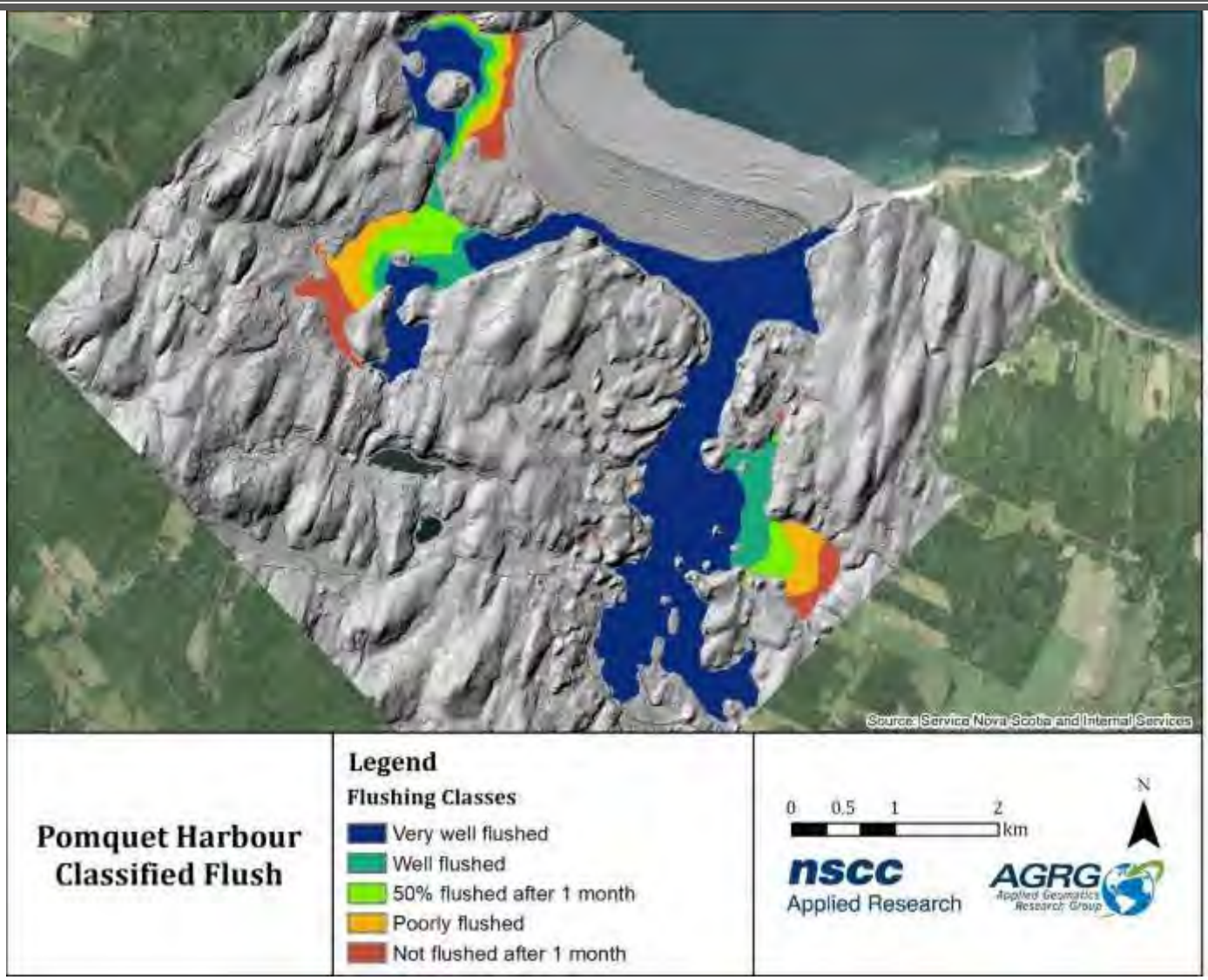


Figure 63: The minimum concentration left in the harbour after the hydrodynamic model simulation was classified into five flushing classes.

3.7.4 Storm Surge

The additional water levels of a 1.5 m storm surge were added to the tidal boundary condition of the hydrodynamic model that showed that the areas around the island and many parts in the harbour were potential zones for flooding (Figure 64). A water level with a high of 1.95 m could be observed in the harbour during a storm event.

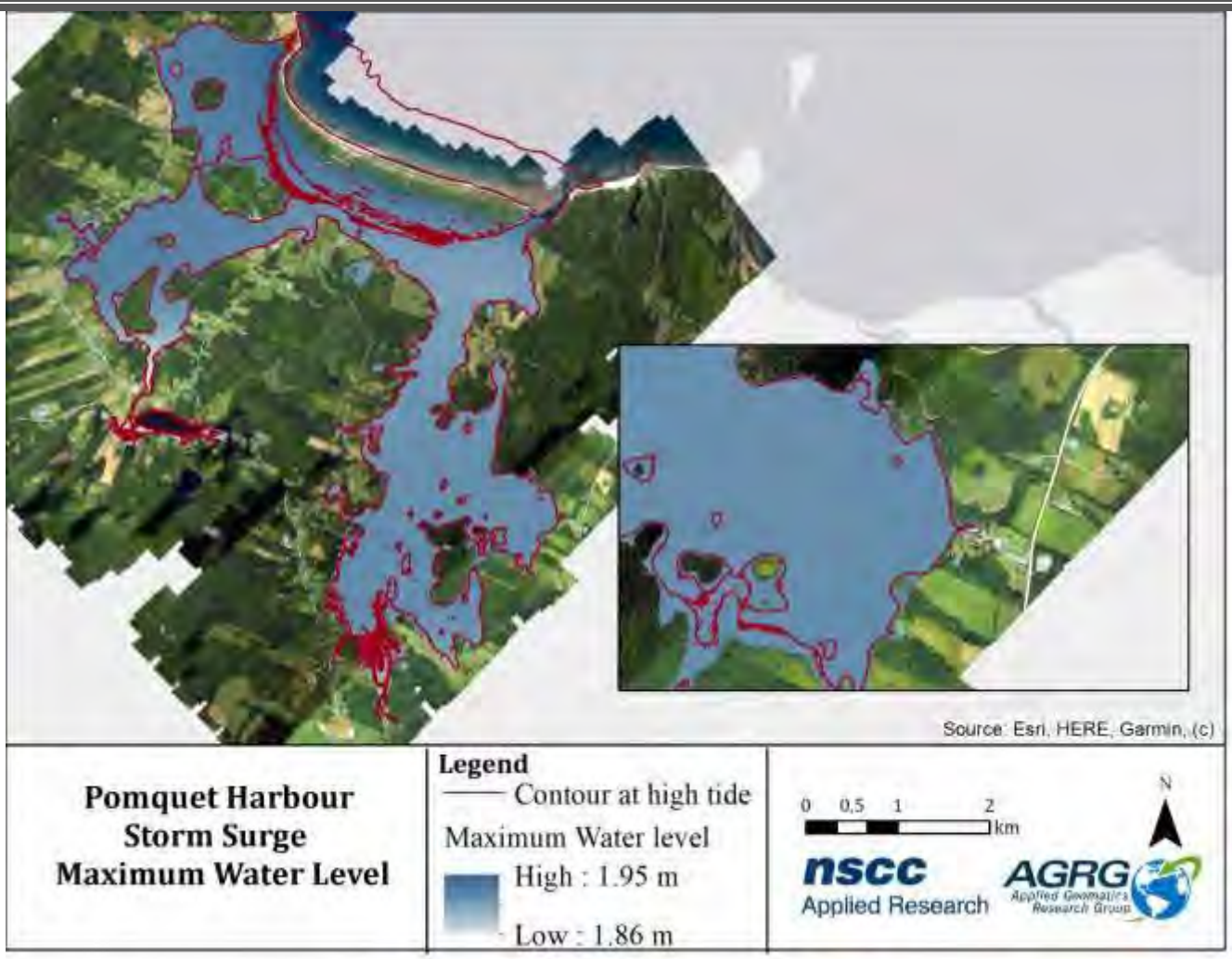


Figure 64: Maximum water level during storm surge, modelled in Mike 21 and a contour at high tide. Inset shows the water level in Church Cove.

Mean and maximum current speeds were slightly greater, especially near the mouth of the harbour, when compared to regular tides (Figure 65; Figure 66). Maximum current speed near the mouth on a storm surge, as modelled in Mike 21, showed a value of 1.78 m/s. It was also observed that the current speed in the channel to the Monks Head harbour was greater than usual.

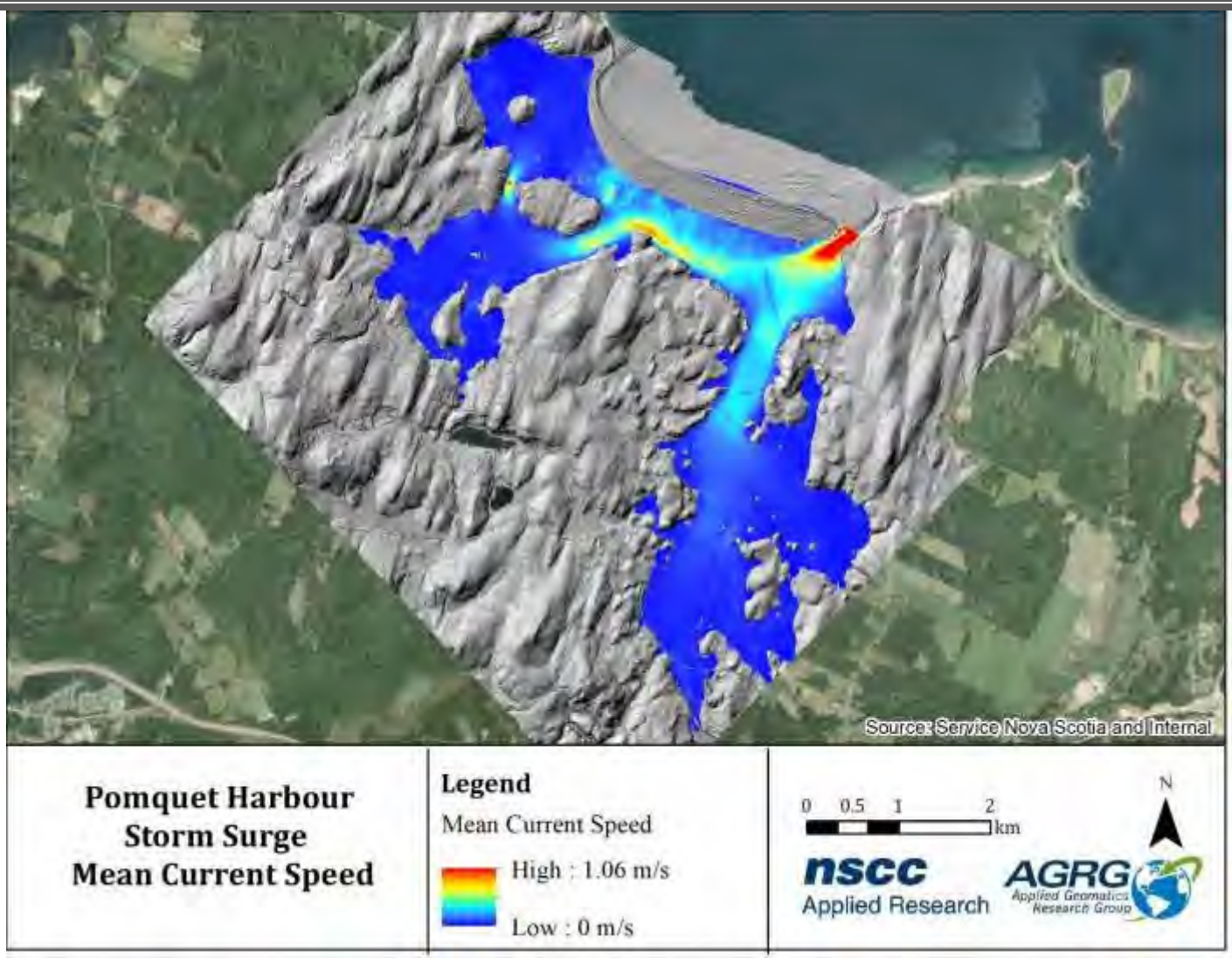


Figure 65: Mean Current magnitudes during a storm event modelled in Mike 21 Flex Mesh.

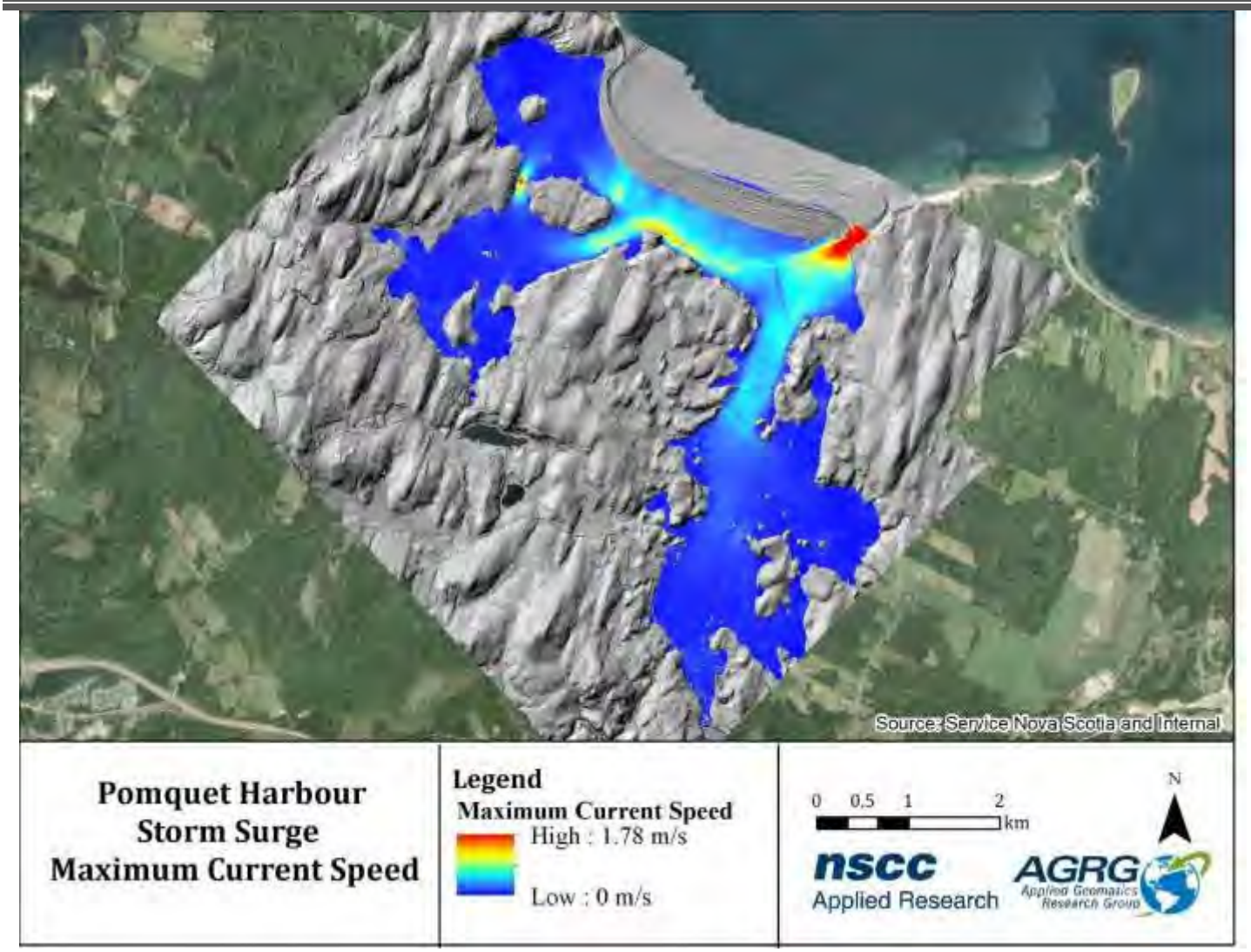


Figure 66: Maximum current magnitudes during a storm event modelled in Mike 21 Flex Mesh.

3.7.5 Particle Tracking

The validated hydrodynamic model was used to support a particle tracking simulation developed to model an oyster spat release event. Spat particles were dispersed by water movement generated in the HD model and natural horizontal dispersion (0.01 m^2/s). Initial release concentrations varied based on the release potentials of each of the identified natural oyster reef production areas (Figure 67).

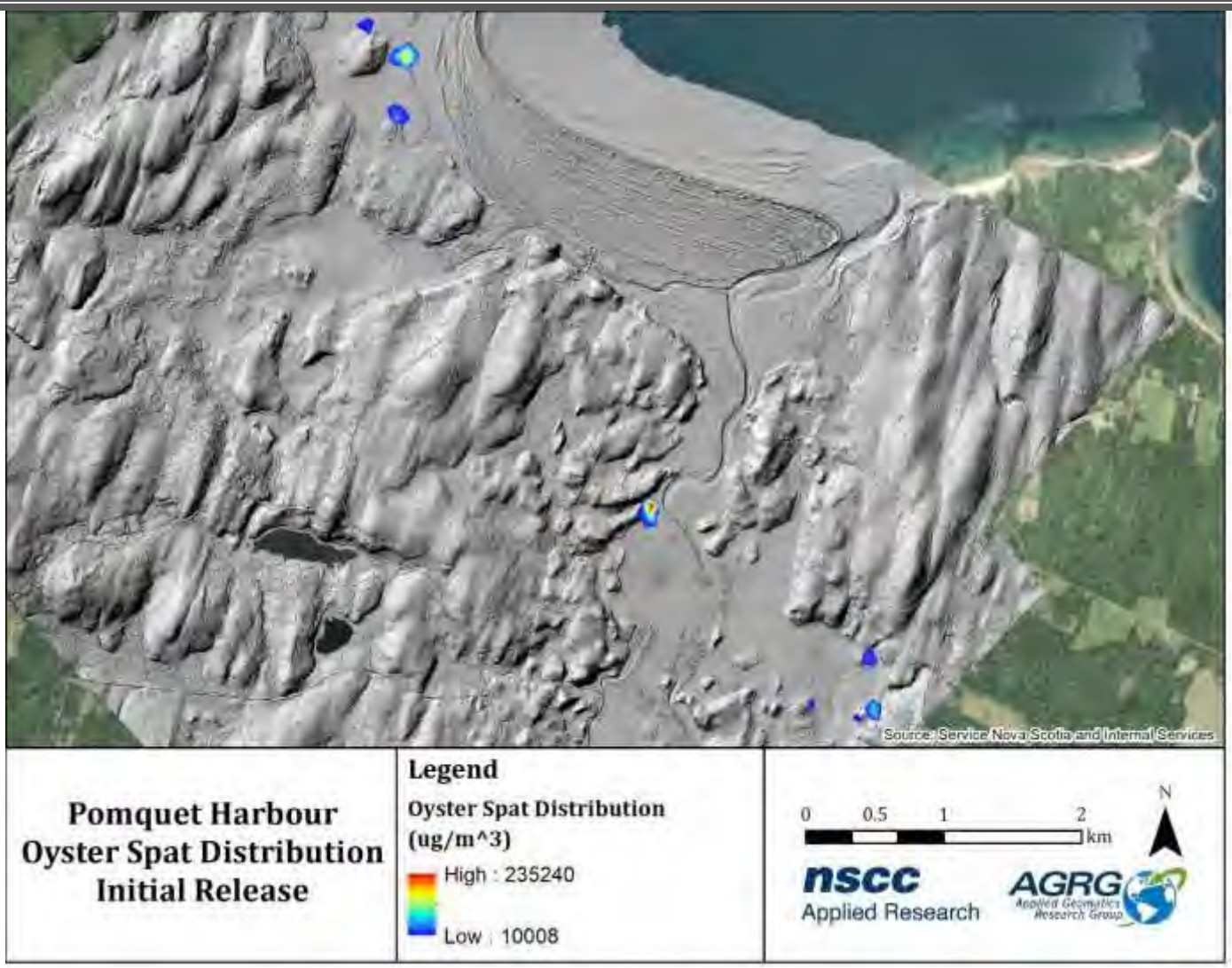


Figure 67: Simulated oyster spat concentrations during the initial model timesteps.

The fate of spat particles was heavily determined by the tidal action at the time of settling roughly two weeks after initial release. Since this variability could not be predicted, it was determined that spat distribution results should be generated for both an outgoing tide settling event and an incoming tide settling event. Particle tracking results were qualitatively assessed for each of the events and showed that outgoing tides presented a linear distribution of particles along the main channel with a significant concentration occurring along the western coast of the bay. High concentrations were also found to be present in the coastal areas around the eastern bay where natural spat producers were identified. Additionally, very high concentrations were modelled for the northwest bay where little to no tidal influence impacted the distribution of spat (Figure 68).

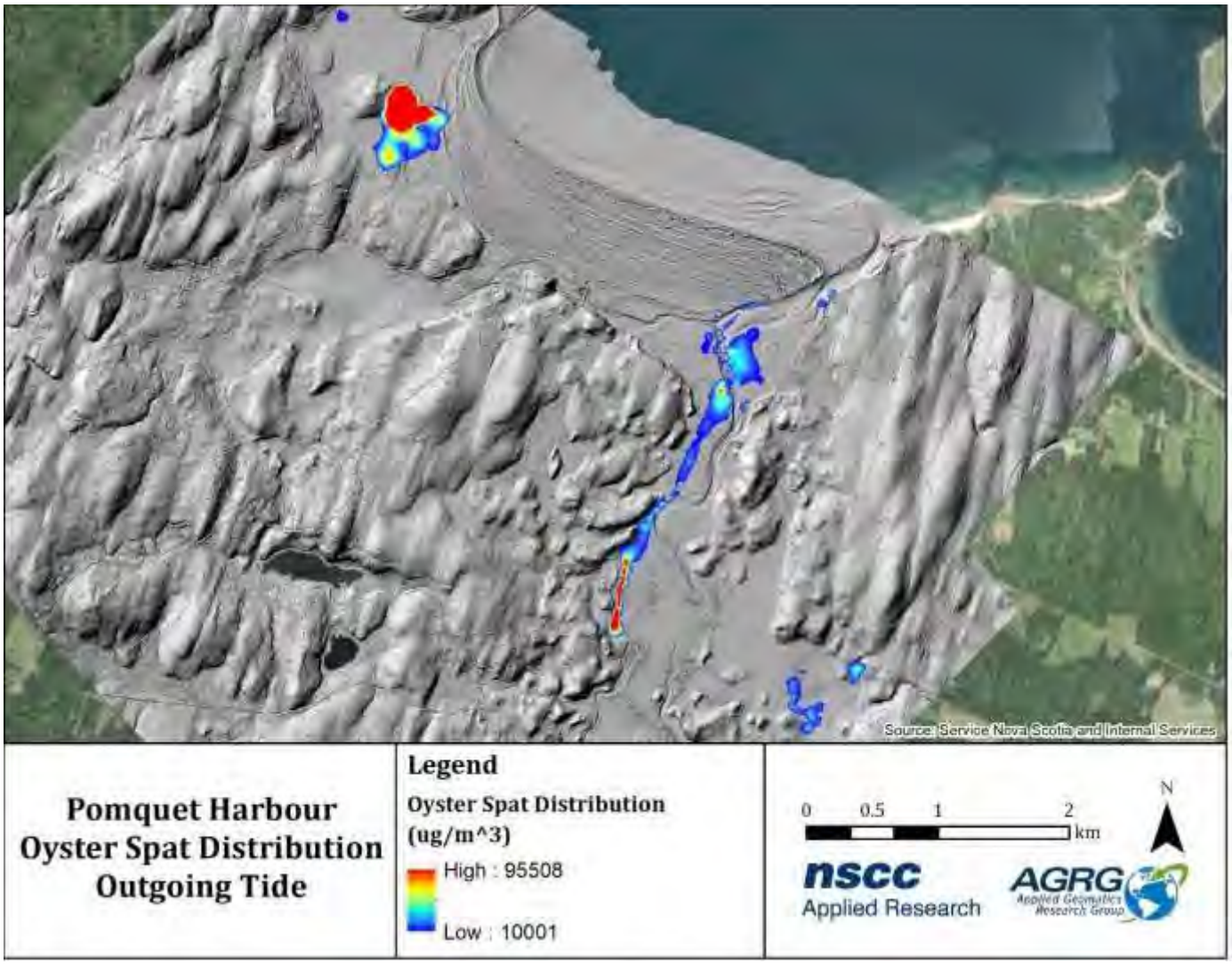


Figure 68: Modelled spat distribution during an outgoing tide scenario. Highest concentrations were observed in the northwestern bay which exhibited minimal tidal distribution.

The fate of particles was found to be much different if settling occurred on an incoming tide. More spreading was observed as water was pushed outward from the main channels resulting in the distribution of particles along the surrounding shallow-water areas. Three main areas were identified as having high concentrations of spat distribution on incoming tides, including the northwest isolated bay, the western shore south of a major contributing oyster reef, and the northern shore of the east bay where particles from several sources were concentrated on incoming tides (Figure 69).

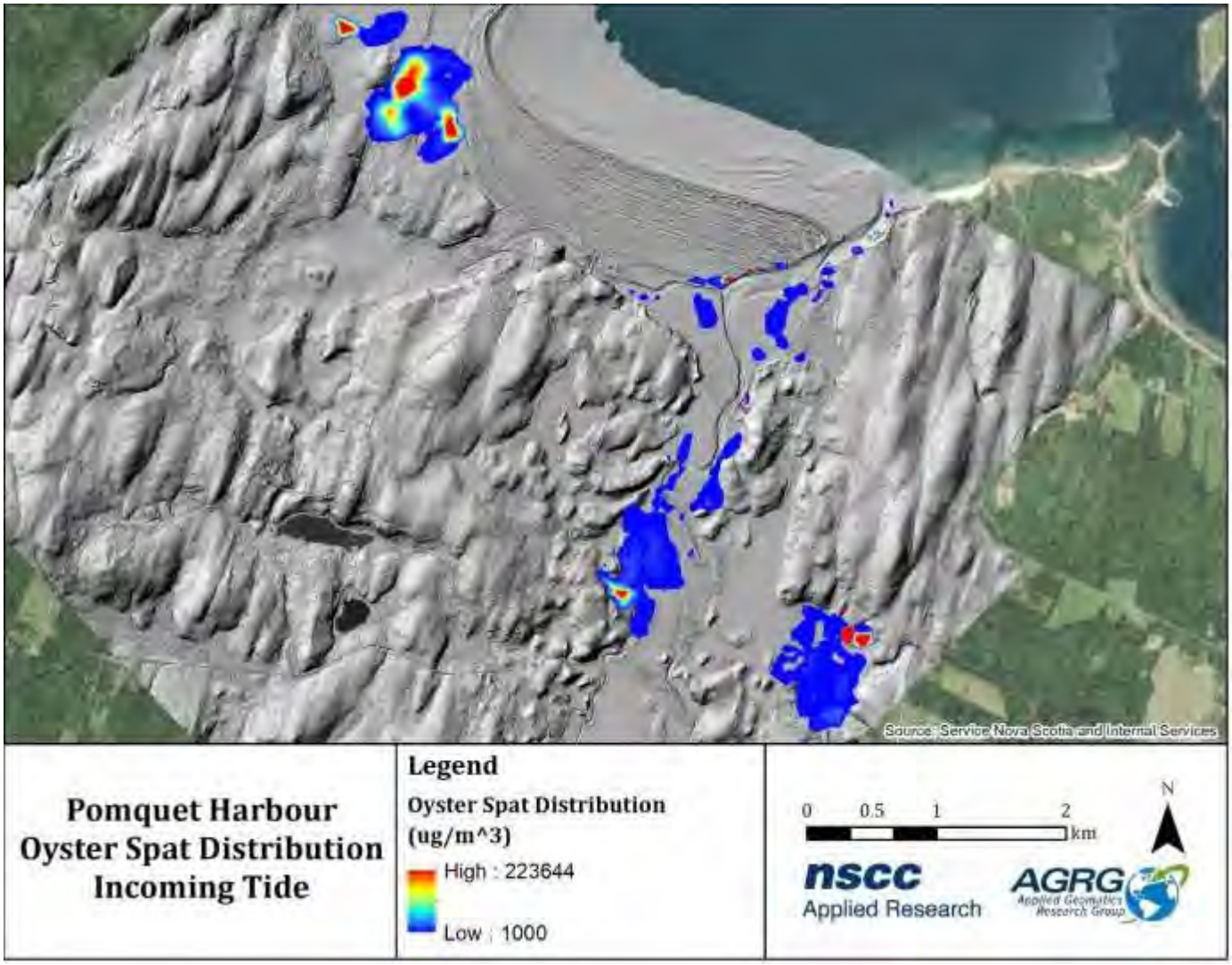


Figure 69: Modelled spat distribution during an incoming tide scenario. Highest concentrations were observed in the southeastern bay where onshore forcing concentrated particles on the north shore.

4 Validation

4.1 Lidar Validation

4.1.1 Topographic Validation

To validate topographic lidar returns on areas of hard and flat surfaces, ground elevations were obtained using a Real-Time Kinematic GPS with corrections transmitted via SmartNet network. The GPS unit was mounted on a vehicle and was driven around while collecting points every second. A total of 1,364 GPS points was collected along roads and bridges in the study site. 1,216 GPS points were within the tolerance of survey grade position precision. The elevation difference (Dz) was calculated by extracting the Z from the DEM at the points and subtracting them from the GPS elevations. A mean of 0.03 m with a standard deviation of ± 0.10 m showed that the topographic lidar points met the validation requirements within the specifications of the system (Figure 70).

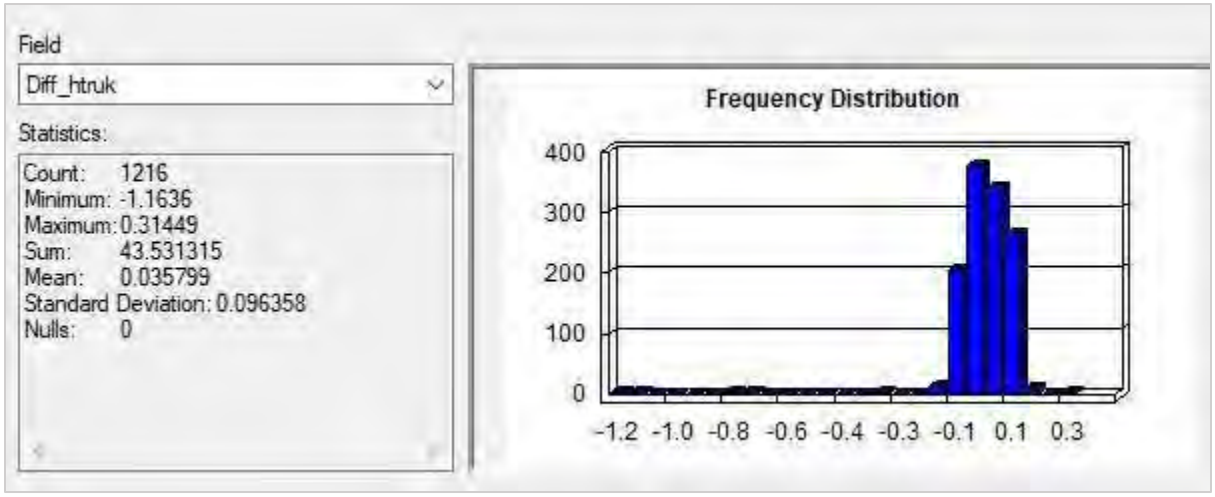


Figure 70: Validation statistics for topographic points.

4.1.2 Bathymetric Validation

For bathymetric lidar validation, several GPS points were collected at various locations in the harbour using a receiver with RTK corrections mounted on a painter's pole. A total of 11 points were collected. The elevation difference (Dz) was calculated by extracting the Z from the DEM at the points and subtracting these from the GPS elevations, which gave a mean of -0.04 m with a standard deviation of ± 0.19 m, as shown in the below figure (Figure 71).

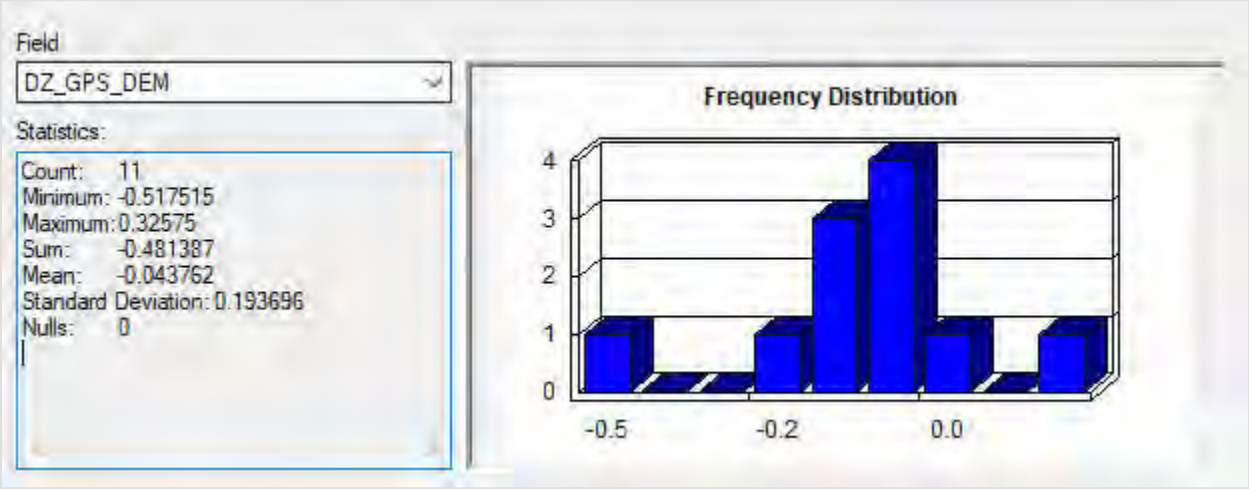


Figure 71: Validation statistics for bathymetric points.

There were certain areas where the lidar could not penetrate and hit the seabed due to the clarity of the water or depth, and other areas where the underwater vegetation was very thick which resulted in the higher standard deviation than on land. The GPS points where the lidar did hit the bottom showed that the bathymetric lidar points meet the validation requirements within the specifications of the system.

4.2 Hydrodynamic Model Validation

Simulated water levels and current characteristics were extracted from the hydrodynamic model at the point where the ADCP was deployed for the duration of the deployment. These data were compared against ADCP observations to validate the accuracy of the developed model. Simulated water levels matched ADCP observations for the majority of deployment period and were superior to standard predicted tidal elevations which severely over-predicted low tide values (Figure 72).

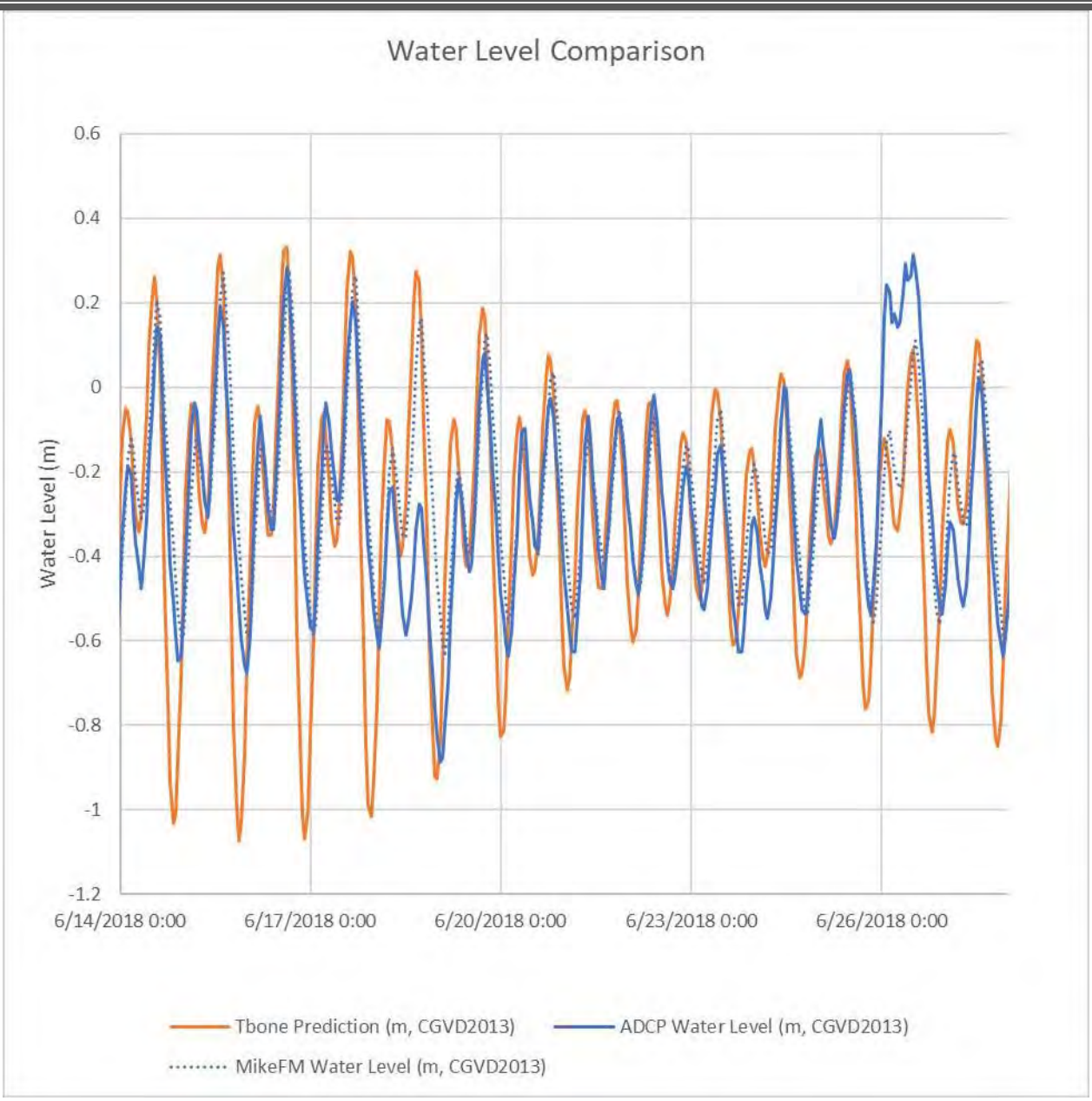


Figure 72: Simulated water levels from the Mike FM hydrodynamic model (blue dash) show good agreement with ADCP observations (blue line) over the validation period in contrast to tidal predictions (orange line).

Major deviations occurred on June 19th during a low-pressure system which occurred with strong offshore winds and similarly on June 26th during a high-pressure system which also occurred with strong onshore winds. The model was not able to force the volume of water necessary to allow the simulated events to match observed water levels during the anomalous events (Figure 73). Simulation results may be improved by extending the model boundary 5 to 10 km north to allow for additional fetch and transfer of water from the Northumberland Strait into the Pomquet system.

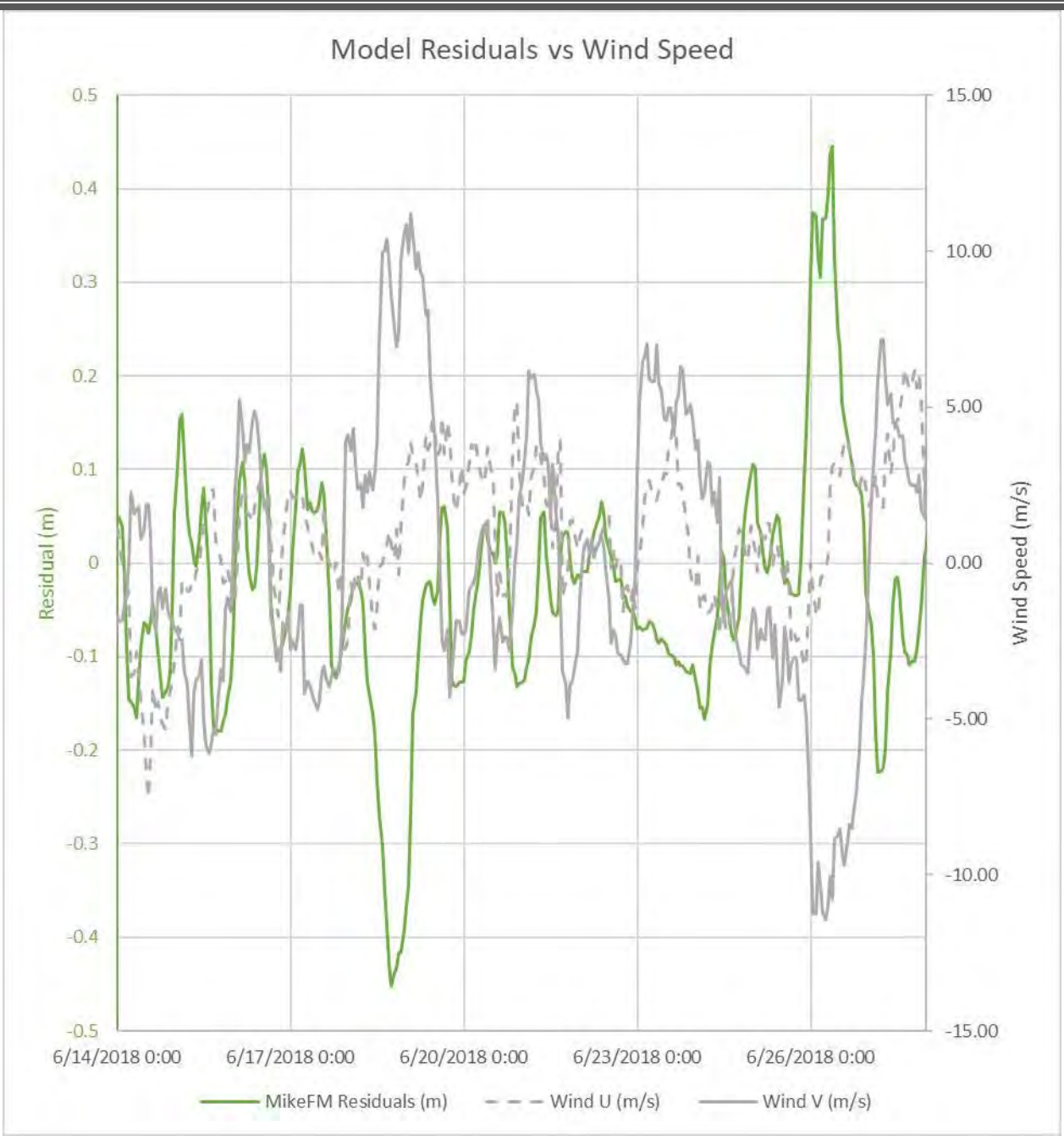
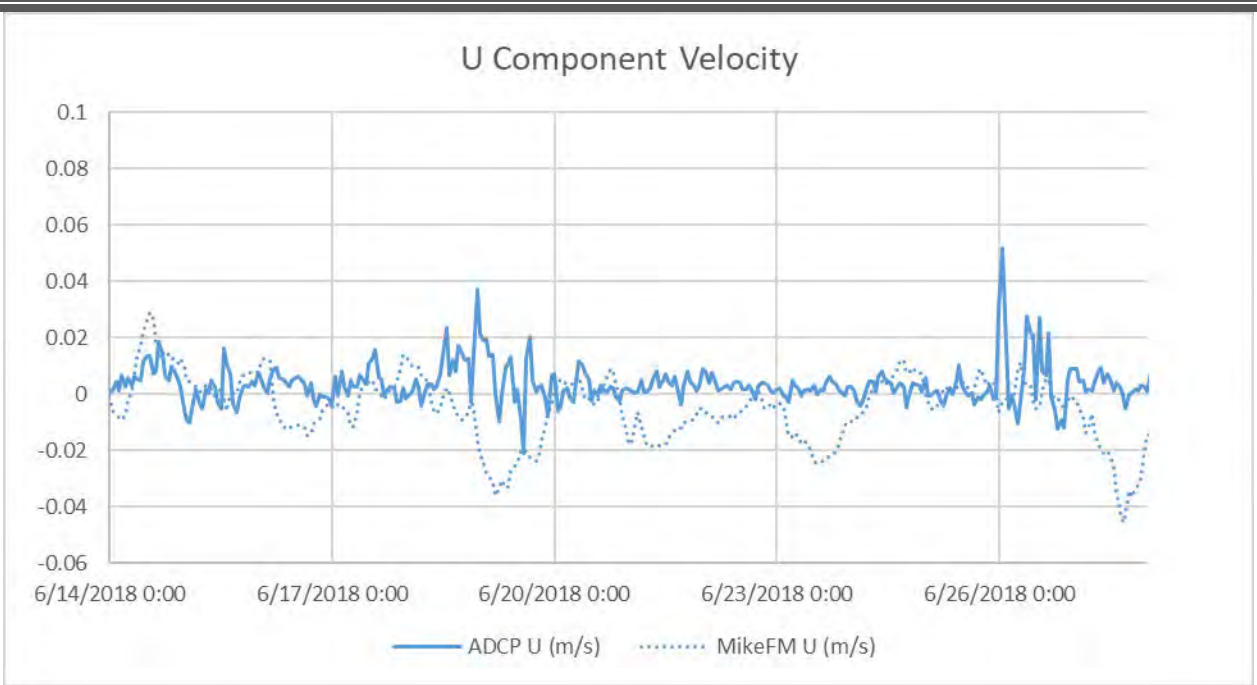


Figure 73: Residual water level (+ observation above simulation, - observation below simulation; green line) plotted against wind velocity components as Wind U (+ East, - West; grey dash) and Wind V (+ North, - South; grey line) showing inverse relation between residual water level and V component velocity.

Hydrodynamic model results demonstrated that simulated water levels matched ADCP observations. When comparing current magnitudes and directions it was found that simulated current magnitudes matched ADCP values in many cases, but simulated directions did not agree with ADCP observations in several cases (Figure 74).



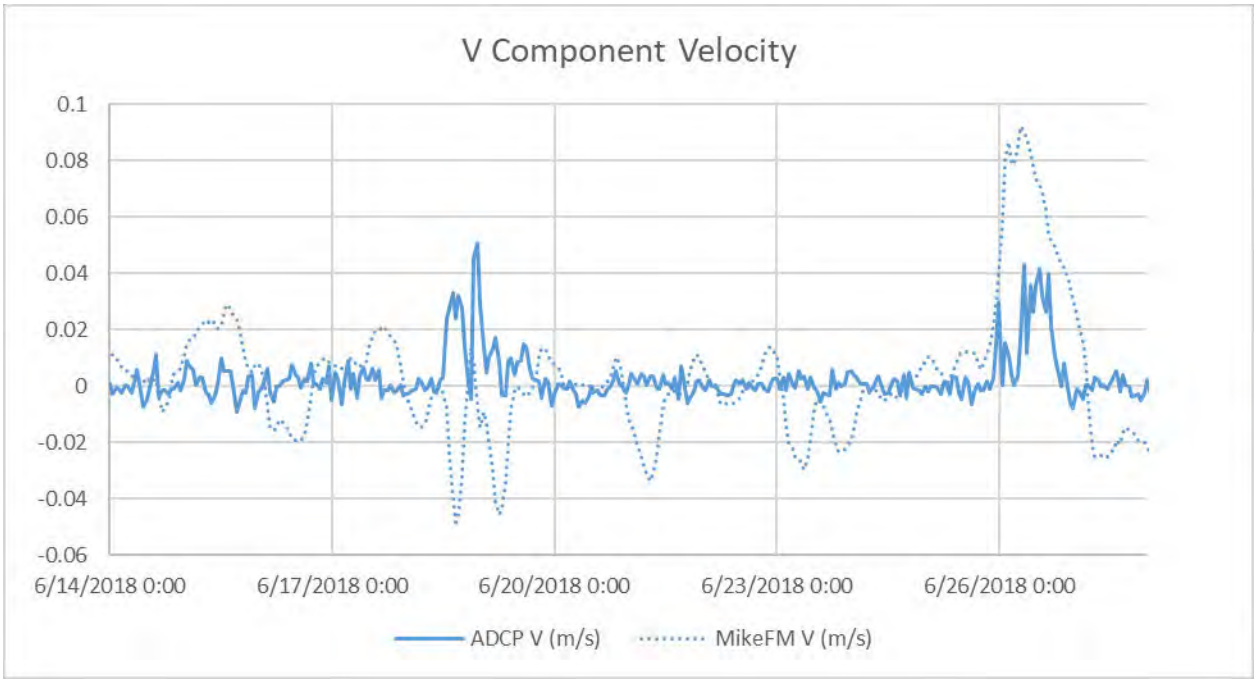


Figure 74: Simulated and observed current velocities presented as Velocity U (+ East, - West; top) and Velocity V (+ North, - South; bottom) showing a dominant V component in both the simulated and observed currents with a high degree of variation between the modelled and observed values.

This disagreement was most likely caused by the complex eddying pattern within the ADCP deployment area. Deviations between the true and modelled coastal morphology could have affected the simulated eddy locations which would result in erroneous current directions. The complexity of the modelled system is evident when comparing an incoming spring tide which produced northward currents over the ADCP and a neap tide which produced southeastward currents over the ADCP location (Figure 75).

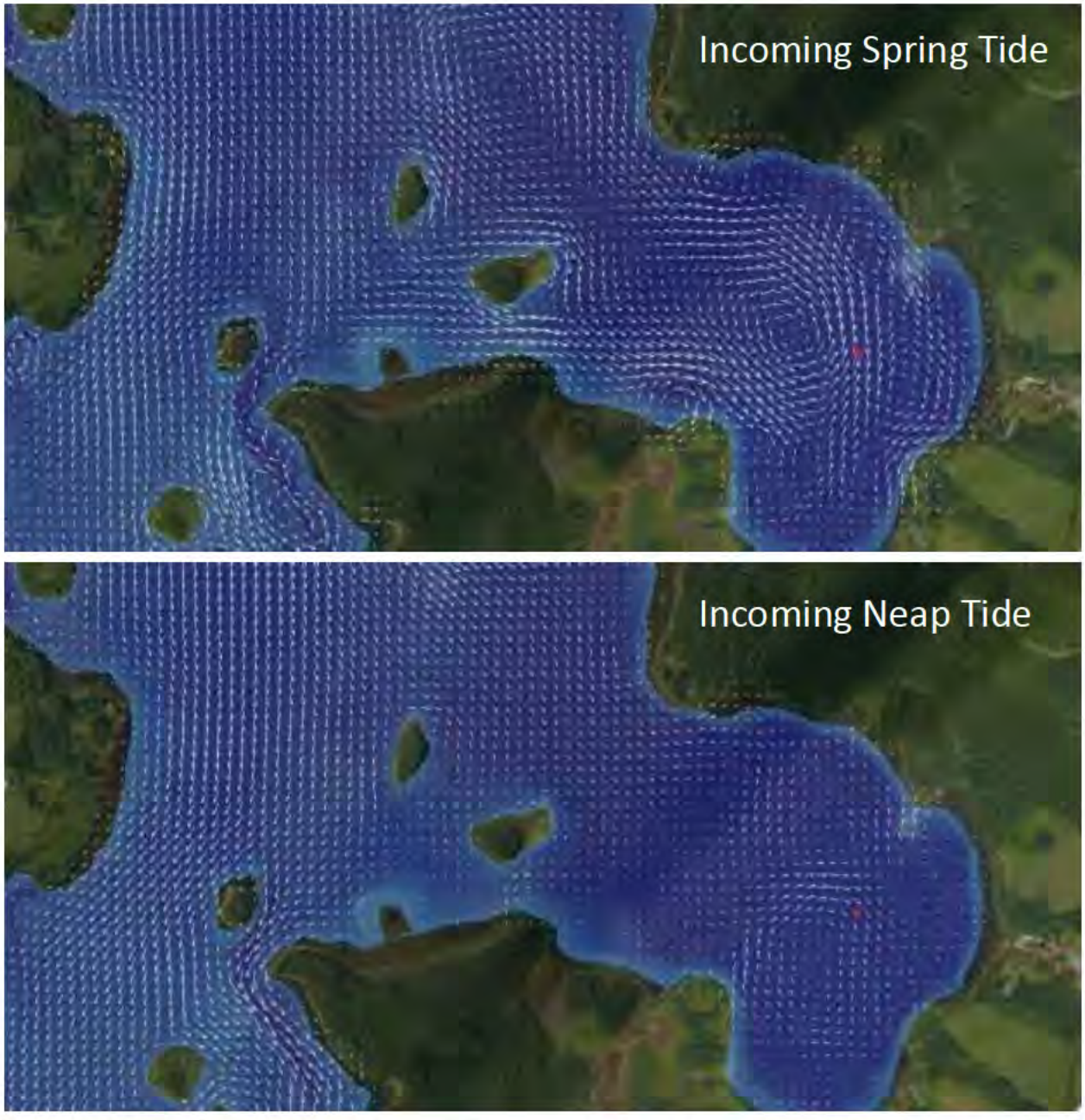


Figure 75: Comparison of incoming spring and neap tidal currents which were found to produce complex and variable eddy patterns over the ADCP validation point (red).

While this result was not optimal, it is often the case that simulated current directions are not in good agreement with ADCP observations. The complexities of the true environment are often not perfectly reflected in the model parameters.

Additionally, current directions and magnitudes were calculated as depth averaged values in the hydrodynamic model which produced two-dimensional results that do not fully represent the layering of current velocities throughout the water column. For these reasons, model results were determined to be acceptable for the study area while accepting that directional errors existed within the complex bay areas. Hydrodynamic model simulations produced stable realistic current results throughout the study area (Figure 76).

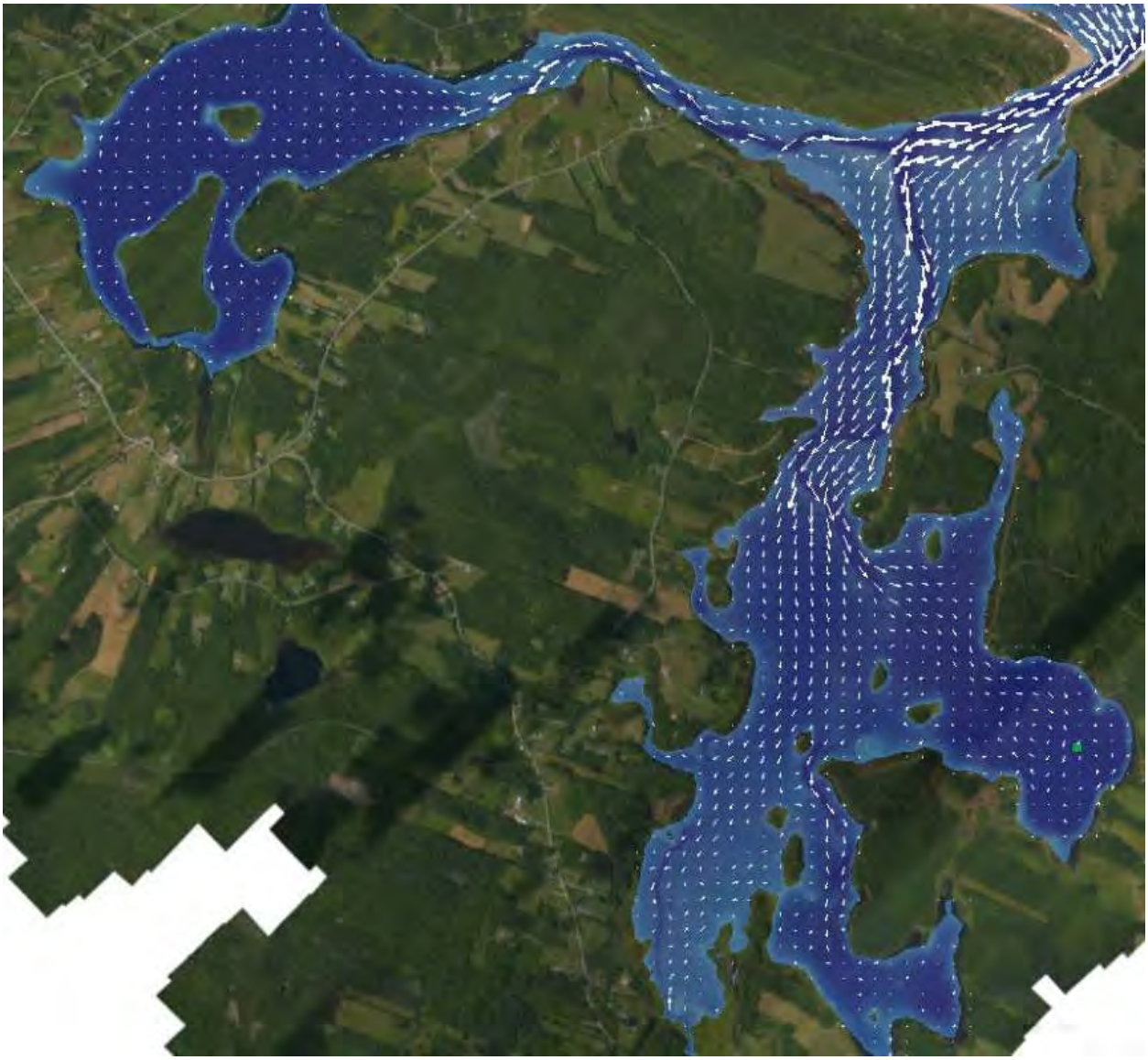


Figure 76: Simulated current magnitudes and directions modelled during the peak flow of an incoming tide.

5 Aquaculture Suitability Index

5.1 GIS Data Layers

Data layers generated for the Web Visualization Application and the Weighted Overlay tool were derived from a variety of sources. ArcMap Desktop version 10.8.3 was used to process and project the layers to Universal Transverse Mercator projection (UTM, Zone 20N), and reference them to the North American Datum: Canadian Spatial Reference System of 1983 (CSRS NAD83) and the Canadian Geodetic Vertical Datum of 2013 (CGVD2013). Table 6 shows each of the data layers and the source from which they were generated.

Data Source	Data Layer
DEM	Intertidal Zone
	Classified Ice Impact-free Depth Map
	Continuous Depth
	Classified Depth
	Depth Contours
	DEM Colour Shaded Relief
	DEM Hillshade
DSM	DSM Colour Shaded Relief
	DSM Hillshade
Lidar Intensity	Intensity Model
	Normalized Bathymetric Intensity Model
DEM + Lidar Intensity	DEM Colour Shaded Intensity Model
Orthophoto	RGB Orthophoto
	Near IR Orthophoto
DEM + Orthophoto	Classified Channel
	Classified Eelgrass Presence
Hydrodynamic Model	Continuous Mean Monthly Currents
	Classified Mean Monthly Currents
	Continuous Maximum Monthly Currents
	Classified Maximum Monthly Currents
	Continuous Dominant Wave Height
	Classified Dominant Wave Height
	Continuous Flushing Rate
	Classified Flushing Rate
	Oyster Spat Distribution: Initial Release
	Oyster Spat Distribution: Outgoing Tide
	Oyster Spat Distribution: Incoming Tide
DFO Traditional Ecological Knowledge (polygons)	Alewife
	American Eel
	American Smelt
	Atlantic Salmon
	Sea Trout
	American Oyster
	Blue Mussel
	Quahog
	Razor Clam
	Softshell Clam
DFO Traditional Ecological Knowledge (points)	Green Crab
Stuart Oyster Stock Survey (points)	Wild Oyster Locations
	Wild Oyster Spat Producers
	Number of Oysters Times Average Size
	Temperature
	Salinity
	Number of Oysters per Length (0 – 20 mm)
	Number of Oysters per Length (20 – 30 mm)
	Number of Oysters per Length (30 – 40 mm)
	Number of Oysters per Length (40 – 50 mm)
	Number of Oysters per Length (50 – 60 mm)
	Number of Oysters per Length (60 – 80 mm)
	Number of Oysters per Length (80 – 100 mm)
	Number of Oysters per Length (>100 mm)
Observed Data (points)	ADCP Deployment
NSFA (polygons)	Aquaculture Leases

Table 6: Data layers utilized by the Web Application and its components.

The index used to inform the aquaculture suitability map is described in the following section. For additional information on oyster site selection, the New Brunswick Department of Agriculture, Aquaculture and Fisheries provides a document that goes into detail about many of the main parameters (Doiron, 2008).

5.2 Weighted Overlay Suitability Model

Suitability modelling, also known as site selection or overlay analysis, involves the combination of spatial data from diverse sources which satisfy a set of criteria to produce an output map of potential (Bonham-Carter, 1994; AGRG, 2018). Suitability models identify the best location for specific phenomena; in this case, the most ideal locations for oyster aquaculture development in Pomquet Harbour. In raster overlay analysis, each cell or pixel of each input layer references the same geographic location, which makes combining characteristics of numerous layers into a single output map appropriate (ESRI, 2016a). Numeric values, or weights, are assigned to each characteristic or variable, allowing the user to mathematically combine the layers and assign a new value to each cell in the output layer.

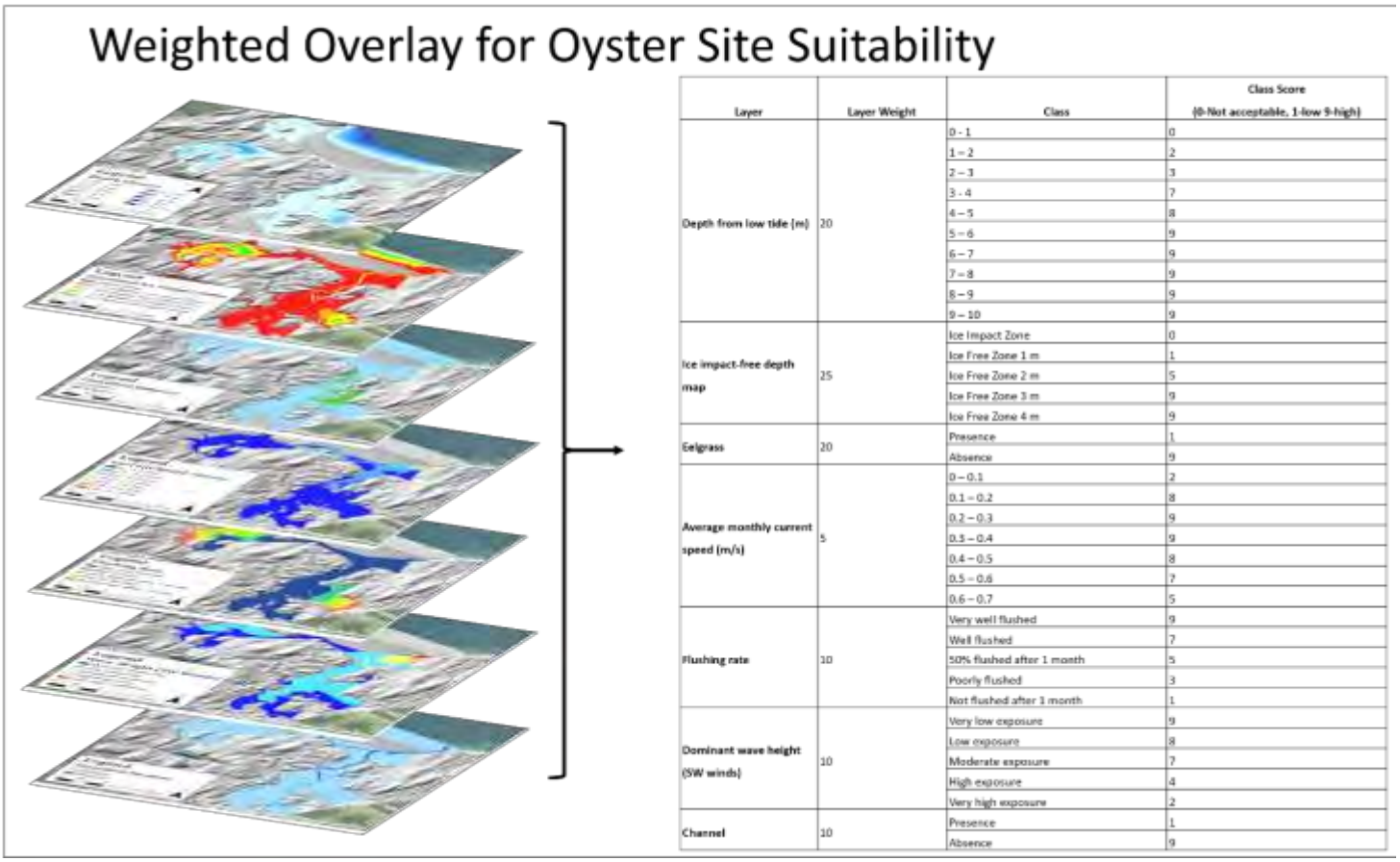
The suitability model for this project was generated by using ArcMap's Weighted Suitability, which implements several of the steps for weighted suitability in one tool (ESRI, 2016b). Experts from DFO, NSFA, and CMAR were consulted for map weights and scores for this example. The process for this method begins with assigning each raster layer a weight in the suitability analysis (the sum of weights must add to 100%). For use in the Weighted Overlay tool, continuous rasters must first be grouped in to ranges and assigned a single value by using the Reclassify tool. The values in these rasters are then scored for the suitability analysis (1 to 9, with 9 being the most favorable). The next step in the process involves overlaying the rasters and using a layer weight to multiply each raster's suitability score. The total values are used to determine a suitability value which is written to new cells in an output layer. The resulting symbology of the suitability layer is reflective of the derived suitability values.

5.3 Suitability Model Parameter Weighting

A portion of the GIS layers described in the previous sections were selected to be used in the Weighted Suitability Model (Table 7; Figure 77). Each of the layers was assigned a weight (to add to 100%), and each of the classes was assigned a score (0-9). Classes that were assigned a score value of 0 were assigned a "Restricted" score in the Weighted Overlay tool, as the evaluation scale ranged from 1 - 9. The Restricted value assigns the minimum value of the evaluation scale set, minus 1, which equated to 0 in the output raster cells. The final Aquaculture Suitability Index was produced using the sum of the weighted layers and scored classes. This index indicates areas most and least suitable for oyster aquaculture development. Figure 78 shows the resulting Oyster Suspension Aquaculture Suitability map that was generated from the Weighted Overlay tool.

Layer	Layer Weight (%)	Class	Class Score (0-Not acceptable, 1-low 9-high)
Depth from low tide (m)	20	0 - 1	0
		1 – 2	2
		2 – 3	3
		3 - 4	7
		4 – 5	8
		5 – 6	9
		6 – 7	9
		7 – 8	9
		8 – 9	9
		9 – 10	9
Ice impact-free depth map	25	Ice Impact Zone	0
		Ice Free Zone 1 m	1
		Ice Free Zone 2 m	5
		Ice Free Zone 3 m	9
		Ice Free Zone 4 m	9
Eelgrass	20	Presence	1
		Absence	9
Average monthly current speed (m/s)	5	0 – 0.1	2
		0.1 – 0.2	8
		0.2 – 0.3	9
		0.3 – 0.4	9
		0.4 – 0.5	8
		0.5 – 0.6	7
		0.6 – 0.7	5
Flushing rate	10	Very well flushed	9
		Well flushed	7
		50% flushed after 1 month	5
		Poorly flushed	3
		Not flushed after 1 month	1
Dominant wave height (SW winds)	10	Very low exposure	9
		Low exposure	8
		Moderate exposure	7
		High exposure	4
		Very high exposure	2
Channel	10	Presence	1
		Absence	9

Table 7: Data layers used to inform the Aquaculture Suitability Map.



Layer	Layer Weight	Class	Class Score (0-Not acceptable, 1-low 9-high)
Depth from low tide (m)	20	0 - 1	0
		1 – 2	2
		2 – 3	3
		3 - 4	7
		4 – 5	8
		5 – 6	9
		6 – 7	9
		7 – 8	9
		8 – 9	9
		9 – 10	9
Ice impact-free depth map	25	Ice Impact Zone	0
		Ice Free Zone 1 m	1
		Ice Free Zone 2 m	5
		Ice Free Zone 3 m	9
		Ice Free Zone 4 m	9
Eelgrass	20	Presence	1
		Absence	9
Average monthly current speed (m/s)	5	0 – 0.1	2
		0.1 – 0.2	8
		0.2 – 0.3	9
		0.3 – 0.4	9
		0.4 – 0.5	8
		0.5 – 0.6	7
		0.6 – 0.7	5
Flushing rate	10	Very well flushed	9
		Well flushed	7
		50% flushed after 1 month	5
		Poorly flushed	3
		Not flushed after 1 month	1
Dominant wave height (SW winds)	10	Very low exposure	9
		Low exposure	8
		Moderate exposure	7
		High exposure	4
		Very high exposure	2
Channel	10	Presence	1
		Absence	9

Figure 77: The Pomquet Aquaculture Suitability Index includes seven classified raster layers: depth from low tide, ice impact-free depth, eelgrass presence, average monthly current speed, flushing rate, dominant wave height, and the channel location.

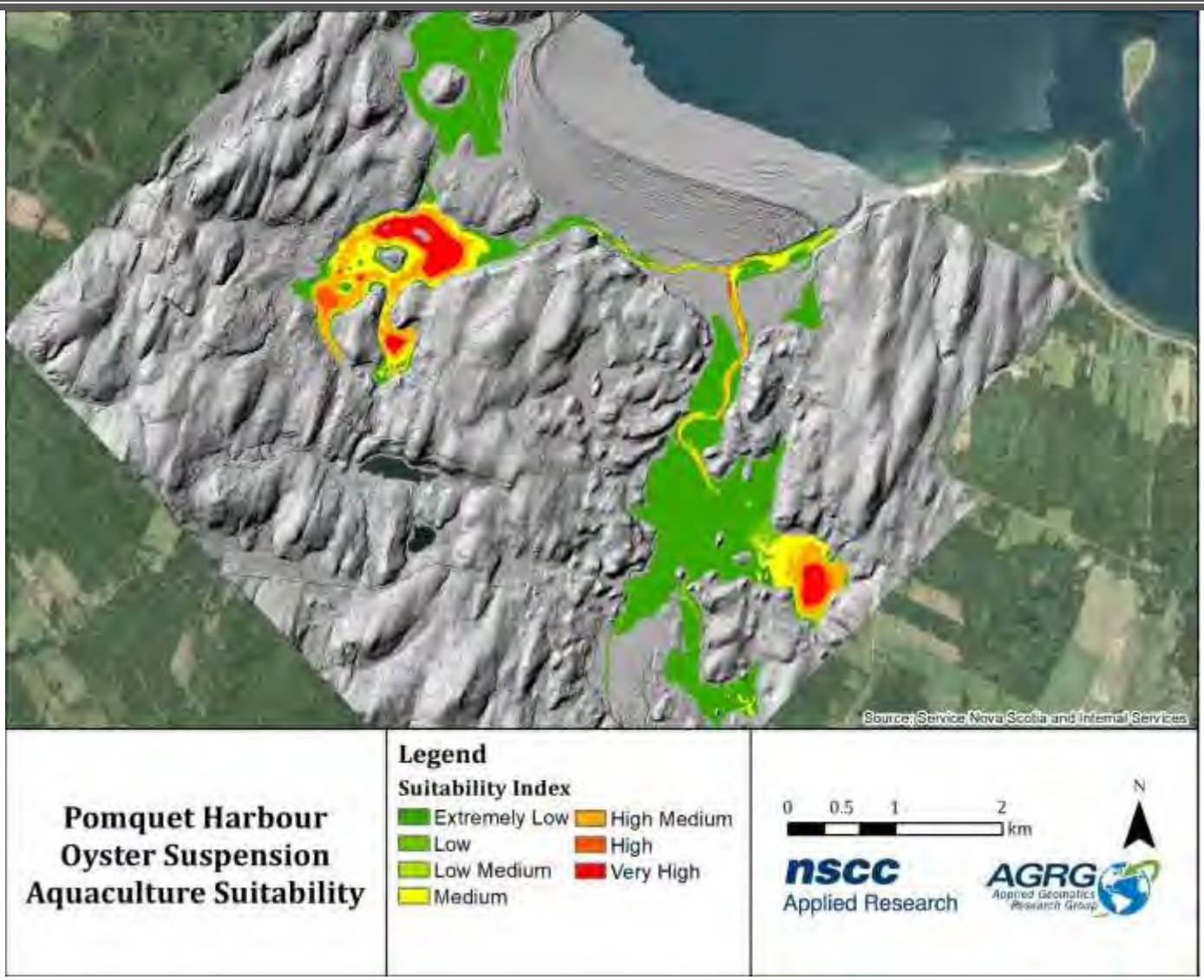


Figure 78: Pomquet Harbour Oyster Suspension Aquaculture Suitability map.

6 Web Visualization

Development and hosting of the web-based suitability modeller application required the following programs and tools:

- ArcGIS Pro 2.01 or newer
- ArcGIS Enterprise 10.5 or newer
- ArcGIS Image Server
- GeoPlanner for ArcGIS or Web AppBuilder
- Weighted Raster Overlay Service toolbox (https://github.com/Esri/weighted-raster-overlay-service-toolbox)

Suitability modeling input datasets that were originally presented in a vector format were converted to rasters with 1 metre cell sizes. The Weighted Raster Overlay Service toolbox contained tools for assembling the input raster datasets into a mosaic dataset and assigning the class ranges and default rankings to be used in the application. The mosaic dataset

was published to an ArcGIS Server. All input datasets and supplemental datasets, such as colour shaded relief models and orthophotos, were symbolized and published to the ArcGIS Server for visualization in the web application. Larger, high-resolution datasets were tiled prior to publishing to the ArcGIS Server for smoother delivery over the internet, while smaller datasets are tiled and served dynamically.

https://agrgims.cogs.nscc.ca/PomquetAFF/

The finalized web application displays the GIS data layers (hydrodynamic model output, lidar-derived layers, etc.) and the suitability maps for users to interact with. The application can be used to select from a list of layers, adjust their transparency, and overlay various datasets to examine overlapping areas and data trends (Figure 79). The user may also click on any vector layer to view a pop-up showing the attributes associated with that feature. For more detailed instructions on how to use the web application, see the *Pomquet AFF Aquaculture Suitability User Guide* in Appendix 3.

Figure 79: Pomquet AFF suitability web application, https://agrgims.cogs.nscc.ca/PomquetAFF/

6.1 Aquaculture Suitability Modeller

The weighted suitability tool is one of many widgets available within the ArcGIS Web AppBuilder environment. The widget allows the user to evaluate several factors at once by combining and weighting different raster layers (ESRI, 2020). For this project, the weighted suitability tool was configured to allow the user to generate a model of suitable oyster growing sites within Pomquet Harbour, similar to the model described in Section 5. The location of the tool is displayed in Figure 80.

Figure 80: Location of suitability modeller tool on the Pomquet AFF web application.

To begin the analysis, the user should select their desired layers that will be incorporated into the model (Figure 81).

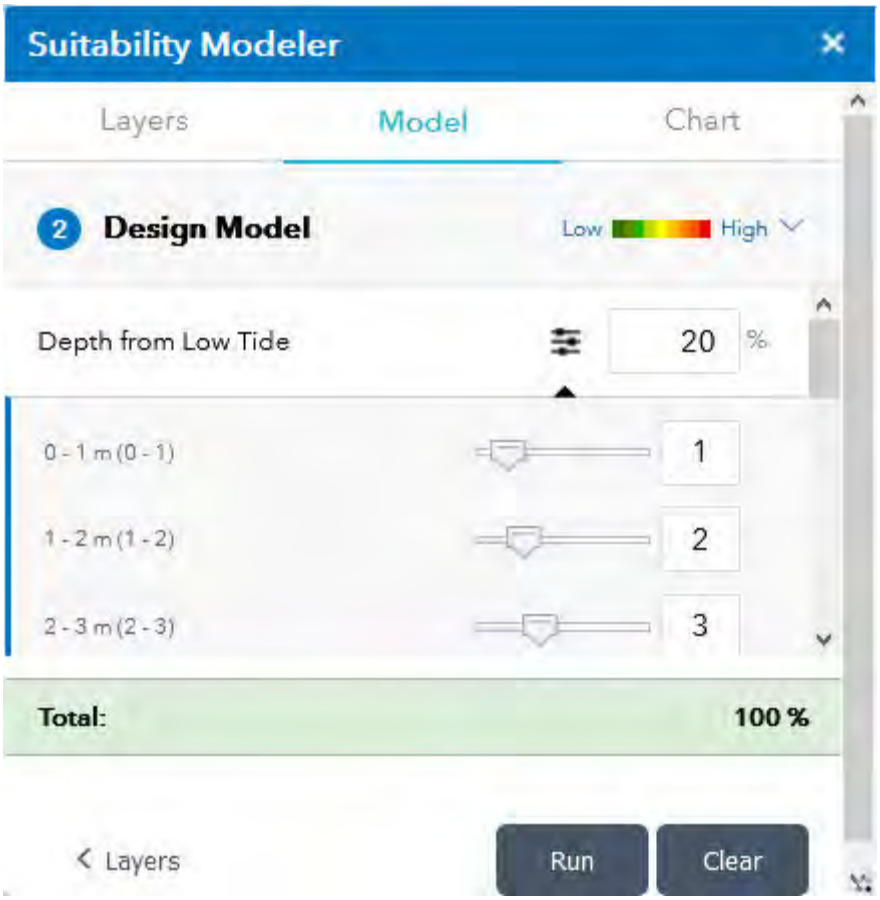


Figure 81: Partial list of layers available to conduct suitability analysis.

A percentage corresponding to each layer must be entered to assign it a relative importance in the analysis (Figure 82). The total percentage of these layers should equate to 100. Users can optionally expand each of the layers to adjust the class weights (0 – restricted, 1 being least suitable; 9 being most suitable). The class weights will decide how layer values are mapped to a suitability scale.

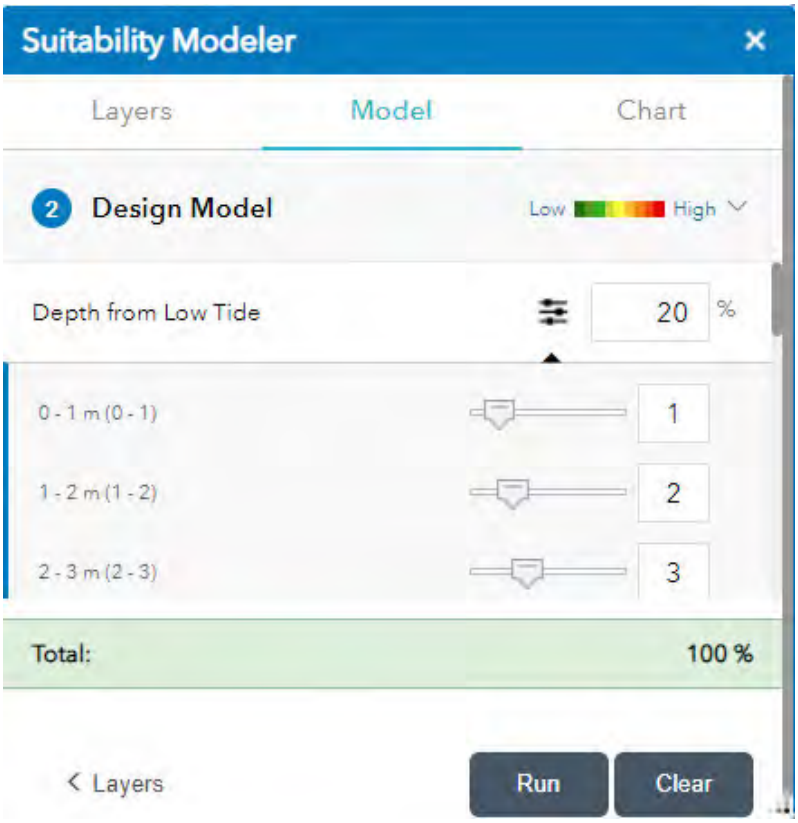


Figure 82: Relative importance assigned to each layer in the suitability analysis, as determined by the user.

When the user is satisfied with their suitability criteria, the analysis can be executed, and the resulting model will appear as an additional layer on the map and in the layer list as "rest- Pomquet_Suitability_1_Low_9_High" (Figure 84; Figure 84).

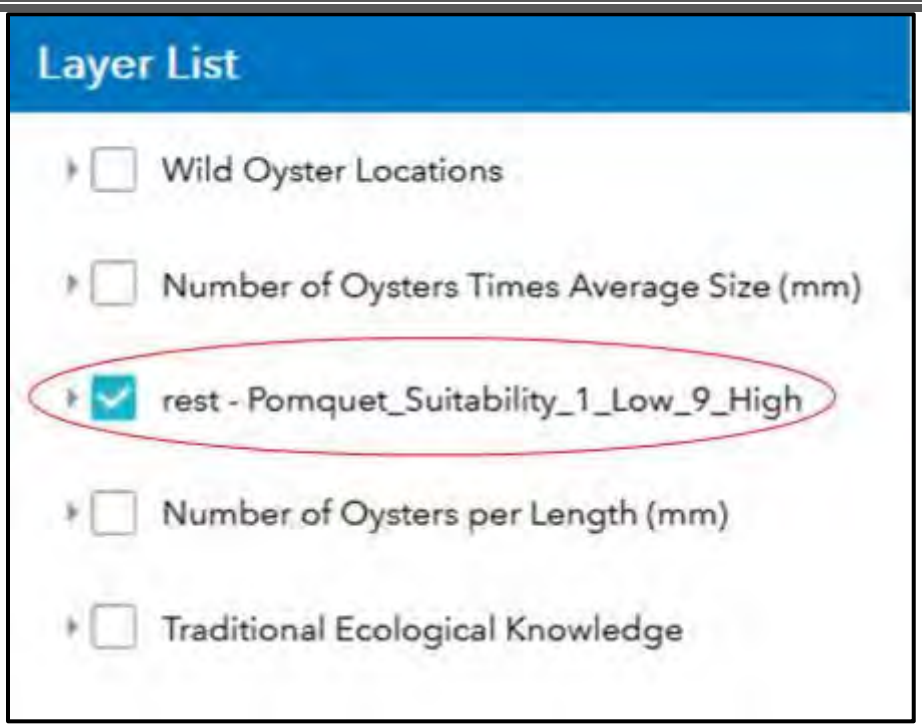


Figure 83: The suitability model will appear in the list of layers when the analysis is complete.

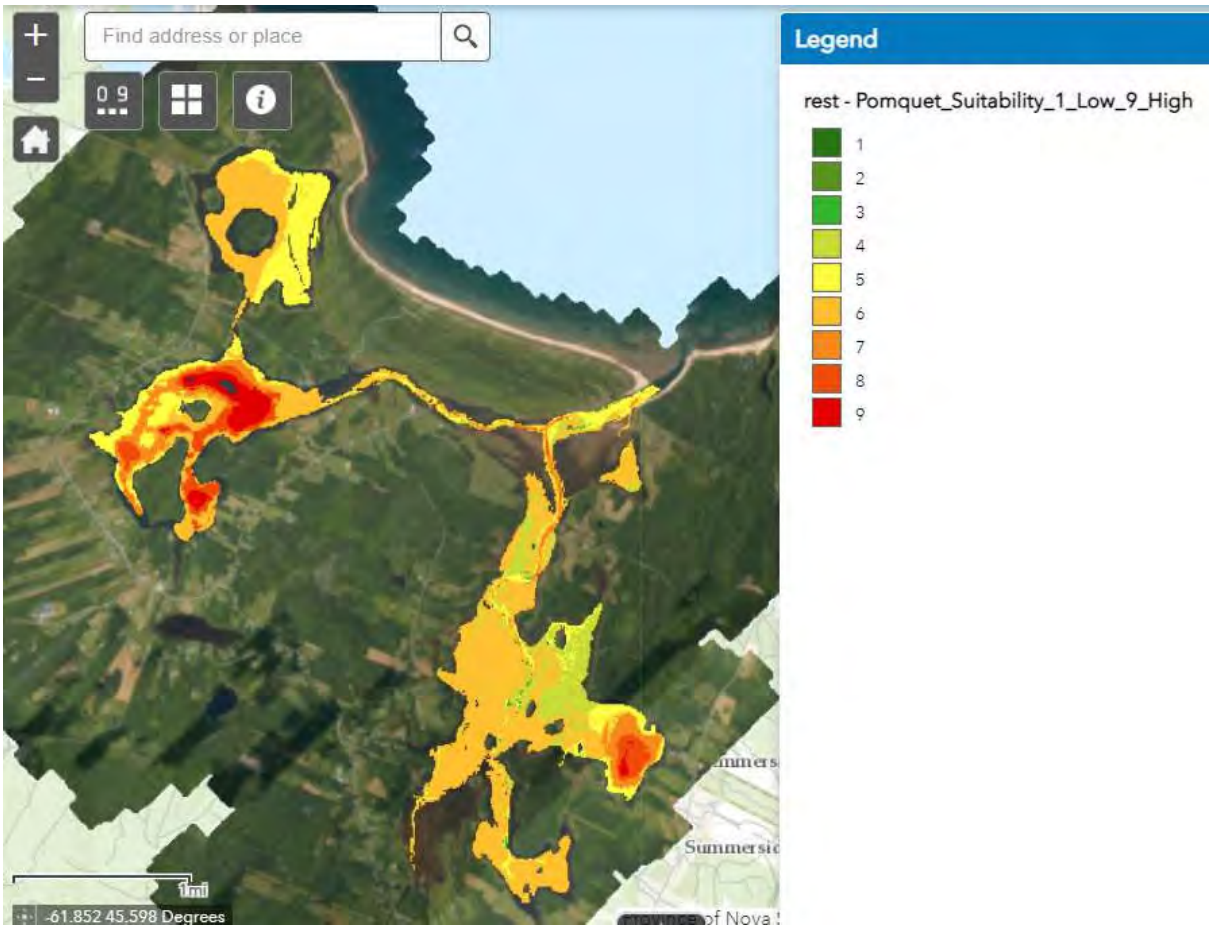


Figure 84: Output of suitability model. The visualization of the model will change as the user selects different layers and assigns different values of relative importance. Scores go from least suitable (1) to most suitable (9).

Once the suitability map is generated, the user can choose to design a chart of the model from one of the available features. The first feature allows the user to design a polygon by constructing vertices around their area of interest (Figure 85). The user can also choose to draw a freehand polygon around their desired selection or select a feature from a list of available layers.

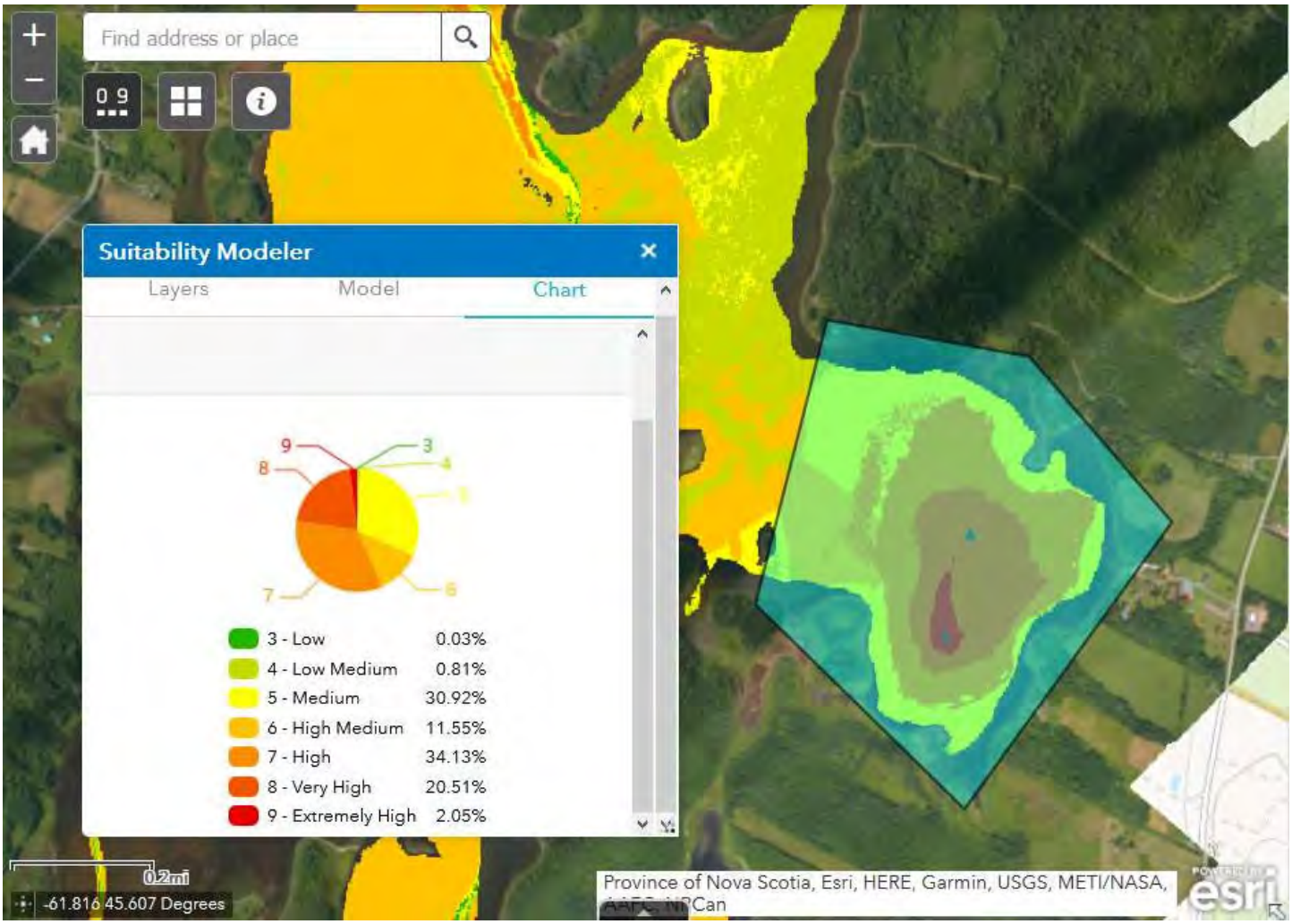


Figure 85: Chart of the suitability model generated by drawing a polygon around the area of interest.

7 Conclusion

This project has demonstrated the multiple uses of data derived from a single airborne topo-bathymetric lidar survey, supplemented by an ADCP deployed for one month, to support shellfish aquaculture site selection and possible spat collection areas. Several key data layers were derived from the lidar seamless land-sea elevation data including water depth, ice impact zone, intertidal area, the channel location and from the orthophotos the eelgrass presence map. The lidar elevations were supplemented with a multibeam survey conducted by AGRG and depth sounding from CHS charts where the lidar did not penetrate to the bottom because of water clarity limitations. The resultant DEM was used to construct a hydrodynamic (HD) model using the DHI Mike-21 suite of modelling tools. The model results were compared

and validated against the ADCP measurements. The water levels agreed quite well apart from some significant wind events. There was more variability between the current velocities modelled and those measured by the ADCP. This was interpreted to be a result of the complex movement of the water in Church Cove. The results of the HD model included the mean and maximum monthly current speeds, an estimate of flushing times and the significant wave height from the predominant wind. These additional layers were used as important site selection criteria. The results from the oyster stock survey conducted by Robin Stuart in Pomquet Harbour in 2014 were used to estimate spat release in the harbour which was represented as a series of particles that were then tracked using the HD model. Maps showing the distribution of the spat particles on an incoming and outgoing tide can be used to determine potential sites for spat collection. The ADCP data were analyzed with weather data, specifically wind, from the nearest Environment and Climate Change Canada weather station at Tracadie. It was observed that strong wind events influence both water level and current velocities but did not increase the wave height significantly for Church Cove. Animations were constructed to aid in visualizing the dynamic nature of the ADCP and HD model output. A suitability map was constructed in GIS for potential oyster growing sites. This used a weighted overlay technique where each map was assigned a weight and then each class within the map was assigned a score (1 low suitability, 9 high suitability). Advise was obtained by aquaculture experts from DFO, NSFA and CMAR to assign the weights and scores.

The various layers derived during this study as well as existing layers such as Traditional Ecological Knowledge and aquaculture leases were made available through a web mapping system. These layers can be toggled on and off and their transparency can be set so that multiple maps can be viewed at once. As well the attributes of any GIS layer are also available to query, for example the data collected by Stuart (2014) for the oyster stock survey are now available on-line and can be queried. The web-system also allows the user to construct their own site suitability map. This involves selection the layer for the overlay from those available in the list. The layers available on the website include both continuous data as well as classified data. A User Guide is available on the website accessed through the About icon ***i*** as well as a description of the project and funders. The classified data are recommended for use in this overlay system. Once the user selects the layers of interest, weights are assigned to each ensuring the sum of all the weights is equal to 100. Each map class is then scored from 0-unacceptable, flagged to be unacceptable regardless of how high the scores are for other map layers, to a range of scores between 1- low and 9 high. The weighted overlay is then executed, and a new suitability map is displayed on the web (rest – Pomquet_Suitability_1_Low_9_High). A chart can also be constructed showing the area of each suitability class. A polygon of interest can be digitized within the web mapping system over the suitability map to calculate a graph of the area for each class within the polygon.

Overall, this project has demonstrated the benefits of high-resolution coastal data for shellfish management and site selection. The ability to access these large data set through a web viewer allows easy access for multiple stakeholders. The ability to overlay maps to calculate possible suitable areas for siting farms was also built into the web-mapping system as part of the project making it easy for non-GIS experts. These results of this project could be expanded to other bays

within the Maritimes to improve our understanding of the coastal processes and assist in marine spatial planning and aquaculture site selection.

8 Acknowledgements

We would like to thank Paqtnkek Mi'kmaw Nation and the Atlantic Fisheries Fund - Fisheries and Oceans Canada - DFO-MPO and Nova Scotia Fisheries and Aquaculture for funding support. We would especially like to thank [redacted] and [redacted] of NSCC's AGRG for their assistance with data collection and processing. Thanks to staff from Airborne Hydrography and Leica Geosystems, and LEG staff for operations support and AGRG staff for administrative support. We are grateful for the eelgrass ground truthing information supplied by Dr. [redacted] and [redacted] of St. FX Biology Department. Support from the following individuals and organizations for the discussion of maps weights and class scores for the suitability overlay including Monique Niles – DFO Gulf Region, Matthew King – NSFA, Gregor Reid, Laila Nargis, and James Cunningham of CMAR-Perennia.

9 References

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Bonham-Carter, G. F. (1994). Geographic Information Systems for Geoscientists Modelling with GIS. (G. F. Bonham-Carter, & D. F. Merriam, Eds.) New York: Elsevier.

Doiron, S. (2008). Reference Manual for Oyster Aquaculturists. New Brunswick Department of Agriculture, Aquaculture, and Fisheries.

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ESRI. (2020). Suitability Modeler widget – ArcGIS Web AppBuilder.

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10 Appendix 1: Number of Oysters per Length

The following maps represent the count values of eight different oyster shell size classes observed in Pomquet Harbour during oyster stock surveys (Figure 86; Figure 87; Figure 88; Figure 89; Figure 90; Figure 91; Figure 92; Figure 93). These observations were made in areas identified as having a suitable oyster habitat. Station 21 reported the highest count of oysters in the shell size classes between 0 – 80 mm. Market size oysters, defined as having a shell length of greater than 76 mm, had the highest count at station 13 with 156 oysters.

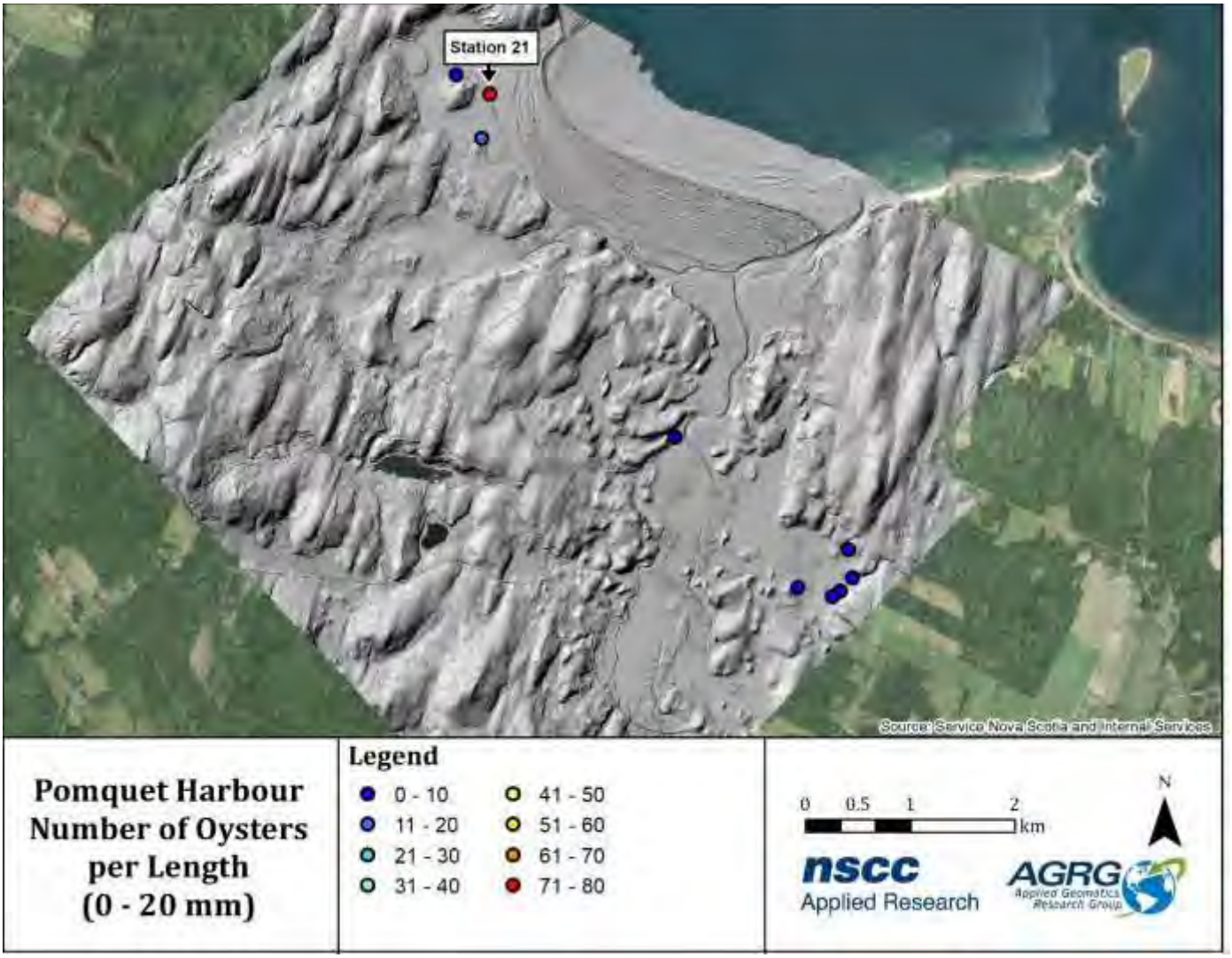


Figure 86: Count values of the 0 – 20 mm oyster shell size class collected at each station during oyster stock surveys conducted by [redacted] on Paqtnkek First Nation's behalf.

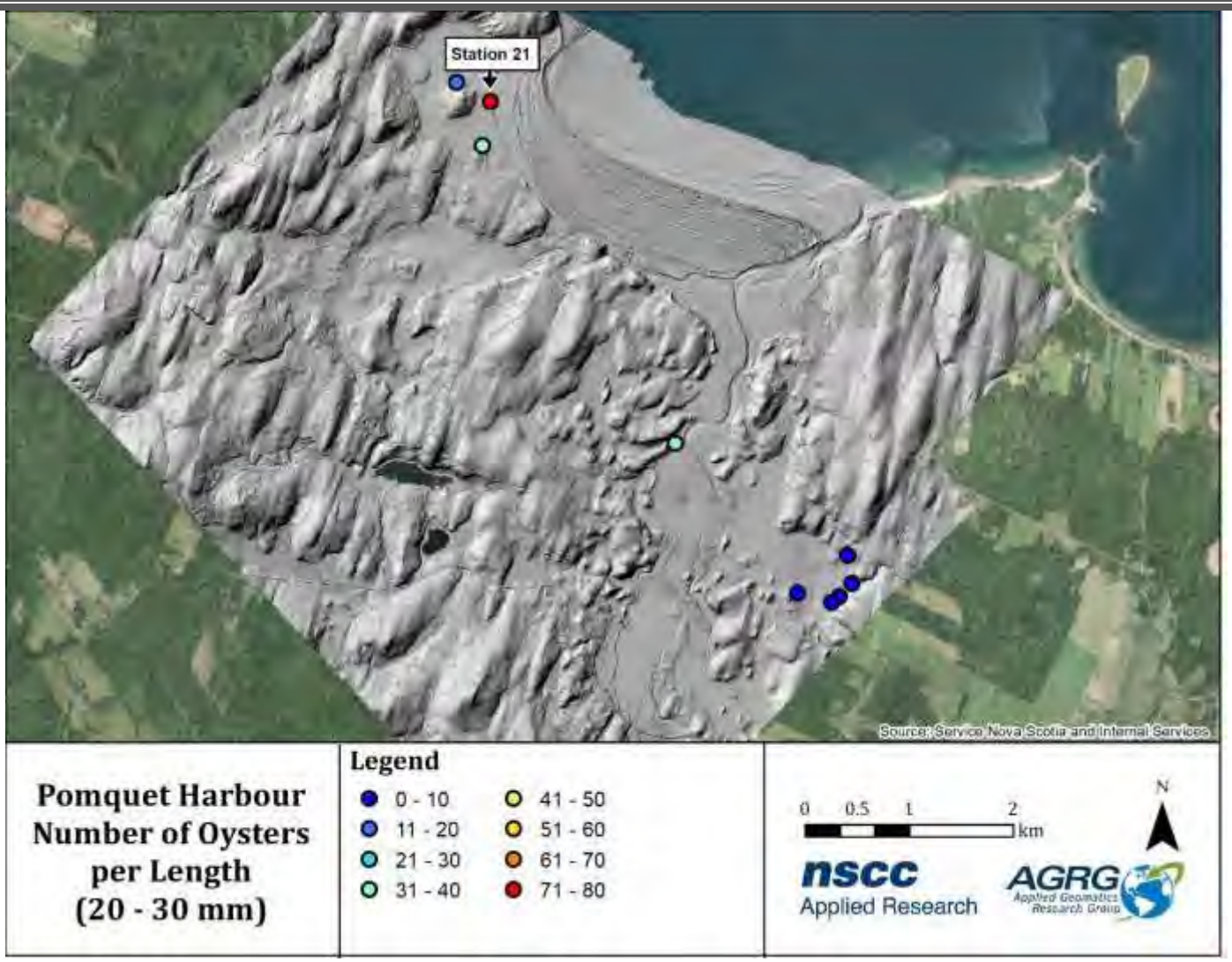


Figure 87: Count values of the 20 – 30 mm oyster shell size class collected at each station during oyster stock surveys conducted by [redacted] on Paqtnkek First Nation's behalf.

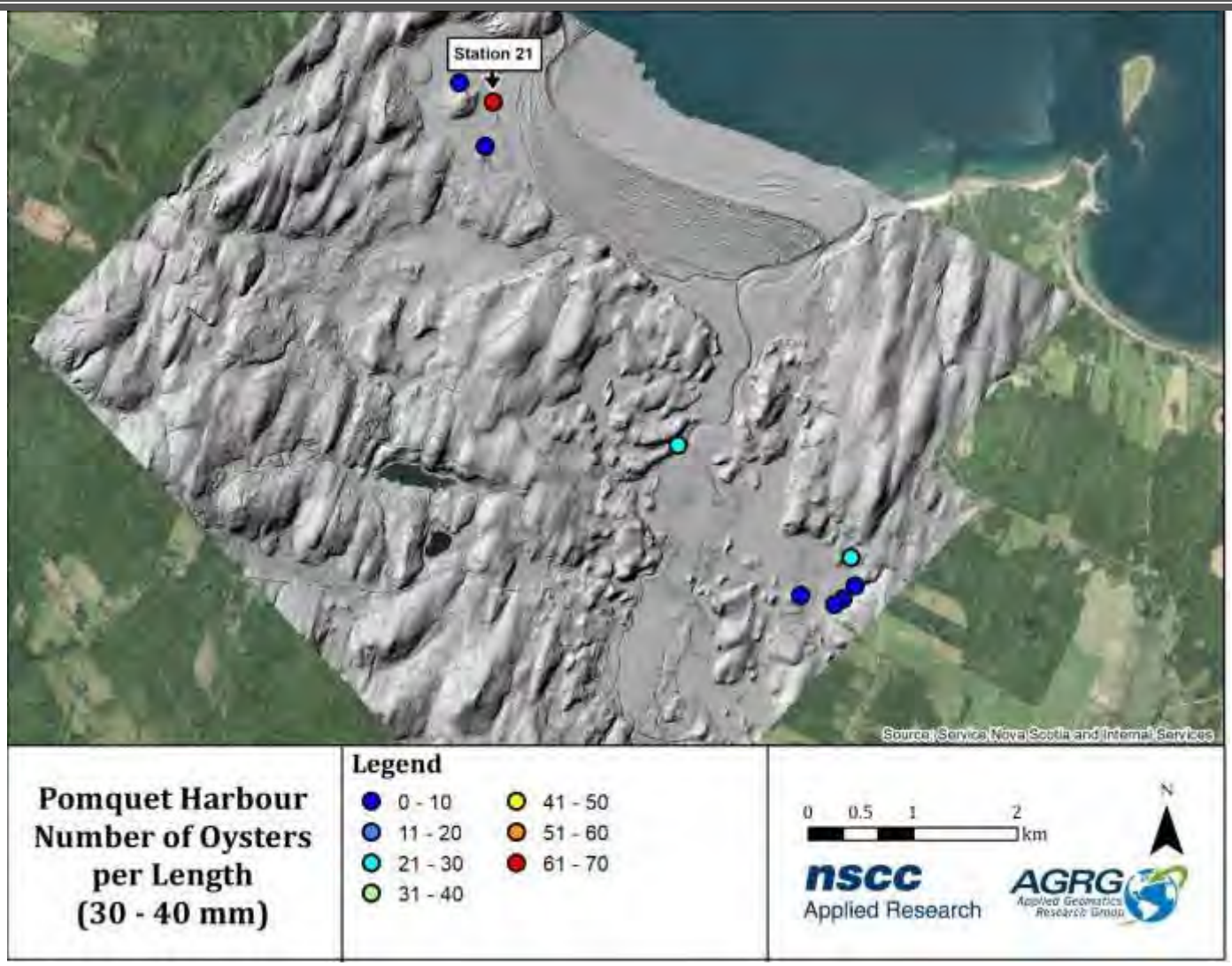


Figure 88: Count values of the 30 – 40 mm oyster shell size class collected at each station during oyster stock surveys conducted by [redacted] on Paqtnkek First Nation's behalf.

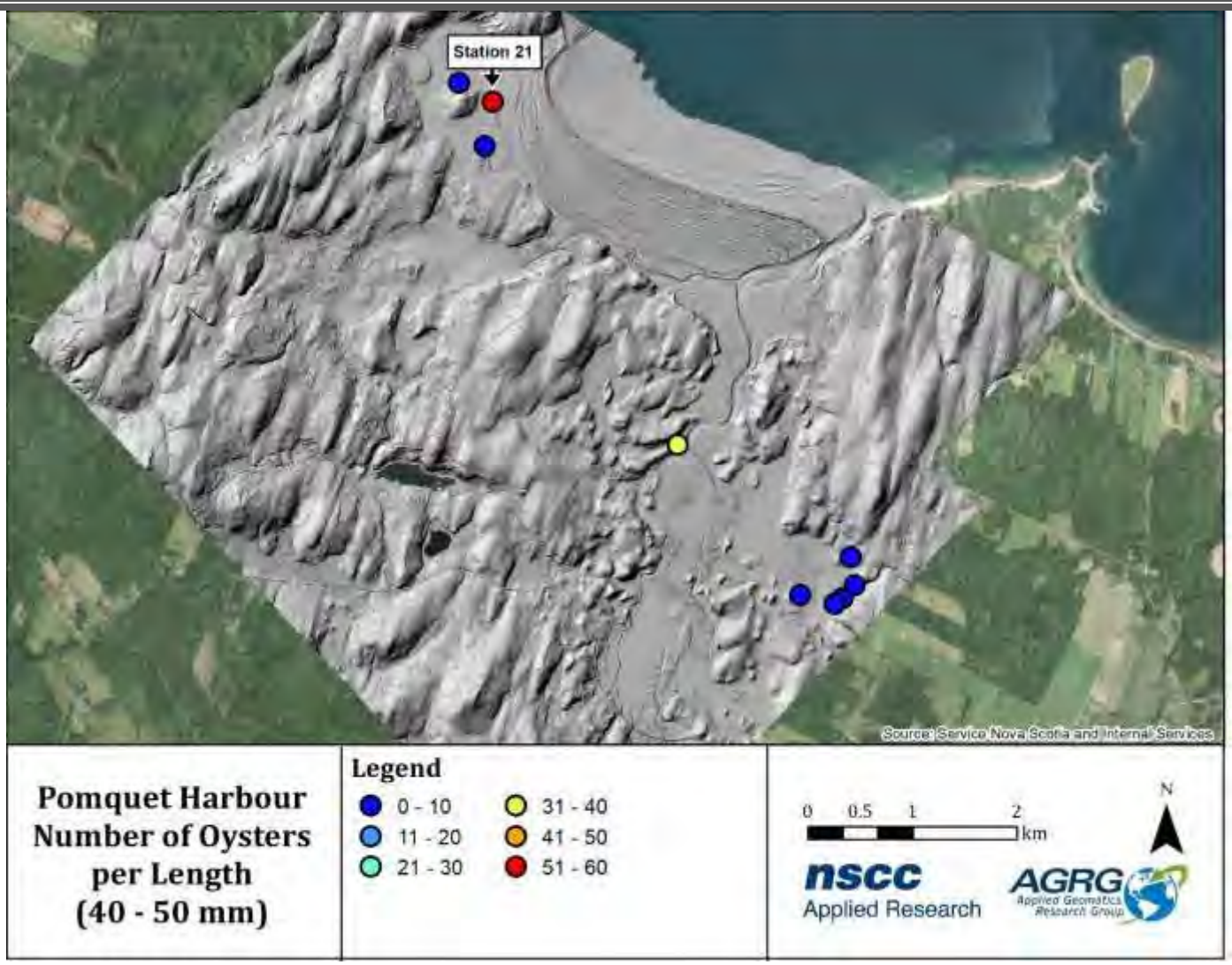


Figure 89: Count values of the 40 – 50 mm oyster shell size class collected at each station during oyster stock surveys conducted by [redacted] on Paqtnkek First Nation's behalf.

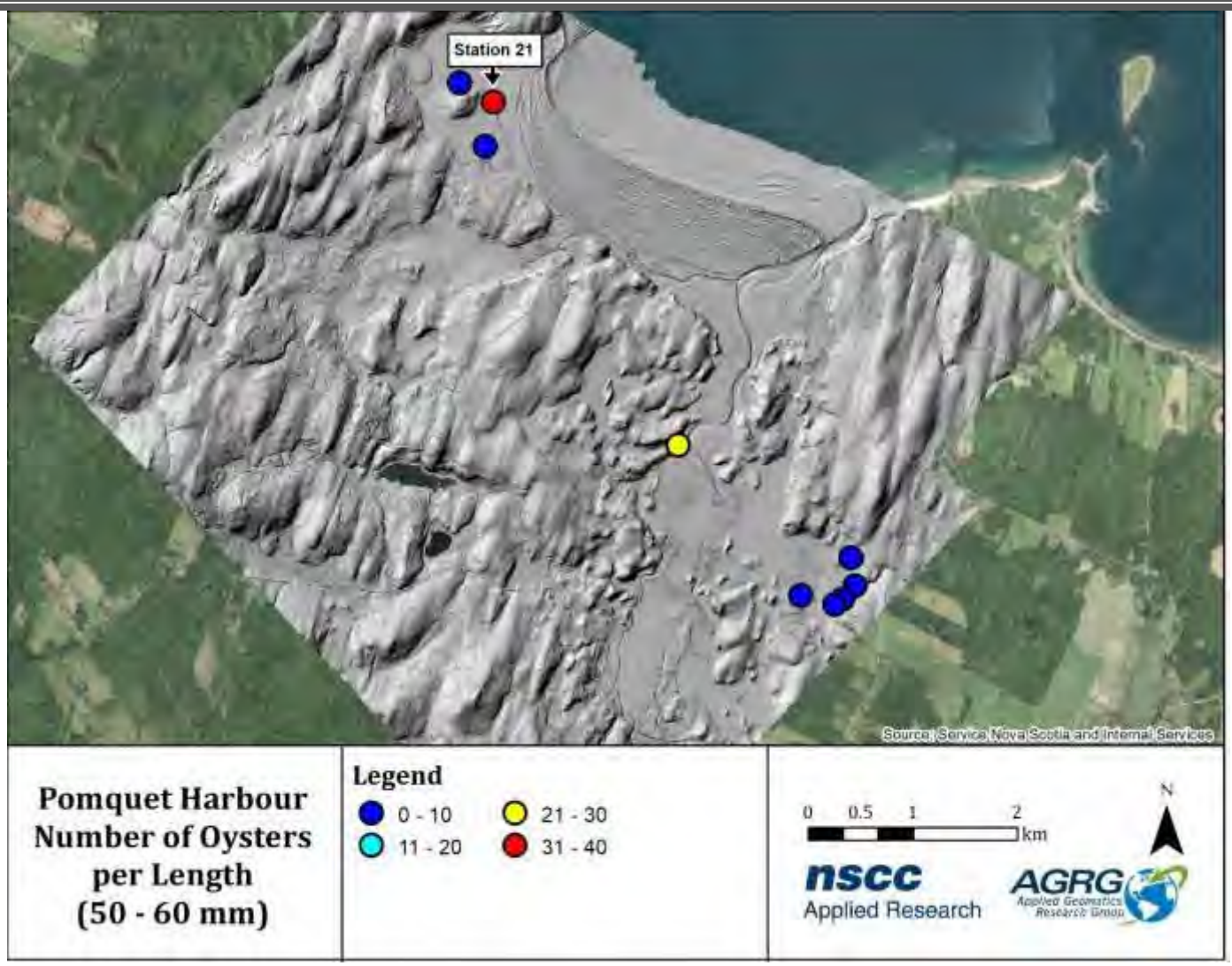


Figure 90: Count values of the 50 – 60 mm oyster shell size class collected at each station during oyster stock surveys conducted by [redacted] on Paqtnkek First Nation's behalf.

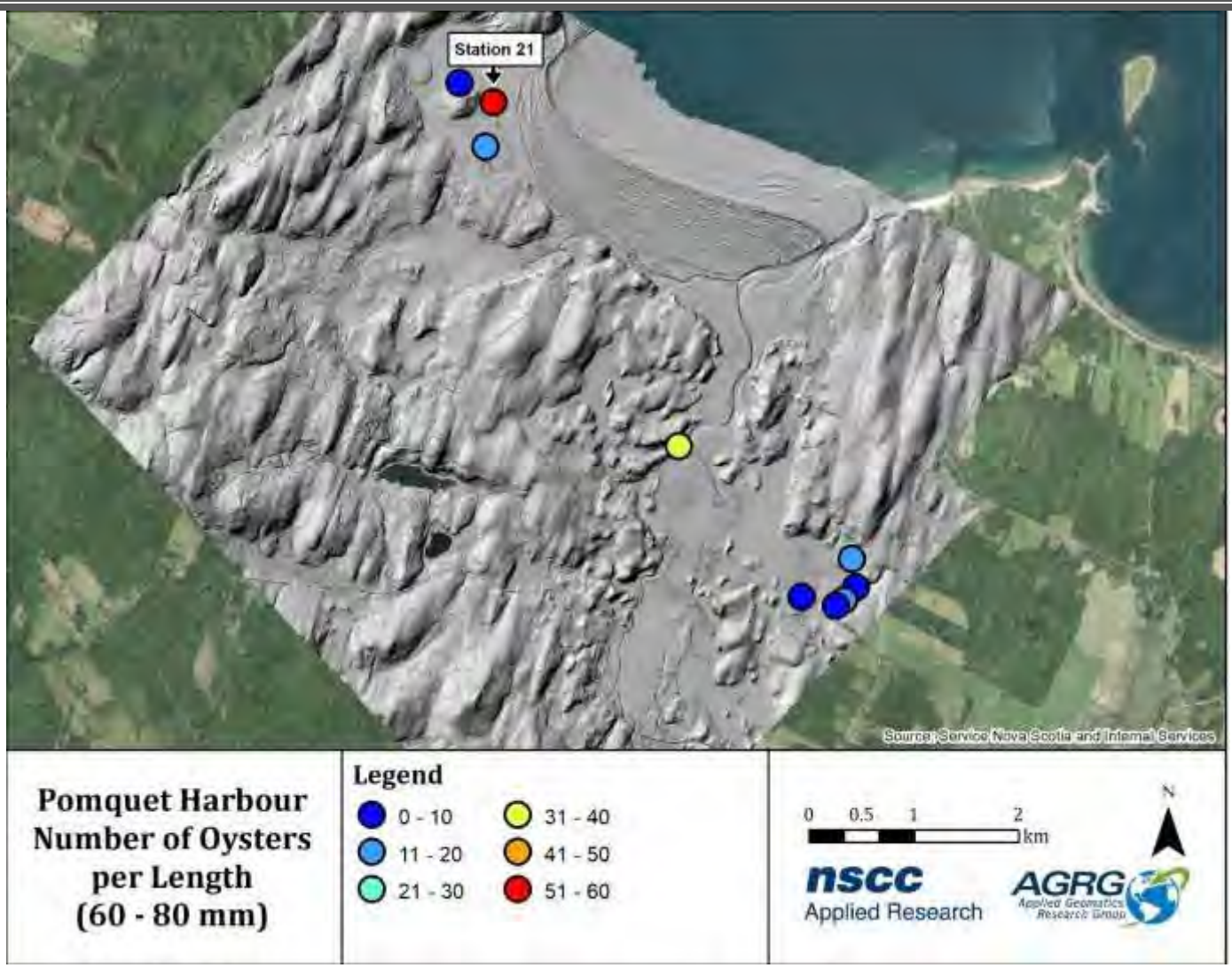


Figure 91: Count values of the 60 – 80 mm oyster shell size class collected at each station during oyster stock surveys conducted by [redacted] on Paqtnkek First Nation's behalf.

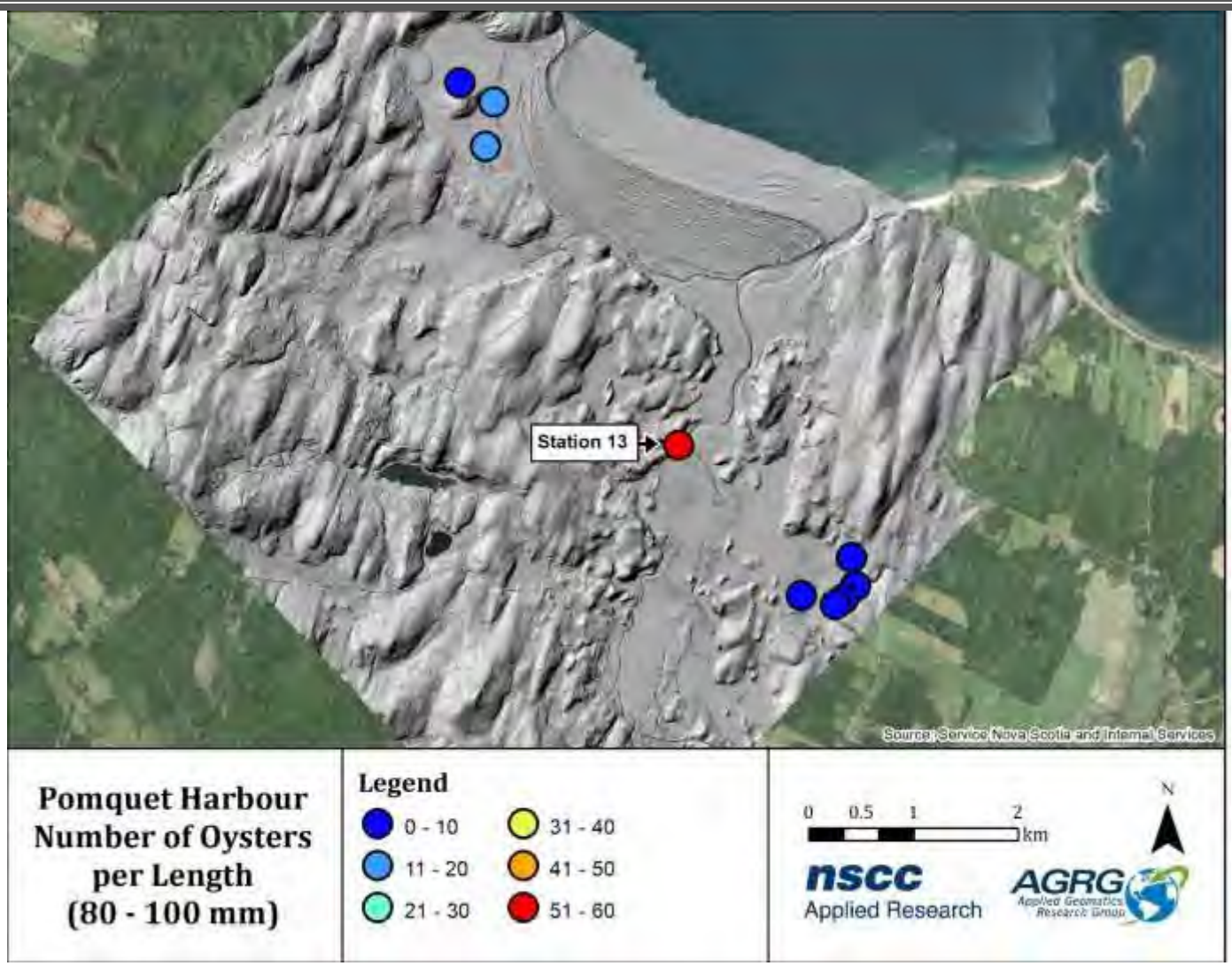


Figure 92: Count values of the 80 – 100 mm oyster shell size class collected at each station during oyster stock surveys conducted by [redacted] on Paqtnkek First Nation's behalf.

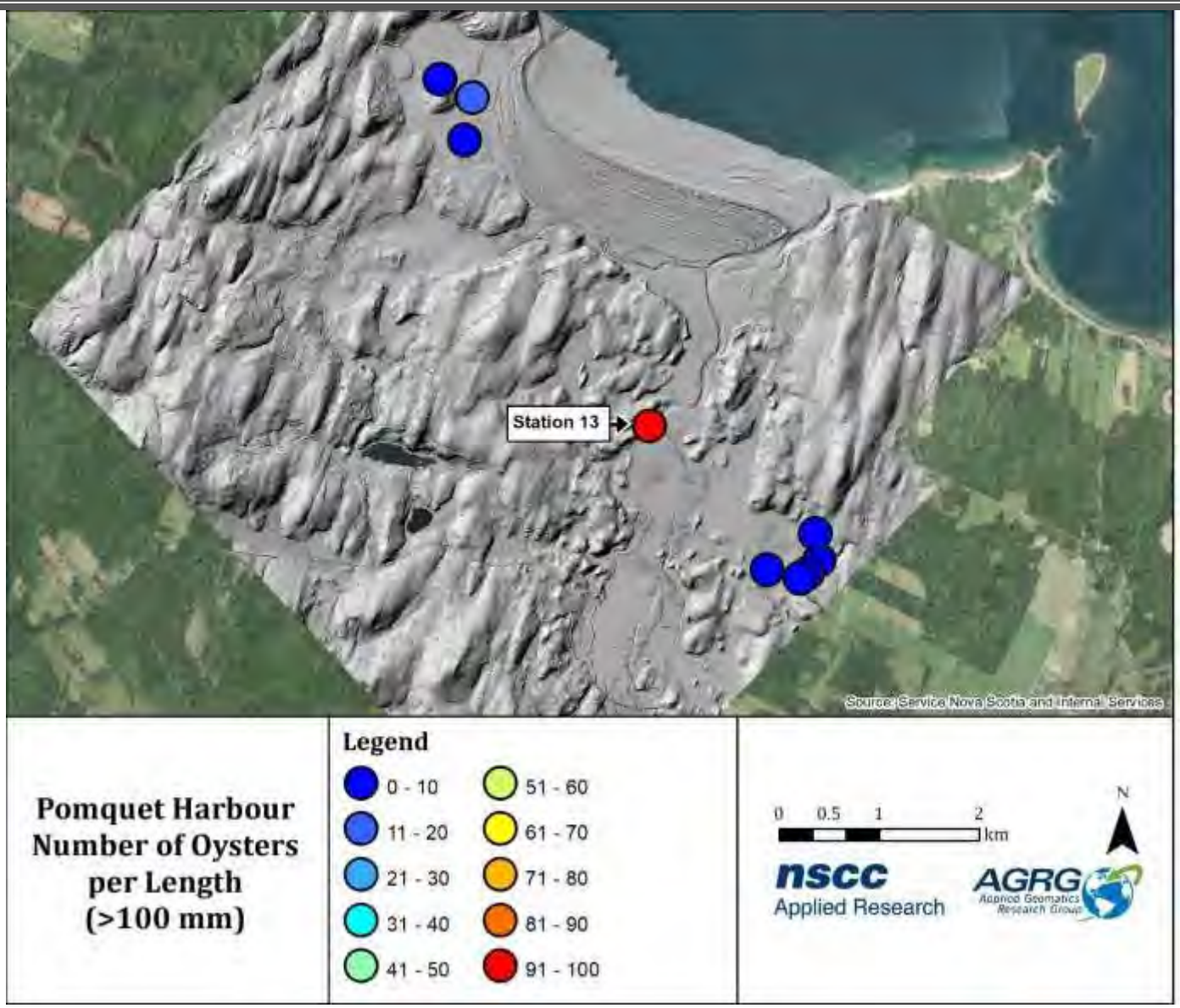


Figure 93: Count values of the >100 mm oyster shell size class collected at each station during oyster stock surveys conducted by [redacted] on Paqtnkek First Nation's behalf.

11 Appendix 2: Hillshade Models

The maps in this section show hillshade models of the DEM and the DSM (Figure 94; Figure 95).

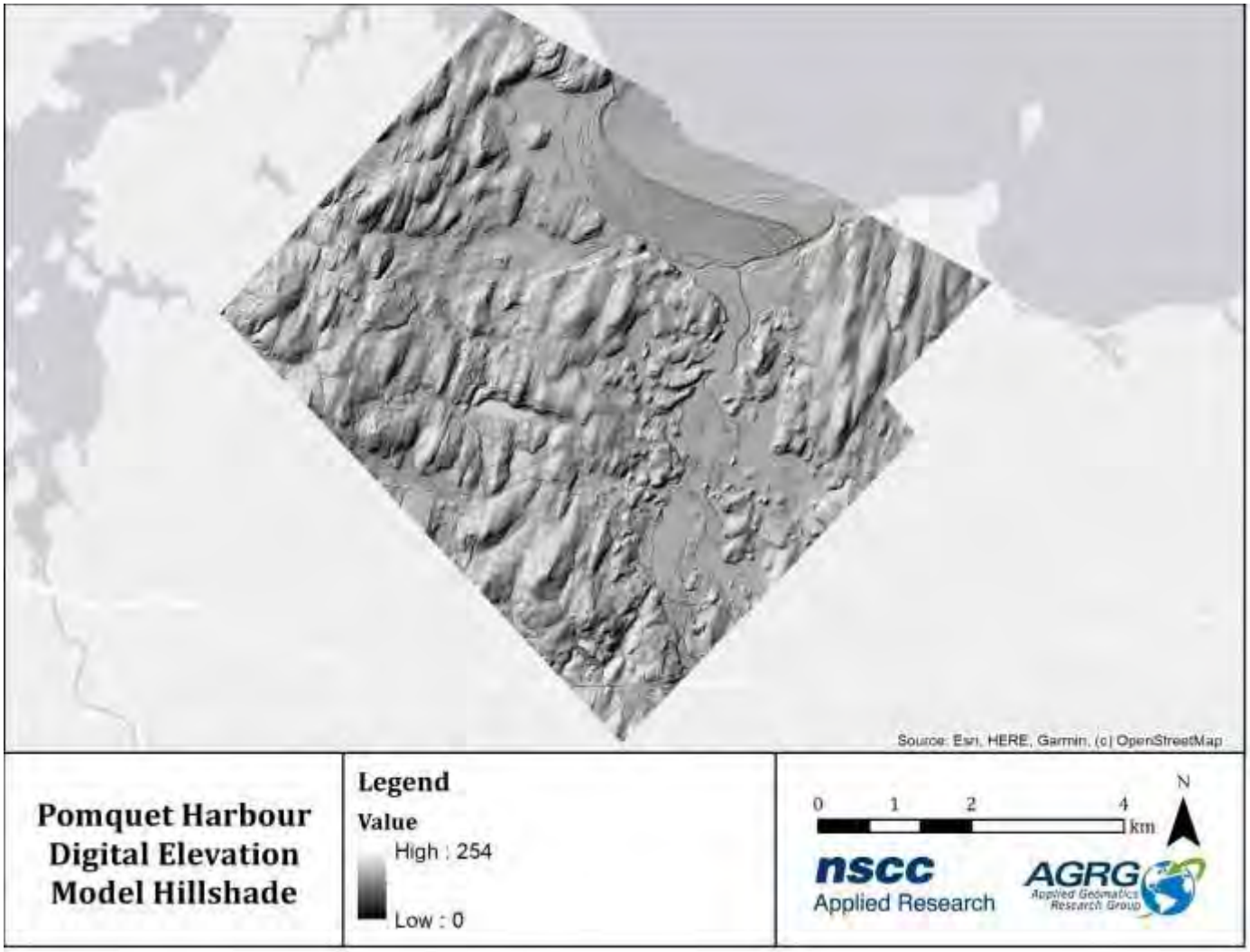


Figure 94: Hillshade generated from the digital elevation model.

Figure 95: Hillshade generated from the digital surface model.

12 Appendix 3: Pomquet AFF Aquaculture Suitability Modeller User Guide

Pomquet AFF Aquaculture Suitability Web Map

User Documentation

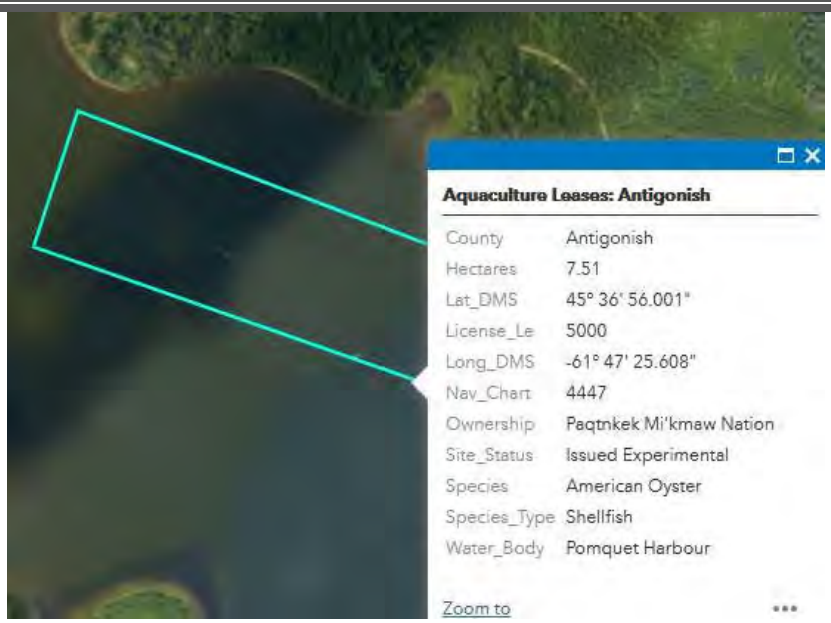
Prepared by:

Applied Geomatics Research Group
NSCC, Middleton
Tel. [redacted]
email: [redacted]

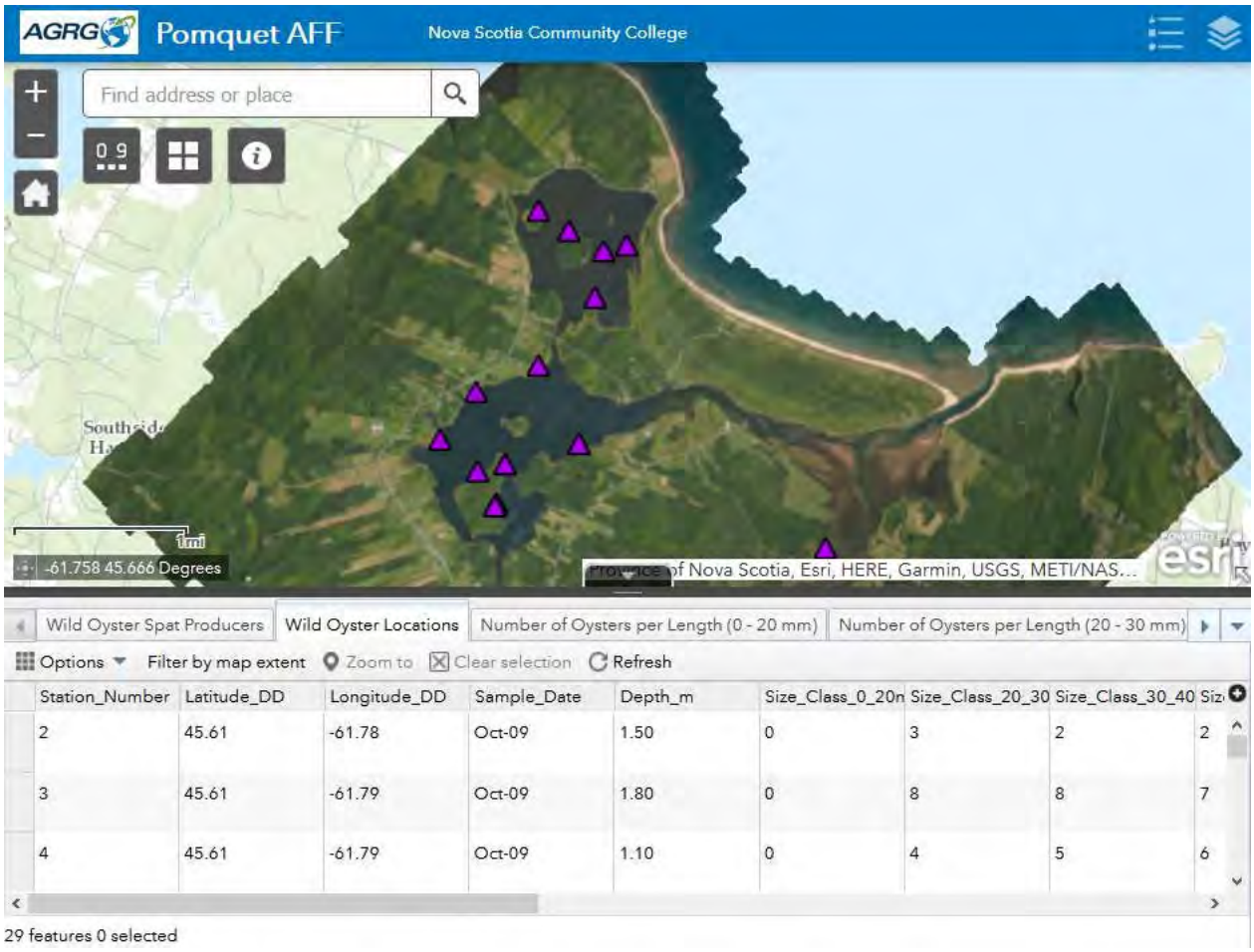
Getting Started

- When initially landing the Pomquet AFF Aquaculture Suitability Map's main page, the user will see a 5 cm resolution aerial image of the Pomquet Harbour study area.

- To zoom in and out of the map, click the "+" and "-" buttons located in the web application's top left corner. To return to the default map extent, click the home button located below the zoom buttons.
- To find a specific address or place, type into the search bar located next to the zoom buttons.
- To change the default basemap, click the basemap gallery button positioned below the search bar. The user can select one of ten available Esri basemaps to change the display on the web application.
- The user can click on an activated vector layer to display a popup of the associated attributes.



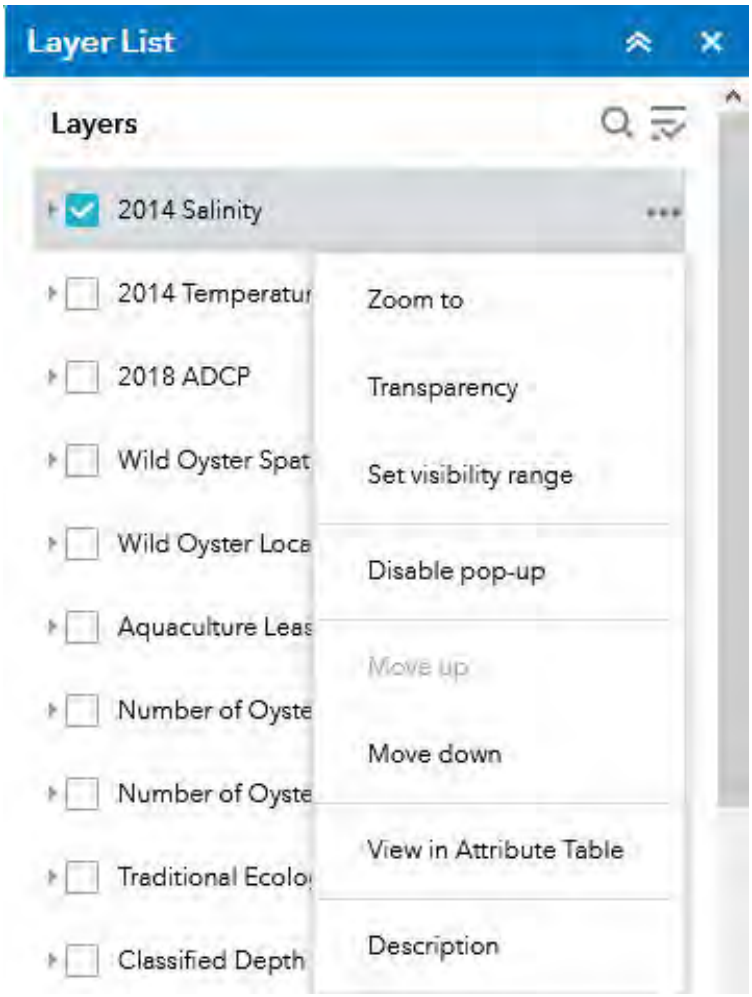
- The user can also view any vector layer's attribute table by clicking the arrow at the bottom of the map.



- A description of the key layers and the Suitability Modeller tool is outlined in the following section.

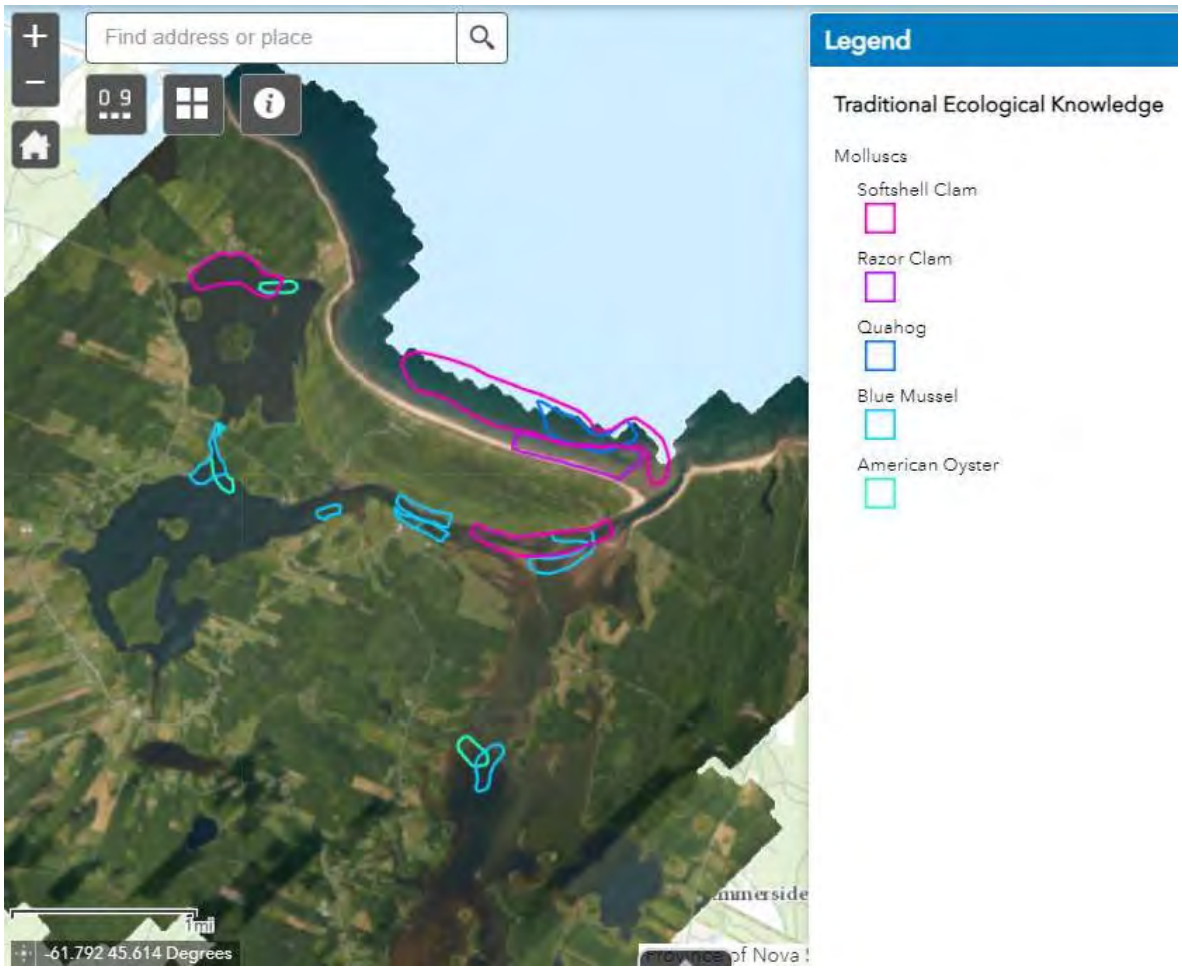
12.1 GIS Data Layers

- The user can activate any of the layers in the layer list by clicking the checkbox next to it.
- By clicking the three dots next to one of the layers, a list of options, such as adjusting the transparency or setting a visibility range, will appear.



12.1.1 Traditional Ecological Knowledge (TEK): Molluscs

- Polygon locations representing the habitat of several mollusc species (American oyster, blue mussel, quahog, razor clam, softshell clam) are displayed on the map when activated by the user. These layers were provided by the Department of Fisheries and Oceans (DFO) and clipped to the study area.

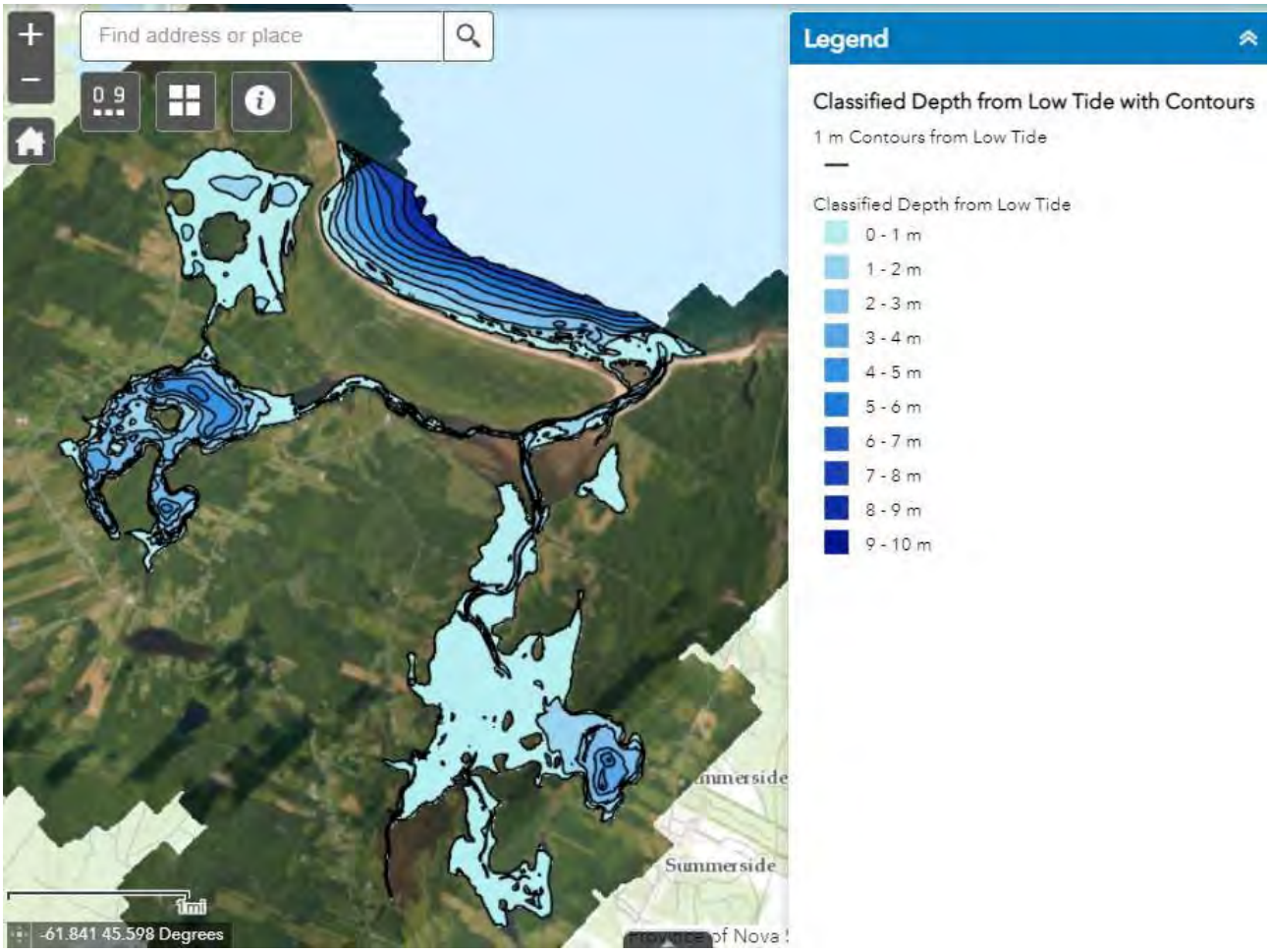


12.1.2 Channel Location

- The classified channel layer was derived from the continuous depth layer.

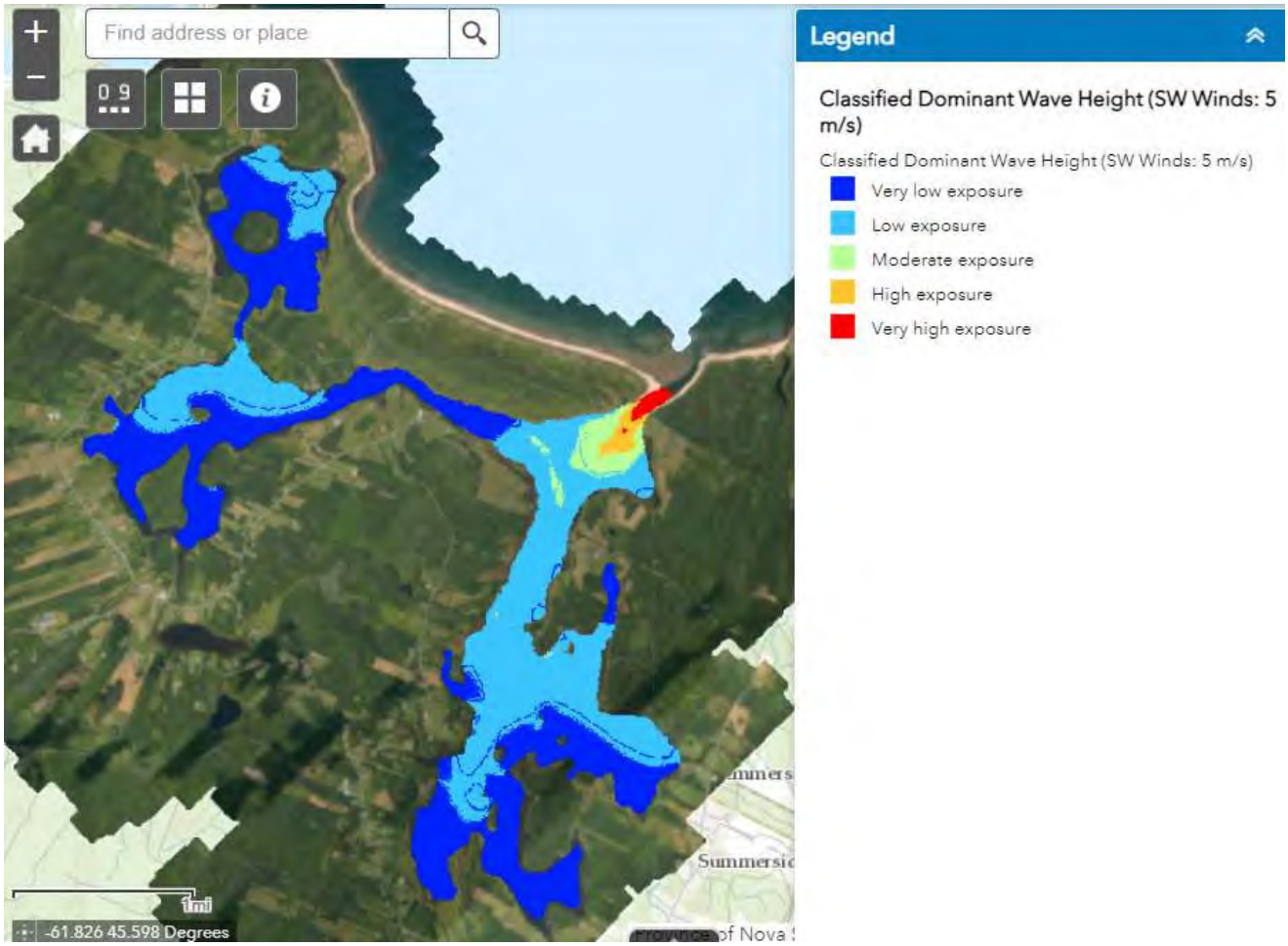
12.1.3 Classified Depth from Low Tide

- The classified depth layer relative to low tide layer was generated from the seamless Digital Elevation Model and is binned in 1 m increments.



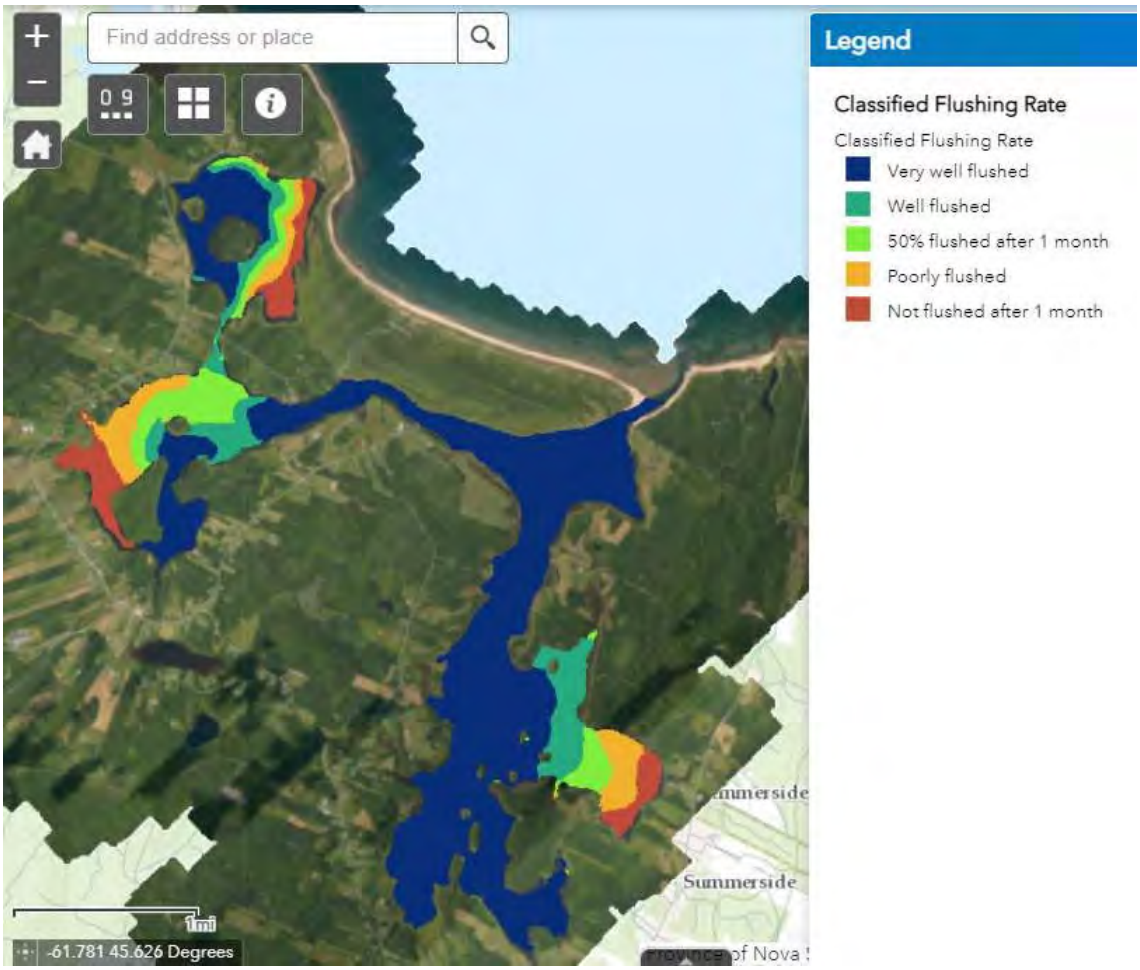
12.1.4 Classified Dominant Wave Height

- The classified dominant wave height layer was generated by using the hydrodynamic modelling software, Mike 21, to apply strong south winds to the Pomquet Harbour study area over two tidal cycles. Wave height was determined to be a suitable proxy for fetch.



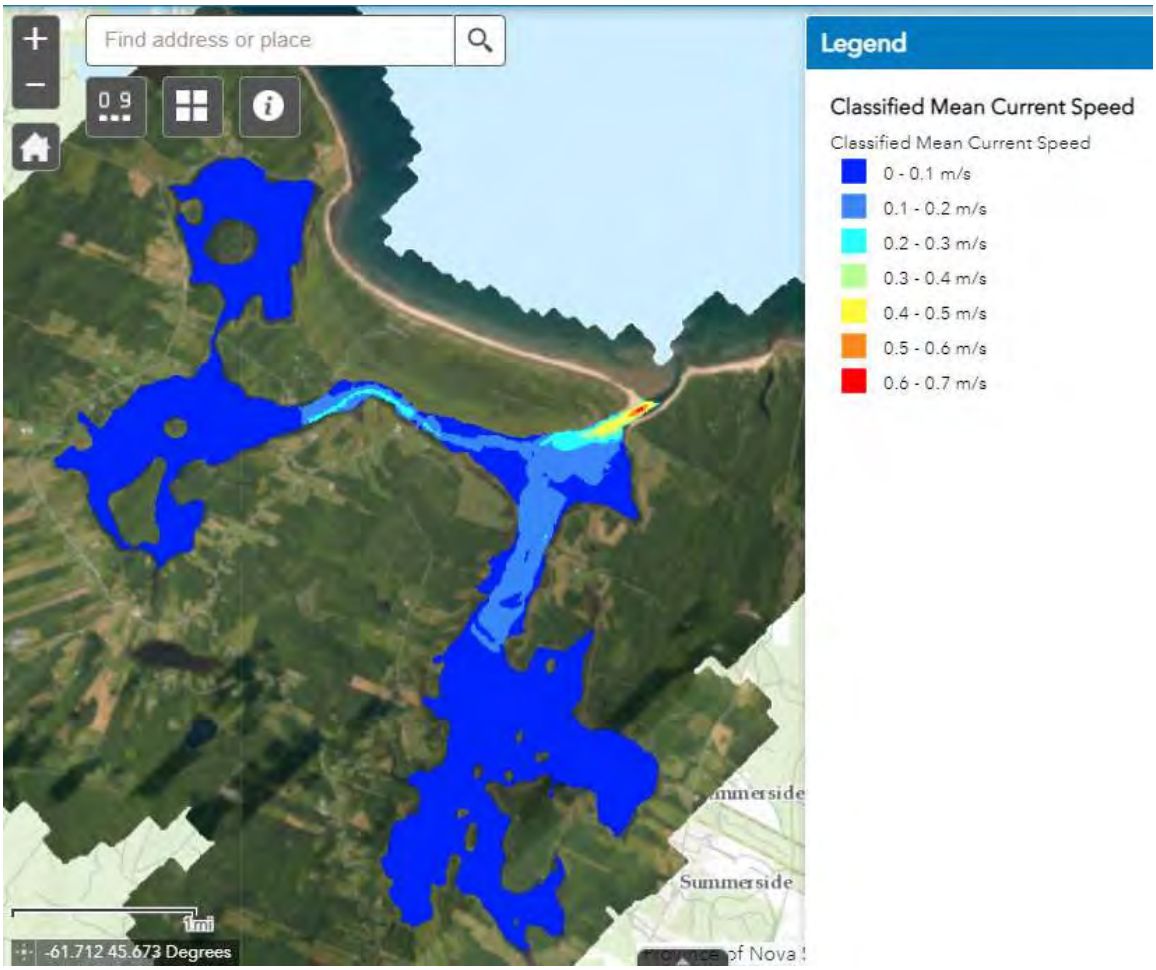
12.1.5 Classified Flushing Rate

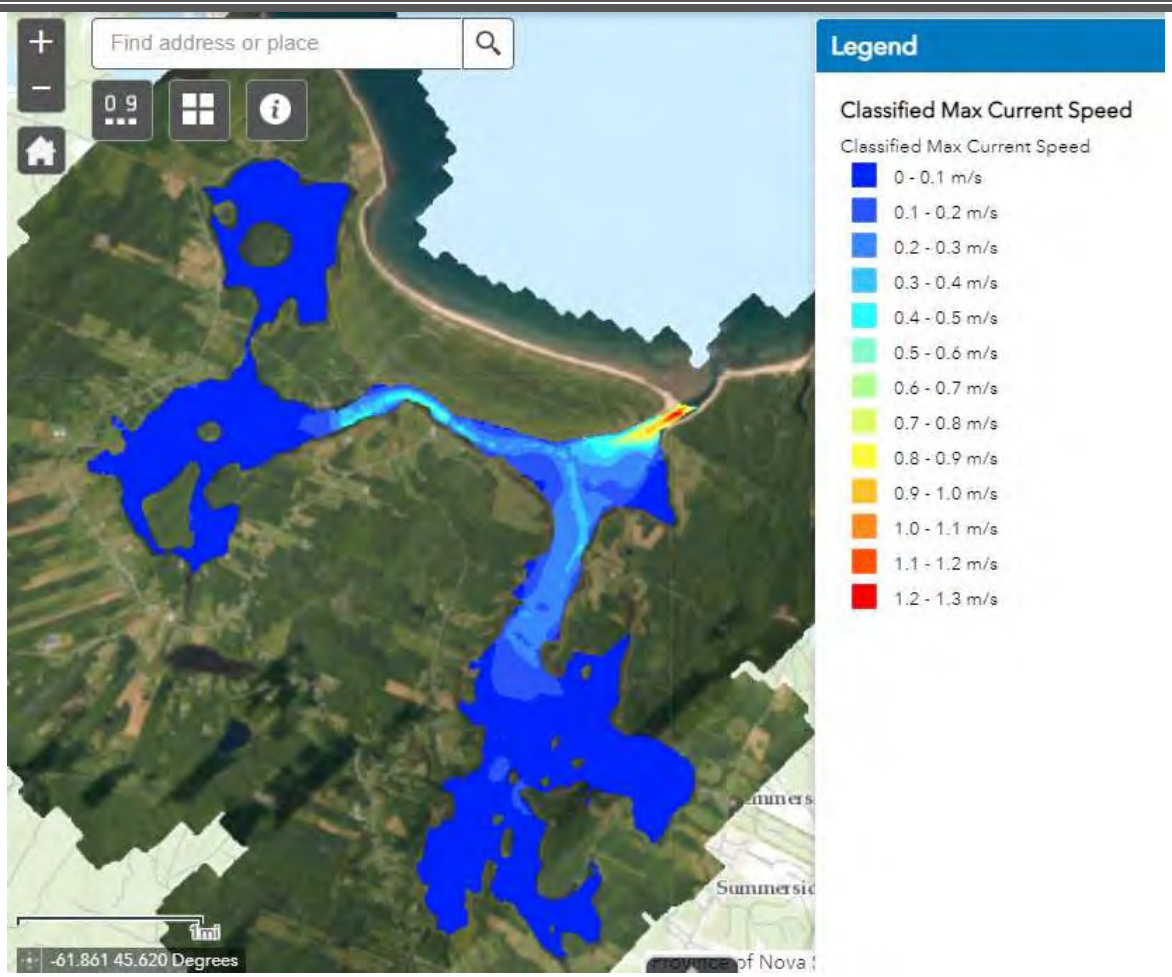
- The classified flushing rate layer was generated by using an arbitrary concentration of 1 on the first day of a 30-day simulation in the Transport Model of Mike 21. The resulting raster represents the minimum concentration in Pomquet Harbour during this simulation.



12.1.6 Classified Mean and Maximum Monthly Current Speed

- The classified mean and maximum current speed layers were derived directly from the hydrodynamic model simulation in Mike 21, which ran throughout the ADCP deployment.



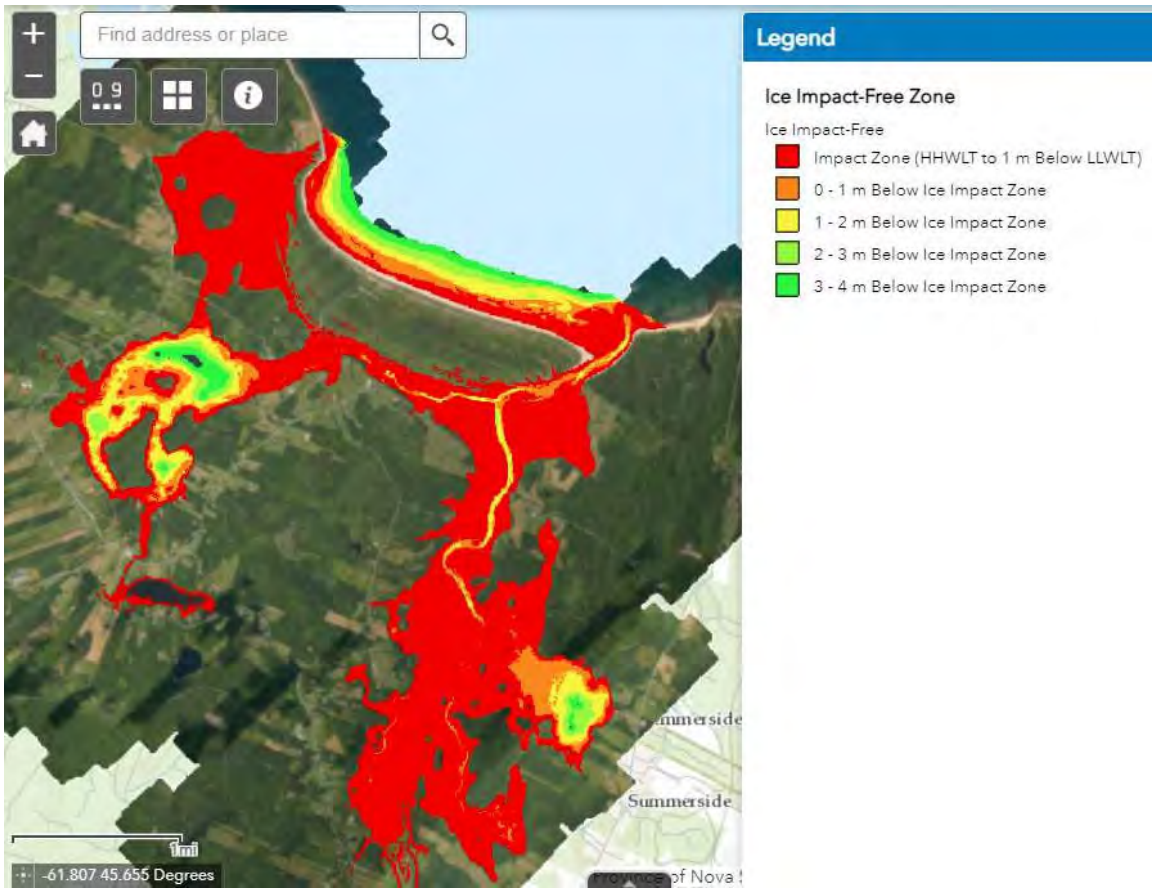

Find address or place
Legend
Classified Max Current Speed
Classified Max Current Speed
0 - 0.1 m/s
0.1 - 0.2 m/s
0.2 - 0.3 m/s
0.3 - 0.4 m/s
0.4 - 0.5 m/s
0.5 - 0.6 m/s
0.6 - 0.7 m/s
0.7 - 0.8 m/s
0.8 - 0.9 m/s
0.9 - 1.0 m/s
1.0 - 1.1 m/s
1.1 - 1.2 m/s
1.2 - 1.3 m/s
-61.861 45.620 Degrees

12.1.7 Classified Eelgrass

- The eelgrass layer was derived from a Fuzzy K-Means unsupervised classification of the benthic habitat in Pomquet Harbour.

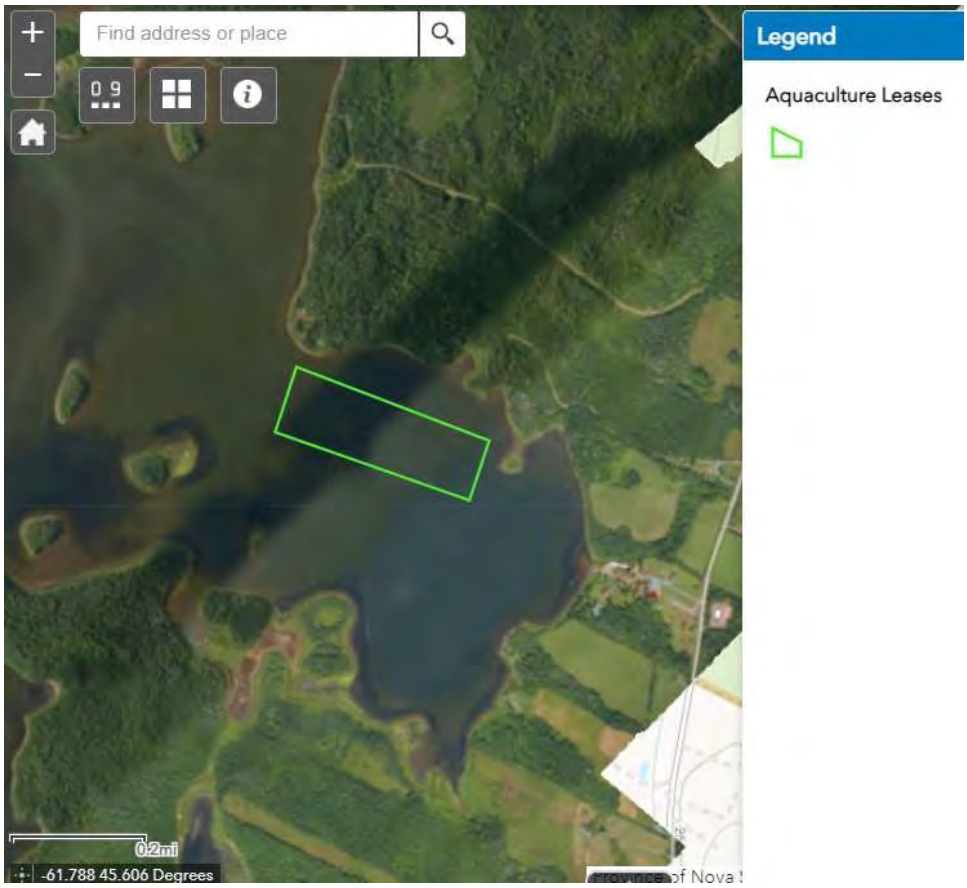
12.1.8 Ice Impact-Free

- The Ice Impact Zone layer was generated from the seamless Digital Elevation Model (DEM). The ice impact zone was defined as the area between Higher High Water Large Tide (HHWLT) and 1 m below Lower Low Water Large Tide (LLWLT). Ice impact-free zones were defined as areas deeper than 1 m below LLWLT.



12.1.9 NS Marine Aquaculture Leases

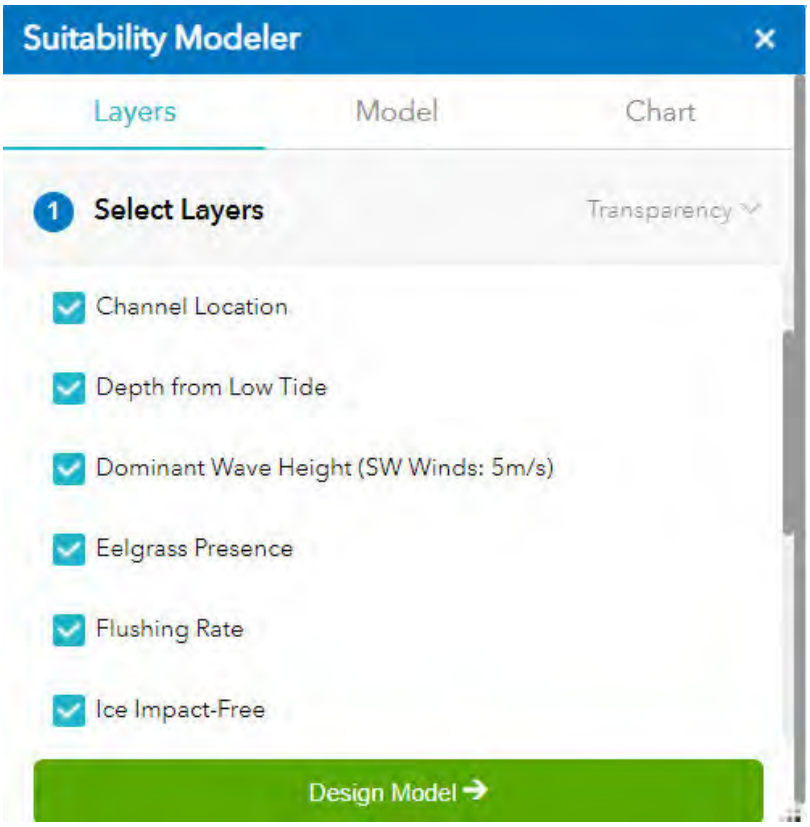
- Polygon locations of issued aquaculture leases within Pomquet Harbour are displayed on the map when activated by the user. This layer was provided by Nova Scotia Fisheries and Aquaculture (NSFA) and clipped to the study area.



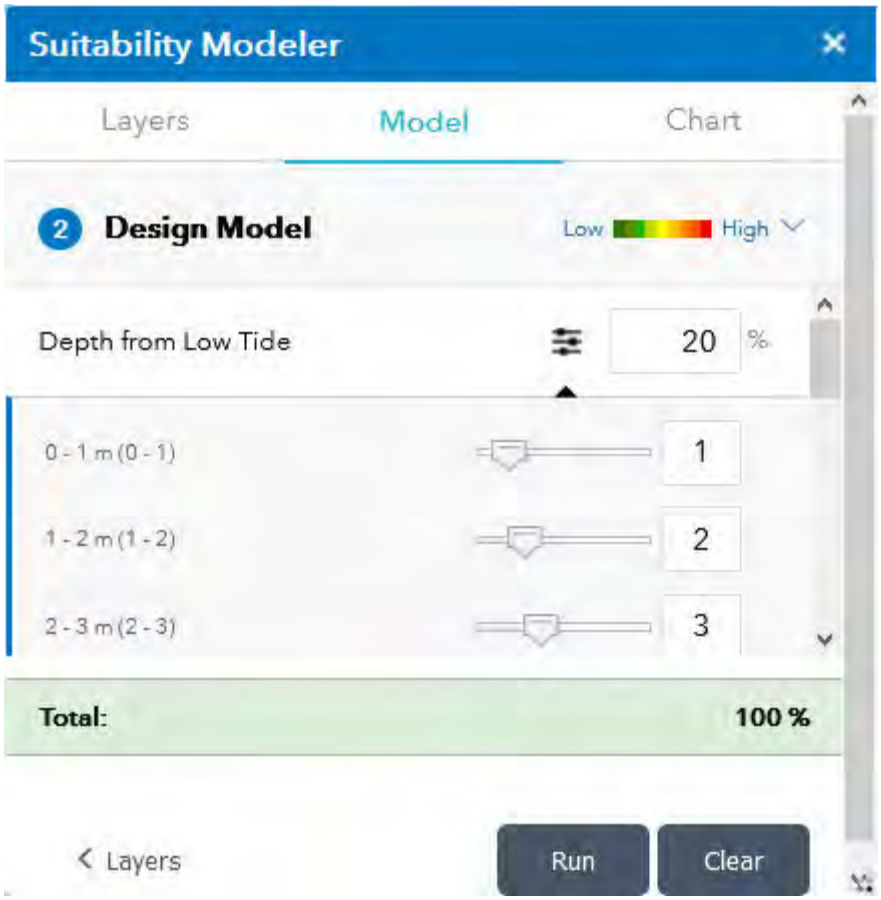
12.2 Suitability Modeller Tool

- The suitability modeller tool allows the user to generate a model of suitable oyster spat collection sites within Pomquet Harbour by conducting a weighted raster overlay analysis.

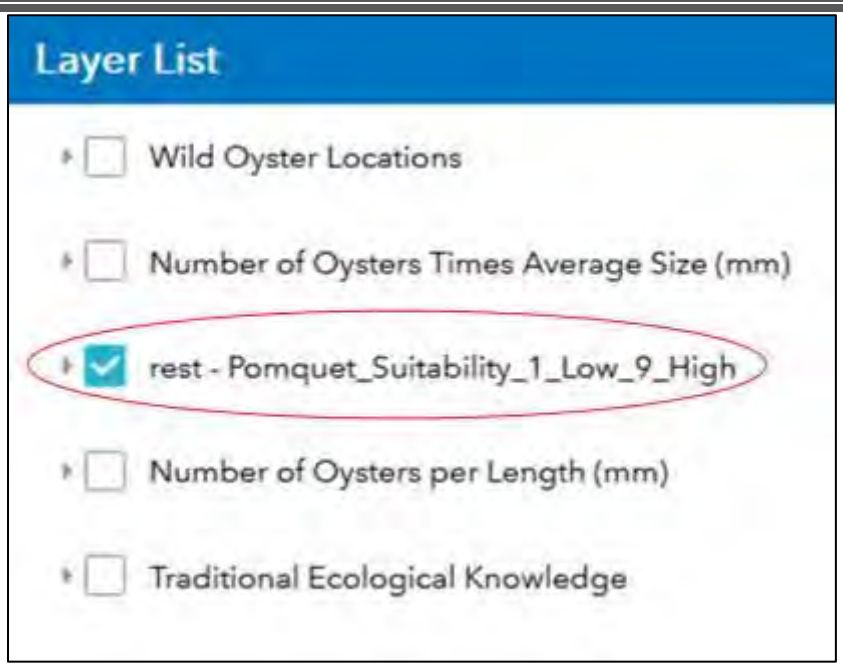
- To design the model, begin by selecting the layers you want to use in your analysis. Scroll down to see the full list of available layers.

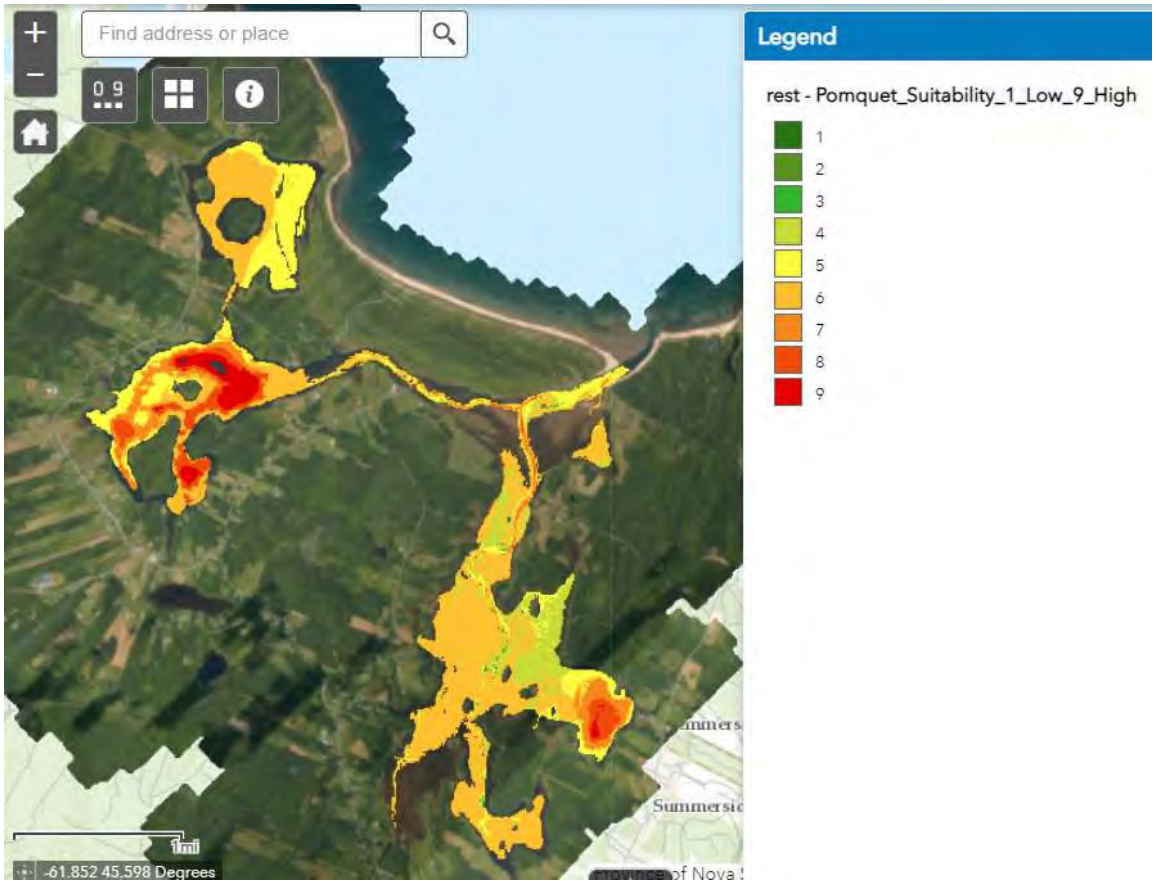


- Click "Design Model".
- Under the Model section, type a number into the percentage (%) text box to assign each layer a relative importance in the analysis. The total percentage must equate to 100 before the analysis can be run.

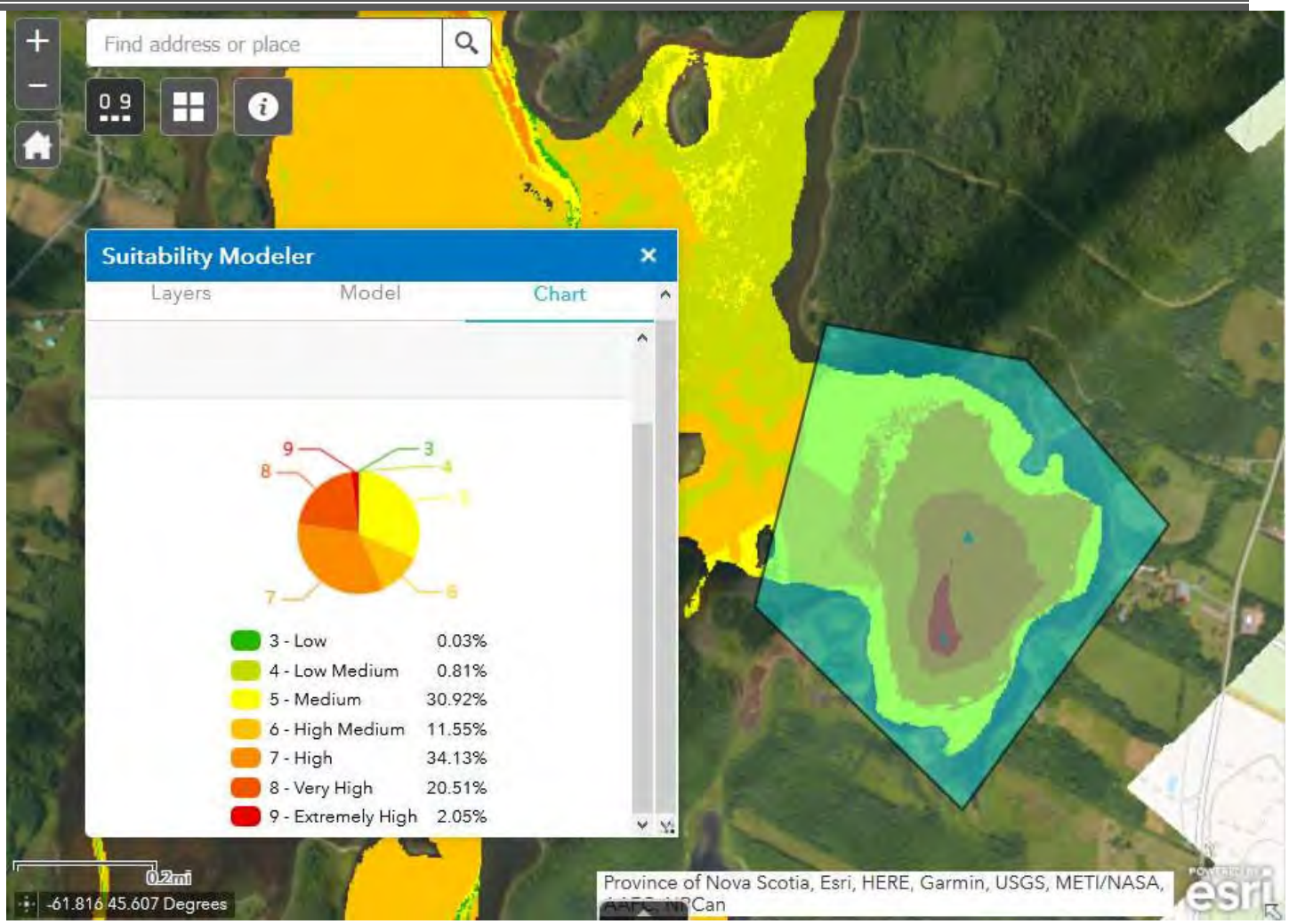


- Users can optionally expand each of the layers to adjust the class weights (1 being least suitable and 9 being most suitable). The class weights will decide how layer values are mapped to a suitability scale.
- To change your model's colour ramp, select the ramp labelled "Low" to "High" in the top right corner of the Suitability Modeller window.
- Click "Run" for a model to appear on the map as a layer.





- Under the Chart section, choose between the features to design a chart of your model. The tools you can use are:
    - Draw a polygon.
        - Click the map to start drawing polygon vertices around your area of interest.



- Draw a freehand polygon.
  - Click and press down your mouse to draw a freehand polygon around your area of interest. Finish your polygon by letting go of the mouse.
- Select from a layer.
  - Begin by choosing one of the available layers from the drop-down list. Users can then click and press down their mouse to select the desired feature from a layer.
- Pan.
  - Click this tool to pan around the model.

- To design a new chart, the user must first select "clear".

Appendix E Aquaculture suitability model inputs

Table listing the layers, their weightings, the classes within the layers, and the class scores used as inputs to an aquaculture suitability tool that conducts a weighted raster overlay analysis according to information collected during the project described in Appendix D: Paqtnkek Aquaculture Bay Management Tool Report.

Layer	Layer Weight (%)	Class	Class Score (0-Not acceptable, 1-low 9-high)	
			NSCC informed model	Project biologist informed model
Depth from low tide (m)	20	0-1	0	1
		1-2	2	5
		2-3	3	9
		3-4	7	9
		4-5	8	9
		5-6	9	9
		6-7	9	9
		7-8	9	9
		8-9	9	9
		9-10	9	9
Ice impact-free depth map	25	Ice Impact Zone	0	0
		Ice Free Zone 1m	1	1
		Ice Free Zone 2m	5	5
		Ice Free Zone 3m	9	9
		Ice Free Zone 4m	9	9
Eelgrass	20	Presence	1	1
		Absence	9	9
Average monthly current speed (m/s)	5	0-0.1	2	2
		0.1-0.2	8	8
		0.2-0.3	9	9
		0.3-0.4	9	9
		0.4-0.5	8	8
		0.5-0.6	7	7
		0.6-0.7	5	5
Flushing rate	10	Very well flushed	9	5
		Well flushed	7	7
		50% flushed after 1 month	5	9
		Poorly flushed	3	7
		Not flushed after 1 month	1	1
Dominant wave height	10	Very low exposure	9	9
		Low exposure	8	9
		Moderate exposure	7	5
		High exposure	4	3
		Very high exposure	2	1
Channel	10	Presence	1	1
		Absence	9	9

DATA REPORT 7145: Paqtnkek Summerside, NS

Prepared 11 January 2022
by J. Pender, Data Manager

CONTENTS OF REPORT

Map 1. A 100 km buffer around the study area

1.0 PREFACE

The Atlantic Canada Conservation Data Centre (AC CDC; www.accdc.com) is part of a network of NatureServe data centres and heritage programs serving 50 states in the U.S.A, 10 provinces and 1 territory in Canada, plus several Central and South American countries. The NatureServe network is more than 30 years old and shares a common conservation data methodology. The AC CDC was founded in 1997, and maintains data for the jurisdictions of New Brunswick, Nova Scotia, Prince Edward Island, and Newfoundland and Labrador. Although a non-governmental agency, the AC CDC is supported by 6 federal agencies and 4 provincial governments, as well as through outside grants and data processing fees.

Upon request and for a fee, the AC CDC queries its database and produces customized reports of the rare and endangered flora and fauna known to occur in or near a specified study area. As a supplement to that data, the AC CDC includes locations of managed areas with some level of protection, and known sites of ecological interest or sensitivity.

1.1 DATA LIST

Included datasets:

Filename	Contents
PaqtnkekSummNS_7145ob.xls	Rare or legally-protected Flora and Fauna in your study area
PaqtnkekSummNS_7145ob100km.xls	A list of Rare and legally protected Flora and Fauna within 100 km of your study area
PaqtnkekSummNS_7145msa.xls	Managed and Biologically Significant Areas in your study area
PaqtnkekSummNS_7145ff_py.xls	Rare Freshwater Fish in your study area (DFO database)

1.2 RESTRICTIONS

The AC CDC makes a strong effort to verify the accuracy of all the data that it manages, but it shall not be held responsible for any inaccuracies in data that it provides. By accepting AC CDC data, recipients assent to the following limits of use:

a) Data is restricted to use by trained personnel who are sensitive to landowner interests and to potential threats to rare and/or endangered flora and fauna posed by the information provided.
b) Data is restricted to use by the specified Data User; any third party requiring data must make its own data request.
c) The AC CDC requires Data Users to cease using and delete data 12 months after receipt, and to make a new request for updated data if necessary at that time.
d) AC CDC data responses are restricted to the data in our Data System at the time of the data request.
e) Each record has an estimate of locational uncertainty, which must be referenced in order to understand the record's relevance to a particular location. Please see attached Data Dictionary for details.
f) AC CDC data responses are not to be construed as exhaustive inventories of taxa in an area.
g) The absence of a taxon cannot be inferred by its absence in an AC CDC data response.

1.3 ADDITIONAL INFORMATION

The accompanying Data Dictionary provides metadata for the data provided.

Please direct any additional questions about AC CDC data to the following individuals:

Plants, Lichens, Ranking Methods, All other Inquiries
Sean Blaney
Senior Scientist / Executive Director
(506) 364-2658
sean.blaney@accdc.ca

Animals (Fauna)
John Klymko
Zoologist
(506) 364-2660
john.klymko@accdc.ca

Plant Communities
Caitlin Porter
Botanist / Community Ecologist
(902) 719-4815
caitlin.porter@accdc.ca

Data Management, GIS
James Churchill
Conservation Data Analyst / Field Biologist
(902) 679-6146
james.churchill@accdc.ca

Billing
Jean Breau
Financial Manager / Executive Assistant
(506) 364-2657
jean.breau@accdc.ca

Questions on the biology of Federal Species at Risk can be directed to AC CDC: (506) 364-2658, with questions on Species at Risk regulations to: Samara Eaton, Canadian Wildlife Service (NB and PE): (506) 364-5060 or Julie McKnight, Canadian Wildlife Service (NS): (902) 426-4196.

For provincial information about rare taxa and protected areas, or information about game animals, deer yards, old growth forests, archeological sites, fish habitat etc., in New Brunswick, please contact Hubert Askanas, Energy and Resource Development: (506) 453-5873.

For provincial information about rare taxa and protected areas, or information about game animals, deer yards, old growth forests, archeological sites, fish habitat etc., in Nova Scotia, please contact Donna Hurlburt, NS DLF: (902) 679-6886. To determine if location-sensitive species (section 4.3) occur near your study site please contact a NS DLF Regional Biologist:

Western: Emma Vost
(902) 670-8187
Emma.Vost@novascotia.ca

Western: Sarah Spencer
(902) 541-0081
Sarah.Spencer@novascotia.ca

Central: Shavonne Meyer
(902) 893-0816
Shavonne.Meyer@novascotia.ca

Central: Kimberly George
(902) 890-1046
Kimberly.George@novascotia.ca

Eastern: Harrison Moore
(902) 497-4119
Harrison.Moore@novascotia.ca

Eastern: Maureen Cameron-MacMillan
(902) 295-2554
Maureen.Cameron-MacMillan@novascotia.ca

Eastern: Elizabeth Walsh
(902) 563-3370
Elizabeth.Walsh@novascotia.ca

For provincial information about rare taxa and protected areas, or information about game animals, fish habitat etc., in Prince Edward Island, please contact Garry Gregory, PEI Dept. of Communities, Land and Environment: (902) 569-7595.

2.0 RARE AND ENDANGERED SPECIES

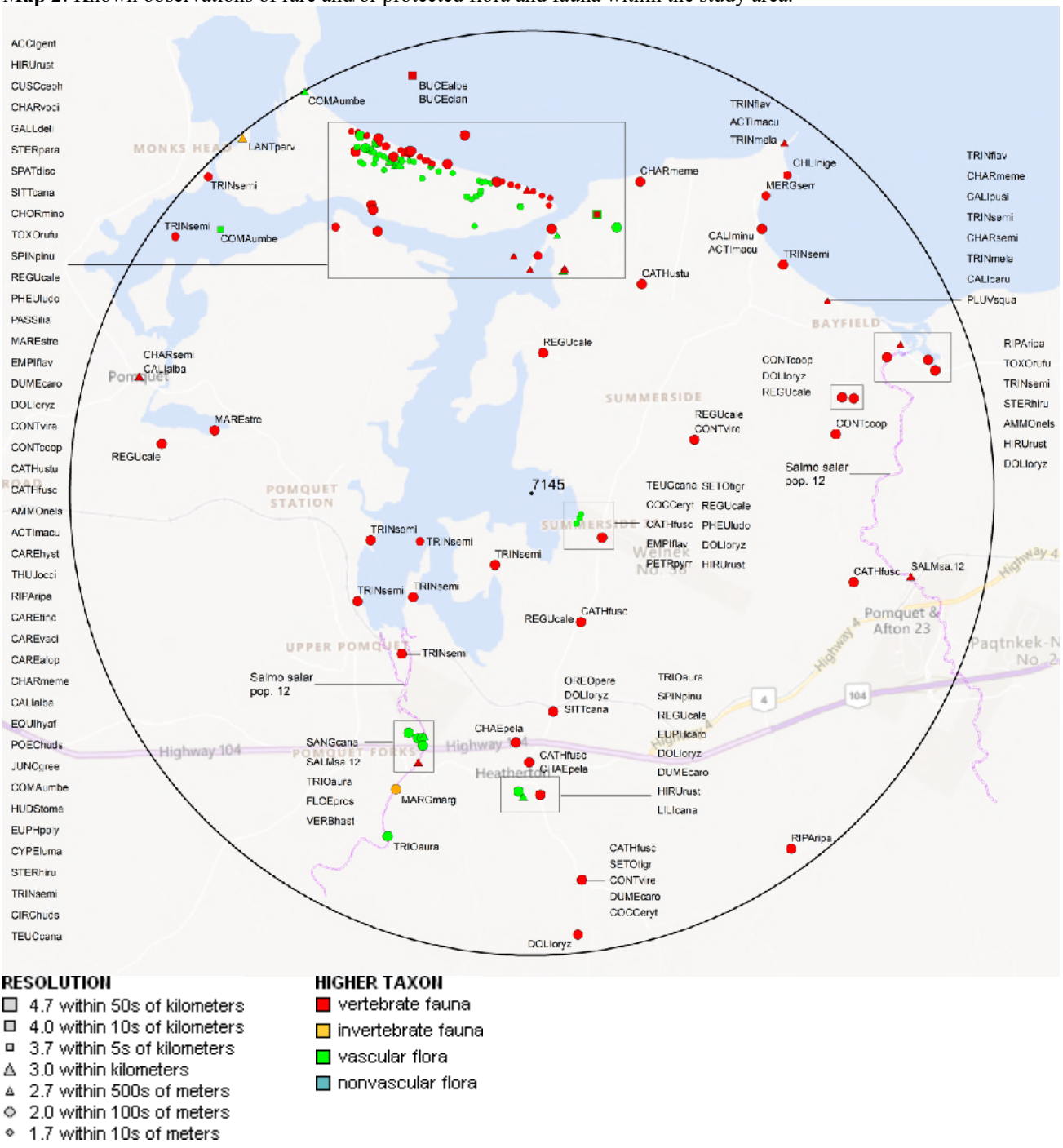
2.1 FLORA

The study area contains 76 records of 18 vascular, no records of nonvascular flora (Map 2 and attached: *ob.xls).

2.2 FAUNA

The study area contains 296 records of 48 vertebrate, 2 records of 2 invertebrate fauna (Map 2 and attached data files - see 1.1 Data List). Please see section 4.3 to determine if 'location-sensitive' species occur near your study site.

Map 2: Known observations of rare and/or protected flora and fauna within the study area.



3.0 SPECIAL AREAS

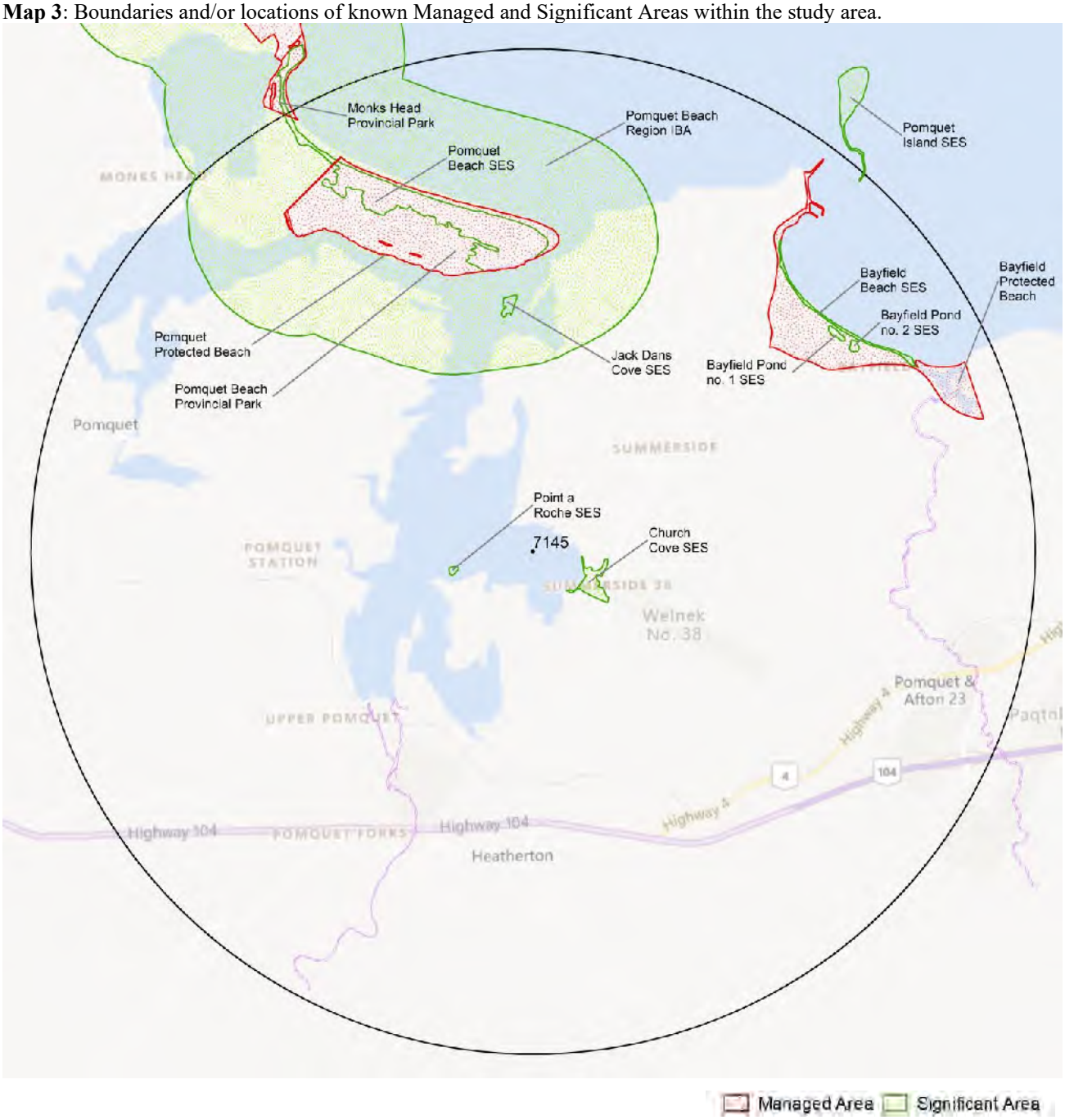
3.1 MANAGED AREAS

The GIS scan identified 5 managed areas in the vicinity of the study area (Map 3 and attached file: *msa.xls).

3.2 SIGNIFICANT AREAS

The GIS scan identified 9 biologically significant sites in the vicinity of the study area (Map 3 and attached file: *msa.xls).

Map 3: Boundaries and/or locations of known Managed and Significant Areas within the study area.



4.0 RARE SPECIES LISTS

Rare and/or endangered taxa (excluding “location-sensitive” species, section 4.3) within the study area listed in order of concern, beginning with legally listed taxa, with the number of observations per taxon and the distance in kilometers from study area centroid to the closest observation (± the precision, in km, of the record). [P] = vascular plant, [N] = nonvascular plant, [A] = vertebrate animal, [I] = invertebrate animal, [C] = community. Note: records are from attached files *ob.xls/*ob.shp only.

4.1 FLORA

	Scientific *Name*	Common Name	COSEWIC	SARA	Prov Legal Prot	Prov Rarity Rank	# recs	Distance (km)
P	*Floerkea proserpinacoides*	False Mermaidweed	Not At Risk			S2	1	2.9 ± 1.0
P	*Thuja occidentalis*	Eastern White Cedar			Vulnerable	S1	1	3.0 ± 0.0
P	*Hudsonia tomentosa*	Woolly Beach-heath				S1	1	3.8 ± 1.0
P	*Carex alopecoidea*	Foxtail Sedge				S1	2	2.4 ± 0.0
P	*Carex tincta*	Tinged Sedge				S1	1	2.4 ± 1.0
P	*Cyperus lupulinus ssp. macilentus*	Hop Flatsedge				S1	8	3.3 ± 0.0
P	*Juncus greenei*	Greene's Rush				S1S2	1	3.9 ± 1.0
P	*Carex vacillans*	Estuarine Sedge				S1S3	2	2.4 ± 0.0
P	*Comandra umbellata*	Bastard's Toadflax				S2	30	3.1 ± 0.0
P	*Carex hystericina*	Porcupine Sedge				S2	1	2.8 ± 0.0
P	*Lilium canadense*	Canada Lily				S2	1	3.3 ± 1.0
P	*Cuscuta cephalanthi*	Buttonbush Dodder				S2?	1	3.1 ± 7.0
P	*Triosteum aurantiacum*	Orange-fruited Tinker's Weed				S2S3	6	2.9 ± 0.0
P	*Euphorbia polygonifolia*	Seaside Spurge				S2S3	2	3.4 ± 0.0
P	*Teucrium canadense*	Canada Germander				S3	4	0.6 ± 0.0
P	*Verbena hastata*	Blue Vervain				S3	1	3.0 ± 0.0
P	*Sanguinaria canadensis*	Bloodroot				S3S4	1	2.9 ± 0.0
P	*Equisetum hyemale ssp. affine*	Common Scouring-rush				S3S4	12	3.4 ± 0.0

4.2 FAUNA

	Scientific *Name*	Common Name	COSEWIC	SARA	Prov Legal Prot	Prov Rarity Rank	# recs	Distance (km)
A	*Charadrius melodus melodus*	Piping Plover melodus ssp	Endangered	Endangered	Endangered	S1B	102	3.1 ± 0.0
A	*Chaetura pelagica*	Chimney Swift	Threatened	Threatened	Endangered	S2B,S1M	2	2.7 ± 0.0
A	*Riparia riparia*	Bank Swallow	Threatened	Threatened	Endangered	S2S3B	9	2.4 ± 0.0
A	*Tringa flavipes*	Lesser Yellowlegs	Threatened			S3M	5	3.8 ± 0.0
A	*Dolichonyx oryzivorus*	Bobolink	Threatened	Threatened	Vulnerable	S3S4B	12	0.9 ± 0.0
A	*Salmo salar pop. 12*	Atlantic Salmon - Gaspe - Southern Gulf of St Lawrence pop.	Special Concern			S1	2	3.2 ± 1.0
A	*Euphagus carolinus*	Rusty Blackbird	Special Concern	Special Concern	Endangered	S2B	1	3.3 ± 0.0
A	*Chordeiles minor*	Common Nighthawk	Special Concern	Threatened	Threatened	S2B	1	3.1 ± 7.0
A	*Contopus cooperi*	Olive-sided Flycatcher	Special Concern	Threatened	Threatened	S2B	7	3.1 ± 7.0
A	*Hirundo rustica*	Barn Swallow	Special Concern	Threatened	Endangered	S2S3B	8	0.9 ± 0.0
A	*Contopus virens*	Eastern Wood-Pewee	Special Concern	Special Concern	Vulnerable	S3S4B	3	1.9 ± 0.0
A	*Chlidonias niger*	Black Tern	Not At Risk			S1B	1	4.4 ± 0.0
A	*Sterna hirundo*	Common Tern	Not At Risk			S3B	8	2.9 ± 0.0
A	*Accipiter gentilis*	Northern Goshawk	Not At Risk			S3S4	1	3.1 ± 7.0
A	*Circus hudsonius*	Northern Harrier	Not At Risk			S3S4B	3	3.1 ± 7.0
A	*Ammospiza nelsoni*	Nelson's Sparrow	Not At Risk			S3S4B	5	3.1 ± 7.0
A	*Calidris canutus rufa*	Red Knot rufa subspecies	E,SC	Endangered	Endangered	S2M	2	3.8 ± 0.0
A	*Toxostoma rufum*	Brown Thrasher				S1B	2	3.1 ± 7.0
A	*Calidris minutilla*	Least Sandpiper				S1B,S3M	3	3.8 ± 0.0
A	*Charadrius semipalmatus*	Semipalmated Plover				S1B,S3S4M	4	3.8 ± 0.0
A	*Mareca strepera*	Gadwall				S2B	2	3.1 ± 7.0
A	*Setophaga tigrina*	Cape May Warbler				S2B	2	0.9 ± 0.0
A	*Bucephala clangula*	Common Goldeneye				S2B,S5N	2	4.7 ± 8.0

	Scientific *Name*	Common Name	COSEWIC	SARA	Prov Legal Prot	Prov Rarity Rank	# recs	Distance (km)
A	*Spinus pinus*	Pine Siskin				S2S3	2	3.1 ± 7.0
A	*Tringa semipalmata*	Willet				S2S3B	30	0.9 ± 0.0
A	*Petrochelidon pyrrhonota*	Cliff Swallow				S2S3B	3	0.9 ± 0.0
A	*Pheucticus ludovicianus*	Rose-breasted Grosbeak				S2S3B	5	0.9 ± 0.0
A	*Poecile hudsonicus*	Boreal Chickadee				S3	5	3.1 ± 7.0
A	*Sitta canadensis*	Red-breasted Nuthatch				S3	2	2.4 ± 0.0
A	*Charadrius vociferus*	Killdeer				S3B	1	3.1 ± 7.0
A	*Gallinago delicata*	Wilson's Snipe				S3B	1	3.1 ± 7.0
A	*Sterna paradisaea*	Arctic Tern				S3B	1	3.1 ± 7.0
A	*Coccyzus erythropthalmus*	Black-billed Cuckoo				S3B	2	0.9 ± 0.0
A	*Dumetella carolinensis*	Gray Catbird				S3B	4	3.1 ± 7.0
A	*Tringa melanoleuca*	Greater Yellowlegs				S3B,S3S4M	2	3.8 ± 0.0
A	*Pluvialis squatarola*	Black-bellied Plover				S3M	1	3.8 ± 0.0
A	*Calidris pusilla*	Semipalmated Sandpiper				S3M	2	3.8 ± 0.0
A	*Calidris alba*	Sanderling				S3M,S2N	2	4.1 ± 0.0
A	*Spatula discors*	Blue-winged Teal				S3S4B	1	3.1 ± 7.0
A	*Actitis macularius*	Spotted Sandpiper				S3S4B	6	3.1 ± 7.0
A	*Empidonax flaviventris*	Yellow-bellied Flycatcher				S3S4B	2	0.9 ± 0.0
A	*Regulus calendula*	Ruby-crowned Kinglet				S3S4B	10	0.9 ± 0.0
A	*Catharus fuscescens*	Veery				S3S4B	20	0.9 ± 0.0
A	*Catharus ustulatus*	Swainson's Thrush				S3S4B	3	2.6 ± 0.0
A	*Oreothlypis peregrina*	Tennessee Warbler				S3S4B	1	2.4 ± 0.0
A	*Passerella iliaca*	Fox Sparrow				S3S4B	1	3.1 ± 7.0
A	*Mergus serrator*	Red-breasted Merganser				S3S4B,S5N	1	4.1 ± 0.0
A	*Bucephala albeola*	Bufflehead				S3S4N	1	4.7 ± 8.0
I	*Margaritifera margaritifera*	Eastern Pearlshell				S2	1	3.5 ± 0.0
I	*Lanthus parvulus*	Northern Pygmy Clubtail				S3S4	1	5.0 ± 1.0

4.3 LOCATION SENSITIVE SPECIES

The Department of Natural Resources in each Maritimes province considers a number of species "location sensitive". Concern about exploitation of location-sensitive species precludes inclusion of precise coordinates in this report. Those intersecting your study area are indicated below with "YES".

Nova Scotia

Scientific *Name*	Common Name	SARA	Prov Legal Prot	Known within the Study Site?
Fraxinus nigra	Black Ash		Threatened	No
Emydoidea blandingii	*Blanding's Turtle - Nova Scotia pop.*	Endangered	Vulnerable	No
Glyptemys insculpta	Wood Turtle	Threatened	Threatened	No
Falco peregrinus pop. 1	Peregrine Falcon - anatum/tundrius pop.	Special Concern	Vulnerable	No
Bat hibernaculum or bat species occurrence		**[Endangered][1]**	**[Endangered][1]**	**YES**

1 *Myotis lucifugus* (Little Brown Myotis), *Myotis septentrionalis* (Long-eared Myotis), and *Perimyotis subflavus* (Tri-colored Bat or Eastern Pipistrelle) are all Endangered under the Federal Species at Risk Act and the NS Endangered Species Act.

4.4 SOURCE BIBLIOGRAPHY

The recipient of these data shall acknowledge the AC CDC and the data sources listed below in any documents, reports, publications or presentations, in which this dataset makes a significant contribution.

# recs	CITATION
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5.0 RARE SPECIES WITHIN 100 KM

A 100 km buffer around the study area contains 34967 records of 151 vertebrate and 731 records of 57 invertebrate fauna; 5623 records of 260 vascular, 2949 records of 121 nonvascular flora (attached: *ob100km.xls).

Taxa within 100 km of the study site that are rare and/or endangered in the province in which the study site occurs (including “location-sensitive” species). All ranks correspond to the province in which the study site falls, even for out-of-province records. Taxa are listed in order of concern, beginning with legally listed taxa, with the number of observations per taxon and the distance in kilometers from study area centroid to the closest observation (± the precision, in km, of the record).

Taxonomic Group	Scientific Name	Common Name	COSEWIC	SARA	Prov Legal Prot	Prov Rarity Rank	# recs	Distance (km)	Prov
A	*Myotis lucifugus*	Little Brown Myotis	Endangered	Endangered	Endangered	S1	61	1.9 ± 0.0	NS
A	*Myotis septentrionalis*	Northern Long-eared Myotis	Endangered	Endangered	Endangered	S1	36	78.2 ± 1.0	PE
A	*Salmo salar pop. 1*	Atlantic Salmon - Inner Bay of Fundy pop.	Endangered	Endangered		S1	1	86.0 ± 0.0	NS
A	*Salmo salar pop. 4*	Atlantic Salmon - Eastern Cape Breton pop.	Endangered			S1	23	41.1 ± 0.0	NS
A	*Salmo salar pop. 6*	Altantic Salmon - Nova Scotia Southern Upland pop.	Endangered			S1	33	20.7 ± 1.0	NS
A	*Eubalaena glacialis*	North Atlantic Right Whale	Endangered	Endangered		S1	1	78.9 ± 1.0	NS
A	*Charadrius melodus melodus*	Piping Plover melodus ssp	Endangered	Endangered	Endangered	S1B	1492	3.1 ± 7.0	NS
A	*Sterna dougallii*	Roseate Tern	Endangered	Endangered	Endangered	S1B	74	54.7 ± 0.0	NS
A	*Dermochelys coriacea (Atlantic pop.)*	Leatherback Sea Turtle - Atlantic pop.	Endangered	Endangered		S1S2N	2	28.6 ± 0.0	NS
A	*Antrostomus vociferus*	Eastern Whip-Poor-Will	Threatened	Threatened	Threatened	S1?B	3	16.0 ± 7.0	NS
A	*Catharus bicknelli*	Bicknell's Thrush	Threatened	Threatened	Endangered	S1S2B	4	70.8 ± 7.0	NS
A	*Asio flammeus*	Short-eared Owl	Threatened	Special Concern		S1S2B	7	48.2 ± 7.0	NS
A	*Limosa haemastica*	Hudsonian Godwit	Threatened			S1S2M	7	10.5 ± 0.0	NS
A	*Glyptemys insculpta*	Wood Turtle	Threatened	Threatened	Threatened	S2	3885	9.7 ± 0.0	NS
A	*Anguilla rostrata*	American Eel	Threatened			S2	3	64.1 ± 0.0	NS
A	*Chaetura pelagica*	Chimney Swift	Threatened	Threatened	Endangered	S2B,S1M	185	2.7 ± 0.0	NS
A	*Riparia riparia*	Bank Swallow	Threatened	Threatened	Endangered	S2S3B	1134	2.4 ± 0.0	NS
A	*Oceanodroma leucorhoa*	Leach's Storm-Petrel	Threatened			S3B,S5M	67	28.4 ± 0.0	NS
A	*Tringa flavipes*	Lesser Yellowlegs	Threatened			S3M	271	3.8 ± 0.0	NS
A	*Dolichonyx oryzivorus*	Bobolink	Threatened	Threatened	Vulnerable	S3S4B	581	0.9 ± 0.0	NS
A	*Sturnella magna*	Eastern Meadowlark	Threatened	Threatened		SHB	2	54.3 ± 0.0	NS
A	*Hylocichla mustelina*	Wood Thrush	Threatened	Threatened		SUB	13	18.6 ± 0.0	NS
A	*Salmo salar pop. 12*	Atlantic Salmon - Gaspe - Southern Gulf of St Lawrence pop.	Special Concern			S1	30	3.2 ± 1.0	NS
A	*Passerculus sandwichensis princeps*	Savannah Sparrow princeps ssp	Special Concern	Special Concern		S1B	2	57.0 ± 7.0	NS
A	*Bucephala islandica (Eastern pop.)*	Barrow's Goldeneye - Eastern pop.	Special Concern	Special Concern		S1N	7	65.7 ± 0.0	NS
A	*Euphagus carolinus*	Rusty Blackbird	Special Concern	Special Concern	Endangered	S2B	232	3.3 ± 0.0	NS
A	*Chordeiles minor*	Common Nighthawk	Special Concern	Threatened	Threatened	S2B	246	3.1 ± 7.0	NS
A	*Contopus cooperi*	Olive-sided Flycatcher	Special Concern	Threatened	Threatened	S2B	1059	3.1 ± 7.0	NS
A	*Histrionicus histrionicus pop. 1*	Harlequin Duck - Eastern pop.	Special Concern	Special Concern	Endangered	S2N	36	49.8 ± 16.0	NS
A	*Balaenoptera physalus*	Fin Whale	Special Concern	Special Concern		S2S3	2	99.6 ± 0.0	NS
A	*Hirundo rustica*	Barn Swallow	Special Concern	Threatened	Endangered	S2S3B	952	0.9 ± 0.0	NS
A	*Morone saxatilis pop. 1*	Striped Bass- Southern Gulf of St Lawrence pop.	Special Concern			S2S3N	1	10.3 ± 1.0	NS
A	*Chelydra serpentina*	Snapping Turtle	Special Concern	Special Concern	Vulnerable	S3	34	11.6 ± 0.0	NS
A	*Cardellina canadensis*	Canada Warbler	Special Concern	Threatened	Endangered	S3B	676	5.8 ± 0.0	NS
A	*Contopus virens*	Eastern Wood-Pewee	Special Concern	Special Concern	Vulnerable	S3S4B	561	1.9 ± 0.0	NS

Taxonomic Group	Scientific Name	Common Name	COSEWIC	SARA	Prov Legal Prot	Prov Rarity Rank	# recs	Distance (km)	Prov
A	*Coccothraustes vespertinus*	Evening Grosbeak	Special Concern	Special Concern	Vulnerable	S3S4B,S3N	560	5.8 ± 0.0	NS
A	*Phocoena phocoena*	Harbour Porpoise	Special Concern			S4	2	28.6 ± 0.0	NS
A	*Podiceps auritus*	Horned Grebe	Special Concern	Special Concern		S4N	7	12.8 ± 0.0	NS
A	*Chrysemys picta picta*	Eastern Painted Turtle	Special Concern			S4S5	2	25.2 ± 1.0	NS
A	*Lynx canadensis*	Canadian Lynx	Not At Risk		Endangered	S1	15	45.6 ± 1.0	NS
A	*Accipiter cooperii*	Cooper's Hawk	Not At Risk			S1?B	2	77.8 ± 0.0	NS
A	*Fulica americana*	American Coot	Not At Risk			S1B	5	85.9 ± 0.0	NS
A	*Chlidonias niger*	Black Tern	Not At Risk			S1B	3	4.4 ± 0.0	NS
A	*Falco peregrinus pop. 1*	Peregrine Falcon - anatum/tundrius	Not At Risk	Special Concern	Vulnerable	S1B,SNAM	4	27.6 ± 0.0	NS
A	*Sorex dispar*	Long-tailed Shrew	Not At Risk			S2	4	73.6 ± 0.0	NS
A	*Aegolius funereus*	Boreal Owl	Not At Risk			S2?B	7	14.3 ± 0.0	NS
A	*Hemidactylium scutatum*	Four-toed Salamander	Not At Risk			S3	13	23.2 ± 0.0	NS
A	*Megaptera novaeangliae*	Humpback Whale (NW Atlantic pop.)	Not At Risk			S3	2	28.6 ± 0.0	NS
A	*Sterna hirundo*	Common Tern	Not At Risk			S3B	529	2.9 ± 0.0	NS
A	*Sialia sialis*	Eastern Bluebird	Not At Risk			S3B	20	21.9 ± 7.0	NS
A	*Buteo lagopus*	Rough-legged Hawk	Not At Risk			S3N	5	25.2 ± 4.0	NS
A	*Accipiter gentilis*	Northern Goshawk	Not At Risk			S3S4	110	3.1 ± 7.0	NS
A	*Lagenorhynchus acutus*	Atlantic White-sided Dolphin	Not At Risk			S3S4	4	29.1 ± 0.0	NS
A	*Circus hudsonius*	Northern Harrier	Not At Risk			S3S4B	295	3.1 ± 7.0	NS
A	*Ammospiza nelsoni*	Nelson's Sparrow	Not At Risk			S3S4B	117	3.1 ± 7.0	NS
A	*Calidris canutus rufa*	Red Knot rufa subspecies	E,SC	Endangered	Endangered	S2M	22	3.8 ± 0.0	NS
A	*Morone saxatilis*	Striped Bass	E,SC			S2S3	2	11.2 ± 0.0	NS
A	*Martes americana*	American Marten			Endangered	S1	4	73.8 ± 1.0	NS
A	*Alces americanus*	Moose			Endangered	S1	125	26.0 ± 0.0	NS
A	*Picoides dorsalis*	American Three-toed Woodpecker				S1?	10	23.8 ± 0.0	NS
A	*Passerina cyanea*	Indigo Bunting				S1?B	8	7.0 ± 7.0	NS
A	*Uria aalge*	Common Murre				S1?B,S5N	1	71.9 ± 0.0	NS
A	*Nycticorax nycticorax*	Black-crowned Night-heron				S1B	2	16.0 ± 7.0	NS
A	*Anas acuta*	Northern Pintail				S1B	12	5.1 ± 1.0	NS
A	*Oxyura jamaicensis*	Ruddy Duck				S1B	2	19.0 ± 0.0	NS
A	*Gallinula galeata*	Common Gallinule				S1B	1	99.3 ± 7.0	NS
A	*Haematopus palliatus*	American Oystercatcher				S1B	7	66.4 ± 7.0	NS
A	*Myiarchus crinitus*	Great Crested Flycatcher				S1B	4	79.6 ± 7.0	NS
A	*Mimus polyglottos*	Northern Mockingbird				S1B	23	16.0 ± 7.0	NS
A	*Toxostoma rufum*	Brown Thrasher				S1B	4	3.1 ± 7.0	NS
A	*Vireo gilvus*	Warbling Vireo				S1B	5	9.8 ± 7.0	NS
A	*Setophaga pinus*	Pine Warbler				S1B	6	33.3 ± 0.0	NS
A	*Calidris minutilla*	Least Sandpiper				S1B,S3M	183	3.8 ± 0.0	NS
A	*Charadrius semipalmatus*	Semipalmated Plover				S1B,S3S4M	341	3.8 ± 0.0	NS
A	*Vespertilionidae sp.*	bat species				S1S2	80	6.7 ± 0.0	NS
A	*Pluvialis dominica*	American Golden-Plover				S1S2M	28	10.5 ± 0.0	NS
A	*Microtus chrotorrhinus*	Rock Vole				S2	10	73.6 ± 0.0	NS
A	*Vireo philadelphicus*	Philadelphia Vireo				S2?B	29	19.5 ± 7.0	NS
A	*Spatula clypeata*	Northern Shoveler				S2B	7	64.3 ± 0.0	NS
A	*Mareca strepera*	Gadwall				S2B	8	3.1 ± 7.0	NS
A	*Empidonax traillii*	Willow Flycatcher				S2B	5	9.8 ± 7.0	NS
A	*Setophaga tigrina*	Cape May Warbler				S2B	227	0.9 ± 0.0	NS
A	*Piranga olivacea*	Scarlet Tanager				S2B	14	31.4 ± 0.0	NS
A	*Pooecetes gramineus*	Vesper Sparrow				S2B	18	19.5 ± 7.0	NS
A	*Molothrus ater*	Brown-headed Cowbird				S2B	66	7.0 ± 7.0	NS
A	*Alca torda*	Razorbill				S2B,S4N	10	85.3 ± 0.0	NS
A	*Bucephala clangula*	Common Goldeneye				S2B,S5N	209	4.7 ± 8.0	NS
A	*Branta bernicla*	Brant				S2M	1	49.8 ± 16.0	NS
A	*Phalacrocorax carbo*	Great Cormorant				S2S3	386	14.9 ± 0.0	NS
A	*Asio otus*	Long-eared Owl				S2S3	27	9.1 ± 0.0	NS

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A	*Spinus pinus*	Pine Siskin				S2S3	445	3.1 ± 7.0	NS
A	*Cathartes aura*	Turkey Vulture				S2S3B	5	65.4 ± 0.0	NS
A	*Rallus limicola*	Virginia Rail				S2S3B	15	9.4 ± 0.0	NS
A	*Tringa semipalmata*	Willet				S2S3B	687	0.9 ± 0.0	NS
A	*Petrochelidon pyrrhonota*	Cliff Swallow				S2S3B	175	0.9 ± 0.0	NS
A	*Pheucticus ludovicianus*	Rose-breasted Grosbeak				S2S3B	428	0.9 ± 0.0	NS
A	*Icterus galbula*	Baltimore Oriole				S2S3B	37	9.8 ± 7.0	NS
A	*Pinicola enucleator*	Pine Grosbeak				S2S3B,S5N	120	16.0 ± 7.0	NS
A	*Numenius phaeopus hudsonicus*	Hudsonian Whimbrel				S2S3M	77	10.5 ± 0.0	NS
A	*Calidris melanotos*	Pectoral Sandpiper				S2S3M	30	12.6 ± 0.0	NS
A	*Perisoreus canadensis*	Canada Jay				S3	535	9.8 ± 7.0	NS
A	*Poecile hudsonicus*	Boreal Chickadee				S3	1132	3.1 ± 7.0	NS
A	*Sitta canadensis*	Red-breasted Nuthatch				S3	965	2.4 ± 0.0	NS
A	*Alosa pseudoharengus*	Alewife				S3	30	39.8 ± 0.0	NS
A	*Salvelinus fontinalis*	Brook Trout				S3	56	5.1 ± 1.0	NS
A	*Salvelinus namaycush*	Lake Trout				S3	1	82.7 ± 0.0	NS
A	*Menidia menidia*	Atlantic Silverside				S3	3	54.6 ± 0.0	NS
A	*Synaptomys cooperi*	Southern Bog Lemming				S3	4	73.6 ± 0.0	NS
A	*Pekania pennanti*	Fisher				S3	7	16.3 ± 0.0	NS
A	*Calidris maritima*	Purple Sandpiper				S3?N	33	31.8 ± 0.0	NS
A	*Calcarius lapponicus*	Lapland Longspur				S3?N	1	13.0 ± 0.0	NS
A	*Falco sparverius*	American Kestrel				S3B	325	7.0 ± 7.0	NS
A	*Charadrius vociferus*	Killdeer				S3B	279	3.1 ± 7.0	NS
A	*Gallinago delicata*	Wilson's Snipe				S3B	721	3.1 ± 7.0	NS
A	*Sterna paradisaea*	Arctic Tern				S3B	99	3.1 ± 7.0	NS
A	*Coccyzus erythropthalmus*	Black-billed Cuckoo				S3B	62	0.9 ± 0.0	NS
A	*Tyrannus tyrannus*	Eastern Kingbird				S3B	132	9.8 ± 7.0	NS
A	*Dumetella carolinensis*	Gray Catbird				S3B	291	3.1 ± 7.0	NS
A	*Cardellina pusilla*	Wilson's Warbler				S3B	135	13.1 ± 0.0	NS
A	*Tringa melanoleuca*	Greater Yellowlegs				S3B,S3S4M	359	3.8 ± 0.0	NS
A	*Rissa tridactyla*	Black-legged Kittiwake				S3B,S5N	4	32.6 ± 3.0	NS
A	*Fratercula arctica*	Atlantic Puffin				S3B,S5N	9	60.2 ± 0.0	NS
A	*Pluvialis squatarola*	Black-bellied Plover				S3M	251	3.8 ± 0.0	NS
A	*Arenaria interpres*	Ruddy Turnstone				S3M	127	5.3 ± 0.0	NS
A	*Calidris pusilla*	Semipalmated Sandpiper				S3M	260	3.8 ± 0.0	NS
A	*Calidris fuscicollis*	White-rumped Sandpiper				S3M	67	12.6 ± 0.0	NS
A	*Limnodromus griseus*	Short-billed Dowitcher				S3M	136	12.6 ± 0.0	NS
A	*Calidris alba*	Sanderling				S3M,S2N	180	4.1 ± 0.0	NS
A	*Chroicocephalus ridibundus*	Black-headed Gull				S3N	22	14.7 ± 0.0	NS
A	*Somateria mollissima*	Common Eider				S3S4	588	10.7 ± 10.0	NS
A	*Picoides arcticus*	Black-backed Woodpecker				S3S4	120	10.5 ± 0.0	NS
A	*Loxia curvirostra*	Red Crossbill				S3S4	89	12.6 ± 0.0	NS
A	*Sorex palustris*	American Water Shrew				S3S4	2	80.5 ± 0.0	PE
A	*Botaurus lentiginosus*	American Bittern				S3S4B	296	6.0 ± 0.0	NS
A	*Spatula discors*	Blue-winged Teal				S3S4B	150	3.1 ± 7.0	NS
A	*Actitis macularius*	Spotted Sandpiper				S3S4B	763	3.1 ± 7.0	NS
A	*Empidonax flaviventris*	Yellow-bellied Flycatcher				S3S4B	1127	0.9 ± 0.0	NS
A	*Regulus calendula*	Ruby-crowned Kinglet				S3S4B	3589	0.9 ± 0.0	NS
A	*Catharus fuscescens*	Veery				S3S4B	554	0.9 ± 0.0	NS
A	*Catharus ustulatus*	Swainson's Thrush				S3S4B	2624	2.6 ± 0.0	NS
A	*Oreothlypis peregrina*	Tennessee Warbler				S3S4B	473	2.4 ± 0.0	NS
A	*Setophaga castanea*	Bay-breasted Warbler				S3S4B	477	7.0 ± 7.0	NS
A	*Setophaga striata*	Blackpoll Warbler				S3S4B	119	13.6 ± 0.0	NS
A	*Passerella iliaca*	Fox Sparrow				S3S4B	132	3.1 ± 7.0	NS
A	*Mergus serrator*	Red-breasted Merganser				S3S4B,S5N	169	4.1 ± 0.0	NS
A	*Bucephala albeola*	Bufflehead				S3S4N	45	4.7 ± 8.0	NS
A	*Lanius borealis*	Northern Shrike				S3S4N	6	71.9 ± 1.0	NS
A	*Leucophaeus atricilla*	Laughing Gull				SHB	3	54.8 ± 0.0	NS

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A	*Progne subis*	Purple Martin				SHB	4	60.2 ± 0.0	NS
A	*Eremophila alpestris*	Horned Lark				SHB,S4S5N	1	95.4 ± 7.0	PE
A	*Morus bassanus*	Northern Gannet				SHB,S5M	75	29.2 ± 0.0	NS
I	*Bombus (Psithyrus) bohemicus*	Gypsy Cuckoo Bumble Bee	Endangered	Endangered	Endangered	S1	7	12.5 ± 5.0	NS
I	*Danaus plexippus*	Monarch	Endangered	Special Concern	Endangered	S2B	73	12.7 ± 0.0	NS
I	*Alasmidonta varicosa*	Brook Floater	Special Concern	Special Concern	Threatened	S1S2	8	24.7 ± 0.0	NS
I	*Bombus terricola*	Yellow-banded Bumblebee	Special Concern	Special Concern	Vulnerable	S3	75	12.7 ± 0.0	NS
I	*Coccinella transversoguttata richardsoni*	Transverse Lady Beetle	Special Concern		Endangered	SH	4	61.2 ± 2.0	NS
I	*Papilio brevicauda bretonensis*	Short-tailed Swallowtail				S1	4	96.2 ± 2.0	NS
I	*Satyrium acadica*	Acadian Hairstreak				S1	7	72.8 ± 2.0	NS
I	*Neurocordulia michaeli*	Broadtailed Shadowdragon				S1	26	45.7 ± 0.0	NS
I	*Lycaena dorcas*	Dorcas Copper				S1?	29	57.0 ± 0.0	NS
I	*Polygonia satyrus*	Satyr Comma				S1?	4	90.2 ± 2.0	PE
I	*Strymon melinus*	Grey Hairstreak				S1S2	2	64.7 ± 0.0	NS
I	*Nymphalis l-album*	Compton Tortoiseshell				S1S2	2	68.5 ± 2.0	NS
I	*Coenagrion resolutum*	Taiga Bluet				S1S2	12	76.7 ± 1.0	PE
I	*Haematopota rara*	Shy Cleg				S1S3	1	85.2 ± 0.0	NS
I	*Lycaena hyllus*	Bronze Copper				S2	11	14.5 ± 0.0	NS
I	*Lycaena dospassosi*	Salt Marsh Copper				S2	7	57.4 ± 0.0	NS
I	*Satyrium calanus*	Banded Hairstreak				S2	1	66.7 ± 2.0	NS
I	*Aglais milberti*	Milbert's Tortoiseshell				S2	4	68.5 ± 2.0	NS
I	*Somatochlora septentrionalis*	Muskeg Emerald				S2	1	91.1 ± 0.0	NS
I	*Somatochlora williamsoni*	Williamson's Emerald				S2	1	100.0 ± 0.0	NS
I	*Margaritifera margaritifera*	Eastern Pearlshell				S2	76	3.5 ± 0.0	NS
I	*Pantala hymenaea*	Spot-Winged Glider				S2?B	2	52.4 ± 1.0	NS
I	*Thorybes pylades*	Northern Cloudywing				S2S3	25	10.1 ± 0.0	NS
I	*Amblyscirtes hegon*	Pepper and Salt Skipper				S2S3	8	46.8 ± 0.0	NS
I	*Satyrium liparops*	Striped Hairstreak				S2S3	8	66.4 ± 2.0	NS
I	*Euphydryas phaeton*	Baltimore Checkerspot				S2S3	50	10.9 ± 0.0	NS
I	*Gomphus descriptus*	Harpoon Clubtail				S2S3	16	40.8 ± 0.0	NS
I	*Ophiogomphus aspersus*	Brook Snaketail				S2S3	5	40.8 ± 0.0	NS
I	*Ophiogomphus mainensis*	Maine Snaketail				S2S3	14	28.1 ± 0.0	NS
I	*Ophiogomphus rupinsulensis*	Rusty Snaketail				S2S3	36	45.7 ± 0.0	NS
I	*Somatochlora forcipata*	Forcipate Emerald				S2S3	7	89.5 ± 1.0	NS
I	*Somatochlora franklini*	Delicate Emerald				S2S3	1	86.3 ± 1.0	PE
I	*Alasmidonta undulata*	Triangle Floater				S2S3	6	25.2 ± 0.0	NS
I	*Naemia seriata*	a Ladybird beetle				S3	1	16.1 ± 0.0	NS
I	*Iphthiminus opacus*	a Darkling Beetle				S3	1	57.2 ± 0.0	NS
I	*Monochamus marmorator*	a Longhorned Beetle				S3	2	49.3 ± 0.0	NS
I	*Callophrys henrici*	Henry's Elfin				S3	2	35.3 ± 0.0	NS
I	*Callophrys lanoraieensis*	Bog Elfin				S3	2	78.7 ± 1.0	NS
I	*Speyeria aphrodite*	Aphrodite Fritillary				S3	7	12.7 ± 2.0	NS
I	*Polygonia faunus*	Green Comma				S3	9	21.9 ± 0.0	NS
I	*Megisto cymela*	Little Wood-satyr				S3	11	62.5 ± 1.0	NS
I	*Oeneis jutta*	Jutta Arctic				S3	11	35.3 ± 0.0	NS
I	*Aeshna clepsydra*	Mottled Darner				S3	3	32.3 ± 0.0	NS
I	*Aeshna constricta*	Lance-Tipped Darner				S3	4	72.7 ± 1.0	NS
I	*Boyeria grafiana*	Ocellated Darner				S3	7	52.7 ± 0.0	NS
I	*Gomphaeschna furcillata*	Harlequin Darner				S3	3	33.9 ± 0.0	NS
I	*Nannothemis bella*	Elfin Skimmer				S3	3	33.9 ± 0.0	NS
I	*Sympetrum danae*	Black Meadowhawk				S3	7	12.6 ± 0.0	NS
I	*Enallagma vernale*	Vernal Bluet				S3	4	33.8 ± 0.0	NS
I	*Amphiagrion saucium*	Eastern Red Damsel				S3	11	57.7 ± 0.0	NS
I	*Cupido comyntas*	Eastern Tailed Blue				S3?	1	80.0 ± 0.0	NS
I	*Polygonia interrogationis*	Question Mark				S3B	27	13.6 ± 0.0	NS
I	*Erynnis juvenalis*	Juvenal's Duskywing				S3S4	1	13.5 ± 1.0	NS
I	*Amblyscirtes vialis*	Common Roadside-Skipper				S3S4	17	40.5 ± 0.0	NS
I	*Polygonia progne*	Grey Comma				S3S4	30	13.6 ± 0.0	NS

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I	*Lanthus parvulus*	Northern Pygmy Clubtail				S3S4	16	5.0 ± 1.0	NS
I	*Lampsilis radiata*	Eastern Lampmussel				S3S4	18	14.9 ± 0.0	NS
N	*Erioderma pedicellatum (Atlantic pop.)*	Boreal Felt Lichen - Atlantic pop.	Endangered	Endangered	Endangered	S1	465	35.5 ± 0.0	NS
N	*Erioderma mollissimum*	Graceful Felt Lichen	Endangered	Endangered	Endangered	S1S2	18	65.8 ± 0.0	NS
N	*Peltigera hydrothyria*	Eastern Waterfan	Threatened	Threatened	Threatened	S1	33	34.1 ± 0.0	NS
N	*Pannaria lurida*	Wrinkled Shingle Lichen	Threatened	Threatened	Threatened	S1S2	23	91.4 ± 0.0	NS
N	*Fuscopannaria leucosticta*	White-rimmed Shingle Lichen	Threatened			S2S3	3	82.0 ± 0.0	NS
N	*Anzia colpodes*	Black-foam Lichen	Threatened	Threatened	Threatened	S3	12	46.5 ± 1.0	NS
N	*Sclerophora peronella (Atlantic pop.)*	Frosted Glass-whiskers (Atlantic population)	Special Concern	Special Concern		S1?	16	20.3 ± 0.0	NS
N	*Pectenia plumbea*	Blue Felt Lichen	Special Concern	Special Concern	Vulnerable	S3	472	25.2 ± 0.0	NS
N	*Fissidens exilis*	Pygmy Pocket Moss	Not At Risk			S1S2	5	8.0 ± 0.0	NS
N	*Pseudevernia cladonia*	Ghost Antler Lichen	Not At Risk			S2S3	3	37.8 ± 0.0	NS
N	*Cinclidium stygium*	Sooty Cupola Moss				S1	2	60.8 ± 0.0	NS
N	*Cladonia brevis*	Short Peg Lichen				S1	1	86.0 ± 0.0	NS
N	*Lathagrium cristatum*	Fingered Jelly Lichen				S1	1	80.5 ± 0.0	NS
N	*Peltigera lepidophora*	Scaly Pelt Lichen				S1	3	80.7 ± 0.0	NS
N	*Hypogymnia hultenii*	Powdered Honeycomb Lichen				S1	17	53.6 ± 0.0	NS
N	*Campylostelium saxicola*	a Moss				S1?	1	99.5 ± 0.0	PE
N	*Conardia compacta*	Coast Creeping Moss				S1?	1	62.3 ± 2.0	NS
N	*Oligotrichum hercynicum*	Hercynian Hair Moss				S1?	1	94.0 ± 0.0	NS
N	*Paludella squarrosa*	Tufted Fen Moss				S1?	1	96.8 ± 5.0	NS
N	*Polychidium muscicola*	Eyed Mossthorns Woollybear Lichen				S1?	2	38.5 ± 0.0	NS
N	*Parmeliella parvula*	Poor-man's Shingles Lichen				S1?	11	38.6 ± 0.0	NS
N	*Sphagnum platyphyllum*	Flat-leaved Peat Moss				S1S2	4	60.6 ± 0.0	NS
N	*Tetrodontium brownianum*	Little Georgia				S1S2	1	99.5 ± 0.0	PE
N	*Cyrto-hypnum minutulum*	Tiny Cedar Moss				S1S2	1	81.9 ± 0.0	NS
N	*Hamatocaulis vernicosus*	a Moss				S1S2	1	60.5 ± 0.0	NS
N	*Enchylium bachmanianum*	Bachman's Jelly Lichen				S1S2	1	86.2 ± 0.0	NS
N	*Enchylium limosum*	Lime-loving Tarpaper Lichen				S1S2	1	99.5 ± 0.0	PE
N	*Peltigera ponojensis*	Pale-bellied Pelt Lichen				S1S2	1	77.3 ± 0.0	NS
N	*Sticta limbata*	Powdered Moon Lichen				S1S2	2	64.9 ± 2.0	NS
N	*Barbilophozia lycopodioides*	Greater Pawwort				S1S3	1	92.6 ± 0.0	NS
N	*Peltigera neckeri*	Black-saddle Pelt Lichen				S1S3	2	16.4 ± 0.0	NS
N	*Nephroma resupinatum*	a lichen				S2	1	15.1 ± 0.0	NS
N	*Riccardia multifida*	Delicate Germanderwort				S2?	1	55.8 ± 0.0	NS
N	*Anacamptodon splachnoides*	a Moss				S2?	1	25.2 ± 0.0	NS
N	*Anomodon viticulosus*	a Moss				S2?	1	61.1 ± 0.0	NS
N	*Atrichum angustatum*	Lesser Smoothcap Moss				S2?	1	16.3 ± 3.0	NS
N	*Drepanocladus polygamus*	Polygamous Hook Moss				S2?	2	80.4 ± 0.0	NS
N	*Pseudocampylium radicale*	Long-stalked Fine Wet Moss				S2?	1	55.3 ± 0.0	NS
N	*Dicranum condensatum*	Condensed Broom Moss				S2?	2	88.5 ± 0.0	PE
N	*Ditrichum rhynchostegium*	a Moss				S2?	1	93.4 ± 0.0	PE
N	*Fissidens taxifolius*	Yew-leaved Pocket Moss				S2?	3	61.1 ± 0.0	NS
N	*Platydictya jungermannioides*	False Willow Moss				S2?	3	13.3 ± 0.0	NS
N	*Pohlia sphagnicola*	a moss				S2?	2	61.9 ± 0.0	NS
N	*Scorpidium scorpioides*	Hooked Scorpion Moss				S2?	11	55.2 ± 0.0	NS
N	*Sphagnum subnitens*	Lustrous Peat Moss				S2?	2	87.2 ± 0.0	NS
N	*Tetraplodon angustatus*	Toothed-leaved Nitrogen Moss				S2?	2	32.3 ± 0.0	NS
N	*Tortella fragilis*	Fragile Twisted Moss				S2?	3	74.8 ± 0.0	NS
N	*Scytinium teretiusculum*	Curly Jellyskin Lichen				S2?	9	13.5 ± 0.0	NS
N	*Cladonia labradorica*	Labrador Lichen				S2?	1	37.2 ± 0.0	NS
N	*Rostania occultata*	Crusted Tarpaper Lichen				S2?	5	45.3 ± 0.0	NS

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N	*Scytinium imbricatum*	Scaly Jellyskin Lichen				S2?	1	68.7 ± 0.0	NS
N	*Nephroma arcticum*	Arctic Kidney Lichen				S2?	2	89.9 ± 0.0	NS
N	*Peltigera collina*	Tree Pelt Lichen				S2?	65	30.5 ± 0.0	NS
N	*Ephemerum serratum*	a Moss				S2S3	1	87.6 ± 3.0	NS
N	*Tetraplodon mnioides*	Entire-leaved Nitrogen Moss				S2S3	1	69.9 ± 0.0	NS
N	*Scorpidium revolvens*	Limprichtia Moss				S2S3	6	60.5 ± 0.0	NS
N	*Collema leptaleum*	Crumpled Bat's Wing Lichen				S2S3	81	23.6 ± 0.0	NS
N	*Solorina saccata*	Woodland Owl Lichen				S2S3	6	20.4 ± 0.0	NS
N	*Ahtiana aurescens*	Eastern Candlewax Lichen				S2S3	5	52.3 ± 6.0	NS
N	*Usnocetraria oakesiana*	Yellow Band Lichen				S2S3	1	97.0 ± 0.0	PE
N	*Cetraria muricata*	Spiny Heath Lichen				S2S3	2	48.6 ± 1.0	NS
N	*Cladonia incrassata*	Powder-foot British Soldiers Lichen				S2S3	1	66.1 ± 0.0	NS
N	*Scytinium tenuissimum*	Birdnest Jellyskin Lichen				S2S3	13	13.0 ± 0.0	NS
N	*Melanohalea septentrionalis*	Northern Camouflage Lichen				S2S3	1	93.2 ± 0.0	PE
N	*Parmelia fertilis*	Fertile Shield Lichen				S2S3	7	48.8 ± 0.0	NS
N	*Parmeliopsis ambigua*	Green Starburst Lichen				S2S3	3	54.7 ± 0.0	NS
N	*Usnea mutabilis*	Bloody Beard Lichen				S2S3	1	52.4 ± 0.0	NS
N	*Usnea rubicunda*	Red Beard Lichen				S2S3	3	50.0 ± 0.0	NS
N	*Stereocaulon condensatum*	Granular Soil Foam Lichen				S2S3	7	34.7 ± 0.0	NS
N	*Cladonia coccifera*	Eastern Boreal Pixie-cup Lichen				S2S3	4	58.6 ± 0.0	NS
N	*Cladonia deformis*	Lesser Sulphur-cup Lichen				S2S3	1	99.2 ± 0.0	PE
N	*Ramalina thrausta*	Angelhair Ramalina Lichen				S3	10	17.0 ± 0.0	NS
N	*Enchylium tenax*	Soil Tarpaper Lichen				S3	3	23.1 ± 0.0	NS
N	*Collema nigrescens*	Blistered Tarpaper Lichen				S3	4	78.5 ± 0.0	NS
N	*Sticta fuliginosa*	Peppered Moon Lichen				S3	20	40.0 ± 0.0	NS
N	*Scytinium subtile*	Appressed Jellyskin Lichen				S3	16	21.9 ± 0.0	NS
N	*Fuscopannaria ahlneri*	Corrugated Shingles Lichen				S3	65	37.7 ± 0.0	NS
N	*Heterodermia speciosa*	Powdered Fringe Lichen				S3	16	43.3 ± 0.0	NS
N	*Heterodermia squamulosa*	Scaly Fringe Lichen				S3	6	71.1 ± 0.0	NS
N	*Leptogium corticola*	Blistered Jellyskin Lichen				S3	20	66.1 ± 0.0	NS
N	*Scytinium lichenoides*	Tattered Jellyskin Lichen				S3	12	10.1 ± 0.0	NS
N	*Nephroma bellum*	Naked Kidney Lichen				S3	9	27.2 ± 0.0	NS
N	*Placynthium nigrum*	Common Ink Lichen				S3	2	70.8 ± 10.0	NS
N	*Platismatia norvegica*	Oldgrowth Rag Lichen				S3	107	33.4 ± 0.0	NS
N	*Moelleropsis nebulosa ssp. frullaniae*	Blue-gray Moss Shingle Lichen				S3	1	69.0 ± 0.0	NS
N	*Moelleropsis nebulosa*	Blue-gray Moss Shingle Lichen				S3	39	37.2 ± 0.0	NS
N	*Fuscopannaria sorediata*	a Lichen				S3	10	38.3 ± 0.0	NS
N	*Ephebe lanata*	Waterside Rockshag Lichen				S3	2	31.6 ± 0.0	NS
N	*Barbula convoluta*	Lesser Bird's-claw Beard Moss				S3?	1	85.1 ± 0.0	PE
N	*Calliergon giganteum*	Giant Spear Moss				S3?	3	77.0 ± 0.0	NS
N	*Anomodon tristis*	a Moss				S3?	1	75.9 ± 0.0	NS
N	*Elodium blandowii*	Blandow's Bog Moss				S3?	2	92.9 ± 3.0	NS
N	*Sphagnum riparium*	Streamside Peat Moss				S3?	1	93.8 ± 0.0	NS
N	*Phaeophyscia pusilloides*	Pompom-tipped Shadow Lichen				S3?	9	31.3 ± 0.0	NS
N	*Cladonia stygia*	Black-footed Reindeer Lichen				S3?	2	73.6 ± 0.0	NS
N	*Dicranella varia*	a Moss				S3S4	4	57.5 ± 0.0	NS
N	*Dicranum leioneuron*	a Dicranum Moss				S3S4	1	58.8 ± 0.0	NS
N	*Encalypta procera*	Slender Extinguisher Moss				S3S4	6	12.0 ± 0.0	NS
N	*Sphagnum lindbergii*	Lindberg's Peat Moss				S3S4	4	61.9 ± 0.0	NS
N	*Splachnum ampullaceum*	Cruet Dung Moss				S3S4	2	79.9 ± 0.0	NS
N	*Thamnobryum alleghaniense*	a Moss				S3S4	25	95.6 ± 0.0	NS

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N	*Schistidium agassizii*	Elf Bloom Moss				S3S4	1	53.9 ± 3.0	NS
N	*Hylocomiastrum pyrenaicum*	a Feather Moss				S3S4	1	80.0 ± 3.0	NS
N	*Arctoparmelia incurva*	Finger Ring Lichen				S3S4	4	71.2 ± 0.0	NS
N	*Hypogymnia vittata*	Slender Monk's Hood Lichen				S3S4	254	29.3 ± 0.0	NS
N	*Leptogium acadiense*	Acadian Jellyskin Lichen				S3S4	29	31.3 ± 0.0	NS
N	*Cladonia floerkeana*	Gritty British Soldiers Lichen				S3S4	1	86.2 ± 0.0	NS
N	*Vahliella leucophaea*	Shelter Shingle Lichen				S3S4	22	32.6 ± 0.0	NS
N	*Melanohalea olivacea*	Spotted Camouflage Lichen				S3S4	3	49.8 ± 0.0	NS
N	*Parmeliopsis hyperopta*	Gray Starburst Lichen				S3S4	5	54.7 ± 0.0	NS
N	*Parmotrema perlatum*	Powdered Ruffle Lichen				S3S4	1	71.2 ± 0.0	NS
N	*Peltigera hymenina*	Cloudy Pelt Lichen				S3S4	2	45.0 ± 0.0	NS
N	*Physconia detersa*	Bottlebrush Frost Lichen				S3S4	7	38.6 ± 0.0	NS
N	*Sphaerophorus fragilis*	Fragile Coral Lichen				S3S4	1	72.0 ± 0.0	NS
N	*Coccocarpia palmicola*	Salted Shell Lichen				S3S4	713	31.0 ± 0.0	NS
N	*Physcia tenella*	Fringed Rosette Lichen				S3S4	2	75.8 ± 3.0	NS
N	*Anaptychia palmulata*	Shaggy Fringed Lichen				S3S4	54	29.6 ± 0.0	NS
N	*Bryoria pikei*	Pike's Horsehair Lichen				S3S4	3	93.4 ± 0.0	PE
N	*Evernia prunastri*	Valley Oakmoss Lichen				S3S4	9	12.2 ± 0.0	NS
N	*Dermatocarpon luridum*	Brookside Stippleback Lichen				S3S4	9	24.1 ± 0.0	NS
N	*Heterodermia neglecta*	Fringe Lichen				S3S4	55	34.1 ± 0.0	NS
P	*Fraxinus nigra*	Black Ash	Threatened		Threatened	S1S2	148	6.0 ± 0.0	NS
P	*Bartonia paniculata ssp. paniculata*	Branched Bartonia	Threatened	Threatened		SNA	1	92.2 ± 10.0	NS
P	*Juncus caesariensis*	New Jersey Rush	Special Concern	Special Concern	Vulnerable	S2	81	83.3 ± 0.0	NS
P	*Floerkea proserpinacoides*	False Mermaidweed	Not At Risk			S2	18	2.9 ± 1.0	NS
P	*Salix candida*	Sage Willow			Endangered	S1	47	69.5 ± 0.0	NS
P	*Thuja occidentalis*	Eastern White Cedar			Vulnerable	S1	4	3.0 ± 0.0	NS
P	*Sanicula odorata*	Clustered Sanicle				S1	8	53.2 ± 0.0	NS
P	*Zizia aurea*	Golden Alexanders				S1	19	5.5 ± 1.0	NS
P	*Antennaria parlinii ssp. fallax*	Parlin's Pussytoes				S1	1	94.5 ± 0.0	NS
P	*Arnica lonchophylla*	Northern Arnica				S1	1	60.8 ± 7.0	NS
P	*Bidens hyperborea*	Estuary Beggarticks				S1	2	10.5 ± 1.0	NS
P	*Ageratina altissima*	White Snakeroot				S1	2	9.8 ± 7.0	NS
P	*Cardamine dentata*	Toothed Bittercress				S1	3	56.0 ± 0.0	NS
P	*Cochlearia tridactylites*	Limestone Scurvy-grass				S1	12	59.9 ± 0.0	NS
P	*Stellaria crassifolia*	Fleshy Stitchwort				S1	2	62.7 ± 2.0	NS
P	*Hudsonia tomentosa*	Woolly Beach-heath				S1	12	3.8 ± 1.0	NS
P	*Desmodium canadense*	Canada Tick-trefoil				S1	10	68.6 ± 0.0	NS
P	*Fraxinus pennsylvanica*	Red Ash				S1	1	85.3 ± 0.0	PE
P	*Bistorta vivipara*	Alpine Bistort				S1	1	70.6 ± 1.0	NS
P	*Montia fontana*	Water Blinks				S1	2	33.7 ± 3.0	NS
P	*Agalinis purpurea var. parviflora*	Small-flowered Purple False Foxglove				S1	2	56.1 ± 0.0	NS
P	*Scrophularia lanceolata*	Lance-leaved Figwort				S1	1	30.4 ± 1.0	NS
P	*Pilea pumila*	Dwarf Clearweed				S1	3	50.6 ± 6.0	NS
P	*Carex alopecoidea*	Foxtail Sedge				S1	2	2.4 ± 0.0	NS
P	*Carex granularis*	Limestone Meadow Sedge				S1	21	56.8 ± 0.0	NS
P	*Carex gynocrates*	Northern Bog Sedge				S1	16	55.8 ± 0.0	NS
P	*Carex haydenii*	Hayden's Sedge				S1	3	32.7 ± 5.0	NS
P	*Carex pellita*	Woolly Sedge				S1	8	68.6 ± 0.0	NS
P	*Carex plantaginea*	Plantain-Leaved Sedge				S1	2	90.7 ± 0.0	NS
P	*Carex tenuiflora*	Sparse-Flowered Sedge				S1	3	58.8 ± 1.0	NS
P	*Carex tincta*	Tinged Sedge				S1	1	2.4 ± 1.0	NS
P	*Carex viridula var. elatior*	Greenish Sedge				S1	54	55.8 ± 0.0	NS
P	*Carex grisea*	Inflated Narrow-leaved Sedge				S1	6	9.7 ± 0.0	NS
P	*Cyperus lupulinus ssp. macilentus*	Hop Flatsedge				S1	15	3.3 ± 0.0	NS
P	*Eleocharis erythropoda*	Red-stemmed Spikerush				S1	2	67.3 ± 0.0	NS

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P	*Rhynchospora capillacea*	Slender Beakrush				S1	8	64.5 ± 1.0	NS
P	*Scirpus atrovirens*	Dark-green Bulrush				S1	1	71.1 ± 0.0	NS
P	*Iris prismatica*	Slender Blue Flag				S1	3	38.8 ± 1.0	NS
P	*Luzula spicata*	Spiked Woodrush				S1	1	9.8 ± 0.0	NS
P	*Triantha glutinosa*	Sticky False-Asphodel				S1	14	69.5 ± 0.0	NS
P	*Malaxis monophyllos var. brachypoda*	North American White Adder's-mouth				S1	1	21.9 ± 7.0	NS
P	*Bromus latiglumis*	Broad-Glumed Brome				S1	15	41.0 ± 0.0	NS
P	*Calamagrostis stricta ssp. inexpansa*	Slim-stemmed Reed Grass				S1	1	84.6 ± 0.0	NS
P	*Elymus wiegandii*	Wiegand's Wild Rye				S1	13	41.2 ± 0.0	NS
P	*Elymus hystrix*	Spreading Wild Rye				S1	1	65.8 ± 1.0	NS
P	*Potamogeton nodosus*	Long-leaved Pondweed				S1	1	70.3 ± 5.0	NS
P	*Sparganium androcladum*	Branching Bur-Reed				S1	3	69.0 ± 1.0	NS
P	*Dryopteris goldiana*	Goldie's Woodfern				S1	1	96.4 ± 0.0	NS
P	*Equisetum palustre*	Marsh Horsetail				S1	8	54.4 ± 0.0	NS
P	*Solidago hispida*	Hairy Goldenrod				S1?	1	75.7 ± 7.0	NS
P	*Bolboschoenus robustus*	Sturdy Bulrush				S1?	2	96.6 ± 5.0	NS
P	*Dichanthelium lindheimeri*	Lindheimer's Panicgrass				S1?	1	63.9 ± 0.0	NS
P	*Rudbeckia laciniata*	Cut-Leaved Coneflower				S1S2	4	9.8 ± 7.0	NS
P	*Betula minor*	Dwarf White Birch				S1S2	1	56.3 ± 0.0	NS
P	*Cornus suecica*	Swedish Bunchberry				S1S2	2	69.5 ± 0.0	NS
P	*Anemone virginiana var. alba*	Virginia Anemone				S1S2	6	59.1 ± 0.0	NS
P	*Hepatica americana*	Round-lobed Hepatica				S1S2	1	91.4 ± 0.0	NS
P	*Ranunculus sceleratus*	Cursed Buttercup				S1S2	1	88.9 ± 7.0	NS
P	*Parnassia parviflora*	Small-flowered Grass-of-Parnassus				S1S2	11	33.4 ± 1.0	NS
P	*Carex livida*	Livid Sedge				S1S2	23	7.1 ± 0.0	NS
P	*Juncus greenei*	Greene's Rush				S1S2	1	3.9 ± 1.0	NS
P	*Juncus alpinoarticulatus ssp. americanus*	Northern Green Rush				S1S2	11	49.4 ± 0.0	NS
P	*Platanthera huronensis*	Fragrant Green Orchid				S1S2	3	30.1 ± 10.0	NS
P	*Calamagrostis stricta ssp. stricta*	Slim-stemmed Reed Grass				S1S2	3	94.6 ± 0.0	PE
P	*Cinna arundinacea*	Sweet Wood Reed Grass				S1S2	24	41.0 ± 0.0	NS
P	*Sparganium hyperboreum*	Northern Burreed				S1S2	4	51.9 ± 0.0	NS
P	*Cryptogramma stelleri*	Steller's Rockbrake				S1S2	17	60.1 ± 0.0	NS
P	*Selaginella selaginoides*	Low Spikemoss				S1S2	2	78.8 ± 0.0	NS
P	*Carex vacillans*	Estuarine Sedge				S1S3	3	2.4 ± 0.0	NS
P	*Conioselinum chinense*	Chinese Hemlock-parsley				S2	1	87.0 ± 5.0	NS
P	*Osmorhiza longistylis*	Smooth Sweet Cicely				S2	24	16.4 ± 0.0	NS
P	*Erigeron philadelphicus*	Philadelphia Fleabane				S2	8	19.5 ± 7.0	NS
P	*Symphyotrichum ciliolatum*	Fringed Blue Aster				S2	3	30.7 ± 0.0	NS
P	*Impatiens pallida*	Pale Jewelweed				S2	25	16.0 ± 7.0	NS
P	*Caulophyllum thalictroides*	Blue Cohosh				S2	36	14.7 ± 0.0	NS
P	*Draba arabisans*	Rock Whitlow-Grass				S2	3	64.7 ± 1.0	NS
P	*Lobelia kalmii*	Brook Lobelia				S2	89	49.3 ± 0.0	NS
P	*Stellaria humifusa*	Saltmarsh Starwort				S2	7	68.0 ± 0.0	NS
P	*Stellaria longifolia*	Long-leaved Starwort				S2	1	41.0 ± 0.0	NS
P	*Oxybasis rubra*	Red Goosefoot				S2	4	16.0 ± 7.0	NS
P	*Hudsonia ericoides*	Pinebarren Golden Heather				S2	10	88.4 ± 0.0	PE
P	*Hypericum majus*	Large St John's-wort				S2	2	83.7 ± 1.0	NS
P	*Crassula aquatica*	Water Pygmyweed				S2	2	70.8 ± 7.0	NS
P	*Myriophyllum farwellii*	Farwell's Water Milfoil				S2	4	20.9 ± 7.0	NS
P	*Myriophyllum verticillatum*	Whorled Water Milfoil				S2	4	76.8 ± 0.0	NS
P	*Utricularia resupinata*	Inverted Bladderwort				S2	1	94.1 ± 0.0	NS
P	*Oenothera fruticosa ssp. tetragona*	Narrow-leaved Evening Primrose				S2	2	70.5 ± 7.0	NS
P	*Persicaria arifolia*	Halberd-leaved Tearthumb				S2	9	24.4 ± 0.0	NS
P	*Rumex triangulivalvis*	Triangular-valve Dock				S2	4	42.7 ± 10.0	NS
P	*Primula mistassinica*	Mistassini Primrose				S2	1	96.6 ± 7.0	NS

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P	*Anemonastrum canadense*	Canada Anemone				S2	2	19.1 ± 1.0	NS
P	*Anemone quinquefolia*	Wood Anemone				S2	14	46.4 ± 0.0	NS
P	*Anemone virginiana*	Virginia Anemone				S2	31	9.7 ± 0.0	NS
P	*Caltha palustris*	Yellow Marsh Marigold				S2	40	19.2 ± 0.0	NS
P	*Galium labradoricum*	Labrador Bedstraw				S2	83	52.2 ± 0.0	NS
P	*Salix pedicellaris*	Bog Willow				S2	13	53.5 ± 0.0	NS
P	*Salix sericea*	Silky Willow				S2	1	95.3 ± 0.0	NS
P	*Comandra umbellata*	Bastard's Toadflax				S2	32	3.1 ± 0.0	NS
P	*Saxifraga paniculata ssp. laestadii*	Laestadius' Saxifrage				S2	1	59.2 ± 7.0	NS
P	*Tiarella cordifolia*	Heart-leaved Foamflower				S2	10	43.1 ± 3.0	NS
P	*Viola nephrophylla*	Northern Bog Violet				S2	13	41.8 ± 0.0	NS
P	*Carex bebbii*	Bebb's Sedge				S2	27	11.6 ± 10.0	NS
P	*Carex castanea*	Chestnut Sedge				S2	15	59.5 ± 0.0	NS
P	*Carex comosa*	Bearded Sedge				S2	3	83.0 ± 1.0	NS
P	*Carex hystericina*	Porcupine Sedge				S2	34	2.8 ± 0.0	NS
P	*Carex tenera*	Tender Sedge				S2	5	17.4 ± 1.0	NS
P	*Carex tuckermanii*	Tuckerman's Sedge				S2	1	80.2 ± 0.0	NS
P	*Carex atratiformis*	Scabrous Black Sedge				S2	2	65.1 ± 1.0	NS
P	*Eleocharis quinqueflora*	Few-flowered Spikerush				S2	23	49.9 ± 0.0	NS
P	*Juncus stygius ssp. americanus*	Moor Rush				S2	28	78.7 ± 1.0	NS
P	*Allium schoenoprasum*	Wild Chives				S2	1	72.8 ± 3.0	NS
P	*Allium schoenoprasum var. sibiricum*	Wild Chives				S2	1	61.1 ± 7.0	NS
P	*Lilium canadense*	Canada Lily				S2	67	3.3 ± 1.0	NS
P	*Cypripedium parviflorum var. pubescens*	Yellow Lady's-slipper				S2	32	10.1 ± 0.0	NS
P	*Cypripedium parviflorum var. makasin*	Small Yellow Lady's-Slipper				S2	14	25.7 ± 0.0	NS
P	*Cypripedium reginae*	Showy Lady's-Slipper				S2	365	21.6 ± 0.0	NS
P	*Platanthera flava var. herbiola*	Pale Green Orchid				S2	6	29.2 ± 1.0	NS
P	*Platanthera macrophylla*	Large Round-Leaved Orchid				S2	2	95.8 ± 5.0	NS
P	*Spiranthes lucida*	Shining Ladies'-Tresses				S2	42	30.7 ± 1.0	NS
P	*Calamagrostis stricta*	Slim-stemmed Reed Grass				S2	5	94.9 ± 0.0	PE
P	*Dichanthelium linearifolium*	Narrow-leaved Panic Grass				S2	1	69.6 ± 7.0	NS
P	*Potamogeton friesii*	Fries' Pondweed				S2	15	41.5 ± 0.0	NS
P	*Potamogeton richardsonii*	Richardson's Pondweed				S2	10	41.2 ± 1.0	NS
P	*Cystopteris laurentiana*	Laurentian Bladder Fern				S2	6	64.8 ± 1.0	NS
P	*Dryopteris fragrans*	Fragrant Wood Fern				S2	3	31.5 ± 7.0	NS
P	*Polystichum lonchitis*	Northern Holly Fern				S2	5	51.5 ± 100.0	NS
P	*Woodsia glabella*	Smooth Cliff Fern				S2	3	64.8 ± 0.0	NS
P	*Symphyotrichum boreale*	Boreal Aster				S2?	64	55.7 ± 0.0	NS
P	*Cuscuta cephalanthi*	Buttonbush Dodder				S2?	7	3.1 ± 7.0	NS
P	*Epilobium coloratum*	Purple-veined Willowherb				S2?	8	11.1 ± 0.0	NS
P	*Rumex persicarioides*	Peach-leaved Dock				S2?	1	85.9 ± 0.0	NS
P	*Crataegus submollis*	Quebec Hawthorn				S2?	2	29.4 ± 7.0	NS
P	*Eleocharis ovata*	Ovate Spikerush				S2?	1	30.6 ± 0.0	NS
P	*Scirpus pedicellatus*	Stalked Bulrush				S2?	6	41.0 ± 0.0	NS
P	*Hieracium robinsonii*	Robinson's Hawkweed				S2S3	1	99.3 ± 7.0	NS
P	*Senecio pseudoarnica*	Seabeach Ragwort				S2S3	9	33.1 ± 1.0	NS
P	*Betula michauxii*	Michaux's Dwarf Birch				S2S3	19	50.1 ± 0.0	NS
P	*Sagina nodosa*	Knotted Pearlwort				S2S3	3	68.6 ± 1.0	NS
P	*Sagina nodosa ssp. borealis*	Knotted Pearlwort				S2S3	1	90.5 ± 5.0	PE
P	*Hypericum x dissimulatum*	Disguised St. John's-wort				S2S3	1	36.0 ± 1.0	NS
P	*Triosteum aurantiacum*	Orange-fruited Tinker's Weed				S2S3	173	2.9 ± 1.0	NS
P	*Shepherdia canadensis*	Soapberry				S2S3	38	51.8 ± 0.0	NS
P	*Empetrum atropurpureum*	Purple Crowberry				S2S3	2	69.5 ± 3.0	NS
P	*Euphorbia polygonifolia*	Seaside Spurge				S2S3	14	3.4 ± 0.0	NS
P	*Halenia deflexa*	Spurred Gentian				S2S3	23	32.4 ± 0.0	NS
P	*Hedeoma pulegioides*	American False Pennyroyal				S2S3	2	29.3 ± 5.0	NS
P	*Polygonum aviculare ssp. buxiforme*	Box Knotweed				S2S3	1	66.3 ± 0.0	NS

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P	*Polygonum oxyspermum ssp. raii*	Ray's Knotweed				S2S3	11	36.5 ± 1.0	NS
P	*Amelanchier fernaldii*	Fernald's Serviceberry				S2S3	4	54.1 ± 1.0	NS
P	*Potentilla canadensis*	Canada Cinquefoil				S2S3	1	49.3 ± 2.0	NS
P	*Galium aparine*	Common Bedstraw				S2S3	3	10.0 ± 0.0	NS
P	*Salix pellita*	Satiny Willow				S2S3	4	32.8 ± 1.0	NS
P	*Carex adusta*	Lesser Brown Sedge				S2S3	1	70.9 ± 5.0	NS
P	*Carex hirtifolia*	Pubescent Sedge				S2S3	26	16.7 ± 0.0	NS
P	*Eleocharis flavescens var. olivacea*	Bright-green Spikerush				S2S3	3	15.3 ± 5.0	NS
P	*Eriophorum gracile*	Slender Cottongrass				S2S3	8	53.4 ± 0.0	NS
P	*Oreojuncus trifidus*	Highland Rush				S2S3	2	77.0 ± 0.0	NS
P	*Cypripedium parviflorum*	Yellow Lady's-slipper				S2S3	89	10.2 ± 0.0	NS
P	*Poa glauca*	Glaucous Blue Grass				S2S3	9	64.7 ± 1.0	NS
P	*Stuckenia filiformis*	Thread-leaved Pondweed				S2S3	36	43.2 ± 0.0	NS
P	*Botrychium lanceolatum ssp. angustisegmentum*	Narrow Triangle Moonwort				S2S3	13	49.4 ± 3.0	NS
P	*Botrychium simplex*	Least Moonwort				S2S3	3	29.5 ± 1.0	NS
P	*Ophioglossum pusillum*	Northern Adder's-tongue				S2S3	1	99.0 ± 0.0	NS
P	*Angelica atropurpurea*	Purple-stemmed Angelica				S3	29	40.7 ± 0.0	NS
P	*Erigeron hyssopifolius*	Hyssop-leaved Fleabane				S3	48	10.1 ± 0.0	NS
P	*Hieracium paniculatum*	Panicled Hawkweed				S3	5	95.5 ± 0.0	NS
P	*Bidens beckii*	Water Beggarticks				S3	9	18.5 ± 0.0	NS
P	*Packera paupercula*	Balsam Groundsel				S3	125	9.4 ± 0.0	NS
P	*Betula pumila var. pumila*	Bog Birch				S3	1	66.8 ± 7.0	NS
P	*Betula pumila*	Bog Birch				S3	18	54.7 ± 0.0	NS
P	*Campanula aparinoides*	Marsh Bellflower				S3	19	32.0 ± 0.0	NS
P	*Viburnum edule*	Squashberry				S3	2	91.9 ± 0.0	NS
P	*Empetrum eamesii*	Pink Crowberry				S3	4	88.7 ± 0.0	PE
P	*Vaccinium boreale*	Northern Blueberry				S3	8	54.1 ± 1.0	NS
P	*Vaccinium cespitosum*	Dwarf Bilberry				S3	46	45.8 ± 0.0	NS
P	*Bartonia virginica*	Yellow Bartonia				S3	1	71.5 ± 0.0	NS
P	*Proserpinaca palustris*	Marsh Mermaidweed				S3	50	19.2 ± 0.0	NS
P	*Proserpinaca pectinata*	Comb-leaved Mermaidweed				S3	2	85.9 ± 1.0	NS
P	*Teucrium canadense*	Canada Germander				S3	69	0.6 ± 0.0	NS
P	*Decodon verticillatus*	Swamp Loosestrife				S3	5	61.6 ± 7.0	NS
P	*Epilobium hornemannii*	Hornemann's Willowherb				S3	2	96.9 ± 2.0	NS
P	*Epilobium strictum*	Downy Willowherb				S3	39	13.3 ± 0.0	NS
P	*Polygala sanguinea*	Blood Milkwort				S3	5	40.5 ± 0.0	NS
P	*Persicaria pensylvanica*	Pennsylvania Smartweed				S3	17	9.8 ± 0.0	NS
P	*Fallopia scandens*	Climbing False Buckwheat				S3	26	9.8 ± 7.0	NS
P	*Plantago rugelii*	Rugel's Plantain				S3	2	68.9 ± 0.0	NS
P	*Samolus parviflorus*	Seaside Brookweed				S3	21	9.8 ± 0.0	NS
P	*Pyrola asarifolia*	Pink Pyrola				S3	10	51.5 ± 0.0	NS
P	*Pyrola minor*	Lesser Pyrola				S3	6	66.6 ± 2.0	NS
P	*Ranunculus gmelinii*	Gmelin's Water Buttercup				S3	109	13.3 ± 0.0	NS
P	*Endotropis alnifolia*	alder-leaved buckthorn				S3	504	22.1 ± 0.0	NS
P	*Agrimonia gryposepala*	Hooked Agrimony				S3	229	9.3 ± 0.0	NS
P	*Amelanchier spicata*	Running Serviceberry				S3	8	9.7 ± 5.0	NS
P	*Galium kamtschaticum*	Northern Wild Licorice				S3	9	62.5 ± 0.0	NS
P	*Geocaulon lividum*	Northern Comandra				S3	76	29.1 ± 2.0	NS
P	*Limosella australis*	Southern Mudwort				S3	10	72.6 ± 0.0	PE
P	*Lindernia dubia*	Yellow-seeded False Pimperel				S3	13	24.3 ± 0.0	NS
P	*Laportea canadensis*	Canada Wood Nettle				S3	24	16.5 ± 0.0	NS
P	*Verbena hastata*	Blue Vervain				S3	60	3.0 ± 0.0	NS
P	*Carex cryptolepis*	Hidden-scaled Sedge				S3	12	14.7 ± 1.0	NS
P	*Carex eburnea*	Bristle-leaved Sedge				S3	103	10.3 ± 5.0	NS
P	*Carex lupulina*	Hop Sedge				S3	12	13.4 ± 0.0	NS
P	*Carex rosea*	Rosy Sedge				S3	9	17.5 ± 0.0	NS
P	*Carex tribuloides*	Blunt Broom Sedge				S3	14	24.6 ± 0.0	NS

Taxonomic Group	Scientific Name	Common Name	COSEWIC	SARA	Prov Legal Prot	Prov Rarity Rank	# recs	Distance (km)	Prov
P	*Carex wiegandii*	Wiegand's Sedge				S3	3	36.4 ± 0.0	NS
P	*Carex foenea*	Fernald's Hay Sedge				S3	2	36.0 ± 0.0	NS
P	*Schoenoplectus americanus*	Olney's Bulrush				S3	1	9.8 ± 0.0	NS
P	*Elodea canadensis*	Canada Waterweed				S3	8	75.0 ± 0.0	NS
P	*Juncus subcaudatus*	Woods-Rush				S3	8	40.9 ± 0.0	NS
P	*Juncus dudleyi*	Dudley's Rush				S3	93	46.4 ± 0.0	NS
P	*Goodyera oblongifolia*	Menzies' Rattlesnake-plantain				S3	6	83.6 ± 10.0	NS
P	*Goodyera repens*	Lesser Rattlesnake-plantain				S3	30	42.2 ± 0.0	NS
P	*Neottia bifolia*	Southern Twayblade				S3	50	35.0 ± 0.0	NS
P	*Platanthera grandiflora*	Large Purple Fringed Orchid				S3	84	14.4 ± 5.0	NS
P	*Platanthera hookeri*	Hooker's Orchid				S3	3	17.4 ± 0.0	NS
P	*Platanthera orbiculata*	Small Round-leaved Orchid				S3	22	17.1 ± 0.0	NS
P	*Spiranthes ochroleuca*	Yellow Ladies'-tresses				S3	12	55.8 ± 0.0	NS
P	*Alopecurus aequalis*	Short-awned Foxtail				S3	10	13.5 ± 0.0	NS
P	*Dichanthelium clandestinum*	Deer-tongue Panic Grass				S3	81	45.4 ± 0.0	NS
P	*Potamogeton obtusifolius*	Blunt-leaved Pondweed				S3	22	10.8 ± 1.0	NS
P	*Potamogeton praelongus*	White-stemmed Pondweed				S3	17	21.5 ± 1.0	NS
P	*Potamogeton zosteriformis*	Flat-stemmed Pondweed				S3	8	71.0 ± 0.0	NS
P	*Sparganium natans*	Small Burreed				S3	16	19.2 ± 0.0	NS
P	*Asplenium trichomanes*	Maidenhair Spleenwort				S3	4	31.3 ± 0.0	NS
P	*Asplenium viride*	Green Spleenwort				S3	20	33.3 ± 0.0	NS
P	*Equisetum pratense*	Meadow Horsetail				S3	20	47.2 ± 0.0	NS
P	*Equisetum variegatum*	Variegated Horsetail				S3	43	14.2 ± 0.0	NS
P	*Isoetes tuckermanii ssp. acadiensis*	Acadian Quillwort				S3	3	34.2 ± 0.0	NS
P	*Diphasiastrum sitchense*	Sitka Ground-cedar				S3	22	29.5 ± 1.0	NS
P	*Huperzia appressa*	Mountain Firmoss				S3	1	55.2 ± 1.0	NS
P	*Sceptridium dissectum*	Dissected Moonwort				S3	4	35.6 ± 1.0	NS
P	*Polypodium appalachianum*	Appalachian Polypody				S3	9	66.2 ± 0.0	NS
P	*Bidens vulgata*	Tall Beggarticks				S3?	1	66.7 ± 0.0	NS
P	*Persicaria amphibia var. emersa*	Long-root Smartweed				S3?	1	24.4 ± 0.0	NS
P	*Diphasiastrum x sabinifolium*	Savin-leaved Ground-cedar				S3?	9	29.9 ± 5.0	NS
P	*Atriplex glabriuscula var. franktonii*	Frankton's Saltbush				S3S4	4	35.0 ± 0.0	NS
P	*Suaeda calceoliformis*	Horned Sea-blite				S3S4	8	27.3 ± 0.0	NS
P	*Myriophyllum sibiricum*	Siberian Water Milfoil				S3S4	13	9.7 ± 0.0	NS
P	*Nuphar microphylla*	Small Yellow Pond-lily				S3S4	1	75.3 ± 2.0	NS
P	*Sanguinaria canadensis*	Bloodroot				S3S4	187	2.9 ± 0.0	NS
P	*Polygonum fowleri*	Fowler's Knotweed				S3S4	2	9.8 ± 0.0	NS
P	*Rumex fueginus*	Tierra del Fuego Dock				S3S4	6	67.4 ± 0.0	NS
P	*Fragaria vesca ssp. americana*	Woodland Strawberry				S3S4	54	11.9 ± 0.0	NS
P	*Fragaria vesca*	Woodland Strawberry				S3S4	1	71.2 ± 0.0	NS
P	*Salix petiolaris*	Meadow Willow				S3S4	6	53.5 ± 0.0	NS
P	*Agalinis neoscotica*	Nova Scotia Agalinis				S3S4	3	44.8 ± 0.0	NS
P	*Carex argyrantha*	Silvery-flowered Sedge				S3S4	2	80.7 ± 5.0	PE
P	*Eriophorum russeolum*	Russet Cottongrass				S3S4	5	34.6 ± 5.0	NS
P	*Triglochin gaspensis*	Gasp ├⌐ Arrowgrass				S3S4	9	44.2 ± 0.0	NS
P	*Juncus acuminatus*	Sharp-Fruit Rush				S3S4	4	24.5 ± 0.0	NS
P	*Luzula parviflora ssp. melanocarpa*	Black-fruited Woodrush				S3S4	5	51.4 ± 0.0	NS
P	*Liparis loeselii*	Loesel's Twayblade				S3S4	17	32.2 ± 0.0	NS
P	*Panicum philadelphicum*	Philadelphia Panicgrass				S3S4	1	56.4 ± 0.0	NS
P	*Trisetum spicatum*	Narrow False Oats				S3S4	2	70.0 ± 0.0	NS
P	*Cystopteris bulbifera*	Bulblet Bladder Fern				S3S4	300	9.4 ± 0.0	NS
P	*Equisetum hyemale ssp. affine*	Common Scouring-rush				S3S4	43	3.4 ± 0.0	NS
P	*Equisetum scirpoides*	Dwarf Scouring-Rush				S3S4	67	46.6 ± 0.0	NS
P	*Diphasiastrum complanatum*	Northern Ground-cedar				S3S4	5	61.6 ± 5.0	NS
P	*Schizaea pusilla*	Little Curlygrass Fern				S3S4	11	40.5 ± 0.0	NS
P	*Viola canadensis*	Canada Violet				SH	1	60.2 ± 0.0	NS

5.1 SOURCE BIBLIOGRAPHY (100 km)

The recipient of these data shall acknowledge the AC CDC and the data sources listed below in any documents, reports, publications or presentations, in which this dataset makes a significant contribution.

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10	Cameron, R.P. 2017. 2017 rare species field data. Nova Scotia Environment, 64 recs.
10	Curley, F.R. 2005. PEF&W Collection 2003-04. PEI Fish & Wildlife Div., 716 recs.
10	e-Butterfly. 2019. Export of Maritimes records and photos. McFarland, K. (ed.) e-butterfly.org.
10	Erskine, D. 1960. The plants of Prince Edward Island, 1st Ed. Research Branch, Agriculture Canada, Ottawa., Publication 1088. 1238 recs.
10	Holder, M.L.; Kingsley, A.L. 2000. Kinglsey and Holder observations from 2000 field work.
10	McNeil, J.A. 2020. Snapping Turtle and Eastern Painted Turtle records, 2020. Mersey Tobeatic Research Institute.
10	Munro, Marian K. Nova Scotia Provincial Museum of Natural History Herbarium Database. Nova Scotia Provincial Museum of Natural History, Halifax, Nova Scotia. 2014.
10	NatureServe Canada. 2019. iNaturalist Maritimes Butterfly Records. iNaturalist.org and iNaturalist.ca.
10	Newell, R.E. 2004. Assessment and update status report on the New Jersey Rush (Juncus caesariensis) in Canada. Committee on the Status of Endangered Wildlife in Canada, 15 recs.
9	Bryson, I. 2020. Nova Scotia and Newfoundland rare species observations, 2018-2020. Nova Scotia Environment.
9	Gilhen, J. 1984. Amphibians & Reptiles of Nova Scotia, 1st Ed. Nova Scotia Museum, 164pp.
9	Neily, T.H. Tom Neily NS Sphagnum records (2009-2014). T.H. Neily, Atlantic Canada Conservation Data Centre. 2019.
9	Ogden, K. Nova Scotia Museum butterfly specimen database. Nova Scotia Museum. 2017.
9	Phinney, Lori; Toms, Brad; et. al. 2016. Bank Swallows (Riparia riparia) in Nova Scotia: inventory and assessment of colonies. Merset Tobeiatc Research Institute, 25 recs.
9	Whittam, R.M. 1999. Status Report on the Roseate Tern (update) in Canada. Committee on the Status of Endangered Wildlife in Canada, 36 recs.
8	Belland, R.J. Maritimes moss records from various herbarium databases. 2014.
8	Benjamin, L.K. 2009. Boreal Felt Lichen, Mountain Avens, Orchid and other recent records. Nova Scotia Dept Natural Resources, 105 recs.
8	Blaney, C.S.; Spicer, C.D.; Rothfels, C. 2004. Fieldwork 2004. Atlantic Canada Conservation Data Centre. Sackville NB, 1343 recs.
8	Neily, T. H. 2018. Lichen and Bryophyte records, AEI 2017-2018. Tom Neily; Atlantic Canada Conservation Data Centre.
8	NS DNR. 2017. Black Ash records from NS DNR Permanent Sample Plots (PSPs), 1965-2016. NS Dept of Natural Resources.
8	Oldham, M.J. 2000. Oldham database records from Maritime provinces. Oldham, M.J; ONHIC, 487 recs.
7	Amirault, D.L. 1997-2000. Unpublished files. Canadian Wildlife Service, Sackville, 470 recs.
7	Basquill, S.P. 2012. 2012 Bryophyte specimen data. Nova Scotia Department of Natural Resources, 37 recs.
7	Basquill, S.P. 2012. 2012 rare vascular plant field data. Nova Scotia Department of Natural Resources, 37 recs.
7	Dibblee, R.L. 1999. PEI Cormorant Survey. Prince Edward Island Fisheries, Aquaculture & Environment, 1p. 21 recs.
7	Neily, T.H. & Pepper, C.; Toms, B. 2020. Nova Scotia lichen database [as of 2020-05-25]. Mersey Tobeatic Research Institute, 668 recs.
7	Nova Scotia Nature Trust. 2013. Nova Scotia Nature Trust 2013 Species records. Nova Scotia Nature Trust, 95 recs.
7	Powell, B.C. 1967. Female sexual cycles of Chrysemy spicta & Clemmys insculpta in Nova Scotia. Can. Field-Nat., 81:134-139. 26 recs.
7	Robinson, S.L. 2014. 2013 Field Data. Atlantic Canada Conservation Data Centre.
7	Taylor, B.R., and Tam, J.C. 2012. Local distribution of the rare plant Triosteum aurantiacum in northeastern Nova Scotia, Canada. Rhodora, 114(960): 366-382.
6	Blaney, C.S.; Mazerolle, D.M.; Klymko, J; Spicer, C.D. 2006. Fieldwork 2006. Atlantic Canada Conservation Data Centre. Sackville NB, 8399 recs.
6	Bryson, I. 2013. Nova Scotia rare plant records. CBCL Ltd., 180 records.
6	O'Neil, S. 1998. Atlantic Salmon: Northumberland Strait Nova Scotia part of SFA 18. Dept of Fisheries & Oceans, Atlantic Region, Science. Stock Status Report D3-08. 9 recs.
6	Plissner, J.H. & Haig, S.M. 1997. 1996 International piping plover census. US Geological Survey, Corvallis OR, 231 pp.
6	Tranquilla, L. 2015. Maritimes Marsh Monitoring Project 2015 data. Bird Studies Canada, Sackville NB, 5062 recs.
5	Basquill, S.P. 2003. Fieldwork 2003. Atlantic Canada Conservation Data Centre, Sackville NB, 69 recs.
5	Cameron, R.P. 2009. Cyanolichen database. Nova Scotia Environment & Labour, 1724 recs.
5	Cameron, R.P. 2018. Degelia plumbea records. Nova Scotia Environment.
5	Lawrence Benjamin. 2009. Wood Anemone records from Victoria Co., from personal communication with S. Ferguson. Nova Scotia Department of Natural Resources, 5 records.
5	Neily, T.H. Atlantic Canada Conservation Data Centre botanical fieldwork 2018. T.H. Neily, Atlantic Canada Conservation Data Centre.

# recs	CITATION
5	Ogden, J. NS DNR Butterfly Collection Dataset. Nova Scotia Department of Natural Resources. 2014.
5	Power, T. 2019. Cape Breton Wood Turtle records. NS Lands and Forestry.
5	Whittam, R.M. 1997. Status Report on the Roseate Tern (Sterna dougallii) in Canada. Committee on the Status of Endangered Wildlife in Canada, 5 recs.
4	Belland, R.J. 2012. PEI moss records from Devonian Botanical Garden. DBG Cryptogam Database, Web site: https://secure.devonian.ualberta.ca/bryo_search.php 748 recs.
4	Blaney, C.S.; Mazerolle, D.M. 2011. Fieldwork 2011. Atlantic Canada Conservation Data Centre. Sackville NB.
4	Cameron, R.P. 2014. 2013-14 rare species field data. Nova Scotia Department of Environment, 35 recs.
4	Clayden, S.R. 2007. NBM Science Collections databases: vascular plants. New Brunswick Museum, Saint John NB, download Mar. 2007, 6914 recs.
4	Edsall, J. 2007. Personal Butterfly Collection: specimens collected in the Canadian Maritimes, 1961-2007. J. Edsall, unpubl. report, 137 recs.
4	Neily, T.H. & Pepper, C.; Toms, B. 2018. Nova Scotia lichen database Update. Mersey Tobeatic Research Institute, 14 recs.
4	Richardson, D., Anderson, F., Cameron, R, McMullin, T., Clayden, S. 2014. Field Work Report on Black Foam Lichen (Anzia colpodes). COSEWIC.
4	Rousseau, J. 1938. Notes Floristiques sur l'est de la Nouvelle-Ecosse in Contributions de l'Institut Botanique de l'Universite de Montreal. Universite de Montreal, 32, 13-62. 11 recs.
4	Westwood, A., Staicer, C. 2016. Nova Scotia landbird Species at Risk observations. Dalhousie University.
3	Blaney, C.S. 2003. Fieldwork 2003. Atlantic Canada Conservation Data Centre. Sackville NB, 1042 recs.
3	e-Butterfly. 2018. Selected Maritimes butterfly records from 2016 and 2017. Maxim Larrivee, Sambo Zhang (ed.) e-butterfly.org.
3	Klymko, J. Henry Hensel's Butterfly Collection Database. Atlantic Canada Conservation Data Centre. 2016.
3	Manthorne, A. 2019. Incidental aerial insectivore observations. Birds Canada.
3	Neily, T.H. 2016. Email communication (May 6, 2016) to Sean Blaney regarding Fissidens exilis observations made in 2016 in Nova Scotia. Pers. Comm., 3 recs.
3	Newell, R.E. 2001. Fortress Louisbourg Species at Risk Survey 2001. Parks Canada, 4 recs.
3	O'Neil, S. 1998. Atlantic Salmon: Eastern Shore Nova Scotia SFA 20. Dept of Fisheries & Oceans, Atlantic Region, Science. Stock Status Report D3-10. 4 recs.
3	Parker, G.R., Maxwell, J.W., Morton, L.D. & Smith,G.E.J. 1983. The ecology of Lynx , Lynx canadensis, on Cape Breton Island. Canadian Journal of Zoology, 61:770-786. 51 recs.
3	Speers, L. 2001. Butterflies of Canada database. Agriculture & Agri-Food Canada, Biological Resources Program, Ottawa, 190 recs.
3	Zahavich, J. 2017. Canada Warbler and Olive-sided Flycatcher records 2017. Island Nature Trust, 14 recs.
2	Blaney, C.S. Miscellaneous specimens received by ACCDC (botany). Various persons. 2001-08.
2	Boyne, A.W. & Grecian, V.D. 1999. Tern Surveys. Canadian Wildlife Service, Sackville, unpublished data. 23 recs.
2	COSEWIC (Committee on the Status of Wildlife in Canada). 2013. COSEWIC Assessment and Status Report on the Eastern Waterfan Peltigera hydrothyria in Canada. COSEWIC, 46 pp.
2	Curley, F.R. 2007. PEF&W Collection. PEI Fish & Wildlife Div., 199 recs.
2	Daury, R.W. & Bateman, M.C. 1996. The Barrow's Goldeneye (Bucephala islandica) in the Atlantic Provinces and Maine. Canadian Wildlife Service, Sackville, 47pp.
2	Frittaion, C. 2012. NSNT 2012 Field Observations. Nova Scotia Nature Trust, Pers comm. to S. Blaney Feb. 7, 34 recs.
2	Gillis, J. 2007. Botanical observations from bog on Skye Mountain, NS. Pers. comm., 8 recs.
2	Harding, R.W. 2008. Harding Personal Insect Collection 1999-2007. R.W. Harding, 309 recs.
2	Hill, N. 2003. Floerkea proserpinacoides at Heatherdale, Antigonish Co. 2002. , Pers. comm. to C.S. Blaney. 2 recs.
2	Kelly, G. 2005. Fraxinus nigra. Dept of Agricuture, Fisheries, Aquaculture & Forestry. Pers. comm. to C.S. Blaney, Mar. 2, 11 recs.
2	Kelly, Glen 2004. Botanical records from 2004 PEI Forestry fieldwork. Dept of Environment, Energy & Forestry, 71 recs.
2	Klymko, J.J.D. 2018. 2017 field data. Atlantic Canada Conservation Data Centre.
2	Layberry, R.A. 2012. Lepidopteran records for the Maritimes, 1974-2008. Layberry Collection, 1060 recs.
2	Marshall, L. 1998. Atlantic Salmon: Cape Breton SFA 18 (part) & SFA 19. Dept of Fisheries & Oceans, Atlantic Region, Science. Stock Status Report D3-09. 5 recs.
2	Neily, Tom. 2020. Lichen surveys for PEI Forested Landscapes Priority Place. Chapman, C.J. (ed.) Atlantic Canada Conservation Data Centre, 158 records.
2	Olsen, R. Herbarium Specimens. Nova Scotia Agricultural College, Truro. 2003.
2	Quigley, E.J. 2006. Plant records, Mabou & Port Hood. Pers. comm. to S.P. Basquill, Jun. 12. 4 recs, 4 recs.
2	Scott, F.W. 1988. Status Report on the Gaspé Shrew (Sorex gaspensis) in Canada. Committee on the Status of Endangered Wildlife in Canada, 12 recs.
2	Spicer, C.D. 2004. Specimens from CWS Herbarium, Mount Allison Herbarium Database. Mount Allison University, 5939 recs.
2	Thomas, H.H., Jones, G.S. & Diblee, R.L. 1980. Sorex palustris on Prince Edward Island. Can. Field Nat., vol 94:329-331. 2 recs.
2	Whittam, R.M. et al. 1998. Country Island Tern Restoration Project. Canadian Wildlife Service, Sackville, 2 recs.
2	Zahavich, J. 2018. Canada Warbler and Olive-sided Flycatcher records 2018. Island Nature Trust, 14 recs.
2	Zahavich, J.L. 2020. Canada Warbler, Olive-sided Flycatcher and Eastern Wood-Pewee observations, Prince Edward Island, 2017-2019. Island Nature Trust.
1	Anderson, D. 2019. Black Ash observation, Baddeck, Nova Scotia. pers. comm. to J.L. Churchill.
1	Anderson, D.G. 2011. New site for showy ladyslipper on Cape Breton. Nova Scotia Department of Natural Resources, pers.comm. to R. Lautenschlager, Jul 5, 2011.
1	Baechler, Lynn. 2016. Plant observations & photos, 2016. Pers. comm. to S. Blaney, May 2016, 2 recs.
1	Bagnell, B.A. 2001. New Brunswick Bryophyte Occurrences. B&B Botanical, Sussex, 478 recs.
1	Bateman, M.C. 2001. Coastal Waterfowl Surveys Database, 1965-2001. Canadian Wildlife Service, Sackville, 667 recs.
1	Benedict, B. Connell Herbarium Specimens (Data) . University New Brunswick, Fredericton. 2003.
1	Benjamin, L.K. 2009. NSDNR Fieldwork & Consultants Reports. Nova Scotia Dept Natural Resources, 143 recs.
1	Bridgland, J. 2006. Cape Breton Highlands National Park Digital Database. Parks Canada, 190 recs.
1	Cameron, R.P. 2005. Erioderma pedicellatum unpublished data. NS Dept of Environment, 9 recs.
1	Cameron, R.P. 2009. Nova Scotia nonvascular plant observations, 1995-2007. Nova Scotia Dept Natural Resources, 27 recs.
1	Christie, D.S. 2000. Christmas Bird Count Data, 1997-2000. Nature NB, 54 recs.
1	Clayden, S.R. 1998. NBM Science Collections databases: vascular plants. New Brunswick Museum, Saint John NB, 19759 recs.
1	Crowell, M. 2013. email to Sean Blaney regarding Listera australis at Bear Head and Mill Cove Canadian Forces Station. Jacques Whitford Environmental Ltd., 2.
1	Curley, F.R. 2003. Glen Kelly records for Betula pumila & Asclepias syriaca on PEI. , Pers. comm. to C.S. Blaney. 9 recs.

# recs	CITATION
1	Curley, F.R. 2021. Nymphalis l-album record from near Belfast PEI. Pers. comm. to J. Klymko.
1	Doucet, D.A. 2007. Lepidopteran Records, 1988-2006. Doucet, 700 recs.
1	Doucet, D.A. 2009. Census of Globally Rare, Endemic Butterflies of Nova Scotia Gulf of St Lawrence Salt Marshes. Nova Scotia Dept of Natural Resources, Species at Risk, 155 recs.
1	Haughian, S.R. 2018. Description of Fuscopannaria leucosticta field work in 2017. New Brunswick Museum, 314 recs.
1	Klymko, J. 2019. Atlantic Canada Conservation Data Centre zoological fieldwork 2018. Atlantic Canada Conservation Data Centre.
1	Klymko, J.J.D. 2012. Maritimes Butterfly Atlas, 2010 and 2011 records. Atlantic Canada Conservation Data Centre, 6318 recs.
1	Klymko, J.J.D. 2016. 2015 field data. Atlantic Canada Conservation Data Centre.
1	MacQuarrie, K. 1991-1999. Site survey files, maps. Island Nature Trust, Charlottetown PE, 60 recs.
1	McKendry, Karen. 2016. Rare species observations, 2016. Nova Scotia Nature Trust, 19 recs.
1	McNeil, J.A. 2016. Blandings Turtle (Emydoidea blandingii), Eastern Ribbonsnake (Thamnophis sauritus), Wood Turtle (Glyptemys insculpta), and Snapping Turtle (Chelydra serpentina) sightings, 2016. Mersey Tobeatic Research Institute, 774 records.
1	McNeil, J.A. 2019. Snapping Turtle records, 2019. Mersey Tobeatic Research Institute.
1	Mersey Tobetic Research Institute. 2021. 2020 Monarch records from the MTRI monitoring program. Mersey Tobetic Research Institute, 72 records.
1	NatureServe Canada. 2018. iNaturalist Butterfly Data Export . iNaturalist.org and iNaturalist.ca.
1	Neily, P.D. Plant Specimens. Nova Scotia Dept Natural Resources, Truro. 2006.
1	Neily, T.H. & Pepper, C.; Toms, B. 2019. Boreal Felt Lichen Observation, April 2019. Mersey Tobeatic Research Institute.
1	Neily, T.H. & Pepper, C.; Toms, B. 2019. Boreal Felt Lichen Observation, January 2019. Mersey Tobeatic Research Institute, 1 rec.
1	Neily, T.H. 2013. Email communication to Sean Blaney regarding Agalinis paupercula observations made in 2013 in Nova Scotia. , 1 rec.
1	New York Botanical Garden. 2006. Virtual Plant Herbarium - Vascular Plant Types Catalog. Sylva, S.; Kallunki, J. (ed.) International Plant Science Centre, Web site: http://sciweb.nybg.org/science2/vii2.asp. 4 recs.
1	Newell, R.B.; Sam, D. 2014. 2014 Bloodroot personal communication report, Antigonish, NS. NS Department of Natural Resources.
1	Oehlke, W. 1999. Record of Polygonia satyrus from Prince Edward Island. http://www.silkmoths.bizland.com/ppsatyr.htm.
1	Porter, K. 2013. 2013 rare and non-rare vascular plant field data. St. Mary's University, 57 recs.
1	Robinson, C.B. 1907. Early intervale flora of eastern Nova Scotia. Transactions of the Nova Scotia Institute of Science, 10:502-506. 1 rec.
1	Schmidt, B.C. 2017. Details about a Speyeria aphrodite specimen at the Canadian National Collection from Baddeck, NS, sent via email on 15 February 2017.
1	Standley, L.A. 2002. Carex haydenii in Nova Scotia. , Pers. comm. to C.S. Blaney. 4 recs.
1	Stevens, C. 1999. Cam Stevens field data from PEI vegetation plots. Sent along with specimens to C.S. Blaney. UNB masters research project, 732 recs.
1	Webster, R.P. Atlantic Forestry Centre Insect Collection, Maritimes butterfly records. Natural Resources Canada. 2014.
1	White, S. 2019. Notable species sightings, 2018. East Coast Aquatics.
1	Whittam, R.M. 2000. Senecio pseudoarnica on Country Island. , Pers. comm. to S. Gerriets. 1 rec.
1	Zahavich, J.L. 2017. Locations of Round-leaved Orchid (Platanthera orbiculata) at Townshend Woodlot and Bird Island. Island Nature Trust, 2 records.

Public Scoping Report, Summerside, NS

Paqtnkek has been operating an experimental suspended oyster aquaculture licence and lease in the area for the past several years. The proposed commercial lease would be in the same location as the experimental lease. Community members have been able to observe the activity on the water and the infrastructure that is in place for the operation.

General Public Meeting, June 12, 2022

The venue and the date for a general public meeting for the site proposed for Summerside, NS were set to ensure access to as many community members as possible. It was held at a traditional Paqtnkek community gathering location in an outdoor gazebo located across from St. Anne's Catholic church, off Summerside Road. The location overlooked Paqtnkek's current spat collecting and experimental site, which is also the proposed site for this commercial application. The date was Sunday, June 12, 12:00 pm. Scheduling on a Sunday was intentional to enable lobster fishers who generally do not fish on Sundays to attend, and to enable persons who work during the week to be able to attend. Plans for the location, time, and advertisement were sent to NSDFA for their review. The letter to NSDFA and their response are shown in Appendix A.

Notice of public meeting

A hard copy of the notice was posted at the Heatherton Post Office, the Heatherton Community Centre, in locations adjacent to the gazebo where the meeting was held, and at Paqtnkek's Band Office. Hard copies were put in 20 mailboxes of houses (cottages and/or permanent homes) that are within sight of the water. One was hand delivered. The notice was also posted on Paqtnkek's Facebook page. The notice and photos of its posting can be found in Appendix B.

General organization of the public meeting

The gazebo was set up with posters at the front and back of the gazebo and approximately 30 chairs for attendees. Refreshments (water, cookies, pie) were available to attendees. A snapshot of the two large posters of the proposed site (36" X 48" and 24" X 23") hung in the gazebo to show an aerial view of where and how big the proposed site would be is shown in Appendix C.

Attendees were asked to sign in upon entry. And forms were available upon entry for attendees to record their questions and concerns. The sign in-sheet, form for recording concerns and general set up of the entryway and gazebo are shown in pictures in Appendix D.

With the low number of attendees, each person was able to have individual discussions with Paqtnkek representatives during the afternoon. Ten people signed in. Three are involved in the oyster project. The seven others are from the local area. Signatures collected at the meeting are found within Appendix E.

Meeting format

The meeting format was for Paqtnkek to present the plans for the oyster aquaculture development while referring to the posters hung in the gazebo (Appendix C) and to the site visible in the distance; and follow it with a question-and-answer period.

Notes taken during this public meeting are documented in Appendix D. No written questions or concerns were received.

After the meeting, the attendees approached the Paqtnkek representatives to discuss the plans as individuals or in small groups. The Paqtnkek representatives that provided information were [redacted], Norma Prosper, [redacted], and [redacted].

Outcomes

Perspectives from this June 12 meeting are listed in Table 1 located at the end of this document, organized according to the factors that must be considered in decisions related to marine aquaculture sites.

Table 1: Concerns, issues and perspectives collected during the public scoping for Summerside, organized according to the eight factors that must be considered in decisions related to marine aquaculture sites.

Factor	Concern/Issue/Perspective	Method concern was raised	Mitigation
The contribution of the proposed operation to community and Provincial economic development	How profitable is the operation	June 12 Public Meeting	Still relying on grant money but the scale that is intended when it is commercial will be profitable.
The public right of navigation	Concerns that the cove will still be navigable	June 12 Public Meeting	The site will be marked according to Transport Canada requirements to permit safe navigation.
Other	Making sure gear stays on site	June 12 Public Meeting	Responsible farm practices to be used include procedures for ensuring that gear is properly maintained on site and frequent checks scheduled for finding and retrieving loose gear. These procedures will be part of the Farm Management Plan that will be approved for implementation by NSDFA, as required within the Aquaculture Management Regulations for aquaculture sites in Nova Scotia.
Other	Would it be possible to put a slipway here that others could use?	June 12 Public meeting	The intention is to put in a better slipway. The area is open to the public but Paqtnkek is cautious to opening up to other boats due to invasive species.

MI'KMAW NATION
PAQTNKEK
~HONOURING CULTURE~
KEPMITE'TMU'KW TA'N WEMI'KW

May 20,2022

Hello Amanda:

Paqtnkek wishes to share their intended public engagement plans for their lease applications in Summerside and Havre Boucher. These are the applications described in the recent presentation given to NSDFA and network partners (May 3, 2022). The public engagement plans are below:

Summerside location: Public, outdoor meeting at the community gazebo in Summerside, tentatively scheduled for 1-3pm June 12, 2022. There will be a poster of the proposed lease location and handouts with information. Public notice to be given by posting paper notices at public venues in Summerside, Heatherton and Bayfield. It will also be posted on Paqtnkek's website (https://paqtnkek.ca) in the "Latest News and Events" section. There is no community newspaper that would be appropriate to cover that location so notice in a newspaper is not intended. Attempts will also be made to contact the occupants of properties adjacent to the intended site by going door-to-door with information in hand. PLEASE CONFIRM THIS MEANS OF PUBLIC ENGAGEMENT AND ADVERTISEMENT IS SUFFICIENT FOR SUMMERSIDE.

Havre Boucher location: Public, indoor meeting at the community hall or firehall in Havre Boucher, tentatively scheduled for 6-8pm June 12, 2022. There will be a presentation given to the attendees as well as handouts with information. Public notice to be given by posting paper notices at public venues in Havre Boucher. It will also be posted on Paqtnkek's website (https://paqtnkek.ca) in the "Latest News and Events" section. There is no community newspaper that would be appropriate to cover that location so notice in a newspaper is not intended. The Havre Boucher Harbour Authority has been contacted with an intention to meet with them prior to this public meeting. PLEASE CONFIRM THIS MEANS OF PUBLIC ENGAGEMENT AND ADVERTISEMENT IS SUFFICIENT FOR HAVRE BOUCHER.

The meetings were intentionally scheduled on a Sunday to accommodate lobster fishers who traditionally choose to not fish on Sunday.

As the date is fast approaching, comments on the above plans would be appreciated.

Kind regards,

[redacted]

Norma Prosper
Paqtnkek Oyster Administrator

Paqtnkek Mi'kmaw Nation 7 Dillon Street Antigonish, Nova Scotia B0H 1A0 TELEPHONE (902) 386-2781 FACSIMILE (902) 386-2043

Melissa Rommens

From: [redacted]
Sent: Tuesday, May 31, 2022 11:20 AM
To: [redacted]
Subject: Fwd: AQ#4028 & 4029 Public Engagement Plans
Attachments: Public Engagement Letter Amanda.pdf; Untitled attachment 00490.htm

Begin forwarded message:

From: "Feehan, Jennifer" <Jennifer.Feehan@novascotia.ca>
Date: May 31, 2022 at 11:16:56 AM ADT
To: Norma Prosper <norma.prosper@paqtnkek.ca>
Cc: "Greenwood, Megan N" <Megan.Greenwood@novascotia.ca>, "Ceschiutti, Robert" <Robert.Ceschiutti@novascotia.ca>, "Feindel, Nathaniel J" <Nathaniel.Feindel@novascotia.ca>, [redacted]
Subject: RE: AQ#4028 & 4029 Public Engagement Plans

Hi Norma,

Thank you for providing the letter outlining your intended public engagement plans in Summerside and Havre Boucher for Options AQ#4028 and AQ#4029.

The information presented in your letter appears to meet the minimum requirements for Public Meeting and Notice as outlined in the Proponent's Guide to Scoping (found here: https://novascotia.ca/fish/aquaculture/licensing-leasing/Scoping_Guide.pdf). The scoping guide describes advertising in a local newspaper as a suggestion for public notice, not a requirement, so you the methods you have described should be sufficient. Please be sure to document all methods of public notification and include in your report on the scoping process.

I also wanted to note that the Department will assess that the minimum requirements for scoping are met; however, we do not assess the adequacy of the scoping. That is something that would be taken into consideration by the Nova Scotia Aquaculture Review Board.

Please do not hesitate to reach out if you have any additional questions.

Kind regards,
Jennifer

Jennifer Feehan
Aquaculture Advisor
Nova Scotia Department of Fisheries and Aquaculture
1800 Argyle Street, 6th Floor WTCC
Halifax, NS B3J 2R5
902-237-0771
jennifer.feehan@novascotia.ca

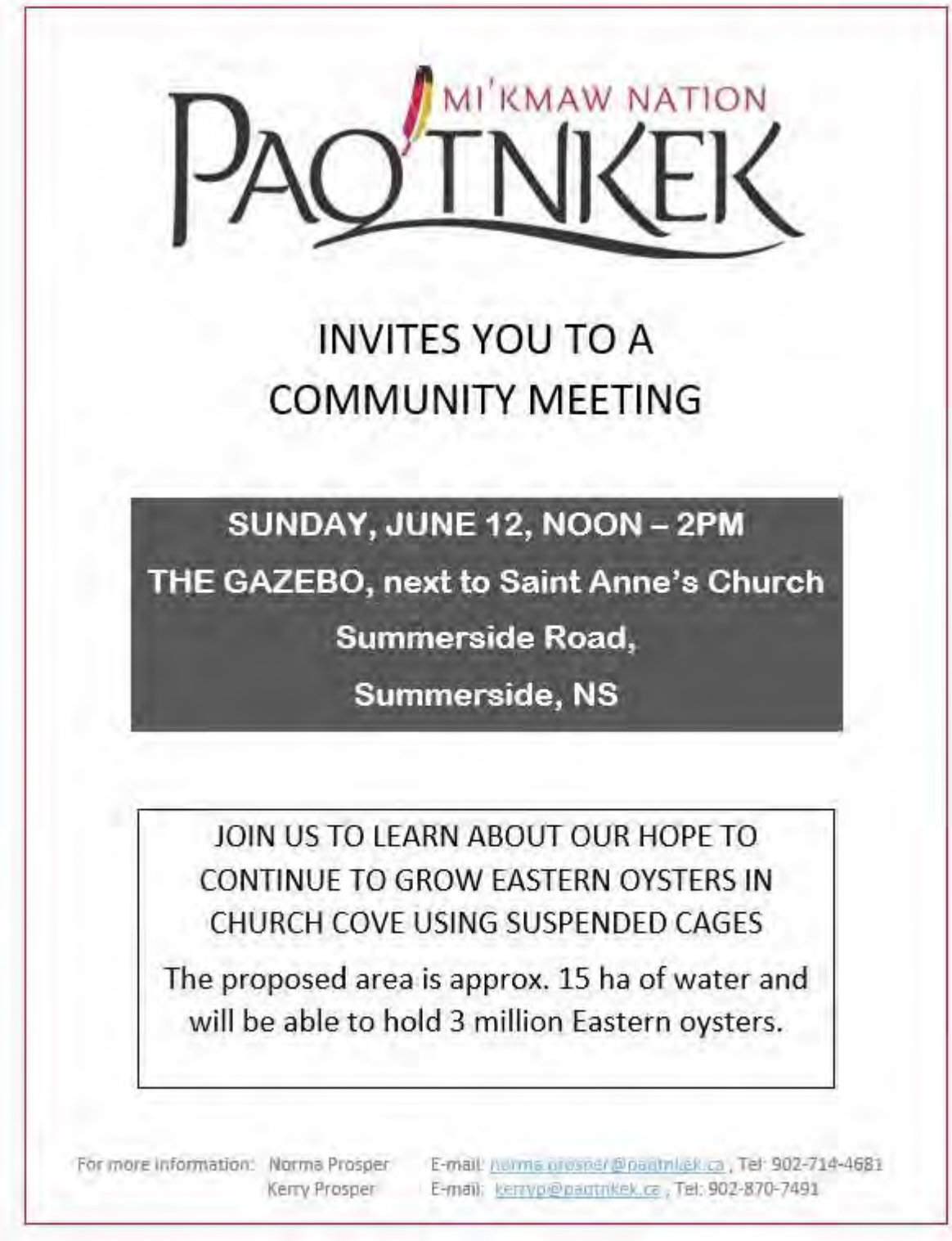


Figure A: Public notice of community meeting, Summerside

Figure B: Posting at the Heatherton Post Office

Figure C: Posting at the Heatherton Community Centre

Figure D: Posting at the Paqtnkek Band Office, 7 Dillon St.

Figure E: Postings in and around Church Cove and Summerside

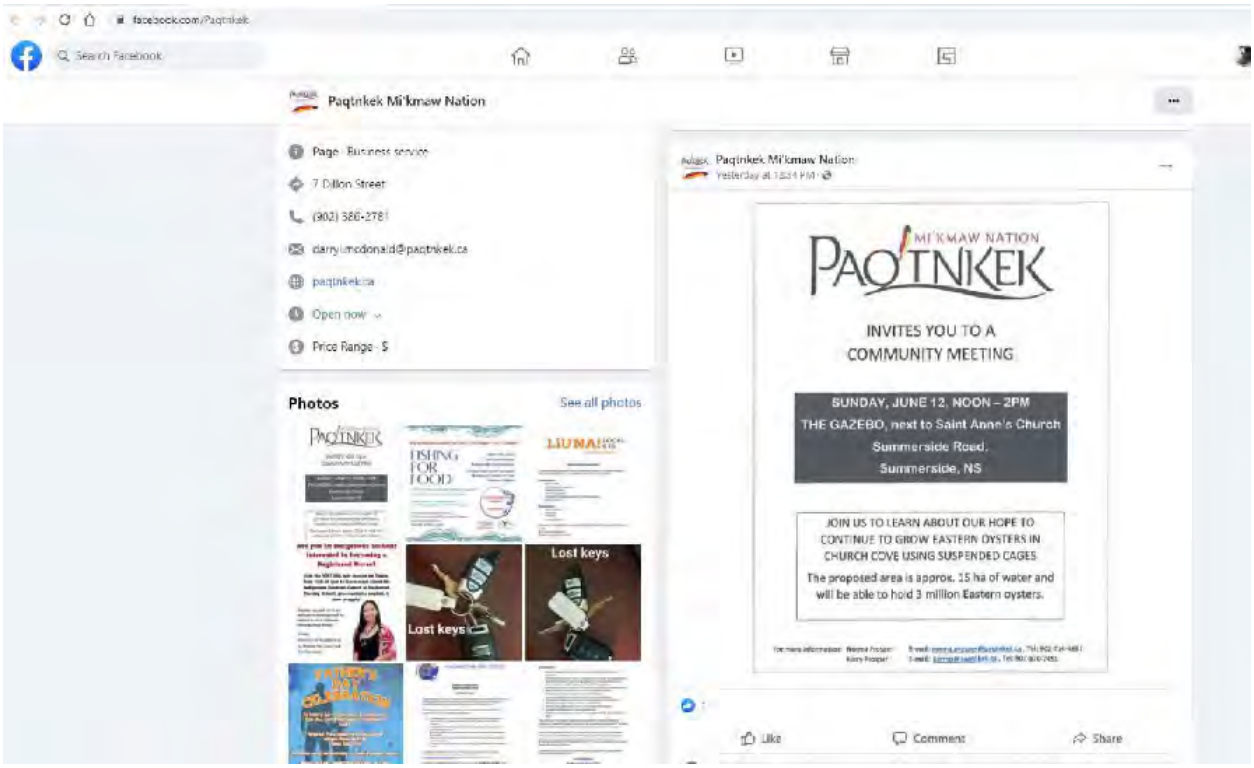
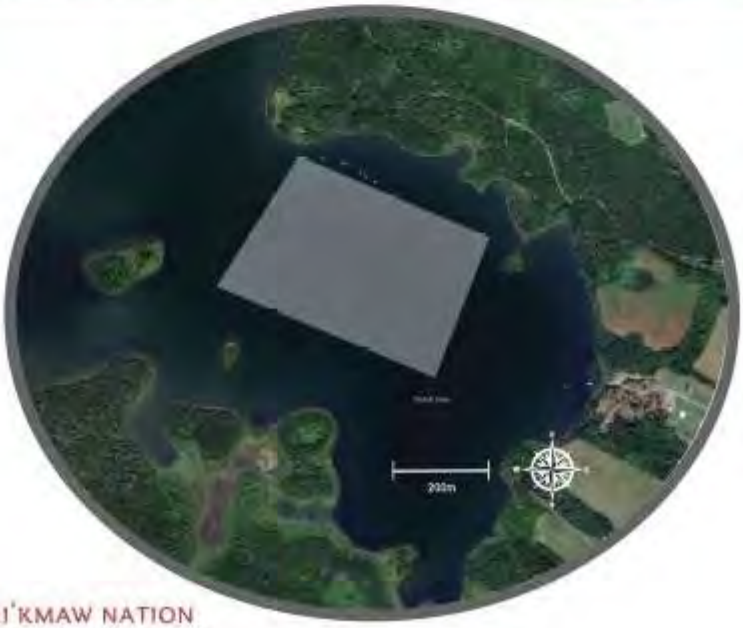


Figure F: Posting on Paqtnkek's Facebook page

Summerside Eastern Oyster Farm



MI'KMAW NATION
PAQ'TNKEK

Record of Summerside Public Meeting

Photos of meeting

Figure A: Table at entry to meeting

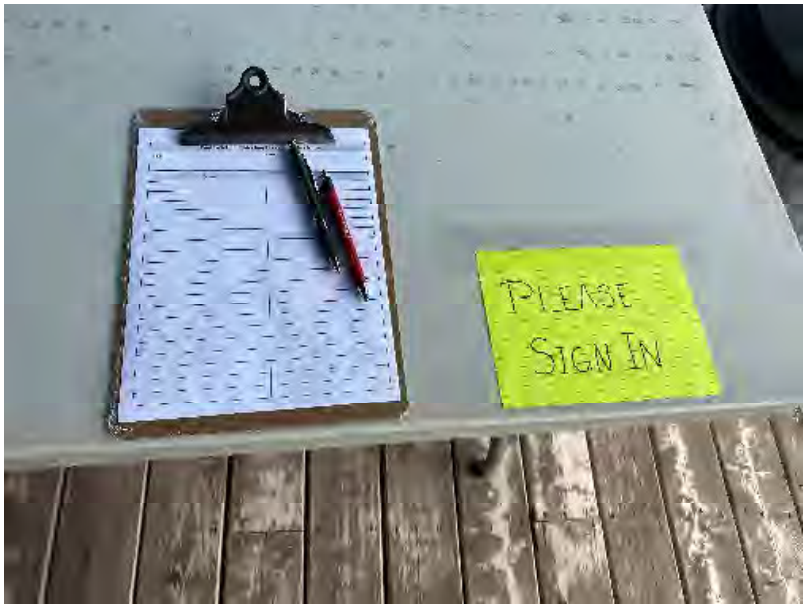


Figure B: Sign in sheet

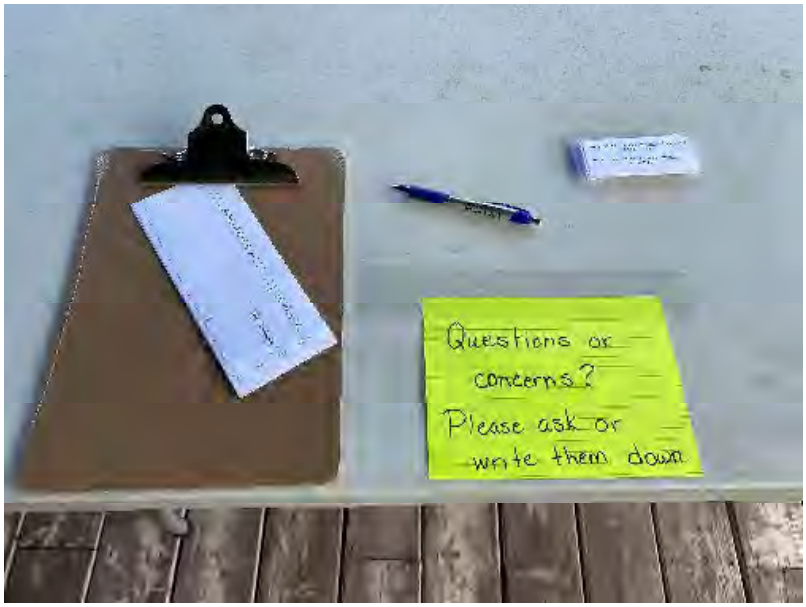


Figure C: Contact cards and forms for questions at entrance to meeting

Figure D: Gazebo set up

Figure E: [redacted] *talking to attendees*

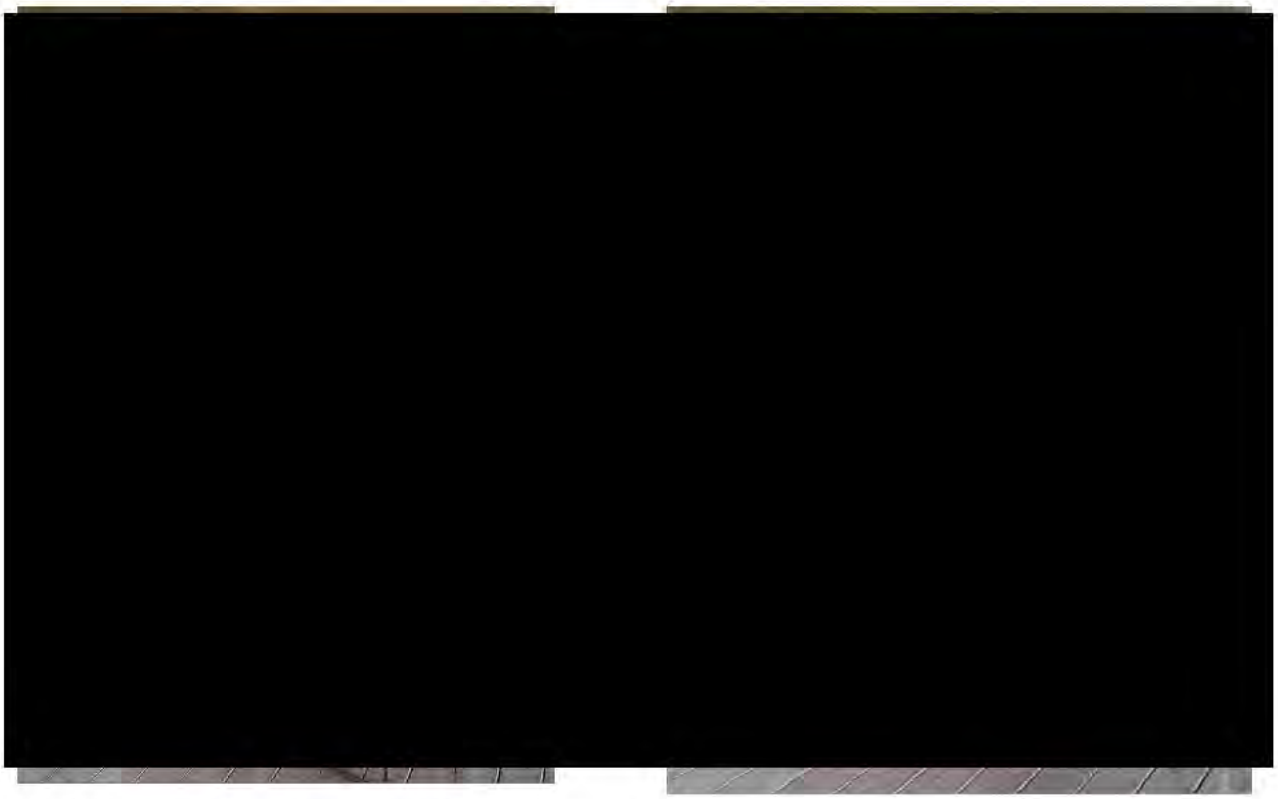


Figure F: [redacted] *and* [redacted] *having conversations with individual groups*

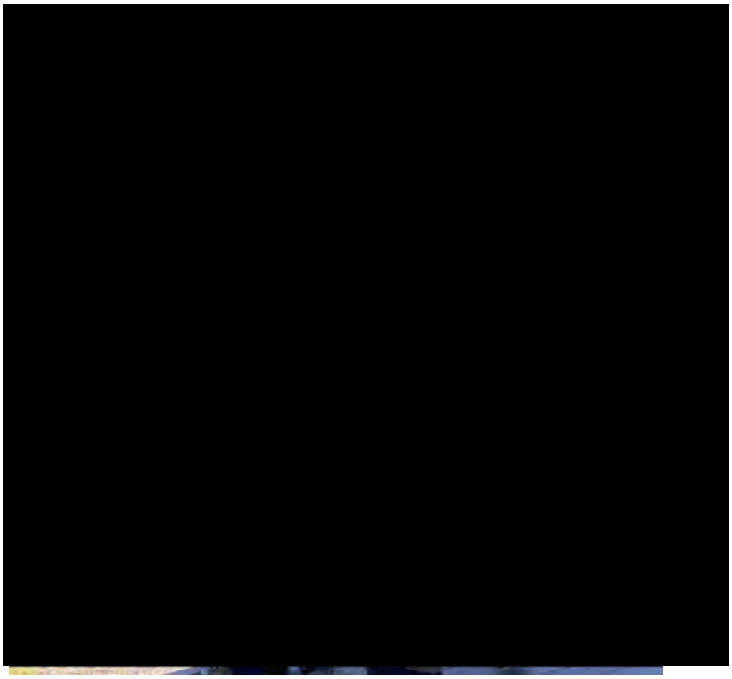


Figure G: [redacted] having an individual conversation with an attendee

Figure H: View of the current aquaculture experimental site from the gazebo with an eagle circling overhead

Summerside Public Meeting
June 12, 2022
Gazebo in Summerside
Minutes and Notes

Presentation

[redacted] began a short presentation at 12:30 where he welcomed the attendees and described how the intended oyster farm is anticipated to provide a source of food and employment for Paqtnkek. There is an extensive oyster population in the area which has not been fished since the 70's due to closure of the area to shellfish harvesting. Contamination due to sewage was the likely cause of the closure. There is a sewage treatment plant still operating but it is thought that bacterial levels would be decreased now because of improvements in sewage containment and treatment. The Band has proposed to monitor the harbour to see if it can be reopened to shellfish harvesting as they would prefer to harvest directly from this location. As it stands now, shellfish from this site would have to be relayed to another location for cleansing prior to sale. It is hoped that this can happen in Havre Boucher which is the closest area open for shellfish harvesting.

The original plan for this site and business was to do spat collection and sell the spat to other growers. But this turned out to be not feasible since when spatfall was good in this area, it was also good in other areas and there was no market for the spat. As a result, the plans changed to building a grow out operation, while selling spat on the side. This would make more money.

[redacted] referred to the large poster of the proposed site and indicated that the lease shown in the photo would be the maximum size and would hold three year classes of oysters with a maximum number of 3 million oysters – consisting of three year classes. This would result from an entry of 1 million oysters per year, with expected harvest of 800,000 oysters annually.

The experimental site has allowed the crew to get trained on spat collection and grow out. You can see the cages in the water now. (The experimental site was visible behind.) They are the Oyster Gro cages which are good for grading and inventory control. They are flipped to expose the so the sun can kill the biofouling. Oysters can withstand this drying out. The cages are held in place with lines attached to helical Archimedes crew anchors. If this commercial lease goes through, we will have to add more lines with anchors which will be done in the winter on the ice.

[redacted] then spoke and welcomed the attendees to Wal'neq, which means beautiful cove. There has been a long relationship with the harbour. Many of the Paqtnkek people were relocated to Eskasoni and Shubenacadie as the government tried to centralize First Nations people, but some wanted to stay, and did stay, in the area. This cove is the area where [redacted] was charged with fishing eels which turned into the landmark court case regarding fishing rights still being debated today.

The area is important to the Mi'kmaq, Acadian and Black communities. We share this history together. The harbour has given a lot of food to the area. We hope that the oysters grown here will play their part.

We had a LIDAR study done of the area to research the conditions of the harbour and help plan for a better future for this and for the fish and eels. We know that climate change is affecting things in terms of algae growth and water levels. These are a concern. We have interactions with the university doing studies and intend to do more. We hope our children will learn science and become more involved with these studies. We also need to have our own people share their knowledge and have their knowledge considered. We worry about our kids and we need to survive and will do so by working together. So come and ask questions.

Group question & answer

Q: Is the intent of this proposal to make the site bigger?
A: We need to make the lease a permanent one.

Q: Thank-you for inviting us. Let us know if we can help.
A: It is important to make the harbour healthy. We are trying to get the kids out and engage in things more.

Q: We have watched what you are doing and wondered what it was.

Q: Will the oysters purify the water?
A: The oysters take their food from the water. They drink it and filter out their food. A single oyster can filter a gallon an hour.
This is part of the circle of food. We're all interdependent.

Q: Any thoughts of putting a slipway here?
A: The area is very soft and not very deep. We are working on a proposal to put in a better slipway.

Q: Would everyone be able to use it?
A: We have had to turn people away the past few years due to COVID. But this area is open to the public. We want to add monuments and increase the use of the area. We are cautious of opening up to boats from other places as we are concerned about bringing in invasive species.

Q: How profitable is the operation?
A: We are relying on grant money now. So we want to harvest the oysters to make more money and make it profitable. But we need to have a place to clean them in order to sell them.

Q: Will you ensure that it is still navigable?
A: Transport Canada will tell us how to mark and we will make sure people can still go around.

Q: Is there any way to clean the oysters here?
A: We could put in a land-based depuration plant, but it is very expensive – couple of million dollars. Havre Boucher has clean water where we can clean them. We would take the oysters from here to Havre Boucher and sink them. This area may be clean enough already but it is closed to harvesting. We are sampling to see if it is clean enough to allow it to be open (to harvesting).

If you see a buoy or something loose, let us know and we'll come and take care of it. There is also a regular shoreline clean up that happens, but things may drift and we need to know.

The community website will be updated with activities as things go on.

Q: Would like more information about the project, like things have been going on for 7 years and it is not making money yet?
A: We have not sold any oysters yet but intend to sell them soon as we have some that are big enough. We have four year classes on site now.

Q: How far do you have to send them?
A: We intend to collect and send to Havre Boucher. Intend to process locally eventually.

Q: I have heard there will be 20-30 people hired?
A: No, you may be thinking about the operation in WhiteHead with 5000 cages. This will be much smaller.

Q: Will expansion go beyond Church Point?
A: No.

Q: Will we be able to navigate around?
A: Yes, it will be marked with buoys according to Transport Canada requirements.

Q: I understood it would close off the whole harbour?
A: No, just what is shown on the map.

The formal "sit down session" ended but one on one, informal discussions continued.
The session was packed up at 1:45pm since everyone had left.

Appendix E: Sign in sheet for Summerside Public Meeting

Paqtnkek Public Meeting Record of Attendance	
Location: Summerside, Bayfield, NS.	Date: Sunday, June 12th 2022

Name	Community
[redacted]	BAYFIELD.
	Bayfield.
	Summerside Rd
	Summerside Rd.
	Earth
	Paqtnkek
	Paqtnkek FN
	Paqtnkek First Natior
	BAY [redacted]
	[redacted]